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Training and Development

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STANDARD SPECIFICATIONS FOR CONSTRUCTION AND MAINTENANCE OF ROADS AND BRIDGES

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Second Edition - June 2009

Ministry of Construction and Engineering Services

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PREFACE TO THE SECOND EDITION

We are pleased to publish this Second Edition of the "Standard Specifications for Construction and Maintenance of Roads and Bridges", after effecting revisions to the First Edition, jointly by the Institute for Construction Training & Development (ICTAD) and Road Development Authority (RDA). The Resource Personnel inputs for the revised edition were provided by the RDA while the ICTAD was responsible for co-ordinating the process and providing financial assistance. The Sub - Committee engaged for the revision are given below:

Eng J K Lankatillake	-	Director General, ICTAD (Chairman, Sub-Committee)
Resource Personnel		
Eng D P Mallawaratchie	-	Consultant, RDA (former General Manager, RDA)
Eng R M Amarasekera	-	Addl. General Manager (Asset Development), RDA
Eng J Jayamanne	-	Director (Research & Development), RDA
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Eng M G J Munasinghe	-	Senior Designs Engineer (Bridge Designs), RDA
Convener		
Eng (Mrs.) V Ranasinghe	-	Director (Advisory Services), ICTAD

The Steering Committee on ICTAD Publications which consisted of representatives from the Institution of Engineers Sri Lanka, Sri Lanka Institute of Architects, Society of Structural Engineers Sri Lanka, Association of Consulting Engineers Sri Lanka, Institute of Quantity Surveyors Sri Lanka, Institute of Project Managers Sri Lanka, National Construction Association of Sri Lanka, Institute for Construction Training & Development, recommended this revision for the approval of the Board of Management of ICTAD.

The Board of Management of ICTAD approved the recommendations of the Steering Committee.

I wish to acknowledge with grateful thanks the valuable contributions of Resource personnel of RDA, the members of the sub committee and the Steering Committee on ICTAD Publications for the successful completion of this revision. I appreciate the assistance rendered by Mrs. Dammika Gunasekera for the Secretarial work and the staff of ICTAD, who contributed in numerous ways in the publication of this document.

I am confident that this revised edition will comprehensively address the current developments of the Highway Sector in Sri Lanka.

Eng. J K Lankatillake
Director General – ICTAD

12th June 2009

Foreword

This edition of the Specifications for Construction and Maintenance of Roads & Bridges is the first revision since first published twenty years ago. During the last 4 years significant developments have taken place in the road sector due to the large Road Rehabilitation and Reconstruction Projects as well as New Road Construction Projects undertaken during this period. As a result, the inadequacies of the first edition of the specifications to cater to the new developments have been realized. This revised edition of the Standard Specification for Construction and Maintenance of Roads and Bridges has taken necessary measures to address the shortcomings of the first edition by including several new sections and effecting amendments to the existing sections.

The New Sections 109, 110, 112, 114, 115, 116, 117, 118, 119, 203, 204, 205, 301A, 307, 308, 409A, 410, 508, 509, 812, 813, 814, 815, 816, 817, 818, 819, 901A, 901B, 1011, 1012, 1013, 1014, 1015, 1016, 1017, 1018, 1019, 1020, 1021, 1105, 1106, 1107, 1108, 1109, 1206, 1503, 1603, 1710, 1805, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1912, 2001, 2002, 2003 and 2004 have been added while many amendments to the existing sections have been incorporated.

The publication of this revised edition has been possible due to the valuable contributions made by the resource personnel of the RDA and co-ordination by the ICTAD. I wish to express my sincere gratitude to all of them.

Road Development Authority has taken a policy decision to use this revised document for works carried out by the Road Development Authority from June 2009 and also consent is granted to ICTAD to publish the same.

R W R Pemasiri
General Manager
Road Development Authority
01st June 2009

CONTENTS

100 GENERAL

101 ABBREVIATIONS

Where the following abbreviations are used in these Specifications or on the Plans, they shall be considered as representing the same as the respective expression as given below:-

AASHTO	-	American Association of State Highway & Transportation Officials
AC	-	Asphalt Concrete
AIV	-	Aggregate Impact Value
ASTM	-	Ameriean Society for Testing and Materials
BS	-	British Standards
BOQ	-	Bills of Quantities
CEA	-	Central Environment Authority
CB1	-	Stabilised Road Base 1
CB2	-	Stabilised Road Base 2
CBR	-	California Bearing Ratio
cm	-	Centimetre
CMS	-	Cationic Medium Setting
CRS	-	Cationic Rapid Setting
CSS	-	Cationic Slow Setting
CS	-	Ceylon Standards
CSB	-	Stabilized Sub Base
CP	-	Code of Practice
Cu.m	-	Cubic Metre
DBM	-	Dry Bound Macadam
DBST	-	Double Bituminous Surface Treatment
Dft	-	Dry film thiekness
DIN	-	German Standards
EN	-	European Standards
FIDIC	-	Federation International Des Ingenieurs - Conseils
GI	-	Galvanized Iron
Ggbs	-	Ground Granulated blast furnace Slag
gm	-	Gram
HFL	-	High Flood Level
HMSO	-	Her Majesty's Stationery Office, United Kingdom
HSFG	-	High Strength Fabrication Grip
ICTAD	-	Institute for Construction Training and Development
IP	-	Ingress Protection
ISO	-	International Organization for Standardization
kg	-	Kilogram
km	-	Kilometre
kN	-	Kilo Newton
kPa	-	Kilo Pascal
l	-	Litre
LAAV	-	Los Angeles Abrasion Value
LL	-	Liquid Limit
lm	-	Linear Metre
LS	-	Linear Shrinkage
LWL	-	Low Water Level
m	-	Metre
MC	-	Medium Curing
mc	-	Moisture Content
MDD	-	Maximum Dry Density
mm	-	Millimetre
MPa	-	Mega Pascal
MS	-	Mild Steel
N	-	Newton
Nr (#)	-	Number
OMC	-	Optimum Moisture Content
OPC	-	Ordinary Portland Cement
ORN	-	Overseas Road Note of the Transportation Researeh Laboratory, UK
Pfa	-	Pulverised Fuel Ash
PI	-	Plasticity Index
PL	-	Plastic Limit
Provi S	-	Provisional Sum
PS	-	Provisional Sum
PSC	-	Pre-stressed Conerete
PVC	-	Poly Vinyl Chloride
RCC	-	Reinforced Cement Concrete
ROW	-	Right of Way
RDA	-	Road Development Authority
RR	-	Random Rubble
RSJ	-	Rolled Steel Joist
SBST	-	Single Bituminous Surface Treatment
SLS	-	Sri Lanka Standards
SPT	-	Standard Penetration Test
Sq.m	-	Square Metre
SSCM	-	Standard Specifieation for Construction & Maintenance of Roads & Bridges
SSG	-	Selected Subgrade
TRL	-	Transportation Research Laboratory, United Kingdom
UCS	-	Unconfined Compression Strength
UK	-	United Kingdom
WBM	-	Water Bound Macadam
WMM	-	Wet Mix Macadam

102 DEFINITIONS & EXPLANATIONS

Wherever in these Specifications, the following terms are used, their meaning shall be interpreted as follows: -

However where the definition & explanations in the General Conditions of Contract differ from those in the Standard Specifications, the former shall apply.

At all times – Throughout the Contract period.

Bridge - A roadway structure including supports, erected normally over a waterway, for carrying traffic, having a clear span between supports of more than 3.0m measured along the centre line of the roadway.

Capping Layer or Lower Sub-base or Select Subgrade – They are used in the lower Pavement layers as a substitute for a thick Sub-base to reduce costs.

Carbonation – The reaction of lime (used for stabilization of soils) with atmospheric Carbon dioxide to form un-reactive Calcium Carbonate.

Carriageway - The paved or unpaved area of the roadway designated for vehicular travel.

Culvert - Any structure under the roadway with a clear opening of less than 3.0m measured along the centre line of the roadway.

Drawings - See Plans

Laboratory - Any laboratory authorized by the Engineer.

Lateritic Gravelly Soil – It is a Reddish Brown gravelly soil with hard granular particles that enhances its properties such as the CBR strength when exposed to the atmosphere.

Lower Sub-base - See Capping Layer.

Pavement Structure - The combination of Sub-base, Base and Surfacings placed on a Subgrade to support the traffic.

(i) Sub-base - The layer or layers of specified or selected material of designated thickness placed on the Subgrade on which the road Base will be constructed.

(ii) Base - The layer or layers of specified or selected material of designated thickness placed on Sub-base or Subgrade on which a Surfacing will be constructed.

(iii) Surfacing - The binder application, dressing or surface course constructed on the Base as a protective measure to the Pavement structure, against traffic action and the effects of weather and climate.

Paved Road – A road where the top Pavement surfaces are constructed with bitumen applications on aggregate Bases or bitumen – aggregate mixes or concrete.

Pioneer Layer – First layer of fill on soft ground that is generally not compacted.

Plans - The Contract Drawings which show the location, characteristic details and dimensions of the prescribed work, including layouts, profiles, Cross-sections, etc.

(i) Working Drawings - Supplemental drawings and or sketch diagrams, supplied by the Engineer or submitted by the Contractor and approved by the Engineer, during construction regarding details.

Road bed or Road formation - The prepared surface, formed to line, level and required Cross-section, to receive the Pavement structure. It is also the top of the Subgrade.

Road formation - See Road bed.

Road Side - The area adjoining the outer edge of the roadway including the verges and embankments, but within the ROW.

Roadway - Area covered by the carriageway, shoulders and drains.

Right of Way (ROW) - Extent of the land legally available for the roadway and the roadside.

Selected Subgrade - See Capping Layers.

Shoulder - The portion of the roadway contiguous with the carriageway mainly for emergency use and for lateral support of the Pavement structure.

Side Walk - That portion of the roadway primarily constructed for the use of the pedestrians.

Specification - The compilation of provisions and requirements for the performance of prescribed work.

(i) Standard Specifications - This book of Specifications approved for general application and use.

(ii) Supplemental Specification - Approved additions and revisions to the Standard Specifications.

(iii) Special Provisions - Additions and revisions to the Standard and Supplemental Specifications applicable to an individual project.

Streaking - Broad lines devoid of binder on road surface after application with a binder distributor when its spray bar nozzles are clogged.

Structures - Bridges, culverts, retaining walls, drains and such other constructions which are not otherwise defined herein.

Subgrade - The layer of soil immediately beneath the road formation.

Sub Structure - All that part of a bridge or culvert below the bearings.

Super Structure - All that part of a bridge or culvert above the bearings.

Unbound Bases – All aggregate Bases without coatings of aggregate by bituminous, cementitious and other binders.

Upper Sub-base - In order to reduce costs, Capping Layers or Lower Sub-bases or Selected Subgrade layers are introduced in the lower Pavement layers. In order to distinguish between such layers, the Sub-base layer proper is called the upper Sub-base.

Unpaved Road – Earth or gravel roads.

Utility Services - Useful services for public such as electricity, water supply, drainage, telecommunication, etc.

Windrowing - Making a long pile or row of soil, etc. heaped up generally with a motor grader / bull dozer.

103 ARRANGEMENTS FOR TRAFFIC WITH SAFETY PRECAUTIONS DURING REHABILITATION OR CROSSING OF EXISTING ROADS

103.1 General

The Contractor shall provide and maintain for the period of construction, traffic control and safety devices including Traffic Signs, Barricade Boards, Traffic Cones, Lighting Devices at all locations where work is in progress in accordance with Part II of the "Manual Of Traffic Control Devices, Road Development Authority, Ministry of Transport and Highways-March 2001" or their latest editions.

Materials and equipment temporarily stored on, or adjacent to, the existing roadway shall be so placed, and the work at all times, shall be so conducted as to cause minimum disruption to the road user.

Warning signs, painted barrels and warning tape strung across barrels shall be provided to separate the Contractor's material and equipment and the Contractor's working area from the roadway. Red lanterns or warning lights shall be mounted on barricades at sunset and shall be kept lit until sunrise. Reflective tapes and stickers of minimum size of 50x50 mm shall be pasted on each barrel and directed at on coming traffic.

At the points where traffic is to deviate from its normal path [whether on part of the carriageway (section 103.2) or temporary diversion (section 103.3)] clear directions to the traffic shall be conspicuously exhibited at both ends with the aid of appropriate road signs. The portion of road closed for traffic shall be barricaded and at night these markings shall be adequately lit so as to be clearly visible, as stated in the aforesaid paragraphs of this section 103.1. One way traffic arrangements shall be resorted to, in case the traffic is heavy, in consultation with and with the assistance of the Police Authorities. Signs warning the traffic of the obstructions or diversions ahead shall also be installed well forward of the points of diversion. The Contractor shall arrange for the Traffic Police to be in attendance for traffic management. Necessary flag men with stop / go boards and or traffic lights shall be stationed at both ends to guide the traffic.

The Contractor shall be responsible for the provision and maintenance of adequate standard signing for the duration of any diversion.

If in the opinion of the Engineer, the above Road Safety and Traffic Control measures have not been provided at the start or at any stage of rehabilitation, the Contractor shall not be permitted to start or continue to work at such sections of the road.

103.2 Using Part of the Road

A part of carriageway shall be kept open to traffic while improvement works such as widening of the road or strengthening of the existing Pavement is being carried out in the other part. The above procedure shall be carried out provided the part kept open to traffic is adequate for the purpose, if necessary, by widening the shoulders. In such cases the shoulders shall be dressed and brought in level with the existing carriageway and shall be continuously maintained in a good condition for the entire duration of the work. Where improvement work is in progress in long stretches along important roads, suitable passing bays shall, where possible, be provided with the approval of the Engineer and in consultation with the traffic police. On less important roads, the method of keeping part of the carriageway open to traffic shall, as far as practicable, be adopted even in respect of repairs to or reconstruction of culverts and minor bridges.

The Contractor shall not be permitted to have excavations open on both sides of the road at a particular chainage such that there are steep drops adjacent to traffic, which may create a danger to traffic. That is the excavation and backfilling with Sub-base or Base shall be flush with the existing road level on one side, before excavation can proceed on the other side of the road.

The maximum length of working along one of the lanes of two lane road (one way working) for 1 km of roadway rehabilitation shall be limited to 2 separate sections of 300 metre length each. This length may be further reduced depending on the traffic flow and if visibility is reduced at bends or increased where appropriate at the Engineer's discretion. For one way working the Contractor shall not commence work until the Engineer approves the proposal submitted by the Contractor for this purpose.

During construction for operations which require one way traffic the Contractor shall be responsible for the removal of broken down vehicles, including vehicles damaged in accidents and shall maintain one way uninterrupted traffic flow at all times.

103.3 Temporary Diversion

If, in the opinion of the Engineer, it is not possible to pass the traffic on a part width of the carriageway, or by any other route, a temporary diversion close to the road shall be constructed as directed by the Engineer. Such diversion shall be constructed to Specifications approved by the Engineer by using locally available materials, as far as practicable. Temporary surface and cross drainage arrangements shall also be provided as directed wherever necessary. The diversion shall be maintained in good condition till the original or new road is opened to traffic.

103.4 Measurement and Payment

(a) Measurement

(i) All costs related to the implementation and execution of the traffic safety and management work shall be measured monthly. Provision and maintenance of temporary diversion roads, if any shall be measured for payment as a Provisional Sum.

(b) Payment

A Traffic Safety and Control

(i) Payment shall include all costs necessary and required for the implementation of this work in accordance with these specification, including updating.

(ii) Payment shall be made monthly.

(iii) The Engineer may any time withhold payments if in his opinion this work is not being provided, in due compliance with the requirements and procedures of this specification.

B Provision and maintenance of temporary diversion roads, if any. Payments shall be made as per a provisional sum.

The Pay Items and Pay Units shall be as follows;

Pay Item	Description	Pay Unit
103(1)	Traffic safety and control	Month
103(2)	Provisions and maintenance of temporary diversion roads, if any	Provisional Sum

104 CONTROL OF WORKS

104.1 Not Used

104.2 Conformity with Plans and Specifications

All work performed shall be in accordance with these Specifications and in conformity with lines, levels, grades, Cross-sections and dimensions shown on Plans and working drawings. All materials furnished shall also be in conformity with the Specifications. In the event the work performed and/or the materials furnished are not in conformity with the Plans and Specifications and have resulted in an inferior or unsatisfactory product, such work or material shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

Field Controls

Unless otherwise specified, the Contractor shall set out such initial construction stakes and bench marks that will serve as the field controls for the construction work and obtain the approval of the Engineer for the same. No work shall begin till such bench marks, stakes, setting out points, reference points and all control points of the centre line are certified as correct by the Engineer or his representative.

104.3 Construction Programming

The Contractor shall programme his work so as to reduce as far as is practicable, disruption to all road users during construction of the Works and maintain traffic control measures for the safety of traffic at all times.

For road widening sections of existing roads

To assist with compliance of this requirement the Contractor will be restricted in the use of one way working as described below.

Within any 1 kilometre section of the Site the length of road available to the Contractor for major Pavement construction at any one time involving single lane traffic control shall be restricted to 2 separate sections of 300 metre length each.

The Contractor shall not be permitted to work outside these 2 separate sections of 300 metre lengths (except on a separate 1 km. section) unless otherwise agreed by the Engineer until the full width of the road is completed up to asphalt concrete Surfacing as per Section 506 or the first seal as per Section 505 or first coat, where the road is to be surface dressed with hot bitumen applications, as per Section 503 or any other Surfacing as approved by the Engineer.

The Contractor shall provide with his time/location programme and detailed construction schedule, a list of proposed 2 separate sections of 300 metre lengths with chainage location showing where he intends to commence his Pavement construction. The Engineer shall approve these locations without undue delay subject to compliance with this Clause and the Contractor shall then be given access to these sections. Subsequent sections shall be requested and the Engineer shall approve them in accordance with the above procedure.

Where relevant the Contractor shall also provide with his programme, his proposals for asphalt laying, indicating the sources of asphalt and crushed materials etc., his suppliers of pre-cast products and reinforcing steel, the programme of supplying of them and his resources schedule and their time of availability at site. He shall also provide a complete method statement explaining as to how he commences and proceeds with all major items of work in his programme.

If required, the Contractor shall take into consideration, the works to be completed by him in order to commence the works of the Service Agencies that would be made available to him by the Employer, in preparing his Time/Location programme.

Where relevant, the Engineer has the authority to suspend the commencement of laying of Base course over the existing road surface until the Contractor's asphalt laying proposal is approved and he is ready to undertake the asphalt paving trial.

Other work such as structural work for bridges or extension to culverts or drainage work or work which may be carried out without disruption to traffic, either vehicular or pedestrian, may be undertaken in a properly programmed manner outside these limits with prior approval from the Engineer.

Before any subsequent 300 metre section is made available to the Contractor, the Contractor shall demonstrate that he has sufficient material in approved stockpiles, equipment and labour available to progress the Works and adequate road safety and Traffic Control measures shall be taken as per section 103 of these Specifications. If in the opinion of the Engineer, this is not demonstrated, the Contractor shall not be permitted to start work on the subsequent section.

The layers of the widening section of the road shall be constructed up to the top of Sub-base level on one side, initially, with two or one-way traffic (as appropriate or as directed by the Engineer) using the existing remaining road width. The Contractor shall be fully responsible for traffic control.

Traffic shall then be allowed to pass over the layers so placed with the Contractor responsible for the protection of the Sub-base (e.g. by the application of a suitable cover of Base course material or by any other method approved by the Engineer). No separate payment shall be made for this protection.

Construction of the widening of the opposite side of the road to half width will then take place up to finished surface level (asphalt concrete or first seal of a double surface treatment or first coat as per Section 503 when using hot bitumen or any other

Surfacing as approved by the Engineer). Traffic shall then be allowed to travel over the finished surface once approved.

Completion of the first side of the road will then take place to finished road level.

If, within any 300 metre section where the Contractor has the Engineer's permission to execute major Pavement construction in stages, there are insufficient locations for embankment construction using the excavated suitable material from that section, the Contractor shall request access to adjacent sections where embankments can be constructed and the Engineer shall grant such access unless permission cannot be granted for safety reasons.

104.4 Not Used

104.5 Not Used

104.6 Compaction Equipment

Mechanical equipment shall be used for compacting materials by rolling, tamping and watering the materials before compaction. For other operations such as spreading, mixing and shaping, mechanical equipment only or a combination of mechanical equipment (which shall include graders) and manually operated tools and equipment shall be used. The choice of equipment and the procedure of their use shall be subject to the approval of the Engineer, upon his being satisfied on their effectiveness on the basis of trial compactions.

It shall be understood by the Contractor that different types of materials are likely to require different kind of compaction equipment, including successive applications thereof, for achieving the specified degrees of compaction and the Contractor shall make available a fleet of compaction equipment of the requisite kinds, sizes and numbers.

For compacting along narrow strips e.g. along widening of Pavements and in restricted areas e.g. behind bridge abutments, appropriate sized, purpose made compacting equipment will be required and the same shall be provided by the Contractor.

All equipment shall be manufactured by established manufacturers and of proven efficiency, in good working order and shall be operated and maintained at all times by skilled personnel in a manner acceptable to the Engineer.

104.7 Compaction Trials

For demonstrating the efficacy of mixing and compaction equipment and the working methods proposed to be used by the Contractor for different kinds of materials, the Contractor shall carry out compaction trials before full-scale construction on the road and during construction throughout the course of the Contract as required by and in close cooperation with the Engineer. Based on results of compaction trials and construction observation, the Engineer shall reserve the right to direct the use of particular mixing and compaction equipment and methods and disallow the use of others for compacting different kinds of materials in accordance with these Specifications.

104.8 Dispersal of Hauling Equipment

Hauling equipment bringing materials to the site of work shall be dispersed uniformly over the surface of the previously constructed layers in order to avoid rutting and uneven compaction. The materials from hauling equipment shall not be dumped in concentrated heaps but deposited as evenly distributed layers or windrows consistent with the loose thickness to be achieved before compaction. The hauling equipment shall not be allowed on the proposed shoulder areas. Any defects caused by the hauling equipment on shoulder Pavement layers shall be remedied by complete removal down to the Subgrade level and reconstruction as per these Specifications.

104.9 Protection to Newly Constructed Layers

Except as permitted by the Engineer, no traffic other than construction traffic shall be allowed on any earthwork or Pavement layer until a Surfacing has been applied either as single surface treatment or an asphalt concrete layer or any other Surfacing layer. The approval of the Engineer shall be required before traffic is allowed to pass over newly constructed road. Any defects caused by traffic passing over the construction layers shall be remedied in accordance with these Specifications.

104.10 Bridge Construction Sequence

The Contractor shall programme the construction sequences for all bridges and submit a written statement thereof for the approval of the Engineer. The bridge construction sequence shall consider, as a minimum, each phase of bridge construction with respect to traffic control, the effects on the existing bridges and the completed bridges. Where the Contractor proposes to partially demolish an existing bridge to allow for phased construction, he shall demonstrate to the Engineer's approval that the partially demolished bridge is safe for use by his equipment and other road users.

The control of traffic during the construction of the bridge shall be in accordance with the Section 103. Where the bridge construction sequence has been specified on the Drawings, the Contractor shall follow the sequence specified. The Contractor may propose an alternative construction sequence provided he can demonstrate, in a written statement, that the sequence is not detrimental to the Works or road users in any way.

No work shall commence on a bridge until the written consent to the construction sequence has been given by the Engineer in compliance with the relevant clauses of the General Conditions of Contract and until in the opinion of the Engineer adequate traffic control, road safety and construction safety measures have been taken.

104.11 Measurement and Payment

No separate payment shall be made for compliance under this section. Payment shall be deemed to be included in the Contractor's rates.

105 CONTROL OF MATERIALS

105.1 Source of Supply and Quality Requirements

The Contractor shall be responsible for the provision of all materials required to execute the Works. All material salvaged and/or removed from the works remains the property of the Employer. The Contractor shall be responsible for the cost of replacement in the event of unauthorised use or removal by him.

Information regarding the position of Borrow Areas/Pits and Quarries and results of tests carried out on various samples of materials may be available on request, to the Employer. The Contractor shall be deemed to have considered this information, if available and carefully checked the availability of suitable material in sufficient quantities from these sources and other sources during the Tender Period and have fully satisfied himself of the quality, suitability and characteristics of the materials and suitability of the plant and the method of working on which he has based his rates.

The Contractor shall be responsible for opening up all quarry and borrow areas and shall organize his method of operations so that only materials of a type and quality approved by the Engineer shall be selected for use in the Works.

The Contractor in his proposal for approval of borrow areas and aggregate quarries, shall describe the route of hauling materials from the borrow areas to the site. He shall obtain the permission to use this route for hauling materials from the Authority of the route. Before commencement of hauling, the Contractor shall inspect the proposed route of hauling with the Engineer and the authority of the route, prepare a report on the condition of the route with necessary photographs and indicating agreed commitments to the authority of the route at the end of hauling period. The Contractor shall submit to the Engineer, a copy of this report, before commencing hauling operations.

The Contractor is at liberty to select and use material from his own sources providing the requirements of this section are fully met.

105.2 Storage of Materials

Materials shall be so stored as to ensure the preservation of their quality and fitness for the work. Stored materials shall be located so as to facilitate their prompt inspection. Approved portions of the right-of-way may be used for storage purposes. All storage sites from which the stored materials have been removed shall be restored to their original condition by the Contractor at his expense.

In case of materials, which need stockpiling for storage and measurements, these shall be stockpiled on level areas and to standard shapes so as to facilitate easy measurements and computations of volumes.

105.3 Handling of Materials

All materials shall be handled in such a manner as to preserve their quality and fitness for the work.

105.4 Approval of Sources of Material

The sources of the materials shall be selected by the Contractor, but approved by the Engineer before the materials are used on the site. For this purpose, the

Contractor shall furnish all relevant test data for representative samples from each source area as desired by the Engineer and also afford opportunities for the Engineer to visit the sources areas.

Notwithstanding approval of sources of materials, materials as brought to the work site for use in the Works shall be subject to acceptance or rejection by the Engineer based on quality control tests to be performed before use in construction.

105.5 Stockpiling of Materials

Unless otherwise permitted by the Engineer, natural soils brought from borrow pits shall not be loaded directly from the borrow area for use in the works but shall first be stockpiled. Such stockpiles shall be tested and approved by the Engineer before the material comprising them may be used in the works.

All materials brought to the Site which require temporary stockpiling shall be stored carefully at approved locations and in a systematic manner so as to prevent deterioration or mixing of different materials or contamination. Materials which have suffered contamination or deterioration due to improper storage shall not be used in Works and shall be removed from the stockpiling area.

The materials shall be free from foreign, organic or any other deleterious substances such as vegetation and perishable matters, or any other substance which in the opinion of the Engineer may affect placing, mixing and compaction of the material or adversely affect the future performance of the Works. Material in stockpiles shall be tested by the Engineer to check suitability for use in the Works.

105.6 Temporary Stockpiling of Materials

Where the work programme is such that materials cannot be placed directly in their required positions or where mixing of two or more materials is required to meet the requirements of the Specifications, the Engineer may authorize their removal into temporary stockpiles. Such stockpile sites shall be to the Engineer's approval and shall be prepared by suitably clearing, grading and compaction.

The material shall be stockpiled in successive layers of approved thickness over the full stockpile area to the approximate dimensions required by the Engineer. All storage sites from which the stored materials have been removed shall be restored to their original condition by the Contractor at his expense.

105.7 Payment

No separate payment shall be made for items under otherwise stated in the Conditions of Contract under this section and payment shall be deemed to be included in the Contractor's rates.

106 GENERAL RULES FOR MEASUREMENT AND PAYMENT

All measurements shall be recorded in the metric system unless otherwise specified. Different items of work shall be measured in accordance with the procedures laid down in the relevant sections of Specifications read in conjunction with the relevant stipulations in the Contract. In respect of lump sum Contracts, however, the procedure specified in the Contract shall be adopted.

All measurements, unless otherwise specified, shall be recorded and computed nearest to the following units :

(i)	Length and breadth	.....	10mm
(ii)	Areas	.....	0.01 sq.m.
(iii)	Cubic contents	.....	0.01 cu.m.
(iv)	Height, depth or thickness of Sub-base, Base, Surfacing and structural members	.....	5mm
(v)	Height, depth or thickness of earthwork measured by tape	.....	10mm
(vi)	Height, depth or thickness of earthwork measured with level and staff	.....	5mm

In case of any differences between the above units and those specified under the relevant items of Specifications the latter shall prevail.

The measurement of materials stock piled shall be recorded for arriving at the cubic volume contents by measuring the length, breadth and height of piles. The quantity shall be calculated in Cu.m corrected to two places of decimals.

Unless stated to the contrary, any thickness, area or volume in any items of the Works shall be measured only on finished work after compaction.

The payments for the various items shown in the Bills of Quantities shall constitute full compensation for performing all of the requirements of the Contract for the item of work as specified including furnishing all necessary materials, labour, tools, equipment, supplies, testing, and incidentals.

106.1 Lead for Materials

Lead or transport distance where applicable shall be measured over the shortest practicable route and not necessarily the actual route taken for transport.

(i) Carriage by manual labour shall be measured in units of 30 metres.

(ii) Carriage by animal/mechanical transport shall be reckoned in unit of one km. Distance of 0.5 km. or more shall be taken as one km. and distance of less than 0.5km shall be ignored. However, when the total lead is less than 0.5km, it will not be ignored but paid for separately in stages of 30 metres subject to the condition that the rate worked on this basis does not exceed the rate for one km by mechanical transport.

(iii) The measurements of materials stockpiled and measured as specified at Section 106 above shall be the basis of payment for arriving at the transport charges, in respect of materials transported unless otherwise specified.

(iv) The rate for transport is inclusive of all operations including loading, transport, unloading and piling.

Haulage

No haulage on materials shall be measured or paid. The cost of haulage is deemed to be included in tendered rates for supply of materials in accordance with Conditions of Contract.

106.2 Measurement for Area and Volume Based Payment

(a) Area Basis

When measurement of Base courses and Sub-base courses is stipulated to be made on an area basis, the thickness of the course shall be checked at regular intervals as stated in Section 1600 by cutting holes or by other approved means, as directed by the Engineer.

Dimensions used to determine area shall be measured horizontally.

(b) Volume Basis

The finished thicknesses of Sub-bases, Bases and surface courses to be paid on a volume basis shall be computed in the following manner, unless otherwise specified.

Initial levels shall be recorded before the commencement of the work at a grid of points normally not exceeding 10 metres, centre to centre, longitudinally and at intervals normally not exceeding 2 metres transversely. Transverse levels however, shall include the edges and the centre line. Final levels shall be similarly recorded at the same grid points after completion of each item of work listed separately for payment. The average thickness of the course in any area shall be the mean of the difference of initial and final levels in that area but limited to the thickness stipulated in the relevant drawings, designs and Specifications.

Notwithstanding the above, the Engineer shall have the option to cut cores/holes to check the thickness.

106.3 Scope of Rates for Different Items of Work

In the absence of directions or stipulations to the contrary, the rates are to be considered as full compensation for all the operations, and the rates are to be considered as the full inclusive rates for finished work covering all labour, materials, wastage, temporary works, overhead charges and the obligations and risks arising out of the Conditions of Contract.

106.4 Facilities for Verification of Measurements

The Contractor shall provide all the necessary facilities for checking and verification of the measurements at all stages of work, to the officers of the Engineer or Employers organization.

106.5 Selection of pay items

Selection of pay items given under each section will depend on the method of measurement adopted on the Contract.

106.6 Sub Divisions within Pay Items

Where sub divisions within pay items become necessary, due to variations of type of material, thickness of layer, rate of application etc., letter suffixes in alphabetical order shall be used in the BOQ to denote the sub divisions within each such pay item. These letter suffixes shall be incorporated alongside the number given within the bracketed portion of the pay item number.

107 SIEVE DESIGNATIONS

The sieve sizes that are generally used in these Specifications for grading of soils and aggregates are as stipulated in column 1 of Table 107-1, which also conforms to BS. It should be noted that sieves given therein are the metric equivalents for the original sieves in imperial units given in column 2 of Table 107-1, which conforms, to ASTM E11.

Table 107-1 Sieves used in these Specifications

Sieve Sizes used in these Specifications (BS metric Sieves)		Corresponding Original sieves in imperial units Confirming to ASTM	
mm	µm	inch	Sieve number
(1)		(2)	
75		3	
63		2½	
50		2	
37.5		1½	
28.0		1	
20		¾	
14		½	
10		⅜	
6.3		¼	
5			4
2.36			8
1.18			16
	600		30
	300		50
	150		100
	75		200

Even though some of the above sieves are not in the standard ISO series they are selected for the purpose of these Specifications due to their common usage in Sri Lanka.

108 NOT USED

109 WORKMANSHIP AND QUALITY CONTROL

109.1 General

The Contractor is responsible for producing work which conforms in quality and accuracy of detail to the requirements of the Contract (see relevant clauses of General Conditions of Contract) and the Contractor shall, at his own expense, institute a quality control system and provide experienced engineers, technical officers, surveyors, materials technicians, other technicians and other technical staff, together with all transport, instruments and equipment, to ensure adequate supervision and quality control of the Works at all times.

The cost of all supervision carried out by the Contractor shall be deemed to be included in the rates tendered for the related items of work, except where as specifically provided for in the Contract.

The Contractor's attention is drawn to the provisions of the various sections of the Specifications regarding the minimum frequency of testing that will be required for quality control. The Contractor shall, at his own initiative, increase this frequency where necessary to ensure adequate control.

The Engineer shall have the authority to increase the frequency of testing to check the degree of compliance of works with the Specifications.

On completion of every part of the Works and submission to the Engineer for examination, the Contractor shall submit to the Engineer the results of all relevant tests and survey checks that he has carried out indicating compliance with the Specifications.

For cement, bitumen, mild steel deformed bars, high tensile steel, pre-stressing materials, bridge bearings, and other similar materials, the Contractor shall furnish the manufacturer's test certificates to the Engineer. When required by the Engineer to carry out some essential tests at the manufacturer's plants or at laboratories other than the site laboratory, the cost of samples, sampling shall be borne by the Contractor.

The method of sampling and testing of materials shall be as required under relevant clauses stipulated in these Specifications or as approved by the Engineer.

The Contractor shall be required to demonstrate the adequacy of the equipment for each operation to establish its / their capability to achieve the requirements to the Specification to the satisfaction of the Engineer before commencement of the work.

All equipment provided shall be of proven efficiency and purpose made for the required operation and shall be operated by skilled operators and maintained at all times to perform its proper function in a manner acceptable to the Engineer.

109.2 Measurement and Payment

(a) Measurement

Testing, laboratory and equipment, if set up for Contractor shall be measured as a provisional sum item

Maintenance of laboratory, if set up for Contractor shall be measured as the number of months during which operation of laboratory is carried out.

Special tests ordered by the Engineer shall be measured for payment. Routine tests shall not be measured for payment.

(b) Payment

The certification will require that the Engineer is satisfied that the Contractor has properly discharged his obligations with respect to the item concerned. If it is the opinion of the Engineer that this is not the case, then he may delete the item from any payment certificate or reduce the amount certified.

Pay items and Pay Units are as follows;

Pay Item	Description	Pay Unit
109(1)	Setting up laboratory with equipment for the Contractor	Provisional Sum
109(2)	Maintenance of laboratory	Month
109(3)	Special tests ordered by the Engineer	Provisional Sum

110 STANDARDS

110.1 General

In the absence of any definite provisions in the Specifications on any particular issue reference shall be made to the 2001 or 2002 Codes of SLS, BS, ASTM or AASHTO in this order of sequence. Where these are unhelpful, the execution and completion of the Works and relevant tests shall conform to sound engineering practice and, in case of any dispute arising out of the interpretation of the above, the decision of the Engineer shall be final and binding on the Contractor.

Where BS Tests are stipulated in the Specifications, the equivalent ASTM or AASHTO test method may be substituted as directed by the Engineer.

All the Codes of Practice, Standards and Specification applicable shall be the 2001 or 2002 editions, or as specifically stated in these Specifications.

110.2 Supply of Codes of Practice, Standards and Materials References

The Contractor shall provide for the use of the Engineer technical publications, Codes of Practice and other Standards as stipulated in the Contract or as directed by the Engineer. The documents provided by the Contractor shall be original publications and not Photostat copies. These shall be the valid editions at the end of the year 2001 or 2002 or as stated below or as decided by the Engineer. The type of publications requested may include:

- Sri Lankan Standards
- British Standards
- AASHTO Publications (2002 Edition)
- ASTM Publications
- FIDIC Documents
- HMSO Publications
- ICTAD Publications
- TRL Publications
- DIN

The documents will become the property of the Employer upon Completion of Works.

110.3 Measurement and Payment

Payment will be made for this item as a Provisional Sum. The Contractor shall verify with the Engineer the individual items required, and obtain approval from the Engineer prior to purchase.

The Pay Items and Pay Units shall be:-

Pay Item	Description	Pay unit
110(1)	Provision of Standard and Document	Provisional Sum.

111 NOT USED

112 SERVICES

Any work involved in moving, reinstating existing services and laying of new services, that may be affected by the construction of the Works shall be undertaken by the appropriate Authority or by the Contractor under the supervision of the appropriate authority.

112.1 Existing Services

The Contractor may be required to carry out certain works for and on behalf of various statutory service authorities and he shall also provide, with the prior approval of the Engineer, such assistance to the various bodies as may be authorised by the Engineer.

No removal of or alterations to any public utility shall be carried out unless ordered by the Engineer, after authorization by the appropriate Authority.

The Contractor shall take all reasonable precautions to protect, and shall provide temporary support to, existing services during construction and during relocation of such services.

Whenever services are encountered that interfere with the execution of the works and require moving or relocation, the Contractor shall inform the Engineer who will determine the extent of the work involved.

Any pipe, cable, conduit or other known service of any nature whatsoever, which has been damaged as a result of the Contractor's operations shall be repaired and reinstated forthwith by the Contractor or by the authority concerned, all at the expense of the Contractor and to the satisfaction of the Engineer.

The Employer will not be held liable or responsible for any delay in completion of the Works under the Contract which may occur due to any damage occurring to such services in consequence of the Contractor's operations.

112.2 Payment

The work of temporarily supporting and protecting public utility services during execution of the Works shall be paid under a Provisional Sum.

The Engineer may instruct the Contractor to assist in the demolition and/or rebuilding of property within or outside the ROW. The amount of work involved shall be determined on Site and as instructed by the Engineer.

Payment for such work shall be made under a Provisional Sum and shall be based on the Special Schedule of Rates for such work in force at the time.
The Pay Item and Pay Units shall be:-

Pay Item	Description	Pay Unit
112(1)	Temporary supporting and protecting public utility services during execution of works.	Provisional Sum
112(2)	Demolitions/Rebuilding of Property	Provisional Sum

113 NOT USED

114 PROTECTION OF THE WORKS AND REQUIREMENTS TO BE MET BEFORE THE COMMENCEMENT OF CONSTRUCTION OF NEW WORKS ON ALREADY COMPLETED WORKS

Under this item the following shall be included:-

(i) The provision of temporary drainage works such as drains, open channels, banks etc. and the furnishing and operation of temporary pumps and such other equipment as may be necessary to adequately drain, protect and dewater the Works and Temporary Works. This will be in addition to any permanent drainage works specified and installed, and in addition to any temporary drainage works specifically paid for separately.

(ii) Care shall be exercised not to allow material in borrow pits to become excessively wet, to keep all completed layers properly drained, to avoid dumps of material on completed layer work that shall inhibit surface drainage or form wet spots under and around dumps, and to protect all parts of the Works against erosion by floods and rain.

(iii) Material shall not be spread on a layer that is so wet that damage could be caused to the layer during compaction of a subsequent layer when the road is open to traffic

(iv) When material is spread out on the road, it shall, during wet periods, be given a good cross fall and a sufficient compaction on the surface with a steel-wheeled roller, in order to facilitate run-off during rainy weather.

(v) Fill and cut slopes shall be promptly repaired whenever damaged by surface water.

(vi) Excavations for construction of Pavement layers, pipe drains, culverts, service ducts and similar structures shall be adequately protected against possible ingress of water during rainstorms.

(vii) During widening and overlaying of existing roads, the excavations for construction of Pavement layers for areas to be widened, shall be kept well drained at all times with out stagnant water, which could soften some of the Pavement layers and Subgrade of the existing road.

(viii) The wheels or tracks of plant moving over the various Pavement courses shall be kept free of objectionable materials.

(ix) All completed work of a layer shall be protected and maintained until the following layer is applied. Maintenance shall include immediate repair of any damage or defects which may occur and shall be repeated as often as necessary to keep the layer intact and in a good condition.

(x) Before any completed layer is primed or a following layer is constructed thereon, any damage to the existing layer shall be repaired in a manner approved by the Engineer, so that after repair, or reconstruction if necessary, it will conform in all respects to the requirements specified for that layer. All repair work shall be reported to the Engineer for inspection before covering up.

(xi) The Contractor shall inform the Engineer of damage or defects to any work before repair or maintenance and the Engineer shall instruct the extent and method of repair. The previously constructed layer shall be thoroughly cleaned of all foreign material and the Contractor shall request its inspection by the Engineer before construction of the following layer or application of a prime coat, Surfacing or surface treatment. In the case of all bituminous work, in particular, the existing layer shall be thoroughly broomed and all dung, clay, and other deleterious materials completely removed. Where necessary, the surface shall be sprayed with water before, during and after brooming to remove all foreign material.

114.1 Payment

Work performed as part of the above obligations shall not be measured and paid for separately and the cost thereof is deemed to be included in the Contractor's rates and prices.

115 REMEDIAL WORK

Reference is made to the clause on "Remedial Work" in the Conditions of Contract.

For the guidance of the Contractor an indication about what may be required in the more common cases of defects or damage is given below, but the Engineer will in no way be bound to approve of or adhere to the measures indicated, as the actual remedial measures will be dictated by the circumstances of each particular case.

115.1 Earthworks

(i) Where a cut slope has been over-excavated, reinstatement by backfilling will not normally be permitted and the entire slope may need to be re-trimmed to obtain a uniform slope

(ii) Where the floor of a cutting has been over excavated it will normally require backfilling and re-compaction with approved material of higher quality than the cut material. All necessary measures shall be taken to drain ground water that may accumulate in backfilled sections.

(iii) Excess widths of fills will need to be trimmed to the design profile.

(iv) Where erosion has occurred on the surface of cuts or fills, the damage shall be made good by backfilling with suitable material and re-trimming. In more serious cases, the slope may have to be cut back and backfilled after benching and compacted to the required standard of compaction with suitable small equipment followed by re-trimming.

(v) Over excavation of rock blasting on slopes shall be filled with Grade 20 (20) concrete with 16 mm dowels driven into the rock, as instructed by the Engineer. Over excavation on the road surface shall be filled with the concrete of same grade , as instructed by the Engineer, in such a way that no water would be retained on the finished concrete surface. The cost of this work is deemed to be included in the rates for other items of the Contract.

115.2 Local Defects in Pavement Layers

(i) Where remedial measures are taken to make good localised defects, the length and width of the area to be repaired by equipment shall be such as to accommodate the full width of the equipment used and of a reasonable length to ensure effective repair.

(ii) The depth to which material shall have to be removed will depend on the defect and the type of material. Gravel layers shall need to be broken up to a depth of at least 75mm and crushed stone shall usually need breaking up over its full depth. Asphalt material shall normally require removal for its full depth.

115.3 Concrete

Defective concrete work will normally need the cutting back and complete removal of any weak or honey-combed sections and making good using approved bonding agents to bind fresh concrete to old concrete. Cracks, if permitted to remain, shall be injected with approved compounds and test cores obtained to test the efficacy of the injection process.

115.4 Payment

The Contractor shall undertake remedial work at his own expense.

116 WATER SUPPLY ARRANGEMENTS

The Contractor shall make his own arrangements for the procurement, transportation, storage, distribution and application of water needed for construction and other purposes except where otherwise specified.

Only clean water free from undesirable concentrations of deleterious salts and other materials shall be used. All sources of water used shall be approved by the Engineer.

Mechanically driven and operated water bowsers with effective spray equipment shall be provided at all times to ensure that compaction can proceed without any hold up on account of watering.

116.1 Payment

No direct payment shall be made for providing water and the cost thereof shall be included in the rates tendered for the various items of work for which water is needed.

117 SETTING OUT, CROSS SECTION SURVEYS AND DRAWINGS

117.1 General

The Contractor's attention is drawn to the requirements of the General Conditions of Contract regarding setting out.

The Contractor shall check the condition of all permanent Ground Markers and shall satisfy himself that they have not been damaged or disturbed and are true in regard to position and level. Where markers have been destroyed, damaged or displaced the Contractor shall reinstate a new marker based on the markers which remain. A new marker shall not be used unless its true position and level has been established and the new values verified by the Engineer.

Where a marker is likely to be disturbed during construction operations, the Contractor shall establish suitable reference markers at locations where they will not be disturbed during construction. No marker shall be covered, disturbed or destroyed before accurate reference markers have been established and the details of the position and levels of such markers have been submitted to the Engineer and approved by him. The Contractor's reference markers shall be of at least the same quality and durability as that of the existing markers.

The Contractor shall submit to the Engineer the method of setting out he proposes to employ. To ensure beyond doubt that the complex elements of the road or structure are truly and correctly located, the Contractor shall check all setting out by a suitable approved method. The Engineer may at any time request the Contractor to submit proof that his setting out has been satisfactorily checked.

Accurate control of line and level shall be provided by the Contractor at all stages of construction. In respect of the road itself control shall be at 20m intervals, or such closer intervals as may be directed, on horizontal and vertical curves. Wherever necessary, but particularly on completion of the Subgrade, Sub-base and the Base the Contractor shall re-establish stake-line pegs at sufficiently close intervals to accurately determine the edges of the Base, Surfacing and kerbing, guard-rails and other road elements permanently exposed to the eye.

The Contractor shall make all provisions necessary for the Engineer to check and measure the setting out of the Works and shall be in attendance to agree on measurements and levels before construction works commence.

117.2 Setting Out and Cross-sections

The Contractor shall set out the designed centre-line and establish chain-age reference points which are to be marked out on site and recorded. Level Bench Marks

at the minimum rate of four per kilometre and at locations of structures requiring modification shall be established and checked regularly and tied into the Permanent Ground Markers.

The Contractor shall survey the existing ground along Cross-sections to the centre line at 20m intervals, or such closer intervals with respect to horizontal and vertical curves, junctions, bridges, culverts and other structures as determined by the Engineer. Levels shall be taken at all changes of slope and all features to a distance of 5 metres beyond the right of way. Distance between levels shall not exceed 5 metres.

The Contractor shall prepare cross sections indicating the existing road shoulder and other features, if any, chain-ages, off set and agreed levels, to a format agreed with the Engineer. The cross sections shall be suitable for plotting to a horizontal scale of 11650 and a vertical scale of 1120 on A3 size page.

The Contractor shall provide cross section drawings of the existing ground levels to the Engineer.

The Engineer shall complete the Cross-section drawings by adding the new carriageway, shoulder, ditches, side slopes and Pavement construction layers. Other information such as existing road edge trim line and soft spots shall be added by the Engineer as information becomes available from site operations.

The Cross-sections shall be the basis for measurement and payment.

The Contractor shall complete the setting out of the centre-line within four weeks for 10 km sections following the date of the Engineer's Notice to Commence the Works. Sufficient survey and drafting staff shall be available to enable the full setting out of the Works and for the drawing up of Cross-sections to be complete such that no delay is caused to the setting out of the Works.

The Contractor shall employ on the Works sufficient qualified surveyors with at least 2 years experience in similar works and have a thorough knowledge and experience of computer methods for calculating quantities. The surveyors shall have sufficiently modern survey equipment and instruments available with them which shall be to the Engineer's approval. Competent chainmen shall be employed to assist the Surveyor. The Contractor shall assist and supply services of his surveyor and his team to the Engineer whenever required by the Engineer or his Representatives in checking and measuring the Works.

No construction work shall commence on any section of the road until the Cross-sections for the whole of that section have been completed and agreed by the Engineer.

117.3 Measurement and Payment

(a) Measurement

The survey of Cross-sections shall be measured by the number of km. for which Cross-sections are detailed on drawings, satisfactorily completed and approved by the Engineer. No separate measurement for constructing ground markers shall be made.

Setting out work other than cross sectional detailing shall be measured for payment as a provisional sum item.

(b) Payment

The prices shall be full compensation for all labour, materials, equipment and incidentals required furnishing the required work and as indicated.

Pay Items and Pay Units shall be:-

Pay Item	Description	Pay unit
117.(1)	Cross-sectional detailing of full width as specified	km
117(2)	Setting out work other than cross-sectional detailing	Provisional Sum

118 PROJECT SIGN BOARDS

118.1 Description

The Contractor shall erect firmly, sign boards in accordance with the drawings provided in the Contract or as directed by the Engineer. The project Signboard shall be made up of 1.25 m wide, 1.8 m high text in Sinhala, Tamil & English languages. The board shall be galvanized steel of gauge 18 or 25 mm thick marine plywood. The board shall be erected with the bottom of the board at a minimum of 2.3 metres above the adjacent ground and clear of motor traffic with posts and struts suitably set in concrete foundations. The Engineer shall issue to the Contractor the text (in black letters on yellow background), letter sizes, and construction details prior to the start date.

At the end of the Contract, all such sign boards shall be removed and the ground reinstated to the approval of the Engineer.

The project signboards shall be erected within 2 weeks of the commencement of the works.

118.2 Measurement

Project signboards shall be measured as the number of sign boards, satisfactorily provided and installed and accepted by Engineer and maintained throughout the Contract period, and the removal satisfactorily carried out and accepted by the Engineer.

118.3 Payment

Payment shall be made at the stated unit rate per signboard. The price shall be full compensation for all materials and labour required to perform the work described. Payment for project signboards will be made in the proportion of 70 percent for provision and erection, and 30 percent for maintenance, updating the completion date periodically, removal of board and subsequent reinstatement of the land.

Pay Items and Pay Units shall be :-

Pay Item	Description	Pay unit
118(1)	Provide and maintain Project Sign Board	Number

119 PROVISION OF INSURANCE, BONDS AND SECURITIES

119.1 Description

The Contractor shall provide all necessary Insurances, Bonds, Guarantees and Securities as are required and detailed in the Tender Documents, Conditions of Contract or this Specification.

119.2 Measurement and Payment

Measurement shall be as a lump sum payment for all expenditure with regard to the provision of Insurances, Bonds and Securities.

Payment shall be made on submission of the original Insurance, Bond, Guarantee or Security or proof of payment of the same provided that the original shall be made available to the Engineer within a reasonable time after proof of payment.

Pay Items and Pay Units shall be:-

Pay Item	Description	Pay unit
119 (1)	Provide all necessary Insurances	Lump Sum
119 (2)	Provide all necessary Bonds, Securities	Lump Sum

200 SITE CLEARING

201 CLEARING AND GRUBBING

201.1 Description

This work shall consist of all clearing and grubbing necessary for the performance of the work covered by the Contract in accordance with these Specifications or as directed by the Engineer.

The work shall consist of clearing and grubbing the designated areas within the right of way of all trees (other than those designated for preservation), stumps and roots, dead wood, vegetation, rubbish and objectionable material and disposing of the same. It shall not include the demolition, removal and disposal of structures which are covered under 202 that obtrude into or encroach upon or obstruct the work.

201.2 Preservation of Property

Existing roads, footways, facilities, adjacent property, utilities, services, and trees and plants designated for preservation shall be carefully protected from injury or damage which could result from the Contractor's operations.

201.3 Construction Requirements

(a) General

Generally clearing and grubbing shall be performed on the areas designated by staking or detailed in the Contract Documents. If no areas are designated in the Special Provisions or on the Drawings the areas, shall in principle be carried out over the entire right of way, unless otherwise instructed.

(b) Clearing and grubbing

In areas of embankments, fills are to be constructed, all topsoil shall be removed to an average depth of 0.15m. All surface objects, trees, including stumps and roots, stumps and roots of previously felled trees, overhanging branches, except those trees and objects, the Engineer directs to be left undisturbed, shall be grubbed and cleared subject to the following provisions :

(i) Outside the limits of the earthworks, stumps are allowed to remain provided that the top of the stumps are not more than 0.30m above ground level. However, trees within these limits shall be cut so that the stumps are in line with the natural ground level as far as practicable.

(ii) In areas of embankment construction, stumps and roots and solid objects shall be removed to a minimum depth of 0.5m below the top level of the Subgrade or to a minimum distance from the slopes of the embankments; the removal of these materials shall be to an extent of 1m outside the toe of the embankments.

(iii) Where lined drains or ditches are to be constructed, stumps and roots shall be removed to a minimum depth of 0.25m below the excavated bottom or into the shaped slope.

(iv) Where the embankment fill is more than 3m high, non-perishable solid objects may be permitted to remain provided that the top of such objects is not more than 0.5m above natural ground level and the compaction of earthworks will not be hindered.

(v) In cut areas, stumps and roots shall be removed to a depth of at least 0.5m below the top of the Subgrade over which the Pavement is to be constructed to an extent of at least 0.5m outside the limits of the Base course.

(vi) In areas designated as soft ground and culvert and bridge construction, no clearing and grubbing is to be undertaken and such areas be excluded from measurement under Pay Item No. 201(1).

(vii) All fences, buildings, structures, and encumbrances of any character, except those to be removed by others, upon or within the limits of the right of way, shall be removed by the Contractor and carefully placed on the abutting property or otherwise disposed of as indicated on the Drawings and as directed by the Engineer. Materials so removed, including any existing drain or culvert pipes, which the Engineer may order salvaged shall be carefully removed and shall be the property of the Government.

(viii) Where, as a consequence of over excavation during clearing and grubbing, fill material is required in order to restore the original ground level, acceptable fill material shall be used and compacted to the density prescribed for layers at the depth below finished Subgrade. Such replacement of materials shall be considered incidental to clearing and grubbing and shall not be measured for payment. Acceptable fill material for backfilling depressions or excavations shall include brick, stone and concrete debris if approved by the Engineer and this material shall be compacted in layers to achieve stable backfill to the approval of the Engineer.

(ix) Branches of trees that extend over the carriageway and shoulders, which do not provide a clear height of at least 6m, shall be cut.

(c) Disposal of Cleared Material

(i) Saleable timber as designated by the Engineer shall be neatly stored in an approved accessible place within or near the right of way as directed and shall be trimmed and stacked in accordance with the requirements of the appropriate Government Agency to which the timber belongs.

(ii) Un-saleable timber may be used by the Contractor for his own purposes in connection with the Contract always provided that he has ascertained and complied with the requirements of the appropriate Government Agencies or Authorities.

(iii) All un-saleable timber except that to be used and all brushes, stumps, roots, logs and other refuse from the clearing and from the grubbing operations shall be burned or be disposed by other means approved by the Engineer.

In such cases the Contractor will be solely responsible for making the necessary agreements and for paying the resulting expenses.

Piles of material for burning shall be placed either at or near the centre of the cleared area, or in adjacent open spaces where no damage to trees, other vegetation and adjacent property shall occur.

All burning shall be done in conformance with the regulations and at such times and in such a manner as to prevent the fire from spreading to areas adjoining the right of way.

(iv) Should the clearing and grubbing be done at a time when burning is not permitted, the Contractor shall pile all material which is to be burned outside the slope lines and at a time when burning is permitted he shall return such material to the grade and burn it.

(v) At the end of such operations the roadway and adjacent areas shall be left with a neat and finished appearance. No accumulation of burnt, half burnt or other material shall remain on or adjacent to the right of way.

(vi) The Contractor shall be responsible for any damage caused to property outside the ROW in carrying out the disposal of cleared material and shall be responsible for payment of compensation to owners of such property and any legal consequences arising from such work.

201.4 Back-filling of holes and depression caused by removal of stumps

As instructed by the Engineer, holes and depressions caused by the removal of stumps shall be back-filled in layers with excavated or other approved materials and compacted at the appropriate moisture contents with plate vibrators and vibrator tampers to required densities as per Section 304. The control of quality shall be exercised in accordance with Section 1602.

201.5 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

201.6 Measurement & Payment

(a) Measurement

Clearing and grubbing will be measured on Plan area basis by the Sq.m, as indicated in the Bills of Quantities. The work of clearing and grubbing at disposal sites, material sites, and borrow pit sites shall not be paid for when such are outside the areas designated for clearing or grubbing and the Contractor is permitted to exercise his own option as to whether he elects to use such disposal sites or borrow pit sites.

Any areas occupied by an existing gravel, macadam, and asphalt concrete, concrete or sealed roadway surfaces or otherwise maintained areas are excluded from the designated areas and shall not be included in measurement.

Any areas designated as soft ground and for bridge and culvert construction shall not be included in measurement.

Removal of trees including stumps and roots unless otherwise specified, of girth less than 300 mm shall be considered as included in clearing and grubbing.

Removal of trees including stumps and roots, as well as stumps and roots of previously felled trees of girth greater than 300 mm shall be measured in numbers and separately assessed according to the size categories given below:

(i) Girth greater than or equal to 300 mm and less than 600 mm
(ii) girth greater than or equal to 600 mm and less than 1200 mm
(iii) girth greater than or equal to 1200 mm and less than 2000 mm
(iv) girth greater than or equal to 2000 mm

For the above purpose the girth shall be measured as follows:

- for trees at a level of 1 m above average ground level
- for stumps of previously felled trees at a level of 1 m above average ground level or in case the stumps are lower, at the highest level of the stumps.

Branches of overhanging trees of girth greater than 300 mm shall be measured as directed by the Engineer. The girth shall be the girth of cut.

(b) Payment

(i) Clearing and grubbing

This work measured as provided above shall be paid for at the Contract unit as detailed below per Sq.m. The rates shall be full compensation for furnishing all labour, materials, tools, equipment and incidentals necessary to do the work and for doing all the clearing and grubbing in the designated areas and as specified in these Specifications and the Special Provisions and as directed by the Engineer including the removal and disposal of all the resulting material.

(ii) Removal of trees and removal of stumps of previously felled trees

Payment for removal of trees and stumps shall be made at the Contract unit rates and shall be the payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. These will include felling, excavating, backfilling with suitable material in layers and compacting as per section 201.4, handling, transporting and disposal.

Pay Items and Pay Units shall be as follows :-

Pay Item	Description	Pay Unit
201 (1)	Clearing and grubbing inclusive of backfilling holes and trenches caused by removal of stumps	Sq.m
201 (2)	Removal of trees; girth 300 - 600 mm	Number
201 (3)	Removal of trees; girth 600 - 1200 mm	Number
201 (4)	Removal of trees; girth 1200 - 2000 mm	Number
201 (5)	Removal of trees; over 2000 mm	Number
201 (6)	Removal of stumps of previously felled trees; girth 300 -600 mm	Number
204 (7)	Removal of stumps of previously felled trees; girth 600 -1200 mm	Number
201 (8)	Removal of stumps of previously felled trees; girth 1200 - 2000 mm	Number
201 (9)	Removal of stumps of previously felled trees; girth over 2000 mm	Number
201 (10)	Removal of overhanging branches; girth 300 mm and over	Number

202 REMOVAL OF EXISTING STRUCTURES

202.1 Description

This work shall consist of dismantling and removing, as hereinafter set forth, existing culverts, masonry and brickwork structures, foot-walks, medians, kerbs and other structures such as guard-rails, manholes, catch basins, inlets etc. which are in place, but interfere with the new construction and are not suitable to remain in place, and salvaging/disposing of the resulting materials. It shall include the demolition, removal and disposal of buildings or parts thereof necessary to widen the existing right of way when such has not been undertaken or completed by the Employer or building owners. All materials obtained from dismantling shall be the property of the Employer.

Culverts and other structures, which are within the existing highway boundary and which are designated to be removed, shall be removed down to the limits and extent specified hereinafter or as shown in the Drawings or as indicated by the Engineer.

Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed, adjacent Pavement, structures and any other specified to be left in place.

All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

Demolition, removal and disposal of private and public buildings etc. necessary to widen the existing highway boundary to achieve the full right of way shall be deemed to be included in the item. Clearing and grubbing where not previously removed by the Employer or land occupier, shall be also included in this item.

Prior to the work, the Contractor shall submit his "Disposal Plan" to the Engineer for approval.

202.2 Dismantling of Structures

The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the serviceable materials to be salvaged, the part of the structure to be retained and any other properties or structures nearby.

Unless otherwise specified, the superstructure portion of culverts shall be entirely removed and other parts removed to below the ground level or as necessary depending upon the interference they cause to the new construction. Removal of overlaying or adjacent material if required in connection with the dismantling of the structures shall be deemed to be included in this item.

Where existing culverts are to be rehabilitated only such part or parts of the existing structure shall be removed as are necessary to provide a proper connection to the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained. Reinforcing bars, which are to be left in place, so as to project into new work as dowels or ties, shall not be damaged during removal of concrete.

Pipe culverts shall be carefully removed in such a manner as to avoid damage to the pipes.

Masonry and brick work structures shall be dismantled to the extent shown in the Drawing and as directed by the Engineer.

All concrete Pavements in carriageway designated for removal shall be broken up for ease of removal and carried to stockpiles at locations designated by the Engineer.

Where the existing road signs, kilometre posts, mile posts or guard stones are to be removed they shall be carefully excavated and removed including breaking of the concrete Base. The serviceable materials shall be transported and stacked at locations approved by the Engineer, and the unserviceable materials shall be disposed of as directed by the Engineer.

202.3 Salvaged Materials

Materials which may be used directly in the Permanent Works shall be stockpiled separately from those which require processing for reuse. The materials selected for processing should be of such quality that will meet the Specifications after breaking, screening and/or mixing with better quality materials if necessary. The responsibility of selecting a particular material for processing and/or incorporating in the Permanent Works shall lie with the Contractor.

Acceptability of the materials (after processing as the case may be) shall be determined by the Engineer and only such materials that fully satisfy the Specifications in all respects shall be permitted for incorporation in the Permanent Works. The materials failing to satisfy the Specifications may be used in the Temporary Works or may be used in the lower layers of embankments or to fill depressions, stump holes etc. with the approval of the Engineer. The materials not required by the Contractor for incorporation in the Works, but which are of use to the Employer shall be neatly stockpiled as directed by the Engineer.

Structural/reinforcing steel obtained from dismantling of the existing structures shall not be considered suitable for use in the Permanent Works and shall be stored in a neat and presentable manner in locations suitable for loading. Structures or portions thereof which are specified in the Contract for re-erection shall be stored in separate stockpiles.

Pipes that are removed from culverts in good condition shall be cleaned and neatly stockpiled at points designated by the Engineer.

All the products of dismantling operations which in the opinion of the Engineer cannot be used in the Works or reused by the Employer shall be disposed of outside the highway right-of-way or may be spread in deep borrow pits, as directed by the Engineer.

202.4 Removal of Fences

The work shall consist of removal at locations as instructed by the Engineer. The re-useable material shall be removed with due care and stacked and stored for re-use. The unusable material and debris shall be transported and disposed as instructed by the Engineer.

202.5 Back-filling

As instructed by the Engineer, holes and depressions caused by dismantling operations shall be back-filled as per section 201.4.

202.6 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

202.7 Measurement & Payment

(a) Measurement

The required and accepted work of dismantling and removal of the structures etc. shall be measured as the Cu.m of structures in place before demolition. Removal of culvert pipes shall be taken as the cylindrical volume based on the outer diameter. Removal of fences shall be measured per linear metre.

The measurement for the removal of existing buildings or dwellings shall be determined by building area and the number of stories high. The area of the building shall be at foundation level, rounded to the nearest Sq.m.

(b) Payment

Payment of the lump sum for dismantling and removal of structures shall be made after the successful disposal of cleared materials as specified in Section 201.3(c) and in proportion to the actual length of highway cleared compared to the total length of highway included in the Contract as agreed by the Engineer.

Payment shall include full compensation for carrying out the operations described including but not limited to excavation, backfilling of excavations using approved materials, preparing and shaping, handling, sorting out, salvaging, stockpiling, disposing etc. of material.

Pay Items and Pay Units shall be:-

Pay Item	Description	Pay Unit
202(1)	Dismantle the Existing brick masonry structures & culvert pipes	Cu.m
202(2)	Dismantle the concrete structures	Cu.m
202(3)	Remove fencing	Linear metre
202(4)	Removal of existing buildings – Floor area (State number of floors)	Sq.m

Note:

Refer Sub section 106.6 regarding subdivision of Pay Items.

203 UTILITIES RELOCATION

203.1 Description

Where utility relocation is encountered in road construction work, it could be executed by

(a) The utility agencies by themselves or

(b) The road Contractor under the co-supervision of the Engineer and the utility agency with the consent of the utility agency.

This item makes the provisions for the Contractor to give assistance or undertake such work as directed by the Engineer.

203.2 Measurement and Payment

(a) If executed by the utility agencies themselves

Pay Item	Description	Pay Unit
203(1)	Assist utility agency	PS
203(2)	Mark-up on above item	Percent

(b) If executed by the Contractor under the co-supervision of the Engineer and the utility agency.

Pay Item	Description	Pay Unit
203(3)	Relocation of utility services as per requirements of the utility service agency and the road agency	PS
203(4)	Reinstatement of road as directed by the Engineer	PS
203(5)	Mark up on item 203(3), 203(4)	Percent

204 PROPERTY CONDITION SURVEY

204.1 Description

As instructed by the Engineer, the Contractor shall survey the road right of way and locate and identify the road furniture and all properties within or adjacent to the right of way that do not require demolition but may be damaged by the Contractor's operations. Location shall include position and dimensions in relation to the right of way. Identification shall include the nature of the property, the type and condition of construction, the nature, the magnitude and the dimensions of the existing damages, the owner and, if different, the occupant, and shall include photographs of the property and existing damages sufficient to define their type, nature, physical and structural conditions.

Such surveys may be conducted, at the Engineer's discretion, both before, during and after the works have passed any given property. The findings of such surveys shall be used in evaluating representations, if any, from property owners or occupants regarding allegations of damage to their property arising from the Contractor's operations.

204.2 Measurement and Payment

(a) Measurement

Measurement shall be by the kilometre of road fully surveyed to the Engineer's satisfaction and acceptance, as measured along the centre line. Fully surveyed shall mean that all the properties along both sides of the road have been surveyed. Less complete surveys will be measured on a pro-rata basis.

(b) Payment

Separate payment will be made for surveys conducted before; during and after the works have passed the point of survey. The Contract unit rate specified for the work concerned shall be full compensation for furnishing all labour, materials, tools, equipment and incidentals necessary to complete all the work required by the Contract and as directed by the Engineer.

Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
204(1)	Property condition survey	km

205 MISCELLANEOUS

205.1 Description

This item provides for discretionary expenditure by the Engineer on items relevant to this part of the Bill of Quantities but not elsewhere covered.

205.2 Measurement and Payment

Measurement and payment shall be as described for Provisional Sums in the Preamble to the Bill of Quantities.

Pay Item	Description	Pay Unit
205(1)	Miscellaneous site clearing works	PS
205(2)	Mark-up on above item	Percent

300 EARTHWORKS

301 ROADWAY EXCAVATION AND PREPARATION OF SUBGRADE IN CUT AREAS

301.1 Description

Roadway Excavation shall consist of all the required excavation within the limits of the right of way except excavation otherwise classified. The work shall include the removal, stock piling, handling, hauling and proper utilisation in the Works or disposal to spoil tips, located by the Contractor and approved by the Engineer, of all excavated materials and shaping of excavation and preparation of exposed surfaces of excavation including the preparation of the Subgrade on the entire length of the roadway and approaches, in accordance with these Specifications and the lines, grades, dimensions and Cross-sections shown on the Drawings or as directed by the Engineer.

Roadway excavation shall include the following:

(a) All excavations indicated in the Drawings within the faces of the Cross-sections, excavation of all materials for approach roads, streets, intersections and all other areas but not including excavation for ditches, channels, berm ditches, drains and flumes.

(b) All top soil required to be salvaged within the limits of the roads in accordance with Section 801 "Top soiling", except under embankment which exceeds 3m height.

(c) The removal and disposal of existing Surfacing, side walks within the limits of construction. The removal of structures is covered under Section 202.

(d) Excavation for removal of slides, breakages and cave-ins.

(e) Excavation for stream and channel diversions except where covered under Section 301A "Channel Excavation".

(f) Excavation required in cuts below Subgrade level or under embankment below the lowest normal limit of excavation indicated on the Drawings or below ground line, for the removal of unsuitable material, or as otherwise instructed.

(g) Excavation not specified elsewhere but nonetheless required for a proper execution of the Works (including necessary excavation instructed by the Engineer outside the right of way).

301.2 Classification of Materials

(a) Soil Suitable for Fill

Soils suitable for fill shall include all suitable materials excavated in accordance with the Specification which are not otherwise specified below as hard rock, soft rock, boulders, unsuitable soil, including top soil material obtained from road Pavement excavation, material from slips/slides or Subgrade replacement.

(b) Hard Rock

Roadway excavation classified as hard rock shall include only roadway excavation which, in the judgement of the Engineer, is not practicable without the use of pneumatic tools or drilling and blasting operation. (Blasting operations are described in Section 306). Hard rock shall not include boulders less than one Cu.m in size. Hard rock shall not include material which, in the judgement of the Engineer, can be loosened or excavated with equipment equivalent to that of the following description :

(i) Tractor Unit: Equipment with a minimum weight of 17 tonnes and net horse power rating of 150 HP or more. The tractor unit is to be in good condition and operated by experienced personnel skilled in the use of ripping equipment.

The ripper to be attached to the tractor shall be the most efficient parallelogram type recommended by the tractor or ripper manufacturer. The ripper shall have a single shank in first class condition with sharpened cutting point.

(ii) Bucket Excavator (backhoe): Equipment able to be fitted with a bucket of maximum size 0.3 Cu.m.

(c) Soft Rock

Soft rock shall comprise weathered rock, sandstone, limestone and such materials which, in the opinion of the Engineer, can be excavated by picking, ripping or other similar means without resorting to blasting.

(d) Boulders

Boulders shall comprise solid pieces of rock that are between $0.25m^3$ and $1.0m^3$ in volume. Boulders that exceed the stated volume shall be classified as Hard Rock. Boulders that are less than the stated volume shall be measured as Unsuitable Soil.

Measurement of boulders will be taken as the maximum dimension along the longest axis of the boulder (length) multiplied by the area of a circle of a circumferrrence equal to the measured girth of the boulder at its widest point.

(e) Unsuitable Soil

Excavation of soil from cuts above Subgrade level judged by the Contractor to be unsuitable in accordance with the Specifications for use in the Works and approved as such by the Engineer.

Normally highly organic clays and silts, peaty soils containing excess of roots, grass and other vegetable matter shall be considered unsuitable. Materials that are soft or unstable merely because they are too wet or too dry shall not be classified as unsuitable unless otherwise so classified by the Engineer. No soils shall be classified as unsuitable without the approval of the Engineer. Such unsuitable soil shall be excavated and disposed of to spoil tips as instructed by the Engineer.

(f) Road Pavement Excavation

Excavation of or in the existing road Pavement, either manually or mechanically, shall be taken as Road Pavement Excavation.

(g) Material from Slips/Slides

Removal of material in slips occurring in areas where the Contractor is not working and where the slip is judged by the Engineer to be beyond the control of the Contractor. All slipped materials including debris, earth, vegetation, rock and boulders shall be cleared and disposed of as directed by the Engineer.

(h) Subgrade Replacement

Material below Subgrade level in cut areas and below foundation level of embankments that is judged by the Engineer as unsuitable for the stability of the road Pavement or road embankment or any other part of the Works shall be excavated and disposed of to spoil tips as instructed by the Engineer. Backfill to voids created by such excavation shall be filled with approved material and compacted in accordance with Section 304 and in a manner approved by the Engineer. Payment for backfill shall be made under respective pay item in Section 304.4

301.3 Construction Requirements

(a) All roadway excavation and embankment construction shall be performed as specified herein and in Section 304 Embankment Construction, and the completed roadway shall conform to the required alignment, levels, grades and Cross-sections.

(b) Unless otherwise indicated in the Drawings, excavation in hard rock shall extend a minimum 0.2 m below the required Subgrade level for the entire roadway width and shall be backfilled and compacted with suitable materials as indicated in the Drawings and as directed by the Engineer. The uneven surface of the exposed rock shall be brought to an even surface with required mild slopes to facilitate drainage over it using infill concrete of Grade 20(20) as specified in 1001.5.

(c) Topsoil encountered in excavation and classified as suitable for re-use shall be removed to such a depth as the Engineer may direct and be neatly stockpiled. The topsoil so stockpiled shall be made available for the Works without additional charge. No topsoil shall be disposed of without prior written approval of the Engineer.

(d) All suitable excavated materials shall be deemed to be used in constructing the roadway. Unsuitable material and roadway excavation in excess of that needed for executing the Works shall be known as spoil. Spoil shall be removed and disposed of at designated areas or spoil tips located by the Contractor and approved by the Engineer in such a manner as to present a neat appearance and to avoid obstruction to drainage or drainage to any road or road works or other property. The final condition of spoil tips shall be to the approval of the Engineer.

(e) Unsuitable material shall be excavated below Subgrade level in cut and below embankment foundation level to the depth shown on the Drawings and as directed by the Engineer. Where unsuitable material is excavated below the normal Subgrade level or below embankment foundations or for benching under embankments, the excavation shall be backfilled with material and in a manner that conforms to Section 201.4 "Back-Filling".

(f) Soft soil material shall be excavated by appropriate approved special methods such as drag line, grabbing, pumping or by approved special methods approved by the Engineer and the void created is filled with an approved granular material with the least possible delay to ensure, to the maximum extent practicable, the exclusion of all unsuitable material from within the limits of the road foundation. In widening areas,

benching shall be provided along the interface of the old and the new construction as shown in the Drawings and as directed by the Engineer, to avoid differential settlements.

(g) All slopes shall be finished in a neat and workmanlike manner and to accuracy appropriate to the material and care shall be taken that no material is loosened below the required slopes. Breakages and slides shall be removed and disposed of as instructed.

(h) Preparation of Subgrade in cut areas.

In cut areas, the top of the Subgrade on which Base or Sub-base is to be placed shall be trimmed, prepared and compacted to a minimum depth of 0.15 m to not less than 95 % of the maximum dry density of the material at a moisture content within 2% of the optimum moisture content as determined by BS1377 part 4 1990 method using 4.5 kg hammer Test 13 (Modified Proctor). Except where top of Subgrade compaction is required in an excavation of less than 1,200 mm in width in which case, the top of the Subgrade on which Base or Sub-base or fill material is to be placed shall be trimmed, prepared and compacted to a minimum depth of 0.15m to not less than 93% of maximum dry density as determined by BS1377 part 4 1990, Method using 4.5kg hammer Test 13 (Modified Proctor). The control of quality shall be exercised in accordance with the provisions of Section 1602.

(i) The surface of the finished Subgrade shall be neat and workmanlike and shall have the form, super-elevation, levels, grades and Cross-section as shown on the Drawings. The surface shall be finished to the specified accuracy to permit the construction of subsequent layers of material to the thickness, cross-section, surface tolerance and compaction specified in Sub section 1601 herein.

(j) If the Contractor wishes to obtain material by widening cuts he shall first request permission in writing from the Engineer and if written permission is granted widening of cuts will be permitted within the limits indicated but not beyond the limits of the right of way. Such material shall be classified as borrow and will not be paid for as excavation. If widening of cuts is carried out on a written order of the Engineer the cut shall be measured and paid for as Roadway Excavation.

(k) The material excavated from the existing carriageway for Pavement strengthening and widening, if suitable, shall be used either as part of the new Sub-base layer in the new shoulder and Pavement or in embankment construction as instructed by the Engineer.

(l) All material derived from any excavation required for the Works shall be deemed to be the property of the Employer and the use of all such materials shall be in accordance with the Contract to the approval of the Engineer.

(m) The Contractor shall allow for the testing of materials in roadway excavation to determine classification of materials, depth of soft materials and compaction of top of Subgrade. No payment shall be made for such testing. Such testing shall comprise a minimum of one Dynamic Cone Penetration (DCP) test (carried out as given in ORN 31 for determination of CBR values) every 50m, one Atterberg limit test and grading analysis every 300 m and one CBR test and compaction test every 600 m. Test frequency will be dependent on the uniformity of the materials and as instructed by the Engineer.

(n) As a consequence of any type of excavation, if a RDA boundary marker is displaced, the Contractor shall re-fix the same at the same location on firm footing or if a structure is to be constructed at the boundary, the marker stone shall be embedded to the structure at the same location.

The Contractor shall pay to the RDA, a sum indicated by the RDA under pay item 301(17) for each boundary stone which is dislocated due to by works but not fixed as stated above or not handed over to the RDA in good condition.

301.4 Tests and Standards of Acceptance

The material shall be tested in accordance with these Specifications and shall be prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

301.5 Measurement & Payment

(a) Measurement

Unless otherwise specified, all required and acccpted roadway excavation shall be measured in its original position and the volume determined in Cu.m by the average end area method as computed from the original and final Cross-sections of required and completed work. No allowance shall be made for bulking or shrinkage. Separate measurements shall be made for each class of material encountered.

Measurement of rock excavated below Subgrade level as required in section 301.3 (b), for Construction Requirements, shall be computed on the basis of excavation to the specified minimum depth below Subgrade level only and no over break shall be included. Interim payment may be made on measured volumes of required excavation actually executed, before final shaping, provided the Contractor's intention to complete the work is clear. Excavation for removal of slides, breakages and cave-ins as a result of the Contractor's work shall not be measured nor paid for and shall deemed to be included in the Contractor's rates unless otherwise decided by the Engineer.

Subgrade in cut areas shall be measured in Sq.m The pay back to RDA for displacing boundary markers shall be measured in Numbers.

(b) Payment

The quantities of roadway excavation measured as specified above will be paid for at the Contract unit rates per Cu.m for the various types as detailed below. Such rates shall include laboratory and field testing, excavation, removal, stockpiling, multiple handling, haulage to embankment areas for re-use and satisfactory disposal of all roadway excavation, to designated spoil tips or spoil tips located by the Contractor and approved by the Engineer for shaping, dressing and completion of all surfaces and for furnishing all labour, materials, tools, equipment and incidentals necessary to complete the work. The rate for topsoil shall include stockpiling or disposal as instructed. The rates for Excavation of unsuitable material excludes backfill, which shall be measured and paid for as Embankment type 1, Embankment type 2, Sub-base or Base course as the case may be.

The Contract unit rate specified for the work concerned shall be full compensation for furnishing all labour, materials, tools, equipment and incidentals necessary to complete the work, including compaction and trimming to specified tolerances of the top of Subgrade as instructed by the Engineer.

Pay Items and Pay Units shall be as follows:

Pay Item	Description	Pay Unit
301(1)	Road way excavation, soil suitable for fill	Cu. m
	Road excavation, soft rock	
301(2)	0 to 500 m^3	Cu. m
301(3)	500 to 1000 m^3	Cu. m
301(4)	Above 1000 m^3	Cu. m
	Road excavation, boulders	
301(5)	0 to 250 m^3	Cu. m
301(6)	250 to 500 m^3	Cu. m
301(7)	Above 500 m^3	Cu. m
	Road excavation, hard rock	
301(8)	0 to 500 m^3	Cu. m
301(9)	500 to 1000 m^3	Cu. m
301(10)	Above 1000 m^3	Cu. m
301(11)	Roadway excavation, unsuitable soil	Cu. m
301(12)	Roadway excavation, Subgrade replacement	Cu. m
301(13)	Road Pavement excavation	Cu. m
301(14)	Excavation in Marshy areas and disposal of soft soils including peaty soils	Cu. m
301(15)	Material from slips / slides	Cu. m
301(16)	Preparation of Subgrade in cut areas	Sq. m
301(17)	Pay back to RDA for displacing boundary markers	Number

301A CHANNEL EXCAVATION

301A.1 Description

This work consists of excavation for all channels, drains and ditches etc. both inside and outside the right of way where shown on the Drawings and as directed by the Engineer. The work shall include the proper utilisation and hauling or disposal of all excavated materials, backfilling where required, constructing, shaping and finishing all earth work involved in conformity with the required alignment, levels, grades and Cross-sections as shown in the Drawings or as directed by the Engineer.

301A.2 Classification of Material

Materials excavated shall be classified as given in Section 301.2. "Roadway Excavation," herein.

301A.3 Construction Requirements

All suitable materials removed from excavations shall be deemed to be used in the formation of embankments specified under the items of embankment. Only material in excess of that required for execution of the Works shall be disposed of as instructed by the Engineer.

Material deemed not suitable for embankment or topsoil shall be disposed of at designated locations or to spoil tips located by the Contractor and approved by the Engineer and as directed by the Engineer.

Any over excavation resulting due to removal of boulders or due to any other reason shall be rectified as instructed by the Engineer. The cost of this rectification work is deemed to be included in the designated pay items under clause 301A.4 and no separate payment would be made for this rectification works.

The channels, drains etc. shall be excavated to the alignment levels, grades and Cross-sections, required on the Drawings or as directed by the Engineer. Any excavation beyond the limits required shall not be paid for.

Where instructed by the Engineer culverts shall be cleaned to provide for free flow of water. The work shall include removing all trapped material inside the culvert to spoil tips as instructed by the Engineer.

Clearing, clearing and de-silting of culverts shall be paid for under section 1303 herein.

301A.4 Tests and Standards of Acceptance

The material shall be tested in accordance with these Specifications and shall be prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

301A.5 Measurement and Payment

(a) Measurement

Excavation

Channel or unlined drain excavation shall be measured as channel excavation and classified in accordance with section 301.2, herein.

Quantities of channel excavation shall be measured in Cu.m determined by the average end area method computed from the original and the final Cross-sections of the authorised and completed excavations. No allowance shall be made for bulking and shrinkage.

(b) Payment

The payment shall be full compensation for all excavation, dewatering, backfilling where required, multiple handling, hauling and otherwise properly using and disposing of materials in spoil tips for establishing and maintaining access to channels and for all labour, materials, tools equipment and incidentals.

Pay Items and Pay Units shall be as follows:

Pay Item	Description	Pay Unit
301A(1)	Channel excavation, soil suitable for fill	Cu. m
301A(2)	Channel excavation, soft rock	Cu. m
301A(3)	Channel excavation, boulders	Cu. m
301A(4)	Channel excavation, hard rock	Cu. m
301A(5)	Channel excavation, unsuitable soil	Cu. m

302 EXCAVATION AND BACKFILL OF STRUCTURES

302.1 Description

This work shall consist of the necessary excavation for foundation of bridges, culverts, retaining walls, head walls, wing walls, lined drains and other structures.

The work shall include the necessary diverting of streams; construction and subsequent removal of necessary cofferdams and cribs; all necessary sheeting, shoring, bracing, dewatering and pumping; removal of logs, stumps and other deleterious matter and obstructions for placing the foundations; trimming of excavation; backfilling; clearing the site of debris and the disposal of excess excavated material.

The work shall be carried out in accordance with these Specifications and with the lines, levels, grades, dimensions and Cross-sections as shown in the Drawings or as directed by the Engineer.

302.2 Classification of Materials

(a) Excavated material

The classification of excavated material shall be as given in Sub section 301.2

(b) Backfill Materials

Backfilling shall be with material approved as embankment material Type I and Type II. It shall be obtained from the structure excavation if the material is approved as suitable material for backfilling. Any additional material needed shall be obtained from roadway or borrow excavation unless otherwise instructed by the Engineer.

(c) Concrete for Foundation Fill

Concrete shall conform to the general requirements of Section 1001. Concrete to be placed under water shall conform to the requirements of Section 1001.10. Concrete to be used as foundation fill in dry excavation shall be made with an aggregate and cement conforming to the requirements of Section 1001.2 and shall be mixed and placed in accordance with Section 1001.8 except that minimum cement content shall be 250 kilograms per Cu.m.

(d) Foundation Fill Material

Material for foundation fill shall consist of graded sand, gravel or stone as shown in the Drawings and as directed by the Engineer.

302.3 Construction Requirements

(a) General

Prior to commencement of excavation operations, the limits of excavation shall be set out as shown in Drawings and as directed by the Engineer.

The depth of excavation shall be as shown in the Drawings, unless the foundation strata encountered is such as to require changes. In the latter case the depth of excavation shall be as directed by the Engineer. Where blasting is required it shall be

carried out according to Section 306 and all necessary precautions given therein carefully observed.

After each excavation is completed the Contractor shall notify the Engineer to that effect, and no bedding material or structure shall be commenced until the Engineer has approved the depth of excavation and the characteristics of the foundation material.

(b) Excavation for Foundation above Water Table

Unless otherwise directed excavation for foundations above water table shall be carried out to the width of the lowest step of the footings and the sides left vertical without shoring where the nature of the soil and the depth of excavation allow it. Where this is not possible the Contractor shall erect all necessary shoring, shuttering and planking for the safety of personnel and works, subjected to the approval of the Engineer.

(c) Excavation for Foundations below water Table

Where water is encountered within the excavation due to stream flow, seepage, springs etc. the Contractor shall take adequate measures such as bailing, pumping, construction of diversion channels and bunds, coffer damming and any other measures to keep the foundation trenches free from water as necessary.

Where coffer damming is required, these shall be constructed to adequate depths and heights with due regard to safety and stability and made as water-tight as necessary to permit work to be carried out inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for the construction and inspection and to permit installation of pumping machinery etc., as may be required within the enclosed area.

(d) Preparation of Foundation

The bottom of the foundation shall be to the lines and levels as given in the Drawings or as required by the Engineer. Where this is in soil and above the water table it shall be watered where necessary and rammed and where it is below the water table it shall be prepared as directed by the Engineer.

Where rock strata are encountered, soft and weathered material shall be removed as necessary and the surface trimmed and dressed as directed by the Engineer.

If the excavation has been carried out deeper than necessary, as given in the Drawings or as otherwise directed by the Engineer, the extra depth shall be made good with concrete or masonry of the foundation grade or any other approved material at the cost of the Contractor.

When in the opinion of the Engineer the foundation material is soft, contains organic matter, or is otherwise unsuitable, the Contractor shall remove the unsuitable material and backfill with suitable foundation fill material such as sand or rubble or concrete as specified or shown on the Drawings or instructed by the Engineer. If foundations fill material is specified, it shall be placed and compacted in layers not more than 0.20 m (compacted) thickness and as directed by the Engineer. The degree of compaction shall be the same as for embankment fill. Rubble used shall conform to section 1006.2 herein and sand used shall conform to Section 1701.2 and Table 1701-2 herein.

(e) Backfilling

Backfilling of the foundation shall be carried out in accordance with Sub section 304.3j (iv). As stated therein it shall be noted that the backfilling shall be done only after the foundation concrete or masonry has been in position for at least 7 days and in a manner not to cause undue thrust on any part of the foundation. Wherever possible, the sides of the pit to be backfilled should be brought to the straight shapes enabling the use of small compactors or rollers. A step of 150mm on every two layers of backfill and as directed by the Engineer shall be maintained, especially on the road side to avoid differential settlements.

Where backfilling is required to the same level on more than one side of the structure, it shall be maintained at heights not differing by more than 400 mm on opposing sides of the structure as backfilling proceeds, unless otherwise agreed by the Engineer.

If backfilling is required on more than one side of the structure, due to over excavation or collapse of sides or due to any other reason, backfilling shall be carried out in accordance with Sub section 304.3(j)(iv).

(f) Use and Disposal of Surplus Material

All suitable material from the surplus of excavation shall as far as possible be used in the construction of the roadway.

All excess soil and other material from the excavation, including logs, boulders, shall be removed from the site as directed by the Engineer.

(g) Lined Drains

Casting of concrete against the excavated earth faces will be permitted subject to the Engineer's approval.

Any spaces between the lined drain and over excavation for drains shall be cleared of all debris prior to backfill. Such spaces shall be backfilled with suitable material in layers of appropriate thickness as detailed on the Drawings and as directed by the Engineer.

302.4 Tests and Standards of Acceptance

The material shall be tested in accordance with these Specifications and shall be prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

302.5 Measurement & Payment

(a) Measurement

All excavation shall be according to dimensions as given in the Drawings prepared for the purposes of excavation and as directed by the Engineer, in Cu.m for each class of material encountered. Any excavation in excess of above other than what had been allowed by the Engineer shall be considered as carried out for the convenience of the Contractor in exceeding the work and shall not be measured for payment.

For lined drains, excavation shall be measured as lined drain excavation and shall be measured to the dimensions of the drain as shown on the Drawings.

Backfilling shall be measured in Cu.m using the types of materials given in the Drawings or as directed by the Engineer.

(b) Payment

The quantities of excavation for structures as measured above will be paid for at the Contract unit rate per Cu.m for each class of material encountered. Such rates shall include full compensation for all labour, materials, tools, equipment, safety measures and incidental necessary to carry out the work to this Specification. This work shall include;

(i) Setting out

(ii) Removal of all logs, stumps and other deleterious matter and obstructions for placing the foundations

(iii) Clearing the site and disposal of all surplus material

The quantities of backfilling for structures as measured above will be paid for at the contract unit rate for filling for each type of fill material used. Such rates shall include full compensation for all labour, materials, tools, equipments, safety measures and incidentals necessary to carry out the work to these specifications.

For lined drains no separate or extra payment shall be made for backfilling which shall be deemed to be included in the Contractor's rates. No extra or separate payment shall be made for over-excavation and there shall be no allowance for bulking or shrinkage.

Unless otherwise stated in the special provisions, payment for the following items shall be made under a Provisional Sum and shall be based on the special schedules of Rates for such work in force at the time.

1 Preparation of base of foundation

2 Construction of necessary cofferdams, crib sheeting and bracing and subsequent removal

3 Dewatering and 4 diverting of streams

Payment for clearing of site shall be made under Pay Item 201(1) at Section 201.

Pay Items and Pay Units shall be as follows:

Pay Items	Description	Pay Unit
302(1)	Excavation for structures, soil suitable for backfill	Cu. m
302(2)	Excavation for structures, soft rock	Cu. m
302(3)	Excavation for structures, boulders	Cu. m
302(4)	Excavation for structures, hard rock	Cu. m
302(5)	Excavation for structures, unsuitable soil	Cu. m
302(6)	Backfill with sand	Cu. m
302(7)	Backfill with crush stone aggregate (Granular material)	Cu. m
302(8)	Backfill with granular material	Cu. M
302(9)	Preparation of base of foundation	Provisional Sum
302(10)	Construction of necessary cofferdams, crib sheeting, shoring and bracing and subsequent removal	Provisional Sum
302(11)	Dewatering	Provisional Sum
302(12)	Diverting of streams	Provisional Sum
302(13)	Removal of obstructions	Provisional Sum

303 BORROW EXCAVATION

303.1 Description

This section describes and specifies all the work necessary in obtaining borrow materials for work under the Contract, either from borrow areas inside or outside the right of way clearing the borrow site, stripping and disposing of excess overburden, excavating selected materials for use in the Works and reinstating borrow areas.

The Contractor shall obtain approval of the Engineer in writing for use of borrow material either from within the right of way or outside the right of way prior to commencing any borrow operation.

Where the Employer has identified certain borrow areas outside the right of way which are expected to provide material in compliance with the Specification. The Contractor is at liberty to use these areas for which licenses have been obtained but it shall be the Contractor's responsibility to satisfy him as to the quantity and quality of material so removed so that it meets the requirements of the Specification for use in the Works. No claims regarding the quantity or suitability of material in the identified borrow areas shall be considered by the Employer. The Contractor may use any other borrow source provided that the material supplied complies with the requirements of the Specification for the use for which it is intended.

The use, depth, location and dimensions of borrow pits within the right of way shall be subject to the approval of the Engineer. The Contractor will be deemed to have satisfied himself before entering into the Contract as to the use of borrow pits within the right of way and to have allowed in the rates for the risk of borrow pits not being permitted in areas of uncertainty. Not withstanding any general advice given by the

Employer or the Engineer before the submission of bids, borrow pits may be prohibited or restricted in dimensions and depth by the Engineer for reasons such as:

(a) They may affect the stability or safety of the road users or road or structures.

(b) They may interfere with natural or artificial drainage or irrigation.

Borrow material shall only be used where there is a deficiency of suitable material from roadway or structure excavation, or for the convenience of the Contractor when he decides after the approval of the Engineer to spoil suitable excavation material at one location and borrow material to replace it at another location.

The work shall be carried out in accordance with these Specifications and with the lines, levels, grades, dimensions and Cross-sections as shown in the Drawings or as directed by the Engineer.

303.2 Construction Requirements

Where the Contractor decides to use other borrow sources he shall be responsible for all negotiations with the owner of land on which his intended borrow areas are situated and these negotiations shall take place and be conducted to the satisfaction of both parties and confirmed in writing prior to the opening up of the borrow area. The Contractor shall be responsible for compensation to the owners directly in respect of royalties or loss of crops or any other compensation to which the owner is entitled and for any legal consequences arising from the borrow operation.

Whenever the Contractor elects to obtain material from a borrow area after written approval from the Engineer he shall excavate the necessary trial holes, take such samples and perform or have such tests performed as per section 1900 and as are deemed necessary by the Engineer. The Contractor shall submit the results to the Engineer in sufficient detail to satisfy him that the quality and quantity of the material available in the proposed borrow area are acceptable for the intended use, all at the Contractor's own expense. Permission to use any borrow material, including its suitability, shall be obtained in writing from the Engineer before execution of the work. It is the responsibility of the Contractor to submit a request for tests at least three weeks prior to the day the Contractor intends to remove material from the borrow area.

The Contractor shall exercise all reasonable care to avoid contamination of approved material by the inclusion of clayey or otherwise unsuitable material from the floor of the borrow pit, from overburden or from unsuitable layers.

The material in borrow pits shall be blasted, ripped and excavated in a manner that will ensure the effective breaking down of the material in the borrow pit before it is loaded. Rippable material which tends to break into large blocks shall be cross ripped. During loading hard oversize material which will not break down during processing on the road shall be excluded or removed during spreading.

A schedule of borrow pits may be provided as a supplement to the Schedule of Quantities but it remains the Contractor's responsibility to satisfy himself as to the quality and quantity of material in each borrow pit and its suitability in use in the Works.

During borrow excavation the borrow areas shall be kept drained as far as possible and the Contractor shall take all necessary precautions to prevent any erosion or interference with exiting drainage facilities. The Contractor shall also ensure that

borrow operations are carried out in a manner not to affect the stability or safety of any structure or cause any other damage to adjacent property.

The working of borrow areas within the right-of-way shall be subject to the approval of the Engineer. No borrowing shall be permitted, below the level of the toe of the embankment, without the prior approval of the Engineer.

All suitable material removed from borrow sources shall be used as directed by the Engineer.

On completion of borrow operations, borrow areas shall be left in a neat condition with proper drainage.

303.3 Tests and Standards of Acceptance

The material shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

303.4 Measurement & Payment

(a) Measurement

Borrow shall not be measured.

(b) Payment

No payment will be made to the Contractor for borrow. Payment under the items of the work in which the borrow material is placed shall be full compensation for the cost of searching for and finding borrow pits, for acquiring the right to occupy the sites and extract material, for the cost of any negotiations in connection with borrow pits, for the cost of obtaining right of access, for the cost of establishing and maintaining access, for any fees, licences or royalties in connection with borrow pits, for clearing, grubbing, sloping, draining, and cleaning up of pits, for furnishing, excavation and hauling material from borrow pits and for all labour materials, tools, equipment and incidentals necessary to complete the work.

304 EMBANKMENT CONSTRUCTION

304.1 Description

This work shall consist of the construction of embankment and other miscellaneous backfills with approved material obtained either from the excavation of the roadway, borrow pits or other sources in accordance with these Specifications and lines, levels and grades, dimensions and Cross-sections shown in the Drawings or as directed by the Engineer.

304.2 Materials

(i) Type 1 & 2 embankment material used shall conform to Sub section 1708.

304.3 Construction Requirements

(a) Sources of Supply of Embankment Material

All suitable material available from the roadway and other excavation shall be used for embankment construction as directed by the Engineer. Where additional material is necessary they shall be obtained from approved borrow pits or other approved sources. Borrow excavation shall be carried out in accordance with Section 303.

(b) Setting Out

After the site has been cleared the limits of embankment shall be set out as required. The pegs or stakes showing the limits of the embankment shall be fixed a suitable distance outside the actual limits of the fill and such pegs or stakes shall be painted in a distinctive colour for visibility.

(c) Removal of Top Soil and Compaction of In-situ Soil

Where the height of embankment fill is more than 500 mm and less than 3.0m, the top soil shall be removed as described in 201, herein. Topsoil shall also be removed under embankments whose height is greater than 3.0m and where topsoil is required in other locations or on the instructions of the Engineer. If the in situ material conforms to Type II embankment material it shall be compacted, to a minimum depth of 0.15 m, to not less than 93% of the maximum dry density of the material at moisture content within 2% of the predetermined optimum moisture content as determined by BS1377, Test 13 (Modified Procter) or AASHTO T180. The degree of compaction shall be checked by field density measurements (BS1377 test 15).

Where the height of embankment fill is less 500 mm or where the road is in cutting, the top soil shall be removed as described in 201. If the in-situ material conforms to Type I embankment material, it shall be compacted to a minimum depth of 0.15 m below formation level or to such depth as instructed by the Engineer, to not less than 95% of the maximum dry density of the material at moisture content within 2% of the predetermined optimum moisture content as determined by BS1377, Test 13 (Modified Procter) or AASHTO T180. The degree of compaction shall be checked by field density measurements (BS1377 test 15). The control of quality shall be exercised in accordance with Section 1602.

(d) Placing and Compaction of Embankment Material

(i) Placing

The Contractor shall ensure that oversize material be disposed of or utilised elsewhere in the construction of the Works. The Contractor shall exercise all reasonable care to avoid bringing onto the road material which cannot be broken down to the required size by processing on the road. This shall be avoided by proper selection in excavation, in cut or in borrow. In cut, such material shall be taken directly to spoil or shall be utilised as instructed by the Engineer.

Fill shall be placed in successive layers whose planes are parallel to the final road surface, wherever this is practicable, and the construction of tapered layers shall be restricted to the bottom layers of fill where it may be unavoidable due to cross fall, tapering out of fills or super elevation of the final road surface.

All materials which are deposited in place prior to compaction shall be evenly spread over the whole of the designated area for the layer concerned and in such quantity that the thickness of any one layer, when measured after compaction, shall comply with the requirement specified.

Any new layer less than 75mm in compacted thickness shall be bonded to the previous layer by scarifying the previous layer to a depth not less than 25mm or to such greater depth so that the total compacted thickness of the new layer plus the scarified portion of the previous layer will not be less than 100mm.

The material placed on the road bed shall be thoroughly broken down throughout the layer by means of equipment suitable for this purpose. During such processing the layer shall be frequently bladed using a grader to bring oversize material to the surface to facilitate breaking down.

The material shall be broken down to a size not exceeding 70% of the compacted layer thickness. The compacted thickness of the layers will be dependent upon the size to which the material can be broken down by the technique used but shall in general not be greater than 225mm.

In order that layer thicknesses are not dictated by the presence of isolated larger rocks or stones, the Engineer shall instruct that the material which cannot be broken down to the size generally achievable for the rest of the material in the layer be removed from the embankment.

If the material is too wet it shall be dried by aeration and if it is too dry the material shall be sufficiently watered prior to compaction.

Any water required before material is compacted shall be added to the material in successive applications by means of water bowsers fitted with sprinkler bars or by means of pressure distributors all capable of applying the water evenly and uniformly over the area concerned.

The water shall be thoroughly mixed with the material to be compacted by means of motor graders or other suitable equipment. Mixing shall continue until the required amount of water has been added and until a uniform mixture is obtained. Compaction may proceed when the moisture content of the uncompacted layer is within 2% of the predetermined optimum moisture content.

(ii) Compaction - General

During compaction of soils and other materials using rollers, rolling shall commence at the edges and progress towards the centre except in super elevated and other stretches of unidirectional cross-fall, where the rolling shall commence at the lower edge and progress towards the upper edge. When commencing rolling from an edge, rollers shall run forward and backward along the edge sufficient times till the edge strip becomes firm enough to provide necessary lateral support. The roller shall then move inwards parallel to the centre line of the road in successive passes with the tracks made by successive passes overlapping. Rolling shall continue till the specified degree of compaction is achieved throughout. When rolling is terminated at an edge, the procedure similar to that for commencing rolling at an edge shall be adopted. During rolling, the top of the layer being rolled shall be checked for levels and cross-fall and any irregularities in these shall be corrected by scarifying the material in the affected area and by removing or adding materials and continuing with the rolling until

the entire area being rolled has been brought to a state of uniform and desired compaction.

Before any filling above the original ground or any other layer is commenced, the Contractor shall improve the drainage on the sides of the road in such a way that no rain water stagnation adjacent to the work will take place.

(iii) Compaction Procedure

The types of compaction equipment to be used and the amount of rolling to be done shall be such as to ensure that specified densities are obtained without damage to the underlying layers or to structures. During compaction the layer shall be maintained to the required shape and Cross-section and all holes filled and ruts and laminations shall be removed.

The Engineer may permit thicker layers than as specified above to be constructed, provided that he is satisfied that the specified densities can be obtained throughout the full depth of each layer and that the layers will be uniformly compacted by using equipment specifically suited for this purpose.

Each successive layer shall be placed only after the previous layer has been tested and found satisfactory as specified in Sub section 304.3 (e) herein.

If at any time after compaction the layer is damaged by drying out or is damaged by rain, it shall be scarified, and recompacted to the requirements of the Specifications at the Contractor's expense and to the approval of the Engineer.

Unless otherwise specified, the top 500 mm of the embankment shall be constructed using Type I material and the lower layers of the embankment shall be constructed using Type II material, as specified in Sub section 1708.1, herein.

(e) Degree of Compaction of Embankment Fills / Subgrade Layer

The top 150mm Subgrade layer of the embankment shall be compacted to not less than 95% of the maximum dry density of the material at moisture content within 2% of the optimum moisture content as determined by BS1377, Test 13 (Modified Procter) or AASHTO T180.

The embankment other than the top 150 mm shall be compacted to not less than 93% of the maximum dry density of the material at a moisture content within 2% of the optimum moisture content as determined by BS1377, Test 13 (Modified Procter) or AASHTO T180.

The degree of compaction shall be checked by field density measurements (BS1377 test 15).

(f) Drainage and Protection of Embankments

Water shall not be allowed to accumulate at any point in the earthworks. The Contractor shall arrange for the quick disposal of all water from the works, whatever the source may be, and shall at his own expense effectively drain the whole of the works during the entire period of construction. Such provision shall include carrying out the work of forming the cuttings and embankments in such a manner that their surfaces are maintained at all times to a sufficient minimum crossfall and longitudinal gradient.

Any damage caused to the completed surface of embankment as a result of construction traffic or lack of proper drainage or by any other means that could be attributed to the negligence of the Contractor shall be made good by the Contractor at his own expense.

All permanent drains shall be constructed at the earliest opportunity, along with any temporary drains that may be necessary to protect the road embankment, and they shall be maintained in working condition throughout the construction period.

Side drains discharging from cuts and all other drains shall be constructed in such a way that damage to embankment by erosion is avoided.

(g) Finishing Operations

The embankment shall be finished to levels, grades, slopes and Cross-sections shown on the Drawings and as directed by the Engineer, subject to the requirements of section 1601. Both the upper and the lower edge of the side slopes shall be rounded off to improve appearance and to merge with the adjacent terrain.

Where specified the slopes of embankment shall be top soiled and grassed, measured and paid in accordance with Sections 801and 802 respectively.

(h) Not Used

(i) Not Used

(j) Embankment Construction under Special Conditions

(i) Re-instating and Widening Existing Embankments

Where existing embankments are to be widened, adequate bonding between the old and new filling shall be established by removing the top soil and benching into the existing slope in vertical and horizontal faces including rock and the embankment built in successive layers.

(ii) Embankment on hill slopes

Where embankments are to be constructed on hill slopes the slopes shall be scarified and benched as described in Sub section 304.3 (j) (i).

(iii) Embankment / Subgrade over existing paved surfaces

Where embankment / Subgrade material has to be placed over existing paved surfaces to a height less than 1.0 m the existing surface shall be completely removed along grooves at 1m intervals. The grooves shall be cut by roller tynes or by any other method approved by the Engineer. The exposed surface shall suitably be compacted with embankment / Subgrade material prior to laying embankment / Subgrade material.

Where the height of fill is greater than 1 m the need to scarify the existing surface shall be decided by the Engineer, depending on the site conditions.

(iv) Embankment around structures

The Contractor shall take special precautions to see that the construction work of structures is not disturbed as a result of the embankment filling operations and that the filling in the vicinity of a structure shall not be carried out till the concrete or masonry had been in position at least for 7 days, unless otherwise directed by the Engineer.

Filling around structures shall be carried out using suitable material and compacted to densities given in Sub section 304.3(e) using special equipment such as mechanically operated hand rammers. The control on the quality of materials and works shall be exercised in accordance with Section 1602. Care shall be exercised that no damage is done to the structure by these operations.

The embankment shall be brought up simultaneously on each side of the structure to avoid unequal pressures acting on it.

Any damage that is caused to the structures by the negligence of the Contractor shall be made good by him at his own expense.

(v) Embankment Construction Over Soft and Marshy Ground

a. Where the depth of soft soil is greater than 1 metre

The work shall be carried out as per Section 307 and as per special provisions.

b. Where the depth of soft soil is less than 1 metre

(i) Construction below water table: Rockfill under water on top of Geofabric

Where embankment is to be constructed from below the water table level, rock-fill shall be deposited in successive layers of a thickness determined by the Engineer on the size of rock and depth of water, to a height of 0.3 m above the highest water level. Each layer shall be constructed starting at one end of the embankment under construction and placing the rock by means of a bulldozer or any other suitable machine in such a manner that the larger rock shall be placed on quarry fines layer of 100mm thick on a separation geo-fabric conforming to Section 2003 and of the non woven type, which has been laid out and pegged in position, and the spaces between the layer filled with stones having finer material to form a dense interlocking and stable layer. If a separation geo-fabric of woven type conforming to Section 2003 is used, it shall be anchored by extending the same to a minimum of 4 m around embankment material of thickness of minimum of 0.5 m with a minimum cover of 0.5 m thickness of embankment material at the edges in order to safeguard against exposure to sunlight. The maximum size of rock shall be 250 mm. The rockfill shall be blinded with a layer of 40 mm graded aggregate sufficient to fill all voids in the upper layer of the rockfill.

or

Alternatively rock-fill can be constructed by manually placing several layers of rock on the quarry fines laid on geo-textile as mentioned as above and adding quarry fines and water until all voids are filled with quarry fines.

On completion of few layers of rock-fill as mentioned hereinabove, rolling shall be carried out with an 8 tonne vibratory compactor. This procedure shall be continued until all layers of rock-fill are completed and there is no visible movement of the rock-fill under the compacting roller.

(ii) Construction above water table: Pioneer layer on soft unstable ground on geo-fabric

Where embankment fills are to be constructed over very wet or soft ground that displays excessive movement under normal compaction equipment and haulage trucks, thereby precluding the effective compaction of the bottom layer, the Engineer may direct that a pioneer layer be constructed on the unstable ground. This layer shall be constructed over geofabric of non woven type which has been laid out and pegged, by end dumping and spreading successive loads of suitable rockfill or granular material in a uniform layer of thickness sufficient to provide a stable working platform for the construction of further embankment layers which shall be compacted to a controlled density. If a geo-fabric of woven type is used, it shall be anchored by extending the same to a minimum of 4 m around embankment material of thickness of minimum of 0.5 m with a minimum cover of 0.5 m thickness of embankment material at the edges in order to safeguard against exposure to sunlight. Light hauling equipment shall be used to place the material, and the layer shall he compacted by the use of compaction equipment that will provide the most effective compaction without over-stressing the road bed. Pioneer layers need not be compacted to a controlled density.

Note:

The compacted volume of material used may be determined on the basis 70% of the loose volume in trucks as an alternative to taking Cross-sections before and after construction.

Pioneer layers shall be paid for under the appropriate construction rate.

(k) Construction of drainage (filter) layers behind structures

Drainage (filter) layers specified behind structures shall be constructed, in accordance with section 705, along with the laying of the fill material.

(l) Finishing Operations and Quality Control

The top of the Subgrade layer shall be trimmed to line and level within the tolerances specified in Sub section 1601, herein.

The Subgrade shall be finished to the requirements of Section 1601.

The control on the quality of materials and work shall be exercised in accordance with Section 1602.

304.4 Measurement and Payment

(a) Measurement

Embankment construction shall be measured as compacted in Cu.m. The volume of fill material shall be computed by the average end area method on Cross-sections given in the Drawings or on actual Cross-sections taken at site before and after the construction of the embankment. Where the embankment foundation is likely to settle under the weight of the fill, the extra volume of material required due to such settlements shall be included in the measurement.

Embankment construction using roadway excavation and using borrow excavation shall be measured separately. (See note below).

Embankment construction using rock fill shall be measured in Cu.m in the same manner as for earth fill.

The trimming, levelling and compaction of original ground shall be measured in Sq.m.

The provision and placement of geo-fabric and also provision of placement of 300 mm sand blanket shall both be measured in sq.m

Application of topsoil on embankment slopes and verges shall be measured as given in Section 801.

Filter medium behind earth retaining structures shall be measured separately as given in Section 705.

Note:

(The Contractor is required to use all suitable materials resulting from roadway excavation, except that which is in excess, in embankment construction as given in Sub section 301.3(c). However the Contractor may opt to discard suitable material from roadway excavation and use material from borrow excavation for his convenience, provided that this additional volume of borrow material is reckoned to have resulted from roadway excavation).

(b) Payment

Payment will be based on the Contract unit rate for the separate items as measured above and shall include full compensation for all labour, materials, transport, tools equipment and other incidentals necessary to complete the work to the Specification. This work shall include the following where applicable.

(i) Setting out and pegging

(ii) Scarifying and benching slopes of existing embankments and hill sides

(iii) Cutting grooves on existing paved roads

(iv) Special arrangements and equipment that may be necessary for working under restricted conditions such as in the vicinity of structures.

(v) Excavation of borrow material

(vi) Transport, laying and compaction of suitable borrow material

(vii) Compaction and trimming to line and level of the Subgrade layer

The Pay Items and Pay Units will be as follows:-

Pay Item	Description	Pay Unit
304(1)	Embankment construction using material from roadway excavation compacted in position	
	a) Embankment Type II material	Cu. m
	b) Embankment Type I material	Cu. m
	c) Selected Subgrade or Capping Layer material	Cu. m
304(2)	Embankment construction using borrow material compacted in position	
	a) Embankment Type II material	Cu. m
	b) Embankment Type I material	Cu. m
	c) Selected Subgrade or Capping Layer material	Cu. m
304(3)	Trimming, levelling and compaction of original ground	Sq. m
304(4)	Provide and place Geofabric	Sq. m
304(5)	Provide and place 300mm Sand Blanket	Sq. m
304(6)	Embankment construction using Rock Fill	Cu. m

305 TRENCH EXCAVATION FOR UTILITY SERVICES AND REINSTATEMENT

305.1 Description

This work shall consist of all trench excavation within the road formation for the purpose of laying of utility services. The work shall include the reinstatement of the trenches and disposal of unsuitable or surplus material.

The work shall be carried out in accordance with these Specifications and with the lines, levels, grades, dimensions and Cross-sections as shown in the Drawings or as directed by the Engineer.

305.2 Materials

The material for the backfill up to formation level shall conform to the requirements of Sub section 304.2.

The materials excavated (other than the Pavement layers) shall be classified as given in Sub section 301.2.

305.3 Construction Requirements

(a) Trench Excavation

Trench excavation shall be carried out using equipment and tools approved by the Engineer and to the lines, levels and Cross-sections shown in the Drawings and as directed by the Engineer. When excavating an asphalt concrete surfaced road, a suitable asphalt cutter approved by the Engineer, shall be used initially to cut the asphalt concrete layer.

The sides of the trenches shall be adequately supported at all times to ensure the stability of the rest of the road platform. Any damage done to the rest of the road platform and any over-break shall be made good by the Contractor at his own expense.

Trench excavation shall be programmed to be carried out in sections so as to cause the least inconvenience to the road users. The programme shall be approved by the Engineer.

(b) Reinstatement of Trenches

The surround for the pipe or duct or cables as appropriate shall be constructed according to the Specification of the agency to which the utility services belong.

Prior to the commencement of reinstatement of the fill above the surround the trench shall be cleared of any material unsuitable for incorporation in the fill. Where necessary dewatering is done care shall be taken to ensure that the water is drained away from the roadway.

All suitable materials from the excavation shall be used for the backfill. However any material contaminated with topsoil or other unsuitable material shall not be used. Any material that becomes unsuitable by contamination due to the negligence of the Contractor shall be made good by him at his own expense.

The placing and compaction of material from the top of the surround material upto formation level shall be done according to the provisions of Sub section 304.3(j)(iv) and to the required degree of compaction as given in Sub section 304.3(e). The equipment used for compaction shall be approved by the Engineer.

The construction of the Sub-base, Base and Surfacing or shoulder affected by the trench shall then be carried out as per the relevant Specifications and as described in the Contract and as directed by the Engineer.

305.4 Tests and Standards of Acceptance

The material shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

305.5 Measurement and Payment

(a) Measurement

Trench excavation for all required and completed work shall be measured in its original position and the volume determined in Cu.m. Trench excavation shall be measured separately in unclassified soil, soft rock, hard rock and in Pavement layers in aggregate and bitumen/cement bound material.

Trench reinstatement upto formation level in embankment fill material shall be measured as compacted in position in Cu.m. Reinstatement using suitable material resulting from the excavation and using borrow excavation shall be measured separately.

The reinstatement of the Pavement layers and/or shoulder shall be measured as given in the relevant section of these Specifications.

(b) Payment

The quantities of trench excavation will be paid for at the Contract unit rates for each class of material encountered.

The reinstatement of the excavation shall be paid at the Contract unit rates for the separate items as measured above.

All prices shall include full compensation for all labour, materials, tools, equipment etc. necessary to complete the work to these Specifications and in addition shall include the following where applicable :-

(i) Setting out

(ii) Planking and any other precautionary measure taken to ensure the stability of adjacent areas.

(iii) Removal of excess or unsuitable materials, logs, stumps etc.

(iv) Road safety measures

(v) Measures required for working under restricted conditions. Dewatering shall be paid for separately

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
305(1)	Trench excavation in unclassified soil	Cu.m
305(2)	Trench excavation in classified rock (State whether soft or hard)	Cu.m
305(3)	Trench excavation in Pavement layers (state type)	Cu.m
305(4)	Trench reinstatement upto formation level using suitable material from the excavation	Cu.m
305(5)	Trench reinstatement upto formation level using borrow material	Cu.m
305(6)	Trench reinstatement in Pavement layers and shoulders (state type of layer and type of construction)	As given in relevant Specification

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

306 EXPLOSIVES AND BLASTING OPERATIONS

306.1 Description

This work shall consist of handling, transport, storing, and use of explosives for carrying out blasting operations in the formation of roads, preparation of foundations of structures or for production of aggregates, according to these Specifications or as approved by the Engineer.

These Specifications shall be read in conjunction with the Mines and Mineral Act, Explosives Act and other regulations issued from time to time by the Controller of Explosives and other relevant authorities.

306.2 Materials

All explosives used shall be of approved manufacture and of Non-electric and electric type with delay elements and shall belong to the following categories.

Initiating Explosives (non electric and electric)
Low Explosives
High Explosives
Stemming materials

(a) Initiating Explosives

These shall consist of non-electric detonators, safety fuse (firing cord), detonating fuse & electric detonators with delay elements and igniting cords, used to initiate the main charge.

(b) Low Explosives

Low explosives are mixtures of potassium nitrate or sodium nitrate, charcoal and sulphur in suitable proportions manufactured to have a granular form with coarse, medium or fine grains, glazed with graphite, usually referred to as black blasting powder.

(c) High Explosives

High explosives shall be gelatines, gelignites, dynamites in powder form, all of which contain nitroglycerine as sensitizers, or Amonium Nitrate or slurries based on Tri-Nitrotoluene (TNT) or mixtures of Ammonium Nitrate and fuel oil (ANFO).

(d) Stemming Material

Material for stemming shall be quarry fines or sand.

306.3 Blasting Operations and the Required Personnel

(a) The Contractor shall have on his blasting site whenever electric detonator blasting operations are taking place, a qualified mining Engineer (shot firers) fully experienced in mining work and he shall design and supervise the field work.

(b) Choice of Explosives

In the choice of explosives, in addition to job requirements, consideration shall be given to the following factors.

(i) Type of rock including geological features such as strength of rock mass and presence of fractures, fissures etc.

(ii) Degree of fragmentation desired

(iii) Number, size and depth of drill hole

(iv) Ground vibrations, noise, air blast pressure, fly rock and proximity to buildings and other structures

(c) Safety precautions and other pre-blast operational engineering aspects

The following technical considerations shall be implemented prior to commencing blasting operations.

(i) Obtaining relevant licences under the prevailing Acts and Regulations such as Mines & Mineral Act and National Environmental Act, if necessary.

(ii) Appointing mining engineers (shot firers) for electric detonator blasting crews.

(iii) Appointing monitoring groups to monitor blasting effects such as ground vibration, air blast over pressure etc.

(iv) Mapping of buildings and structures, which are situated within 400 m circles from the proposed blasting area with GPS coordinates.

(v) Conducting pre-blast surveying activities of structures and buildings which are situated within 400m distances from the blasting area (this distance may change subject to the existing environmental and technical considerations) and preparation of technical reports for each and every building and structure.

(d) Conduct of blasting activities

(i) Initiation by Firing Cord (safety fuse)

Normally the standard plain detonator shall be used to initiate the main charges.

To prepare the capped fuse, the fuse shall be cut straight across with a sharp knife. The detonator shall then be slipped over the freshly cut end of the fuse so that "the mixture" and fuse are in contact. The detonator shall then be crimped gently but securely with approved crimpers. Force shall not be used when inserting the fuse into the detonator. The part of the detonator containing the detonating mixture shall not be crimped. The ends of the fuse shall not be allowed to be damp or contact oil or grease. When capped fuses are to be used in wet conditions the junction between the fuse and the detonator shall be well coated with a water proofing or cap sealing compound. Sufficient length of free end of the fuse shall be left so that ample time is available to fire all the boreholes charges and to enable the workmen to get away to a safe place.

Preparation of the capped fuse shall not be done at or close to the face of the rock. This shall be done at a safe place immediately before the commencement of charging the shot holes.

(ii) Initiation by Detonating Fuse

Detonating fuse shall be used in large scale excavation or quarry work to initiate high explosives. A plain detonator or an electric detonator shall be attached to the detonating fuse with adhesive tape, or string, firmly so that it points towards the explosive charge. Delay or short delay detonators shall be used if a method of delay firing is employed. When fixing the detonating fuse to the primer cartridge sufficient length of the detonating fuse shall be in contact with detonating cord the free ends of the detonating cord from the shot holes shall be firmly fixed to a main cord using adhesive tape, string or thin wire. At least 50mm of the branch lines shall be in contact with the main cord at the joint.

(iii) Initiation by Electric Detonators

Electric detonators shall be used for initiating explosives when electric shot firing is adopted. Firing shall be done only with blasting machines, approved by the Engineer. Use of mains for Mains firing shall not be permitted. The primer shall be prepared by making a hole in the cartridge with an aluminium or brass pricker and inserting the detonator until it is completely buried in the explosive. The leading wires shall then be hitched round the cartridge to prevent the detonator from being withdrawn. All electrical connections shall be made with clean wires well twisted together. Care shall be taken to ensure that the insulation of leading wires, connecting wires and cables is not damaged due to rough handling. All joints shall be well insulated. The bared ends of the leading wires shall be well protected to prevent contact with any conductors. Electric shot firing shall not be carried out if a thunderstorm is imminent. The number of shots to be fired shall not exceed the recommendation of the manufacturer of blasting machines.

(e) Charging Boreholes

When the structure of the rock is distributed and irregular small diameter short boreholes shall be used. The faces shall be worked in steps of benches by blasting with short vertical holes of 1-5 metre in depth, drilled in a line parallel to the face. The horizontal distance from the bottom of the borehole to the face shall be always less than the depth of the borehole. The diameter of the boreholes shall normally be 25 to 50mm. Special gelatine of 80% strength or as recommended for this type of work shall be used. The borehole shall be cleaned out with compressed air or other approved method. The cartridges of explosives shall then be inserted into the borehole one at a time and pressed with a wooden rod. The primer cartridge shall then be pushed until it rests against the main charge.

Metal rods shall never be used to charge boreholes. No drill or metal equipment of any kind shall be introduced into the hole once explosives have been inserted. After loading the explosives, stemming shall be inserted. Material for stemming shall be quarry fines or sand which shall be gently tamped for the first few inches from the bottom. Pressure shall be gradually increased for tamping so that the stemming is firmly packed in the hole. During tamping the leading wires of the detonators, safety fuse or detonating cord shall be held taut onto one side of the borehole to prevent damage to wire or fuse.

In quarrying operations, small diameter long boreholes charged with a high explosive and fired at a predetermined pattern using shot delay detonators shall be used to produce well-fragmented rock and reduce ground vibrations.

(f) Not used

(g) Preparations for firing

(i) When using Detonating Cord

(a) All connections between lines of detonating cord shall be made at points where the core load is known to be dry. Where the ends have been, or may be, exposed to wet conditions, connections shall be made at least 500 mm from the ends, and the excess folded over and secured to the main line.

(b) The angle between branch lines and the part of the main lines carrying the incoming detonation waves shall be 90^0 or more, and the connections shall be made firmly, e.g. by taping or by slip-proof knots, to the satisfaction of the Engineer. Care shall be taken that branch lines do not loop back and cross over the main lines before entering the hole.

(c) Lines of detonating cord shall be laid or hung in straight lines or smooth curves, without excessive slack or tension and shall be kept at least 200 mm apart. For core loads over 12.5 g/m, greater separation may be required, and the manufacturers' instructions shall be followed.

(d) When detonating relays are used to achieve the desired delay pattern, the manufacturers' instructions for the type in use shall be followed. Care shall be taken to ensure that detonating relays are properly connected to ensure protection.

(e) The full length of the detonator shall be firmly taped to the line of detonating cord, with the base of the detonator pointing in the desired direction of detonation in the cord.

(f) To ensure that the desired delay pattern is achieved, the manufacturers' recommendations on the required separation between detonators and / or detonating relays, and adjacent lines of cord, shall be followed.

(ii) When using Fuse and Plain Detonators

(a) The method of lighting the fuses shall be decided at the planning stage, after consideration has been given to the number of fuses, the burning time of the fuses, and the time required to come to safety after the last fuse has been lit.

(b) Where fuses are lit individually by the shot firer, fuse lighters shall be used. It is desirable that a second person shall control the time which has elapsed from the lighting of the first fuse.

(c) Where igniting cord is used in conjunction with fuse, the delay pattern shall be drawn up so that all the fuses are burning in the holes before the first charge detonates.

(iii) When using Electric Detonators

(a) All detonators used in a blast shall be of the same electrical sensitivity and be produced by the same manufacturer.

(b) The choice of detonator type, shot firing cable, connecting wire, connecting system (series, series/parallel etc.) and firing device (exploder, etc) shall be made at the planning stage of the blast.

(c) All connections in the shot firing circuit shall be clean, tight and insulated from Contract with each other and the ground. The type of insulation shall be chosen after consideration of local conditions. i.e. presence of water, conducting rock, firing voltage and checks shall be made of insulation to ground where conditions are known to be difficult.

(d) Only instruments approved by the Engineer shall be used at the blast site for checking circuit values.

(e) The resistance of the firing circuit shall be measured and the result shall be consistent with the calculated value in accordance with the number and type of detonators. In the case of series/parallel connection, the resistance of each circuit shall be balanced to the limits appropriate for the exploder and the detonators being used.

(f) The shot firing cable shall be checked visually for mechanical damage before every blast. It shall also be checked for correct open and closed circuit resistance before it is connected to the detonator circuits.

(g) Exploders and testing equipment shall be regularly tested for correct performance. The intervals between tests shall be decided after consideration of the local factors, but the tests shall always be carried out if the exploder and/or tester equipment have been subjected to abnormal conditions, or following a misfire.

(h) The means for controlling the discharge of the electrical energy into the firing circuit shall always be under the control of the shot firer.

(iv) When using other methods

The manufacturers' instructions shall be followed at all times. Where any doubt exists, advice shall be sought at the planning stage.

(h) Precautions before and after firing

(i) The shot firer shall determine the danger area for the blast being fired, with regard to the type of operation and to local conditions, e.g. visibility. He shall be responsible for checking that the danger area is clear of all personnel before going to the place of safety from which the blast is to be fired.

(ii) Sentries shall be posted to guard all possible entries to the danger area, where it is large and/or not completely visible from the shot firer's place of safety. Sentries shall carry an unmistakable form of identification e.g. red flags and shall prohibit entry into their sector of the danger area until the shot firer has checked that it is clear and has relieved him of his duty.

(iii) The post-firing examination of the blast area shall not be undertaken before sufficient time has elapsed to allow for the dilution of the shot firing fumes to a safe level. The time required shall be decided after consideration of the local conditions.

(iv) The shot firer's duty shall include an examination of the blasting site, and this shall be completed before work is resumed. This examination shall include inspections for;

- dangerous rock conditions,
- presence of un-detonated explosives and / or accessories in the rock pile,
- presence of un-detonated explosives and / or accessories in blast holes,
- abnormal appearance of the blast, which could suggest that not all the blast holes had detonated correctly.

(v) In many types of blasting work, a considerable accumulation of empty cases can be built up during the charging operation. The cases shall first be checked for freedom from explosives material, and then destroyed by burning on the surface, preferably after the blast has been fired. The burning operation shall preferably take place at a designated site removed from the charged boreholes, explosives materials, or explosives stores, and in accordance with manufacturer's instructions.

(i) Secondary Blasting

Secondary blasting in quarries shall be done either by pop shooting or plaster shooting to reduce the size of boulders, produced from the primary blast, to smaller size for easy handling.

(j) Not used

(k) Dealing with misfires

(i) General

(a) No attempt shall be made to fire a hole or holes which have misfired before a very careful examination of the conditions has been made.

(b) All normal rules detailed in Sub section 306.3(h) "Precautions before and after firing" shall be observed when firing misfired holes.

(c) When misfires occur, action shall be divided into two parts. The first is dealing with the immediate situation. The second is an analysis of why the misfire occurred, and what can be done to prevent repetition. Consideration shall always be given to seek qualified professional assistance in the second phase, and also in the first phase if the misfire has resulted in an especially difficult situation, in the opinion of the Engineer.

(d) Where the charge could be damaged by water, or where the hole cannot be safely fired, the charge shall be retrieved. In horizontal holes, this is most easily done by washing the charge out. In vertical holes, it may as a last resort be necessary to fire a succession of short small diameter holes or plaster shots to dislodge the rock, and recover the explosives from the rock. Great care shall be taken that the holes drilled for this purpose are angled away from the charge at least 300 mm away from the misfired hole and parallel to it.

(ii) When using Plain Detonators

(a) If a misfire occurs, no person shall be allowed to reach the area until a specified period has lapsed. The specified period shall not be less than one hour. After the period has lapsed the exposed fuse shall be examined. If it is found that the fuse has burnt only along part of its length, the stemming shall be carefully washed out and a new primer cartridge inserted and fired. No attempt shall be made to remove the explosive from the borehole. No metal objects shall be used to remove the stemming.

(b) Where the fuses are accessible, they shall be trimmed and the holes fired.

(c) Where the fuses are inaccessible or damaged, the principles detailed in 306.3 (c) shall be observed.

(iii) When using Electric Detonators

(a) If a misfire occurs in electric shot firing a time lapse of at least fifteen minutes shall be allowed before any person is allowed to approach the misfire.

(b) After this time, where the detonator leads are accessible, the individual assemblies shall be checked for continuity. If the test gives a positive result, the hole/s can be fired. It is advisable to use another, tested, exploder and the cable shall be examined carefully for faults before the attempt to fire is made.

(c) Where the leads are inaccessible or where the test for continuity gives negative results, the hole/s shall be re-primed. The stemming shall be washed out with water, and new primers inserted. This method shall be used only if the main charge will not be seriously affected by the water used to remove the stemming. No attempt shall be made to dig out the stemming from the hole.

(l) Warning to Residents and Traffic

Adequate warning shall be given to neighbouring residents before blasting operations are carried out. A siren shall be sounded and men with red flags posted, on all roads at close proximity to the quarry, to warn traffic, as approved by the Engineer.

306.4 Safety in Handling, Transport and Storage

(a) Explosives, detonators, detonating fuse etc., shall not be stored except in a proper magazine which is clean, dry, well ventilated, well locked and approved by the Controller of explosives.

(b) Explosives and detonators shall be stored separately either in separate magazines or in a separate compartment of the magazine. Detonating fuse shall be stored with explosives and not with detonators.

(c) Smoking, matches or open light shall not be allowed in or near the magazine or while handling explosives and detonators. A permanent notice board in Sinhala, Tamil and English warning "NO SMOKING" shall be displayed in a prominent place near the magazine.

(d) Only wooden tools shall be used to open cases of explosives. No metal tools shall be kept in the magazine or used. Cases shall not be opened inside the magazine.

(e) Cases of explosives shall be handled with care and shall not be dropped, pushed or slid in a rough manner.

(f) When a case has been opened its contents shall be used before opening other cases.

(g) Explosives and detonators shall be issued in the sequence of manufacturing dates marked on the boxes.

(h) Primer cartridge shall not be made in the magazine.

(i) Not used

(j) Explosives shall not be transported with any other materials, particularly with tools or inflammable liquids.

(k) Whenever possible, explosives and detonators shall be transported in separate vehicle or conveyed by different men. If both have to be carried in the same vehicle they shall be placed in separate compartments.

(l) When transporting, the explosives shall be kept furthest from the engine. Explosives shall not be carried in the driver's cabin.

(m) Loading and unloading of explosives to the vehicle shall be done as gently as possible.

(n) No explosives or detonators shall be transported without a valid transport pass.

(o) Only the essential quantity of explosives and detonators shall be transported to the blasting site. Explosives and detonators shall be kept apart until they are used.

(p) A monthly return of explosives indicating the quantity of each kind of explosives used, the quantity of rock blasted, opening and closing stock balances shall be sent to the Engineer and to the responsible authority for the district in which the explosives are kept.

306.5 Tests and Standards of Acceptance

The material shall be tested in accordance with these Specifications and shall be prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

307 SOFT GROUND TREATMENT FOR MAJOR PROJECTS

307.1 Description

The Contractor shall review the soil profile Drawings and plan the required additional soil investigation in cooperation with the Engineer. The required soft ground treatment including trial areas shall be planned and proposed based on findings of additional soil investigation data by the Contractor and agreed by the Engineer. During the construction, the Contractor shall monitor the soil movement carefully and test the performance for the safe completion of the Work. It shall be the responsibility of the Contractor to carry out the work in such a way that it will maintain the stability of embankment and meet the settlement criteria. For this purpose, the embankment shall be designed to have a short and long term factor of safety of 1.20 and 1.25 respectively.

This work shall consist of the supply and installation of a geo-textile, vertical band drains, gravel mat, sand / gravel compaction piles and pile and slab embankment construction and also replacement of soft soil specified in the Specifications and on the Drawings or as required by the Engineer.

Testing and Criteria of Soft Ground Treatment

The Contractor shall supply and install the testing equipment, as well as test and monitor the soft ground treatment as part of the Works during and after the treatment. The embankment shall be designed and constructed by the Contractor so that any continued settlement at the road centre after a period of 3 years following the acceptance of the paving shall not exceed 150 mm. In this regard, settlement

predictions shall be prepared by the Contractor based on reliable theory, soil data, actual observations and the like and submitted to the Engineer for acceptance.

If any unusual movement or failure is anticipated, the Contractor shall immediately report and discuss the solution with the Engineer. If the ground conditions differ from those expected from his interpretation of the ground investigation reports, the Contractor shall do the same. If the predicted settlement for 3 years based on monitored data exceeds 150 mm the contractor shall immediately report and discuss the solution with the Engineer.

307.2 Materials

(a) Sand/Gravel for Sand/Gravel mat and Sand/Gravel Compaction Pile(SCP/GCP)

Gravel/sand to be used for the sand/gravel mat & sand/gravel compaction pile (SCP/GCP) shall be crushed stone/river sand, suitably graded for high permeability and shall be free from clay, lumps of dirt, organic matter or any other deleterious matter. The material for sand/gravel mat shall meet the grading requirements in Table 307-1 of the Specification.

Samples of sand/gravel shall be submitted by the Contractor to the Engineer for approval.

Table 307-1 Grading Requirement for Gravel/Sand Mat and Sand / Gravel Compaction Pile Material

	Gravel Mat and Gravel Compaction Pile	Sand Mat and Sand Compaction Pile
BS Test Sieve (mm)	Percentage by Mass Passing the Sieve	Percentage by Mass Passing the Sieve
50	100	
37.5	85-100	
20.0	50-80	100
10.0	-	90-100
5.0	15-40	80-100
2.0	5-25	50-100
0.6	-	0-50
0.3	-	0-15
0.075	0-5	0-5

(b) Geo-textile

Geo-textiles have two kinds, woven and non woven. The Contractor shall study and select the required characteristics of the product and propose to the Engineer for acceptance.

Geo-textile shall be UV-stabilized and made of polypropylene yarns either woven with different or the same strength for both warp and weft directions. The geo-textile shall be tested in accordance with ISO 10319 or equivalent and requirements in Section 2003.

The Permeability for separation geo-textile (ISO 11058, water head of 50 mm), shall not be less than 85 litre/m^2/s. End parts shall have sufficient allowance for pulling due to settlement

(c) Band Drain [Pre-fabricated Vertical Drain (PVD)]

The drain shall consist of a continuous band-shaped core enclosed in a filter jacket.

The core shall form a three-dimensional open labyrinth structure. The filter jacket shall be a non-woven polyester fabric or similar with effective opening size not bigger than 80 µm and minimum filter velocity of 6.5 x 10^{-4} m/sec. The drain shall have a minimum water discharge capacity of 40 x 10^{-6} m^3/sec after being compressed under 300 to 350 kN/m^2, and minimum filter strength of 8 kN/m to withstand the installation stress.

(d) Pile and Slab

Pile and slab structure shall be as shown in the Drawings. It consists of:

- Pre-cast reinforced concrete square piles, Example 0.3-0.4m x 0.3-0.4m, L=10-14 m.
- Reinforced concrete slab, Example 0.4 m thick.

The materials shall conform to:

- Section 1004, Piling
- Section 1001, Portland cement concrete structures.

(e) Pre-loading and surcharging of embankments

Pre-loading and surcharging (if adopted) of embankments are shown in the Drawings for the same for soft soil treatment. The material for preloading and surcharging shall conform to type I embankment material of Sub section 1708. If this material is removed prior to the embankment construction any material as decided by the Contractor could be used for its construction.

307.3 Construction Methods

(a) Replacement of Unacceptable Soil

Referring to the results of additional soil investigation and the Engineer's instructions, the Contractor shall construct the trial areas of Soft ground treatment, in particular replacement of Unacceptable material in a safe manner. Approximate maximum depth of peat for replacement is about 6 m, with 12-14 m for short sections.

In addition to soft ground treatment, the Contractor shall prepare the adequate excavation equipment for the estimated depth and shall demonstrate the Work and check the performance for acceptance of the Engineer.

(i) Replacement filling below the water table - rock fills under water

- Where replacement filling is to be constructed from below the water table level, rock fill shall be deposited in successive layers of a thickness determined by the size of rock and depth of water, to a height of 300 mm above the surrounding water level.

- Each layer shall be constructed starting at one end of the filling under construction and placing the rock by means of a bulldozer in such a manner that the larger rock shall be placed, and the spaces between the layer, filled with finer material to form a dense interlocking and stable layer.

- The maximum size of rock shall be 125-500 mm. The rock fill shall be blinded with a layer of 40 mm nominal maximum size graded aggregate sufficient to fill all voids in the upper layer of the rock fill.

- Rock fill shall be compacted by heavy vibratory rollers (minimum weight of 8 tonnes) until there is no visible movement of the rock fill under the equipment.

(ii) Embankment construction above the water table with pioneer layer on soft unstable ground

- Where embankment filling is to be constructed over very wet or soft ground that displays excessive movement under normal compaction equipment and haulage trucks, thereby precluding the effective compaction of the bottom layer, the Engineer may direct that a pioneer layer be constructed on the unstable ground. This layer shall be constructed by end dumping and spreading successive loads of soil suitable for embankment construction in a uniform layer of thickness sufficient to provide a stable working platform. This layer shall be suitably compacted and shall be 0.5 meter high from original natural ground level for the construction of further embankment layers which shall be compacted to a controlled density.

- Light hauling equipment shall be used to place the material, and the layer shall be compacted by the use of compaction equipment that will provide the most effective compaction without over-stressing the roadbed. Pioneer layers need not be compacted to a controlled density.

Note:

The compacted volume of material used may be determined on the basis of 70 % of the loose volume in trucks as an alternative to taking Cross-sections before and after construction.

Pioneer layers shall be paid for under the appropriate embankment construction rate. It shall be paid only for the layer above the original ground level before the next layer is constructed and not paid for the soil penetrated into original soft soil ground.

(b) Not Used

(c) Sand/Gravel Mat and Sand / Gravel Compaction Pile (SCP / GCP)

The Contractor can propose to use Sand / Gravel Compaction Pile (SCP / GCP) for soft ground treatment. The Contractor shall form Sand / Gravel Compaction Pile in existing natural soils by filling gravels with vibro-replacement or vibro-displacement in the manner and in the area as given below.

(i) If directed by the Engineer a temporary earth dyke shall be formed around the work area to protect the drains, filling materials and other related works from water.

Surface settlement plates with vertical rods shall be installed on a 100 mm thick level gravel Base in such a way that the top of the Base plate is horizontal. Before placing any embankment material, the Engineer will inspect the completed installation and take initial elevations on the top of the Base plate and the top of the

rod. A 300 mm thick layer of gravel shall be placed on the settlement plate base to eliminate bedding errors. As embankment construction advances the rods shall be extended as necessary.

The settlement plates shall be installed so as to check not only vertical but also horizontal movements.

The work shall also include the installation and maintenance of other settlement monitoring and measuring devices as required by the Engineer. Prior to loading the soft soil, the Engineer may instruct the construction of an additional 0.5 m deep 1 m width of gravel to be placed at the toe of the gravel mat and to be later removed after the settlement is completed.

(ii) Unless otherwise approved by the Engineer, the method of construction shall be as given below:

a. Prior to the commencement of the work, subsoil investigations as approved by the Engineer shall be carried out by the Contractor, and the Contractor shall submit his proposal for the SCP/GCP system including a complete description of the SCP GCP machine type, capacity, calculations and work method, which shall demonstrate the capability of the stability and drain to meet the requirements stated hereinafter. The proposal shall be based on the available subsoil data and on the results of the soil investigation required under the contract. The proposal shall be approved by the Engineer before commencement of the work. The work shall be carried out in close conformity with the requirements, which will be established by the Engineer after the results of the soil investigation are available.

b. Prior to the installation the Contractor shall submit details of the sequence and method of forming SCP/GCP to the Engineer for review and approval.

c. The Contractor shall form SCP/GCP in existing natural soils by filling gravel with vibro displacement in the manner and in the areas as given below.

i. Sand / Gravel piles shall be installed by driving a casing pipe with a special device at its lower end to form a sand/gravel plug using pile-driving equipment. When it has penetrated to the required depth by vibration as well as water jetting, the inside of the pipe is filled with sand / gravel through the upper hopper on the pipe top. The upper end of the pipe is then closed, and compressed air is applied inside the pipe while it is raised to certain height from the ground level and the sand / gravel inside are expelled out of the pipe end simultaneously. Casing pipe shall be penetrated again with compaction of the sand / gravel in the ground by further vibration. After the vibration has attained its required compaction degree and to the required diameter of the sand / gravel compaction pile, casing is raised to expel the remaining sand / gravel out of the casing pipe. Same penetration accompanying with vibration for compaction work is repeated until the whole sand / gravel compaction pile is completed to the required ground level.

d. Through all procedures of forming SCP / GCP, bottom level of casing pipe and top level of gravel in the casing pipe shall be monitored by automatic monitoring recorder continuously up to each completion of pipe forming to ensure the definite SCP / GCP forming.

e. Heaving of the ground is expected during SCP / GCP forming, therefore before and after SCP / GCP execution, ground levels in cross sections shall be measured at least in 50 m interval along the SCP / GCP execution area, plus any

additional sections that will be needed to arrive at correct volume of heaving of ground.

f. If there is any structure within twice the length of SCP / GCP, the Contractor shall not construct SCP / GCP, unless otherwise instructed by the Engineer.

g. Completion of each SCP / GCP shall be checked and accepted by the Engineer at site. On completion of all vertical SCP / GCP to the diameter and spacing specified in the drawings, a horizontal layer of geo-textile (if necessary, strength of geo-textile will vary depending on the locations) and suitable gravel shall be spread evenly over the area to the depth specified in the drawings unless otherwise instructed by the Engineer.

h. When the abutments of viaducts and box culverts are located in the soft ground, the soft ground shall be treated with the following procedure:

i. Compacted general fill for pioneer layer to the height of 500 mm from initial natural ground level shall be provided for supporting construction machinery.

ii. SCP / GCP shall be carried out as shown in the drawings

iii. After the SCP / GCP, it shall be left for more than one to three months to stabilise the existing treated ground and recovering of its strength shall be confirmed before embankment work.

iv. Then preload shall be spread and compacted in layers to an agreed density to the designed road level.

v. Each layer shall be checked whether it has been compacted to the agreed density,

vi. Pre-load shall be left on the embankment for more than one month along with monitoring the piezometers and settlement gauges of the ground.

vii. The piezometer and settlement monitoring data shall be submitted to the Engineer for his review and approval of the time for removal.

viii. After the approval of the Engineer, the preload shall be removed.

ix. The abutments and box culverts shall then be constructed.

i. Not Used

j. SCP / GCP often causes noise, vibration and heaving of the surrounding ground. Therefore the Contractor shall monitor them continuously at the SCP / GCP sites and the surrounding areas. Noise and vibration shall be monitored during SCP /GCP execution. If residencies are located within 50 m from SCP / GCP execution area or the Engineer finds the negative impact is serious, the Contractor shall take immediate action, such as suspension of the work, introduction of low noise and low vibration SCP / GCP machines and provision of ditches around the SCP / GCP sites, depending on the circumstances of the site. The SCP / GCP shall reach at least the firm clayey soil layer or medium dense sand layer.

k. Geo-textile material shall be installed at the specified location in the arrangement as shown on the Plans or as otherwise directed by the Engineer.

l. The ground surface where the geo-textile is laid shall be cleared from all stumps, stones etc, that could cause puncture or tear to the fabric.

m. The ground surface shall be flat and level. Unevenness of the ground surface shall not be more than 100 mm and inclination across the road shall not be more than 5%. The geo-textile shall be overlapped by at least 500 mm and shall be anchored at the edges of the geo-textile as given below.

n. The gravel mat placement after the installation of geo-textile shall be in such a way so that the fabric is not partially overstretched. The gravel shall be well distributed in a layer not thicker than 500 mm, 200 mm and 300 mm before and after PVD installation respectively and the distribution of gravel shall be carried out in one direction without any alteration, starting from one point. Non woven type geo-textile shall be pegged at the edges of the embankment width, while woven geo-textile shall be wrapped at the effective road width to form an effective anchorage as directed by the Engineer.

o. To limit the build up of pore water pressure in the underlying formation where countermeasures for soft ground treatment are to be provided in locations marked on the Soil Profile Drawings, the rate of construction of embankments above natural ground level in these locations shall be designed by the Contractor and agreed by the Engineer.

(d) Geo-textile

The applicable location, material, strength, number of layers and method of construction of the geo-textile which may include separator shall be proposed by the Contractor, referring to the Soil Profile Drawings, and shall conform to Section 2003.

(e) Band Drain Construction

(i) This work shall consist of the installation of a system of vertical band drains and a horizontal gravel mat so as to accelerate settlement and improve the subsoil in areas of soft ground as shown on the Drawings or as directed by the Engineer.

Prior to the commencement of the work, subsoil investigations as directed by the Engineer shall be carried out by the Contractor, and the Contractor shall submit his proposal for the vertical drain system including a complete description of the band drain type, calculations and work method, which shall demonstrate the capability of the drain to meet the requirements stated hereinafter. The proposal shall be based on the available subsoil data and on the results of the soil investigation required under the Contract. The proposal shall be approved by the Engineer before commencement of the work. The work shall be carried out in close conformity with the requirements, established by the Engineer after the results of the soil investigation are available.

(ii) A pioneer layer of soil suitable for embankment construction of 500 mm thickness shall be provided for supporting installation machinery.

(iii) Drains shall be installed with approved equipment to the specified depth and spacing and arrangement as shown on the Plans or as otherwise directed by Engineer.

The drain installation equipment shall be strong enough to install band drains of minimum of 5000 m per day per equipment to depths of 25 m without breakdowns. Before import of such equipment for the project, the Contractor shall guarantee such capabilities as given in these Specifications.

(iv) The sand/gravel mat shall be laid to form the horizontal gravel drainage path of the soft soil treatment.

(v) A geo-textile shall be placed over the gravel mat as a separator, if required by the Engineer.

The drains installation equipment shall be the type, which will cause a minimum disturbance to the subsoil during the installation operation. Constant load or constant rate of advancement method or the so-called 'static' method is preferred. Vibrator, falling weight impact hammers, and jetting will not be allowed unless otherwise approved by the Engineer and restricted only for assistance in penetration in areas where the design depths cannot be achieved by static method.

The drains shall be installed using a mandrel or steel sleeve that will be advanced through the soil to the required depth. The mandrel shall protect the drain material from tears, cuts and abrasions during installation and shall be withdrawn after installation of the drain. The mandrel shall be rectangular or rhombic in shape with appropriate Cross-sectional area.

(vi) Prior to the installation, the Contractor shall submit details of the sequence and method of installation to the Engineer for review and approval.

The equipment shall be carefully checked for verticality prior to the advancing of each drain. Drains that are out of their proper location by more than 150 mm, drains that are damaged in construction, and drains that are improperly completed shall not be accepted, and no compensation will be allowed for any materials furnished or for any works performed on such drains.

During installation of the drains, the Contractor shall provide suitable means for determining the depth of the drain at any given time. Joints or connections in the drain material shall be made in an approved workmanlike manner so as to ensure continuity of the material. Minimum length of overlap in the join shall be 300 mm. The drain material shall be cut neatly at its upper end and there shall be a 300 mm top cutting of tip length of drain material protruding above the working ground at each installation.

(f) Pile and Slab Construction

Pile and slab structure is as shown in the Drawings. It consists of:

- Pre-cast reinforced concrete square piles, the actual length shall be confirmed based on the additional geotechnical Investigation during construction.
- Reinforced concrete slab.

For piles and slab construction, the Contractor shall follow the relevant clauses in:

Section 1004 – Pile foundation for structures
Section 1001 – Concrete for structures

Where concrete piles are driven in peaty soil areas, special precautions shall be taken to use sulphate resistant cement in the production of concrete piles and to use higher concrete cover for reinforcements in the concrete piles.

(g) Pre-load and Surcharge (if adopted)

(i) Pre-load and surcharge (if adopted) shall be placed for all required sections. They shall be placed on the top of road bed.

Before shaping the Subgrade and placing a Sub-base course after completion of period of consolidation settlement, if top level of pre-load and surcharge (if adopted) is higher than bottom level of Subgrade, such extra pre-load and surcharge (if adopted) shall be removed.

For the construction of the pre-load and surcharge (if adopted), the Contractor shall conform to Section 304.

(ii) If the preload or surcharge is removed prior to the embankment construction, this material could be placed and compacted to the requirements of the Contractor.

(h) Instrumentation and Monitoring

The Contractor shall provide and install various instruments for soft ground treatment monitoring as directed by the Engineer. The monitoring shall be done at the sections which are approved by the Engineer at intervals along the longitudinal alignment of the road as given in Section 307.3(j)(iv)(c). Monitoring shall be started before construction of embankment and continued to the end of construction period. The instrumentation and monitoring shall include for:

1) Instruments for soft ground treatment monitoring
2) Tubing or cabling
3) Recording water levels
4) Cleaning and keeping hole free of harmful materials,
5) Connections and joints,
6) Sand and gravel filters
7) Removing contaminated water,
8) Recording data and monitoring and supplying one copy to the Engineer,
9) Proving correct functioning,
10) Bedding and required fencing

(i) Not Used

(j) Testing of Soft Ground Treatment

i. Test to be carried out

The following tests or alternatives shall be carried out at the positions and frequency agreed by the Engineer.

a) Penetration Tests

The static cone penetration test (CPT), the standard penetration test (SPT) or dynamic cone penetration (DCP) tests shall be carried out as per Chapter 1900.

b) Unconfined compression tests for clayey soils

Sampling and testing of unconfined compression test (UCS) samples shall be carried out in clayey soils to correlate the UCS to bearing capacity. Then unconfined test values can be correlated to DCP-CBR as defined in

TRL UK Road Note 31 (1993) and such values can be used to determine the bearing capacity of such strata. If the value of the bearing capacity is in doubt, SPT tests as per Section 1900 shall be carried out.

When in doubt, site investigation by carrying out i) SPT and, ii) Sampling, tri-axial and consolidation tests shall be carried out by the Contractor to determine the bearing capacity and settlement criteria.

ii. Trial Areas

- The purpose of carrying out of trial embankment is to confirm the performance of all soft ground treatment methods. It is to the benefit of the Contractor to initiate the trials.

- Trial areas are to be treated and tested. The trial areas, which meet the performance requirements, may form part of the Permanent Works. If they fail to meet the requirements, they shall not form the Permanent Works. The failed trial areas in the Permanent work site shall be reinstated at the Contractor's own expense until satisfaction of the Engineer.

- Equipment and materials used in trial areas shall be identical to those proposed for the Permanent Works.

- Trial area location shall be proposed by the Contractor for acceptance of the Engineer or otherwise instructed by the Engineer.

iii. Records and Reports

- Complete records of plant, equipment and materials shall be maintained during all soft ground treatment operations.

- Records shall be made available to the Engineer, including all information identified in Table 307-2.

- All records pertaining to a particular day's operations shall be made available to the Engineer at the start of the following day's operation.

- The Contractor shall prepare Special reports on soft ground treatment using adequate computer software, from time to time, in coordination with the Engineer. The reports shall include:

  1) Slope stability analysis,
  2) Embankment and settlement analysis,
  3) Performance of soft ground treatment including lateral movement and water table,
  4) All results of instrumentation, monitoring and tests

Table 307-2 Records and Reports- Information Required

Soft Ground Treatment	In situ Testing
For each column / area treated: Date Contract title Area identification Ground level at commencement Ground level at completion	For each area tested: Date Contract title Area identification Test position, co-ordinates and level Method of test used
Material used Approximate column diameter Bottom and top level of penetration / installation of each treatment point Vibratory power consumption during operation Monitored record of noise and vibration during GCP execution Automatic monitoring record of levels for casing bottom and top of gravel inside the casing pipe	All information required by appropriate BS standard test procedure Water table Other
Material consumption / installation volume during treatment work Jetting pressure (where applicable) During of penetration Obstructions and delays No. and type of tests carried out	

iv. Detail Procedure of Monitoring Soft Ground Treatment

(a) Introduction

To monitor the progression of embankment settlement and assess the effectiveness of the soft ground treatment method, a field instrumentation system shall be installed. Also it is necessary to have reliable field monitoring data, to assure the conformance by the contractor the contract requirements of the maximum settlement of 150mm under the embankment fill at the end of 3 years after the construction.

This section describes the details of field monitoring instrumentation systems and monitoring plan for soft ground treatment works during construction and post-construction period. The types of field instrumentation, measurement procedures and interpretation and report of monitoring data shall be as explained below.

(b) Soft Ground Treatment Works

The 4 types of the soft ground treatment method are described in these specifications. The categories of soft ground treatment method shall be as follows;

1. Non-treatment fills areas / pile and slab construction
2. Pre-loading and surcharging
3. Replacement of unacceptable soil
4. Band drain and preloading and surcharging / sand or gravel mat and sand or gravel compaction pile (SCP/GCP)

(c) Field Monitoring Instrumentation

Type and function of field instrumentation shall be as follows. The instrumentation shall be installed as specified in Section 1900 or as instructed by the Engineer.

Item	Type of Instrumentation	Measurement	Measurement Procedures	Locations
1	Settlement Plate	Vertical settlement	By level instrument. The high accuracy level instruments shall be used for monitoring works during the final loading.	Centreline and at shoulder of carriage way installed on top of the soft soil layer (below the pioneer layer)
2	Differential Settlement Gauge	Vertical settlement for different depths of subsoil	By level instrument. The high accuracy level instruments shall be used for monitoring works during the final loading.	Centreline
3	Settlement Marker	Vertical settlement	By high accuracy level instrument.	Centreline at the finished surface of surcharge or final loading layer
4	Displacement Stake	Horizontal and vertical movement	By level instrument and total station.	Toe line and some distance from toe line.
5	Inclinometer	Horizontal movement for different depths of subsoil	By inclinometer probe and reading unit.	Toe line and some distance from toe line
6	Piezometer	Pore water pressure	By various procedures	Centreline and toe lines

(d) Monitoring Program

The monitoring programs for each category of soft ground treatment method shall be as shown below. Joint inspections of the Engineer's and the Contractor's staff shall be carried out as required.

Item	Soft Ground Treatment Method	Measurement	Duration	Frequencies
1	Non-treatment area / pile and slab construction	1. Settlement plates	1. Initial – After installation 2. Weekly – during embankment and pavement works and up to one month after completion of work 3. Monthly – after finished pavement works 4. Each time – extension of settlement rods	1 Every 100m subjected to a minimum of one per section
2	Preloading and surcharging	1. Settlement plates	1. Initial – After installation 2. Weekly – during embankment and surcharge works and up to one month after completion of work 3. Weekly – during removal of surcharge and construction of pavement works 4. Monthly – after finished pavement works 5. Each time – extension of settlement rods	1 Every 50m subjected to a minimum of one per section
		2. Piezometer	1. Initial – After installation 2. Weekly – during embankment and surcharge works 3. Weekly – during removal of surcharge and construction of pavement works 4. Monthly – after finished pavement works 5. Each time – soon after the load application, extension of standpipe PVC	One set (that is one at centreline and two at tor lines) every 200m subjected to a minimum of one set per section

3	Replacement of unacceptable soil	1. Settlement plates	1. Initial – After installation 2. Weekly – during embankment and pavement works and up to one month after completion of work 3. Weekly – during removal of surcharge and construction of pavement works 4. Monthly – after finished pavement works 5. Each time – extension of settlement rods	1 Every 100m subjected to a minimum of one per section
4	Band drain and preloading and surcharging /sand or gravel mat and sand or gravel compaction pile (SCP/GCP)	1. Settlement plates 2. Deep settlement gauges	1. Initial – After installation 2. Weekly – during embankment and surcharge works and up to one month after completion of work 3. Weekly – during removal of surcharge and construction of pavement works 4. Monthly – after finished pavement works 5. Each time – extension of settlement rods	1. Settlement plates Every 50m subjected to a minimum of one per section 2. Deep settlement gauges As required by the Engineer
		3. Displacement stakes	1. Initial – After installation 2. Weekly – during embankment and surcharge works	As required by the Engineer
		4. Piezometer	1. Initial – After installation 2. Weekly – during embankment and surcharge 3. Weekly – during removal of surcharge and pavement works 4. Monthly – after finished pavement works 5. Each time – soon after the load application, extension of standpipe PVC	1 Every 100m subjected to a minimum of one per section

307.3/1 Tests and Standards of Acceptance

The material shall be tested in accordance with these Specifications and shall be prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

307.4 Measurement

The measurement of the pioneer layer shall be in Cu.m and as per Section 307.3(a)(ii).

The quantity of sand/gravel mat shall be measured by Cu.m installed as one pay item.

Sand / Gravel compaction pile will be measured by the linear meter for the diameter as given in the Pay Item Description. The SCP / GCP shall include:

- Trial areas
- Demonstrations
- Site control, observation, records and reports
- Additional gravel required due to penetration into surroundings ground.

Vertical band drains shall be measured by the linear metre for the size as given in the Pay Item Description. Measurement shall not be made for joints. The pay item shall include the cost for equipment establishment, bringing, erecting, setting up, moving, dismantling and removing from the site on completion.

Geo-textile (strength varies) shall be measured by Sq.m for area covered. Measurement will not be made for joints.

The concrete slab for RC pile head, including concrete, reinforcement shall be measured in Sq.m.

The RC pile as per Drawing, including concrete, reinforcement, pile shoes, splicing steel plate etc. shall be measured in metres.

Measurement for fill for preload or surcharge that is placed, and compacted and removed as per 307.3 (g)(ii) shall be measured in Cu.m.

Measurement for fill of pre-load and excavation of excess surcharge shall be carried out as per measurements for Pay Items 304(1) or 304(2) and 301(1) respectively.

Instrumentation, monitoring and testing shall be measured according to progress.

Trial areas shall be paid through a Provisional sum with major quantities measured in cu.m. The rate shall be agreed by the Engineer, the Employer and the Contractor. Instrumentation, monitoring and testing shall be measured by Lump sum. Any other costs related to soft ground treatment are deemed to be included in the Contract unit price for the pay items given below in Section 307.5.

The replacement of unacceptable soil with rock shall be measured in Cu.m.

Additional soil investigation shall be under pay items under Section 1900.

307.5 Payment

The work measured as provided above shall be paid for at the Contract price per unit of measurement for the item listed below, which price and payment shall be full compensation for furnishing and placing all materials, and for all labour, equipment and other incidentals necessary to complete the work in accordance with the Drawings, Specifications and as directed by the Engineer.

Payment for fill of pre-load and surcharge (if adopted) and excavation of excess of the same shall be carried out as per Pay Items 304(1) or 304(2) and 301(1) respectively.

Payment for excavation of unsuitable material for disposal and fill for soft soil excavated locations shall be carried out as per Section 301 and 304 respectively.

Pay Items	Description	Pay Unit
307(1)	Pioneer layer	Cu.m
307(2)	Gravel Mat (gravel size maximum 50mm)	Cu.m
307(3)	Sand / Gravel Compaction Pile (state diameter)	meter
307(4)	Band Drains (state size)	metre
307(5)	Geo-textile (800 kN/m/ 100 kN/m)	Sq.m
307(6)	Geo-textile (600 kN/m/ 50k N/m)	Sq.m
307(7)	Geo-textile (400 kN/m/ 50 kN/m)	Sq.m
307(8)	Geo-textile (300 kN/m/ 50 kN/m)	Sq.m
307(9)	Geo-textile (200 kN/m/ 50 kN/m)	Sq.m
307(10)	Geo-textile (100 kN/m/ 50 kN/m)	Sq.m
307(11)	RC square pile (state size)	metre
307(12)	Concrete Slab for RC pile head (state thickness)	Sq.m
307(13)	Preload or surcharge that is placed, compacted and removed as per 307.3(g)(ii)	Cu.m
307(14)	Instrumentation, Monitoring and testing	Prov. Sum
307(15)	Replacement of unsuitable soil	Cu.m
307(16)	Trial Sections	Prov. Sum

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

For geo-textile separator, please refer to pay item 2002 (1) Geo-textile (9.5 KN/m) under Section 2003.

308 MISCELLANEOUS

308.1 Description

This item provides for discretionary expenditure by the Engineer on items relevant to this part of the Bill of Quantities but not elsewhere covered.

308.2 Measurement and Payment

Measurement and payment shall be as described for provisional sums in the preamble to the Bill of Quantities.

Pay Items and Pay Units shall be as follows;

Pay Item	Description	Pay Unit
308(1)	Miscellaneous earthworks	PS
308(2)	Mark-up on above items	Percent

400 SUB-BASES, BASES AND SHOULDERS

401 SUB-BASE – UPPER AND LOWER (CAPPING LAYER) AND SELECTED SUBGRADE

401.1 Description

This work shall consist of placing and compacting of upper Sub-base and Lower Sub-base (Capping Layer or Selected Subgrade) in layers on an existing Pavement or prepared Subgrade in accordance with these Specifications and lines, levels, grades, dimensions and cross sections shown on the Drawings or as directed by the Engineer.

The upper Sub-base and Lower Sub-base (Capping Layer or Selected Subgrade) shall be referred to as Sub-base in these Specifications.

401.2 Materials

The material shall be obtained from approved sources in borrow or cut or from such other sources of supply as may be specified or approved for use from time to time. The material used shall be crushed stone aggregate, as dug soils, or material obtained by blending two or more soils or soil and sand or soil and crusher dust mixes referred to as mechanical stabilization.

The Contractor's attention is drawn to the scarcity of naturally occurring Sub-base material and shall make due allowance for mixing of materials in mechanical stabilization in accordance with Sub section 401.3 below.

Material for upper Sub-base Type 1 & 2 and Lower Sub-base (Capping Layer or Selected Subgrade) Type 1 & 2 shall be as specified in Sub section 1708.2, herein. For flexible and rigid Pavement the accepted values of LL & PI are 40 & 15 and 25 & 6 respectively.

401.3 Mechanical Stabilization (blending of materials)

Blending of materials shall be carried out at borrow pits or at designated central yards on a method and equipment approved by the Engineer. Blending shall be continued until a homogeneous mix is produced and tested.

When site mixing is done for the above purpose soils to be blended shall be spread uniformly on the prepared surface in the required proportions and then pulverized and mixed by means of a rotorvator, disc harrow, rotary tiller or any other approved equipment or a combination of these equipment. The pulverizing and mixing shall be continued until uniformity of the mix is achieved as far as practicable.

Alternatively the different soils after pulverization shall be mixed by windrowing using a motor grader.

Manual mixing using pickaxes, spades etc shall be carried out only on small jobs and with the approval of the Engineer.

When the mixing is done at borrow pits or at designated central yards, it shall be carried out in a manner as outlined above or any other manner as directed by the Engineer.

401.4 Construction Requirements

(a) Preliminaries

Normally the construction of the Sub-base shall not commence in any section of the works until the drainage works in that section have been completed. When this is not practicable, temporary cross drains shall be provided to suitably drain the Subgrade as approved by the Engineer.

Immediately prior to spreading of Sub-base material, the Subgrade that has already been prepared in conformity with Section 304 shall be cleared of any extraneous matter, notwithstanding any earlier approval of Subgrade, and the surface shall be suitably moistened.

Where the Sub-base is to be placed on an existing surface dressed or hot bitumen surfaced (Section 503) road, the bituminous crust shall be removed completely along grooves at 1 m intervals. The grooves shall be cut by roller tynes or by any other method approved by the Engineer. The exposed surface shall suitably be compacted with Sub-base material prior to laying of the Sub-base.

Where Sub-base is laid over existing asphalt concrete surfaced Pavement, the surface shall be punctured to permit drainage through the surface. Puncturing shall be carried out to create drainage holes of not less than 20 mm in diameter through the existing Surfacing layer to the underlying Base at 500 mm centres on a grid across the area being prepared. These holes shall be filled with coarse sand and suitably tamped as approved by the Engineer.

(b) Placing and Compacting of Sub-base Materials

The Sub-base shall be constructed after checking that the underlying layer conforms to the specified requirements and has been approved by the Engineer. Immediately before placing the material, the underlying layer shall be checked by the Contractor for any damage or deficiencies, which shall be made good as instructed by the Engineer.

The Sub-base material shall be placed, spread, broken down, watered and compacted and oversize material shall be removed, all in accordance with the requirements of the Specifications. There shall be no separate payment for removal of oversize material.

All materials which are deposited in place prior to the compaction shall be evenly spread over the whole of the designated area for the layer concerned and in such quantity that the thickness of any one layer, when measured after compaction, shall comply with the requirements specified.

The Sub-base material shall normally be spread in layers of thickness not exceeding 225mm for compaction using 8-10 tonne smooth wheeled roller or any other roller of comparable compaction effort. Where necessary, the material may be spread in thicker layers with the approval of the Engineer provided a heavier roller is used for the compaction.

The compaction shall be carried out at moisture content within 2% of the predetermined optimum moisture content.

The moisture content of the material shall be checked at the time of compaction at the frequency specified in Table1602-1 and as directed by the Engineer. If the material is too wet it shall be dried by aeration and if it is too dry, the material shall be sufficiently watered prior to compaction.

Any water required before the material is compacted shall be added to the material in successive applications by means of water bowsers fitted with sprinkler bars or by means of pressure distributors capable of applying the water evenly and uniformly over the area concerned.

The water shall be thoroughly mixed with the material to be compacted by means of motor graders or other suitable equipment. Mixing shall continue until the required amount of water has been added and a uniform homogeneous mixture is obtained. Thereafter compaction may proceed.

Rolling shall be carried out in accordance with the provisions of Sub section 304.3d (ii).

Where the Sub-base is built up of more than one layer the layers to follow shall be placed only after the degree of compaction of the previous layer has been tested and found satisfactory as given in Sub section 401.4(c).

Where an existing Sub-base layer is to be improved by the addition of a layer of material less than 100mm thick, the existing surface shall be scarified to a depth instructed by the Engineer, mixed with the imported material to form a homogeneous layer of minimum depth 100mm of the required Sub-base strength, re-compacted to the dry density specified for the layer and formed to the lines and levels shown on the Drawings or as directed by the Engineer.

(c) Degree of Compaction of Sub-base

The upper Sub-base and Lower Sub-base (Capping Layers / Selected Subgrade) shall be compacted to not less than 98% and 95% of the maximum dry density respectively of the material as determined by BS1377, Test 13 (Heavy) or AASHTO T-180 (Modified).

(d) Quality Control

The quality control of materials and works shall be carried out in accordance with Section 1602 herein.

(e) Finishing Operations

The compacted Sub-base shall be finished to levels, grades and cross sections shown in the Drawings and as directed by the Engineer, subject to the requirements given in Section 1601.

(f) Protection of Sub-base

The Contractor shall protect and maintain the Sub-base at his own expense. Maintenance shall include the immediate repair of any damage or defects which may occur and shall be repeated as often as is necessary to keep the Sub-base continuously intact. Repairs shall be done in such a manner that ensures restoration to an even and uniform surface and may involve scarifying, watering and re-compacting.

401.5 Measurement and Payment

(a) Measurement

The Sub-base shall be measured by the Cu.m of material compacted in place. Measurement shall be based on the cross section of the Sub-base shown in the Drawings and the actual length measured horizontally along the centre line of the surface of the road, or in case of edge widening, along the centre-line of the widened section.

(b) Payment

The payment for Sub-base shall be based on the Contract unit rate for the completed work of the Sub-base which shall include full compensation for providing all materials labour, tools, equipment and incidentals necessary to carry out the construction works in accordance with the Specifications.

The Pay items and Pay units shall be as follows:-

Pay Item	Description	Unit of Measurement
401(1)	Provide and place Sub-base (State type)	Cu. m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

402 STABILIZED SOIL SUB-BASES AND BASES

402.1 Description

This work shall consist of the construction of a Sub-base or Base, using soil stabilized with lime or cement, on a prepared Subgrade or Sub-base, in accordance with these Specifications and in conformity with lines, grades and cross-sections shown on the Drawings or as directed by the Engineer.

402.2 Materials

Materials shall conform to the following requirements

(a) Soil for lime or Cement-stabilization to Sub section 1708.3.

(b) Lime for Lime-stabilization to SLS 552. Lime shall be properly stored to avoid prolonged exposure to the atmosphere and consequent carbonation that would reduce its binding properties.

(c) Cement for Cement-stabilization to Section 1703

(d) Water for utilization shall be clean and free from injurious substances. Potable water shall be preferred.

402.3 Construction Requirements

(a) General

Stabilized soil Sub-bases and Bases shall be constructed by the mix-in-place method unless otherwise specified or approved by the Engineer.

The plant used for the mix-in-place construction shall be capable of pulverizing the soil to the full thickness of the layer being processed and of achieving uniformity of the stabilized material on completion of the mixing.

If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for work.

The material to be stabilized could either be material brought to site or the in-situ material or a blend of these materials. Stabilizing the in-situ material shall be subject to the approval of the Engineer where permission shall depend upon whether in his opinion suitable material for stabilization is not available within economic haul distance or whether the existing road need not be raised.

The thickness of any layer to be stabilized shall be not less than 100 mm when compacted. The maximum compacted thickness shall be 200mm, provided the plant used is accepted by the Engineer.

(b) Weather Limitations

Soil stabilization shall not be done when the air temperature in the shade is less than 10^0C.

(c) Quantity of Stabilizer in the Mix

The quantity of lime or cement to be added to the soil shall be that specified in the Contract and as directed by the Engineer based on laboratory tests depending on the strength requirements of the stabilized mixes and shall not exceed 5% and 8% respectively, unless otherwise specified.

(d) Strength Requirements of Stabilized Soil

The strength of lime and Cement-stabilized soils shall be measured in terms of the Unconfined Compression Strength (UCS) using 150 mm cubes as per Transport Research Laboratory (TRL) (UK) Overseas Road Note 31 (1993) of the material compacted to 97% maximum dry density as determined by BS 1377, test 13 (heavy compaction) or AASHTO T-180 (modified). The UCS value and the maximum dry density shall be determined by the UCS test and the modified compaction test respectively as specified in Section 1804. The samples shall be tested for the UCS value after 7 days for cement stabilization and 21 days for lime stabilization of moisture curing and 7 days soaking in water as per Transport Research Laboratory TRL (UK) Overseas Road Note 31 (1993) and BS 1924 (1990), at the frequency specified in Table 1602-1.

The UCS value required shall be specified in the Contract or by the Engineer depending on whether the stabilized material is to be used as a Sub-base or Base, as per Overseas Road Note 31 (1993). In the case of stabilized Sub-bases (CSB), the UCS shall be between 0.75 – 1.50 MPa and in the case of stabilized Road Bases (CBI &

CB2), the UCS shall be between 1.5 – 3.0 & 3.0 – 6.0 MPa respectively, as per TRL (UK) Road Note 31 (1993) and BS 1924 (1990).

(e) Preparation of Surface

Prior to the commencement of stabilizing operations, the preparation of the existing surface shall be carried out as per Sub section 401.4(a).

(f) Depth of Scarifying and Spreading

The depth of spreading of soil brought to site and the depth of scarifying of the existing soil shall depend on the machinery available for compaction, pulverization and mixing. Where 8 – 10 tonne smooth wheeled rollers are used for compaction and where agricultural implements such as rotorvators, disc ploughs and rotary tillers are used for pulverizing and mixing, the depth of loose soil spread or scarified shall not exceed 225mm. Careful control of the depth of spreading and/or scarifying shall be exercised at all times. The depth of spreading or scarifying may be increased with the approval of the Engineer provided a heavier roller is used for the compaction

(g) Pulverization of Soil

The loose soil shall be pulverized to the extent as required in Sub section 1708.3, using a disc plough, rotary tiller, rotorvator or any other approved plant. Care shall be taken to ensure that the depth of pulverization is equal to the depth of loose soil. Water may be added to the soil if required for the necessary pulverization.

(h) Blending of Soils (Mechanical Stabilizations)

Blending of the in-situ material and the material brought to site where required shall be carried out either by uniformly spreading and mixing or by a process of windrowing as directed, after such blended soil is suitably pulverized.

Where it is required to mix two different materials brought to site, to obtain the soil type required, the blending of such soils shall be carried out as given in Sub section 401.3. The degree of pulverization of the mixed materials shall conform to the requirements of Sub sections 1708.3.

(i) Mixing of Stabilizer and Soil

The stabilizer shall be spread manually or by a suitable spreader uniformly over the entire surface of the pulverized soil. Mixing of the stabilizer and soil shall then be carried out using a rotary tiller, rotorvator or any other approved equipment until such time that the soil mixed with stabilizer is as nearly homogeneous as practicable. Careful control of the depth of layer shall be maintained in order to obtain a uniform percentage of stabilizers in the mix.

In the case of Cement-stabilization, the soil and cement shall be dry mixed initially prior to bringing the soil cement to the optimum moisture content. However, in the case of Lime-stabilization, the lime may be in the form of dry powder or a slurry.

(j) Compaction of Stabilized Soil Mixture

The stabilized soil mix shall be compacted at or near the optimum moisture content using an 8 – 10 tonne smooth wheeled roller or any other roller approved by the Engineer.

The moisture content of the material shall be checked at the time of compaction at the frequency specified in Table 1602-1 and as directed by the Engineer.

The rolling shall be carried out in accordance with the provisions of Sub section 304.3 d (ii).

In the case of Cement-stabilized mixes, care shall be taken to complete the rolling within 2 hours on addition of water or such smaller period as found necessary in dry weather as directed by the Engineer.

(l) Degree of Compaction of Stabilized Sub-bases and Bases

Stabilized soil Sub-bases shall be compacted to a density not less than 97% of the maximum dry density of the soil mix as determined by the BS 1377, test 13 (heavy) or AASHTO T-180 (modified) test specified in Section 1804.

(m) Quality Control

The control of quality of the materials and the works shall be carried out as given in Section 1602.

In order to prevent carbonation and subsequent failure of stabilized soil course/s, the stabilizer shall be mixed uniformly and compacted uniformly to the full depth of the course/s.

(n) Finishing Operations

The compacted Sub-base or Base shall be finished to levels, grades and cross sections shown on the Drawings and as directed by the Engineer, subject to the requirements of Section 1601.

(o) Curing and Protection

The stabilized Sub-bases or Base shall be cured by covering with sand 30 mm thick which shall be kept moist by either sprinkling water at frequent intervals or by other approved means for a period of seven days or for a period specified by the Engineer. Alternatively, the stabilised Sub-bases or Base shall be cured by the application of a thin coat of bitumen. This coat shall be applied by lightly spraying water on the Stabilized Base or Sub-base followed by either MC 3000 or 10% cut back bitumen or CSS-1 at the rate of 0.5 l/m^2. In the alternative method of curing traffic shall not be allowed on this membrane for seven days. After this time, any excess bitumen shall be blotted by sanding the surface.

Until the construction of the subsequent Pavement layers or Surfacing, the Contractor shall protect the stabilized Sub-bases or Base from damage. Any damage caused shall be made good and where such damage may be attributed to the negligence of the Contractor, the repair shall be at his own expense.

402.4 Measurement and Payment

(a) Measurement

Stabilized soil Sub-bases or Base shall be measured as finished work in Cu. m given in Sub section 106.2(b) or in any other manner approved by the Engineer.

The quantity of lime and cement used shall be measured separately in kg or tonnes.

(b) Payment

Payment for stabilized soil Sub-bases or Base shall be based on the Contract unit rate for the item which shall include full compensation for providing all materials (other than lime or cement), transport, labour, tools, equipment and incidentals necessary to complete the work to the Specifications.

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
402(1)	Stabilized Pavement layer (state type of Pavement layer, type of stabilization)	Cu.m
402(2)	Lime	kg or Tonne
402(3)	Cement	kg or Tonne

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

403 SINGLE SIZED AGGREGATE BASES

403.1 Description

This work shall consist of the construction of Base courses, using nominal single sized crushed stone aggregate, on a prepared Subgrade, or existing Pavement, in accordance with the Specifications and the lines, levels dimensions and cross sections as shown in the Drawings or as directed by the Engineer.

The Base courses are formed by mechanically inter-locking larger sized aggregate and choking the surface interstices with smaller sized aggregate.

403.2 Materials

The aggregate used shall be broken or crushed stone of nominal single sizes 50mm or 37.5mm and 20 mm or 14 mm respectively and broken stone of nominal single size 100mm, all conforming to the general requirements of Sub section 1701.3(a). The size requirements of 100mm aggregate shall be as given in 1701.3(c) and the grading requirements of the other aggregates shall be as given in Table 1701-4 of Sub section 1701.3(b).

403.3 Construction Requirements

(a) Thickness of Base Course

The nominal compacted thickness of the Base course shall be 75mm or 150mm depending on whether only two spreads of 50mm aggregate or whether one spread of 100mm aggregate and two spreads of 50mm aggregate are used in the construction respectively. Where 37.5mm aggregate is used instead of the 50mm aggregate, the

nominal compacted thickness given above shall be reduced to 55mm and 130mm respectively. For higher thickness of Bases, the composition of the aggregate courses shall be as specified, and as directed by the Engineer.

(b) Preparation of Existing Surface

(i) Where the Base course is laid over a prepared Subgrade or Sub-bases, the surface shall be brushed free of dust and extraneous matter and, as required and as directed by the Engineer wetted before laying the Base course.

(ii) Where the Base course is laid over an existing gravel road any unevenness of the surface and places of failure shall be corrected as required and as directed by the Engineer and the surface shall be prepared and wetted as given above, prior to laying operations.

(iii) Where the Base is to be placed on an existing paved road, the bituminous crust shall be completely removed along grooves of width of about 50 mm at 1m intervals. The grooves shall be cut by roller tynes or by any other method approved by the Engineer. The exposed surface shall suitably be compacted with material used for bases prior to laying the Base course.

(iv) Where the Base is laid over an existing asphalt concrete surfaced Pavement the surface shall be punctured to permit drainage through the surface. Puncturing shall be carried out to create drainage holes of not less than 20 mm in diameter through the existing Surfacing layer to the under laying Base at 500 mm centres on a grid across the area being prepared. The holes shall be filled with coarse sand and suitably tamped as approved by the Engineer.

(c) Construction of a Base with 50mm or 37.5mm Aggregate

(i) The 50mm or 37.5mm aggregate shall be spread evenly on the prepared surface at a rate given in Table 403-1, to form a uniform layer two stones thick.

(ii) Prior to spreading the aggregate Base, the full width of the shoulder, shall be constructed to the elevation of the top of each compacted layer of Base being placed. The construction of the partial width of shoulder shall conform to the requirements of section 409. The inside edges of this shoulder fill shall be made to follow the proposed edge of the Pavement and after compaction shall be trimmed to a near vertical face.

The edge of Base and the full width of shoulder may be compacted together provided mixing of soil and aggregate at the interface shall be effectively prevented.

(iii) The aggregate shall be compacted using a 8-10 tonne steel wheeled roller or any other approved roller.

(iv) The rolling shall be carried out in accordance with the provisions of Sub section 304.3d (ii).

(v) While the rolling proceeds fresh aggregate shall be added where necessary, and removed from places where there is excess. The surface shall be watered to help the bedding in of the aggregate except where the Base course is laid over an existing bituminous Pavement. Rolling shall be continued till the aggregate does not shift or wave in front of the roller. However, excessive rolling which would cause rounding of aggregate particles shall be avoided.

(vi) The 20mm or 14mm choker stone shall then be spread evenly at the rate specified in Table 403-1 and rolled to ensure that the stones are well embedded in the surface interstices of the Base course. While the rolling is being done, the surface shall be wetted and lightly brushed so as to ensure that the finer aggregate including fines are worked into the crevices.

(d) Construction of Base with 100mm and 50mm/37.5mm Aggregate

The full width of shoulder shall be constructed as given in Sub section 403.3(c)(ii).

Unless otherwise directed, 100mm aggregate shall be spread and where necessary hand packed uniformly to one stone thickness on the prepared surface at the rate indicated in Table 403-1, and shall be rolled using a 10 tonne roller, to achieve sufficient embedment without excessive rounding of aggregate edges. Where directed in the Contract, the surface voids of the 100mm aggregate layer shall be in filled with crusher dust prior to spreading the next layer. 50mm or 37.5mm aggregate of two stone thickness shall then be spread uniformly at the rate indicated in Table 403-1, and compacted using an approved 8-10 tonne steel wheeled roller in accordance with the method of rolling as given in Sub section 403(c)(iii) to (v).

The choker stone shall be spread and compacted in accordance with the method of rolling described in Sub section 403(c)(vi).

Table 403-1 - Rates of Spread of Aggregate

Nominal compacted thickness of Base layer	Aggregates Size	Rate of Spread of loose material Cu.m per 100 Sq.m.
75mm	50mm aggregate	8.5 – 10.0
	20mm choker stone	1.0 – 1.3
55mm	37.5mm aggregate	6.6 – 7.5
	14mm choker stone	0.8 – 1.0
150mm	100mm aggregate	8.5 -10.0
	50mm aggregate	8.5 - 10.0
	20mm choker stone	1.0 – 1.3
130mm	100mm aggregate	8.5 – 10.0
	37.5mm aggregate	6.6 – 7.5
	14mm choker stone	0.8 – 1.0

(e) Finishing Operations and Quality Control

The single sized aggregate Base shall be finished to the requirements of section 1601.

The control on the quality of materials and works shall be exercised in accordance with Section 1602.

(f) Aftercare

The Contractor shall protect and maintain the completed Base layer at his own expense until the Surfacing is applied. Maintenance shall include the immediate repair of any damage or defects which may occur and shall be repeated as often as is necessary to keep the layer continuously intact and in a good condition. Repairs shall be done in such a manner that will ensure restoration of the Base to an even and uniform course. Traffic shall not be allowed directly on any Base layer on which a first coat is not applied unless instructed or authorized by the Engineer.

On the completed Base, a first coat shall be applied as per Section 503 as soon as possible after approval from the Engineer.

403.4 Measurement & Payment

(a) Measurement

Method of measurement shall be any one of the following as specified.

(i) Aggregate Base course, shall be measured as finished by Sq.m of plan area of surface in place. Separate measurement shall be made in respect of each different nominal thickness of Base.

(ii) The materials of the finished and accepted Base course shall be measured as supplied and stock piled in Cu.m and the construction of the aggregate Base course shall be measured in Cu.m of aggregate used separately in each layer of construction. In this regard 100mm aggregate shall constitute one layer and the 50mm and 20mm or the 37.5mm and 14mm aggregate shall constitute another layer.

(b) Payment

The payment shall be based on the Contract unit rate of aggregate Base course measured as finished work in position and shall include full compensation for providing all materials, transport, labour, tools, equipment and incidentals necessary to complete the work to the Specifications, and shall include preparation of the existing road surface as directed by the Engineer.

The unit rate for material/s supplied and stock piled shall include full compensation for the supply, transport and piling of the material/s at site.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
403(1)	Single sized aggregate Base compacted in position (state nominal thickness)	Sq. m

or the following

403(2)	Single sized aggregate Base material as stock piled (state nominal sizes)	Cu. m
403(3)	Construction of single sized aggregate Base (state nominal sizes of aggregate)	Cu. m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

404 WATER BOUND AND DRY BOUND MACADAM BASES

404.1 Description

This work shall consist of spreading and rolling crushed rock aggregate on a prepared Subgrade, Sub-bases, Base or on an existing road to form a mechanically interlocked layer and then filling the voids to refusal with crusher fines or gravel in accordance with the Specifications and the lines, levels, dimensions and cross sections as shown in the Drawings or as directed by the Engineer.

The infilling of the voids with fines shall be assisted by watering in water bound macadam and by vibrating with a vibratory roller in dry bound macadam.

Where more than one course has to be built, the process shall be repeated.

404.2 Materials

Materials used shall conform to the requirements of the following:-

(a) The aggregate used shall be broken or crushed stone of nominal single size 50mm or 63mm and crusher fines all in accordance with Sub section 1701.3(a) for general requirements and to Table 1701-6 of Sub section 1701.3(b) for grading.

(b) Natural gravels to Sub section 1708.6.

404.3 Construction Requirements

(a) Preparation of Existing Surface

The preparation of existing surface shall be carried out as per Sub section 403.3(b) and as applicable, prior to the laying of the water bound or dry bound macadam Base.

(b) Preliminary Layer of Fines

Unless otherwise specified or directed, where the water bound/dry bound macadam is to be laid directly on the Subgrade or on a soil Sub-base, a 20-30mm course of crusher fines shall be spread as a preliminary layer on the prepared Subgrade or Sub-bases prior to spreading of coarse aggregate. Where the material infilling voids in the coarse aggregate are natural gravel, the preliminary layer also shall be of the same natural gravel.

(c) Spreading and Rolling of Coarse Aggregate

Prior to spreading the aggregate Base, the full width of the shoulder shall be constructed to the elevation of the top of each compacted layer of Base being placed. The construction of the full width of shoulder shall conform to the requirements of Section 409. The inside edges of this shoulder fill shall be made to follow the proposed edge of the Pavement and after compaction shall be trimmed to a near vertical face.

The edge of Base and the full width of shoulder may be compacted together provided mixing of soil and aggregate at the interface shall be effectively prevented.

The coarse aggregate shall be spread, uniformly over the prepared surface, so as to ensure that the thickness of the course after compaction is between one and a half to two times the nominal maximum sizes of aggregate. Rolling of the aggregate shall then be done using 8-10 tonne steel wheeled rollers or approved vibratory rollers. The method of compaction shall be in accordance with Sub section 403.3(c)(iii) to (v).

(d) Application of Crusher Fines or Gravel

The crusher fines or gravel in a dry state shall be worked into the compacted aggregate layer by a gradual process of spreading, brushing and rolling. The crusher fines or gravel shall not be dumped in piles but be spread uniformly in successive layers. When tippers are used for spreading, care shall be exercised to see that the aggregate layer is not disturbed in the process.

(e) Vibratory Rolling in Dry Bound Macadam Base

For dry bound macadam Base, the crusher fines in a dry state, spread as given in Sub section 404.3(d) shall be vibrated further into the interstices using an 8-10 tonne vibratory roller. Should patches deficient in fines develop during compaction, additional fines shall be applied and the process continued until no more can be worked in. The final compaction shall be carried out by using the same roller without vibration or an 8-10 tonne steel wheeled roller.

(f) Wet Rolling in Water Bound Macadam Base and Curing

For water bound macadam Base, the surface or the layer shall be watered and additional crusher fines or gravel applied and the rolling continued until all the voids are completely filled and a wave of grout flushes in front of the roller.

The Base course so formed shall be cured and allowed to dry out completely, before another course or a bituminous coat is applied.

(g) Construction of Additional Courses

Where additional courses are required to be constructed, the surface shall be brushed free of dust using mechanical brooms or hand brooms or both until the aggregate surface stands proud of the compacted fines. The construction procedure in Sub section 404.3(c) – 404.3(f) as relevant shall then be repeated to form the additional course/s, as required.

(h) Finishing Operations and Quality Control

The water bound/dry bound macadam Base shall be finished to the requirements of Section 1601.

The control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 1602.

(i) Aftercare

The Contractor shall protect and maintain the completed Base layer at his own expense until it has been covered by the next Pavement layer. Maintenance shall include the immediate repair of any damage or defects which may occur and shall be repeated as often as is necessary to keep the layer continuously intact and in a good condition. Repairs shall be done in such a manner that will ensure restoration of the Base to an even and uniform course. Traffic shall not be allowed directly on any un-primed surface or until surface dressing has been constructed on the Base layer, unless instructed or authorized by the Engineer.

The completed Base shall be primed or surface dressed as soon as possible after approval from the Engineer.

404.4 Measurement and Payment

(a) Measurement

Water bound/dry bound macadam Base shall be measured in Sq.m or in Cu.m of accepted work in position, as specified. Method of measurement shall be as given in Sub section 106.2 and as directed. The preliminary layer of crusher fines or gravel shall be measured separately in Sq.m of area completed and accepted.

(b) Payment

Payment shall be based on the Contract unit rate for the item which shall include full compensation for providing all materials, labour, tools, equipment and incidentals necessary to complete the work to the Specifications, and shall include light scarification of the existing road where such is directed by the Engineer.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
404(1)	Preliminary layer of fines (state whether crusher fines or gravel)	Sq. m
and Either		
404(2)	Water bound/dry bound macadam Base (state size of aggregate and type of infill)	Cu.m
or		
404(3)	Water bound/dry bound macadam Base (state size of aggregate, layer thickness and type of infill)	Sq. m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

405 DENSE GRADED AGGREGATE BASES

405.1 Description

This work shall consist of providing a Dense Graded Aggregate Base, on a prepared Sub-base or existing paved surface, in accordance with the Specifications and the lines, levels, dimensions and cross sections shown in the Drawings or as directed by the Engineer.

405.2 Materials

The aggregate shall be graded crushed rock of nominal size of 37.5 mm or 28 mm or 20 mm conforming to the general requirements of Sub section 1701.3 (a). and grading requirements of Table 1701-5 of Sub section 1701.3 (b), herein.

The aggregate shall be derived from a parent rock that is hard, sound, durable and un-weathered. It shall consist of hard durable particles of fragmented rock from a quarry approved by the Engineer, and shall be free of dust, organic matter, clay and silt or any other deleterious matter.

405.3 Construction Requirements

(a) Preparation of Existing Surface

Where the Base course is laid over the prepared Sub-bases, the surface shall be brushed free of dust and extraneous matter and, when instructed by the Engineer, watered before laying the Base course.

Where the Base course is laid over an existing bituminous Pavement, the preparation of the existing surface shall be carried out as per Sub section 403.3b(iii) and cleaned of any scarified material before laying the Base course. During this operation, the Contractor shall not damage the underlying Pavement layer. Any damage to the existing underlying layer which results due to careless scarification shall be rectified

forthwith by the Contractor to the approval of the Engineer at the Contractor's own cost.

(b) Spreading and Rolling

The aggregate shall be spread uniformly and without segregation over the prepared surface of an underlying layer which complies with the specified requirements for the layer concerned, or on an existing Pavement, and in quantities sufficient to ensure that after compaction the completed layer will comply with all requirements of layer thickness, levels, cross section and density.

Aggregate shall be spread such that the minimum thickness of each layer after compaction shall be not less than 75 mm. The maximum thickness will depend on the type of compaction equipment used and on the specified layer thickness but shall not normally exceed 200 mm compacted thicknesses unless otherwise agreed or instructed by the Engineer.

In order to minimise segregation, the material shall be kept wet during transport and spreading. The dumps of material shall be spread out to a flat-surfaced layer with a thickness suitable for mixing. Thereafter the required amount of water shall be added and the material thoroughly mixed with a motor grader or other suitable approved means until a uniform homogeneous mixture is achieved. The required amount of water and moisture content shall be determined by carrying out field trials but shall normally be within 2% of the predetermined optimum moisture content at the time of compaction. The material deposited on the prepared existing surface may be spread and shaped by any method which causes no segregation of coarse and fine particles. The Contractor shall ensure that joints in consecutive Pavement layers do not coincide. All areas of segregated coarse and fine material shall be corrected by re-mixing or removing and replacing with well graded material to the approval of the Engineer. The Base material shall be compacted using approved vibratory compaction equipment whose vibrators shall function correctly in accordance with the manufacturer's instructions.

After mixing the material shall be graded to achieve the specified thickness with due allowance made for decrease in thickness due to compaction such that after compaction the surface of the aggregate Base is within the specified level tolerance. The material shall then be thoroughly compacted by means of approved equipment so that the specified density is obtained throughout the whole layer.

The rolling shall be carried out in accordance with the provisions of Sub section 304.4d (ii).

The finally compacted layer shall be firm and stable with a closely knit mosaic like surface texture of exposed aggregate free from surface laminations, portions exhibiting segregation of the fine and coarse aggregates, corrugations or other defects that may be detrimental to the performance of the layer. The surface shall be brushed to ensure a surface free from excess fines and loose aggregate.

Where, in the opinion of the Engineer, the completed surface of the Base is unacceptable, the surface shall be rectified in a manner approved by the Engineer.

The aggregate Base shall be compacted to not less than 98% of the maximum dry density of the material as determined by BS1377, Test 13 (Heavy) or AASHTO T180 (Modified).

(c) Finishing Operations and Quality control

The dense graded aggregate Base shall be finished to the requirements of Section 1601, herein.

The control of quality of materials and works shall be exercised in accordance with Section 1602.

On completion of the Base the Contractor shall remove all windrows left behind by motor graders to facilitate proper drainage of the finished surface.

(d) Aftercare

The Contractor shall protect and maintain the completed Base layer at his own expense until it has been covered by the next Pavement layer. Maintenance shall include the immediate repair of any damage or defects which may occur and shall be repeated as often as is necessary to keep the layer continuously intact and in a good condition. Repairs shall be done in such a manner that will ensure restoration of the Base to an even and uniform course. Traffic shall not be allowed directly on any un-primed Base layer unless instructed or authorized by the Engineer.

The completed Base shall be primed as soon as possible after approval from the Engineer.

405.4 Measurement and Payment

(a) Measurement

The dense graded Base shall be measured by the Cu.m of material compacted in place. Measurement shall be based on the cross section of the Base shown in the Drawings and the actual length measured horizontally along the centre line of the surface of the road, or in case of edge widening, along the centre line of the widened section.

(b) Payment

The payment shall be based on the Contract unit rate for the completed work of the dense graded Base which shall include full compensation for providing all materials, labour, tools equipment and incidentals necessary to carry out the construction works to the Specifications, and shall include light scarification of the existing road surface where such is directed by the Engineer.

The Pay items and Pay units shall be as follows:-

Pay Item	Description	Unit of Measurement
405(1)	Dense Graded Aggregate Base (state aggregate size)	Cu. m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

406 PENETRATION MACADAM BASES

406.1 Description

This work shall consist of one or more courses of compacted coarse aggregate with alternate applications of bituminous binder and key aggregate, to form penetration macadam Bases, on a prepared Sub-base or a paved surface, in accordance with the Specifications and the lines, levels, dimensions and cross sections shown in the Drawings or as directed by the Engineer.

406.2 Materials

(a) The coarse aggregate shall be of nominal maximum size 50mm or 37.5mm and the key aggregates shall be of nominal maximum size 20mm or 14mm conforming to the general requirements of Sub section 1701.3(a) and the grading requirements of table 1701-7 in Sub section 1701.3(b).

The aggregate shall be derived from a parent rock that is hard, sound, durable and un-weathered. It shall consist of hard durable particles of fragmented rock from a quarry approved by the Engineer, and shall be free of dust, organic matter, clay and silt or any other deleterious matter.

(b) Bituminous binder shall be 80-100 penetration grade bitumen or 10-20 percent cutback bitumen or MC 800 or MC 3000 cutback bitumen or bitumen emulsion CRS-2 conforming to Section 1702.

406.3 Construction Requirements

(a) Thickness of Base Course

The nominal compacted thickness of each course of penetration macadam Base shall be 75mm or 55mm depending on whether the coarse aggregate used is of maximum nominal size 50mm or 37.5mm respectively. If higher thicknesses are required such Bases shall be built up by construction of two or more courses.

(b) Weather and Other Limitations

Penetration macadam Base shall not be constructed during rainy weather or when the ambient temperature is 15 degree centigrade or lower. It shall also not be constructed when the underlying surface is damp unless the binder used is bitumen emulsion.

(c) Preparation of Existing Surface

The surface on which the penetration macadam is to be constructed shall be prepared to the lines, grades and cross sections given in Drawings and as directed by the Engineer.

In the case of existing Pavements all potholes, ruts and depressions shall be repaired in advance as per Section 1102.

The preparation of existing surface shall be carried out as per Sub section 403.3(b) and as applicable, prior to the laying of the Base.

The surface shall be brushed free of dust and extraneous matter. Any prime coat or tack coat specified or directed to be applied shall be carried out in accordance with Sections 501 and 502 respectively.

(d) Spreading and Compacting Coarse Aggregate

The coarse aggregate in a dry state shall be spread uniformly at the rate specified in Table 406-1. The spreading shall be carried out no further in advance of the rolling, penetrating and laying operations that can be completed on the same day. The coarse aggregate shall then be rolled, using an 8-10 tonne smooth wheeled roller or any other roller approved by the Engineer, until the aggregate is well interlocked and compacted.

The rolling shall be carried out in accordance with the provisions of Sub section 304.3d (ii).

On completion of the above rolling, the surface regularity shall conform to the tolerances given in Sub section 1601. Irregularities exceeding the above tolerances shall be corrected by removing or adding aggregate as required. The compacted surface shall have a texture that will allow free and uniform penetration of the bituminous binder.

(e) Application of Bituminous Material

The bituminous binder shall be applied on the compacted aggregate at the rate of application given in Table 406-1, unless otherwise specified. The temperature of application of the binder shall be as given in Table 406-2. The application of the bituminous binder shall be carried out using pressure distributors. Manual applications shall be resorted to only with the approval of the Engineer.

Table 406-1 - Rate of spread of binder and aggregate

Compacted nominal thickness of course	Rate of spread of aggregate Cu. m per 100 Sq. m		Rate of spread of binder litres per Sq. m		
mm	Coarse aggregate	Key aggregate	Penetration Grade bitumen	Cutback bitumen	Bitumen Emulsion
75	9.0	1.8	6.8	7.5	10
50	6.0	1.5	5.0	5.5	7.5

Table 406-2 - Temperature of application of binder

Binder	Temperature of application - ^{0}C
Penetration grade bitumen	160-175
MC 3000 or 10% cutback bitumen	120-130
MC 800 or 20% cutback bitumen	105-115
Bitumen Emulsion CRS-1 or CRS-2	Ambient Temp.

Note

Where the ambient temperature is low, the bitumen emulsion shall be sufficiently heated to facilitate spraying. With CRS-2 heating will be necessary in most instances.

(f) Application of the Key Aggregate

Immediately after the application of the bituminous binder, key aggregate in a dry state shall be spread uniformly over the surface by means of an approved mechanical spreader or by approved manual methods at the rate specified in Table 406-1. Where necessary, the surface shall be broomed to ensure uniform application of the key aggregate. Rolling shall then be resumed and continued until the surface is hard and smooth and shows no visual movement under the roller.

(g) Surface Finish and Quality Control

The penetration macadam Base shall be finished to levels, grade and cross sections shown in the Drawings and as directed by the Engineer, subject to the requirements given in Section 1601. The control of the quality of materials and works shall be carried out as given in Section 1602.

(h) Aftercare

The Contractor shall protect and maintain the completed Base layer at his own expense until it has been covered by the next Pavement layer. Maintenance shall include the immediate repair of any damage or defects which may occur and shall be repeated as often as is necessary to keep the layer continuously intact and in a good condition. Repairs shall be done in such a manner that will ensure restoration of the Base to an even and uniform course. Traffic shall not be allowed directly on any un-primed surface until surface dressing has been constructed on the Base layer, unless instructed or authorized by the Engineer.

The completed Base shall be primed as soon as possible, after approval from the Engineer.

406.4 Measurement and Payment

(a) Measurement

Method of measurement shall be any one of the following as specified :-

(i) Penetration macadam Base shall be measured in Sq. m of accepted work. Bases of different thicknesses shall be measured separately.

(ii) Coarse aggregate and key aggregate shall be measured as supplied and stock piled in Cu.m and the bitumen shall be measured as supplied in litres, both measurements being limited to the quantities used in the accepted work. The construction of the penetration macadam Base shall be measured in Sq. m of completed and accepted work. The construction of different thicknesses of the penetration macadam Base shall be measured separately.

(b) Payment

Payment shall be based on the Contract unit price/s for the item/s, which shall include full compensation for the components given below for the item/s.

The price for penetration macadam Base measured as finished work shall include full compensation for providing all materials, transport, labour, tools, equipment and incidentals necessary to complete the work to the Specifications.

The price for coarse aggregate and key aggregate supplied and stockpiled shall include full compensation for the supply, transport and stockpiling of the materials at site. The price for bitumen shall be full compensation for the supply and transport to site.

The price for the construction of penetration macadam Base shall include full compensation for providing all labour, tools, equipment and incidentals necessary to carry out the construction work to the Specifications.

The Pay Items and Pay Units will be as follows: -

Pay tem	Description	Pay Unit
Either		
406(1)	Penetration macadam Base (state thickness of layer)	Sq. m
or the following		
406(2)	Coarse aggregate as stockpiled (state size)	Cu.m
406(3)	Key aggregate as stockpiled (state size)	Cu.m
406(4)	Bituminous binder (state type and grade)	Litres
406(5)	Constructions of penetration macadam Base (state thickness)	Sq. m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

407 BITUMEN BOUND BASES

407.1 Description

This work shall consist of the construction of courses of dense graded or open graded bitumen bound Bases on prepared Sub-bases, Bases or existing roads in accordance with these Specifications and with lines, levels, grades, dimensions and cross sections shown on the Drawings or as directed by the Engineer.

407.2 Materials

Unless otherwise specified by the Engineer, all materials shall conform to the requirements of the following:-

(a) The binder shall be 60-70 penetration grade bitumen to Sub section 1702.1

(b) Coarse aggregate of nominal maximum size 37.5mm & 20mm and the fine aggregate shall conform to general requirements of Sub section 407.3

The aggregate shall be graded crushed rock of nominal size 37.5 mm, conforming to the general requirements of Sub section 1701.3(a). Their combined grading shall conform to the requirements of Sub section 407.3.

The aggregate shall be derived from a parent rock that is hard, sound, durable and un-weathered. It shall consist of hard durable particles of fragmented rock from a quarry approved by the Engineer, and shall be free of dust, organic matter, clay and silt or any other deleterious matter.

407.3 Mix Requirements

(a) Combined Grading of Aggregate and Binder Content

The grading requirements for combined aggregate and the binder contents shall be as given in Table 407-1 for the open graded and dense graded Base courses.

Table 407-1 - Aggregate grading, binder content and thickness requirements

Mix Classification No.	1	2	3	4
Nominal maximum size of aggregate in mm	37.5	37.5	19	19
Course	Dense graded	Open graded	Dense graded	Open graded
Thickness mm – Max. - Min.	100 60	100 60	50 30	40 30
Sieve Size	Total % of weight passing			
mm μm				
50	100	100		
37.5	95 -100	95 - 100		
28	80 - 95	53 - 75	100	100
20	-	-	80 - 98	96 -100
14	62 - 77	10 - 27	-	50 - 75
10	-	-	49 - 67	22 - 42
5	-	-	29 - 44	-
2.36	30 - 45	0 - 10	18 - 30	5 – 20
1.18	-	-	13 - 24	-
300	-	-	5 - 14	-
75	3 - 8	0 - 2	1 - 5	0 – 2
Percent binder content By total weight of mix	3.0 - 4.0	2.5 - 3.5	3.5 - 4.5	3.0 - 4.0

Note

The sieve sizes used herein are as per BS designation. However equivalent ASTM sizes as given in Table 107-1 in section 107 may be used with the prior approval of the Engineer.

(b) Mix Characteristics

The optimum bitumen contents for dense graded mixes for mix classifications 1 & 3 of Table 407-1 shall be determined in accordance with the Marshall Test (ASTM D 1559) so as to obtain a bituminous mixture meeting the following requirements.

- Stability 5.5 kN (minimum)
- Flow 2 – 5 mm
- Air voids in Total mix 3 – 7 %

407.4 Job Mix Formula

The Contractor shall conform to the requirements of Sub section 506.4 in proposing the job mix formula.

407.5 Construction Requirements

(a) Construction requirements shall conform to section 506.5(a) to (m) subject to the following modifications:-

(i) The compaction procedure as given in 506.5(h) shall apply, except that the section "Transfer of refusal mix design to compaction trials" does not apply and for the requirement of the density check, which shall be amended as stated below:-

The density of all samples taken from the compacted Base course shall not be less than 92% of the theoretical maximum density as per AASHTO T209-99, at the point appropriate to the locations by cutting cores of minimum diameter 150 mm.

(ii) The maximum and minimum thickness of any compacted layer shall be as given in Table 407-1.

(b) Finishing Operations and Quality Control

The bitumen bound Base shall be finished to the requirements given in Section 1601.

The control on the quality of materials and works shall be exercised in accordance with Section 1602.

407.6 Measurement and Payment

(a) Measurement

Bitumen sand level shall be measured by the following methods:-

(i) The provision of Sub section 506.6(a)(i) for Asphalt Concrete shall apply for Bitumen Bound Bases of uniform thickness.

(ii) For regulating courses, the bitumen bound shall be measured in tonnes, weighed using a weight bridge. The bitumen bound base measured shall be the number of tones in the accepted pavement. The method of measurement shall be as follows:-

The bitumen bound base material shall be weighted after mixing using on approval weight bridge. The quality of bitumen bound base mixed and laid shall be completed daily from load delivery tickets. This weight shall be adjusted by deducting the weight of mix wasted at joints, the weight of mix laid in areas outride the defined pavement edge and the weight of mix laid within the defined pavement but not accepted by the Engineer. The total weight deducted shall be as assessed by the Engineer.

(b) Payment

Payment for bitumen bound Base will be made at the Contract unit price for the item as measured above. The price shall be full compensation for furnishing all materials, for mixing and placing of the mixed material and for providing all plant, machinery, equipment, tools, labour and incidentals necessary to complete the work to these Specifications.

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
407(1)	Bitumen bound Base of uniform thickness compacted in position [state whether dense or open mixture, size of aggregate and compacted thickness measured by cutting cores]	Sq.m
407(2)	Bitumen bound Base of regulatory course compacted in position [state whether dense or open mixture and size of aggregate]	Tonnes

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

408 RECONSTRUCTION OF EXISTING BASES

408.1 Description

This work consists of the reconstruction of the existing bitumen surfaced Pavement which requires strengthening or reshaping generally in confined areas, in patches or at locations instructed by the Engineer.

Work shall be carried out by scarifying the existing Pavement to the depth instructed by the Engineer, addition of approved imported aggregate and thoroughly mixing with existing Pavement material by grader or by hand or other approved methods in small areas to ensure an un-segregated, homogeneous material. This work shall be carried out in accordance with these Specifications and lines, levels, grades, dimensions and cross sections shown on the Drawings or as directed by the Engineer.

408.2 Material

Material for the reconstruction of existing Pavements shall be aggregates which shall conform to general requirements of Sub section 1701.3(a) and conform to the single sized aggregates or the graded aggregates or other unbound Bases in Chapter 400 as shown in Tables 1701-4 and 1701-5 respectively of Sub section 1701.3(b) herein and as directed by the Engineer.

The aggregate shall consist of hard durable particles of fragmented rock from a quarry approved by the Engineer, and shall be free of dust, organic matter, clay and silt or any other deleterious matter.

408.3 Construction Requirements

(a) Rebuilding of Existing Pavement

The existing Pavement shall be sufficiently scarified to enable the existing bituminous layer to be removed. In removing the bituminous layer the Contractor shall ensure that as much of the adhering existing aggregate as possible is dislodged and left remaining to be mixed with the aggregate to be added.

Where instructed by the Engineer, any existing material considered of poor quality shall be removed and disposed of. Extra aggregate shall then be added to the existing Pavement material and thoroughly mixed either in place or alongside the area to be strengthened.

(i) Single sized aggregate Base material

Extra aggregate either of the 50 mm or 37.5 mm single size shall then be added as specified or directed, on the existing aggregate in the required quantities. It shall be ensured that the added aggregate, in the minimum produce a layer that is at least two stones thick and on compaction gets well interlocked. Layers more than 3 stones thick shall not be constructed. The work shall be completed to the requires cross section, along with the rolling in of 20 mm or 14 mm choker stones, respectively to cover the surface interstices, as given in Section 403.

(ii) Dense graded aggregate Base material

Compaction and surface finish shall be carried out as specified in Section 405.3 herein. Where graded aggregate of 37.5 mm maximum size is used, the added aggregate shall be in such quantities that after compaction there shall be a minimum aggregate thickness at any place of 75 mm and the maximum compacted thickness shall not exceed 150 mm unless otherwise specified or agreed by the Engineer. Once mixed the material shall be compacted to not less than 98% of the maximum dry density of the material as determined by BS-1377 Test 13 (Modified Proctor) or AASHTO T-180.

The degree of compaction shall be checked by field density measurements (BS-1377 Test 15 or AASHTO T-191) at the rate of one test for every 100 Sq. m.

(b) Finishing Operations and Quality Control

The rebuilt Pavement shall be finished to the requirements of Section 1601 herein.

The quality of the materials and works shall be controlled in accordance with Section 1602 herein for the relevant material.

(c) Aftercare

The Contractor shall protect and maintain the completed Pavement layer at his own expense until the Surfacing is applied. Maintenance shall include the immediate repair of any damage or defects which may occur and shall be repeated as often as is necessary to keep the layer continuously intact and in good condition. Repairs shall be done in such a manner that will ensure restoration to an even and uniform surface.

408.4 Measurement and Payment

(a) Measurement

The rebuilt aggregate layer shall be measured by the Cu.m of material (the mixture of existing Pavement material plus additional aggregate) compacted in place. Measurement shall be based on the dimensions as instructed by Engineer.

Scarifying and removal of the bituminous surface layer shall be measured by the Sq.m of surface area.

(b) Payment

The payment shall be based on the Contract unit rate for the completed work of the rebuilt layer, which shall include full compensation for providing all the required material (whether mentioned in the Payment Item or not) and all labour, tools, equipment and incidentals necessary to carry out the construction works in accordance with the Specifications.

Pay Item	Description	Pay Unit
408(1)	Base correction	Cu. m
408(2)	Scarification of existing Base	Sq. m

409 SHOULDER CONSTRUCTION

Shoulders shall be constructed in accordance with these Specifications and as shown on the Drawings and as directed by the Engineer. Widening of the carriageway and shoulders shall be to the depths and widths as specified and as shown on the Drawings. Where components of the shoulder consist of extension of adjacent Pavement layers, such components shall be measured and paid for in accordance with pay items for the corresponding Pavement layer.

Bituminous surface treatment to shoulders shall be measured and paid for under the appropriate Sub section of Section 505 herein

409A EARTHEN SHOULDER

409A.1 Description

This work shall consist of the construction of earthen road shoulders on either side of the Pavement. This type of shoulder shall be constructed of uniform material throughout its depth which may extend over the depth of one or more Pavement layers, shall be of separate construction from the adjacent Pavement layer(s), and shall be constructed as edge support for the adjacent Pavement layer(s).

409A.2 Material

Shoulder construction materials shall conform to the requirements of the following.

(i) Soil to Sub section 1708.5

(ii) Porous material to Sub section 1708.8

409A.3 Construction Requirements

(a) General

Unless otherwise directed by the Engineer or as shown in the Drawings, the Road Shoulder shall be constructed prior to or together with the construction of the Base, except when the Base is of bitumen bound material.

Porous shoulder material where specified, shall be filled in trenches at locations given the Drawings and as directed by the Engineer.

(b) Placing and Compaction of Shoulder Material

The shoulder material shall normally be spread in layers not exceeding 225 mm thickness for compaction using an 8 – 10 ton smooth wheeled roller or any other roller of comparable compaction effort. Where necessary the material may be spread in thicker layers with the approval of the Engineer provided a heavier roller is used for the compaction.

The shoulder material shall be compacted when the moisture content is within plus or minus 2% of the optimum moisture content.

The moisture content of the material shall be checked at the time of compaction at the frequency specified in Table 1602 – 1 and as directed by the Engineer. If the material is too wet it shall be dried by aeration and if it is too dry, the material shall be sufficiently wetted prior to compaction.

During all stages of shoulder construction, the Contractor shall ensure efficient drainage of surface water from the entire road surface, to the approval of the Engineer.

Where the shoulder is built up of more than one layer, the layers to follow shall be placed only after the degree of compaction of the previous layer has been tested and found satisfactory as given in Sub section 409(A).3 (c).

Where shoulder filter drains are to be constructed, unless otherwise instructed by the Engineer, each shall comprise a 200 mm x 200 mm deep excavation into the completed and compacted earthen shoulder, the excavation being backfilled with a 100 mm deep layer of porous material wrapped in geo-textile on all four sides and both ends, covered by 100 mm of compacted earthen shoulder material. These shoulder filter drain channels shall be constructed at 4 m intervals. The porous material shall conform to the requirements of Section 1708.8 herein unless otherwise directed by the Engineer. The geo-textile filter material shall conform to Section 1710 herein.

(c) Degree of Compaction of Shoulders

The Shoulder shall be compacted to a density not less than 95% of the maximum dry density as determined by the modified compaction test specified in Section 1804.

(d) Quality Control

The control on the quality of the materials and the works shall be in accordance with Section 1602.

(e) Finishing Operations

The completed road shoulder shall conform to the levels, slopes and cross sections shown in the Drawings and shall be such as to ensure that water from the road, drains over the shoulder freely.

Where specified or directed by the Engineer, the top surface of the shoulder shall either be grassed or given a bituminous Surfacing to prevent erosion.

409A.4 Measurement and Payment

(a) Measurement

Earthen shoulder construction shall be measured in Cu.m as the completed and approved work based on the lines, levels and dimensions in the Drawings and accepted by the Engineer.

The construction of shoulder filter drains shall be measured as trench excavation in Cu.m, the supply and placing of geo-textile in Sq.m, including an adequate overlap, the supply, placing and compaction of porous material in Cu.m based on the lines, levels and dimensions in the Drawings and as directed and accepted by the Engineer.

(b) Payment

The payment shall be based on the Contract unit rate for the completed work which shall include full compensation for providing all materials, labour, tools, equipment and incidentals necessary to carry out the construction works to the Specification. There shall be no separate measurement for overlaying the shoulder filter drains with shoulder material, or for tidying up after the construction of such drains.

The Pay Items and Pay Units will be as follows;

Pay Item	Description	Pay Unit
409 (1)	Earthen shoulder as compacted in position	Cu.m
409 (2)	Trench Excavation in shoulder for filter drains	Cu.m
409 (3)	Geo-textile for filter drain	Sq. m
409 (4)	Porous material for filter drain	Cu.m

410 BLENDED AGGREGATE BASES AND SURFACING

410.1 Description

This work shall consist of the construction of Base courses, by blending 37.5mm, 20mm and 14mm nominal single sized crushed stone aggregate to 7:2:1 volume proportions or graded aggregate to the same grading band by blending the above aggregate to the same blend, on a prepared Sub-base or Base or an existing surface course, in accordance with these Specifications and lines, levels, grades, dimensions and cross sections shown on the Drawings or as directed by the Engineer.

410.2 Materials

The aggregate shall be single sized crushed rock of nominal single sizes 37.5mm, 20mm and 14mm conforming to the general requirements of Sub section 1701.3(a).

The Surfacing application materials used shall meet the following requirements:

(a) The binder for surface application shall be bituminous emulsion CRS – 1 or CRS-2 conforming to Sub section 1702.3.

(b) Blotting material shall be coarse sand conforming to Sub section 1701.4.

410.3 Construction Requirements

(a) Thickness of Base Course

The nominal compacted thickness of the blended aggregate Base shall be 75mm or 150mm depending on Pavement design requirements. However when constructing a 150mm thick blended aggregate Base, it shall be constructed in two layers of 75mm nominal compacted thickness.

(b) Preparation of Existing Surface

Where the Base course is laid over a prepared Sub-base, the surface shall be brushed free of dust and extraneous matter and wetted as directed by the Engineer.

Where the Base course is laid over an existing gravel road any unevenness of the surface and places of failure shall be corrected as required or and the surface shall be prepared and wetted as directed by the Engineer.

Where the Base course is laid over an existing bituminous Pavement, the preparation of surface shall be carried out as per Sub section 403.3b(iii) and cleaned of any scarified material or a tack coat as specified in section 502 shall be applied, if so directed by the Engineer.

(c) Construction of a Blended aggregate Base.

(i) Uniform blended aggregate Base material shall be obtained by mixing thoroughly 37.5mm, 20mm and 14mm single sized aggregate in the volume ratio of 7:2:1. The aggregate shall be spread evenly without segregation on the prepared surface to form a uniform layer of 75mm nominal compacted thickness.

(ii) Prior to spreading the blended aggregate Base, a full width of the shoulder, shall be constructed to the elevation of the top of each compacted layer of Base being placed. The construction of the full width of shoulder shall conform to the requirements of Section 409. The inside edges of this shoulder fill shall be made to follow the proposed edge of the Pavement and after compaction shall be trimmed to a near vertical face, immediately prior to the laying of the blended aggregate Base material.

If the construction of blended aggregate Base is initially carried out on a single lane steel shutters shall be fixed firmly on the inner edge or a temporary compacted earth fill on the inner edge shall be constructed and trimmed to a near vertical face.

The edge of blended aggregate Base and the full width of shoulder may be compacted together provided that mixing of soil and aggregate at the interface shall be effectively prevented.

(iii) The aggregate shall be compacted using an 8-10 tonne steel wheeled roller or any other approved roller.

(iv) The rolling shall be done in accordance with the provisions of Sub section 304.3d (ii).

(v) When constructing 150mm blended aggregate Base, a second layer of 75mm nominally thick blended aggregate Base shall be constructed as described in c(i) to (iv) above with a change in the procedure in c(i). In c(i), for the top 75mm of the Base, uniformly blended aggregate Base material shall be obtained by mixing thoroughly 37.5 mm and 20 mm single sized aggregate in the volume ratio of 7:2. 14mm choker stone shall then be spread evenly at the rate of 0.5 to 0.7 Cu.m per 100 sq. meters and rolled to ensure that the stones are well embedded in the surface interstices of the finished blended aggregate Base course. While the rolling is being done, the surface shall be wetted and lightly brushed so as to ensure that the finer aggregate including fines are worked into the remaining surface interstices.

(d) Surface Finish and Quality Control

The blended aggregate Base shall be finished to the requirements of section 1601. The control on the quality of materials and work shall be exercised in accordance with Section 1602.

(e) Application of Bituminous Material

The CRS-1 or CRS-2 bitumen emulsion shall be applied on the compacted blended aggregate Base at the rate of 3.5 l/sq. meters for the first coat. The second coat shall be applied at the rate of 1.0 l/sq. meters after three weeks to one month. The application of the bituminous binder shall be carried out using pressure distributors. Manual applications shall be resorted to only with the approval of the Engineer.

(f) Application of Blotting Material

The surface on which the binder has been applied (first coat) shall then be immediately blinded with blotting material, using an approved method of spreading, at an approximate rate of 8 Cu.m per 1000 Sq. m. The blotting material shall conform to the grading requirements given in Table 1701 - 9 of Sub section 1701.5. If so directed, rolling of the surface with two passes of a pneumatic tyred roller or any other approved roller shall be carried out.

(g) Aftercare

Traffic shall normally not be allowed over the newly treated surface area for a period of at least 6 hours after completion of the work. In special circumstances, where the Engineer decides to allow traffic earlier, the speeds shall be limited to less than 15 kilometres per hour.

(h) Surface Finish and Quality Control

The blended aggregate Base shall be finished to the requirements given in 1601.

The control on the quality of materials and water shall be exercised in accordance with 1602.

410.4 Measurement & Payment

(a) Measurement

Blended aggregate Base (without the surfacing) and 1st & 2nd coat shall be measured as finished in Sq. m in position, as specified.

(b) Payment

Payment shall be based on the Contract unit rate for the compacted work as measured which shall include full compensation for providing all materials, labour, tools, equipment and incidentals necessary to complete the work to the Specifications.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
410(1)	Blended aggregate Base compacted in position (state nominal thickness)	Sq. m
410(2)	Applications of 1st coat	Sq. m
410(3)	Applications of 2nd coat	Sq. m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

500 SURFACE APPLICATIONS, SURFACE DRESSINGS AND SURFACINGS

501 PRIME COAT

501.1 Description

This work shall consist of an application of a prime coat on a Base or Sub-base newly constructed using gravelly soil, stabilized soil or aggregate, prior to laying of a surface dressing or a surface course, so as to provide a proper bond between the layers and also to serve as a protective measure for the Base or Sub-base.

The work shall be carried out in accordance with the Specifications or as directed by the Engineer.

501.2 Materials

(a) Prime Material

Materials used shall meet the requirements of the following unless otherwise directed :-

The binder shall be from a source approved and shall consist of medium curing cutback bitumen (25 to 45% cutback) MC-30, MC-70 or MC-250 complying with Sub section 1702.2 or bituminous emulsion of grade CSS-1 or CSS-1h to Sub section 1702.3. The application rate of cutback bitumen or percentage of cut back or bituminous emulsion to be used shall be instructed by the Engineer on Site after field trials. These field trials shall be carried out by the Contractor as instructed by and under the supervision of the Engineer and the cost thereof shall be deemed to be included in the prime coat rates. The object of the trials is to achieve the optimum penetration and efficacy of the prime coat.

The indicative rate of spread of cut back bitumen or emulsion for the prime coat shall be in the range of 0.5 to 1.5 l/m^2

The preparation of cutback bitumen for prime coat shall be carried out in accordance with Transport & Road Research Laboratory TRRL Research Report RR104. "Preparation of Cutback Bitumen" by Hitch and Steward. See Appendix 501.1 to these Specifications.

(b) Mineral Aggregate for blinding

The blinding layer shall be crushed rock or sand to Sub section 1701.4.

501.3 Construction Requirements

(a) Weather Limitations

The prime coat shall be applied only when the existing surface is dry or sufficiently low in moisture to assure uniform distribution of the bituminous material, when the atmospheric temperature is not less than 15°C, and when the weather is not foggy or rainy or rain is imminent, in the opinion of the Engineer.

(b) Preparation of Existing Surface

Prior to the application of prime coat the surface shall be well brushed to remove all dust, loose particles and other objectionable material, with a power broom or any other means approved by the Engineer. In the case of aggregate Bases, such cleaning shall continue until the entire surface shows a pattern of exposed large particles free from dust as far as practicable. The surface shall be prepared in this manner to expose a hard tight mosaic of large aggregate on the Base course. Hardened impervious films or layers of compacted fine material over the larger aggregate shall be removed by appropriate methods which shall avoid damaging the underlying surface as approved by the Engineer.

The surface shall be moistened with water prior to application of the binder, unless otherwise directed by the Engineer. If the moisture content is too high to permit full penetration of the prime coat in the opinion of the Engineer, the Contractor shall delay Prime Coat application until the moisture content is satisfactory for full penetration as instructed by the Engineer.

Before any priming material is sprayed the layer to be primed shall be checked for compliance with the surface and other requirements specified in the Specifications. Any sections not complying with the Specifications shall be corrected and remedial measures taken to the satisfaction of the Engineer before priming operations are permitted.

(c) Application of Binder

The bitumen distributors their operations, safety measures and maintenance shall be carried out in accordance with the provisions of Sub section 505A.3(a).

Prime Coat shall be applied at the instructed rate (the indicative rate shall be in the range given in 501.2) after trials by means of a mechanical sprayer for large areas and a hand sprayer for small and inaccessible area, or any other means approved by the Engineer so as to achieve an even distribution of the prime coat at the temperature within the range given in Table 501-1.

At the start and end of each run building paper or other approved material shall be spread over the surface to ensure a clean joint between adjacent runs, to protect adjacent surfaces and also to permit the distributor to build up sufficient speed so that at the start of each run the distributor shall be travelling at the correct speed for the instructed application rate.

The distributor shall be functioning properly in accordance with the manufacturer's instructions with all spray nozzles functioning and delivering prime coat at the same evenly distributed rate. There shall be no leakages or drips of oil, diesel or bituminous material from the distributor.

The total width of primed surface shall be 150mm wider on the shoulder side than the specified width of the final Surfacing and the edges of the prime coat shall be parallel to the centre-line of the road.

The prescribed prime coat application rate may be achieved by two or more repeated applications when necessary to avoid flow of prime coat on steep cross falls or gradients.

Any areas deemed by the Engineer to be deficient in prime coat after passage of the distributor shall be made good by hand-lance.

Road furniture such as kerbs, post boxes, side walks utility poles, manhole covers and the like, shall be protected from bitumen spray with adhesive paper or similar material. Any material protected and in consequence damaged or affected by the spray will be made good at the Contractor's expense. Such making good shall extend to replacing the affected item entirely if, in the opinion of the engineer, the existing item cannot be cleaned to his satisfaction.

Spray record sheets containing details of ambient temperature, spraying temperature, areas sprayed and quantities of materials used shall be submitted by the Contractor on a daily basis for approval by the Engineer.

Table 501-1 Spraying Temperatures for Prime Coat

Prime Coat Type	Temperature Degrees Celsius
MC 30 or 45% Cutback Bitumen	40-60
MC 70 or 35% Cutback Bitumen	55-80
MC 250 or 25% Cutback Bitumen	75-115
Emulsion	Ambient Temp.

Note

Where the ambient temperatures are low, emulsions shall be suitably heated to facilitate spraying. In the use of CRS-2 such heating will be necessary in most instances.

(d) Aftercare

Traffic shall not be permitted on the primed surface for a period of 2 hours or longer until the binder has penetrated and dried up and in the option of the Engineer will not be picked up by traffic. However, where the engineer deems it impracticable to detour traffic, the Contractor shall spread a sufficient quantity of blotting material in order to prevent the prime coat from being picked up, prior to allowing the traffic to pass. Any areas which are in excess of or deficient in priming material shall be corrected by the addition of blotting material or binder, as appropriate. Such corrections shall be considered as incidental to the work.

As soon as the primed surface has cured sufficiently or mineral aggregate for blinding has been applied to allow traffic to pass over the road without the prime coat being picked up, the road shall, where practicable, be opened to traffic for a period of 14 days or less if agreed by the Engineer. During this period the primed area under traffic shall be maintained and all damage caused by traffic shall be repaired as instructed by the Engineer at no extra cost. Thereafter the Contractor shall maintain the primed surface and shall protect the surface until the application of Surfacing by taking suitable precautions including for example supplying and spreading a protective layer of sand.

No payment shall be made for mineral aggregate for blinding which shall only be used for the convenience of the Contractor in early opening the primed areas to traffic.

(e) **Quality Control**

The Contractor shall not use any bituminous binder until the test certificates are received for that batch. The Contractor shall sample in the presence of the Engineer at least every 100 tonnes and every batch of bituminous binder after delivery to the Site in sufficient quantity to carry out one set of tests for compliance of the bituminous binder with the Specification. Testing shall be carried out at the central lab in RDA and the Contractor shall arrange for transport of the samples in sealed containers to the laboratory.

Control of the quality of materials and work shall be exercised in accordance with Section 1602.

501.4 Measurement and Payment

(a) **Measurement**

The Contractor shall price for one of the following two alternatives for prime coat :

(i) The work shall be measured in litres of binder used in the accepted work. The volume of bitumen and the volume of kerosene/diesel shall be paid for separately according to the pay items but the total of the two volumes shall be the volume of prime coat thoroughly mixed in the correct proportions actually placed on the road calculated at the instructed rate per Sq.m over the area specified to be covered.

or

(ii) The surface application shall be measured in Sq.m of work completed and accepted. Surface measurements shall be based on the width and length of the surface area as approved by the Engineer.

(b) **Payment**

Payment will be made for either alternative (i) or (ii) at the Contract Unit rates or rate for the alternative elected and priced by the Contractor and shall include full compensation for providing all materials, mixing where required, placement, labour equipment and incidentals to complete the prime coat as specified.

Pay Item	Description	Pay Unit
Alternative (i)		
501 (1)	80-100 Penetration grade Bitumen	Litres
501 (2)	Kerosene as Cutter	Litres
501 (3)	Diesel as Cutter	Litres
501 (4)	Emulsion	Litres
OR		
Alternative (ii)		
501 (5)	Prime Coat inclusive of application of blotting material (State type and rate of application of binder)	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

APPENDIX 501.1

PREPARATION OF CUTBACK BITUMENS

EXTRACT FROM TRRL RESEARCH REPORT 104 "THE PREPARATION OF CUTBACK BITUMENS TO ASTM SPECIFICATIONS BY BLENDING READILY AVAILABLE CONSTITUENTS"

Preparation of Cutbacks under Site Conditions

In most tropical and subtropical countries 80/100 penetration grade bitumen is most frequently used for Surfacing mixes and for surface dressing. In very hot areas such as the Gulf States, 60/70 pen grade is more common.

Since the Base bitumen in commercially produced cutbacks is usually 100 pen grade, it is a relatively simple matter to produce otherwise unobtainable cutbacks under field conditions; it is only necessary to establish the appropriate manufacturing techniques, diluents and blending proportions.

Cutbacks are manufactured commercially using blender units. These contain proportioning devices and are designed to produce and efficient mixing action. Typical units produce about 40-50 tonnes per hour but smaller units are available. It is advisable to use a blender unit, if at all possible, because it eliminates the possibility of localized concentrations of diluents during blending and also the risk of generating large amounts of solvent vapour with the attendant fire hazard. It must be remembered that all cutbacks are potentially dangerous and strict precautions shall be taken to avoid sources of ignition such as cigarettes, fires, heating devices and particularly the burners on bitumen distributors and decanters.

Simple equipment can also be effective on preparing cutbacks. The requirements are:

i. Suppliers of hot bitumen and of diluents (unheated), together with a means of proportioning each (eg. Dipstick, contents gauge and drums of known volume for diluent)

ii. A storage tank fitted with a filling and circulating pump system also provision for heating tank contents.

iii. A small hand pump of approximately 40-50 litres per minute capacity, with delivery hose.

Items (i) and (ii) are available as part of the equipment for mechanized surface dressing in the form of the bitumen heater / decanter and distributor respectively. Older distributors which are no longer suitable for spraying can be employed for blending. The procedure given below for preparing blends assumes a distributor is used but is equally applicable to static plant.

1. Calculate the volumes of bitumen and diluent required based on the total volume of blend to be prepared. If a bitumen distributor or similar vessel is to be used, a dipstick or a contents gauge is usually fitted. Prepare the diluent in suitable containers eg. 200 litre drums.

2. Heat the bitumen in the supply vessel to the lowest temperature consistent with efficient pumping (for 80/100 pen grade bitumen this is approximately 140^{0}C).

3. Extinguish all flames, cigarettes etc. and ensure fire extinguishers are on hand. Remove non-essential and unauthorized persons from the area. Essential personnel must wear protective clothing, boots and gloves (if handling hoses etc.). Eye protection is also required.

4. Pump the hot bitumen from the supply vessel into the storage tank (eg. The distributor), controlling the delivery such that the required volume of diluent can also be pumped in before the total volume of blend has been attained. The diluent delivery hose must dip below the level of the binder in the tank at all times. Dispersion of the diluent in the bulk of the binder is then promoted by the vigorous swirling action created by the incoming binder.

5. When the constituents have been loaded, circulate contents of tank for approximately one hour in order to complete mixing.

It is not advisable to pump diluent into a tank already charged with a large volume of bitumen since the circulatory pumps usually available will disperse diluent very slowly. Local concentrations of diluent may also precipitate asphalt sludge but there is little danger of this occurring if the blending procedure described above is followed.

Conclusions

Cutback bitumen blends have been prepared in the laboratory using 100 pen. and 50 pen Bitumen with three diluents, namely kerosene, a 3:1 mixture of kerosene and diesel and diesel. The blends have been examined for compliance with established US Specifications.

It has been shown that:

a. blends made using kerosene as diluent do not contain sufficiently volatile cutter for compliance with 'RC' type Specifications;

b. blends which meet the 'MC' type Specifications can be made using a 3:1 kerosene / diesel mixture with both 100 and 500 pen bitumen;

c. 'SC' type cutbacks can be prepared using 100 pen bitumen blended with diesel fuel. If 50 pen bitumen is used the residual binder after distillation is below the required minimum.

Diluent blending ranges have been established for both MC and SC cutbacks meeting the ASTM classification system and blending proportions have also been established for three cutback grades which are included in British Standard 3690 Part 1. These results should be regarded as a working guide, since in practice, the precise properties of the blends will depend on those of the constituent materials which may differ from those used in this study.

A recommended procedure for field production of cutbacks based on previous experience has been described.

502 TACK COAT

502.1 Description

This work shall consist of an application of a tack coat to an existing Pavement prior to construction of a Surfacing, so as to provide a bond between the two layers.

The work shall be carried out in accordance with the Specifications or as directed by the Engineer.

502.2 Materials

Binder used shall be bituminous emulsions of any specified grade conforming to Sub section 1702.3

502.3 Construction Requirements

(a) Weather Limitations

The provisions of Sub section 501.3(a) shall apply.

(b) Preparation of Surface

Prior to application of the tack coat, the surface shall be dried, thoroughly swept and rendered clean of clay, dust and any other extraneous material. The tack coat shall be applied only when the surface is dry, unless otherwise approved by the Engineer.

(c) Application of Binder

If bitumen distributors are used for the application of the binder, then their operations and safety measures and maintenance shall be carried out in accordance with the provisions of Section 505A.3(a).

Emulsions shall normally be applied at ambient temperatures. However, the emulsions may be warmed to facilitate uniform application, where necessary. They shall be applied using a mechanical sprayer, hand sprayer or by any other means approved by the Engineer.

The rate of application of tack coats shall be as specified, and as directed by the Engineer and shall generally range between 0.25 and 0.55 litre per Sq.m depending on the surface condition.

In areas being treated, precautions shall be taken to prevent the surfaces of structures and trees being spattered or marred, and the binder getting into channels, catch-pits and drains.

The CSS emulsions may be diluted with clean water, if necessary, in order to control the rate of spread. However, dilutions of CRS types are normally not recommended.

Tacked surfaces shall be allowed to dry until the proper condition of tackiness is achieved to receive the surface course. Tack coat shall be applied only so far in advance of the surface course placement as is necessary to obtain the proper

condition of tackiness. Until the surface course is placed, the Contractor shall protect the tack coat from damage. Normally tack coats shall not be left applied for more than about 6 hours without the placement of the surface course.

No tack coat shall be applied on primed aggregate Base course surfaces, before paving with asphalt bound Base course or asphalt concrete. Tack coat shall be applied only on hard surfaces like concrete, steel, old asphalt concrete and bituminous surfaces, cut asphalt surfaces and joints, faces of the structures and kerbs to a height equal to that of the asphalt that is to be laid. Manual application with a brush shall be carried out on vertical faces mentioned above.

(d) Quality Control

Control on the quality of materials and works shall be exercised in accordance with Section 1602.

502.4 Measurement and Payment

(a) Measurement

Method of measurement shall be any one of the following as specified: -

(i) The work shall be measured in litres of binder used in the accepted work. The quantity of binder measured shall be that required to comply with the Specifications and the requirements of the Engineer or shall be the actual quantity used and accepted, whichever is the less.

(ii) The surface application shall be measured in Sq.m of work completed and accepted. Surface measurements shall be based on the width and length of the surface area as approved by the Engineer.

(b) Payment

Payment will be based on the Contract unit rate for the completed work as measured which shall include full compensation for cleaning of the surface, providing all materials, labour, equipment tools and incidentals necessary to complete the work to the Specifications.

The Pay Items and Pay Units will be as follows :-

Pay Item	Description	Pay Unit
Either		
502(1)	Tack Coat (State type of binder)	Litres
	or	
502(2)	Tack coat (state type of binder and rate of application)	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

503 HOT BITUMEN APPLICATIONS (First and Second Coat)

503.1 Description

This work shall consist of the following hot bitumen applications: -

(a) First coat on a single sized aggregate Base constructed as given in section 403.

(b) Second/subsequent coat on a single sized aggregate Base on which a first/second/subsequent coat had been previously applied.

The work shall be carried out by applying a coat of hot bitumen and blinding with sand.

The work shall be carried out in accordance with the Specifications or as directed by the Engineer.

503.2 Materials

Materials used shall meet the requirements of the following :-

(a) Binder shall be 80-100 penetration grade bitumen to Sub section 1702.1.

(b) Blotting (blinding) material shall be coarse sand or gravel to Sub section 1701.4.

503.3 Construction Requirements

(a) Weather Limitations

Provisions of Sub section 501.3(a) shall apply.

(b) Preparation of Surface

In the case of an existing Pavement, the surface shall first be corrected as required by suitably patching potholes, ruts and depressions and eliminating all other surface irregularities, as per Section 1102 and as required by the Engineer. However the corrections shall be done at least before two weeks from the due date of commencing this work.

Prior to application of the binder, the surface shall be dried, thoroughly swept and rendered clean of clay dust and any other objectionable matter.

(c) Application of Binder

If bitumen distributors are used for the application of the binder, then their operations and safety measures and maintenance shall be carried out in accordance with the provisions of Section 505A.3(a).

Prior to application, the binder shall be heated to a temperature not exceeding 175 degrees C and shall be applied at a minimum temperature of 160 degrees C.

The binder shall be applied by the use of a mechanical sprayer or hand sprayer or by any other means approved by the Engineer.

The rates of application shall be as specified and as directed and shall normally be between 1.5 to 2.0 litre per Sq.m and 0.75 to 1.0 litres per Sq.m for first coat and second/subsequent coat applications respectively. The rate shall be determined by the engineer to suit the condition of the road, traffic and the properties of aggregate.

In the case of the second/subsequent coat applications each application of binder shall be limited to such an extent of area of road surface that would be possible to be covered with blotting material before the binder hardens.

503.4 Application of Blotting Material

The surface on which the binder has been applied shall then be immediately blinded with blotting material, using an approved method of spreading, at an approximate rate of 8 Cu.m per 1000 Sq.m. If so directed, rolling of the surface with two passes of a pneumatic tyred roller or any other roller shall be carried out.

503.5 Re-brushing in the Case of Second/Subsequent Coats

The blotting material which gets whipped off by traffic on to the sides of the road shall be re-brushed to the road surface, when the bitumen is soft (preferably at midday on a bright sunny day) as many times as would be required by the Engineer and till such time as the surface bleeding completely disappears.

503.6 Quality Control

The control on the quality of works shall be exercised in accordance with Section 1602.

503.7 Measurement and Payment

(a) Measurement

The surface application shall be measured in Sq.m of work completed and accepted. Surface measurements shall be based on the width and length of the surface area as approved by the Engineer.

Re-brushing of blotting material shall be measured in Sq.m. Surface measurements shall be based on the width and length of the area as approved by the Engineer.

(b) Payment

Payment will be based on the Contract unit rate for each item as measured which shall include full compensation for cleaning the surface, providing all materials, labour, equipment, tools and incidentals necessary to complete the work to the Specifications.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
503(1)	Hot bitumen application (state rate of application)	Sq.m
503(2)	Re-brushing of blotting material	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

504 SAND SEALING

504.1 Description

This work shall consist of constitutes the construction of sand seals on existing bituminous Pavements, which shall consist of the application of binder followed immediately by covering with coarse sand and rolling using a pneumatic tyred roller or for small job, an improvised roller, as approved by the Engineer.

The work shall be carried out in accordance with the Specifications or as directed by the Engineer.

504.2 Materials

Materials used shall meet the requirements of the following, unless otherwise directed by the Engineer: -

(a) Binder shall be 80-100 penetration bitumen to Sub section 1702.1 or bituminous emulsion CRS-1 or CRS-2 to Sub section 1702.3 or cutback bitumen (8-12 percent) or MC 3000 to Sub section 1702.2.

(b) The cover material shall be coarse sand to Sub section 1701.5

504.3 Construction Requirements

(a) Weather Limitations

Sand seals shall generally be applied in dry weather and when the ambient temperature is not below 15 degrees C.

(b) Preparation and Cleaning of the Surface

The existing Pavement surface shall first be corrected as required by suitably patching potholes, ruts and depressions and eliminating all other surface irregularities as per Section 1102 and as required by the Engineer. However the corrections shall be done at least two weeks before the due date of commencing sand sealing.

Prior to the application of the binder, the surface shall be dried, thoroughly swept and rendered clean of clay dust and any other objectionable matter.

(c) Application of Binder

Penetration grade bitumen and cutback bitumen shall be heated to temperatures between 160 degrees C and 175 degrees C and 105 degrees C to 130 degrees C respectively prior to application. Emulsion CRS-1 or CRS-2 shall be applied at the ambient temperatures. Where necessary, as instructed by the Engineer, the binder shall be heated to facilitate spraying. In the use of CRS-1, however, for most ambient temperatures, such heating will not be necessary.

The binder shall be applied uniformly at the rate specified, which shall vary normally between 0.75 to 1.0 litres/Sq.m, depending on the type of binder used and the condition of the surface.

If bitumen distributors are used for the application of the binder, their operations and safety measures and maintenance shall be carried out in accordance with the provisions of Section 505A.3(a).

In the case of penetration grade bitumen or emulsions the application at any one time shall be limited to the area that can be covered with blotting material before the bitumen hardens or the emulsion breaks.

(d) Application of Cover Material and Rolling

The surfaces where the binder has been applied shall be immediately covered with coarse sand using an approved method of spreading at an approximate rate of 8 Cu.m/1000 Sq.m and shall be immediately rolled with an approved pneumatic tired roller until the sand is firmly embedded in the binder. For small jobs, an improvised tired roller may be used with the consent of the Engineer.

(e) Re-brushing

The blotting material which gets whipped off by traffic on to the sides of the road shall be refreshed to the road surface when the bitumen is soft (preferably at midday on a bright sunny day) as many times as required by the Engineer and till such time as the surface bleeding completely disappears.

(f) Aftercare

Traffic shall normally not be allowed over the newly treated surface area for a period of at least 2 hours after completion of the work. This shall be particularly so where cutback bitumen is used. In special circumstances, where the Engineer decides to allow traffic earlier, the speeds shall be limited to less than 15 kilometres per hour.

(g) Quality Control

Control on the quality of materials and works shall be exercised in accordance Section 1602.

504.4 Measurement and Payment

(a) Measurement

Sand seals shall be measured in Sq.m of work completed and accepted.

Re-brushing of blotting material shall be measured in Sq.m and the measurements shall be based on the widths and lengths of such areas refreshed as directed, and accepted.

(b) Payment

Payment will be based on the Contract unit rate for the different items, which shall include full compensation for providing all materials, labour, equipment, tools and incidentals necessary to complete the work to the Specifications.

The Pay Items and Pay Units shall be as follows :-

Pay Item	Description	Pay Unit
504(1)	Sand seal (state type and rates of application of binder)	Sq.m
504(2)	Re-brushing of blotting material	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

505 A SEAL COAT TREATMENTS (SURFACE DRESSINGS) USING CUTBACK BITUMEN

505A.1 Description

Surface Dressing shall consist of the process of spraying the surface to be dressed with bituminous binder, covering the binder with natural or crushed stone cover aggregate and rolling the resulting surface. It shall be carried out in accordance with the recommendations in the UK Transport Research Laboratory Overseas Road Note 3 – "A Guide to Surface Dressing in Tropical and Sub-Tropical Countries" – hereinafter referred to as TRL-ORN 3.

The requirement for a single or double surface dressing shall be specified on the Drawings.

The work shall be carried out in accordance with the Specifications or as directed by the Engineer.

505A.2 Materials

(a) Binders

The bitumen binder shall consist of cutback bitumen as specified in the relevant item of the Bill of Quantities.

Bitumen binder shall comply with Sub section 1702.2 herein approved by the Engineer.

Cutback bitumen binder shall comprise penetration grade 80/100 or 60/70 (when 80/100 is not available) bitumen and cutter which shall be diesel or kerosene or a mixture of both prepared on Site. The type and proportion of cutter if required shall be instructed by the Engineer on Site, in the range 1% to 10% after design of the surface dressing in accordance with the procedures set out in Chapter 5 of TRL-ORN 3. The preparation of cutback bitumen shall be carried out in accordance with TRRL Research Report RR104 "Preparation of Cutback Bitumen" (Hitch and Stewart). An extract from this Report is included as Appendix No. 501.1 which describes the preparation of cutbacks under site conditions.

Approval of the source of supply of bitumen shall be as stated in section 1702.1.

(b) Cover Aggregate

Cover aggregate specified in the relevant items of the Bill of Quantities shall be obtained from a source approved by the Engineer and shall be natural or crushed hard rock/stone, clean and free from adhering dust, achieved by washing and drying, or any other detrimental substance that could impair the adhesion of bitumen and shall conform to the requirements of Sub-clause 1701.3 Cover Aggregate for surface dressings and Table 1701-8 single sized aggregate for seal coat treatments.

Cover aggregate shall be pre-coated using cut back bitumen penetration grade 80-100 in the ratio of 70% to 30% bitumen to cutter unless otherwise instructed by the Engineer.

Pre-coating material shall be thinly and evenly applied by means of a fine pressure spray to a moving stream of aggregate or by mixing with the aggregate in an approved mixing plant so that all particles are fully coated but do not contain excess material. The coating shall be such that no material will drip from a particle of aggregate suspended between the fingers. Mixing in stockpiles will only be permitted if the Contractor can demonstrate compliance for mixing to the approval of the Engineer.

Aggregate shall not contain sufficient moisture to cause uneven distribution of the pre-coating material and shall not be used in the work until the moisture has evaporated and the pre-coating material has adhered effectively to the aggregate.

Pre-coating of aggregate shall not be carried out when rain is imminent unless the aggregate is subsequently covered or unless the mixing of an adhesion agent in the pre-coating material shall be agreed by the Engineer.

In areas subject to dusty conditions, pre-coated aggregate shall not be stockpiled for any period longer than is necessary for cut back to dry out. When there is a visible coating of dust on the particles the Engineer may direct that portions of the stockpiles be pre-coated again. In this case, the Contractor shall carry out trials to obtain another coating of the already pre-coated aggregate such that no material will drip between two fingers. The Contractor shall only be allowed to use such aggregate that has been pre-coated twice, after strict supervision and approval of the Engineer.

Stockpiling of aggregates will be permitted only at locations approved by the Engineer. A separate stockpile shall be made for each nominal size of aggregate at each location.

The site of the stockpile shall be cleared of all vegetation and debris, graded and drained, and where the Engineer deems it is necessary, the area shall be surfaced with a 100 mm compacted layer of approved material to prevent contamination of the lower layer of cover aggregate.

Unless otherwise approved by the Engineer each stockpile shall be built at least two meters high by tipping in layers not more than one metre deep over the whole area of the stockpile. The Contractor shall supply planking or other material required in connection with movement of vehicles over and about the stockpiles.

The bottom 50 mm layer of cover aggregate or any contaminated aggregate shall not be used in the work.

Stockpiles shall be kept dry from rainfall or ingress of water by covering with approved waterproof membranes and maintaining ground drainage to avoid seepage of ground water into stockpile.

(c) Adhesion Agents

Prior to the commencement of the surface dressing, the Contractor shall carry out tests under the supervision of the Engineer to determine the adhesion qualities of the aggregate and binder to be used. These adhesion tests will include, but not be limited to, the Immersion Tray Test described in Appendix C of TRL-ORN 3. If, in the opinion of the Engineer, the tests and trials indicate the need, the Engineer shall instruct the use of a proprietary adhesion agent as admixture to the bitumen binder to be applied along with pre-coating to the cover aggregate.

The Contractor shall supply and apply the specified adhesion agent in the quantities and in the manner instructed by the Engineer and in accordance with the manufacturer's instructions.

505A.3 Construction Requirements

(a) Bitumen Distributors

Operation

Distributors shall be of constant volume or preferably constant pressure types, self-propelled, equipped with pneumatic tires and have a minimum binder capacity of 4000 litres and each machine shall require the approval in writing of the Engineer for use in construction.

Approval will depend on fulfilling the following requirements;

(i) Distributors shall be equipped with low range speedometer (fifth wheel) in good working condition, so located to be visible to the driver to enable him to maintain accurately the constant speed for spraying binder at the uniform specified rate. They shall be fitted with either a calibrated pressure gauge which accurately records the pressure of the bitumen at the spray bar for constant pressure distributors, or a binder pump delivery meter for constant volume distributors. Binder pumps shall be capable of maintaining constant pressure or constant volume during spray runs.

(ii) Distributors shall be fitted with burners in combination with a circulating pump capable of maintaining the bitumen without overheating within the specified

temperature range and an accurately calibrated thermometer for indicating the spraying temperature of the bitumen.

(iii) The spray bar shall be capable of applying bitumen binder to a minimum width of 2.30 meters with provision for application of lesser widths by closing jets. The spray bar shall have the capability of being raised and lowered to specified heights above the road and of being adjusted so that it is parallel with the road surface. The distributors shall be so designed to allow the circulation of hot binder through the spray bar when not spraying.

(iv) Spray bars shall be fitted with either slotted spray jets or preferably whirling spray jets, whose essential features are the ability to spray binder uniformly at the specified rate of spray, such that the speed of the distributor can be matched by the following chipping spreader during its normal chip spreading operation. If whirling spray jets are fitted the spray bar shall be protected by a hood to reduce wind interference. Distributors shall be fitted with hand-lances with nozzle spray attachments for spraying small, inaccessible areas and to correct deficiencies in the spray rate.

(v) Prior to spraying operations, distributors shall be checked for leakages from spray jets and any other sources and these shall be eliminated. Distributors shall then be calibrated by the "Depot Tray Test" as given in BS 1707:1989 and Appendix F in ORN3 and approved by the Engineer and under his supervision, to establish uniformity of lateral spray of bitumen to within ±10% permitted variation at any point on the surface from the mean spray rate.

Calibration shall be undertaken in accordance with the manufacturer's instructions or in accordance with Appendix G TRL-ORN 3 – to establish the relationship between spray rate and road speed for constant pressure distributors and in addition, bitumen pump delivery rate and spray bar width for constant volume distributors. The distributors shall be capable of achieving a mean spray rate measured by the TRL-ORN 3 Section 6.29 Method B, which shall not vary by more than ±5% from the specified spray rate.

Safety and Maintenance

Bitumen heating, pumping and spraying operations shall be entrusted only to personnel who have been adequately trained and who are competent in the use of the equipment. Unauthorised personnel shall not be allowed to remain in the vicinity during the above operations. Authorised personnel shall be provided with, and be required to wear, suitable protective clothing, i.e. overalls, heat-proof gloves, boots, helmets and goggles.

Special care is needed when changing the type of binder being used in the distributor. When changing from hot binders to bitumen emulsions, all residual binder in the tank and spraying system shall be drained completely and the spraying system flushed using kerosene. When changing from emulsions to hot binders, all emulsion shall be drained/flushed from the distributor in order to avoid foaming when hot binder is loaded. When it is necessary to load hot binder after using the distributor for spraying cutback bitumen, the cutback bitumen shall be drained completely and the manhole left open for some time to allow solvent vapour to escape.

The spray bar shall be emptied of binder by blowing with air, or by kerosene flushing when spraying is suspended for lengthy periods and at the end of each day's work.

The binder shall be introduced into the distributor at a temperature equal to or just above the spraying temperature after preheating in separate tanks fitted with burners and circulating pumps for this purpose. The capacity of the decanters/preheating tank shall be sufficient to preheat the binder required for the full day's work.

The distributor burners shall be used only to make relatively small adjustments to the binder temperature and shall not be used to raise the binder from ambient to spraying temperature. Under no circumstances shall distributor burners be operated during the spraying operation, or when the level of binder in the tank is less than 150 mm over the top of the flues, or when the distributor is moving. The need for end of day maintenance of the distributor is essential to reduce fire risk and to ensure its adequate performance when next used for binder application.

Maintenance of all equipment for the surface dressing operation shall be under the control of a competent senior mechanic, approved by the Engineer and fully experienced in the maintenance of all equipment and in the calibration of the bitumen distributor.

The Contractor shall provide all necessary traffic control equipment and shall inform the engineer at least 2 days before commencing the spraying work, of his detailed arrangements for traffic control. After review the Engineer will inform the Contractor in writing of his approval, subject to any modifications to the Contractor's arrangements which he requires for traffic and convenience of the public.

(b) Workmanship

Preparation of Surface

Surface dressing operations shall not commence until the Engineer has inspected and approved the primed Base course. Major defects or damage shall be rectified by complete reworking of the Base course after removal and disposal of the defective primed Base course, where relevant.

However if the surface to be treated contains small but limited holes or depressions, which in the opinion of the Engineer require treatment, such irregularities shall be repaired by removal of all loose and defective material and replacement with a patching mixture compatible with the surrounding surface or other material approved by the Engineer, which shall be compacted to produce a tight surface conforming with the adjacent area.

Irregularities which impair the riding qualities shall be corrected as instructed by the Engineer.

Immediately prior to the application of binder, all loose dust and detrimental material shall be removed by sweeping and blowing by air compressor. If necessary, adhering mud and other material shall be removed by hand using wire brushes and water.

Road furniture such as kerbs, post boxes, foot-walks, utility poles, manhole covers and the like, shall be protected from bitumen spray with adhesive paper or similar material. Any material protected and in consequence damaged or affected by the spray will be made good at the Contractor's expense. Such making good shall extend to replacing the affected item entirely if, in the opinion of the Engineer, the existing item cannot be cleaned to his satisfaction.

(c) Application of Binder

The specified bitumen binder, cut back if instructed by the Engineer, its application rate and spraying temperature shall be instructed by the Engineer on Site after design of the surface dressing, in accordance with the procedures set out in Chapter 5 of TRL-ORN 3. The range of spraying temperature for binders is given in TRRL-ORN 3 Table 9 and is normally within the range 120°C to 170°C.

The Contractor shall present his detailed programme and arrangements and methods for the planning and execution of the surface dressing process to the Engineer for approval at least 7 days before he intends to commence this Work. The Contractor's representative shall be responsible for preparation of the programmes and arrangements and the Contractor shall not commence surface dressing until the Engineer has approved his programme.

The Contractor shall Base his programme on TRRL-ORN 3(1985) – Section 7. The Surface Dressing Process, Sub section 7.1 Planning Sub section 7.2. The Surface Dressing Operation – by selecting the activities appropriate to his particular Work Programme. The Contractor shall appoint a surface dressing overseer approved by the Engineer who shall be fully competent to implement the surface dressing operation with experience in operating all essential equipment.

All operations associated with the surface dressing process shall be described in the Contractor's arrangements and shall include but not be limited to :

(i) method of bitumen supply, decanting, cutting back where required, heating and storing, transfer to distributor including lists of equipment and capacities;

(ii) location and method of production of cover aggregates and pre-coating with type and output of equipment, including crushers where appropriate; and.

(iii) method of performing the surface dressing process including type and capacity/weight of all main and ancillary items of equipment along with workforce details.

The Contractor shall provide, one day in advance, his following day's surface dressing Work Programme, including his expected spray lengths and widths for each run with details of the quantity of cover aggregate available in approved chip spreaders standing by at the commencement of the spray run. Spraying shall not commence until sufficient cover aggregate is in this position to cover the area programmed for spraying.

The distributor shall be filled with preheated bitumen binder on the same day, shortly before start of binder application. The distributor spray bar and jets shall be preheated by circulating hot binder and the jets operated for at least 10 seconds for testing. This operation shall be carried out before each spray run, off-road onto trays, or at a location where no environmental damage will be created. Jets shall be inspected by the Engineer for shape, direction, blockage or any other defects which shall be corrected before spraying is permitted. At the end of each spray run the distributor shall be driven off-road to avoid binder drippage on the Pavement surface. Binder drippage from any location which may contaminate the road surface shall be sufficient for the Engineer to order removal of the offending source from the roadway until repairs are completed. Multiple heating of bitumen in the distributor shall not be accepted.

As emergency / temporary measures, drip protection of the Pavement surface shall be provided by use of buckets/trays etc. These shall be available for use at all times, along with equipment for removal of binder spillages on the Pavement surface, to the approval of the Engineer.

The Contractor shall carry out a trial section of surface dressing at a location instructed by the Engineer to demonstrate to the Engineer that his surface dressing staff along with the machinery, equipment, the methods and other requirements approved by the Engineer are capable of constructing the surface dressing in accordance with the Specification. The trial length shall be minimum 200 meters using full spray bar width with full width application of cover aggregate. If the trial section of surface dressing complies with the Specification, the Contractor shall receive payment for the Work in accordance with the Contract as if it were Permanent Work. If the trial section of surface dressing fails to comply with the Specification, the Contractor shall carry out further trials until his surface dressing operation complies with the Specification. No payment will be made for trial sections that do not comply with the Specification.

When the Engineer is satisfied that the Contractor is capable of constructing surface dressing that complies with the Specification after trial section or sections, the Contractor will receive permission to commence surface dressing as permanent Work on the road Pavement.

Application of binder shall only be undertaken when the surface is dry or slightly damp, but in no circumstances when wet. If in the opinion of the Engineer rainfall is likely before the application of binder or cover aggregate or the temperature or the Pavement surface has time to fall below the specified minimum temperature of 15 °C, the Engineer will instruct the Contractor to delay surface dressing work until weather conditions are satisfactory. Areas damaged by rainfall shall be rectified by the Contractor without additional payment, in a manner instructed by the Engineer.

If in the opinion of the Engineer the ambient temperature is too cold for surface dressing, the Contractor shall delay this operation until the temperature increases to the specified minimum level of 15 °C.

Building paper or other approved protective material shall be used at the start and finish of each spray run of sufficient width (not less than 600mm) to enable the distributor to reach its calibrated road speed with spray jets open before discharging binder onto the Pavement under treatment. Ends of previous surface treatment runs shall be trimmed back to clean, straight transverse edges and these shall form the start point for subsequent runs, with completed work suitably protected as described above. Spray runs will be limited to 300 metres length initially until the Contractor demonstrates his ability to plan and execute longer lengths. Spray widths shall be calculated allowing for 150mm longitudinal overlap with adjoining passes and for the width that the following chipping spreader is able to cover. Longitudinal sprayed butt joints will not be permitted. The Contractor shall submit his spray width and length proposals to the Engineer for approval.

During spraying all passing traffic shall be stopped. If spray jets block, or the chipping spreader stops, or any other event occurs which may affect the surface treatment process, then the spray bar operator immediately shall stop spraying. When the defective equipment or operation is rectified, spraying may restart with the Engineer's approval.

The binder temperature of the distributor shall be recorded before and after each spray run and spray length and width recorded on approved Record Sheets. The application rate shall be calculated and recorded and checked against the specified rate. The calculated actual rate shall not vary by more than ±5% from the specified rate.

At least eight clean pre-weighed metal spray trays of size 0.1m^2 shall be available for sampling the spray rate for each spray run, to be used in accordance with TRRL-ORN 3 – Section 6.3 Method B – if so instructed by the Engineer.

To ensure that the spray runs are parallel with the road Pavement the edge line of the road shall be marked every 25 metres and a string line laid out for the distributor driver to follow with the guide bar attached to his side of the cab.

Where a second surface dressing is specified, the first surface dressing shall be left open to traffic for a maximum period of 42 days and a minimum period of 14 to 21 days, unless special approval is obtained from the Engineer for a shorter period. Surplus chippings shall be removed by firm hand-brooming or power-brooming before applying the second surface dressing.

The spraying widths shall be so selected that the longitudinal joint of the second surface dressing is offset from that in the first surface dressing by a minimum 300 mm.

Hand-pouring pots or hand-lances shall be used to touch up carefully any parts of the first surface missed by the distributor/chipping spreader, or for the treatment of areas in which the distributor cannot operate and in this case only, chippings may be applied by an approved manual method.

Areas damaged by excess bitumen or spillages of diesel or other deleterious material shall be repaired by careful cutting out and removal followed by careful hand-poured or hand-lance application of binder and chipping in a manner approved by the Engineer.

The second surface dressing shall be undertaken when the first surface has been approved by the Engineer after all surplus chippings are removed, repairs carried out and the surface thoroughly cleaned as specified. The procedures to be followed are those specified for Surface Dressing in this Specification.

(d) Application of Cover Aggregate

The cover aggregate shall be laid at the rate instructed by the Engineer on Site in Sq.m of coverage per Cu.m of loose aggregate after design of the surface dressing, in accordance with procedures set out in Chapter 5 of TRRL-ORN 3.

The cover aggregate shall be laid within 3 minutes after the binder is applied and with the approval of the Engineer may be applied slightly damp if not pre-coated to depress dust and help adhesion. Aggregate applied to sprayed bitumen emulsion shall, however, be dry.

The cover aggregate shall be applied using approved mechanical spreaders, which shall be tailgate mounted on tipper trucks, pushed spreaders or self-propelled spreaders, specifically manufactured for the purpose and they shall preferably be metered. They shall be capable of uniformly spreading cover aggregate at the

instructed rate such that they can deliver the rate specified whilst moving at the same speed as the binder distributors during spraying.

The bitumen binder surface shall be covered with cover aggregate closely packed in one layer so that adjacent chippings are touching and no bitumen binder is left uncovered.

A sufficient number of loaded spreaders shall be available at the start of binder application to provide cover aggregate over the whole area programmed for spraying. The Contractor shall not commence spraying unless sufficient loaded spreaders are in place. Aggregate spreading by manual methods will not be permitted except in circumstances where:

(i) mechanical spreaders cannot operate effectively or safely;

(ii) additional aggregate (back-up work) is required;

(iii) breakdown of mechanical spreaders occurs during the spreading operations before stoppage of spraying;

(iv) minor surface repairs are instructed.

The spreader shall follow the distributor at an interval not exceeding 10m for hot binder work and not exceeding 5m when using bitumen emulsion binder. A back-up vehicle or other approved means shall be constantly in attendance during surface dressing, from which additional aggregate may be hand-applied to ensure complete and rapid coverage.

Where an adjoining pass of the distributor is required, no aggregate shall be applied to the binder over a 150 – 200 mm strip so as to permit subsequent overlap.

Under no circumstances will general brooming of the chipped surface be permitted. Aggregate spillage shall be removed with care and excess aggregates may be brushed off carefully after a minimum of 3 days under traffic, after approval of the Engineer.

The cover aggregate shall be rolled with pneumatic multi – tired power rollers. Pneumatic – tired rollers shall have a wheel load in the 1000 – 2000kg range. Tire pressures and sizes shall be in accordance with the manufacture's recommendations and shall be the same on each axle and tires shall be smooth and in good condition to provide uniform rolling of chippings. The roller shall follow directly behind the spreader and shall continue to roll at a speed of approximately 8 – 10kph, so as to provide minimum 6 passes over the entire treated area. Each pass shall overlap the previous pass by minimum half width of roller rolling shall be continued until all cover aggregate particles are firmly bedded. Tires shall be in good condition and be kept clean and smooth to avoid pick-up of bitumen and chippings.

(e) Aftercare

Traffic shall not be allowed over the newly treated surfaces till such time as the aggregate is well embedded in the binder and no whip-off takes place. Normally this period shall be not less than 12 hours. Where, for special reasons, the Engineer decides to allow traffic earlier it shall be ensured that their speeds do not exceed 15 km.p.h. Where practicable, traffic shall be limited to less than 30 km.p.h. during the first one to two weeks after completion.

(f) Quality Control

Bitumen

The Contractor shall obtain a manufacturer's test certificate clearly cross-referenced to each bituminous binder consignment purchased for use in the Works confirming compliance of that consignment with the Specification.

Bitumen Binder shall comply with the requirements of Section 1702.

Cover Aggregate

The Contractor shall sample, in the presence of the Engineer initially one set of 3 representative specimens for each source of supply and subsequently when warranted by changes in the quality of aggregate. The frequency of testing shall be as given in Section 1602 Additional samples shall be taken for testing where visible changes in the properties of the cover aggregates are observed by the Engineer.

Cover aggregate shall comply with the requirements of Sub section 1701.3.

Surface finish

The surface dressing shall be finished to levels, grades and Cross-sections shown in the Drawings and as directed by the Engineer, and shall conform to the requirements of Section 1601.

505A.4 Measurement & Payment

(a) Measurement

The quantity of binder measured for payment of bitumen grade 80/100 pen and, if applicable, cutter shall be the actual number of litres at 15.6^{0}C used in the accepted work as instructed by the Engineer on site. The conversion of binder material from the spraying temperature at the time of measurement of the volume at 15.6^{0}C shall be carried out according to ASTM D 1250-56, ASTM-IP Petroleum Measurement Tables. The measured quantity shall be calculated as the product of the area sprayed and the application rate instructed by the Engineer or the actual quantity sprayed on the area and accepted, whichever is the lower.

If cut-back bitumen is used as binder, the quantity of binder measured for payment shall be separated into bitumen grade 80/100 pen and cutter in the proportion instructed by the Engineer for cut-back bitumen. The quantities of bitumen grade 80/100 pen and cutter so calculated shall be paid separately at the rates in the relevant items in the Bill of Quantities.

The quantity of adhesion agent measured for payment shall be the actual quantity in litres at 15.6^{0}C used as directed by the Engineer. The Contractor shall inform the Engineer 24 hours in advance of his intension to apply the adhesion agent in the manner and quantity instructed by the Engineer so that joint measurement of the quantity used shall be agreed. If the Contractor fails to inform the Engineer no payment will be made for adhesion agent.

The quantity of cover aggregate measured for payment shall be the number of Cu.m used as instructed by the Engineer on Site. The measured quantity shall be calculated as either the product of the area which received cover aggregate or the

application rate instructed by the Engineer or the actual quantity used and accepted, whichever is the lower.

(b) Payment

Payment shall be made at the Contract unit rates as per the net quantities of materials instructed by the Engineer or actually used and measured for the surface dressing works, which ever rate is the lower per litre for supplying and applying (a) bitumen grade 80/100 pen (b) cutter, and (c) adhesion agent (Provisional Item); and per Cu.m for supply and application of cover aggregate. These prices shall include full compensation for furnishing all materials and for all preparation, delivering and application of these materials and for all labour, equipment, tools and incidentals required for completing the surface dressing to these Specifications.

Pay Item	Description	Pay Unit
505A(1)	Bitumen [state grade (80-100) or (60-70)]	Litre
505A(2)	Kerosene/diesel or other approved cutter	Litre
505A(3)	Adhesion agent	Litre
505A(4)	Cover aggregate [state sizes]	m^3

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

505 B SEAL COAT TREATMENTS (SURFACE DRESSINGS) USING EMULSIONS OR HOT BITUMEN

505B.1 Description

The work shall normally consist of construction of Single Bitumen Surface Treatments (SBST) or Double Bitumen Surface Treatments (DBST) on existing bituminous surfaces using emulsion or hot bitumen.

Triple seal treatments where required shall also be constructed according to these Specifications, except that the aggregate sizes and rates of spread of aggregate and binder, in such cases, shall be as given in Contract documents or as directed by the Engineer.

The work for each seal of the above mentioned treatments essentially consists of the application of binder followed immediately by spreading of single sized aggregate and compacting with a pneumatic tyred roller or any other roller approved by the Engineer. Steel rollers are not recommended to be used for rolling.

Where these treatments are carried out on newly constructed single sized aggregate Bases, the surface shall first be treated with a first coat binder application complying with Section 503. In the case of WBM, DBM and dense graded aggregate Bases the surface shall be first treated with a prime coat complying with Section 501B. Alternatively in the case of WBM or DBM aggregate Bases, seal coat treatments may be constructed without the application of a prime coat, provided the surface is prepared as given separately in these Specifications.

The work shall be carried out in accordance with the Specifications or as directed by the Engineer.

505B.2 Materials

The materials used shall conform to the following requirements: -

(a) Aggregate to the general requirements of Sub section 1701.3(a) and grading requirements of Table 1701-8 of Sub section 1701.3 (b).

(b) The binder for surface application shall be hot penetration grade bitumen to Sub section 1702.1 or bituminous emulsions. CRS-2 to Sub section 1702.3.

(c) Pre-coated chippings shall not be used with emulsion surface dressings, because the breaking of the emulsion will be adversely affected.

505B.3 Construction Requirements

(a) Weather and Other Limitations

(i) Surface treatment shall not be carried out in wet weather or when rain in imminent.

(b) Preparation of the Surface

(i) Existing Pavement surfaces

Existing Pavement surfaces shall first be brought to the required profile by suitably patching depressions and defective areas and eliminating all irregularities.

Prior to the application of the binder, the surface shall be dried, thoroughly swept and rendered clean of clay, dust and any other objectionable matter. This shall apply to the second application as well as the first.

(ii) Newly constructed aggregate Base

Where the surface treatment is done on newly constructed Base course, the surfaces shall be cleaned thoroughly and a prime coat applied as given in section 501. Any binder application for surface dressing shall not be carried out till such time as the prime coat is sufficiently dried out as determined by the Engineer.

(iii) Alternative method of seal coating or WBM and DBM surfaces

In this case, the surface shall be brushed by means of power brooms and other approved methods until the fines infilling the surface interstices of coarse aggregate are removed to a depth of 12 to 20mm. The surface shall then be sprinkled with water in order to wash the dust on the exposed surface of the coarse aggregate and allowed to dry prior to the application of the binder.

(c) Washing of Aggregate

Where specified or where directed by the Engineer, the aggregate shall be washed and dried to eliminate the dust to improve bonding.

(d) Construction of SBST

(i) Application of the binder

The operation, safety and maintenance of bitumen distributors shall conform to the requirements of Sub section 505A.3(a)

The binder shall be uniformly applied over the surface with a bitumen distributor or other approved means.

The bitumen distributors their operations and safety measures and maintenance shall be carried out in accordance with the provisions of Sub section 505A.3(a).

The rates of application of binder and the aggregate shall be as specified in the Contract or approved by the Engineer and shall normally be within the limits given in Table 505B-1.

Table 505B-1 Quantities of materials for SBST

Nominal size of aggregate in mm	Rate of Application	
	Aggregates Cu.m per 100 sq.m.	Binder Litres/sq.m.
20	1.3 to 1.7	1.0 to 1.25
14	1.0 to 1.3	0.75 to 1.0
10	0.7 to 1.0	0.65 to 0.9
6.3	0.55 to 0.75	0.50 to 0.75

Note

The rates of application of binder given above are that for penetration grade bitumen. In the case of emulsion, corrections have to be made by dividing these rates by the fraction of bitumen present in these binders.

Table 505B-2 Spraying Temperatures of binder

Binder Type	Temperature in ^{0}C
80-100 Penetration grade bitumen	160 – 175
Emulsion	Ambient Temperature

Note

Where the ambient temperatures are low emulsions shall be suitably heated to facilitate spraying. In the use of CRS-2 such heating will be necessary in most instances.

The area to be sprayed with binder shall be such that it could be covered with aggregate at the specified rate and compacted before the binder hardens. Normally the maximum time duration from the commencement of spraying to completion of the first pass of the roller shall not exceed 3 minutes.

Care shall be taken that the application of the binder at the junction of spreads is not in excess of the approved amount. Areas of excess binder shall be suitably squeegeed and areas that are deficient suitably reapplied.

In mechanical spraying, where the full width cannot be sprayed in one operation, suitable spraying widths shall be worked out, in order to avoid thin strips.

In areas being treated, precautions shall be taken to prevent the surfaces of adjoining structures and trees being spattered and the binder getting into channels, catch-pits and drains.

(ii) Application of cover aggregate

Immediately following the application of the binder, the aggregate of the designated size, shall be applied using approved spreading equipment at the rates given in the Contract or established by the Engineer, which shall be within the ranges given in Table 505B-1. All thinly spread areas shall be covered suitably and where necessary, the surface shall be boomed to ensure uniform spreading of the aggregate.

Hand spreading of the aggregate shall be done only on small jobs and with the approval of the Engineer.

(iii) Rolling

Rolling shall be carried out by using pneumatic tyred rollers approved by the Engineer.

Rolling shall commence immediately after the spreading of aggregate is completed and continued until all the aggregate is well embedded in the binder.

(e) **Construction of DBST**

The first and the second seals shall be constructed without exposing the first seal to traffic. However, sufficient curing time between the two seals shall be allowed if emulsion is used as a binder. The curing times shall not be less than one hour for emulsions.

In this method, each seal shall be constructed exactly as that of a SBST as given in Sub section 505B.3(a) to (d) except that the rates of application of aggregate and binder for the second method shall normally be within the limits as given in Table 505 B-3

Table 505B-3 Quantities of materials for DBST

Nominal Size of Aggregate mm	mm	Rate of Application			
		Aggregates		Penetration grade bitumen	
First Seal	Second seal	First seal Cu.m per 100 sq.m	Second seal Cu.m. per 100 sq.m	First seal Litre per sq.m	Second seal Litre per sq.m
20	10	1.3-1.7	0.7-1.0	0.65-0.85	1.0-1.3
14	6.3	1.0-1.3	0.55-0.75	0.5-0.7	0.75-1.05

Note

The rates of application of binder given above are that for penetration grade bitumen. In the case of emulsion, corrections have to be made by dividing these rates by the fraction of bitumen present in these binders.

(f) The alternative method of construction of Seal Coat Treatments on WBM and DBM Bases

(i) Single seal or first seal of double seal coat

The construction of single seal or first seal of double seal shall be carried as per Sub section 505B.3(a) to (d) except that the rates of application of aggregate and binder shall be as given in Table 505B-3. The size of aggregate used shall be 20mm.

Table 505B-4 – Quantities of materials for the first and second seal of the alternative Surfacing of WBM or DBM

Nominal size of aggregate in mm		Rate of Application			
		First Seal		Second Seal	
First Seal	Second Seal	Aggregates Cu.m per 100 sq.m.	Hot Bitumen Litre per sq.m.	Aggregates Cu.m per 100 sq.m.	Hot Bitumen Litre per sq.m.
20	10	1.7 to 1.9	2.0 to 2.5	1.0 to 1.3	0.6 to 0.9

Note

The rates of application of binder given above are that for penetration grade bitumen. In the case of emulsion, corrections have to be made by dividing these rates by the fraction of bitumen present in these binders.

(g) Second Seal of Double Seal coat

Unless otherwise specified, the second seal shall be carried out using 10mm aggregate and as per Sub section 505.B (a) to (d) except the rates of application of aggregate and binder shall be as given in Table 505B-4. The second seal shall not be constructed till traffic is allowed on the first seal for at least two weeks. Which period, however, shall normally not exceed 8 weeks.

(h) Aftercare

Traffic shall not be allowed over the newly treated surfaces till such time as the aggregate is well embedded in the binder and no whip-off takes place. Normally this period shall be not less than 12 hours. Where, for special reasons, the Engineer decides to allow traffic earlier it shall be ensured that their speeds do not exceed 15 km.p.h. Where practicable, traffic shall be limited to less than 30 km.p.h. during the first one to two weeks after completion.

In the case of DBST second method traffic shall not be allowed on the first seal before the completion of the second seal.

(i) Not Used

(j) Quality Control

Control on the materials and works shall be exercised in accordance with Section 1602.

505B.4 Measurement and Payment

(a) Measurement

Seal coat shall be measured by either of the two following method as specified: -

(i) First method of measurement

The work shall be measured based on the quantities of the materials used in the accepted work.

The binder shall be measured in litres and the aggregate shall be measured loose in Cu.m in the truck or as stockpiled and as accepted by the Engineer.

The quantity of each of the above materials measured shall be that required to comply with the Specification and the requirements of the Engineer or shall be the actual quantity used and accepted whichever is the less.

(ii) Second method of measurement

In the alternative, surface treatments shall be measured in Sq.m of each type of completed and accepted work. Surface measurements shall be based on the width and length of the surface area and as accepted by the Engineer.

(b) Payment

In the first method of measurement given above, the quantities, measured as provided above, will be paid for at the Contract unit price for each of the items listed in the bill of quantities. The payment shall be full compensation for furnishing the materials, and providing all labour, equipment, tools and incidentals necessary to complete the work using the material supplied.

In the second method of measurement for payment will be based on the Contract unit rate which shall include full compensation for providing all materials, labour, tools, equipment and incidentals necessary to complete the work to Specifications.

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
Method 1		
505B(1)	Binder for seal coat work (state type)	Litres
505B(2)	Aggregate for seal coat (state size/s and whether pre-coated)	Cu.m
Method 2		
505B(3)	Seal coat treatment (state type and other details)	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

506 ASPHALTIC CONCRETE SURFACING

506.1 Description

This work shall consist of furnishing materials, mixing at a central mixing plant, and spreading and compacting asphalt concrete Surfacing on an approved Base course as shown on the Drawings or as instructed by the Engineer.

The asphalt concrete Surfacing shall consist of Binder course and a wearing course or a wearing course only, as specified.

This work shall be carried out in accordance with these Specifications and with the lines, levels, grades, dimensions and Cross-sections as shown on the Drawings or as directed by the Engineer.

506.2 Materials

Materials used shall conform to the requirements of the following, unless otherwise specified :-

(a) The bitumen binder shall be 60-70 penetration grade bitumen to Sub section 1702.1.

(b) Aggregate - coarse aggregate

The coarse aggregate shall be of nominal maximum size 20 mm and fine aggregate shall conform to the general requirements of Sub section 1701.3(a)

When the coarse and fine aggregate are combined, along with filler where required, the combined grading requirements shall be as given in Sub section 506.3 for Binder course & wearing Course Type 1, 2 & 3.

The Contractor shall control the production of coarse aggregate, fine aggregate and filler for asphalt concrete at the crushing and screening plant such that the grading of aggregates in stockpiles shall be uniform and consistent throughout the period of asphalt production and paving operations. Regular sampling of stockpiles by the Contractor shall be carried out to demonstrate the uniformity and consistency of grading of the aggregate production to the satisfaction of the Engineer.

(d) Filler, where separately used in the mix, shall be chemically active cement and hydrated lime and chemically inert limestone dust and crusher fines or other non plastic inert materials to section 1706.

506.3 Mix Requirements

(a) Combined Grading of Aggregate and Binder Content

The grading requirements for the combined aggregate and the binder content shall be as given in Table 506-1 for the Binder course & wearing courses type 1, 2, 3 & 4.

Table 506-1 - Aggregate grading, binder content and thickness requirements for Binder course and wearing courses

Mix classification	Binder Course	Wearing Course Type-1	Wearing Course Type-2	Wearing Course Type-3	Wearing Course Type-4
Compacted Thickness mm -					
Max.	75	75	75	75	75
Min.	35	35	35	40	40
Sieve Size					
Mm µm					
28	100	100	-	100	100
20	90 – 100	85 - 100	100	93 – 100	95 - 100
14	-	-	82 - 92	-	-
10	56 – 82	66 - 94	61 - 81	59 – 94	58 - 84
5	36 – 58	46 - 74	41 - 66	38 – 69	36 - 66
2.36	21 – 38	35 - 58	27 - 48	25 – 48	23 - 49
1.18	15 – 32	26 - 48	20 - 40	20 – 40	-
600	10 – 26	18 - 38	15 - 35	15 – 32	-
300	6 – 20	11 - 28	10 - 25	10 – 23	5 - 19
150	3 – 13	7 - 20	7 - 17	4 – 15	-
75	1 – 7	3 - 12	5 - 9	3 – 12	2 - 8
Percentage binder content by total weight of mix	3.5 – 5.5	4.0-6.5	4.0-6.0	4.0 – 6.5	4.0-6.0

(b) Mix Characteristics

The mix characteristics as determined by the Marshall Mix Designs procedure shall be as given in Table 506-2(a) and 506-2(b) for Binder courses and for wearing courses respectively for low, medium or high traffic depending on whether the cumulative number of standard axles (CNSA), for the design life of the Surfacing, is less than 10^4 or between 10^4 and 10^6 or greater than 10^6 respectively.

In the determination of the above, laboratory samples shall be prepared and tested as specified in Sub section 1802.4(a).

The wearing course & Binder course mix shall be determined by using Table 506-2(b) - High Traffic category, under otherwise stated in the Contract Documents or according to the Traffic category.

Table 506-2(a) – Binder Courses

No	Description	Low Traffic CNSA < 10^4	Medium Traffic CNSA between 10^4&10^6	High Traffic CNSA > 10^6
1.	Marshall stability in kN	Not less than 3.33	Not less than 5.34	Not less than 8.0
2.	Marshall flow (0.25mm)	8 to 20	8 to 18	8 to 16
3.	Air voids in mix percent (VIM)	3 to 7	3 to 7	3 to 7
4.	Voids in mineral aggregate VMA (%)			
	(i) for design VIM of 4%	Not less than 13	Not less than 13	Not less than 13
	(ii) for design VIM of 5%	Not less than 14	Not less than 14	Not less than 14

Table 506-2 (b) – Wearing Courses

No	Description	Low Traffic	Medium Traffic	High Traffic
1.	Marshall stability in kN	Not less than 3.33	Not less than 5.34	Not less than 8.0
2.	Marshall flow (0.25mm)	8 to 20	8 to 18	8 to 16
3.	Air voids in total mix (VIM) (percent)	3 to 5	3 to 5	3 to 5
4.	Voids in mineral aggregate VMA (Percent)			
	For design VIM of 4%	Not less than 13	Not less than 13	Not less than 13

The asphalt contents on the "Wet" or right-hand increasing side of the VMA curve shall be avoided

The air voids in total mix at refusal density as per TRL UK Overseas Road Notes 19 & 31 for High Traffic and severe sites (slow moving heavy traffic) shall not be less than 2.5 and 3% respectively.

506.4 Job Mix Formula

The Contractor shall submit to the Engineer in writing at least two weeks before the start of the work, the job mix formula proposed to be used by him for the work based on trial mix designs carried out in accordance with "Mix Design Methods for Asphalt Concrete (MS - 2)" published by the American Asphalt Institute or similar approved method which shall give the following details :-

(i) A single percentage of aggregate passing each specified test sieve.

(ii) A single percentage of binder content by total weight of total mix.

(iii) A single temperature at which the mix is emptied from the mixer which shall not be less than 145 degrees C.

(iv) A single temperature at which the mix is to be delivered to the paver on the road which shall not be less than 135 degrees C.

In addition the Contractor shall give the sources, locations of all materials and the details of the mix design based on requirements given in Table 506-2(a) and (b).

The Engineer shall check the proposed Job Mix Formula for compliance with the Specification and shall approve the same when compliance is achieved.

All mixes produced shall conform to the job mix formula approved by the Engineer within the ranges of tolerances given in Table 506-3. In the case of the sieves, the overall grading shall be within the grading bands as given in Table 506-1.

Table 506-3 – Permissible Variations from job Mix Formula

Aggregate Passing 14 mm and larger	± 8%
Aggregate Passing 10 mm and 5 mm sieves	± 7%
Aggregate Passing 2.36 mm and 1.18 mm sieves	± 6%
Aggregate Passing 600 µm and 300 µm sieves	± 5%
Aggregate Passing 150 µm sieves	± 4%
Aggregate Passing 75 µm sieves	± 1.5%
Binder content percent by weight of total mix	± 0.3%
Temperature of mixture when emptied from mixer	± 10 ^{0}C
Temperature of mixture when delivered on road	± 10 ^{0}C

If a change in the materials or source of materials is proposed, or a change in the grading of the coarse and fine aggregate or filler occurs a new job mix formula shall be submitted and approved before the mix containing the new material is delivered to site.

When unsatisfactory results or changed conditions make it necessary, the Contractor, if required, shall submit a new job mix formula to the Engineer for approval.

506.5 Construction Requirements

(a) Preparation of Existing Surface

(i) Where asphalt concrete Surfacing is laid over newly constructed aggregate Bases with total asphalt concrete thickness is more than 100mm, asphalt can be laid directly over the un-primed surface of the aggregate Base course. Prior to laying of the asphalt concrete Surfacing, the surface shall be cleaned of extraneous matter and dust as per paragraph 1 of Sub section 501.3(b) and shall be free of moisture and shall not be opened for traffic.

If the total thickness of asphalt is less than 100mm, the newly constructed aggregate Base surfaces shall be cleaned of extraneous matter and dust and shall be primed as per Section 501.

(ii) Where asphalt concrete Surfacing are laid on existing bituminous Pavements, the surfaces of such Pavements shall be corrected to the required width and profile as directed by the Engineer.

On the corrected surfaces, a tack shall be applied as per Section 502.

(iii) Where the mix is laid over cement concrete Pavements or bridge decks, joints and cracks shall be cleaned and filled with bituminous material as approved, and any unevenness of the surface shall be corrected as required. A tack coat as per Section 502 shall then be applied to the surface.

(b) Weather Limitations

The bituminous mix shall not be laid during rainy weather or when the surface on which it is laid is damp or wet.

(c) Limitations due to Lack of Equipment Etc.

No work shall be carried out when there is insufficient equipment for hauling, spreading, compaction and finishing or insufficient labour to ensure progress at a rate compatible with the output of the mixing plant to ensure a continuous paving operation.

(d) Thickness of Compacted Mix

The maximum and minimum thickness of any compacted layer shall be as given in Table 506-1.

Tolerances for the wearing course thickness shall be in accordance with Section 1601.

(e) Mixing Plant and the Preparation of Mix

An approved mixing plant of the automatic batch type shall be used for the preparation of the mix, which shall have the capacity sufficient to supply the paver continuously. The asphalt mixing plant shall generally comply with and be operated in accordance with the "Asphalt Plant Manual (MS-3) " published by the American Asphalt Institute.

The mixer shall be capable of accurately batching the aggregates, filler and binder and mixing the same thoroughly so that the mixed material on discharge from the mixer is uniform in composition and that all aggregate particles are completely coated.

Batch type plants, shall be equipped with suitable means for accurately weighing of each bin size of aggregate and the filler. The scales of such weighing mechanisms shall be calibrated at least once a month or at the frequencies as instructed by the Engineer using standard weights. The Contractor shall always have at hand sufficient weights for such calibration.

The mixing plant shall be capable of heating the aggregate and the binder separately to the appropriate temperatures.

The binder and mineral aggregate shall be heated separately to temperatures between 140 and 170 degrees C, and 150 and 170 degrees C respectively. The materials shall be mixed at temperatures within absolute limits of 145 and 170 degrees C, even allowing for tolerances.

The plant shall, if situated in urban areas or required by the relevant authorities be equipped with an approved dust collector so constructed as to waste or return uniformly to the elevator all or any part of the material collected.

The mixing plant shall be capable of loading the mix into transport vehicles in such a manner that segregation does not occur.

In addition the plant shall be provided with the following:-

(i) Covered protected ladders or stairways with secure hand rails in adequate number which shall be placed at all points required for accessibility to all operations.

(ii) Covering devices for pulleys, belts and drive mechanisms and other moving parts.

(iii) Ample and unobstructed space on the mixing platform.

(iv) A clear and unobstructed passage at all times in and around the tipper loading space which shall be kept free from drippings from the mixing platform.

(v) Insulated flexible pipe connections to carry hot bitumen from the heated storage tanks to the mixer.

(f) Transport of Mix

The mix shall be transported from the mixing plant to the point of use in suitable purpose made tipping trucks.

The trucks shall be in good mechanical condition at all times. They shall have clean and smooth metal beds, that have been sprayed with water or lime solution or any other detergent solution approved by the Engineer, to prevent the mix from adhering to the beds. The amount of sprayed fluid shall however be kept to a practical minimum. All precautions shall be taken to avoid segregation of mixed materials and to ensure that they do not become contaminated with dust or foreign matter.

Any truck causing excessive segregation of bituminous material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts or that causes undue delays shall be removed from the Works until such conditions are corrected.

Each load shall be covered with a properly fastened canvas or other suitable material of such size as to protect the mix from the weather or dust. In order that the mix shall be delivered to the Site within the specified temperature range, during cold weather or during long hauls, properly fastened insulating covers shall be used.

Loading and transporting shall be coordinated such that spreading, compacting and finishing shall be completed during daylight hours. Working during darkness will not be permitted, unless adequate illumination, as approved by the Engineer is provided by the Contractor.

The mix shall not be delivered to the paver at the site at a temperature below 135 degrees Centigrade.

(g) Paving Plant and Laying of the Mix

The mix shall be laid at temperatures not below 135^0C by means of approved mechanical self powered pavers. They shall be capable of spreading, finishing and providing initial compaction to the mix so that, the Surfacing can be finished to the required lines, grades, levels, dimensions and Cross-sections intended, either over the entire width or over such other partial widths as may be practicable.

The pavers shall be equipped with receiving hoppers and spreading screws of the reversing type to place the mix evenly in front of adjustable steering devices and shall have reverse as well as forward travelling speeds. They shall also be furnished with a vibrating screed (levelling) unit equipped with suitable burners or heaters and tamping bars or vibration attachments all operating in accordance with the manufactures instructions.

The pavers shall be able to confine the edges of the Pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be adjustable to achieve the Cross-sectional shape and level tolerances prescribed and shall be so designed and operated as to place the required thickness and weight per Sq.m of material.

A fully trained and experienced operator shall be in direct charge of the paver at all times. The pavers shall be operated so as to avoid dragging of the material.

If the asphalt is to be laid on a Bitumen Base surface which is 7 days old after laying and is not used by any form of traffic, no tack coat is required to be applied before laying asphalt if not otherwise instructed by the Engineer. If the Bitumen Bound Base surface is older than the time specified above and/or was opened for traffic, a tack coat shall be evenly applied, as specified in Section 502, at a rate of

0.25 to 0.50 l/m^2 or at a rate determined by the Engineer. Payment for the tack coat shall be made under the pay items in Section 502.

The bituminous mix, after spreading, finishing and initial compaction by the paver, shall have a smooth surface free of irregularities caused by dragging, tearing or gouging.

During construction, if it is seen that the paver in operation leaves on the Surfacing tracks or indented areas or other objectionable irregularities or segregation of mix that cannot be satisfactorily corrected by normal operations, the use of such a paver shall be discontinued forthwith and another satisfactory paver shall be provided by the Contractor.

In narrow widths and in restricted areas where the paver cannot operate, the mix may be manually laid, in which case, care shall be taken to avoid segregation. Manually laid strips shall be rolled at the same time as the paver laid work and allowance shall be made for extra compaction of these strips using appropriate approved purpose made compaction equipment. Any defects in the laid surface shall immediately be rectified before rolling commences and there shall be no unnecessary scattering back by hand of material on paver laid work.

(h) Compaction Procedure

Immediately after the mix has been spread and struck off, the surface shall be checked and any irregularities adjusted. Rolling shall commence as soon as the material will support the roller without undue displacement or cracking. The mix shall then be thoroughly and uniformly compacted by rolling, according to the sequence of rolling as given below :-

i. Transverse joints
ii. Longitudinal joints, where applicable
iii. Outside edge
iv. Initial or breakdown rolling
v. Second or intermediate rolling
vi. Finish or final rolling

Normally the first rolling of all joints and edges and the initial or breakdown rolling, shall all be done with static weight tandem or vibratory steel wheeled tandem rollers and the second or intermediate rolling with pneumatic tired rollers. Use of any other rollers for the above purposes shall be with the prior approval of the Engineer.

During initial or breakdown rolling, the direction of travel of the roller shall be such that the powered or driving wheel passes over the un-compacted mix first, before the driven wheel. The second intermediate rolling shall follow the initial or breakdown rolling as closely as possible while the bituminous mix is still plastic and at a temperature that will result in maximum density. The final rolling shall be accomplished with static weight tandems or vibratory tandems (without vibration) while the material is still warm enough for removal of roller marks.

In general the type of roller or roller combination to be used shall be proposed by the Contractor for the approval of the Engineer prior to the commencement of work and the rollers shall satisfy the requirements given in 506.5(j).

The speed of the rollers shall not exceed the limits given in Table 506-4 and shall be at all times be slow enough to avoid displacement of the hot mix.

Table 506-4 – Number of roller passes and the speed of the roller

Type of roller	Speed (km/hr)		
	Breakdown	Intermediate	Finish
Steel Wheeled Rollers	3	5	5
Pneumatic Tired Rollers	5	5	8
Vibratory Rollers	5	5	-

During stages of initial, intermediate and final rolling, rolling shall commence at the lower side of the spread and progress towards the higher side parallel to the centre line of the Pavement.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by either removing or by adding fresh material. The rolling shall be continued till the entire surface has been compacted adequately and the roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one half of the proceeding pass. The roller wheels shall be kept damp if required to avoid the material sticking to the wheels and being picked up. However, the quantity of water used for this purpose shall be the minimum required and shall not form puddles on the area under compaction.

When using a vibratory roller for the compaction of a Surfacing the vibration shall be turned off before the roller stops when reversing direction, and turned on after it starts in the new direction.

Vibratory rollers shall not be used for Surfacing of thickness less than 50mm, unless otherwise approved by the Engineer.

The breakdown and the intermediate rolling shall be carried out at temperatures not less than 135 degrees C and 115 degrees C respectively.

The final rolling shall be completed before the temperature of the mix falls below 90 degrees C.

Rollers shall not be allowed to stand on newly laid material until 6 hours has elapsed after completion of the compaction of the Surfacing.

When the bituminous mix is spread in areas that are inaccessible to rollers such as places near kerbs and manholes etc., compaction shall be achieved by hand tampers, mechanical tampers, or small vibrating plate compactors to the approval of the Engineer. In such locations spreading and compacting shall be carried out without any delay before the mix cools below a minimum of 120 degree C.

The density of all samples taken from the compacted surface course shall not be less than 97% of the Marshall Density at the point appropriate to the locations. The sample densities shall be determined as given in Sub section 1802.4(c) by cutting cores of minimum diameter 100mm.

Transfer of refusal density mix design to compaction trials

A mix shall be laid and compacted on the road to give a mean value of not less than 95% of it's refusal density and no individual value should be less than 93 percent of it's refusal density.

The compacted layer thickness shall be 2.5 to 4 times the maximum aggregate particle size to obtain satisfactory workability.

A minimum of three trial lengths shall be constructed with bitumen contents at the laboratory optimum for refusal density and at 0.5% above and at 0.5% below the optimum.

These trials shall be used to:

i Confirm the mix is workable and can be compacted to a satisfactory density.
ii Establish the best rolling patterns for the available road rollers
iii Obtain duplicate sets of cores so that the maximum binder content which allows the required VIM to be retained at refusal density, can be confirmed.

(i) Not Used

(j) Requirements of Compacting Equipment

(i) General

Generally, with each paver, a minimum of 3 rollers shall be provided by the Contractor. On small projects involving a total of less than 5000 tonnes of material the minimum requirements shall be two tandem rollers.

All rollers shall be self propelled, capable of being reversed without backlash and equipped with power steering, dual controls allowing operation from either the right or left side. They shall have water tanks with sprinkler systems to ensure even wetting of wheels or tires.

The rolling surface of the wheels of a steel wheel roller shall be checked for wear. If grooves or pits have been formed on the rolling surface, the roller shall not be used on the work area.

Each roller shall have a calibration chart showing the relationship between depth of ballast and weight and giving the tare weight of the roller. Each roller shall be in a good condition and shall be operated by a competent and experienced driver.

(ii) Steel Wheeled Rollers

Steel wheeled rollers (tandem) shall weigh not less than 8 metric tonnes. The minimum rolling pressure of the rear wheels of each three wheeled roller or at least one roll of each tandem roller shall be 35 kN/m of roller width.

(iii) Pneumatic Tired Rollers

Pneumatic tired rollers shall have not less than seven wheels (3 wheels on the front axle and four on the rear) fitted with smooth tread compactor tires, of equal size and construction, capable of operating at inflated pressures up to 850 kN/square meter. The wheels shall be able to move up and down independently of one another. Wheels shall be equally spaced along both axle lines and arranged so that tires on one axle line tract falls midway between those on the other with an overlap. The tires shall be kept inflated to the manufacturers specified operating pressures with variation not exceeding 36 kN/square meter. Means shall be provided for checking and adjusting

the tire pressures on the job at all times. For each size and type of tire used, each roller shall have charts or tabulations showing the relationship between wheel load, inflation pressure and tire contact pressure, width and area. Each roller shall be equipped with means of adjusting its total weight by ballasting so that the load per wheel can be varied from 1,500 to 2,500 kilograms. In operation the tire inflation pressure and the wheel load shall be adjusted, as required by the Engineer, to meet the requirements of each particular application in general the compaction of any course with a pneumatic tired roller shall be accomplished with contact pressures as high as the material will support.

(iv) Vibratory Rollers

Generally Vibratory rollers shall be equipped with automatic vibration control which cuts out the vibratory system before the machine comes to a halt.

The minimum operating weight of the roller shall be 6 tonnes and minimum drum width 0.9 m, the minimum linear drum applied force 44 kN/m and the minimum frequency of vibration 33 Hz (2000 cycles/min).

(k) Joints

Both longitudinal and transverse joints in successive courses shall be staggered so as not to be one above the other. As far as practicable, longitudinal joints shall be arranged so that the joints in the top course shall be at the location of the line dividing the traffic lanes, and the transverse joints shall be staggered at a minimum of 250 mm and be straight.

Longitudinal and transverse joints shall be made in a careful manner so that well bonded sealed joints are provided for the full depth of the course. No mixture shall be placed against previously rolled material unless the edge is trimmed vertically to line and the vertical edge applied with a thin coating of binder just before additional mix is placed against the previously compacted material.

Paving shall be as nearly continuous as possible and rollers shall pass over the unprotected end of freshly laid mix only when authorised by the Engineer. In all such cases provision shall be made for a properly bonded and sealed joint with the new surface for the full depth of the course as specified above. Before placing mix against them, all contact surfaces of kerbs, gutters, manholes, etc., shall be given a thin uniform coating of hot bitumen and the joints between these structures and the surface mix shall be effectively sealed by the subsequent spreading, finishing and compaction operations.

(l) Miscellaneous Requirements

The Contractor shall provide suitable means for keeping all tools clean and free from accumulations of bituminous material. He shall provide and have ready for use at all times enough tarpaulins or covers, as may be directed by the Engineer, for use in any emergency such as rain, chilling wind, excessive dust or unavoidable delay, for the purpose of covering or protecting any material that may have been dumped and not spread. Generally the hot mix shall be discharged directly from the asphalt delivery trucks into paver receiving hopper unless the Engineer approves dumping and spreading by hand in difficult areas not accessible by paver.

(m) Aftercare

Sections of the newly finished work shall be protected from traffic of any kind until the mix has sufficiently hardened. Also traffic shall normally, not be permitted over newly laid surfaces at least for twelve hours after laying or the temperature of the newly laid Surfacing has achieved the ambient temperature.

In the event any Binder course is constructed initially the surface so formed shall be maintained in its finished condition until the surface course is placed thereon, and any damage caused shall be made good by the Contractor. If the damage could be attributed to the negligence of the Contractor, it shall be corrected at his own expense.

(n) Surface Finish and Quality Control

The asphalt concrete surfacing shall be finished to the requirements given within this Section and in conformance with Section 1601.

The Control of the quality of materials and works shall be exercised in accordance with Section 1602.

506.6 Measurement and Payment

(a) Measurement

Asphalt concrete surfacing shall be measured by the following methods:-

(i) For uniform thicknesses

Asphalt concrete surfacing shall be measured by sq.m of mix furnished, spread, compacted, completed and accepted. Measurements shall be of the areas and thickness as shown on the Drawings, described in the Specification or instructed by the Engineer.

Deficiencies in thickness of the wearing course shall, unless an overlay is constructed at the Contractor's expense, result in a proportion only of the wearing course area being measured for payment. Proportions shall be determined in accordance with the thickness deficiencies and area proportions described below.

Thickness of asphalt concrete wearing course shall be determined by average calliper measurement of cores, rounded upwards to the nearest mm.

Paved sections to be measured separately shall consist of each 100 lin.m section in each traffic lane. The last section in each traffic lane shall be 100 m plus the fractional part of 100 m remaining. At areas such as intersections, entrances, crossovers, ramps, etc. it shall be measured at one section and the thickness of each shall be determined separately. Small irregular unit areas may be included as part of another section.

One core shall be taken from each section by the Contractor at approved locations and in the presence of the Engineer. When the measurement of the core from any paved section is not deficient by more than 5mm from the specified thickness, the core will be deemed to be of the specified thickness as shown on the Drawings.

When the measurement of the core from any paved section is deficient by more than 5 mm but not more than 15 mm, 2 additional cores spaced at not less than 25 m and as decided by the Engineer shall be taken and used together with the first core to determine the average thickness of such section.

When the measurement of the core from any paved section is less than the specified thickness by more than 15 mm, the average thickness of such section shall be determined by taking additional cores at not less than 5 m intervals parallel to the centreline in each direction from the affected location until, in each direction, a core is taken which is not deficient by more than 20 mm. Exploratory cores for deficient thickness will not be used in average thickness determinations.

Any deficiencies in the total thickness of wearing courses shall be subject to a proportional reduction in the area of wearing course measured for payment. Alternatively, the Contractor shall construct all at his own expense, a wearing course overlay, if practicable in the judgment of the Engineer. Any such overlay shall be a minimum of 40 mm compacted thicknesses and to the specified standard of the course it is overlaying.

Table 506-5 Deficiencies in Thickness of Wearing and Binder Courses

Deficiencies in Thickness as Determined by Cores (mm)	Proportion of Wearing Course Area Measured for Payment
0.0 to 5.0	100%
5.1 to 10.0	80%
10.1 to 15.0	60%
15.1 to 20.0	40%

(ii) For regulating courses, in tonnes weighted using a weigh bridge

The asphalt concrete measured shall be the number of tonnes in the accepted pavement. The method of measurement shall be as follows;

The asphalt concrete shall be weighted after mixing using an approved weigh bridge. The total quantity of asphalt concrete mixed and laid shall be computed daily from load delivery tickets. This weight shall be adjusted by deducting the weight of mix wasted at the joints, the weight of mix laid in areas outside the defined pavement edge and the weight of mix laid within the defined pavement but not accepted by the Engineer. The total weight deducted shall be as assessed by the Engineer.

(b) Payment

Payment for asphalt concrete Surfacing will be made at the Contract unit rate for the item as measured above. The price shall be full compensation for furnishing all materials, for mixing and placing of the mixed material and for providing all plant, machinery, equipment, tools, labour and incidentals necessary to complete the work to these Specifications.

The Pay Item and Pay Unit will be as follows :-

Pay Item	Description	Pay Unit
Either		
506 (1)	Asphalt Concrete Surfacing of uniform thickness (state compacted thickness)	sq. m.
or		
506(2)	Asphalt concrete surfacing for regulating courses	Tonnes

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

507 COLD MIX SURFACING

507.1 Description

This work shall consist of construction of cold mix bituminous Surfacing, on existing Pavements or on bridge decks.

These mixes shall either be dense graded or open graded. However, the open graded mixes are normally not recommended for use on bridge decks.

This work shall be carried out in accordance with these Specifications and with the lines, levels, grades, dimensions and Cross-sections as shown on the Drawings or as directed by the Engineer.

507.2 Materials

All materials shall meet the requirements of the following, unless otherwise specified:-

(a) The binder shall be medium curing cutback bitumen (10 to 20 percent) or MC 800 or MC 3000, or bituminous emulsions (CMS-2, CMS-2 h, CSS-1, or CSS-1 h) to Sub section 1702.3.

(b) The coarse aggregate of nominal maximum sizes 20mm and 14mm and the fine aggregate shall conform to the general requirements of Sub section 1701.3(a). and when combined they shall conform to the mix requirements of Sub section 507.3.

(c) The fine aggregate shall be crusher fines or sand to Sub section 1701.3(a).

507.3 Preparation of Cold Mix

(a) Proportioning of Aggregate and Binder

In preparing cold mix, aggregate and binder shall normally be proportioned by weight.

On small jobs, however, with the approval of the Engineer, proportioning may be carried out on a volume basis.

For weight proportioning the combined aggregate gradings and the binder contents given in Table 507-1 shall be used.

Volume batching shall be carried out on the basis of the nominal aggregate ratios given Table 507-2 and the proportioning of aggregates and binder as given in Table 507-3.

Table 507-1 - Aggregate grading and the binder contents

Grading Type	Dense graded		Open graded	
Nominal max. Size of agg.	20mm	14mm	20mm	14mm
Sieve Size	Total percentage passing by weight			
mm µm				
28	100	-	100	-
20	92-100	100	92-100	100
14	-	93-100	67-85	88-100
10	58-82	-	-	-
5	36-66	46-76	20-37	38-53
2.36	23-49	28-56	-	15-30
300	5-20	5-22	-	-
75	0-5	0-8	0-3	0-3
Binder content as % of wt. of aggregate				
(a) Cutback Bitumen	4.5-5.5	5.0-6.0	4.5-5.0	4.5-5.5
(b) Emulsion	5.0-6.5	5.5-6.5	4.5-5.5	5.0-6.0

Table 507-2 - Volume ratios for aggregate

Nominal maximum Size of aggregate	Volume ratios ; coarse: fine	
	Dense graded	Open graded
20mm	3:2	4:1
14mm	2:1	4:1

Table 507-3 - Volume proportioning of aggregates and binder

Nominal max:	Coarse agg. In unit Volume	Fine agg. In unit Volumes	Cutback In litres	Emulsions In litres
(a) Dense graded				
20mm	6	4	22.0-24.0	23.0-25.0
14mm	6	3	21.0-23.0	22.0-24.0
(b)Open graded				
20mm	8	2	17.0-19.0	20.0-21.0
14mm	8	2	20.0-21.0	21.0-23.0

Note

A unit volume=1 cu.ft. (0.028 cu.m.). In measuring, unit volume boxes shall be made use of.

(b) Preparation of the Mix using Cutback Bitumen

The coarse and fine aggregate shall be proportioned as specified, thoroughly mixed, dried and heated to a temperature within the range of 115 to 155 degree C in a suitable mixer or on heated metal plates or by any other appropriate means as approved.

Cutback bitumen shall also be heated to a temperature within the same range and mixed with the heated aggregate in a mixing plant or manually, till all the particles are fully coated.

(c) Preparation of the Mix using Bituminous Emulsion

Bituminous emulsion of the medium and slow setting types shall be used for open graded mixes, while for dense graded mixes, only the slow setting types shall be used.

Firstly, the coarse and fine aggregates shall be proportioned and mixed in a mechanically operated mixer or by manual means as approved by the Engineer. Where the mixer is used the period of mixing shall be 1 to 2 minutes. The aggregate shall have a damp but not wet surface at the time of mixing. Where it is too dry adequate quantity of water shall be added to the aggregate before mixing. The specified quantity of emulsion shall then be added and mixed in the mixer or manually with the aggregate, for a period of ½ to 1 ½ minutes. Over mixing shall be avoided. In machine mixing, the mixed material shall be immediately discharged into vehicles or wheel barrows as appropriate for purposes of transport.

507.4 Transporting for Use or Stockpiling of Mix

The mix shall then be transported to the point of use or stockpiles as required. The vehicle employed for transport shall be clean and where required, the material shall be covered in transit.

The material, which is stockpiled for later use, shall be protected from the elements. The mix shall be used within 7 days of preparation, unless otherwise allowed by the Engineer.

507.5 Construction Requirements

(a) Thickness of Surfacings

The thickness of Surfacing shall be as specified and as directed and shall normally be within the limits of 20-30mm for 14mm aggregate and 30-45mm for 20mm aggregate.

(b) Weather and Other Limitations

Cold mix Surfacing shall not be laid during rainy weather or when the surface on which it is laid, is damp or wet or when the atmospheric temperature is below 15 degrees C.

(c) Preparation of Base

The Base on which the bituminous Surfacing are to be laid shall first be corrected, as required, by suitably patching potholes, ruts, depressions and eliminating all other surface irregularities.

(d) Application of a Prime Coat or Tack Coat

A prime coat complying with Section 501 shall be applied over newly constructed aggregate Bases, or a tack coat complying with Section 502 shall be applied over existing bituminous Surfacing, prior to laying of cold mix Surfacing. Application of tack coat shall, however, not be necessary when laying of a cold mix Surfacing follows soon after the construction of a bituminous Base or levelling course. Also a tack coat shall not be necessary where a second layer of cold mix is laid soon after the first.

(e) Spreading and Rolling

The premixed material shall be spread, to the required thicknesses and levels either manually using rakes and other suitable implements, or by using a paver, where appropriate.

When using the cold mix prepared with cutback bitumen, the mix shall be aerated by suitably spreading and exposing so as to reduce the volatile content in the binder prior to compaction.

When using the cold mix prepared with emulsion, it is preferable to commence rolling when, or just before the emulsion starts to break.

When sufficient length of the material has been laid, compaction shall be carried out by using a 6-8 tonne smooth wheel tandem roller, or any other approved roller. The method of rolling shall be carried out as described in Sub section 403.3(c)(iv).

As far as practicable, the mix shall be rolled in the following order, as described in Sub section 506.5(j).

(i) Transverse joints

(ii) Longitudinal joints where applicable

(iii) Outside edge

(iv) Breakdown rolling

(v) Finish or final rolling

When the roller has passed over the whole area once, any high spots or depressions shall be corrected by removing or adding premixed material. Rolling shall then be continued until the entire surface has been compacted and all the roller marks are eliminated. The wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up.

Rollers shall not be allowed to stand on newly laid Surfacing.

(f) Joints

Joints shall be constructed in accordance with Sub section 506.5(k).

(g) Construction of a Second Course

Where cold mix prepared with cutback bitumen is used, the construction of a second course if required shall not be carried out for a period of at least 1 week, after the completion of the first course and till the first layer is completely cured and the solvent (kerosene) has evaporated. Where cold mix prepared with emulsion is used, the time lag shall not be less than 4 hours.

(h) Finishing Operations and Quality Control

The cold mix Surfacing shall be finished to the requirements of Section 1601.

The control on the quality of materials and work shall be in accordance with Section 1602.

(i) Aftercare

Traffic shall not be permitted to run on any newly laid areas until a period of 12 hours has elapsed after the completion of the construction of Surfacing, unless otherwise directed.

507.6 Measurement and Payment

(a) Measurement

Cold mix Surfacing shall be measured by one of the following methods specified in the Contract.

(i) In Cu.m, as compacted in position measured by taking levels
Method of measurement shall be as given in Sub section 106.2.

(ii) In Cu.m measured as loose volume

The cold mix Surfacing shall be measured as piled or in the hauling vehicle. This method is essentially for small works including small scale regulating courses.

The volume of cold mix measured as above shall be adjusted for material wasted at the joints, for material laid outside the defined Pavement edges, for excess laid and for material laid within the defined Pavement edge but not accepted by the Engineer.

(b) Payment

Payment for cold mix Surfacing shall be made at the Contract unit price for the item as measured above. The price shall be full compensation for furnishing all materials, for mixing and placing of the mixed material and for providing all plant, machinery, equipment, tools, labour and incidentals necessary to complete the work to these Specifications.

Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
Either		
507(1)	Cold mix Surfacing, compacted in position (state compacted thickness)	Cu.m
or		
507(2)	Cold mix Surfacing, in loose state	Cu.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

508 SLURRY SEAL SURFACE DRESSINGS

508.1 Description

This work shall consist of construction of slurry seal Surfacing on existing Pavement or newly constructed Pavement by mechanical or manual methods.

The work shall be carried out in accordance with the Specifications or as directed by the Engineer.

508.2 Materials

508.2(a) Aggregate

The aggregate shall be graded crushed rock with nominal maximum size of 10 mm conforming to general requirements of Sub section 1701.3(a) and grading requirements conforming to Table 508-1.

Table: 508-1 - Grading Requirements for aggregate

Sieve size mm µm	Percentage by weight passing sieve		
	Type-1	Type-2	Type-3
10	-	100	100
5	100	91-100	72-92
2.36	90-100	65-90	45-70
1.18	65-90	45-70	28-50
600	40-60	30-50	19-34
300	25-42	18-30	12-25
100	15-30	10-21	7-18
75	10-20	5-15	5-15

(i) Mineral filler

Chemically active mineral fillers such as Portland cement, hydrated lime, and ammonium sulphate are used to improve the workability, regulate the setting and in some cases to alter aggregate gradation.

Chemically inactive mineral fillers such as lime stone dust, fly ash, and rock dust are used mainly to alter the aggregate gradation.

Both the mineral fillers such as chemically active and chemically inactive shall conform to the requirements given below.

(ii) Physical requirements

Mineral filler shall be graded within the following limits.

Table 508-2 - Grading band of the Mineral Filler

Sieve µm	Percent passing (by weight)
600	100
300	95-100
75	70-100

Mineral filler prepared from rock dust, slag dust and similar materials shall be essentially free from organic impurities and have a plasticity index not greater than 4.

(3) Manual Mixing

For type 2 or type 3 mixes, the aggregate is normally obtained in coarse aggregate (10mm maximum single sized), fine aggregate (10 mm graded aggregate) and filter material.

508.2(b) Bitumen Emulsion

The bitumen emulsion shall be bituminous slow setting emulsion, CSS-1 to Sub section 1702.3.

508.2(c) Water

All water used for mixing shall conform to SLS 522

508.3 Laboratory Tests on Component Materials

508.3(a) Aggregate

A complete laboratory evaluation of slurry aggregate consists of the following tests:-

The aggregate shall conform to the general requirements of Sub section 1701.3 and the mix requirements shall conform to Sub section 508.4.

The combined aggregate prior to the addition of any chemically active mineral filler shall have a sand equivalent of not less than 45, when tested in accordance with ASTM D2419.

508.3(b) Bitumen Emulsion

The bitumen emulsion shall conform to grade CSS-1 or CSS-1h where the properties shall conform to Sub section 1702.3

508.4 Mix Requirements

A job mixture shall be selected that conforms to the Specification limits and that is suitable for the traffic, climatic conditions, curing conditions and final use. All the materials to be used shall be tested for the suitability of the mixture as described in Sub section 508.5

The mixture shall attain an initial set time of not less than 15minutes nor more than 12 hours. The setting time may be regulated to suit the condition by addition of mineral filler or a chemical agent.

The mixture shall be one of three types, whose combined aggregate conform to the gradation requirements of Table 508-1. These mixtures shall be used as given below.

Type-1 is suitable to seal cracks, fill voids and correct surface erosion conditions. The residual bitumen content shall be from 10 to 16 by weight of dry aggregate. It shall be applied at a rate of 3.3 to 5.4 kg/m^2. This type shall be used on surfaces where surface sealing and skid resistance are the primary needs.

Type-2 is suitable to fill surface voids, correct severe surface erosion conditions and provide a minimum requirement for a wearing surface. The residual bitumen content shall be from 7.5 to 13.5% by weight of dry aggregate. It shall be applied at a rate of 5.4 to 8.2 kg/ m^2. This type is used on airfields and road Pavements that are severely eroded or have numerous cracks. It may also be used as a wearing surface on bituminous Base courses or soil–cement Bases, or a sealer on stabilized Base courses.

Type-3 is suitable to provide a new wearing surface or build up a crown. The residual bitumen content shall be from 6.5 to 12 % by weight of dry aggregate. It shall be applied at a rate of 8.2 kg/ m^2

508.5 Quality Control of the Mixture

The following tests shall be carried out in order to determine the quality of the mixture.

508.5(a) Consistency test.

This test is used to determine optimum mix design for aggregate, filler, water and emulsion. A flow of 2 to 3 cm is considered to be the consistency normally required for a workable field mix.

508.5(b) Set time

This test shall be used to determine the time required for slurry to reach initial set with paper blot method. A properly mix designed slurry shall be set at the end of the 12 hours. A 1 hour set time shall be considered acceptahle for quick setting slurry.

508.5(c) Cure time

This test shall be used to determine initial cohesion of slurry mat and resistance to traffic. A properly designed slurry mix shall be completely cured at the end of 24 hour after placement.

508.5(d) Wet Track Abrasion test

This test method covers measurement of the wearing quality of slurry seal under wet abrasion condition. A slurry shall show a loss of not more than 800 g/m^2.

508.6 Slurry Seal Construction

The work shall cover by this procedure consists of furnishing all labour, equipment and performing all operations necessary in connection with the proper application of an emulsified bitumen slurry seal on the designated surface.

508.6(a) Equipment

(i) General

All equipment, tools and machines used in the performance of this work shall be maintained in satisfactory working order at all times.

(ii) Manual mixing and laying

Shovels and other equipment for mixing and squeegees and other equipment for laying shall be used

(iii) Machine mixing

The slurry mixing machine shall be continuous flow mixing unit and capable of delivering accurately a predetermined proportion of aggregate water and bitumen emulsion to the mixing chamber and to discharge the thoroughly mixed product on a continuous basis. The equipment shall be capable of pre wetting the aggregate immediately prior to mixing with the emulsion. The mixing unit of the mixing chamber shall be capable of thoroughly blending all of the ingredients together without violent mixing.

The mixing machine shall be equipped with an approved fines feeder that includes an accurate metering device or method to introduce a predetermined proportion of mineral filler into the mixer. The mineral filler shall be fed at the same time and location as the aggregate. The fines feeder shall be required whenever added mineral filler is a part of the aggregate blend.

The mixing machine shall be equipped with a water pressure system and a spray bar adequate for complete fogging of the surface receiving slurry treatment.

(a) Slurry Spreading Equipment

Attached to the mixer machine shall be a mechanical type squeegee distributor, equipped with a flexible material in contact with the surface of the Pavement to prevent loss of slurry from the distributor. It shall be maintained so as to prevent loss of slurry from the distributor. It shall be maintained so as to prevent loss

of slurry on varying grades and crown by adjustments to insure uniform spread. The spreader box shall have an adjustable width. The box shall be kept clean. The box shall not allow the build up of bitumen and aggregate on the box or in the corners.

(b) Auxiliary Equipment

Hand squeegees, shovels, and other equipment shall be provided to perform the work.

(c) Cleaning equipment

Power brooms, power blowers, air compressors, water flushing equipment, and hand brooms, suitable for cleaning the surface and cracks of the existing surface shall be available at the construction site.

508.6(b) Preparation of the Surface

All loose material, mud spots, vegetation and other objectionable material shall be removed immediately prior to applying the slurry. Water flushing shall not be permitted in areas where cracks are present in the Pavement surface.

If the slurry is being placed over a brick or concrete surface, high absorbent asphalt surface or over a surface where the aggregate has become exposed and is polished and slick, one part of emulsion which is also diluted with three parts of water shall be applied, prior to the application of the slurry. The rate shall be 0.25 to 0.50 l/Sq.m.

508.7 Design and Composition of the Slurry Mix

The amount of asphalt emulsion to be blended with the aggregate shall be that as determined by laboratory mix design after final adjustment in the field.

Table 508-3 - Mix proportions of the slurry mixes.

Item	Type-1	Type-2	Type 3
Aggregate	98%	98%	98%
Filler	2%	2%	2%
Emulsion	13%*	13%*	12%*
Water	13%*	!2%*	12%*

* Percentage of Emulsion and water shall be calculated as a percentage of the weight of total aggregate. The degree of saturation of aggregate shall be considered as very important in machine slurry sealing.

508.8 Weather Limitations

The slurry seal shall not be applied if either the Pavement or air temperature is below 13^{0}C except that the mix can be applied when both the air and Pavement temperature is 7^{0}C or above. The mix shall not be applied when the temperature of the Pavement is above 30^{0}C. (Slurry seals are expected to be applied in the morning hours and not in hot weather.)

Slurry seals shall not be applied during raining weather or when rain, in the opinion of the Engineer, is imminent.

508.9 Traffic Control

Suitable methods shall be applied to protect the slurry from all types of traffic until it is sufficiently cured to withstand traffic. The duration before traffic is allowed shall be determined depending on the type of the emulsified bitumen mixture characteristics and weather conditions.

508.10 (a) Mixing and Application of Manually Constructed Slurry Seal Application

(i) Mixing

The procedure for manual mixing shall be as given below or any other procedure as approved by the Engineer.

(a) Mix proportions of the coarse aggregate (10mm down graded) and a fine aggregate (crusher dust) for the preparation of slurries shall be worked out on a weight basis to conform to Type 2 grading band. These weight proportions and the weight proportions of bitumen emulsion, filler and water shall be converted into volume proportions by using the densities of the constituent materials.

(b) Based on the above data, the required constituent materials for a batch that can be mixed within a stipulated time of 4 minutes by four labourers shall be proportioned and stacked. The time of mixing from the time of adding emulsion to the aggregate cement mix shall be restricted to the above value in order to obtain workable slurry.

(c) Firstly the Portland cement shall be mixed with the fine aggregate thoroughly using shovels.

(d) The above mix shall be mixed with the coarse aggregate.

(e) Half the estimated quantity of water shall be added to the aggregate cement mix and mixed to achieve a uniform consistency using shovels.

(f) The material obtained from the previous step shall be made into a form of an invert cone with the depression in the middle.

The emulsion (CSS-1 or CSS-1h) shall be poured into this depression and mixed immediately using shovels. Addition of emulsion shall be done in two equal halves to avoid overflowing of the same.

(g) The balance water shall be added and mixed thoroughly to achieve slurry of uniform consistency for easy spreading.

(ii) Application

The procedure for manual application shall be as given below or any other procedure as approved by the Engineer.

(a) The surface shall be pre wetted by spraying water ahead of the slurry if required by local conditions. Water used in pre wetting the surface shall be applied at such a rate that the entire surface is damp with no apparent flowing water in front of the slurry.

(b) The slurry after mixing shall immediately be spread over a predetermined area of the Pavement using shovels and rakes and levelled with straight edges and rubber squeegees to a thickness of about 10 mm. Precautions shall be taken to avoid segregation of aggregate. No material with lumping, balling or unmixed aggregate shall be permitted in the slurry for application and therefore such materials shall be removed from the laying strip area prior to laying.

(c) 30 minutes after levelling, the layer shall be compacted using a wooden tamper to obtain a uniform surface with even texture and to expedite the setting time of emulsion.

(d) Then two hours after the commencement of the trials, the layer shall be compacted using a plate vibrator.

(e) After 4 hours the layer shall be compacted using 2-4 passes of a small two drum roller of 650 kg weight without vibration.

(f) The area shall be opened for traffic with a maximum speed of 15 kmph during the first few hours after completion of work.

(b) Mixing and Application of Machine Constructed Slurry Seal

(i) Mixing

The mixing and then spreading on the road shall be carried out using the slurry sealing machine and spreading, auxiliary and cleaning equipment described in Sub section 508.6 (a)(iii)

(ii) Application

(a) The surface shall be pre wetted by spraying water as stated in Sub section 508.6(a) ii(a)

(b) The slurry mixture shall be of the desired consistency. The total time of mixing shall not exceed 4 min. A sufficient amount of slurry shall be carried in all the parts of the spreader at all times so that a complete coverage is obtained. No lumping, balling, or unmixed aggregate shall be permitted. No segregation of the emulsion and aggregate fines from the coarse aggregate shall be permitted.

(c) The coarse aggregate shall not settle to bottom of the mix. If so the mix shall be removed from the surface. No excessive breaking of the emulsion shall be allowed in the spreader box.

(c) Joints

Transverse and longitudinal joints shall be kept to a minimum.

(d) Hand work

Approved squeegees shall be used to spread slurry in areas not accessible to the slurry machine. Care shall be exercised in leaving no unsightly appearance from the hand work.

(e) Curing

Treated areas shall be allowed to cure until such time the Engineer permits to open for traffic.

(f) Rolling

For machine oriented slurry seal, rolling is normally not required on slurry surfaces. However in areas of slow turning traffic, the paved surface shall be rolled with a 4.5 metric ton roller. The paved area shall be subjected to a minimum of five coverages of roller. When a pneumatic roller is used it shall be operated at a tire pressure of 34.5 kPa.

508.11 Surface Finish and Quality Control

The surface shall be finished to the requirements of Section 1601. The control of quality of materials and works shall be exercised in accordance with Section 1602.

508.12 Measurement and payment

(a) Measurement

This work shall be measured in Sq.m of slurry seal used in the accepted work.

(b) Payment

Payment will be made at the Contract unit rate for the completed work as measured, which shall include full compensation for providing all materials, labour, equipment, tools and incidentals necessary to complete the work to the Specifications.

Pay items and pay units shall be as follows.

Pay Item	Description	Pay Unit
508(1)	Slurry seal (manual) (State type of aggregate grading)	q. m
508(2)	Slurry seal (machine) (State type of aggregate grading)	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

509 CEMENT INCORPORATED COLD MIX SURFACING

509.1 Descriptions

This work shall consist of construction of cement incorporated cold mix Surfacing on existing Pavement.

Cement incorporated cold mix is a mixture of coarse and fine crushed stone aggregate, emulsion and cement. This construction is more suitable for areas where drainage facilities are very poor.

This work shall be carried out in accordance with these Specifications and with the lines, levels, grades, dimensions and Cross-sections as shown on the Drawings or as directed by the Engineer.

509.2 Materials

All materials shall meet the requirements of the following unless otherwise specified.

(a) The binder shall be bituminous slow setting emulsion, CSS-1 to Sub section 1702.3.

(b) The aggregate shall be graded crushed rock with nominal maximum size of 20mm conforming to general requirements of Sub section 1701.3(a) and grading requirements with cement and without cement conforming to requirements of Table 1701-10 of Sub section 1701.3.

(c) Cement to Section 1703.

(d) Water for mixing shall conform to SLS 522.

509.3 Preparation of Cement Incorporated Cold Mix.

The recommended mix proportions of materials by volume shall be

(i) 0.6 parts of Portland cement.

(ii) One part of emulsion (CSS-1)

(iii) Eleven parts of graded aggregate conforming to the grading band without cement given in Table 1701-10

509.4 Mixing procedure

The procedure for mixing shall be as given below or any other procedure as approved by the Engineer.

(a) Cement shall be added to dry fine aggregate in the proportions given in 509.3 and mixed uniformly by using a front end loader or any other equipment approved by the Engineer.

(b) Coarse particles of the aggregate in the proportions given in 509.3 shall be coated with a sufficient quantity of slow setting emulsion by using the same equipment as above.

(c) The balance slow setting emulsion in the proportions given in 509.3 shall be added to the mixes of (a) & (b) above and shall be thoroughly mixed by using the same equipment as above, in order to produce a uniformly mixed cement incorporated cold mix. If required, a sufficient amount of water shall be added to this mix along with emulsion, in order to improve the workability of the mix.

509.5 Construction Requirements

(a) Thickness of Surfacing

The thickness of Surfacing shall be as specified and as directed and shall normally be within 30-50 mm for 20mm aggregate.

(b) Preparation of Base

The Base on which the bituminous Surfacing is to be laid shall first be corrected as required, by suitably patching potholes, ruts, depressions and eliminating all other surface irregularities as given in Section 1100.

(c) Application of a Prime Coat or Tack Coat

A prime coat complying with section 501 shall be applied over newly constructed soil or aggregate Sub-bases or Bases, or a tack coat complying with section 502 shall be applied over the existing bituminous Surfacing, prior to laying of cement incorporated cold mix Surfacing. Application of tack coat shall however not be necessary when laying of a cold mix Surfacing follows soon after the construction of a bituminous Base or levelling course. Also a tack coat shall not be necessary where a second layer of cement incorporated cold mix is laid soon after the first layer of cement incorporated cold mix surfacing.

(d) Spreading and Rolling

The premixed material shall be spread to the required thickness and levelled either manually using rakes or other suitable implements, or by using graders or by using pavers where appropriate, as approved by the Engineer.

As cement and bitumen emulsion are used as the binders to prepare cement incorporated cold mix, the rolling shall be commenced as soon as the cold mix is laid, and completed within 1.5 hours, on the addition of emulsion and water to the mix as stated under 509.4 or a shorter period as determined by the Engineer.

When sufficient length of the material has been laid compaction shall be carried out by using a 6-8 tonne smooth wheel tandem roller or any other approved roller. The method of rolling shall be carried out as described in Sub section 403.3 (c) (iv).

As far as practicable, the mix shall be rolled in the following order, as described in Sub section 506.5 (j)

(i) Transverse joints

(ii) longitudinal joints where applicable

(iii) outside edge

(iv) breakdown rolling

(v) finish or final rolling

When the roller has passed over the whole area once, any high spots or depressions shall be corrected by removing or adding premixed material. Rolling shall then be continued until the entire surface has been compacted and all the roller marks are eliminated. The wheels shall be kept damp to prevent the cement incorporated cold mix from adhering to the wheels and being picked up.

Rollers shall not be allowed to stand on newly laid Surfacing.

(e) Joints

Joints shall be constructed in accordance with Sub section 506.5 (k)

(f) Finishing Operations and Quality Control

The cement incorporated Surfacing shall be finished to the requirements given in this section and in conformance with Section 1601.

The control on the quality of materials and works shall be exercised in accordance with section 1602.

(g) Aftercare

Traffic shall not be permitted to run on any newly laid areas until a period of 12 hours has elapsed after the completion of the construction of Surfacing, unless otherwise directed.

509.6 Measurement and Payment

(a) Measurement

Cement incorporated cold mix Surfacing shall be measured by one of the following methods specified in the Contract.

(i) In Cu.m, as compacted in position measured by taking levels.
Method of measurement shall be as in Sub section 106.2.

(ii) In Cu.m measured as loose volume.

The cold mix Surfacing shall be measured as stockpiled or in the hauling vehicle. This method is essentially for small works including small scale regulating courses.

The volume of cold mix measured as above shall be adjusted for material wasted at the joints, for material laid out side the defined Pavement edges, for excess laid and for material laid within the defined Pavement edges but not accepted by the engineer.

(b) Payment

Payment for cold mix Surfacing shall be made at the Contract unit price for the item as measured above. The price shall be full compensation for furnishing all materials, for mixing and placing of the mixed material and for providing all plant, machinery, equipment, tools, labour and incidentals necessary to complete the work to these Specifications.

Pay items and pay Units shall be as follows:-

Pay Item	Description	Pay unit
Either		
509(1)	Cement incorporated cold mix Surfacing, compacted in position (State thickness)	Cu.m
or		
509(2)	Cement incorporated cold mix Surfacing, in loose state	Cu.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

600 UNPAVED ROADS AND THEIR MAINTENANCE

601 GRAVELLING OF EARTH ROADS AND REGRAVELLING OF GRAVEL ROADS

601.1 Description

This work shall consist of the gravelling of earth roads or re-gravelling of gravel roads. The gravelly soil used may be as excavated soil or material obtained by a process of blending soils referred to as mechanical stabilization.

The work shall be carried out in accordance with these Specifications and with the lines, levels, grades, dimensions and Cross-sections shown in the Drawings or as directed by the Engineer.

601.2 Materials

(a) The material used shall be gravelly soil or such material obtained by blending two or more soils and meeting the requirements of Sub section 1708.5.

601.3 Mechanical Stabilization(Blending)

Where blending two or more soils is required, the method of mechanical stabilization as given in Sub section 401.3 shall be adopted, and the mixed material shall be checked for grading by carrying out sieve analysis tests in accordance with Sub section 1804.1.

601.4 Construction Requirements

(a) Minimum Thickness of Gravelling or Re-gravelling

The minimum thickness of gravelling or re-gravelling shall be 75mm unless otherwise specified.

(b) Preparation of Existing Surface

Unless otherwise specified in the Contract or directed by the Engineer, the following shall be carried out prior to gravelling or re-gravelling.

The earth or gravel road to be re-gravelled shall be cleared of all extraneous matter and the surface irregularities such as potholes, ruts and depressions corrected as required, Places of failure shall be examined for the cause of failure and corrected suitably either by excavating and filling or by filling over as appropriate. Any loose material requiring removal shall be removed as directed. Where specified or directed, the surface shall be graded, re-cambered, and scarified. The surface shall be moistened before the placement of new gravelly soil.

(c) Placing and compacting Gravel

The gravel or blended soil shall be spread over the prepared earth road, or gravel road to a uniform thickness, which will give the required thickness, when compacted.

The gravel shall be compacted, by using an 8-10 tonne steel wheeled roller or any other roller approved by the Engineer, at or near the optimum moisture content. The moisture content of the material shall be checked just before compaction at the frequencies given in Table 1602-1 or as directed by the Engineer. If the material is too wet, it shall be dried by aeration and if it is too dry, water shall be sprinkled and mixed uniformly prior to compaction. Rolling shall commence at the edges and proceed towards the centre, except at super elevated sections where it shall commence at the lower edge and proceed towards higher edge. The rolled surface shall be checked transversely and longitudinally with straight edges and camber boards and any irregularities corrected by loosening the surface, adding or removing necessary amount of gravel, and re-compacting the same until the entire surface conforms to desired camber and grade. The gravel shall be compacted to at least 100 percent of the maximum standard dry density of the material as determined by the standard compaction tests carried out in accordance with Section 1804.

(d) Surface Finish and Quality Control

The surface shall be finished to the tolerances given in Section 1601.

The control on the quality of materials and works shall be exercised in accordance with Section 1602.

601.5 Measurement and payment

(a) Measurement

Method of measurement shall be any one of the following as specified.

(i) First method

Gravelling or re-gravelling shall be measured as finished and accepted work in position in cubic meters. Volume measurements shall be based on the Cross-section shown on the Drawings or as directed by the engineer by taking existing and finished levels of Cross-section with the actual length measured parallel to the grade line of the road.

(ii) Second method

Gravelling or re-gravelling material shall be measured as supplied and stockpiled in cubic meters but limited to the volume used in the accepted work and the construction of gravelling or re-gravelling work shall be measured as the volume of material used in cubic meters (as stockpiled) in accepted work.

(b) Payment

Payment shall be based on the Contract unit price/s for the item/s and shall include full compensation for the components given below for the item/s.

In the first method the price for gravelling or re-gravelling shall be measured as finished work in position shall include full compensation for the supply, transport, piling of the material/s at site and for the construction of gravelling or re-gravelling including full compensation for providing all labour, tools, equipment and incidentals necessary to carry out the construction work to the Specifications.

In the second method the price for gravelling or re-gravelling shall be measured as finished work in position shall include full compensation for the supply, transport, and stockpiling of the material/s at site. The price for the construction of gravelling or re-gravelling shall include full compensation for providing all labour, tools, equipment and incidentals necessary to carry out the construction work to the Specifications.

The pay Items and pay units will be as follows:-

Pay Item	Description	Pay unit
Either		
601(1)	Gravelling or re-gravelling compacted in Position	Cu.m
Or the following		
601(2)	Gravelly soil, as stockpiled	Cu.m
601(3)	Gravelling or re-gravelling construction	Cu.m

602 PRIMING CUM SURFACE DRESSING OF GRAVEL ROADS

602.1 Description

This work shall consist of priming cum surface dressing of prepared gravel road using cutback bitumen.

The work shall include moistening the surface, applying the cutback bitumen. blinding with coarse sand and compacting.

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

602.2 Materials

The material used shall meet the requirements of the following, unless otherwise specified:-

(a) The binder shall be medium curing cutback bitumen (20-45 percent) or MC 30or MC 70 or MC 250 or MC 800 in accordance with Sub section 1702.2.

(b) The blotting (blinding) material shall be coarse sand to Sub section 1701.4

602.3 Construction requirements

(a) Preparation of existing surface

Prior to the application of the Surfacing, the prepared gravel road shall be cleared of extraneous matter and dust.

(b) Weather Limitation

The priming cum surface dressing application shall not be carried out in wet weather or when rain is imminent.

(c) Application of Binder

The prepared road shall be wetted uniformly to obtain a lightly soaked surface.

The cutback bitumen shall be heated to temperatures given in Table 501-1 and shall be applied at a rate of 1.5 to 2.0 litres per square meter on the prepared surface of the gravel Base as uniformly as possible using hand sprayers, machines sprayers or any other means approved by the Engineer.

The binder coat shall not be squeegeed and shall be allowed to stand for period of not less than 15 minutes. It shall then be blinded with coarse sand at the rate of about 1.6 Cu.m per 100 Sq.m, and rolled with a suitable smooth wheel roller.

(d) Aftercare

Traffic shall normally not be allowed over the newly treated surface for a period of 6 hours after the completion of the work. Where the Engineer decides to allow traffic earlier, the speeds shall be limited to less than 15 kilometers per hour.

(e) Quality Control

The control on the quality of materials and works shall be exercised in accordance with Section 1602.

602.4 Measurement and Payment

(a) Measurement

Priming cum surface dressing of gravel roads shall be measured by either one of the two following methods as specified:-

(i) First method of measurement

Priming cum surface dressing of gravel roads shall be measured in Sq.m of each type of completed and accepted work. Surface measurements shall be based on the width and length of the surface area as approved by the Engineer.

(ii) Second method of measurement

The work shall be measured based on the quantities of the materials used in the accepted work.

The binder shall be measured in litres and the blotting material shall be measured in Cu.m as measured loose as stockpiled.

The quantity of each of the above materials measured shall be the quantity required to comply with the Specification and the requirements of the Engineer or shall be the actual quantity used as accepted which ever is the less.

(b) Payment

In the first method of measurement given in Sub section 602.4, payment will be based on the Contract unit rate for the item which shall include full compensation for providing all labour, tools, equipment and incidentals necessary to complete the work to Specifications.

In the second method of measurement given in 602.4, the quantities, measured as provided, will be paid for at the Contract unit price for each of the items which shall include full compensation for carrying out the work utilizing all materials, including all labour, equipment, tools and incidentals necessary to complete the work.

The pay Items and pay units will be as follows:-

Pay Item	Description	Pay Unit
Either		
602(1)	Cut back bitumen Surfacing (State type of binder and rates of Application of binder and sand)	Sq.m
Or the following:-		
602(2)	Binder (State grade and type of binder)	Litres
602(3)	Sand (Blotting material)	Cu.m

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

603 MAINTENANCE OF EARTH AND GRAVEL ROADS

603.1 Description

This work shall consist of the following maintenance operations on earth and gravel roads.

(a) Repairing potholes, ruts, depressions and erosions gullies, and also dragging where necessary, as recurrent maintenance activities.

(b) Grading and correcting the surface profile on a periodic basis.

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

603.2 Materials

Suitable soil for repair of earth roads shall be type II embankment material meeting the requirements of Sub section 1708.1. Gravelly soils for repair on gravel roads shall meet the requirements of Sub section 1708.5

603.3 Work requirements

(a) Recurrent Maintenance

All potholes, ruts, depressions and erosion gullies shall be repaired by using approved suitable soil or approved gravelly soil as appropriate.

Such damaged places as above shall first be trimmed as necessary using mammoties, pickaxes and other implements and then sprinkled with water till uniformly wet.

The soil in a moist state (close to optimum moisture content) shall then be spread sufficiently proud of adjacent surface, compacted with a tamper and finished flush with the adjacent surface. Places of excessive depth shall be compacted in layers where practicable.

Dragging shall be carried out, where necessary, to arrest the formation of corrugations and to smoothen the surface, using suitable drags attached to tractors or by other suitable means.

(b) Periodic Maintenance

Where the road surface requires restoration of profile and removal of corrugations in addition to other irregularities the surface shall be graded as required.

Grading of the road surface shall be done using a motor grader or other approved means, to move material and shape the surface as required. Where necessary, areas of hardened soil may be ripped prior to grading using the grader tines or other suitable means. The material that had accumulated on the sides shall also be graded to the centre if suitable.

These operations shall normally be carried out during suitable periods of the wet season when it easy to grade the surface and when the graded material is at or near the optimum moisture content for compaction.

After grading and correcting the surface to required profiles the loosened soil shall be compacted with about 6 to 8 passes of a 8-10 tonne steel wheeled roller. The surface shall be aerated or moistened as necessary before compaction.

603.3/1 Tests and Standards of Acceptance

The material shall be tested in accordance with these Specifications and shall be prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

603.4 Measurement and payment

(a) Measurement

Unless otherwise specified, the work carried out shall be measured as follows:-

Repair of potholes, ruts, depressions and erosion gullies, shall be measured in Sq.m of surface correction. Soil used for such correction shall be measured in Cu.m.

Dragging or grading of gravel surfacing shall be measured in Metres or Km. of roadway.

(b) Payment

Unit rate of payment for each item of work done shall include full compensation for plant, equipment, tools, labour and other incidentals necessary to complete the work.

Payment for soils used for repair work shall be separate unless otherwise specified.

The pay Item and pay Units shall be as follows:-

Pay Item	Description	Pay Unit
603(1)	Soil for repair work (state type)	Cu.m
603(2)	Repair of potholes, ruts etc. using material Supplied	Cu.m
603(3)	Dragging of surface	Metres or km of road way.
603(4)	Grading of surface	Metres or km of Road way

Note

Refer Sub section 106.6 regarding sub division of pay items.

700 DRAINAGE CONSTRUCTION

701 ROADSIDE AND LEADAWAY SURFACE DRAINS

701.1 Description

This work shall consist of the construction of roadside and lead-away surface drains, unlined or lined, and covered where required, to dimensions, grades and in positions shown in the Drawings or as directed by the Engineer.

701.2 Materials

The materials used for lining the drains shall meet the requirements of the following, unless otherwise specified.

(a) Precast concrete units including cover slabs to Section 1705.

(b) Class A or B concrete for precast sections or for insitu lining to Section 1001.

(c) Reinforcing steel to SLS 375, SLS 26 or BS 4449

(d) Random Rubble (RR) masonry and brick or block masonry to Sections 1006 and 1007 respectively.

(e) Formwork used shall be of steel or any other material approved by the Engineer conforming to Section 1008.

(f) Cement mortar used shall conform to requirements of Sub section 1703.2 of the Specifications.

701.3 Construction Requirements

(a) Cutting and formation of earth drains

Drains shall be cut to Cross-sectional dimensions and grades given in Drawings or as instructed by the Engineer. Where site conditions require changes of Cross-section or grades, the Engineer's approval shall be obtained for such changes. The excavation shall be carried out as per Section 301A.

Rock out-crops or rock boulders, encountered during excavation for the drain shall be removed by sledging or blasting or by other approved means. Where such operations are not advisable to be carried out due to site conditions, the drains may be suitably deviated with the prior approval of the Engineer. Such deviations however, shall not impair the smooth flow of storm water in the drain and where necessary, they shall be suitably lined, using concrete or RR masonry as suitable.

All loose and erodible material shall be removed and such pockets shall be filled back with suitable material approved by the Engineer and compacted as required. Where necessary, random rubble paving with cement mortar jointing shall be provided over such excavated and back filled areas, to be flushed with the adjoining sections.

Where the gradients are steep, due to site conditions, suitable drop structures and stilling basins shall be constructed as given in Drawings or as directed by the Engineer.

(b) Lined drains

All drains that are designated to be lined shall be constructed as shown in Drawings or as directed by the Engineer.

Where the lining is of pre-cast concrete sections, they shall be of A or B class concrete of grade 20/20 as per Sections 1001 & 1705, laid to line and level on a prepared bed of sand, dry mortar, approved soil, concrete or other material as indicated in the Drawings or instructed by the Engineer. Unless otherwise instructed, the joints shall be filled using 1:3 cement sand mortar.

In-situ construction with concrete (A or B class concrete of Grade 20/20 as per Section 1001), RR masonry or brick or block work as per section 1006 & 1007 respectively, shall be carried out as given in the Drawings or as directed. Where specified, or where found necessary, they shall be plastered with 1:3 cement sand mortar and smoothed as directed. Bricks, blocks and other materials used shall be subject to the approval of the Engineer.

Rubble paving with mortar jointing, where specified, shall be carried out using selected rubble, hammer dressed as necessary, to ensure proper embedment of the rubble and also to obtain a reasonable smoothness of the surface finish after jointing with 1:3 cement sand mortar is completed.

(c) Cover Slabs

Where it is required for the lined drains to be covered, unless otherwise instructed, the slabs shall be of pre-cast concrete of class A or B of grade 25/20, and reinforced as indicated in the Drawings.

701.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

701.4 Measurement & Payment

(a) Measurement

The excavation for lined and unlined drains shall be measured and as provided in Section 302.

Measurement of lining of drains shall be in linear metres for pre-cast units. For in-situ constructions with RR masonry brick or block masonry or concrete, the measurement shall be in Cu.m of such work without plastering. Plastering shall be measured in Sq.m. Reinforcement for concrete shall be measured separately in metric tonnes to the requirements of Section 1002 and form work shall be measured separately to the requirements of Section 1008.

Rubble paving shall be measured in Sq.m paved and accepted.

Pre-cast reinforced concrete cover scales shall be measured in Sq.m.

(b) Payment

The excavation for lined and unlined drains shall be paid as provided in Section 301A.

Payment shall be at the Contract unit rate for the different items of work and shall include full compensation for all labour, materials, tools and incidentals necessary for completion of the work.

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
701(1)	Lining of Drains with pre-cast units (State thickness, class and grade of concrete)	Linear metre
701(2)	Lining of Drains with in-situ concrete (State thickness, class and grade of concrete)	Cu.m
701(3)	Lining of Drains with R.R. Masonry, brick or block masonry.	Cu.m
701(4)	Rubble Paving in Drains	Sq.m
701(5)	Plastering	Sq.m
701(6)	Pre-cast reinforced concrete cover slabs (State thickness, class and grade of concrete)	Sq.m

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

702 SUB SURFACE DRAINS (UNDERDRAINS OR TRENCH DRAINS)

702.1 Description

This work shall consist of construction of subsurface drains (under-drains or trench drains) and drain outlets using perforated pipes, non-perforated pipes and granular filter material. The work shall be carried out in accordance with this Specification and in conformity with the Plans or as directed by the Engineer.

702.2 Materials

(a) The non perforated pipes shall be of concrete, PVC or earthen, conforming to following standards.

- Concrete pipes to SLS 452
- PVC pipes to SLS 147
- Earthen ware pipes to SLS 449
- Geotextiles / filter fabrics to section 1710 & 2000

Unless otherwise instructed, perforated pipes shall be of 150 mm diameter PVC pipe of at least 4 mm thick. The pipe shall be drilled with 4 holes of 8 mm diameter on the bottom half of the perimeter of the pipe at intervals of 150 mm or as shown in the Drawings or as instructed by the Engineer.

(b) Granular filter material, for bedding and for surrounding the pipe under-drains, shall be graded aggregate of maximum size 37.5mm conforming to the requirements of Sub section 1701.1(b) unless otherwise specified by the Engineer.

702.3 Construction Requirements

(a) Under-drains

Trenches shall be excavated to the dimensions and grades required and a minimum of 150 mm thick bedding layer of granular filter material shall be compacted in the bottom of the trench for its full width and length.

Care shall be taken to prevent the contamination of the granular filter material with soil or silt or other deleterious material during construction of the sub surface drains and all filter material contaminated shall be removed and replaced by the Contractor at his own expense.

Perforated pipes unless otherwise required, shall be laid with the perforations down and the pipe sections shall be securely jointed by collars, mortar joints etc., as specified or as directed.

Non-perforated pipes of the bell and spigot type when used shall be laid with the bell end upgrade and the spigot ends entered into the bell ends and spot mortared to provide for centring of the pipe but open enough to allow the infiltration of water.

After the pipe installation has been approved, granular filter material shall be placed to a depth as specified so as to completely surround the pipe as shown in the Drawings or required by the Engineer. If a geo-fabric filter as per the next paragraph is used as shown in the Drawings, single sized aggregate of nominal maximum size of 37.5 mm, instead of granular filter material can be used with the approval of the Engineer. The remaining portion of the trench shall then be filled and lightly compacted in layers of 300mm with either granular or impervious material, as may be specified.

Where specified or ordered by the Engineer, geo-fabric filter as specified in Section 1710.6 & 2000 shall be installed as shown on the Drawings. Filter fabric shall not be exposed to direct sunlight for prolonged periods and shall be protected from mechanical damage during installation and construction.

(b) Subsurface Drain Outlets

Trenches for the outlets shall be excavated, to the dimensions required by the Engineer. The outlet pipes shall be laid on approved compacted bedding in the trench with their ends firmly jointed as required. On approval of the pipe installation the trench shall be back filled with approved suitable material and compacted in layers in accordance with section 305.3(b).

702.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

702.4 Measurement & Payment

(a) Measurement

Excavations and approved soil back fills shall be measured and paid for as provided for in Section 302.

Perforated and outlet drain pipes shall be measured by the linear metre along the centre line of the pipe for each type and size specified.

Granular filter material, when specified in the Contract as a separate pay item, shall be measured in place by the Cu.m, completed and accepted.

The filter fabric shall be measured in Sq.m. by taking the width required to encircle and overlap the perforated pipe by one and a half times the circumference and multiplying by the length of the perforated pipes.

(b) Payment

The quantities as determined above will be paid for at the Contract unit price which shall be full compensation for furnishing and placing of all materials including all labour, equipment, tools and incidentals necessary to complete the work prescribed.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
702(1)	Drain pipes (State type and size)	Linear metre
702(2)	PVC pipe, (state size), perforated	Linear metre
702(3)	Granular filter material/single sized aggregate of nominal maximum size of 37.5mm	Cu.m
702(4)	Provide and place Geofabric filter	Sq.m

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

703 MANHOLES, CATCHPITS AND INLETS

703.1 Description

This work shall consist of construction of manholes, catch-pits and inlets for underground drainage systems in accordance with these Specifications and with the lines and levels as shown on Drawings or as directed by the Engineer.

The inlets may be of the gully type or side entry type or a combination of both as shown in the Drawings.

703.2 Materials

Concrete for pre-cast units or for in-situ construction shall be of class A or B and grade 20/20 as specified in section 1001. Materials for rubble, brick or block masonry shall be as specified in sections 1006 & 1007 respectively.

Other materials shall conform to the requirements of the following unless otherwise specified.

(a) Reinforcing steel to SLS 375 or CS 26

(b) Cement mortar for jointing to Sub section 1703.2

(c) Mastic joint filler shall be of the approved varieties.

(d) Frames, grating, covers and any other incidental items shall be as given in the Drawings or elsewhere in the Contract documents.

703.3 Construction Requirements

All excavations and backfill required for construction shall be carried out in accordance with the requirements of Section 301A.

Inlets, catch-pits and manholes shall be either, prc-cast and installed or shall be constructed in-situ.

Pre-cast units, reinforced or unreinforced, shall be manufactured using concrete of class A or B and of grade 20/20. The installations of precast units shall be to required lines and levels and on prepared beds of sand, dry mortar, approved soil, concrete or any other materials as indicated in Drawings or as instructed by the Engineer.

Insitu construction of catchpits and manholes shall be carried out using concrete, rubble masonry, brick masonry or block masonry as specified or instructed at site. The Concrete used shall be of class A or B and of grade 20/20. Rubble masonry, brick or block masonry shall conform to the requirements of Sections 1006 and 1007 respectively.

Insitu construction of inlets shall be carried out using concrete of class A or B and of grade 20/20.

Formwork for insitu concreting of units shall conform to the requirements of Section 1008.

Pipe ends that are connected to the catchpits or manholes shall be flush on the inside of the structure wall and project outside sufficiently for proper connection with the next pipe section.

Pipe end joints of pre-cast concrete manhole sections and pipe to pipe joints shall be made with 1:1 cement mortar, mastic joint fillers or a combination of these or any other approved material as may be specified. The completed mortar joint shall be finished smooth and suitably cured. The mastic joint filler where used shall be applied in accordance with the manufacturers recommendations or as required by the Engineer, so as to form a water tight seal.

Metal frames for gully inlets shall be set in mortar beds or be otherwise properly secured as indicated in Drawings.

703.4 Grade Adjustment of Existing Structures

When grade adjustment of existing structures has to be carried out, the covers gratings and frames shall be removed as necessary and the walls reconstructed as required. The cleaned frames shall be reset at the required elevations. Frames, covers or gratings that are unfit for further use shall be replaced with new units. Upon completion, each structure shall be cleaned of any accumulation of silt, debris or foreign matter of any kind and shall be kept clean of such accumulation until final acceptance of the work.

On resurfacing Contracts the metal frames for gulley inlets shall be adjusted to grade after the Base course is laid and prior to placing the surface course.

703.5 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

703.6 Measurement and Payment

(a) Measurement

Manholes, inlets and catchpits, new or reconstructed shall be measured by the number.

All work measured for payment shall be satisfactorily carried out by the contractor and accepted by the Engineer.

(b) Payment

The accepted quantities of manholes, inlets and catchpits shall be paid for at the Contract unit price for each complete in place and shall be full compensation for excavation, bedding, backfill, replacing Pavement where required. Disposal of surplus material shall not be measured and paid for separately but shall be included in the Contract price for each structure unless otherwise specified.

The quantities as determined above will be paid for at the Contract unit price which shall be full compensation for furnishing and placing of all materials including all labour, equipment, tools and incidentals necessary to complete the work prescribed.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
703(1)	Manholes (state type)	Number
703(2)	Catch pits	Number
703(3)	Inlet (state type)	Number
703(4)	Manhole reconstructed (state type)	Number

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

704 UNDERGROUND PIPE DRAINS

704.1 Description

This work shall consist of construction of underground pipe drains and surround in accordance with the Specification and in conformity with lines, grades and dimensions shown in Drawings and as instructed by the Engineer. The backfilling shall be carried out, measured and paid as per Section 305.

The work shall include the furnishing and construction of joints and connections to other pipes and catchpits and other items as required to complete the structure in accordance with these Specifications and as shown in the Drawings or as directed by the Engineer.

704.2 Materials

Materials shall meet the requirements of the following unless otherwise specified.

(a) Concrete pipes and fittings shall meet the requirements of SLS 452.

(b) Earthenware pipes shall meet the requirements of SLS 449.

(c) PVC pipes and fittings shall meet the requirements of SLS 147.

(d) Cement grout and cement mortar used for jointing of concrete and earthen / ware pipes shall meet the requirements of the Sub sections 1703.1 & 1703.2 respectively.

(e) Plastic sealing compounds used for jointing of PVC pipes shall meet the manufacturer's requirements.

(f) Pipe bedding materials shall be concrete of class B conforming to requirements of Section 1001 or granular material conforming to requirements of Sub section 1701.1 (b) as specified.

(g) Pipe surround material may be pipe bedding material or selected fill material as shown in Drawings or specified elsewhere in the Contract documents or as required by the Engineer.

704.3 Construction Requirements

(a) Excavation of Trenches

Excavation shall be done to a sufficient width to allow for proper jointing of pipes and thorough compaction of bedding and backfill under and around the pipes. The sides of the trenches shall be adequately supported till the backfill is in progress and construction is complete. The bottom of the trench shall be well compacted and of uniform density throughout its full length and width.

All excavated material not required for backfilling shall be disposed of as required by the Engineer.

(b) Bedding, laying and jointing of pipes

Immediately following excavation, the bedding of concrete or granular material shall be laid and compacted, as directed, to required levels. When a firm foundation is not encountered and soft, spongy or unstable soil is found, they shall be removed for a width of at least one diameter on each side of the pipe and to the depth as directed by the Engineer. After the removal, gravel or other suitable selected material is placed and compacted at the appropriate moisture contents using plate vibrators and vibrator tampers to the required densities as per section 304. The pipes shall then be laid, so as to uniformly bear on the bed, and jointed. The bed shall be cut away and removed at each socket or sleeve, in the case of socketed or sleeve jointed pipes, to give a clearance of at least 50mm so that the socket or sleeve does not bear on the bed.

Pipes shall be jointed such that the inner surfaces are reasonably flush and even and the ends are centred as required.

Joints shall be made with cement mortar (1:2), cement-grout, plastic sealing compound or by a combination of these types or any other approved material as may be specified.

Mortar joints shall be made with an excess of mortar to form a continuous bead around the outside of the pipe and finished smooth on the inside. For grouted joints, moulds or runners shall be used to retain the poured grout. Joints in concrete and earthen ware pipes shall be thoroughly wetted, before mortar or grout is applied. Cement mortar or grout, where used shall be protected against rapid drying by a suitable curing method.

Pipes shall be inspected after the jointing operations are over. Any pipe found to be out of alignment, or damaged shall be re-laid or replaced. Any other defective work such as leaky joints and defective grouting shall be redone.

(c) Completion of bedding and surrounding of pipes

Completion of bedding and surrounding of pipes shall be done immediately following the jointing of pipes, except where the Engineer decides that the pipes have to be tested.

The bedding shall be completed so that the pipes bear uniformly at least upto 10 percent of the vertical diameter in concrete or at least 25 percent in granular material.

The pipe surround material as per Sub section 704.2(g) shall be laid in layers not exceeding 150mm thickness and carefully compacted. The surround shall be taken up to a height of 300mm above the top of the pipe unless otherwise stated in the Contract or directed by the Engineer.

(d) Backfilling of Trenches

Backfilling of trenches above the surround shall be carried out as given in Section 305, using material suitable for embankment construction.

Care should be taken to compact the material evenly without dislodging or damaging pipes.

704.4 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

704.5 Measurement & Payment

(a) Measurement

Pipes of different types and sizes shall be measured by the linear metre in place along centre line of the pipe. The above measurement, unless otherwise specified, will include excavation, pipe bedding, surround and the backfill upto the original ground level. Branch connections and elbows may be included in the length measurement for pipe, or they may be measured by the number of units installed if so specified.

Specials of various types shall be measured in numbers.

Pipe bedding and pipe surround material shall be measured in Cu.m.

(b) Payment

The accepted quantities of pipe shall be paid for at the Contract unit price per linear metre of the type and size of pipe as specified, complete in place.

Branch connections, end connections, elbows if separately measured, shall be paid for at the Contract unit price per each of the kind and size specified complete in place. Appropriate deductions shall be made for these specials in the total length of pipe measured for payment.

Excavation and backfill where separately measured, shall be paid for as given in under Section 305. Pipe bedding and pipe surround where separately measured shall be paid for at the Contract unit price per Cu.m laid and compacted.

The quantities as determined above shall be paid for at the Contract unit price which shall be full compensation for furnishing and placing of all materials including all labour, equipment, tools and incidentals necessary to complete the work prescribed.

The Pay Items and Pay Units will be as follows: -

Pay Item	Description	Pay Unit
704(1)	Pipes laid (state type and size)	Linear metre
704(2)	Specials (state type)	Number
704(3)	Pipe bedding material	Cu.m
704(4)	Pipe surrounding material	Cu.m

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

705 DRAINAGE BACKFILL BEHIND EARTH RETAINING STRUCTURES

705.1 Description

This work shall consist of the construction of a permeable double layer of aggregate behind earth retaining structures to facilitate the free drainage of the retained soil layers (including any backfill) through the weepholes of the structure.

The double layer shall consist of a layer of large sized aggregate backfill immediately behind the wall and a layer of graded small aggregate, referred to as the filter medium placed along the sloping face of the aggregate backfill.

All work shall be carried out in accordance with the Specification and in conformity with Drawings or as directed by the Engineer.

705.2 Materials

(a) Aggregate Backfill

The aggregate backfill shall be free draining and normally consist of aggregate larger than 50mm and smaller than 200mm, shall consist of hard and durable crushed stone or naturally occurring stones.

(b) Filter Medium

The filter material shall be graded aggregate of 37.5mm maximum size and conforming approximately to grading requirement given in Sub section 1701.1(b).

The aggregate and filter medium shall be free of organic material, clay or other materials which will adversely effect the free drainage of water.

705.3 Construction Requirements

Prior to placement of the larger sized aggregate behind the structure, the soil layer, on which the aggregate is placed, shall be well compacted and made impervious either by constructing a clay puddle or by the application of a bituminous binder as required.

The aggregate backfill shall be placed along the wall and to a stable configuration as indicated in the Drawings to a width not less than 200 mm or as instructed. The material shall be hand packed and compacted using a hand tamper.

The filter medium of graded aggregate shall be placed simultaneously and compacted along the sloping face of the aggregate back fill to a thickness not less than 200 mm. The material shall be hand packed and compacted using a hand tamper.

705.4 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

705.5 Measurement & Payment

(a) Measurement

The quantity to be measured shall be the number of Cu.m placed, compacted and accepted in place, separately for the aggregate backfill and the filter medium. Impervious layer shall be measured in Sq.m.

(b) Payment

This work measured as provided above will be paid for at the unit price per Cu.m of drainage backfill behind earth retaining structures. The price shall be full compensation for all labour, materials, equipment and incidentals required to furnish and acceptably place the materials.

The Pay Items and Pay Units will be as follows: -

Pay Item	Description	Pay Unit
705(1)	Aggregate backfill	Cu.m
705(2)	Filter medium	Cu.m
705(3)	Impervious layer	Sq.m

706 WEEP-HOLES FOR EARTH RETAINING STRUCTURES

706.1 Description

This work shall consist of providing openings in earth retaining structures to facilitate the drainage of any water collected at the back of the structure, as given in the Drawings or as directed by the Engineer and in accordance with these Specifications.

The weep-holes may either be cast insitu or consist of pipes embedded in the structure.

706.2 Materials

The pipes shall be made of concrete, PVC or any other suitable material approved by the Engineer.

The moulds for cast in-situ weep-holes shall be of timber or similar material approved by the Engineer.

706.3 Construction Requirements

When pipes are embedded in the earth retaining structure, they shall be laid to the slope given in Drawings or required by the Engineer and shall extend from the rear face to the front face of the structure. They shall be protected from ingress of materials during construction and shall be cleaned before backfilling is placed behind the structure.

When the weepholes are cast insitu the moulds used shall be longitudinally straight, and shall be laid to the required slope in their designated places as the work proceeds. Where neeessary extra eement mortar shall be placed round them and the moulds worked, loose to facilitate easy removal when the material round them has sufficiently hardened. If PVC pipes are used as weep-holes at least gauge 600 shall be obtained.

706.4 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

706.5 Measurement and Payment

(a) Measurement

The weepholes for earth retaining structures shall be measured in linear metres of weepholes.

(b) Payment

Payment shall be based on the Contract unit price for the item and shall include full compensation for all materials, labour, tools, equipment and incidentals necessary to complete the work to the Specifications.

The Pay Items and Pay Units will be as follows:-

Pay Item	Description	Pay Unit
706(1)	Weepholes using pipes (state type and size)	linear metre
706(2)	Weepholes cast insitu (state type & size)	linear metre

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

707 PIPE CULVERTS

707.1 Description

This work shall consist of supplying, jointing, bedding of reinforced concrete pipes of the required type, diameter and length in the construction of culverts. The scope of work shall also include the extension and modification of existing pipe culverts.

The work also includes the construction of headwalls, wingwalls, aprons, catchpits and other ancillary items necessary to complete the structure.

All work shall be carried out in accordance with these Specifications and with lines and levels and dimensions shown in Drawings or as directed by the Engineer.

707.2 Materials

Concrete for pipe bedding shall be of class C as specified in Section 1001.

Other materials shall conform to the following, unless otherwise specified.

(a) Reinforced concrete pipes and fittings to SLS 452.

(b) Granular pipe bedding material to Sub section 1701.1(a).

(c) Cement mortar for pipe jointing to Sub section 1703.2

(d) Reinforcement for concrete encasement of pipes to Sub section 1002

Materials used for construction of head walls, wingwalls and other ancillary items shall conform to the requirements given in Section 1106 for R.R masonry, 1107 for brick masonry and 1001 for concrete.

707.3 Construction Requirements

(a) Excavation

Excavation for pipe culverts shall conform to the requirements of Section 301 A of the Specification.

The Contractor shall take all necessary precautions to safeguard the stability of all trench excavations and ensure that the safety of no person is be placed in jeopardy by his operations or working methods.

Surface drainage shall be controlled by the construction of temporary earth berms and drainage channels to prevent storm water entering the working area. No separate payment shall be made for such temporary drainage measures.

The amount by which the excavation is to exceed the proposed level of the invert of the culvert shall be sufficient to allow for the type and thickness of bedding material to be placed as specified or as shown on the Drawings.

Trench when shaped and completed to receive the pipes shall be of sufficient width, depending on pipe size and other considerations, to provide working space for satisfactory bedding, laying and jointing of the pipe and for satisfactory compaction of bedding material and backfill.

The width of excavation normally shall be equal to the nominal external diameter of the pipe plus 500 mm on each side. Where pipe culverts consist of two or more rows of pipes laid parallel in the same trench the minimum clear spacing between each rows of pipes shall be 300mm or half the external diameter, whichever is the greater, up to a maximum of 900 mm.

When completed, the bottom of the trench shall be well compacted and of uniform density throughout its full length and width.

When pipe culverts are to be constructed in embankment fill, excavation for culvert construction shall be made, after construction of the embankment, to the specified depths below the formation as shown in the Drawings, unless otherwise directed by the Engineer.

(b) Bedding of Pipes

After completing the outlet structure, the culvert units shall be laid in the normal manner, starting from the lower end and placing successive units firmly against each other to prevent subsequent movement. The lowest unit shall be securely cast into the outlet structure.

Unless otherwise specified pipes shall be bedded according to one of the methods described in (i), (ii) or (iii) below depending on the site conditions and as given in Drawings or decided by the Engineer.

(i) Concrete Bedding

The pipes shall be bedded in a continuous cradle of class C concrete having a minimum thickness of 0.25 times the external diameter of the pipe or 200mm, whichever is greater. The concrete shall extend up to the sides of the pipes to a height of at least 10% the external diameter or 200 mm whichever is the greater. The minimum width of the cradle shall be the external diameter of the pipe plus 0.25 times the external diameter on either side and shall be constructed monolithically without horizontal construction joints. The cradle shall be such that the pipe can be seated fully in it and the pipe shall be laid on the concrete bedding before the concrete has set.

Where shown on the Drawings or instructed by the Engineer pipes shall be fully encased in class A or B concrete of grade 20/20 of minimum thickness 200 mm and reinforcement shall be provided when the thickness of the fill over the culvert is anywhere 500 mm or less. Temporary support shall be provided near the pipe ends to support the pipes during the placing of the concrete. The concrete shall be placed in such a way that all spaces under the pipe are completely filled. Poker vibrators shall be used to ensure that all spaces under and around the pipe are properly filled with concrete. Concrete casing shall be cast in one continuous operation until completed.

(ii) Granular Bedding

The granular bedding shall be sand or any other selected fill and shall be accurately shaped by a template to fit the lower part of the pipe. The selected granular bedding shall surround the pipe up to a height of 100mm above the top of the pipe. In appropriate circumstances the Engineer may permit compaction of sand bedding by hydraulic compaction (flooding) subject to approval of trials carried out by the Contractor.

(iii) Stable soil bedding

In stable ground conditions, and where so indicated in Drawings or directed by the Engineer, the pipes shall be bedded on existing hard soil suitably shaped to uniformly fit the lower part of the pipe exterior for at least 10 percent of its diameter. A template shall be used to obtain the required shape.

Prior to placing of the pipes the soil bed shall be lightly scarified and moistened to facilitate uniform embedment and where necessary, fresh soil shall be added so that the pipes when placed are firmly and uniformly bedded into the soil.

(c) Laying of pipes

Unless otherwise directed by the Engineer, laying of pipes on prepared foundation shall be started at the outlet and proceeded towards inlets, with the abutting sections properly matched and fitted in. Where collars are used for jointing the pipes, cross trenches shall be excavated to accommodate the collar and to facilitate jointing. Ends of the pipe shall be carefully cleaned before they are placed. As each length of pipe is placed, the mouth of the pipe shall be protected to prevent entry of earth or bedding materials. Once laid the pipes shall be properly aligned.

707.4 Jointing

Where partial demolition is required for extension work to existing structures, the contact face shall be cut to predermined lines and levels, loose and fragmented material removed and projecting steel cleaned and bent or cut as instructed by the Engineer. Where no partial demolition but only extension is required, the contact area shall be roughened and cleaned of all dirt and loose particles.

Where dowels are required they shall be installed with an approved type of epoxy-resin grout in holes drilled into the existing structure in accordance with details shown on the Drawings or as instructed by the Engineer.

New concrete shall be bonded to the old concrete by using a cement paste or slurry or an approved type of bonding agent.

Each pipe joint shall be sealed to prevent leakage and infiltration of water on to the bedding, unless shown on the Drawings or specified, jointing and sealing shall conform to one of the following :-

(a) Cement Mortar Joints Using Collars

Abutting ends of adjacent pipes shall be connected with concrete collars and the space between the pipe and the collar shall be tightly sealed with stiff 1:2 cement mortar, to uniform thickness round the pipe.

(b) Socket and Spigot Joints

Where a pipe with spigot at one end and socket at the other are jointed with pipe of the same type and size, the spigot of one pipe shall be inserted into the socket of the other with the flexible joint ring fitted at the spigot end, and where a mortar joint is specified, cement mortar of 1:1 composition shall be worked into the joint by hand or by an approved tool.

(c) Lap Joints

In jointing pipes with tapered ends, the end with external taper of one pipe shall be joined with the end with internal taper of the other pipe and the space between the pipes at the joint shall be patched with 1:2 cement sand mortar. In addition to this the joint shall be provided with a covering with cement mortar of the same composition having a minimum width of 100mm and minimum thickness of 25mm placed across, and running continuously round the pipe at the joint.

707.5 Backfilling

Backfilling of trenches or around the pipes shall begin at the lower end and be carried out in horizontal layers.

The material used for the backfilling of those portions of culverts subject to traffic loads shall be selected material of at least Sub-base quality or such lower quality as the Engineer may permit.

The backfilling material shall be thoroughly tamped under the flanks of the culverts to provide a uniform bedding to the Engineer's satisfaction. Adequate cover over the culvert shall be provided before the Contractor routes his construction equipment across it. Hydraulic compaction of backfilling may be permitted in appropriate circumstances after successful trials.

Backfilling shall be undertaken as early as practicable after concrete and jointing material has sufficiently hardened. Work shall be carried out according to section 302. Care shall be taken to compact the material evenly without dislodging or damaging pipes, in accordance with Sub section 304.3j (iv). Material shall not be heaped in the trench before being spread. Power rammers are not to be used within 300 mm of any part of the pipe or joint.

707.6 Headwalls, wingwalls and other ancillary works

Headwalls, wing walls, aprons and other ancillary works shall be constructed in accordance with the details shown in the Drawings or as directed by the Engineer. Rubble masonry or brick masonry for the walls etc., shall conform to requirements of Section 1006 or 1007 respectively as specified and concrete for head walls, wing walls and other ancillary works, if so specified, shall conform to concrete of class B or Section 1001.

707.7 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

707.8 Measurement and Payment

(a) Measurement

Measurement shall be made by any one of the following as specified:-

(i) Concrete for bedding, encasement, granular aggregate bedding and soil bedding shall be measured in Cu.m of material laid and compacted. The rate shall include shuttering, if required and payment for shaping and compacting of stable in-situ bedding material.

Reinforcement steel for concrete encasement of pipes shall be paid by weight and to the requirements of Section 1002.

Formwork shall conform to the requirements of Section 1008.

Pipes shall be measured as supplied, laid and jointed in linear metres along the centre line of the laid pipes.

Measurement for excavation and backfilling and construction of headwalls etc., shall be as specified in the respective sections.

(ii) The culvert construction shall be measured as linear metres for various Numbers and sizes of pipes.

(b) Payment

Payment shall be made by any one of the following as specified:-

(i) Payment for bedding and laying of pipes measured as above will be based on the Contract unit rate for the items which shall include full compensation for all labour tools, equipment and incidentals necessary. Payment for excavation, backfilling and dewatering and construction of headwalls etc., shall be as specified in the respective sections.

(ii) Payment shall be made for full compensation for constructing the culvert measured as above which will be based on the Contract unit rate for the item which shall include full compensation for all labour tools, equipment and incidentals necessary.

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
	Either	
707(1)	Concrete bedding/Cradle	Cu.m
707(2)	Granular aggregate bedding	Cu.m
707(3)	Concrete for encasement of pipes	Cu.m
707(4)	In-situ soil bedding material	Cu.m
707(5)	Reinforcement steel for concrete encasement	Metric tonne
707(6)	Concrete pipes	linear metre
	or	
707(7)	Reinforced concrete pipe culverts with one or more pipes (state No. of pipes & size of the pipe)	linear metre

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

800 INCIDENTAL CONSTRUCTION

801 TOP SOILING

801.1 Description

This work shall consist of supply of topsoil furnished and transported from approved sources or stockpiles and spread in conformity with these Specifications at locations shown on Drawings or as directed by the Engineer.

801.2 Materials

Top soil provided by the Contractor or salvaged during clearing and grubbing shall consist of loose friable natural surface soil free of admixtures of sub soil, refuse, stumps, roots, rocks, weeds or other material which would be conducive to proper development of vegetative growth.

801.3 Construction Requirements

The Contractor shall notify the Engineer at least 7 days before he intends to start collecting topsoil from specified areas.

Unless otherwise specified top soil shall not be spread on slopes steeper than 1.5:1 (1.5 horizontal to 1 vertical). Slopes steeper than 3:1 shall be scarified to depths indicated in Plans or established by the Engineer, prior to placing topsoil. The area to be top soiled shall normally be roughened by hand scarifying, or by any other means approved by the Engineer, to ensure the stability of the topsoil spread.

After the Engineer has approved the prepared and graded areas, top soil shall be spread to a thickness after settlement shall not be less than 75 mm or the depth shown on Drawings or as instructed by the Engineer. Spreading shall not be done when the ground or the topsoil is excessively wet or in a condition considered detrimental to the work. The topsoil layer shall be levelled off and raked.

The roadway surface shall be kept clean during hauling and spreading operations. After spreading has been completed, large clods, stones larger than about 40mm in diameter and any roots, stumps and other litter shall be raked up and removed and disposed of at an approved location.

801.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

801.4 Measurement & Payment

(a) Measurement

The quantities to be paid for shall be the number of Sq.m of topsoil of 100 mm loose thickness completed in place and accepted as per the Specification

(b) Payment

The quantities of top soil will be paid for at the Contract unit price which shall be full compensation for roughening the surface to be top soiled and for furnishing,

transporting from stockpile and spreading to the required thickness, levelling to a smooth surface and removing any stones, subsoil, refuse, roots & weeds as specified. Rate shall include all labour equipment tools and incidentals necessary to complete the work.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
801(1)	Topsoil furnished, transported, spread levelled and tamped.	Sq.m
801(2)	Topsoil salvaged from cleaning and grubbing, transported, spread, levelled and tamped	Sq.m

802 GRASSING

802.1 Description

This work shall consist of providing grass cover by seeding, sprigging or sodding, including soil preparation, fertilizing, mulching and watering as required, in conformity with these Specifications and with the Drawings or as directed by the Engineer.

802.2 Materials

(a) Grass Seeds

The grass seeds shall be of an accepted variety reputed to produce a good grass cover. Seeds shall be furnished by the Contractor in standard sealed containers along with seed name, weight and other details as necessary.

Where required, a certificate from the vendor stating that the seeds have been tested within a stipulated period of time, not exceeding 6 months, and prior to the time of delivery shall be furnished.

(b) Grass Sprigs

Grass sprigs shall be healthy living stems, with attached roots of accepted turf forming grass specified in the Contract and approved by the Engineer, harvested without adhering soil and obtained from approved sources in the locality of work.

(c) Grass Sods

Grass sods shall be of living vigorous growth of the type of grass to the size of 200 mm x 150 mm and thickness specified, having a dense root system, contained in suitable sods and free from noxious weeds and diseases and shall contain a minimum of 50 mm of topsoil.

(d) Fertilizer

Fertilizer shall be from a standard commercial grade conforming to all relevant regulations and shall provide the minimum percentage of nutrients specified.

The fertilizer shall be evenly applied over all surfaces where grass is to be planted and shall then be thoroughly mixed with the soil to a depth of 100mm either mechanically or manually.

Where the type of fertilizer is not specified the Contractor shall obtain the Engineers approval prior to use of a particular fertilizer.

(e) Mulch

Mulch used shall be straw, hay, saw dust or any other similar material specified in the Contract. They shall be free from material injurious to plant growth.

(f) Water

Water used in planting or care of vegetation shall be free from oils, acids, alkalis, salts or any other substance injurious to plant life.

802.3 Construction Requirements

The areas to be grassed shall meet the specified finish grades, be free of any weeds or plant growth, stones and other debris.

If topsoiling is required it shall be done in accordance with the requirements of section 801. The surface, where required, shall be loosened by raking.

Seeding shall be done just before or during the rainy season or as instructed by the Engineer. The method of seeding and application of fertilizer, water and mulch shall be subject to the approval of the Engineer.

In grassing by sprigging, the Contractor shall notify the Engineer at least 7 days before sprigs are to be harvested, and the source shall be approved by the Engineer before harvesting begins. Not more than 24 hours shall elapse between harvesting and planting sprigs, except that when weather or other uncontrollable condition interrupts the work, a reasonable time extension may be granted by the Engineer.

Fertilizing, watering and mulching shall be done as required and with the Engineer's approval. Unless otherwise specified or directed, sprigs shall be planted at approximate intervals of 150mm apart.

Sodding shall be done just before or during the rainy season or as instructed by the Engineer. The Contractor shall notify the Engineer not less than 7 days before cutting of sods begin. Sods shall be approved by the Engineer, in its original position before cutting and delivery to the site. Areas to be covered with sods shall be given a layer of topsoil 75 mm thick unless, due to the presence of suitable subsoil, the Engineer orders that the topsoil be omitted.

The areas to be covered with sods shall be thoroughly watered beforehand so that they are wet to a depth of at least 150 mm when sodding is done.

Sods shall be laid on the prepared sod-bed within 24 hours after cutting except where the Engineer has approved their being stored in stacks or piles, grass to grass or root to root, for a period not exceeding 3 days.

The moving and laying of sods shall be done as far as possible, when weather conditions and soil moisture are favourable. Sodding may be done in one of the following methods as designated in the Drawings or as approved by the Engineer:

(a) Solid sodding

(b) Strip sodding

(c) Spot sodding

In solid sodding, sods shall be laid edge to edge with staggered joints and the joints where necessary shall be filled with suitable top soil. After laying and joint filling, sodding shall be tamped in an approved manner to provide an even surface. On slopes of 2:1 or steeper sods shall be pegged after tamping, at approximately 0.6 metre centres and close to the centre of the sods.

Strip sods shall be laid in parallel rows as indicated in Drawings or as required by the Engineer. Each strip of sod shall be of width shown in Drawing or approved by the Engineer and shall be laid in a shallow trench and firmly tamped until the surface of the sod is approximately level with the adjacent ground.

Spot sodding shall consist of sod blocks laid as shown on Drawings or as required by the Engineer. The pieces of sod shall be firmly tamped so that the surfaces of sod blocks are approximately level with the adjacent ground.

All springs and sods shall be planted with roots well buried in firm material.

All grassed areas, be it by seeding, sprigging or by sodding, shall be watered and cared for and maintained for a minimum period of 3 months in a satisfactory condition until final inspection and acceptance of the work.

Seeded area where grass has not taken root, and sprigged and sodded areas where grass has died, shall be made good by the Contractor by suitably replanting before final acceptance. At the time of acceptance, areas considered by Engineer as poorly grassed shall not be measured for payment and the Contractor may be given a further extension of time for replanting and correction of such areas as required.

802.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

802.4 Measurement and Payment

(a) Measurement

The quantity measured for payment, in each method of grassing (i.e.: seeding, sprigging or sodding) shall be the area measured along the slope in Sq.m., and accepted in place.

(b) Payment

The work measured as above will be paid for at the Contract unit rate for the particular method of grassing. The payment shall be full compensation for furnishing of

materials , labour, equipment, tools and incidentals necessary to complete the work and shall include for pre-watering and watering the sods, replanting dead areas and for the supply and placing of timber stakes and for all other incidentals that may be required to establish an acceptable cover and to maintain the grass.

Payment for furnishing and supplying fertilizer shall be made under a Provisional Sum.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
802(1)	Grassing (method unspecified)	Sq.m
802(2)	Sprigging	Sq.m
802(3)	Seeding	Sq.m
802(4)	Sodding (specify type)	Sq.m
802(5)	Furnish and Supply Fertilizer	Provisional sum

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

803 PLANTING TREES, SHRUBS, VINES ETC

803.1 Description

This work shall consist of furnishing, delivering and planting trees, shrubs, vines and ground cover plants of the required type, size or age indicated in Contract documents including all materials and incidental operations completed in conformity with these Specifications, and with the Drawings or as directed by the Engineer.

803.2 Materials

Materials shall meet the requirements of the following, unless otherwise specified.

(a) Top soil shall meet the requirements of Sub section 801.2

(b) Fertilizer, mulch & water shall meet the requirements of Sub section 802.2.

(c) Plant Materials shall be acceptable representatives of their normal species or varieties. Unless otherwise specified, they shall be nursery grown stock that has been transplanted. All plants shall be of normal development and free from knots, injuries, and abrasions, dead or dry wood or any other disfigurements.

803.3 Planting Requirements

(a) Planting Season

The planting shall be done during the seasons specified in the Contract or established by the Engineer. No planting shall be done when the soil is in an unsatisfactory condition for planting.

(b) Delivery and Inspection

The Contractor shall notify the Engineer in writing not less than 15 days in advance of delivery of plant from the nursery of the collecting source. All plant materials shall be available for inspection in the nursery or collecting fields before they are dug. Contractor shall ensure that the plants are delivered at the site without damage during transit.

(c) Protection and temporary storage

Contractor shall keep all plant material moist and protected from drying out. Protection shall include the time when the plants are in transit, in temporary storage or on the project site awaiting planting.

(d) Location of Plants

Location of plants or plant beds shall be carried out as shown in Plans or as directed by the Engineer. Contractor may adjust positions, due to ground conditions, but such adjustments shall be approved by the Engineer.

(e) Excavation for plant pits

Excavation for plant pits shall be done. to dimensions shown in Plans or established by the Engineer. All weeds roots and other objectionable material from the excavation, which is unsuitable for backfill, shall be removed from the site and disposed of by the Contractor in a manner acceptable to the Engineer.

(f) Setting plants and backfilling

The plants shall be set approximately plumb and at the same level or slightly lower than the depth at which they were grown in the nursery or collecting field. The backfill soil, prepared as specified, shall be placed in the plant pit and carefully worked round and over the roots and firmly settled by tamping.

(g) Fertilizing

A commercial fertilizer of the type specified shall be provided and applied uniformly around the pit area of individual trees and in bed areas of plants grown in prepared beds. The rate of application and the time of application of fertilizer shall be as specified or as established by the Engineer.

(h) Watering

All plants shall be watered during and immediately after planting and at such intervals during the plant establishment period as determined by the Engineer. Water shall not contain elements toxic to plant life. At each watering the soil around each plant shall be thoroughly saturated.

(i) Pruning, Staking and Mulching

Pruning shall be done before or immediately after planting in such a manner as to preserve the actual character of the plant. All pruning shall be done by experienced personnel in keeping with accepted horticultural practices.

Plants that require staking shall be staked in accordance with the details shown on Plans or as required by the Engineer as soon as the plant is in place.

Mulch material shall be furnished and placed over the pit area of individual plants and over the entire bed area of shrub beds to the depth as indicated in Plans. Mulch shall be placed within 24 hours after planting.

(j) Restoration and Clean up

Where existing grass areas have been damaged during planting operations the Contractor shall be required to restore the disturbed areas to their original conditions as directed by the Engineer at no additional cost to the Client. The Contractor shall clean up all debris, spoil, piles etc., and have the project area in an acceptable condition.

(k) Plant Establishment Period and Replacements

During the establishment period specified in the Contract or by the Engineer as the plant establishment period, which is normally one full growing period of one year the Contractor shall care for the plants by watering, adjustment of stakes, pruning and such other work which are necessary to preserve plants in healthy growing condition. Dead or unsatisfactory plants shall be promptly removed from the site and replaced by healthy plants approved by the Engineer.

(l) Material for Vines

Vines shall be species native to Sir Lanka, harmless and inoffensive to people and animals and not a kind recognised as a nuisance to agriculture. They shall be rapid-spreading and deep-rooted. *Vadalia* is available as a vine grown on cut slopes of hilly terrain in Sri Lanka. The Contractor shall notify the Engineer not less than 15 days in advance of delivery of vines from their source of collection for the Engineer's inspection.

Vines shall be planted at 500 mm intervals on each cut berm, with sufficient excavation (including hard and soft rock) carried out if necessary to allow the spread of plant roots. Fertiliser shall be applied and the Contractor shall spray insecticides if necessary, at least every 6 months until the vines are fully established to the satisfaction of the Engineer.

803.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

803.4 Measurement & Payment

(a) Measurement

The quantity of plants to be paid for shall be the number of living trees, shrubs and vines of specified kinds and sizes furnished and planted in accordance with these Specifications and accepted. (only living plants in healthy condition at the end of the establishment period will be accepted).

(b) Payment

The quantity of trees, shrubs and vines, measured as provided above, planted and maintained in accordance with these Specifications, shall be paid for at the Contract unit prices. The unit price shall include for prepared backfill and all activities of planting and caring for, including watering.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
803(1)	Plants supplied planted, nurtured and maintained, during the establishment period (State size)	Number
803(2)	Vines for cut slopes, supplied, planted, nurtured and maintained	Number

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

804 RIP RAP PROTECTION FOR EMBANKMENT SLOPES

804.1 Description

This work shall consist of installation of slope protection rip rap for stream banks, embankment slopes, cut slopes & other surfaces composed of erodible materials where protection is necessary, furnished and constructed in accordance with the Specifications and in conformity with lines grades and dimensions and at locations shown on Drawings or as directed by the Engineer.

The types of rip rap included in this Specification are:

(a) Dumped rip rap

(b) Enclosed rip rap

(c) Grouted rip rap

Where specified, a filter blanket, which consists of a graded material, shall be placed on the bank, before placing the rip rap, in order to prevent the bank material from passing through the rip rap material. The minimum thickness of this layer shall be 75mm unless otherwise specified.

804.2 Materials

All materials shall meet the following requirements unless otherwise specified.

(a) Dumped rip rap

Stones used for dumped rip rap, shall be hard, durable, angular in shape; resistant to weathering and water action. Rounded stones and broken concrete will not be acceptable. The stones shall be 500mm in maximum dimension and more than 100mm minimum dimension and be well graded between these two limiting dimensions.

(b) Enclosed rip rap

Enclosed rip rap shall consist of baskets fabricated from galvanized steel wire-mesh, reinforced plastic material, or any other material as approved by the Engineer, filled with stone, connected together and anchored to the slope. Stone used shall conform to the requirements of 804.2(a) above and the size and gradation of stone shall be such that they are well contained as a compact mass within the wire mesh.

(c) Grouted rip rap

Grouted rip rap consist of rip rap with all the interstices filled with portland cement mortar. The stone for grouted rip rap shall meet the requirements of Sub section 804.2(a). The grout shall, unless otherwise specified, consist of one part of portland cement and three parts sand mixed with sufficient water to obtain the required consistency.

(d) Filter Blanket Material

This material shall conform to the requirement of Sub section 1701.2.

804.3 Construction Requirements

Slopes to be protected by rip rap shall be free of trees, plants, stumps and other objectionable material and be dressed to a smooth surface. Unsuitable soils shall be removed and back filled with suitable soils which shall be compacted as required.

Unless otherwise specified or shown on Drawings the rip rap shall extend from 0.3m below the bottom (toe) of embankment to the expected high water line. Where the embankment abuts a flowing stream the rip rap shall be placed from at least 0.5m below the level of the bed of the stream.

Stone for dumped rip rap shall be placed on the prepared slope in a manner which will produce a reasonably well graded mass of stone with a minimum practicable percentage of voids. Rip rap shall be placed in such a manner as to avoid segregation. Under normal circumstance dumping into chutes, shall not be permitted. Hand placing or re-arranging of individual stones by suitable mechanical equipment may be necessary to secure a stable arrangement.

In wire enclosed rip rap construction the method of filling aggregate into baskets and anchoring the baskets to the slopes shall receive prior approval of the Engineer.

In grouted rip rap the stones shall be first placed as shown on Drawings or as directed by the Engineer on the prepared slope. The stones shall then be thoroughly moistened before grouting.

If penetration of grout is to be obtained by gravity flow, the grout shall be spaded or rodded so as to fill the interstices. Care should be exercised to ensure that the stones are not unseated in the process. Where full grouting is specified, weep holes shall be provided at regular intervals as indicated in Drawings or as required by the Engineer.

804.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

804.4 Measurement & Payment

(a) Measurement

The quantity of riprap to be paid for shall be the number of Cu.m measured in place and accepted. Filter blanket material where specified shall be measured in place in Cu.m. and as accepted.

(b) Payment

The quantities determined as provided above will be paid for at the Contract price which shall be full compensation for the work including trench excavation, preparation of embankment surface, placing of stone; grouting (when required) and all other work incidental to finished construction in accordance with these Specifications.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
804(1)	Rip Rap (state type)	Cu.m
804(2)	Filter blanket	Cu.m

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

805 GABION WALLS AND MATTRESSES USING WIRE BASKETS

805.1 Description

This section covers the construction of gabion walls and mattresses for the construction of retaining walls, lining of channels, revetments, aprons and other anti-erosion structures to hill slopes, embankment slopes, stream banks etc.

The Gabions/mattresses shall be flexible, box/mattresses shape with galvanized steel wire mesh cages of rectangular sides, packed with rock and in constructing the walls/mattresses, as indicated in Drawings or as directed by the Engineer.

805.2 Materials

Unless otherwise specified the material used shall meet the following requirements.

(a) Double twisted hexagonal mesh made of zinc coated mild steel conforming to BS 1052/1980, BS 443/ 1982.

(b) Binding and connecting wire of at least 3.2 mm diameter galvanized to the same standard as the mesh wire.

(c) Broken rock for filling baskets shall preferably be of sizes normally varying from about 100mm in minimum dimension to about 300mm in maximum dimension and they shall be clean, hard and durable, free from weathered pieces and extraneous matter. The rock shall be reasonably well graded between the two limiting sizes.

(d) Where indicated on the Drawings or ordered by the Engineer, a layer of filter fabric, or approved equivalent material shall be placed on the prepared surface prior to the placing of the gabions. The filter fabric shall be placed as instructed in vertical strips with a minimum overlap of 300 mm and shall be properly fastened to prevent any movement or slipping during the placing of gabions.

(e) Concrete for construction of Base shall be of Class B to Section 1001.

(f) Granular backfill material to Sub section 1701.1

805.3 Construction Requirements

The hill slopes, embankment slopes or stream banks, which the Gabion walls are to abut shall be suitably trimmed and the ground on which the Base of gabion walls is to be constructed shall be levelled and compacted as required.

Where indicated in Drawings or required by the Engineer a Base layer of concrete (reinforced or unreinforced) shall be constructed to the required dimensions prior to placement of gabions.

The concrete for the Base layer shall be of class C grade 15/40 for unreinforced Base layer and class B grade 20/20 for reinforced Base layer.

Where no firm Base layer is specified the ground shall be well compacted and levelled prior to placing of the gabions and, if required by the Engineer, a thin layer of granular material of the same composition as the granular backfill material shall be spread over the compacted soil. Baskets shall, where appropriate, be maintained square and with vertical sides during filling. Internal tie wires shall be inserted and baskets shall be tensioned.

The wire baskets for gabions shall be made out of double twisted hexagonal mesh. The width of gabion boxes will be 1-2 metres or as instructed by the Engineer. The length shall be multiples of one metre subject to a maximum of 4.0 m. The gabions shall have diaphragm walls at 1.0 m intervals.

The general Specifications of gabions are as follows:-

Thickness (mm)	Mesh Type (mm x mm)	Wire Dia. (mm)	Stone size (mm)	D_{50} (mm)
500	100x120	2.70	120 – 250	190
1000	100x120	2.70	120 – 250	190

The filling of baskets shall be carried out insitu, unless otherwise directed. This requires that the empty baskets, open on the top, be positioned on the Base or on top of the gabions and infilled with the rock pieces in such a manner as to completely fill up the baskets leaving only the minimum of voids prior to closing and securely tying the lid using wire of approved gauge. In building the wall the gabions shall be placed with staggered joints and where so required they shall be tied together using strands of wire.

The cut edges of all mesh used in the construction of gabions, except the bottom edge of diaphragms and end panels, shall be selvedged with galvanized wire having a diameter of at least 0.5 mm more than that of the mesh wire.

The diaphragms and end panels shall be selvedged on the top and vertical sides only.

Sufficient binding and connecting wire shall be supplied with the gabion cages to perform the connecting operations in accordance to these Specifications. The diameter of the wire shall be at least 3.2 mm.

The methods of assembly shall be in accordance with the manufacturer's instructions but the Contractor shall ensure that sufficient connecting wire braces are provided to prevent deformation of the cages as they are being filled with stone.

It is essential that the corners of the gabion / cages be securely wired together to provide a uniform surface and to ensure that the structure does not appear as a series of blocks or panels.

Particular care shall be exercised in filling visible faces of gabion boxes, for which only selected stone of adequate size shall be used and be so prepacked that a fair faced finish is obtained. The filling of boxes shall be done in stages in order to prevent deformation and bulging.

As the wall is being constructed the space between the gabions and the slopes shall be backfilled in stages with granular backfill material after placing the filter behind gabion wall. After which the granular backfill material shall be compacted well by rodding and other suitable means approved by the Engineer without damaging the filter fabric.

The filling of mattresses shall be carried out by spreading, random stones on the first layer and using selected stones for the top layer so as to present a dry stone-pitched surface.

805.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

805.4 Measurement & Payment

(a) Measurement

The gabion walls shall be measured in Cu.m, completed and accepted.

The filter fabric & mattresses shall be measured in Sq.m.

Concrete Base shall be measured as given in Section 1001.

The granular backfill shall be measured in Cu.m.

(b) Payment

The quantities determined for gabion walls and granular backfill material as provided above shall be paid for at the Contract unit rate which price shall be full compensation for all labour materials tools and incidentals necessary for completion of the work including cutting and shaping the slopes and forming the ground on which the wall is built.

The Pay Items and Pay Units will be as follows: -

Pay Item	Description	Pay Unit
805(1)	Gabions	Cu.m
805(2)	Filter fabric	Sq.m
805(3)	Mattresses (state thickness)	Sq.m
805(4)	Granular backfill material	Cu.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

806 PAVED SIDE WALKS

806.1 Description

This work shall consist of the construction of paved sidewalks in accordance with these Specifications and with lines, levels and grades shown in Drawings or as directed by the Engineer.

The paving shall consist of the following:

(a) Precast or cast insitu concrete slabs laid on a prepared bed.

(b) Bituminous surface applications, surface dressings or surfacings laid on a selected gravely soil Base layer.

(c) Bituminous surface applications, surface dressings or surfacings laid on an aggregate Base.

(d) Bed course material shall consist of sand, gravel, crushed stone or other approved granular material.

806.2 Materials

The concrete used for precast slab construction shall be concrete of class A. For cast insitu construction, concrete used shall be of class A or B to section 1001 and as specified.

The other materials used shall meet the requirements of following, unless otherwise specified.

(a) Aggregate for Bases, surface dressings and Surfacing to Sub section 1701.3.

(b) Bed course material shall consist of sand, gravel, crushed stone or other approved granular material to Subsection 1701.1(a).

(c) Gravely soil for soil Bases to Sub section 1708.5

(d) Cement mortar for slab joints to Sub section 1703.2

(e) Reinforcing steel for concrete slabs to SLS 375 or CS 26.

806.3 Construction Requirements

(a) Construction of Base layers

Gravely soil Bases, where specified, shall be constructed to the required thickness, as per Section 601.

Aggregate Bases, where specified, shall be constructed to the required thickness, as per Section 403 & 405 for single sized aggregate and graded aggregate respectively.

(b) Construction of bituminous Surfacing

Priming of gravel surfaces shall be carried out as per Section 602.

Surface dressings SBST or DBST, shall be constructed as per Section 505B.

Asphalt concrete Surfacing shall be constructed as specified in Section 506.

(c) Precast concrete slab construction

The precast concrete slabs as indicated in Drawings shall be laid to line and level on a prepared bed course material. The bed course material shall be spread and uniformly compacted on an approved solid foundation to a thickness of not less than 50 mm. Unless otherwise instructed by the Engineer, the slabs shall be laid side by side to a close fit and the joints filled with fine sand or crusher dust.

(d) Cast insitu concrete slab construction

The slabs shall be cast on a soil bed or on bed course material, prepared to line and level as in (a) above, in suitable steel or timber forms under-laid with a polythene sheet or any such material approved by the Engineer, to prevent cement grout and water in the mix from being lost to the bed course.

The concrete shall be deposited, preferably in one course, in such a manner as to prevent segregation and compacted thoroughly by light rodding, tamping, vibration and such other means approved by the Engineer.

The surface shall be finished with a wooden float and light brooming; no plastering of the surface shall be permitted. The joints shall be in filled with joint mortar as directed. They may be left without jointing if so directed provided thin steel forms are used in the casting and the joint widths do not exceed a maximum of 5mm. However, the joints shall be filled with fine sand or crusher fines, if so directed.

806.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

806.4 Measurement & Payment

(a) Measurement

Concrete paving shall be measured by Sq.m of the finished surface and as accepted

Bituminous surfacing, hand laid shall be measured in metric tonnes.

Where specified, bed course material may be measured and paid for separately, in Sq.m spread and compacted.

Gravely soil base layer and aggregate base layer shall be measured in Cu.m, compacted in place and accepted.

(b) Payment

Payment shall be at the Contract unit rate for work measured as above which shall be full compensation for all labour, materials, tools, equipment and other incidentals required for completion of the work.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
806(1)	Gravelly soil Base layer	Cu.m
806(2)	Aggregate Base layer	Cu.m
806(3)	Bed course material (state thickness)	Sq.m
806(4)	Concrete paving (state type)	Sq.m
806(5)	Bituminous surfacing, hand laid	Metric tonnes

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

807. PRECAST CONCRETE KERBS AND CHANNELS

807.1 Description

This work shall consist of the construction or resetting of kerbs, channel or combination of kerb and channel units to lines and grades shown on Drawings or as directed by the Engineer.

The dimensions of the units shall be as given in Drawings or as directed by the Engineer.

807.2 Materials

Concrete for precast or cast insitu units and concrete for kerb beds shall be of class A or B of Grade 20/20 in accordance with Section 1001.

The other material used shall meet the requirements of the following, unless otherwise specified.

(a) Reinforcing steel to SLS 375 or CS 26.

(b) Bed course material shall consist of sand, gravel, crushed stone or other approved granular material to Sub section 1701.1.

(c) Cement mortar for jointing to Sub section 1703.2.

807.3 Construction Requirements

(a) Pre-cast Concrete Units

Excavation for placement of precast combined kerb and channel units shall be made to the required depths and the Base upon which they are placed shall be compacted using hand tampers or by other approved means to an even surface. All soft and unsuitable material encountered during such excavation shall be removed and replaced with suitable material, which too shall be thoroughly compacted.

Bed course material where specified, shall be laid and compacted, on the prepared surface, to the required thicknesses.

Where precast kerbs without the channel sections are to be used, they shall be laid over a concrete bed, 275 mm wide and of minimum thickness of 100 mm of Grade 20/20 as indicated in the Drawings. The kerb and channel units are to be laid so that the face and the top lines conform to the lines and grades indicated in the Drawings. Unless otherwise instructed by the Engineer the joint spacing between kerb and kerb and channel units shall be set approximately to a uniform width of 12 mm which shall be filled with 1:3 cement sand mortar, thoroughly rammed and trowelled to a neat finish.

In resetting previously salvaged kerb and channel units the procedure given above shall be followed.

(b) Cast Insitu Kerbs, or Kerb and Channel

Excavation and bedding for insitu kerb or kerb and channel shall conform to the requirements of Sub section 807.3(a).

Forms used for concreting shall be of wood, metal or other suitable material conforming to the requirements of section 1008 and shall extend the full depth of the concrete. All forms shall be free from warp and of sufficient strength to resist the pressure of the concrete without displacement. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal. All forms shall be cleaned and coated with approved form oil before concrete is placed. Expansion joints shall be made at the required intervals using spacer plates made of metal, and in a manner shown in Drawings or as directed by the Engineer.

On curves of 100m radius or less forms shall conform to the specified curvature.

Concrete shall be proportioned, mixed, and placed in accordance with the requirements of grade of concrete specified. Compaction of concrete placed in the forms shall be by vibration or by other acceptable means. Forms shall be left in place for 24 hours or until the concrete has set sufficiently, so that they could be removed without injury to the concrete placed.

The concrete shall be struck off to the Cross-section specified, after which it shall be finished smooth by means of a wood float. Plastering of concrete deficiencies shall be done only with the approval of the Engineer.

The finished concrete shall be kept continuously moist for a minimum period of 3 days and the method of curing shall be subject to the approval of the Engineer. For a further period of 4 days the concrete shall not be exposed to the hot sun.

After the concrete has set sufficiently, the spaces in front and back of the kerb shall be refilled to the required elevation using approved material, which shall be thoroughly compacted.

807.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

807.4 Measurement & Payment

(a) Measurement

Kerbing, new and reset, shall be measured by the linear metre along the front face of the section. Channel and combination kerb and channel will be measured in linear metre along the face of the kerb. No deductions shall be made for drainage structures installed in the kerbs.

(b) Payment

The measured quantities shall be paid at the Contract unit price for metre length of each particular item which shall be full compensation for furnishing and placing of all bedding and jointing materials and shall include for all labour, equipment, tools and incidentals necessary to complete the work. Excavation, backfilling and compaction of soils & other materials in forming the bed etc., shall be considered as incidental to the construction procedure and shall be as specified in the relevant specification.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
807(1)	New Kerbs (pre-cast / cast in-situ concrete)	Linear metre
807(2)	Reset kerbs (pre-cast concrete)	Linear metre
807(3)	Channel	Linear metre
807(4)	Kerb and Channel	Linear metre

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

808 GUARD RAILS AND WALLS, GUARD STONES, GUIDE POSTS AND BOLLARDS.

808.1 Description

This work shall consist of furnishing, fabricating and erection of guard rails, guard walls, guard stones, guide posts and bollards in accordance with these Specifications and with dimensions, lines and levels as shown on Drawings or as directed by the Engineer.

Guard rails and guard walls which are meant essentially to protect vehicles from running off the road in hazardous areas shall be positioned on the roadway platform but sufficiently away from the carriageway edge so as not to interfere with normal movements of traffic.

Guard stones, as they are traditionally called, are usually positioned on either side of culvert headwalls and on top of retaining walls both to guide and to guard vehicles at these places.

Guide posts and bollards shall be positioned at the edges of embankments and such other places essentially to guide vehicles.

808.2 Materials

Concrete used for casting of posts, guard walls, guard stones and footings shall be of grade A or B given in section 1001 and as specified. The other materials shall meet the requirements of the following, unless otherwise specified.

(a) Steel reinforcements for posts to CS 26 or SLS 375.

(b) Timber for posts & railing to Section 1709.

(c) Galvanized steel sheeting for manufacture of railings to SLS 306.

(d) Cement plaster for guard stones to Sub section 1703.2.

(e) Bolts, nuts and screws and washers used for fixing guard posts to SLS 97 & 238 respectively.

(f) Pre-cast units to Section 1705.

(g) Steel railway rails obtained from railway stores or Road Development Authority stores.

(h) Timber protective coating (paints) to Section 1707.

808.3 Construction Requirements

(a) Guard Rails

Guard rails shall consist of posts and railing. Their assembly and erection shall be as shown in Drawings or as required by the Engineer.

Timber Posts, pre-treated with creosote or similar protective coating approved by the Engineer, of size 150x100 mm shall be set vertically in concrete footings of grade 15/40 at intervals of 1.5 m or as directed by Engineer.

Railings made from galvanized steel of thickness not less than 8 gauge, shall be fixed on posts as indicated in Drawings in a manner that will result in smooth continuous tight installation conforming to the line and grade of the highway or as indicated in the Drawings. Laps in railings shall be parallel to the direction of flow of traffic. All cut edges shall be shop painted with approved galvanized paint using two coats.

The holes for the posts shall be or sufficient size to permit proper setting of the posts and to allow sufficient room for backfilling and tamping.

The holes shall be spaced to suit the standard length of guardrail supplied.

The guardrail complete shall be erected true to line and level and the post holes shall be backfilled with a 12:1 mixture of soil cement only after the Engineer has signified his approval. When the backfilling is complete and the bracing removed the posts must be rigid and vertical and the guardrail true to line and level and firmly fastened to the posts. Excess material shall be disposed of as instructed by the Engineer.

As determined by the Engineer at locations adjacent to long sheer drops on the outside of bends the Contractor shall erect steel railway-line guard rail on posts at the same height and at the same centres as for galvanized steel guard rail. Posts shall be erected rigidly in concrete. Steel railway lines shall be bent to the road curvature joined using purpose made plates solidly bolted.

Bolts and screws used for fixing shall be so located that there are no sharp projections.

All posts and railings made of timber shall be treated with wood preservatives of an approved quality and painted with two coats of enamel paint unless required otherwise.

All galvanized steel sheets and steel nuts and bolts and washers shall be cleaned of rust and where necessary shall be treated with a rust inhibitor and then applied with a coat of anti corrosive paint and two coats of enamel paint as directed.

Metal sheet railings where manufactured under shop conditions shall be sprayed with primer and spray paint of a specified brand as directed.

Any damage during assembly or erection to coatings of paint previously applied shall be corrected by applying the necessary primer and paint as specified or as directed.

No site drilling or cutting of existing railings or posts shall be permitted without the prior approval of the Engineer.

(b) Guard walls and guard stones

Guard walls shall be masonry, or reinforced concrete precast or cast insitu to dimensions given in Drawings.

Guard stones shall be either reinforced concrete, precast or cast in-situ concrete or stone masonry all as shown on the Drawings and/or as ordered by the Engineer. The concrete shall be class A or B concrete of grade 20/20. Forms used for concreting shall be wood, metal, or suitable material and shall extend the full depth of the concrete.

All forms shall be free from warp and of sufficient strength to resist pressure of the concrete without displacement.

All forms shall be cleaned and coated with approved form oil before concrete is placed and compacted.

Compaction of the concrete placed in the forms shall be by vibration. Forms shall be left in place for 24 hours or until the concrete has set sufficiently so that they could be removed without injury to the concrete placed. The finished concrete shall be kept moist for a minimum of 7 days. The method of curing shall be subject to the approval of the Engineer.

Guard stones shall be painted after installation as directed or as indicated on the Drawings.

(c) Guide Posts

Guide posts shall be constructed from 100 mm diameter PVC pipes painted and with holes drilled as shown on the Drawings. The holes are to prevent the pipes being useful for any other purpose.

They shall be planted to a minimum depth of 0.5m in dug holes, backfilled and compacted as required. Where necessary the footings shall be strengthened with a concrete infill round the dug hole compacted as required. Posts shall be painted, before and after installation, as directed.

(d) Bollards

Bollards fabricated from 150 mm diameter galvanised iron pipes filled with concrete and set in a concrete foundation, as indicated on the Drawings shall be supplied, painted, marked with reflective paint or reflective tape and installed at locations as directed by the Engineer.

808.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

808.4 Measurement & Payment

(a) Measurement

Unless otherwise specified, guardrails shall be measured by the length in metres of each type and guard stones, guidepost and bollard by the number of each type and guard walls by Cu.m and as accepted.

(b) Payment

The unit rate of payment for each item of work shall be full compensation for all labour, equipment, tools, materials and incidentals necessary to complete the work including painting as specified.

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
808(1)	Guard Rails (W-beam, galvanized steel)	linear metre
808(2)	Guard Rails (Steel Railway Rails)	linear metre
808(3)	Guard wall (concrete)	Cu.m
808(4)	Guard wall (masonry)	Cu.m
808(5)	Guard Stone	Number
808(6)	Guide Posts (100mm Φ PVC pipe)	Number
808(7)	Bollard	Number

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

809 SAFETY FENCING AND BARRIERS

809.1 Description

This work shall consist of construction of property fences and gates of the type indicated and constructed in accordance with the Specification and with the dimensions, lines and levels indicated in Drawings or as instructed by the Engineer.

809.2 Materials

Concrete used for precast posts shall be concrete of class A or B given in section 1001 and as specified.

The other materials shall meet the requirements of the following, unless otherwise specified.

(a) Steel reinforcements for concrete posts to CS 26 or SLS 375.

(b) Steel section for posts and gates to CS 73.

(c) Barbed wire strands for fences to SLS 31.

(d) Woven wire mesh for fences to SLS 407 & 793.

(e) Timber for posts to Section 1709

(f) Anti corrosive paints and enamel paints for steel section to Section 1706.

809.3 Construction Requirements

Prior to planting the fence posts (which shall normally be of precast concrete or timber) in the required manner, the ground should be graded where necessary, so as to provide a neat appearance of the fence line. All posts shall be set vertically and backfilled with suitable material compacted in layers.

Where the Drawings require that the posts be embedded in concrete the Contractor shall install temporary supports as may be required to hold the posts in proper position, until such time as the concrete has set sufficiently to hold the posts. Unless otherwise specified a minimum period of 7 days shall be allowed before such posts etc., are subjected to any stress.

Bracings shall be provided to posts where specified or where required by the Engineer.

Barbed wire or woven wire mesh of the type and size required, shall be firmly attached to the fences, and braced in the manner indicated in the Drawings or directed by the Engineer. All barbed wire and woven wire mesh shall be stretched out and shall be installed to the required elevations.

Gates shall be assembled and positioned as shown on Drawings or as directed by the Engineer.

809.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

809.4 Measurement & Payment

(a) Measurement

Unless otherwise specified, fences shall be measured by the length in metres of each type of fence and gates by the number of each type and as accepted by the Engineer.

(b) Payment

The unit rate of payment for each item of work shall be full compensation for all labour, equipment, tools, materials, and incidentals necessary to complete the work including painting as specified.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
809(1)	Fence (state type)	Linear metre
809(2)	Gate (state type)	Number

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

810 ROAD MARKINGS

810.1 Description

This work shall consist of application of continuous lines, letters or figures and the supply and installation of reflecting road studs on the finished paved areas of roads in accordance with the Gazette or Motor Traffic Act including any necessary excavation, grouting and finishing of Pavement, to the dimensions and at the locations shown in the Contract Documents or as directed by the Engineer.

The work shall also include warning and traffic guidance signs as necessary for the safe and efficient completion of the entire work as per Section 103.

810.2 Materials

The materials used for road markings shall be approved varieties of the following, conforming to the stipulations given below;

(i) Hot applied Thermoplastic material

(ii) Road marking Paint

(iii) Reflecting Road studs used as road markings or as component of road markings.

Before delivery of materials to site the Contractor shall forward certificates of origin specifying the physical and chemical characteristics and the constituents of the paint from the manufacture. Before delivery and during the work, the Engineer may call for any test considered necessary to determine the efficiency of the paint application. All such tests shall be performed at the expense of the Contractor and shall be considered subsidiary to the work.

(a) Hot applied Thermoplastic Material. (Superimposed Type).

The laid material shall be one of the three types (i), (ii) or (iii) detailed below as required by the Contract Documents or as directed by the Engineer.

(i) Non-refectorised Thermoplastic material – the thermoplastic material shall be factory mixed from an approved manufacturer and shall be suitable for the type and location of application. The material shall possess adequate thermoplastic properties over the range of climatic conditions of the location viz. resistance to spreading under traffic at the highest road temperatures and retention of plasticity at the lowest road temperatures and shall give a marking which is effective for at least eighteen months under normal traffic conditions. The composition of the material with minimum and maximum proportions and grading of the constituents , the acid value of the binder,

the temperature range of mixing and application, the setting time, the softening point (^{0}C) and the open flash point (^{0}C) shall be stated.

The material shall be supplied in durable and strong containers which do not contaminate the contents and which protect the contents from contamination and shall be stored in accordance with the manufacturer's instructions.

(ii) Reflectorized Thermoplastic material – the material shall be in accordance with (i) above except that ballotini (glass beads) shall be incorporated in the mixture during the manufacture of the thermoplastic material. The quantity of ballotini included shall be between 13% and 22% by weight of the total mix and shall be counted as part of the aggregate. The whole of the ballotini shall pass a 2mm sieve and not more than 10% by weight shall pass a 425µm sieve. The ballotini shall be free of sharp angular particles and not less than 80% shall be of transparent glass, reasonably spherical and free from flaws.

(iii) Reflectorized Thermoplastic material with Ballotini Surface – the material shall be in accordance with (ii) above except that a layer of ballotini shall be superimposed in the surface of the hot thermoplastic immediately after laying to give immediate reflectivity. The superimposed ballotini shall be of the same quantity as that incorporated in the reflectorized thermoplastic but may be smaller in size, no more that 20% shall pass 212µm sieve. Ballotini shall be applied at a rate of 250-450 grams per Sq.m such that the combined total of ballotini incorporated in and superimposed on the thermoplastic shall be between 20% and 26% by weight of the material.

(b) Road Marking Paint (Hot applied and cold applied)

The paint shall conform to BS EN 1436 and be either hot or cold applied and the laid material shall be one of the three types (i), (ii) or (iii) detailed below as required by the Contract Documents or as detailed by the Engineer. Cold applied paints shall be suitable for applying by brush or mechanical means. The following particulars of the paint shall be supplied:

(i) Composition (analysis by weight)

(ii) Application (hot applied or cold applied)

(iii) Type and maximum amount of reducer (thinner)

(iv) Drying time (to touch)

(v) Setting time (to re-coat)

(vi) Recommended coverage (litres per kilometre of 100 mm stripe)

(vii) Heat resistance i.e. maximum road temperature

(viii) Details of any primer, undercoat or tack coat required. For hot applied paints, the following additional information shall be supplied

(ix) The temperature range of heating and application

(x) The open flash point.

The paint shall be supplied fresh and ready for use in sealed containers, which shall be stored in accordance with the manufacturer's instructions.

(xi) Non-reflectorised Road Marking Paint

The paint shall be a hard gloss paint, from an approved manufacturer, specifically made for road marking, suitable for the type and location of application, factory mixed, and shall be suitable for applying to cement concrete or asphalt Pavement to give a chemically stable, non bleeding film of uniform thickness with a flat (non –glossy) finish. The "drying time" of the paint shall be not more than 15 minutes. The "drying time" shall mean the time lapsed from the time of application of the paint to a road surface to the time the paint ceases to be picked up by the tyres of heavy vehicles traversing over it.

(xii) Reflectorised Road Marking Paint

The paint shall be in accordance with (xi) above except that ballotini shall be incorporated in the paint during manufacture. The quantity of ballotini included shall be 330 to 500 grams per litre, the whole of the ballotini shall pass a 1.18 mm sieve and not more than 5% shall pass the 150μm sieve. The ballotini shall be free of sharp angular fragments and not less than 75% shall be of transparent glass, reasonably spherical and free from flaws.

(xiii) Reflectorised Road Marking Paint with Ballotini Surface

The paint shall be in accordance with (xii) above except that 50% to 70% of the ballotini shall be incorporated in the paint and 30% to 50% of the ballotini shall be superimposed on the surface of the freshly applied paint to give immediate reflectivity.

(c) Reflecting Road Studs

Reflecting road studs shall conform to BS EN 1436 and shall be of an approved design self cleansing reflecting units from a reputable manufacturer. Each stud shall be provided with either one reflecting lens for traffic in one direction (referred to as unidirectional type) or two reflecting lenses for traffic in either direction (referred to as bi-directional type) and the reflecting surface of each lens shall be at least 80 square mm, the lenses shall be capable of withstanding impact of wheel loads and no contact shall be possible between the lenses and vehicle tyres. The studs shall not project more than 20 mm above the level of surrounding road surface and the lowest part of the lenses shall be more than 5 mm above the surrounding road surface. The reflecting units shall be inter-changeable and capable of easy and quick replacement without disturbance of the road surface. The design shall be such as to ensure ample key to the road Pavement with adequately load distribution and such that it shall not be possible for heavy equipment such as road rollers and tracked vehicles travelling in the direction of the road axis to meet with any sharp edges whereby the removal of the stud might be facilitated.

810.3 Construction Requirements

(a) Thermoplastic Materials

(i) Preparation of Road Surface

The material shall be applied only on a surface, which is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous matter, or over an old paint marking, or over an old thermoplastic marking which is faulty, as determined by the Engineer. In the case of smooth polished surfaces, etc. smooth concrete, old

asphalt Surfacing with smooth polished surface stones, and/or where the method of application requires or the Engineer directs, a tack coat shall be applied to the surface prior to the application of the material. The tack coat and the rate of application shall be as the manufacturer of the thermoplastic material shall recommend with the approval of the Engineer.

(ii) Preparation of Thermoplastic Material

The material shall be melted in accordance with manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic and such that local overheating shall be avoided. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material shall be used as expeditiously as possible and for thermoplastics, which have natural resin binders or are otherwise sensitive to prolonged heating the material shall not be maintained in a molten condition for more than 4 hours.

(iii) Laying

Centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings may be applied by hand screen hand-propelled machine as approved or directed by the Engineer. After transfer to the laying apparatus the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency of laying.

In the case of screeded application the material shall be laid to a thickness of not less than 3 mm or not more than 6 mm unless specifically authorized by the Engineer when laid over an existing marking. In the case of sprayed application the material shall be laid to a thickness of not less than 1.5 mm unless specifically authorized by the Engineer. In all cases the surface produced shall be uniform and appreciably free from bubbles and streaks. Where the Contract Documents require, or the Engineer directs, that ballotini shall be applied to the surface of the markings, these shall be applied uniformly to the surface of the hot thermoplastic immediately after laying such that the quantity of ballotini firmly embedded and retained in the surface after completion complies with the requirements of Clause 810.2 (a) (iii).

Road markings of a repetitive nature, other than centre lines, lane lines etc, shall unless otherwise directed by the Engineer be set out with stencils, which comply with the size and spacing requirements of the RDA

(iv) Refuse of Thermoplastic Material

At the end of the day's work as much as possible the material remaining in the heater and /or laying apparatus shall be removed. This may be broken and used again provided that the maximum heating temperature has not been exceeded and that the total time during which it is in a molten condition does not exceed the requirements of Clause 810.3 (a) (ii).

(b) Road Marking Paint

(i) Preparation of Road Surface

The paint shall be applied only on a surface which is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous matter or over a

thermoplastic marking or over an old paint marking which is faulty or incompatible with the paint being applied. If a primer or undercoat is necessary to ensure proper adhesion of the marking paint to the road surface without bleeding or other discoloration, the primer or undercoat shall be fully compatible with the marking paint and the road surface and shall be applied only if, and at the rate of application, approved by the Engineer.

(ii) Preparation of Paint

All cold applied paint shall be thoroughly field mixed before applying in order to keep the pigments in uniform suspension. Hot applied paints shall be heated in a properly designed heater, preferably thermostatically controlled to the correct laying temperature at which it shall be maintained as required for the method of application. The paint shall on no account be allowed to exceed the maximum temperature specified by the paint manufacturer. The use of thinners or other additives shall not be permitted unless otherwise approved by the Engineer.

(iii) Laying

Centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings shall be applied by brush, spray, screed, hand-propelled or self-propelled machine according to the marking configuration and the type of paint approved for use as directed by the Engineer. The rate of application of the paint for each coat shall be that recommended by the manufacturer's instructions unless otherwise directed by the Engineer.

When more than one coat is used the succeeding coat shall not be applied until the previous coat has fully dried.

Road markings of a repetitive nature, other than centre lines, lane lines etc. shall be unless otherwise directed by the Engineer, be set out with stencils which comply with the size and spacing requirements of the RDA.

(iv) Protection of Markings

All road markings shall be protected from traffic until they have dried sufficiently to show no pick up of tyre marks or traffic dirt.

(c) Reflecting Road Studs

Excavation of the road Pavement to form a cavity for each stud shall be carried out in accordance with the manufacturer's instructions. In the case of concrete surfaced road cavities, they shall be at least 50 mm from an expansion joint and shall be clear of dowel bars at the joint. Care shall be taken to ensure a reasonably level floor and vertical sidewalls without projections into the cavity and that all loose material produced in excavating the cavity is cleaned out. A layer of approved stone (6mm to dust chippings) shall be laid and compacted level on the cavity floor. The stud shall be prepared in accordance with the manufacturer's instructions and firmly bedded on the levelling layer such that the correct projection of the stud above the road surface is achieved. A template shall be used to check the line and level of the bedded stud. The cavity walls shall be brushed with asphaltic tack coat and the whole of the remaining cavity grouted with hot filled asphalt in accordance with the recommendations of the manufacture until level with the road surface. Care shall be taken to ensure that no asphalt is spilled on the projecting portion of the stud. Any asphalt, inadvertently spilled shall be carefully removed so that a clean workmanlike

job is presented with a fully effective reflector unit. Traffic shall not be permitted to pass over the stud until the grout has firmly set.

(d) Defective Materials or Workmanship

Materials which are defective or have been applied in an unsatisfactory manner or to incorrect dimensions not conforming to the Specifications and in a wrong location shall be removed according to Specification 1502, the road surface made good and the materials replaced, the road marking reconstructed and /or properly located all at the Contractor's expense and to the satisfaction of the Engineer.

(e) Equipment

The road marking equipment shall be purpose made of approved type and manufacture and be capable of painting the markings to a uniform width within the tolerances specified without the paint running or splashing . The equipment shall be capable of painting lines of different widths by adjustment of the spray jets on the machine or by means of additional equipment attached to the machine.

The machine shall be capable of spraying at a speed of not less than 5.0 km per hour.

(f) Setting out

The lines, symbols, figures or marks shall be set out by means of paint spots of the same colour as that of the proposed final lines and marks. Normally spots of approximately 10mm in diameter spaced at 1.5 m intervals shall be sufficient.

After setting out the positions of the proposed road markings they are to be indicated on the road. These premarkings shall be approved by the Engineer prior to the commencement of any painting operations.

The positions of any road studs shall be marked out on the road and shall be approved by the Engineer before they are fixed in position.

(g) Tolerances

The width of lines and other markings shall not deviate from the specified width by more than 5%. The position of lines, letters, figures, arrows, reflective road studs and other markings shall not deviate from the true position specified by more than 2mm.

The alignment of any edge of a longitudinal line shall not deviate from the true alignment by more than 10mm in 15m.

The lengths of segments of broken longitudinal lines shall not deviate from the specified length by more than 150mm.

(h) Rectification of Faulty Workmanship

If any material not complying with the requirements is delivered to site or used in the Works, or if any sub-standard work is carried out, such material or work shall be removed, replaced or repaired as required by the Engineer, at the Contractor's own cost. Rejected traffic markings and paint that has been splashed or has dripped onto the Surfacing, kerbs, structures or other such surfaces shall be removed by the

Contractor at his own cost, in such a way that the markings or spilt paint will not show up again later.

(i) Protection of Traffic and arrangement of traffic with safety precautions during construction.

The Contractor shall protect pedestrian, vehicular and other traffic adjacent to the working area against damage or disfigurement by construction equipment, tools and materials or by splashes and smirches of paint or other construction materials. The Contractor shall during the course of the work provide and maintain adequate signs and signals for the road safety measures and warning and guidance of traffic in accordance with Section 103.

810.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

810.4 Measurement & Payment

(a) Measurement

Thermoplastic or Road Marking Paint

Road markings shall be measured by the area in Sq.m, completed, accepted and measured in place. Where the width or length of marking laid proves to be greater than that specified and is accepted by the Engineer the specified width or length shall be used when calculating areas for payment. Where the width or length of laid marking proves to be less than that specified and is accepted by the Engineer then actual width or length of laid marking shall be used when calculating areas for payment.

Reflecting Road Studs

The quantity to be paid for shall be the actual number of studs supplied, installed and accepted.

(b) Payment

The work measured as provided above shall be paid for at the Contract unit price per unit of measurement for each of the items listed below that is shown in the Bill of Quantities.

The payment shall be full compensation for providing and placing or installing the materials including all labour, equipment tools and incidentals necessary to complete the work.

The Pay Items Pay Units will be as follows.

Pay Item	Description	Pay Unit
810(1)	Thermoplastic material	Sq.m
810(2)	Road Marking Paint	Sq.m
810(3)	Reflecting Road Studs	number

811 TRAFFIC SIGNS

811.1 Description

(a) General

This work shall consist of furnishing, assembling and erecting posts, signs, sign frames, signs of a permanent nature in accordance with these Specifications and with the details shown on the Drawings or as directed by the Engineer and in conformity with the Motor Traffic Act.

The work shall include all necessary foundations, excavation, backfill, anchorage's fixtures and fastenings, brackets, application of paints and finishes, testing and all the process necessary to complete the work.

Project Information Sign

This work shall be carried out in accordance with section 118 " Project sign Boards".

Chevron Warning Sign

A chevron warning sign shall comprise a reflective V-shaped sign, each face approximately 600 mm x 300 mm, displaying a pattern of red and white chevrons. The signs are for installation on the outside edge of sharp curves and may be mounted on posts or set on or along a guard rail or guard wall. This sign does not appear in the "Manual on Traffic Control Devices" of the Road Development Authority and before ordering such signs the Contractor shall conform to the details as shown on Drawing or as decided by the Engineer.

(b) Sizes, Colours and Types

Unless otherwise indicated on the Drawings or in the Special Provisions, or otherwise directed by the Engineer, signs, and their supports shall be of the sizes, colours and types prescribed by and sited in accordance with the recommendations of the latest edition of the Government Schedule of Motor Traffic Signs and subsequent supplement and amendments.

(c) Alternative Designs and Materials

The Contractor may submit or recommend alternative designs and construction materials to those specified in the Special Provisions or on the Drawings but the Engineer's approval of any alternative shall be subject to the prior consent of the Employer.

811.2 Materials

(a) Mounting posts

The materials used for mounting post of road signs shall meet the requirements of the following

(i) Steel posts

Steel posts shall be tubular or rectangular hollow sections complying with BS 4848 and shall be manufactured from steel complying with grade 43c of BS 4360.

(ii) Aluminium Alloy Posts

Posts shall be tubular or rectangular hollow sections manufactured from one of the following alloys:

- Alloy HT 30 –WP to British Standard 1471 – Drawn Tube
  Alloy HV 30 – WP to British Standard 1474 – Extruded Round Tube and Hollow Sections
  Alloy HE 30 – WP to British Standard 1476 – Bars and Sections

or

- Approved alloy sections to other internationally recognized Specifications acceptable to the Engineer.

- G I pipes of medium type

(iii) Post Caps

Caps for hollow posts or other hollow sections used in construction may be approved cast or sheet metal or a suitable weather resisting plastic material.

(b) Base Housings

Base housings for metal posts carrying illuminated signs shall be of fabricated steel or aluminium alloy not less than 4.5 mm thick or of cast iron or cast aluminium alloy having an average thickness of not less than 8 mm and a minimum thickness of 6.5 mm. Steel shall comply with the requirements of Clause 811.2 (a)(i). Aluminium alloy Bases shall be of material complying with the requirements of Clause 811.2(a)(ii). Cast aluminium alloy Bases shall be either ASTM Designation B26 or B108, alloy SG 79A, Condition T6.

(c) Sign Plates

Sign plates and panels shall be manufactured from Aluminium Alloy complying with

(i) Flat sheets and plates shall be :

Either Alloy NS3-3/4H, NS4-1/2H or HS30-WP complying with BS 1470, or approved alloy sheet or plate complying with such other internationally recognized Specification as is acceptable to the Engineer.

(ii) Extruded panels shall be:

Either Alloy HE9-WP, HE9-P, or HE30-WP complying with BS1476 or approved alloy complying with such other internationally recognized Specification as is acceptable to the Engineer.

(d) Frames and stiffening

Except as otherwise provided on the Drawings or in the Special provisions, sign plates requiring frames or stiffening as specified under Clause 811.3 (e) shall have adequate ribs or flanges as an integral part of the sign plate or shall have frames or stiffening members of material complying with the following:

- A metal frame or stiffening bars constructed of structural sections in aluminium alloy complying with the appropriate Specifications of Clauses 811.2 (a) and 811.2 (c).

(e) Fixtures and Fittings

Brackets and clips shall be manufactured from approved cast metal, mild steel, stainless steel, G.I. or aluminium alloy approved by the Engineer.

Screws, bolts, nuts and washers shall be of steel, aluminium alloy or of a high tensile non-corroding metal. Washers in contact with painted/finished, surfaces, which may be damaged by over tightening of nuts or bolts shall be of suitable soft and weather resisting materiel.

Screws, bolts, nuts and washers which are in contact with a sign face shall be of stainless steel, G.I. or other approved metal which does not give rise to rust streaks on the sign face.

Steel fixings and fittings which are in contact with aluminium shall be coated with zinc or cadmium. All steel fittings shall be rust proofed. Rivets shall be made from copper, brass, aluminium alloy or pure aluminium. Brass, copper, lead or nickel shall not be used in contact with aluminium.

(f) Preservatives, Paints and Finishes

All coatings, paints, varnishes and enamels used in the preparation and finish of the signs, posts and fittings shall be of the best quality, specially made for the purpose they shall serve, and shall be of an approved manufacture and suitable for application in tropical climatic conditions, on the type of material and the surface and of brands and types acceptable to the Engineer. To ensure compatibility, primers. undercoats and finishing coasts shall, wherever possible, be of the same manufacture unless otherwise approved by the Engineer. All materials shall be stored, and used within such time limits as specified or recommended by the manufacturers or in accordance with the directions of the Engineer.

Zinc coating (galvanizing) or steel parts shall comply with ASTM Specification A 123 or A153 as appropriate.

All paints used for steel parts, other than finishes on a sign face, shall be high zinc oxide content coating material of approved formulation containing a minimum of seven kilograms of zinc oxide (acicular type) per one hundred litres of coating material. The colour of the primer shall be different from succeeding coatings.

Priming paints for aluminium alloys, when required, shall be pigmented with chromates or chromes (excluding lead chromes) except on sign faces where the specified finish is unsuitable for use with such primers.

Reflective sheeting shall be 'scotchlite' Engineer Grade or other approved colourfast reflective sheeting material applied in accordance with the manufacturer's Specifications or instructions.

Plastic sheeting, film, sheathings and sprayed plastic finishes shall be of approved types and thickness of durable colour and weather resistant, and shall be fully compatible with any materials with which they will come into contact. Such finishes shall be applied in accordance with the manufacturer's Specifications or instructions and approved by the Engineer.

(g) Reflective Beads

Beads for reflectorization of signs shall be of good quality, optically clear, lead-free of glass with not less than 90% reasonably spherical and free from flaws. The beads shall contain not more than one per cent of sharp angular particles and not more than one half percent of foreign matter and shall be free flowing under normal atmospheric conditions.

For reflectorizing white and yellow, the beads shall have a refractive index of not less than 1.60. For reflectorization of other colours the reflective index shall be not less than 1.60 and not greater than 1.70.

The beads shall contain not less than 80% by weight within one of the size ranges specified below.

Size Range µm	Size Range U.S Sieve Sizes
250-177	60-88
210-149	70-100
177-125	80-120
149-105	100-140
125-88	120-170
105-78	140-200

The binder for the beads shall be formulated so as to provide maximum bead retention, high specular reflection and a firm bond with the surface to which it is applied.

811.3 Construction Requirements

(a) General

When directed by the Engineer, signs shall be mounted on existing posts, lamp columns, walls and structures. The obstruction of footwalks shall be avoided.

(b) Mounting Posts

Posts for mounting standard type of road signs such as an advance warning sign or a regulatory sign or any informative sign other than a direction or an advance direction sign made of material specified in section 811.2 shall have a Cross-section

corresponding to the standard sizes of the signs and the standard clear heights of the signs from the ground as specified or shall be as indicated in the Drawings or as otherwise directed by the Engineer.

Where it becomes necessary the size of the sign post or posts for monitoring the sign shall be increased as indicated in the Drawings or as approved by the Engineer.

Posts shall be adequate in number and size to support the signs and any lighting fittings attached to the frames or posts. Where apertures are cut in posts for fixings / cable entry, etc., due allowance shall be made to ensure that the post will be of adequate strength.

Post shall have sufficient Cross-section and strength such that when a force equivalent to a pressure of 1500 N/sq metre over the area of the sign is applied to the centre of the sign, the maximum deflection at the centre of the sign is limited to one fortieth ($1/40^{th}$) of the height measured from the ground for signs mounted on a single post and to one eightieth ($1/80^{th}$) of the height measured from the ground for signs mounted on more than one post.

The length of posts shall be adequate for the requirements allowing for embedment in the ground and / or extensions for lighting fittings. All posts shall be effectively prevented from rotation in the ground and if necessary in the case of metal posts, suitable metal Base plates shall be provided for this purpose. Unless otherwise shown on the Drawings Base plates shall be not less than 4.5 mm thick and shall have an area as indicated in the Drawing or as specified in Sub section 811.3 (c).

Where a post has to be sited close to a wall either the top of the post shall be angled away from the wall to provide adequate clearance for the sign or an adequate bracket or brackets shall be provided from the post for this purpose. In either case the post shall be of adequate strength and rigidity to withstand the additional bending moments and torsion resulting from the arrangements.

All open ended posts, or other hollow sections used in construction shall be effectively capped to prevent the entry of water.

(c) Base Housings

Base housings for posts shall have ample accommodation for the electrical components to be fixed therein. Suitable means shall be provided for fastening the posts firmly to the Base housing. Base plates shall have an area not less than two and a half times the plan area of the Base housings and shall be not less than 4.5 mm thick in the case of steel and aluminium plate and not less than 6.5 mm thick for cast housings as specified in Sub section 811.2.(b)

A service door or panel of rigid construction shall be provided to give ready accessibility for maintenance purposes. The door or panel shall be weatherproof and shall be capable of being secured with key fastenings. Screws shall be of non-corrosive metal and captive. Screws of a self tapping type shall not be used.

Ventilation and drainage, sufficient to prevent undue condensation, shall be provided and the bottom of the housing shall be sealed to prevent the upward seepage of water. Arrangements shall be made for the service cable or conduit to enter the base housing at any depth between 0.15 m and 0.3 m below ground level and it shall be possible to lift away the post and housing without breaking the service joint. Cable

entry holes shall be sealed, with a suitable gland, against the entry of dirt or water. Adequate earthing arrangements shall be provided.

(d) Sign Plates

Aluminium alloy plates and panels shall have a minimum thickness of 2 mm.

Extruded plank type aluminium panels may be of either the interlocking or bolted type. Where such panel sections are used the ends of the sections shall be covered to present a flanged appearance such that the edges of the sign present the same appearance all round.

Thickness of sign plates fabricated in other materials shall be as approved by the Engineer.

Sign plates and panels shall be cut accurately to the shapes and sizes specified on the Drawings or as required by the Government Schedule of Motor Traffic Signs. All mounting holes shall be accurately located and, after drilling or punching, any burrs, rough spots and loose material shall be removed. All holes shall be drilled before painting.

(e) Frames and Stiffening

Except where ribs of flanges are an integral part of the sign plate and provide the necessary stiffening, sheet metal sign plates exceeding one metre in any dimension shall be stiffened by the attachment of a frame or stiffening member to the back of the sign plate. Any metal stiffening member shall have a minimum thickness of 2mm.

The post or posts supporting a sign may be taken into consideration for stiffening purpose. A bracket may form the stiffening frame or part of it.

The frame for a sign plate or plates shall be simple in design and shall have the minimum number of members to give it the 'required' stiffness'.

The stiffening of frame for a sheet metal sign plate may take the form of flanges round the edges of a sign, welded ribs or steel or aluminium sections with a minimum thickness of 2mm. Where flanges are provided they shall be uniform on all edges of the sign.

Where metal frame members joint they may be welded or joined with suitable brackets and nuts and bolts but in all cases the joints shall be strong enough to withstand the stress induced in them.

(f) Fixtures and Fittings

Where necessary or desirable, signs shall be mounted on existing suitable highway furniture, buildings or structures by means of a properly designed bracket or brackets with the Engineers approval.

The method of fixing sign plates, frames and brackets to posts shall be such as will facilitate removal for replacement or maintenance purposes and permit adjustment in the position of a sign without detaching it from its posts, but the sign and any framing shall be held firmly enough to withstand the load to which it will be subjected without excessive deflection. Signs mounted on single posts shall have fixing to prevent the forced rotation of the signs on the posts. Clips and brackets shall

be shaped to secure a firm hold on the posts without placing any bending strain on the sign plate. The bottom edge of the sign plate shall be generally 2.2 metres above footwalk level.

Where materials with different coefficients of expansion are fixed together, allowance for this shall be made so that the sign will not fail by shearing or buckling of fixing bolts, rivets or welds.

Where dissimilar metals are joined together, precautions shall be taken to prevent electrolytic action particularly in the case of screws and rivets. This may be accomplished by using paint, lacquer or other suitable means to eliminate metal to metal contact.

Brackets used in the construction of signs may be manufactured from sheet or strip aluminium alloy extrude sections, cast aluminium alloy or may be fabricated from steel sections. The minimum thickness of material shall be 3 mm. Welded joints shall be sound and their surfaces smooth. Holes shall be drilled before painting and shall be accurately located.

Steel or aluminium strips used for clips shall not be less than 2mm thick.

Screws and bolts shall not be less than 8 mm in diameter and of adequate length, but without excessive projection of the screwed ends. In any situation where, if a screw were removed, the assembly would be insecure, that screw shall have not less than four full threads engaged when it is tight and shall be fitted with a lock-nut or a spring washer.

(g) Preparation and Painting

(i) General

All painting and finishing shall be carried out in clean, dry surroundings. All paints shall be applied with a pressure spray to form a smooth even film and all surfaces and edges shall be coated unless stated otherwise. Paint shall be applied only when the surface or previous coat is dry. The manufacturer's instructions shall be complied with in preparatory work and painting of sign components.

The following requirements shall, unless otherwise provided in the Special Provisions or on the Drawings, apply to preparation and painting of sign components other than the finish on sign faces but excluding plastics signs and components with finishes of reflective and plastics sheeting, film sheathings and other propriety finishes.

(ii) Aluminium alloys

Aluminium alloys, other than sign faces, shall not be treated or painted unless they are in contact with earth. Surfaces in Contact with earth shall be prepared as described in the next paragraph and two coats of approved asphaltic paint shall be applied.

Before painting, the surfaces of aluminium alloy sign plates shall be thoroughly degreased and pre-treated by anodizing or by an equivalent process or by using and etching primer. The prime coat shall then be applied. The back and edges of the plate shall receive a finish coat of light gray enamel.

(iii) Steel surfaces

All steel components shall be rust proofed by galvanizing, cadmium plating or other approved treatment prior to painting. All surfaces other than sign faces shall receive a finish coat of high zinc oxide paint, tinted light gray.

(iv) Cast Iron

Cast iron surfaces shall be cleaned and painted with a suitable approved primer. Subsequent painting shall comprise at least one undercoat and one top coat

(h) Finishes of Sign Faces

Prior to the application of the finish and protection of the finish, the Contractor shall comply with the recommendations by the manufacturers of paint, reflecting materials, plastics, sheeting or other finishes, regarding the preparation of surfaces.

The finish on the face of the sign shall present an even surface free from twits, cracks or faults or any other blemishes. When reflecting sheeting or film is used it shall, where possible, be in complete sheets. Joints shall be kept to a minimum but where they are necessary they shall be constructed in accordance with the manufacturer's instructions. Care shall be taken to ensure a proper day and night colour match at joints.

Any colour in the finishing coat of a sign shall be homogenous and uniform. Colour shades or signs shall be according to the samples of colour shades as approved by the Engineer. Unless otherwise specified painted sign faces shall have at least one undercoat over the prime coat before the finishing coat is applied.

Legends shall be carefully coloured at their edges to ensure true proportion. On signs where light colours are applied over dark, at least two coats of light colour shall be applied.

Bead type reflectors shall be securely fixed to signs without appreciable reduction of the effective area of the beads. The beads shall be uniformly and closely spaced, giving a smooth and easily cleaned surface without interstices which can retain dirt or moisture. Beads shall not cover the black portions of signs.

(i) Erection of sign Assembly

(a) For mounting posts with concrete Bases

A foundation pit of dimensions as specified or as otherwise directed by the Engineer shall be excavated. The sign assembly shall be correctly centred in the pit, the post vertically aligned and the sign plate shall be correctly oriented. The post shall be held in position with temporary struts and stays. Concrete of class B grade 20/40 shall be placed in the pit and compacted. The top surface of the concrete shall be furnished smooth to a slight slope downwards from the centre to the edges. The temporary struts shall be removed after concrete has hardened.

(b) For mounting posts without concrete Bases

A pit of depth not less than 1/3 the total length of the mounting posts and wide enough to facilitate compaction of the backfill around the post shall be

excavated. The bottom of the pit shall be levelled and compacted. The sign assembly shall be correctly centred in the pit, the alignment of the post shall be correctly oriented. The post shall be held in position with temporary struts and stays. Backfill shall be placed uniformly around the post in loose layers not exceeding 100 mm and each layer compacted. When the backfill has reached a level slightly higher than the surrounding ground level, the top surface of the backfill shall be levelled off. The temporary struts and stays shall be removed.

811.4 Inspection and Testing

Before fabrication of signs the Contractor shall supply a sample of each type of sign with information concerning equipment and procedures and state the location of the workshops manufacturing the signs. The Engineer will inspect the facilities and, if satisfactory shall grant approval to fabricate the remaining signs.

When so requested by the Engineer, samples of preservatives, paints and finishes shall be supplied by the Contractor and shall be tested by him as directed by the Engineer for the appropriate conditions (exposure, compatibility of materials, bindings, reflectance etc.). Testing shall be carried out of sufficient time to ascertain the equality and / or suitability of the materials.

811.5 Measurement and Payment

(a) Measurement

The quantity to be measured for payment, shall be the actual number of completed road signs, chevron warning signs, single poles and double poles of each type and size furnished and accepted.

(b) Payment

The work, measured as provided above, shall be paid for at Contract unit price for each type of sign and necessary post, fixings and fittings which price and payment shall be full compensation for furnishing and erecting the road signs. Road shall also include the cost of all material including all labour, tools, testing and incidental necessary to complete the work to the Specification

The Pay Items and Pay Units shall be as follows;

Pay Item	Description	Pay unit.
811(1)	Single pole, sign area upto 0.5 m^2	Number
811(2)	Double pole, sign area upto 2.0 m^2	Number
811(3)	Chevron warning sign	Number

812 STANDARD STREET LIGHTING AND HIGH MAST LIGHTING

812.1 Description

This work shall consist of furnishing, assembling and erecting either standard lighting equipment or high mast lighting equipment in accordance with the details and locations shown on the Drawings and Specifications or as directed by the Engineer.

The work shall include all necessary foundations, excavations, backfill, anchorages, fixtures and fastenings, brackets, lighting units and electrical installations, where required, and application of paints and finishes, testing and all necessary processes to complete the work.

812.2 Materials

(a) Materials ("Standard" Street Lighting)

The "standard" street lighting equipment shall be inclusive of the following major items of equipment:

- Street Lighting Fittings
- Galvanised Steel Masts with Connector Boards
- 3 core / 2.5mm^2 plain copper conductor PVC insulated
- 4 core / 2.5mm^2 plain copper conductor PVC insulated
- Outdoor type Feeder Pillars with associated Electrical Protection and Control Gear
- Conduits and all accessories for fixing lighting cables
- Anchor bolts and fixing for flanged columns.

Other details of materials are given under construction requirements

(b) Materials ("High Mast" Lighting)

The "high mast" lighting equipment shall be inclusive of the following major items:

- Luminaries (light fittings)
- Lighting support masts
- Power distribution equipment and switch gear
- Comprehensive details of erection, installation and power connection

Other details of materials are given under construction requirements

812.3 Construction Requirements

(a) Standard Street Lighting

(i) Street Lighting Fittings

The Street Lighting Fittings shall have the following minimum features in addition to conforming to other relevant international Specifications, standards and approvals. (BS 4533:2.7)

(a) Completeness of fittings shall include all control gear, bulb, fixing accessories etc.

(b) Unless otherwise shown on the Drawings the lamp shall be semi-cut off type [i.e, LTI (low threshold increment) category]

(c) The bulb shall be High Pressure Sodium Vapour 220 / 250 Watt, 230V, 50HZ having a minimum luminous flux of 22,000 lumens after 2000 hrs of operation and shall be guaranteed for a minimum life of 4000 hrs. or as shown in the Drawings.

(d) The lamp body shall be of Aluminium or corrosion resistant glass reinforced polyfibre complete with injection moulded – clear Acrylic, Vandal, insect and vermin proof resistant bowl and separate high purity polished Aluminium reflector.

(e) The control gear shall include inductor, igniters and power factor correcting capacitor to be integrally housed within the lamp with easy accessibility for maintenance.

(f) The lamp shall be suitable for mounting in a horizontal plane plus or minus 5 degrees

(g) The minimum class of protection shall be Ingress Protection Rating 65 for the entire optical unit and be suitable for tropical humid environment

(h) Lanterns of a particular type shall be of a uniform pattern from a single manufacturer. The lanterns shall be normally designed using semi cut-off luminaries as indicated on the Drawings.

However cut off luminaries shall also be used at specific places as indicated in the Drawings.

(ii) Masts for street lighting

These masts shall be of standard type manufactured by a reputed supplier / manufacturer and shall conform strictly to the required international standards especially in terms of hot dip galvanising, structural strength, finish etc.

All cabling inside the lighting mast shall be of double insulated PVC/PVC/CU (copper) conductor cable of minimum Cross-section of 2.5 mm^2 for the connection between the lighting fitting and its individual protection double pole (DP) circuit breaker and provided with suitably sized earth continuity conductor.

The following requirements shall be satisfied.

(a) The structural material of the mast shall be rolled steel

(b) The finish mast and its components including holding down bolts, shall be hot dipped galvanised to BS EN ISO1461 for both the exterior and interior. All fasteners of the same shall be of stainless steel.

(c) The Contractor shall submit calculations and shall also satisfy that the mast conforms structurally, to a lamp fitting weight loading with an extra 25% of the same and wind loadings calculated for a 100 km/h wind speed. The depth of foundation shall vary accordingly.

(d) The mast cross-section shall be :
(a) continuously tapering from its roots to the extreme tip of same
or (b) telescopic

(e) The mast shall generally be of the planted root type with a minimum provision of 150 mm by 75 mm for cable entry set 300 mm below ground level and a chamber for supporting electrical control equipment. The access for the same shall be by a standard window with vandal proof fastenings.

(f) On structures and other specified locations the columns shall be fitted with flanged Base plates as shown on the Drawings. Cable entry shall be through an opening in the Base plate.

(g) All cable termination accessories required by the cable loop-in, loop out method of wiring shall be contained within the mast together with the terminals for same and the DP Circuit Breaker protecting the lamp circuit. The equipment, completely wired and mounted on a separate mounting board shall be included for in the mast supply.

(h) The maximum mounting height shall be as shown in Drawings and it shall have a minimum outreach of 2m. The buried portion of the mast below ground level shall be minimum of 1200mm.

(i) Not in use

(j) The electrical phase colour to which the particular column is connected shall be clearly identified in the Base compartment of each column.

(k) In double arm columns the supply to each lantern shall be individually wired from the supply cut out in the column Base.

(l) All cut outs and fuse units shall incorporate a means of isolation in both poles of the double pole circuit breaker unit.

(iii) Underground Cabling

The underground cabling shall be of size 2.5 mm^2 conductor Cross-section, 4 core PVC sheathed, steel wire armoured PVC insulated Copper conductor cable manufactured to BS6346 and shall be of the 600/1000V grade complete with relevant end terminations.

All termination of cables shall be carried out strictly in accordance with the cable manufacturer's recommendations. Cable armouring shall be terminated via approved cable glands fitted to suitable gland plates and bonded to the main earth terminal. The Contractor shall terminate all cables in distribution pillars.

Buried 'through' joints shall not be used and cables shall be looped in equipment.

(iv) Feeder Pillar

The feeder pillar shall be complete with all its internal switchgear and control devices complete with their internal wiring in accordance with the attached Drawings for it. The foundation shall be as indicated on the Drawings with an allowance for

cable entries etc. The control photoelectric cell shall be located at the top of the nearest lamp column and wired into the control circuit of the feeder pillar.

Feeder pillars shall be of metal construction large enough to accommodate all the equipment detailed on the Drawings.

Steel cabinets shall be galvanised after fabrication and painted. Cast iron pillars shall be supplied with paint primer applied and shall be finished on site with one undercoat and one gloss coat of good quality paint to give a final colour to BS 4800.

The pillars shall be fitted with wedge locks. Six keys shall be provided and handed to the Engineer on Completion of the Works.

Labels shall be provided for each item of equipment within the feeder pillar. Labels shall be of an approved type with red letters of 6 mm high on a white background.

All internal wiring shall be carried out using single core PVC cable to BS 6004 in plastic trunking of suitable Cross-sectional area. Internal wiring shall be deemed to include all wiring necessary for connection to the main electric supply.

The feeder pillars shall be provided with front screens or insulating materials to shield all live parts. A schematic diagram shall be provided and fixed by the Contractor inside the pillar. The diagram shall be on a non-hygroscopic material with a smooth surface.

Workshop Drawings showing the general arrangement, for the cabinet interior wiring and connections to each pillar shall be submitted to the Engineer for approval before manufacture.

(v) Feeder / pillar control and protective devices

The feeder / pillar shall be complete with all its internal switch gear and control devices complete with their internal wiring in accordance with the manufacturers recommendations and attached Drawing for the same. The feeder / pillar shall be of robust metal construction and suitably finished to give the required protection for an outdoor electrical unit of this type. The Base for the same shall be indicated in the Drawing with allowance for cable entries etc.

The internal switch gear and control gear shall have the following functions:-

The power switching to the lamp circuits to be possible by all of the 3 methods below:-

- photo-electric device
- programmable timer with spring reserve
- manual operation

Each of the above modes shall be selectable by means of a rotary switch located within the feeder pillar.

The incoming protection Moulded Case Circuit Breaker shall be triple pole 63A with minimum interrupting capacity of 25kA. All outgoing circuit breakers whether single-pole or multi-pole shall be of similar interrupting capacity i.e 25kA.

There shall be a total of eight triple-pole outgoing circuits, each protected and controlled by 3 numbers SP 30A Moulded Case Circuit Breakers.

The interrupting capacity of each outgoing circuit breaker shall also be 25KA at 440V. The switching contactor shall have a minimum 3 phase AC duty current rating of 63A, life span of 2 million operations and a control voltage of 230V. Complete protection to the control circuits shall be provided by over current devices and the use of an isolating transformer.

(b) High Mast Lighting

(i) Illumination

It is desired that the roads at roundabouts, intersections / junctions to be lit up a minimum intensity of 20 lux average. Any addition to the intensity of illumination of glare index value shall not exceed the recommendation of the values given by the Institute of Illumination Engineers UK or other equivalent national body.

(ii) Luminaries (light fittings)

These shall be of outdoor type conforming to relevant international standards and with a minimum degree of protection, IP55 shall be of die-cast Aluminium construction with highly polished anodised Aluminium reflectors, toughened glass envelope and water –tight gasket. The lamp shall be of High Pressure Sodium Vapour type (SON) 400W, 240V, 50Hz, complete with all control gear and power factor correcting capacitors. These lamps shall have two dimensional adjustment possibility and shall be fixed on to a crown situated on the top of the single high mast.

(iii) Lighting support masts

These shall be of high grade steel Hot Dipped Galvanised to BSEN ISO 1461 of both exterior and interior. The mast shall be of either tapering or telescopic character with relevant access for incoming cables and windows for control gear. The mast shall incorporate suitable crown for fixing of the requisite number of lamp fittings required for each proposal plus a 25% additional weight capacity and for wind speed of 150 km/h for all directions and wind pressure of 1200 N/m^2. The height of the masts shall be 18m or as indicated in the Drawings or as directed by the Engineer. The mast and the crown proposal shall be such that it provides for an easy maintenance for all light fittings and other associated control gear preferably at ground level. This could be achieved by any safe method i.e. by use of manual gear winch cable arrangement or other. All cabling for such work shall be properly chosen for this purpose.

(iv) Incoming power and power distribution

The mast shall have provision to accept an incoming underground cable steel wire armoured of cross-section up to $35mm^2$ per conductor (4 core cable). The Contractor's equipment shall take over from this point and shall include all equipment as given in Drawings and any additional equipment that shall be necessary to complete the installation to the required IEE standards.

(a) Incoming main circuit breaker minimum interrupting capacity of 10kA and 415V 3 phase.

(b) 3 pole contactor with 2 N/O + N/C obsolete contacts minimum operating current 2mA at AC3 duty.

(c) Photocell with parallel by pass manual switch to operate above contactor.

(d) Individual circuit breakers of 10kA interrupting capacity to control and protect each outgoing lamp circuit (1 circuit per lamp)

(e) Extra on/off push button set for lighting control.

(f) Earth leakage circuit breakers of 4 pole type sensitivity of 300 mA.

All above equipment shall be completely wired and enclosed to suit the IP 55 condition and additions shall be suitable for tropical environment.

(v) Lighting Protection

It is essential that each mast shall be permanently and effectively earthed by separate plate or rod(s) buried in the ground. The earth shall be of such capacity as to safely conduct and dispose any lighting discharge liable to strike the mast during lightning conditions.

812.4/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

812.5 Measurement and Payment

(a) Measurement

Lighting columns, high mast columns, including lighting fittings shall be measured as the number of each type supplied and installed in position as described in the Specification and the Drawing complete with all civil works and accepted by the Engineer.

Feeder Pillars shall be measured as the number supplied and installed in position as described in the Specification and the Drawings complete with all civil works and accepted by the Engineer.

Pre-insulated copper conductor and earthing tapes shall be measured in linear metres, runs through the column or laid in the trenches complete with all civil works as accepted by the Engineer.

(b) Payment

The work measured as provided above shall be paid for at the Contract unit prices as detailed below. The payment shall be full compensation for furnishing, hauling, installing, commissioning and testing the column, feeder pillar or cable and for all labour tools, equipment, material, and plants and incidentals necessary to complete the work.

The pay items and pay units shall be as follows:

Pay item	Description	Pay Unit
812 (1)	Lighting column 12m high – single arm including light fittings	number
812 (2)	Lighting column 12m high – double arm including light fittings	number
812 (3)	High mast lighting columns including light fittings (state height)	number
812 (4)	Feeder Pillar including all switch gear, control devices and photo cells	number
812 (5)	3 Core / 2.5 mm^2 Plain copper conductor pvc insulated	Linear metre
812 (6)	4 Core / 2.5mm^2 Plain copper conductor pvc insulated	Linear metre

Note:

Refer instructions 106.6 regarding sub division of Pay Items.

813 TRAFFIC LIGHT SIGNALS

813.1 Description

813.1.1 General

The work shall consist of furnishing installation and commissioning of, traffic light signals, in accordance with these Specifications and with the details shown on the Drawings or as directed by the Engineer. Only well proven equipment designed and constructed to the highest standards shall be acceptable. Traffic control equipment shall therefore only be accepted after a demonstration to the Engineer of its adequacy in design, construction and reliability.

Variations to the requirements of this Specification shall be considered where the Contractor provides a full justification for the variations explicitly stated. Only those variations authorised by the Engineer shall be permitted.

813.1.2 Approval

Where the Specification calls for the approval of the Engineer to be given to any part of the equipment or work, no equipment shall be shipped from the Contractor's premises until the appropriate approvals have been given by the Engineer in writing.

813.2 Definitions

(a) Controller

- **Minimum green running period**

The duration of a green signal following the extinction of a red/amber signal during which no change of signal light can occur.

- **Maximum green running period**

The maximum time that a green signal can run.

- **Phase**

The sequence of conditions applied to one or more streams of vehicular or pedestrian traffic which during the cycle, receive identical signal light indications. Two or more phases shall overlap in time. A series of phases shall be usually arranged in a pre-determined order but some phases shall be omitted if required by the situation.

- **Stage**

A condition of the signal lights which permits a particular movement of traffic. They are arranged to follow each other in a pre-determined order but stages shall be skipped, if not demanded, to reduce delay.

- **Inter green period**

The period between the end of the green display on one phase and the start of the green display on the next phase is known as the inter-green period. This period comprises the time between leaving amber for the stage losing right-of-way and the starting amber for the stage gaining right-of-way separated by a variable length all red period. For pedestrian phases, the inter-green period as defined, shall display a red man.

- **Cycle -time**

A cycle is a complete series of stages during which all traffic movements are served in turn. The cycle time is the sum of the stages.

- **Demand**

A request for right of way for traffic on a phase that has no right of way when the request is made. The demands, normally being stored in the controller and served in a pre-arranged order.

- **Detector**

A device that detects the presence or passage of a vehicle on the roadway.

- **Traffic Signals**

A system of different coloured lights, including arrow shaped lights, for controlling conflicting streams of traffic.

- **Traffic signal controller**

The electronic control equipment which activates the signal phases at an intersection.

- **Vehicle –actuated signals**

Traffic signalling equipment in which the duration of the green time and cycle length varies in relation to the traffic flow on its approaches.

813.3 Regulations, Codes and Specifications

All equipment and materials supplied shall comply with the regulations, and codes of practice. The said regulations, codes of practice, and other documents shall form part of the Specification, together with all other regulations, requirements, conditions or Specifications referred to therein. Where proprietary equipment has been designed to equivalent regulations, codes of practice and Specification, these shall be stated by the bidder at the time of bid and all differences explicitly stated.

(a) Regulations

(i) Institution of Electrical Engineers UK – Regulations for Electrical Installation (16th Edition, 1991) (BS 7671)

(ii) Ceylon Electricity Board

(b) British Standards Institution Codes of Practice

CP 1006 General aspects of radio interference suppression
CP 1013 Earthing

(c) Specifications

BS EN 12368:2000 Traffic Control Equipment Signal Heads
BS 800 Radio Interference
BS 2011 1977 Methods for the environmental testing of electronic components and electronic equipment.

Part 2.1a Cold (including AMD 3144 – June 1980)

Part 2.1b Dry heat (including AMD 3145 – June 1980)

BS 5378 Safety Signs and Colours

Part 1 1980 Specification for Colour and Design

Part 2 1980 Specification for Colourimetric and Photometric Properties of Materials

Part 3 1982 Specification for Additional Signs to those given in Part I.

813.4 Traffic Signal Equipment

(a) General

(i) All equipment shall be supplied in a new and unused condition except insofar as it has been tested in the course of manufacture.

(ii) All equipment supplied shall be of a type suitable for use on public roads in Sri Lanka.

(iii) The equipment shall be subject to acceptance tests prior to installation. These tests, which shall be conducted at the manufacturer's premises, shall be in accordance with accepted good practice and all to the satisfaction of the Engineer.

(iv) Installation, engineering and commissioning will be carried out at the sites specified in accordance with accepted good practice and all to the satisfaction of the Engineer.

(v) The equipment shall be suitable for the climatic conditions prevalent in Sri Lanka.

(vi) On pedestrian operated signals the legends on the push button box will be in Sinhalese, Tamil and English.

(vii) Initial signal timings will be provided by the Engineer where appropriate.

(viii) The supplier will be responsible for the training of the Employer's staff in the use of the signal control equipment. Any equipment necessary for the reprogramming of the controllers will be supplied.

(b) Construction Requirements for Controller

Traffic Signal Aspect Sequence shall be RED, RED and AMBER, GREEN, AMBER, RED. It shall also be possible to flash AMBER aspects as described in 813.4. (b)(ii) (f).

(i) On stand alone pedestrian crossing signals the pedestrian aspect sequence shall be: red standing man, green walking man, flashing green man, red standing man.

(ii) On signal controlled junctions incorporating pedestrians, the pedestrian aspect sequence shall be: red standing man, green walking man, red standing man.

- The controller shall be a microprocessor based programmable controller.
- All controllers shall be fully equipped to meet the method of control specified for a given location and shall be capable of expansion by the addition of at least one phase on site without back wiring changes. Each phase provided shall be configured as either a vehicle or pedestrian phase, and it shall be possible to combine phases in any order to provide stage sequences.
- Controllers shall be capable of operating in the following modes:

1. Fixed time

In this mode the controller shall cycle through all stages in a pre-determined sequence, when the duration of the red and green signals and the time of the cycle are fixed:

2. Demand dependent

In this mode two or more stages shall be equipped as demand dependent stages. These stages shall be served only when an external demand is present for the stage. The controller shall cycle through all stages in a pre-determined sequence, omitting any demand dependent stage for which no demand is present. When a demand is present the controller shall step to that stage in its correct sequence and shall then step to the next stage on the expiry of the minimum green interval or extensions. In the case of the pedestrian demand dependent stages, demands shall be registered by pedestrian push buttons. In the case of vehicular demand dependent stages, demands shall be registered by approved vehicle detectors;

3. Manual

In this mode it shall be possible to step the controller through all its stages (including demand dependent or vehicle actuated stages) in the pre-determined sequence by the operation of a push button. It shall not be possible to step from one stage to the next until the minimum green period for the running stage has expired. It shall not be possible by use of this mode to override any prohibited stage –to-stage movements. The controller shall remain on the running stage until stopped by the operation of the push button. Provision shall be made for rendering this facility inoperative;

4. Cable-less link

This facility shall have the capacity for at least eight Plans and have a battery back-up system which shall last for 24 hours under fully charged conditions. It shall be possible to programme a plan change:

- on every day of the week;
- on every day, Monday to Friday; and,
- on Saturday and Sunday only..

The number of programmable plan changes in a week shall not be less than 24. Plans shall be changed automatically at times of the week defined by;

- day of week;
- hours;
- minutes; and
- seconds.

The flashing amber mode shall be accessible via the cable less linking facility.

5. Urban traffic control system (UTC) with the vehicle activated system

Facilities shall be provided such that at a later date the controller shall be remotely controlled as part of a computer controlled system;

6. Flashing amber

All amber aspects will flash at a nominal rate of 75 beats per minutes. This mode shall be introduced only when the running stage terminating amber period has finished. During this mode all other vehicle and pedestrian signal indications shall be extinguished; it shall be possible to use the flashing amber mode for specified Plans only;

7. Flashing of pedestrian indicators

When the flashing of either pedestrian walk or clearance intervals is required the sequence should be specified;

8. Vehicle and/or pedestrian activated

In this mode stages shall run in the standard sequence when vehicle or pedestrian demands are registered. Each stage, when called, shall run for at least the minimum green period and shall be extended by further detection of vehicles on the appropriate approaches. The stage shall terminate when a demand is registered for an opposing stage and either no further demands are present for the running stage or the maximum green time for the running has expired.

(c) Priority of modes

The priority of modes shall be:

(a) manual;
(b) computer control
(c) cable-less link
(d) demand dependent
(e) vehicle actuated
(f) fixed time
(g) flashing amber

(d) The following timing intervals and ranges shall apply to any appropriate stage:

(a)	Maximum green	7-10 seconds in one-second steps;
(b)	Leaving amber, amber only	Three seconds fixed
(c)	Starting amber, amber and red	Two seconds fixed;
(d)	Inter-green	4-20 seconds in one-second steps;
(e)	Pedestrian	5-25 seconds in one-second steps;
(f)	Flashing amber	6-18 seconds in one-second steps;
(g)	Minimum green	1-15 seconds in one second steps;
(h)	Vehicle extensions	1-10 seconds in one/two second steps.

(i) All the controller software and intersection parameters shall be held in non-corruptible Programmable Read Only Memory (PROM), or equivalent.

(ii) The controller shall monitor each green signal to ensure against conflicts as set in the PROM by hardware and software means.

(iii) Checks shall also be made by means of a 'watchdog' to monitor the correct operation of the controller. Detection of conflict or faulty operation shall put the controller into a fault condition.

(iv) A keyboard or similar plug in unit shall be provided, to input variable parameters to the controller's Random Access Memory (RAM). This input shall be able to operate whilst the controller is running without interfering with the safe working of the controller. A fixing for plug-in display shall be provided to display all the programmable timings including those held in the cableless linking unit.

(v) The controller shall have a fault log which shall be accessible from the keyboard and display as specified in 813.4.(d) (iv).

(vi) Under controller fault conditions the controller shall go into a flashing amber mode, and shall cause all amber aspects for vehicles at the intersection to flash.

(vii) The start-up sequence upon switch on or resumption of power supply after a failure shall be a blackout period followed by a three second amber to all aspects and a one second red to all aspects. The stage cycle shall then commence with the normal signal sequence.

(e) Construction and Design

(i) The controller housing and control equipment shall be of a suitable manufacture for the climatic conditions of Sri Lanka which will include high temperatures and high humidity.

(ii) One main door on the controller case shall give access to:

(a) control equipment;
(b) keypad input point or push button unit;
(c) main power fuses and switches.

(iii) The control facilities supplied for the use of the police shall be accessible without opening the main controller door and shall be behind a lockable flap or door.

(iv) All timing shall be digitally derived, with a timing accuracy of $\pm$ 1%.

(v) The cableless linking unit shall be controlled by an electronic digital clock synchronised to the mains supply. The accuracy of the clock shall be equal to the accuracy of the mains supply for all conditions except a mains failure of greater than 50 ms.

In the event of a mains failure of greater than 50 ms, all clocks and the cableless linking unit shall be supplied from batteries capable of maintaining the unit in operation for at least 24 hours, under fully charged conditions, over the whole ambient temperature range. The batteries shall be automatically charged when the mains supply is restored. After restoration of the mains supply, the unit shall re-synchronise itself to the mains and continue normal operation.

Under power failure conditions the cableless linking unit shall disconnect itself from the controller if the battery voltage falls below the level at which the unit and its clock shall be relied upon to operate faultlessly.

(vi) A facility shall be provided to indicate the state of charge of the batteries.

(vii) During periods of any mains failure of up to 24 hours stored data shall not be corrupted or lost.

(viii) Facilities shall be provided to set the digital clock to the correct day, hour , minute and second. Digital displays shall be provided to allow the clock time to be observed.

(ix) Operation of all signals shall be positive without flickering or excessive dark periods.

(x) Visual indications shall be provided within the controller to indicate the running stage and the interval currently being timed.

(xi) Power supply units shall employ double-wound transformers which shall include an earth screen. Transformers shall be provided with primary tapping from 200 to 250 volts in steps of 10 volts. Voltage stabilisation shall be required.

(xii) Lamp switching devices shall be solid stage and each circuit shall be capable of switching 5A.

(xiii) All wiring and equipment shall be accessible without removing the controller from its case.

(xiv) All contacts or terminals carrying mains voltage shall be shrouded or covered to avoid the possibility of accidental contact. A warning label shall also be attached to the cover.

(xv) Each controller shall be fitted with two circuit breakers or double pole fused switch units to isolate:

(a) incoming supply to the installation, and
(b) voltages to the controller electronics

(xvi) The controller shall have a switched socket outlet for the connection of mains operated tools and test equipment. It shall be compatible with socket outlets in common use in Sri Lanka. The socket shall not be isolated by the switch specified in 813.4. (e) (xv) (b)

(xvii) A switch shall be provided to switch off all signals while leaving the controller operation. This switch shall be accessible without opening the controller door and protected by the lockable flap specified in 813.4. (e) (iii)

(xviii) Screw terminations shall be of the types that do not allow the screws to come directly into contact with the wires.

(xix) The controller shall continually monitor the mains supply voltage. Shall it fall below the controller's requirements all the signals shall be extinguished. Upon the restoration of the supply the controller shall automatically restart using the procedure stated in 813.4. (b).

(xx) The Engineer shall be responsible for providing the timings and daily Plans to the supplier, for entering into the controller.

(xxi) The Contractor shall allow in his quotation, for the re-programming of the site PROM (s) with information be provided by the Engineer following the commissioning of the installation. This information need not be limited to timing changes. A period of six months shall be allowed for between commissioning and re-programming the PROM(s).

(f) Environmental requirements

- The Contractor shall conduct environmental tests as specified in this section, on all equipment be provided, to the satisfaction of the Specification or shall provide documentary evidence to show that the specified tests have been conducted to the satisfaction of an independent testing authority and acceptable to the Engineer.

- The basic environmental tests shall be conducted in accordance with BS 2011 specified herein, or an internationally recognised Specification. The Contractor shall submit evidence of tests conducted to comply with an alternative internationally recognised Specification, which when submitted shall be accompanied by the alternative Specification.

Environmental Tests

(i) Dry heat

The purpose of the test shall be to determine the suitability of the equipment to withstand conditions of high temperature.

(ii) Damp heat

The purpose of the test shall be to determine the suitability of the equipment for use under conditions of high humidity.

(iii) Solar radiation

The object of the test shall be to determine the suitability of the equipment for use when exposed to solar radiation.

(iv) Driving rain

The object of the test shall be to determine the suitability of equipment to withstand the effects of driving rain.

(v) Bump

The object of the test shall be to determine the suitability of equipment to withstand bumping in transit and to assess structural integrity.

(vi) Random vibration

The object of the test shall be to determine the ability of equipment to withstand random vibration whilst in service.

(vii) Dust sealing

The object of the test shall be to determine the ability of the equipment to prevent the ingress of dust.

(g) (i) Detection

The method of vehicle detection at signal controlled junctions and at pedestrian crossings controlled by signals shall be provided by above ground vehicle detection to TRL 2123 or an internationally approved equivalent. The detection equipment provided shall be able to detect all types of moving vehicles through a controlled area, and all type of stationary vehicles in a defined location.

(ii) Detector failure alarm

The failure of any vehicle detecting equipment specified herein shall cause a 'detector failure' alarm lamp be lit at the signal controller. The indicator shall be coloured red. The lamp shall be easily visible from the outside of the signal controller case and be of such intensity that it may be readily seen under conditions of bright sunlight. The lamp shall be lit within a 'delay period' of a detecting equipment failure and shall be extinguished only by the operation of a manual reset switch.

(h) Pedestrian Crossings

This section covers the operational requirements of traffic control equipment for pedestrian operated traffic signalled crossings away from junctions.

1. Controller Housing

The construction of the controller housing shall be in accordance with the requirements of BS 505 : 1971. Controller housings shall be either free standing or pedestal mounted and shall be capable of accommodating the control equipment for fixed time or vehicle actuated operation environmental tests as described in (813.4.6) shall be carried out.

2. Failure of Controller

All pedestrian controllers shall be equipped with facilities to prohibit:

- the display of a green signal for pedestrians with a green signal for vehicles;
- the display of a steady green signal for pedestrians without the display of a red signal to vehicles;
- the operation of the audible signals unless the steady red signal to vehicles is displayed.

3. Red Lamp Monitoring

A red lamp monitor circuit shall be provided for each approach, and shall detect the presence of a load on any red lamp transformer. Should all red vehicle lamps on any one vehicle approach be extinguished during the red vehicle period, due to lamp failure or any other condition leading to the transformers being off-load, then

the monitor circuit shall cause all signal lamps, with indicator lamps and audible signals to switch off automatically within 500 milliseconds and remain off until the controller is manually re-set by a non-locking switch or push button following replacement of the faulty lamps. Following manual reset no traffic signals shall be illuminated for a period of between 7 and 10 seconds and the signal cycle shall then commence at the start of the flashing amber to vehicles / flashing green to pedestrian with a stored pedestrian demand.

4. Linking Facilities

Provision shall be made to enable, when specified, the normal operation of the equipment to be influenced by control signals from a remote point.

It shall be possible for such control signals to:

(a) bring about an artificial pedestrian demand, or;

(b) hold the equipment indefinitely in the "Vehicle Period" for as long as the control signal is present, any pedestrian demand that arises during the period of such control shall be stored.

5. Pedestrian Audible Signal

Unless otherwise specified an audible signal for pedestrians shall be provided, within one push button box on each footway. The audible signal shall operate only when the steady red signal is shown to vehicles and the steady green signal is shown to pedestrians. Because of the danger to partially sighted or blind people, audible signals shall not be used where a double pedestrian crossing (staggered or otherwise) with each half of a crossing under independent control is provided. The fundamental frequency of sound emitted by the audible signal shall be between 2.0 kHz and 3.5 kHz and it shall be pulsed at 240 ppm (pulse per minute) $\pm$ 60 ppm having on/off ratio of 1.5:1 $\pm$ 10%. A mechanical means shall be provided in the push button box for adjusting the intensity of the sound.

6. Vehicle and Pedestrian Signals

The light signals shown to vehicular traffic and to pedestrians shall comply with the requirements of BS EN 122368:2000: 1971 (see section 813.5 – Signals).

7. Pedestrian 'WAIT' Indicators

The operation of a pedestrian push button or an artificial pedestrian demand at any time other than when a steady green signal is displayed to pedestrians shall result in a demand for the pedestrian stage and the immediate illumination of 'WAIT' indicators in all push button boxes.

The 'WAIT' indicators shall remain illuminated until the commencement of the green signals to pedestrians.

8. Signal Dimming

Signal lamp dimming shall be controlled automatically by means of a solar switch.

9. Sequence of Signals

(a) The equipment shall operate to a predetermined fixed vehicle period cycle on receipt of a pedestrian demand.

(b) In the inactive state with no pedestrian demand, green signals shall be displayed to vehicles and red signals to pedestrians.

10. Conditions to Signal Change

No change of signal shall take place unless initiated by the receipt of a demand for a pedestrian stage.

11. Signal Timings

The Engineer shall be responsible for providing timings to the supplier for entering into the controller.

12. Detection

The method of vehicle detection shall be as described in g (i) & (ii).

813.5 Signals

General

The traffic signal equipment shall comply with BS EN122368:2000, or equivalent, with the following exceptions:

(a) The post shall be manufactured from medium steel tube with an outer diameter of approximately 114 mm and finished in black and white painted stripes of 300 mm width. The poles should also be supplied with pole caps, pole head terminating assemblies, including support for the signal cables and an earthing terminal. The protective paint and/or coatings shall be suitable for the climatic conditions in Sri Lanka.

(b) The lamp supplied shall be a tungsten Halogen lamp with a bayonet type fixing. The spring contact of the lamp holder shall be so designed as to maintain adequate electrical conductivity and to ensure that the lamp remains securely located under traffic vibration. The lamp supplied shall have a rated life of at least 1000 hours. The light output requirements from each signal shall comply with an international standard for a tungsten Halogen lamp signals. The bidder shall specify the standard to which his equipment complies:

(c) Supports for overheads mounted signal shall have the pole section for a height of 3 m above ground level painted with black and white stripes of 300mm width.

(d) Signal heads shall be supplied complete with fixing brackets and accessories;

(e) Backing boards for signal heads shall be provided, but shall not form an integral part of the signal head, such that they can be omitted if site conditions dictate.

The pedestrian signal equipment and push button unit shall comply with BS EN 12368:2000 or equivalent. Legends shall be in Singhalese, Tamil and English.

813.6 Cable-less Linking Unit

(a) **Cableless Linking Unit**

The cableless linking unit (CLU) facility shall allow a method of linking adjacent traffic signals along a route in an area using timing information derived from other master clock systems.

All signal controllers in a linked system are related to a common cycle time for any particular traffic plan. The unit instructs the controller to change from one traffic plan to another and during the plan when to exert specific influences, (e.g to move from one nominated stage to another). In this way a variety of signal linking shall be achieved ranging from a simple coordinate two-controller link to a fully coordinated multi-plan system.

(b) **Plan facilities**

(i) **Plan timings**

The necessary timing signals for the execution of a specific plan are derived from the Group Timer Clock.

(ii) **Offset times**

This time relates the start of the timing cycle on the individual controller to reference time. Alternatively offset times can be derived by varying the times of introduction of particular Plans on linked controllers.

(iii) **Cycle time**

One complete sequence of signalling operations.

(iv) **Group time**

The time period for which specific group influence shall be exerted on the controller operation.

(v) **Group influences**

The function of each group and the number of groups within a cycle shall be programmable within the individual plan to exert one of the following influenees upon the main controller.

a. an immediate move to the specified stage. (This is subject to the constraints imposed by safety timings and stage-to-stage movement restrictions);

b. a demand dependence move. A move to a specified stage if demanded by street demands; and,

c. isolate (allow the controller to follow its own timings)

(vi) Stage structure

The plan shall also allow stages be introduced or deleted, within the constraints of the basic stage/phase definitions.

(c) **Time table**

Plans shall be called into operation by timetable.

a. When a new plan is implemented by the timetable it shall always commence with the first group.

b. A plan shall be a total set of timings, (Offset, Cycle Group times) for the signal.

813.7 Documentation

(a) Technical Handbook

The Contractor shall supply two copies of the technical handbook for each type of traffic signal controller installed as part of the Contract. The handbook shall contain a full technical description of the controller. Contents shall include, but is not confined to, the subject matter described in this section of the Specification.

(i) Hardware

(a) Brief technical description including layout and block diagram.

(b) Full technical description including circuit diagrams of all modules (and exploded component diagrams where necessary to aid comprehension)

(c) Maintenance procedures and fault finding guide.

(d) Parts list and wiring schedules

(ii) Software

(a) Brief description of the software including the system philosophy

(b) Overall description of the system programs its routines, sub-routines and interaction between the software segments.

(c) Flow charts

(d) Software source code listing which shall be annotated to provide ease of understanding

(e) Site data management and storage area description.

(iii) Controller /Operator Interface

The manual shall pay particular attention to all interfaces, both hardware and software, between the controller and operator.

A full technical and operational description shall be included of the terminal device and the means of communication between it and the controller.

(b) Site handbook

The Contractor shall provide two copies of each individual site handbook. The site handbook shall contain:

(i) component module layout of the controller, including reference numbers;

(ii) Controller cable layouts;

(iii) Full details and configurations of the monitoring system of conflicting green signal outputs;

(iv) full description of operator interfaces for the controller, and operating procedures;

(v) site plan, with position of poles, signals detectors, cable runs, stage diagrams etc.

(vi) initial time settings for the controller

(vii) first line maintenance procedures;

(viii) site installation details, cable core allocation, etc.

A draft handbook shall be supplied with the site acceptance test and the final site handbooks shall be approved by the Engineer and delivered within two months following the completion of each installation. The Contractor shall distribute the site handbooks as follows:

- one copy to the Engineer
- one copy in the controller cabinet

The Contractor shall provide a splash-proof wallet in the controller to contain the site documentation and protect it from the environment. This wallet shall be sealable and shall be attached to the inside of the controller case so that it may not be removed.

813.8 Supply of Equipment

(a) Storage

All equipment shall be held in storage by the Contractor, until required for installation.

(b) Delivery

Each controller shall be subject to the tests specified in clause 813.4.1 (iii) and shall not be delivered to site until the said test has been successfully completed or approval has been given by the Engineer.

The controller electronics shall be delivered to site by the Contractor immediately prior to commissioning. At no time shall the controller be left on site and switched off without form of heating in the cabinet to prevent condensation.

(c) Spares

The bidder shall specify, on the form in the Annex to the Bill of Quantities the levels of spares he deems necessary for the maintenance of equipment supplied under this Specification. The spares shall be supplied to the designated maintenance company, responsible for the maintenance of the equipment and shall include 2 copies of technical handbooks. The level of spares shall not be less than two years.

813.9 Installation

(a) Civil Engineering Works

This section of the Specification details the civil engineering works for the installation of traffic signals.

(i) Install all signal poles defined in the Specification.

(ii) Signal poles shall be installed in the footway at a minimum distance from the edge of the road Pavement to comply with the requirements of clause 813.9.(a)(ix).

(iii) Install the controller housing in the position defined by the engineer. Ensure that the position of the Base is such that when the housing is installed, the access doors when fully opened, do not obstruct the footway or cause a danger in any way to members of the public. The housing shall not be positioned adjacent to the kerb as to tender it liable to damage by vehicles or so that the safety of persons working on the controller is endangered.

(iv) The controller housing shall be installed and secured in an upright and vertical position. Ducts shall be extended approximately 100 mm into the area above the foundation and shall be secured in position. An extra duct shall be fitted above the immediate requirement and it shall be firmly sealed at both ends.

(v) Cover all new traffic signal heads, pedestrian lanterns and push button boxes with an opaque material so that during subsequent installation and commissioning signal aspects are not visible to motorists or pedestrians. The covers shall only be removed at the direction of the Engineer.

(vi) At the time of commissioning, provide and install signs on all approaches to the signals with a suitably worded legend warning road users.

(vii) Install all cables required at the intersections as specified in the Specification, and ensure that all draw wires remain in-situ after the cable installation.

(viii) Position all equipment and ensure that all cable apertures and fixing holes for signal heads and push button units are correctly aligned so as to meet the requirements of the Specification.

(ix) Ensure that signal heads are mounted so that a clearance of 450 mm exists between the kerb edge or edge of the carriageway and the nearest part of the complete pole assembly.

(x) Ensure that the height of the centre of the amber optical assembly shall not be less than 2.4 m nor more than 4.0 m above the carriageway. Ensure that signal heads are not mounted so that they present a hazard to members of the public. The height of

overhead mounted signals shall be such that when erected the centre of the amber optical assembly shall not be less than 6.1 m or more than 9 m above the carriageway.

(xi) Pole mounted pedestrian push button units shall be mounted so that the top of the unit is 1.5 m from ground level and positioned at 90 degrees to the kerb facing the crossing. The wait indicator lamp shall be fed by an extra low voltage supply.

(xii) Ensure that all on-street equipment supplied is correctly installed.

(xiii) Unless specified otherwise by the Engineer, direct each signal aspect at a point approximately 1.5 m above the centre of the half of the carriageway concerned at a distance of 50 m from the primary signal face. In the case of overhead or high level signals, the Engineer shall advise the Contractor in this respect.

(xiv) Do not allow any signal aspect to be illuminated during installation or commissioning unless it has been covered in accordance with Clause 813.9.(a)(v)

(b) Electrical Engineering Works

This section of the Specification details the electrical requirements for the installation of traffic signals.

(i) Electricity supply

(a) The Employer, under a separate agreement, shall provide a 230V AC 50 Hz 40A single-phase supply to the equipment.

(b) Where the Electricity Authority shall provide an earthing point which affords a continuous metallic (return path to the earth of the supply system), the Contractor's earthing conductor shall be connected to the earth bar in the feeder control pillar.

(c) The Contractor shall ensure that his equipment complies in all respects with the regulations and requirements of the Electricity Board, which shall form part of this Specification.

(d) The Contractor shall be responsible for all wiring other than electricity services to the feeder pillar which shall be provided by the Ceylon Electricity Board. It shall be the responsibility of the Contractor to inform the Engineer of the earliest date when he shall be ready for the Electricity Board to make the service connections.

(e) The Contractor shall supply the equipment to be terminated to the Electricity Board's service with phase and neutral conductors of not less than 4 mm^2 and earthing conductor of not less than 6 mm^2. The Electricity Board, or skilled person authorised by the Board, shall connect the controller conductors and earth conductor to the terminals provided by the Board.

The Electricity Board's cut-out shall incorporate a high breaking capacity fuse carrier and fuse to BS 88 or BS 1361. The rating shall be specified by the Contractor to comply with the type requirements of Regulation 413-5 of the IEE Regulations.

(ii) Electrical cables

(a) All cable shall comply with the requirements of the IEE Regulations and shall be of adequate size and rating to meet the electrical current carrying requirements and

provide the necessary electrical protection for the system. Cables to signal poles shall be multi-cored 2.5mm^2 copper conductor, PVC insulated, PVC sheathed and armoured, 600-volt grade, or equivalent.

(b) All multi-cored armoured cables, excluding feeder cables but including linking cables to all other equipment housings where specified, shall have a spare core capacity of at least 25% at the time of installation. Where this is not possible using a single cable, a second cable shall be provided which shall be correctly terminated at each end.

(c) A separate neutral conductor shall be provided for each traffic signal head and pedestrian head, push button unit, photoelectric cell unit and regulatory signs.

(d) All unused covers of cables at the various terminating points shall be cut to a minimum length, long enough to connect to the further terminating point of the particular unit in which the termination is housed, and so as to be of equal length. The ends of the cores shall be sealed against the ingress of moisture. The unused cores are to be laid and strapped in a suitable, unobtrusive position.

(e) An extra low voltage supply to the push button unit shall be derived from the controller cabinet and not from within the associated head. Voltage not to exceed 50V.

(iii) Cable joints

(a) Cable joints shall not be permitted on new installations except with the written approval of the Engineer which shall only be given in the most exceptional circumstances.

(b) Where cable joints are unavoidable, in the opinion of the Engineer, the jointing methods and materials shall be of a type approved by the Engineer and, in particular, shall be of a type which allows the integrity of the protective earth conductor(s) to be maintained.

(iv) Earthing requirements

(a) The Contractor shall provide protection against dangerous earth leakage currents by fuses or excess current circuit breakers compliant with the IEE regulations for electricity installation. The Contractor shall ensure that all installations shall be such as to allow for the operation of the protective devices upon the occurrence of a fault and that all non-current carrying metallic parts shall be connected to the earth terminal in such a manner as to ensure that a hazardous voltage cannot exist on exposed conductive metal work.

(b) All cabinets, poles and other metal hardware comprised by the traffic signalling equipment shall be connected to the main terminal by a protective conductor.

(c) Protective conductors shall be designed and installed so that they comply with the IEE Regulations for Electrical Installations (16th Edition, 1991) BS 7671.

(d) All protective conductors shall be colour coded green / yellow stripe. Where an earth conductor is part of a multi-core cable and a green /yellow stripe colour coded core is not available, the Contractor shall ensure that the protective conductor is adequately identified as such.

(e) The armouring of all the signal cables which enter the controller shall be clamped securely by means of a gland or clip. This shall then be correctly bonded to the earth bar in accordance with IEE regulations using a 6.00 mm^2 conductor.

(f) Armoured cable to signal poles and other equipment mounting poles shall be terminated at the top of each pole with a gland or equivalent unit.

(g) The earthing requirements at the head of each traffic signal pole shall be as follows:

(i) The earth terminal of the gland in Clause d(vi) above, shall be connected to the earth conductor of a minimum cross-sectional area of 6.00 mm^2 and correctly terminated with crimp connectors.

(ii) The protective conductors from each signal head, pedestrian head, push button unit or other equipment shall be connected together at the head of each pole and connected to the earth terminal in the controller housing using one core of the multi-core armoured cable;

(iii) The earth connection at the head of the pole specified in (ii) above shall be connected to the earth stud of the pole with a protective conductor terminated with crimp connectors.

(iv) Push button units fixed to a signal pole shall be earthed to the earth stud of the pole with a separate protective conductor terminated with crimp connectors and having a minimum cross-sectional area of 6.00mm^2.

(h) The main earthing terminal or bar shall comply with Regulation 542-19 of the IEE Regulations for Electrical Installation and shall be connected to the earthing point provided by the Ceylon Electricity Board with copper earthing conductor in accordance with Regulation 542-18. It shall have a minimum cross-area of 6.00 mm^2 and shall be green/yellow stripe coded. Where an ELK is used then the cross-sectional area of the earthing conductor shall comply with the requirements of Regulation 543.1.

Note :

The earthing conductor shall be defined as protected conductor connecting a main earthing terminal or bar of an installation to an earth electrode or other means of earthing.

(i) All electrical connections, in particular all earth connections, shall comply with Regulations 527-1 of the IEE Regulations.

(ii) Protective conductors shall be designed and installed so that they comply with Regulations 541-1 and 543-3 of the IEE Regulations. They shall have a cross-sectional area compliant with the requirements of Regulations 431-1. The minimum cross-Sectional area of each protective conductor shall be 2.50 mm^2 unless specified otherwise in this Specification.

The attention of the Contractor shall drawn to the requirements of clause 813.9(b)(iv)(c) of this Specification.

813.10 Commissioning

(a) Electrical tests

On completion of installation, and before commissioning the controller, the following tests shall be carried out by the Contractor to the satisfaction of the Engineer and in accordance with Regulations 613-1 of the IEE Regulations:

(i) Visual inspection in accordance with Regulations 612-1;

(ii) Continuity test of all protected conductors in accordance with Regulations 613-3.

(iii) Insulation resistance test in accordance with Regulations 613-5 to 613-8 inclusive. However, the insulation resistance shall not be less than 100 mega ohms;

(iv) Polarity check in accordance with Regulation 613-14;

(v) Where an earth leakage circuit breaker shall be installed, then tests in accordance with Regulation 613-16 shall be complied with.

The Contractor shall provide the equipment necessary to complete the above tests, and shall provide all other test equipment to demonstrate that the installation complies with the Specification.

Upon the successful completion of the commissioning the controller Base shall be sealed with a minimum of 5 mm of epoxy resin.

813.11 Maintenance

(a) General

(i) Following satisfactory installation and commissioning of the signal equipment, it shall be maintained by the manufacturer for a period of 12 months. The Contract price shall include for 12 months free maintenance of the equipment.

(ii) The Contractor shall submit a price for the maintenance of the signal equipment for a period of four years to commence on the expiry of the first year's maintenance detailed in 813.11.(a) (i). The price shall be supported by a complete summary of services to be provided during a four year period which is included in the Annex to the Bill of Quantities.

The Contractor shall be required to demonstrate that they have a local agent in Sri Lanka shall be capable of maintaining the signals under agreement.

813.11/2 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

813.12 Measurement and Payment

(a) Measurement

The quantity to be measured for payment shall be for the complete traffic signal system for each junction as shown in the Drawings. The system shall included all equipment and materials, including the controller, for the provision of a fully operational traffic signal system. The Contract Drawings show the ducting to be provided for the system, by the highway Contractor, at each junction. Should the Contractor require any additional ducting he must include the cost of providing and installing this in his rates.

(b) Payment

Payment for:

(i) The provision of traffic signal system shall be paid for at the Contract unit rate for each junction and shall be full compensation for furnishing all equipment and materials necessary for a fully operational traffic signal system plus the cost carriage, insurance and freight to the Port of Entry, Colombo, SRI LANKA.

(ii) The commissioning, testing and maintenance of the traffic signal systems shall be full compensation for all the labour, plant and equipment necessary to make the system fully operational, for the testing as required by the Contract and for the maintenance of the system for 12 months following commissioning.

(iii) The provision of site handbooks shall be full compensation for the provision of two copies placed in splash-proof wallets of each individual site handbook one set for the Engineer and another set for the Employer.

(iv) The maintenance of the traffic signal system shall be full compensation for all labour and plant required to maintain the signal system in a fully operational system for 4 years following the expiration of 12 months maintenance period following commissioning.

(v) The spares shall be full compensation for the provision of the spares the Supplier deems necessary for the maintenance of the system for 2 years following commissioning.

(vi) The provision of a keyboard or similar plug in unit to input variable parameters to the controller's Random Access Memory shall be full compensation for providing a unit for each type of controller installed as part of the Contract.

(vii) The provision of technical handbooks shall be full compensation for providing two copies for each type of traffic signal controller installed as part of the Contract, with one set for the Engineer and one set for the Employer.

The pay items and pay units shall be as follows:

Pay Item	Description	Pay Unit
813 (1)	Provide traffic signal system	Prov sum
813 (2)	Commissioning, testing and maintenance of traffic signal system for 1 year	Prov sum
813 (3)	Supplying hand book	Prov sum
813 (4)	Maintenance with spares for 4 years after 1 year maintenance period	Prov sum
813 (5)	Supplying on key board or similar device to input variable parameters	Prov sum
813 (6)	Provision of technical handbooks on variable input parameters	Prov sum

814 PEDESTRIAN SUBWAYS / UNDERPASSES

814.1 Description

The work shall consist of the construction of Pedestrian subway / underpass by excavating of the soil and other materials to the required levels and construction of concrete structures with or without reinforcement in accordance with the Specification or as shown on the Drawings or as directed by the Engineer.

814.2 Materials

Materials used shall meet the requirements of the following unless otherwise specified.

(a) The concrete used for precast or cast insitu units shall be proportioned, mixed & placed in accordance with section 1001 of the Specification and as shown on the Drawings or as instructed by the Engineer.

(b) Reinforcement shall comply with the section 1002 of this Specification and to SLS 375 or CS 26.

(c) All materials used for various items of work involved in construction of pedestrian subways / underpasses shall be in accordance with the relevant part of the Specification.

814.3 Construction Requirements

The various items of work involved in constructing pedestrian subways/ under passes shall be in accordance with the relevant sections of the Specifications.

814.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

814.4 Measurement and Payment

(a) Measurement

There shall be no separate payment for constructing pedestrian subways / underpasses. The individual items of work involved shall be measured as provided for in the relevant section of the Specifications.

(b) Payment

There shall be no separate payment. The individual items of work involved shall be paid for as provided for, in the relevant sections of the Specification.

815 SERVICE DUCTS

815.1 Description

This work shall consist of ducts and draw pits constructed in accordance with this Specification and in accordance with the lines, levels, grades, sizes, dimensions and types shown on the Drawings, or as instructed by the Engineer.

815.2 Materials

Pipes for service ducts shall have a smooth internal bore without any sharp edges. Pipes shall be selected from the permitted alternative designs described in the Contract.

Contractors shall ensure that plastic pipes are stored under cover and not subject to deterioration due to sunlight during the period between manufacture and installation in the ground.

Unless otherwise described in the Contract or agreed with the Engineer, only one type of pipe shall be used within any individual duct run between consecutive draw pits.

The Contractor may provide a different pipe and bed to that which is described in the Contract, subject to the Engineer being satisfied that the design and strength of the proposed pipe together with its support and backfill are equally effective as those described in the Contract, and that the pipe shall not be injuriously affected by either the adjacent ground or the cables to be carried.

815.3 Construction Requirements

(a) Excavation for Ducts and Draw Pits

The sides of pits and trenches shall be adequately supported at all times. Except where otherwise described in the Contract, they shall not be battered.

All excavated material not required for backfilling shall be removed to tips provided by the Contractor.

Soft spots in the bottom of the excavations shall be removed and the resulting space immediately backfilled with Type 1 Sub-base material or pipe bedding material and compacted in accordance with the Contract or with concrete as directed by the Engineer.

Excavations requiring backfilling shall remain open only for the minimum period necessary.

Excavations requiring backfilling in existing paved or other surfaces shall be carried out and reinstated in compliance with the Contract.

The Contractor shall keep excavations free of water including;

(i) Arranging for the rapid removal of water, from the site and prevent water entering the excavation.

(ii) Lowering and maintaining by appropriate measures, the water level in excavations, sufficiently to enable the Permanent Works to be constructed.

(iii) Providing where necessary temporary watercourses, drains, pumping and the like;

(iv) Discharging accumulated water and ground water into the permanent outfalls of the drainage systems.

(v) Providing adequate means for trapping silt on temporary systems discharging into permanent drainage systems.

(b) Bedding, Laying and Surrounding of Ducts

Immediately following the excavation of the trench the ducts shall be laid and jointed on the approved bedding. Ducts shall be laid so that each one is in contact with the bed throughout its length. The bed shall be cut away and removed at each socket or sleeve in the case of socketed or sleeve jointed ducts to give a clearance of at least 50mm so that the socket or sleeve does not bear on the bed.

Unless otherwise described in the Contract, duct bedding material shall be concrete or well graded granular material as described in the Contract in accordance with Section 401.2.

Selected backfill shall be suitable material which is free from lumps of cohesive soil larger than 75 mm and stones larger than 37.5mm.

The completion of bedding and the surrounding of the duct shall be carried out immediately after jointing. The bedding and surround shall be brought up equally on both sides of the ducts ensuring that it is compacted in layers not exceeding 150 mm thickness. Where ducts are to be tested, the bedding or surrounding material shall only be brought up sufficiently to support the duct and joints shall be left exposed until the test is completed and the duct run accepted by the Engineer. The test shall be carried out before Surfacing over the duct run.

Ducts under carriageways shall be laid as shown in the Drawing with the concrete surround.

Where a concrete surround is used a compressible board or a preformed joint filler as described in the Contract shall be placed in contact with the end of the socket at a duct joint and shall extend through the full thickness of any concrete in contact with the duct. Such joints in any concrete surround shall be at intervals not exceeding 5m with the joints located at the pipe joint.

(c) Jointing of Ducts

Joints in PVC pipes shall not be made with plastic solvents.

Joints in steel pipes shall be threaded sleeves

Joints in pipes for service ducts shall comply with the appropriate Sri Lankan Standard and be jointed so that no silt, grit, grout or concrete surround is able to enter the duct.

Pipes with push-fit joints shall have a register to ensure that the pipe is fully pushed into the joint.

(d) Backfilling of Trenches

Backfilling shall wherever practicable be undertaken immediately the specified operations preceding it have been completed. The material as described in the Contract shall be deposited in layers and compacted. Care shall be taken to compact the material evenly without dislodging or damaging ducts. Material shall not be heaped in the trench before being spread. Power rammers shall not to be used within 300mm of any part of the duct or joint.

Material shall be compacted in layers not exceeding 150mm in depth. Each layer shall be compacted to obtain a minimum of 95% of the maximum dry density of the material as determined by BS1377 Test 13(modified). The top surface of the backfill on which Base or Sub-base is to be placed shall be compacted to a minimum depth of 600mm to not less than 98% of the maximum dry density (modified) of the material.

The degree of compaction shall be checked by field density measurements (BS1377 test 15) at the rate specified in sub- section 1602, herein.

Except in carriageways and other paved areas, or as described in the Contract, backfill of trenches for all ducts shall be brought up to ground level. Where the ground surface on the line of the trench consists of top soil, the upper section of the backfill shall be top soil of the thickness described, or of the same thickness and quality of soil as the surrounding ground. For trenches in carriageways or other paved areas the backfill shall be brought up to formation level, or such lower level as described in the Contract and capped with carriageway construction or paving as described in the Contract and to be similar to the adjacent Surfacing.

Unless otherwise described in the Contract sheeting and other excavation supports shall be removed as the filling proceeds.

(e) Connecting to Existing Services

Before entering or breaking into any existing services the Contractor shall give notice of his intention to do so to the Authority responsible for the utility to which the connection is to be made.

(f) Draw Pits

All draw pits shall be constructed as described in the Contract.

Excavation around draw pits,, shall be backfilled with general fill material and compacted. Where mechanical compaction is impracticable, the excavation shall be backfilled with concrete.

Two sets of chamber cover keys shall be delivered to the Engineer for each type of keyway in the covers supplied.

(g) Testing and Cleaning

Service ducts shall be checked by drawing a wooden mandrel 1.5 m long and 90mm diameter for 100 mm diameter ducts through as the ducts are laid. Where a set has to be given to the line of ducts the wooden mandrel shall be replaced by an iron mandrel 250mm long but of the same diameter as for the wooden version. Similar checking shall be carried out with various diameters of ducts.

Each duct shall be fitted with a standard polypropylene draw rope of 5.3 kN breaking load. Immediately after laying, the position of ducts shall be marked and the ends sealed by removable stoppers.

815.4 Measurement and Payment

(a) Measurement

The quantities measured for payment shall be lengths in metres of the types, depths and diameters of ducts; and numbers, depths and types of draw pits; and numbers and types of connections. Cleaning different types of existing draw pits and sealing of different types of draw pits shall not be measured.

The measurement of depths of ducts and chambers shall be the vertical measurement between the invert and existing ground level.

(b) Payment

The quantities, measured as provided above, shall be paid for at the Contract price per unit of measurement, respectively, for each of the items listed below that is shown in the Bill of Quantities. The prices and payment shall be full compensation for excavation, furnishing and placing all materials, labour, equipment, backfilling, removal of surplus material, testing, cleaning, sealing and all incidentals necessary to complete the work.

The pay items and pay units shall be as follows;

Pay item	Description	Pay Unit
815 (1)	Single duct depth to invert less than 1.5 m (state type and diameter)	Linear metre
815 (2)	Two way duct depth to invert less than 1.5 m (state type and diameter)	Linear metre
815 (3)	Three way duct depth to invert less than 1.5 m (state type and diameter)	Linear metre
815 (4)	Four way duct depth to invert less than 1.5 m (state type and diameter)	Linear metre
815 (5)	Draw pits depth to invert less than 1.5m (state size)	Number
815 (6)	Draw pits depth to invert less than 1.5m & 1.8m (state size)	Number
815 (7)	Draw pits depth to invert less than 1.8m & 2.0 m (state size)	Number
815 (8)	Connections of /to existing services (state type)	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay item.

816 BUS BAYS AND PARKING BAYS

816.1 Description

The work shall consist of construction of bus bays at locations of bus stops/halts and construction of parking bays as shown on the Drawings and as directed by the Engineer or in accordance with the Specification.

816.2 Materials

All materials used for various items of work involved in construction of bus bays such as road Pavement work, side walk, road marking, kerbs etc. shall be in accordance with the relevant sections of the Specifications.

816.3 Construction Requirements

The various items of work involved in construction of bus bays & parking bays shall be in accordance with the relevant sections of the Specification.

816.4 Measurement and payment

There shall be no separate payment for constructing bus bays & parking bays. The individual items of work involved shall be paid for as provided for in the relevant sections of the Specification.

817 CONCRETE KERB INLETS

817.1 Description

The work shall consist of construction of kerb inlets in accordance with these Specifications and with the lines, levels and grades as shown on the Drawings or as directed by the Engineer.

The dimension of the inlets shall be as shown on the Drawings or as instructed by the Engineer.

817.2 Materials

Concrete for precast or cast in situ units and concrete for kerbs shall be of Class A or B of Grade 20(20) as per Section 1001.

The other material used shall meet the requirements of the following, unless otherwise specified.

(a) Reinforcement steel to SLS 375 or CS 26

(b) Bed course material shall consist of sand, gravel, crushed stone or other approved material of 10 mm maximum size

(c) Cement mortar for jointing to Sub section 1703.2

817.3 Construction Requirements

The construction requirements shall be the same as Sub section 807.3(a) & (b) for installation of kerbs.

817.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

817.4 Measurement & Payment

(a) Measurement

Kerb inlet furnished accepted and placed shall be measured by the number.

(b) Payment

The payment shall be based on the Contract unit rate for the item which shall include full compensation for supplying and installing the kerb inlet. The rate shall also include the cost of all materials, labour, equipment tools and other incidentals necessary to complete the works to these Specifications.
The Pay Items and Pay Units shall be as follows;

Pay Item	Description	Pay Unit
817(1)	Kerb Inlets	Number

818 NOT USED

819 KILOMETRE POSTS AND BOUNDARY MARKERS

819.1 Description

This item shall consist of:

(a) Replacing missing or damaged kilometre posts with new ones. This work shall consist of precasting, transporting and fixing concrete kilometre posts in accordance with the typical Drawings, complete with all necessary lettering and painting, as specified at locations directed by the Engineer.

(b) Reposition existing kilometre post. This work shall involve the removal of existing kilometre posts, transferring the same and carefully and re-fixing at new location as directed by the Engineer.

(c) Maintain and paint existing kilometre posts. This work shall consists of repainting route marking and lettering on existing kilometre posts in place, or as directed by the Engineer, including scraping and removing old paint and application of any treatment given to the face of the posts, sand papering and marking up any damage with cement mortar prior to painting.

(d) Maintain and paint existing right of way boundary markers. This work shall consist of repainting existing right of way marker posts in place, or as directed by the Engineer, including scraping and removing old paint and application of any treatment given in the face of the posts, sand papering and marking up any damage with cement mortar prior to painting.

819.2 Materials

The new kilometre posts shall be constructed of concrete Grade 30, and the concrete Bases in which they are set shall be of concrete Grade 20. For quality control, trial mix, sampling and testing, materials, tools and equipment and construction methods shall be as stated in Section 1001 herein.

Cement paint shall conform to requirements of SLS-590 and enamel and emulsion paints shall conform to requirements of SLS-539 and 557 respectively.

819.3 Construction Methods

Unless otherwise mentioned or shown in the Drawings the kilometre posts, new or the repositioned old one, shall be mounted on a concrete Base and the posts shall be surrounded with concrete of Grade 20 of minimum thickness of 150 mm and finished flush with ground.

The route number and the appropriate kilometre shall be formed and painted as shown in the typical Drawing.

The exposed surface of the posts shall be finished smooth and areas not required for lettering shall be applied with one coat of primer and two coats of weatherproof emulsion paint, of colour and quality approved by the Engineer.

The posts (new or old) shall be transported and erected at the various locations as directed by the Engineer.

819.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

819.4 Measurement and Payment

(a) Measurement

Measurement shall be in numbers at locations approved and accepted by the Engineer.

(b) Payment

The work measured shall be paid for at the Contract unit rate as detailed below. The payment shall be full compensation for all labour and materials involved in casting, handling, transporting and incidentals necessary to complete the work including excavation for removing and re-fixing, concrete Base with surrounding materials erection, clearing, scraping, sanding, painting, lettering etc. all complete.

Pay Items and Pay Units shall be as follows;

Pay Item	Description	Pay Unit
819 (1)	Provide, install and paint new kilometre post	Numbers
819 (2)	Reposition existing kilometre post	Numbers
819 (3)	Maintain and paint existing kilometre post	Numbers
819 (4)	Maintain and paint existing boundary marker	Numbers

900 RIGID PAVEMENTS

901A CEMENT CONCRETE PAVEMENT – MACHINE ORIENTED CONSTRUCTION

901A.1 Description

The work shall consist of construction of un-reinforced, jointed, plain cement concrete Pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and Cross-sections shown on the Drawings or as directed by the Engineer. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connection with the work, as approved by the Engineer.

There are two distinctive methods of construction specified in these Specifications; they are machine and manual oriented. In this section, machine oriented method of construction is described.

The design parameters, viz., thickness of Pavement slab, grade of concrete, joint details etc. shall be as stipulated in the Drawings.

Where Pavements are reinforced, the requirements are given in special provision.

901A.2 Materials

Materials used shall conform to the requirements of the following, unless otherwise specified.

(a) Cement to Section 1703. The cement shall be subjected to acceptance tests prior to its use.

If the soil around has soluble salts like sulphates in excess of 0.5 percent, the cement used shall be sulphate resistant and shall conform to BS 4027 : 1997.

(b) Water used for mixing and curing of concrete shall be clean and free from injurious amounts of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in SLS 522.

(c) Coarse and fine aggregate shall conform to requirements of Sub section 1701.2.

(d) Admixtures - Usc of admixtures conforming to Section 1704, shall be permitted in order to improve workability of the concrete or increasing the setting time, on satisfactory evidence that they will not have any adverse effects on the properties of concrete with respect to strength, volume change, and durability and have no deleterious effect on steel reinforcements. The details of the admixture and the quantity to be used must be furnished to the Engineer in advance to obtain his approval before use. Satisfactory performance of the admixtures shall be established through the laboratory concrete trial mixes and trial pavings.

(e) Mild steel bars for dowels and tie bars shall conform to the requirements of CS 26.

(f) Polythene sheeting and other materials used as separation membranes between the Sub-base and concrete slabs and any special materials used for curing of concrete shall be approved by the Engineer prior to their use.

(g) Pre-moulded expansion joint filler boards which are proposed for use only at some abutting structures like bridges and culverts shall be of 20-25 mm thickness within a tolerance of ±1.5 mm and of a self expanding cork seal or firm compressible material and complying with the requirements of BS Specification Clause No. 2630 or British Highway Agency, Vol. I Clause 1015. It shall be 25 mm less in depth than the thickness of the slab within a tolerance of ±3 mm and provided to the full width (between the side forms). The filler boards shall be in suitable lengths which shall not be less than one lane width. Holes to accommodate dowel bars shall be accurately bored or punched out to give a sliding fit on the dowel bars.

(h) The joint sealing compound shall be of hot poured, elastomeric type or cold poly-sulphide type having flexibility, resistance to age hardening and durability. If the sealant is of hot poured type it shall conform to BS2499 and cold applied sealant shall be in accordance with BS 5212 (part 1).

901A.3 Concrete mix requirements and testing for quality

(a) Mix Design for Concrete

Consequent to approval of all the materials to be used in the concrete by the Engineer, the Contractor shall submit the mix design based on weighed proportions of all ingredients for the approval of the Engineer. The mix design shall be submitted at least 2 weeks prior to the paving of a trial section and the design shall be based on laboratory trial mixes using approved materials.

The target mean strength for the design mix and minimum cement content shall be determined as indicated in Table 1001–4 of Section 1001.4. The mix design shall be based on the flexural strength of concrete. Casting, curing and testing of cubes shall be carried out as given in Sub section 1001.12 and for beams the procedure given in BS 1881 shall be followed. Unless otherwise specified, a target mean strength value (flexural or crushing) of at least 20 percent in excess of the minimum value shall be achieved during preliminary testing, with respect to the design of mixes.

(b) Concrete Strength and Compliance Testing

During the mix design in the laboratory, correlation between flexural and compressive strengths of concrete shall be established on the basis of at least thirty tests on samples. However, quality control in the field shall be exercised on the basis of flexural strength. It shall be ensured that the materials and mix proportions remain substantially unaltered during the daily concrete production. The water content shall be the minimum required to provide the agreed workability for full compaction of the concrete to the required density as determined by the trial mixes or other means authorized by the Engineer. In this exercise, the maximum free water cement ratio shall be taken as 0.50.

The ratio between the 7 and 28 day strengths shall be determined for the mix to be used in the slab in advance, by testing pairs of beams and cubes at each stage for at least six batches of trial mixes. The average strength of the 7 day cured specimens shall be divided by the average strength of the 28 day specimens for each batch, and the ratio 'R' shall be determined. The ratio 'R' shall be expressed to three decimal places.

901A.4 Construction Requirements

(a) Sub-base

The concrete Pavement shall be laid over the Subgrade or Sub-base constructed in accordance with the relevant Drawings. If the Subgrade or Sub-base is found damaged at some places or it has cracks wider than 10 mm, it shall be repaired before laying a separation layer, with fine cement concrete (1 part of cement and 3 parts of 10 mm nominal sized graded aggregate) for concrete Sub-bases or as per Section 1101 with premixed patching materials for bitumen surfaced Sub-bases or with soil Sub-base material as per Section 401 for gravely soil Surfacing. Prior to laying of concrete it shall be ensured that the separation membrane as per Sub section 901A.4 (b) is placed in position and the same is free from damage and cleaned of dirt or other extraneous materials.

(b) Separation Membrane

A separation membrane shall be placed between the concrete slab and the Sub-base. Separation membrane shall be an impermeable plastic sheeting of 125 microns thick and laid flat without creases. Before placing the separation membrane, the Sub-base shall be swept clean of all the extraneous materials using an air compressor. Wherever overlap of plastic sheets is necessary, it shall be at least 300 mm and any damaged sheeting shall be replaced at the Contractor's expense. The separation membrane shall be fixed to the lower layer with concrete nails.

(c) Joints

The type and location of joints shall be as shown in the Drawing or as approved by the Engineer. Joints shall be constructed depending upon their functional requirement as detailed in the ensuing paragraphs. The location of the joints shall be transferred accurately at the site and mechanical saw cutting of joints done as per stipulated dimensions. It shall be ensured that the full required depth of cut is made from edge to edge of the Pavement. Transverse and longitudinal joints in the Pavement and Sub-base shall be staggered so that they are not coincident vertically and are at least 1m and 0.3 m apart respectively. Sawing of joints shall be carried out with diamond studded blades soon after the concrete has hardened to take the load of the sawing machine and personnel without damaging the texture of the Pavement. Sawing operation shall not be started within 6-8 hours or as approved by the Engineer, according to the climatic conditions.

(c)(i) Transverse joints

Transverse joints shall be contraction and occasionally expansion joints constructed at the spacing indicated in the Drawings. Transverse joints shall be straight within the following tolerances along the intended line of joints which is the straight line transverse to the longitudinal axis of the carriageway at the position proposed by the Contractor and in agreement with the Engineer, except at road junctions or roundabouts where the position shall be as indicated in the Drawings / Plans:

(a) The best fit straight line through the joint grooves as constructed from the intended line of the joint shall not be more than 25 mm.

(b) Deviations of the edges of the joint groove from the best fit straight line of the joint shall not be greater than 10 mm.

If during the construction of the trial section or during normal working, the average value of any 4 consecutive 7 day test results falls below the required 7 day strength as derived from the value of 'R', then the cement content of the concrete shall, without extra payment, be increased by 5 percent by weight or by an amount agreed by the Engineer. The increased cement content shall be maintained at least until the four corresponding 28 day strengths have been assessed for its conformity with the requirements as per Clause 901A.2. Whenever the cement content is increased, the concrete mix shall be adjusted to maintain the required workability.

(c) Workability

At the point of placing the concrete, the workability shall be adequate for the concrete to be fully compacted and finished without undue flow.

The required workability for the concrete mix for the paving plant used shall be established by the Contractor with the approval of the Engineer. The quality control of workability at the site shall be determined by the slump test as per Sub section 1803.2(g).

The requirement of workability for the batching plant and pavers shall be determined by carrying out slump tests during paving trials. Such requirements shall be determined for each season and also when the time for transport from the batch plant to the paver and the type of paver are altered. A slump value can be taken as 30 + or – 15 mm for paving works. But this could be modified depending on the site requirements with the approval of the Engineer. Initially slump test shall be carried out on every truck or dumpers, transporting freshly mixed concrete from the mixing plant to the paving site. Subsequently this frequency can be reduced to alternate trucks / dumpers with the approval of the Engineer.

(d) Design mix

The Contractor shall carry out trials of design mixes in the laboratory with the materials obtained from the approved sources to be used. Trial mixes shall be made in the presence of the Engineer or his assistant, who is an engineer and the design mix shall be approved by the Engineer. Trial mixes shall be repeated, if necessary, until the mix proportions that will produce a concrete complying in all respects with these Specifications, and conforming to the requirements of the design/Drawings have been detained.

The mix proportions as determined by laboratory trial mixes may be adjusted if necessary during the construction of the trials. Thereafter, neither the materials nor the mix proportions shall be altered in any way except with the approval of the Engineer in writing.

Any alterations change in the source of materials or mix proportions proposed by the Contractor during the course of work shall be assessed by making laboratory trial mixes and the construction of a further trial unless approval is given by the Engineer for minor adjustments like minor fluctuations in the grading of aggregate or compensation for moisture content of aggregate.

(c) Transverse joints on each side of the longitudinal joint shall be in line with each other and of the same type and width. Transverse joints shall have a sealing groove that shall be sealed in compliance with Sub section 901A.4 (k).

(d) Deviations of the filler board in the case of expansion joints from the intended line of the joint shall not be greater than ± 10 mm

(c)(ii) Contraction joints

Contraction joints shall consist of a mechanical sawn joint groove, 3 to 5 mm wide and 1/4 to 1/3 (± 5 mm) depth of the slab or as stipulated in the Drawings and dowel bars complying with Sub section 901A.4(d) and as detailed in the Drawings.

The contraction joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take the load of joint sawing machine without causing damage to the slab and as stated in 901A.4(c).

(c)(iii) Expansion joints

The expansion joints shall consist of a joint filler board complying with Sub section 901A.2 (g) and dowel bars complying with Sub section 901A.4(d) and as detailed in the Drawings. The filler board shall be positioned vertically with the prefabricated joint assemblies along the line of the joint within the tolerances given in Sub section 901A.4(c) (i) and at a such depth below the surface that will not impede the passage of the finishing straight edges or oscillating beams of the paving machines. The adjacent slabs shall be completely separated from each other by providing joint filler board. Space around the dowel bars and between the Sub-base and the filler board shall be packed with a suitable compressible material to block the flow of cement slurry through such spaces.

(c)(iv) Transverse construction joint

Transverse construction joints shall be placed whenever concreting is suspended for more than 30 minutes or is completed after a day's work. These joints shall be provided at the regular location of contraction joints using dowel bars. The joint shall be made butt type. At all construction joints, steel bulk heads shall be used to retain the concrete while the surface is finished. The surface of the concrete laid subsequently shall conform to the grade and Cross-sections of the previously laid Pavement. When positioning of bulk head/stop-end is not possible, concreting to an additional 1 or 2 m length may be carried out to enable the movement of joint cutting machine so that joint grooves may be formed and the extra 1 or 2 lengths is cut out and removed subsequently, after concrete has hardened.

(c)(v) Longitudinal joint

The longitudinal joints shall be saw cut as per details of the joints shown in the Drawing. The groove may be cut after the final set of the concrete. As indicated in the Drawing, joints shall be sawn to at least 1/3 (± 5 mm) the depth of the slab.

Tie bars shall be provided at the longitudinal joints as per dimensions and spacing shown in the Drawings and in accordance with Sub section 901A.4(d)(ii).

(d) Steel at joints

(d)(i) Dowel bars

(d)(i)a Dowels shall be round mild steel bars in accordance with section 901A.2(e) with details/dimensions as indicated in the Drawing and free from oil, dirt, loose rust or scale. They shall be straight, free of irregularities and burring restricting slippage in the concrete. The sliding ends shall be sawn or cropped cleanly with no protrusions outside the normal diameter of the bar. The dowel bar shall be supported on cradles/dowel chairs in pre-fabricated joint assemblies positioned prior to the construction of the slabs or mechanically inserted with vibration into the plastic concrete by a method which ensures correct placement of the bars and full re-compaction of the concrete around the dowels.

(d)(i)b Dowel bars shall be positioned at mid depth of the slab within a tolerance of ± 20 mm, unless shown otherwise on the Drawings and centred equally about intended lines of the joint within a tolerance of ± 25 mm. They shall be aligned parallel to the finished surface of the slab and to the centre line of the carriageway and to each other within the following tolerances:

(i) For bars supported on cradles prior to the laying of the slab:

a. No steel bar of the cradle assembly shall be continuous across the joint.

b. All bars in a joint shall be within ± 3 mm per 300 mm length of bar

c. Two-thirds of the bars shall be within ± 2 mm per 300 mm length of bar

d. No bar shall differ in alignment from an adjoining bar by more than 3mm per 300mm length of bar in either the horizontal nor vertical planes

(ii) For all bars inserted after laying of the slab:

a Twice the tolerance for alignment as indicated in (a) above

(d)(i)c The assembly of dowel bars and supporting cradles, including the joint filler board in the case of expansion joints when fixed in position shall have the following degree of rigidity:-

(i) For expansion joints, the deflection of the top edge of the filler board shall be not greater than 13 mm, when a load of 1.3 kN is applied perpendicular to the vertical face of the joint filler board and distributed over a length of 600mm by means of a bar or timber packing, at mid depth and midway between individual fixings or 300 mm from either end of any length of filler board, if a continuous fixing is used. The residual deflection shall be not more than 3mm after removal of the load.

(ii) The joint assembly fixings to Sub-base shall not fail under the 1.3kN load applied for testing the rigidity of the assembly but shall fail before the load reaches 2.6 kN.

(iii) The fixings for contraction joint shall not fail under 1.3 kN load and shall fail before the load reaches 2.6 kN when applied over a length of 600 mm by means of a bar or timber packing placed as near to the level of the line of fixings as practicable.

(iv) Fixings shall be deemed to fail when there is displacement of the assemblies by more than 3 mm with any form of fixing, under the test load. The displacement shall be measured at the nearest part of the assembly to the centre of the bar or timber packing.

Dowel bars, supported on cradles in assemblies, when subject to a load of 110N applied at either end and in either the vertical or horizontal direction (upwards and downwards and both directions horizontally) shall conform to be within the limits given below:

(a) Two-thirds of the number of bars of any assembly tested shall not deflect more than 2 mm per 300 mm length of bar

(b) The remainder of the bars in that assembly shall not deflect more than 3 mm per 300 mm length of bar.

(d)(i)d Dowel bars shall be covered by a thin plastic sheath for at least two-thirds of the length from one end for dowel bars in contraction joints or half the length plus 50 mm for expansion joints. The sheath shall be tough, durable and of an average thickness not greater than 1.25 mm. The sheathed bar shall comply with the following pull-out tests as given below:

(i) Four bars shall be taken at random from stock and without any special preparation shall be covered by sheaths as required in this Clause. The ends of the dowel bars which have been sheathed shall be cast centrally into concrete specimens 150 x 150 x 600 mm, made of the same mix proportions to be used in the Pavement, but with a maximum nominal aggregate size of 20 mm and cured for 7 days. At 7 days a tensile load shall be applied to achieve a movement of the bar of at least 0.25 mm. The average bond stress shall not be greater than 0.14 MPa to achieve this movement.

For expansion joints, a closely fitting cap 100 mm long consisting of waterproofed cardboard or an approved synthetic material like PVC or GI pipe shall be placed over the sheathed end of each dowel bar. An expansion space at least equal in length to the thickness of the joint filler board shall be formed between the end of the cap and the end of the dowel bar by using compressible sponge. To block the entry of cement slurry between dowel and cap, the relevant area shall be taped.

(d)(ii) Tie bars

Tie bars in longitudinal joints shall be deformed steel bars of strength 410 MPa complying with Sub section 901A.2(e) and in accordance with the following requirements. The bars shall be free from dirt, loose rust, scale and oil.

a Tie bars projecting across the longitudinal joint shall be protected from corrosion for 75mm on each side of the joint by a protective coating of bituminous paint as approved by the Engineer. When the tie bars are used, the coating shall be dry.

b During the construction of the slab, the tie bars in longitudinal joints shall be inserted into rigid assemblies with adequate supports and fixings to remain firmly in position. As an alternate method, tie bars at longitudinal joints may be mechanically or manually inserted into the plastic concrete from above by vibration using a method which ensures correct placement of the tie bars and re-compaction of the concrete around the same.

c Tie bars shall be positioned to remain within the middle third of the slab depth as indicated in the Drawings and approximately parallel to the surface and approximately perpendicular to the line of the joint, with the centre of each bar on the intended line of the joints within a tolerance of 50mm, and with a minimum cover of 30mm below the groove of the joint.

901A.4(e) Weather and Seasonal Limitations

For concreting during rainy season and when rain is imminent, a sufficient supply of tarpaulin or other waterproofing cloth shall be provided along the length of the construction site. Prior to rain, all freshly laid concrete that had not been covered for curing purposes shall be adequately protected. Any concrete damaged by rain shall be removed and replaced. If the damage is limited to texture, it shall be removed in accordance with the instructions of the Engineer.

When concreting in hot weather, no concreting shall be carried out when the concrete temperature is above 30°C. Furthermore, in adverse conditions like high temperature, low relative humidity, excessive wind velocity, imminence of rains etc., tents on mobile trusses shall be provided over the freshly laid concrete for a minimum period of 3 hours as directed by the Engineer. The temperature of the concrete mix on reaching the paving site shall not be more than 30^0C. To bring down the temperature, chilled water or ice flakes shall be made use of, if necessary.

No concreting shall be carried out when the concrete temperature is below 5°C and reducing.

(f) Side forms, Rails and Guide wires

(f)(i) Side forms and rails:

The side forms shall be of mild steel with depth equal to the thickness of the concrete slab or slightly less to accommodate the surface irregularity of the Sub-base. The forms can be placed on series of steel packing plates or shims to take care of irregularity of Sub-base. They shall be sufficiently robust and rigid to support the weight and pressure caused by paving equipment. Side forms for use with wheeled paving machines shall incorporate metal rails firmly fixed at a constant height below the top of the forms. The forms and rails shall be firmly secured in position by using not less than 3 stakes/pins per each 3m length so as to prevent movement in any direction. Forms and rails shall be straight with a tolerance of 3 mm in 3m and when in place shall not settle in excess of 1.5mm in 3m, while paving is being carried out. Forms shall be cleaned and oiled immediately before use. The forms shall be bedded on a continuous bed of low moisture content lean cement mortar or concrete and set to the line and levels shown on the Drawings within tolerances of ±10mm and ±3mm respectively. The bedding shall not extend under the slab and there shall be no vertical step between adjacent forms of more than 3mm. The forms shall be installed by the Contractor for the approval of the Engineer and prior to 12 hours on the day before the construction of the slab and shall not be removed until at least 12 hours after concreting.

During construction, sufficient forms shall be used and set to the required alignment and levels for at least 200m length of Pavement in advance of the paving operations, or the anticipated length of concrete slab to be laid within the next 24 hrs. whichever is longer.

(f)(ii) Use of guide wires – slip form paving

Guide wire shall be provided along both sides of the slab, where slip form paving is proposed. Each guide wire shall be at a constant height above and parallel to the required edges of the slab as described in the Drawing with a vertical tolerance of ±3mm. Additionally, one of the wires shall be kept at a constant horizontal distance away from the required edge of the Pavement as indicated in the Contract/Drawing with a ±10mm lateral tolerance.

The guide wires shall be supported on stakes at intervals of not more than 8m apart by connectors capable of fine horizontal and vertical adjustment. The guide wire shall be tensioned on the stakes so that a 500 gram weight shall produce a deflection of not more than 20mm when suspended at the mid point between any pair of stakes. The ends of the guide wires shall be anchored to fixing points or a winch, but not to the stakes.

The stakes shall be positioned and the connectors maintained at their correct height and alignment from 12 hours on the day before concreting takes place until 12 hours after finishing of the concrete. The guide wires shall be erected and tensioned on the connectors at any section for at least 2 hours prior to concreting.

The Contractor shall submit to the Engineer for his approval of line and level, the stakes and connectors which are ready for use in the section of road to be constructed within 12 hours on the working day before the day of construction of slab. Any deficiencies noted by the Engineer shall be rectified by the Contractor who shall then reapply for approval of the affected stakes. Work shall not proceed until the Engineer has given his approval. While concreting is in progress, the Contractor shall ensure that the stakes and guide wires are not affected by the construction equipment.

(g) Construction

Before the commencement of the work, the Method statement for carrying out the work, detailing all the activities including indication of the time-cycle, equipment, personnel etc., shall be approved by the Engineer. The above shall include the type, capacity and make of the batching and mixing plant, the hauling arrangement and paving equipment used for construction.

(g)(i) Batching and mixing:

Batching and mixing of the concrete shall be done at a central batching and mixing plant with automatic controls, located at a suitable place with sufficient space for water tanks and stockpiling of the required cement and aggregates. This shall be, however, situated at a distance approved by the Engineer after considering the transporting arrangements available with the Contractor, requirements of the mix, climate etc.

Mix proportioning of materials except for water shall be carried out in the batching plant by weight, with each of these materials being weighed separately and water being measured by volume. Wherever graded aggregate of uniform quality cannot be obtained as required in the mix design, the grading of aggregates shall be controlled by appropriate blending of various sizes of aggregate. The capacity of batching and mixing plant shall be at least 25 per cent higher than the proposed capacity of the equipment for laying / paving.

(g)(ii) Paving equipment and the compaction of the concrete

The placing of concrete shall be carried out by using an approved fixed form or slip form paver with independent units designed to (i) spread, (ii) consolidate, screed and float-finish and (iii) texture and cure the freshly placed concrete in one complete pass of the machine. The paving equipment shall also place the concrete in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous Pavement in conformity with these Specifications and Drawing. The pavers shall be equipped with electronic controls with sensors to control the line and grade from either or both sides of the paver.

The paver vibrators shall operate at a frequency of 8300 to 9600 impulses per minute under load at a maximum spacing of 600 mm. Variable vibration settings shall also be provided in the paver.

(g)(iii) Concrete saw

The Contractor shall provide adequate number of concrete saws with sufficient number of diamond-edge saw blades. The saw machine shall be either electric or petrol/diesel driven type. A water tank with flexible hoses and pump shall be made available on priority basis, for this activity. The Contractor shall have at least one standby saw in a good working condition. The concreting work shall not commence if the saws are not in working condition.

(g)(iv) Hauling and placing of concrete

Fresh concrete mix from the central batching and mixing plant shall be transported to the paver by means of trucks/tippers of sufficient capacity and approved design in sufficient numbers to ensure a constant supply of concrete to the pavers. Covers shall be used for protection of concrete from the weather. The trucks/tippers shall be capable of maintaining the mixed concrete in a homogeneous state and discharging the same without segregation and loss of cement slurry. The feeding to the paver shall be regulated in such a manner that the paving is done in an uninterrupted manner with a uniform speed throughout the day during concreting.

(g)(v) Placing of concrete

The concrete mixed in central mixing plant shall be transported to the site without delay. The concrete which, in the opinion of the Engineer, has been mixed too long before laying shall be rejected and shall be removed from the site. The total time taken from the addition of the water to the mix, until the completion of the surface finishing and texturing shall not exceed 120 minutes when concrete temperature is less than 25°C and 90 minutes when the concrete temperature is between 25°C to 30°C Trucks/tippers delivering concrete shall not run on plastic sheeting nor shall they run on completed slabs until after 28 days of placing the concrete. The paver shall be capable of paving the carriageway in a single pass and lift, as shown in the Drawings,

Where fixed form pavers are to be used, forms shall be fixed in advance as per Sub section 901A.4(f) of the Specifications. Before any paving is done, the section of site shall be shown to the Engineer, in order to verify the arrangement for paving and checking of dowels, tie-bars etc., as per the relevant clauses of these Specifications. The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the concrete slab.

The temperature of the concrete shall be in all cases, measured at the point of discharge from the delivery vehicle.

The addition of water to the surface of the concrete to facilitate the finishing operations shall not be permitted except with the approval of the Engineer when it shall be applied as a mist by means of equipment approved by the Engineer.

The paving machines shall be provided with approved covers to protect the surface of the slab under construction from direct sunlight or hot wind and rain, if considered necessary by the Engineer.

While the concrete is still plastic, its surface shall be brush textured in compliance with Sub section 901A.4 (h) and the surface and edges of the slab cured by the application of a sprayed liquid curing membrane in compliance with section 901A.4(i) After the surface texturing, but before the curing compound is applied, the chainage of the concrete slab shall be marked on the surface at intervals of 100 m.

Immediately after the side forms are removed, edges of the slabs shall be corrected wherever irregularities have occurred by using fine concrete composed of one part of cement and 3 parts of fine aggregate and 10mm graded aggregate under the supervision of the Engineer.

When the requirements of Sub section 1601.3 for surface regularity fails to be achieved on two consecutive working days, then normal working shall cease until the cause of the excessive irregularity has been identified and corrected.

(g)(vi) Construction including compaction by fixed form paver

The fixed form paving train shall consist of separate powered machines, which spread, compact and finish the concrete in a continuous operation.

The freshly mixed concrete shall be discharged without segregation into a hopper spreader, which is equipped with means for controlling its rate of deposition on to the Sub-base. The spreader shall be operated to place concrete upto a level requiring a small amount of striking off by the distributor of the spreader. The distributor of spreader shall place the concrete to a level slightly proud of the requirement level to ensure that the vibratory compactor thoroughly compacts the layer. If necessary, poker vibrators shall be used adjacent to the edges of the concreting work. The vibratory compactor shall be set to strike off the surface very slightly high so that it is reduced to the required level by the oscillating beam. The machine shall be capable of being rapidly adjusted for changes necessitated by changes in slab thickness or cross fall. The final finisher shall be able to finish the surface to the required level and smoothness as specified, care being taken to avoid bringing up of excessive mortar to the surface by over working the mix.

(g)(vii) Construction including compaction by slip form paver

The slip form paving train shall consist of power machine, which spreads, compacts and finishes the concrete in a continuous operation. The slip form paving machine shall compact the concrete by internal vibration and shape it between the side forms with either a conforming plate or by vibrating and oscillating finishing beams. The concrete shall be deposited without segregation in front of slip form paver across the whole width and to a height which at all times is in excess of the required amount. The deposited concrete shall be struck off to the necessary average and differential surcharge by means of the strike off plate or a screw auger device extending across the

whole width of the slab. The equipment for striking off the concrete shall be capable of being rapidly adjusted for changes necessitated by change in thickness or cross fall of the slab.

The conforming plate and finishing beams level shall be controlled automatically from the guide wires installed as per Sub section 901A.4(f) by sensors attached at the four corners of the slip form paving machine. The alignment of the paver shall be controlled automatically from the guide wire by at least one set of sensors attached to the paver. The alignment and level of ancillary machines for finishing, texturing and curing of the concrete shall be automatically controlled relative to the guide wire or to the surface and edge of the concrete Pavement.

Such paving machines shall have vibrators of variable output, with a maximum energy output of not less than 2.5kW per metre width of slab per 300mm depth of slab for a laying speed up to 1.5m per minute or pro-rata higher speeds. The machines in all situations shall be of sufficient mass to provide adequate reaction during spreading and paving operations on the traction units to maintain forward movements during the placing of concrete.

When the edges of the slip formed slab slump to the extent that the surface of the edge of the slab does not comply with the requirements of Sub section 1601.2, then special measures approved by the Engineer shall be taken to support the edges to the required levels and work shall be stopped until such time as the Contractor can demonstrate his ability to slip form the edges to the required levels of the concrete slab.

(g)(viii) Construction by hand guided method:

Areas in which hand guided methods of construction are required shall be approved by the Engineer in writing in advance. Such work may be permitted only in restricted areas in small lengths.

The work shall be carried out in accordance with the provisions of Sub Section 901B.3(f)(i).

The acceptance criteria regarding level, thickness, surface regularity texture, finish, strength of concrete and all other quality control measures shall be the same as those of work done by machine.

(h) Surface texture

After the final regulation of the slab and before the application of the curing membrane, the surface of concrete slab shall be brush-textured in a direction at right angles to the carriageway longitudinal axis.

The texture of the brushed surface shall be applied uniformly across the slab in one direction by the use of a wire brush not less than 450 mm wide with a preference for wider brushes. The brush shall be made of 32 gauge tape wires grouped together in tufts spaced at 10mm centres. The tufts shall contain an average of 14 wires and initially be 100mm long. The brush shall have two rows of tufts. The rows shall be 20mm apart and the tufts in one row shall be opposite the centre of the gap between tufts in the other row. When the shortest tuft wears down to 90mm long, the brush shall be replaced.

The texture depth shall be determined by the sand patch test. This test shall be carried out at least once for each day's paving and whenever the Engineer considers it necessary at times after construction as given below in the next paragraph.

Five individual measurements of the texture depth shall be taken at intervals of at least 2m, anywhere along a diagonal line across a lane width between points of 50m apart along the Pavement, No measurement shall be taken within 300mm of the longitudinal edges of a concrete slab constructed in one operation.

Texture depth shall not be less than the minimum required when measurements are taken as given in Table 901A-1 nor greater than a maximum average of 1.25mm.

Table 901A-1: Texture Depth

Time of Test	Number of measurements	Required Texture depth (mm)	
		Specified value	Tolerance
1. Between 24 hours and 7 days after the construction of the slab or until the slab is first used by vehicles	An average of 5 measurements	1.00	± 0.25
2. Not later than 6 weeks before the road is opened to regular traffic	An average of 5 measurements	1.00	+ 0.25 - 0.35

After the application of the brushed texture, the surface of the slab shall have a uniform appearance as determined by the Engineer.

Where the texture depth requirements are found to be deficient, the Contractor shall make good the texture across the full lane width over a length as directed by the Engineer, by re-texturing the hardened concrete surface in a manner approved by the Engineer.

(i) Curing

Immediately after the surface texturing, the surface and the exposed sides of the slab shall be cured by the application of approved resin based aluminised reflective curing compound, which hardens into an impervious film or membrane when sprayed using a mechanical sprayer.

Curing compounds shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface with a metallic finish. The curing compounds shall become stable and impervious to evaporation of water from the surface of the concrete within 60 minutes of application and shall be of approved type. The curing compounds shall have a water retention efficiency index of 90 per cent in accordance with BS 7542.

The curing compound shall not react chemically with the concrete and the film or membrane shall not crack, peel or disintegrate within three weeks after application. Prior to application, the curing compound shall be thoroughly agitated. The rate of spread shall be in accordance with the manufacturer's instructions that can be checked during the construction of the trial length and subsequently whenever required by the Engineer. During spaying the mechanical sprayer shall be incorporated

with an efficient mechanical device for continuous agitation and mixing of the compound.

During adverse weather conditions, in addition to spraying of curing compound, the fresh concrete surface shall be protected for at least 3 hours by covering the finished concrete Pavement with tents, as directed by the Engineer. After three hours, the Pavement shall be covered by moist hessian and the same shall then be kept damp for a minimum period of 14 days after which time the hessian may be removed. The hessian shall be kept continuously moist. All damaged/torn hessian shall be removed and replaced by new hessian, regularly.

The Contractor shall at his expense replace any concrete damaged as a result of incomplete curing or cracked concrete on lines other than those at joints.

(j) Trial Section

The trials of sections decided by the Engineer, shall be constructed at least one month in advance of the proposed commencement of concrete paving work. At least one month prior to the construction of the trial section, the Contractor shall submit for the Engineer's approval, a detailed method statement giving description of the proposed materials, plant, equipment and construction methods. All the major equipment like paving train, batching plant, tippers etc., proposed in the construction are to be approved by the Engineer before their procurement. No trials of new materials, plant equipment or construction methods, nor any development of them shall be permitted either during the construction of trial length or in any subsequent paving work, unless they form part of further, approved trials. These trial lengths shall be constructed away from the carriageway but with at least a Sub-base layer below the same.

The Contractor shall demonstrate the use of materials, plant, equipment and methods of construction that are proposed for concrete paving, by first constructing a trial length of slab, at least 60m but not more than 300m long for mechanised construction and at least 30m long for and manual methods. If the first trial is unsatisfactory, the Contractor shall have to demonstrate his capability to satisfactorily construct the Pavement in subsequent trials.

The trial section shall be constructed in two parts over a period comprising at least part of two separate working days, with a minimum of 30m constructed each day for mechanised construction or a minimum of 15m on each day for hand guided construction. The trial length shall be constructed at a similar rate to that which is proposed for the main work.

Transverse joints and longitudinal joints of each type that are proposed for jointed un-reinforced concrete slabs in the main work shall be constructed and assessed in the trial length. If in the trial length the construction of longitudinal joint is not demonstrated, at least the first 150m of longitudinal construction joint for mechanised paving in the main work, shall be considered as the trial length for these joints.

The trial length shall comply with these Specifications in all respects. The tolerances for surface regularity, level, thickness and strength shall conform to the requirements given in Sub section 1601.3.

(k) Preparation and sealing of joints

(k)(i) Preparation and sealing of joint grooves

All transverse joints in surface slabs shall be sealed using sealant described in Sub section 901.2(h). Joints shall be sealed before 14 days after construction.

(k)(ii) Preparation of joint grooves for sealing

Joint grooves usually are not constructed to provide the minimum width specified in the Drawings when saw cut joints are adopted. They shall be widened subsequently by sawing before sealing. Depth/width gauges shall be used to control the groove dimensions.

If rough arises develop when grooves are made, they shall be ground to provide a chamfer approximately 5mm wide. If the groove is at an angle upto 10 degree from the perpendicular to the surface, the overhanging edge of the sealing groove shall be sawn or ground perpendicular. If spalling occurs or the angle of the former is greater than 10 degree, the joint sealing groove shall be sawn wider and perpendicular to the surface to encompass the defect unto a maximum width, including any chamfer, of 35mm for transverse joints and 20mm for longitudinal joints. If the spalling cannot be so eliminated then the arises shall be repaired by an approved thin bonded arris repair using cementitious materials.

All grooves shall be cleaned of any dirt or loose material by air blasting with filtered, oil-free compressed air. If the need arises the engineer may instruct the cleaning of the grooves by pressurised water jets. Depending upon the requirement of the sealant manufacturer, the sides of the grooves may have to be sand blasted to increase the bondage between sealant and concrete.

The groove shall be cleaned and dried at the time of priming and sealing.

Prior to sealing the temporary seal provided for blocking the ingress of dirt, soil etc., in the grooves shall be removed. A highly compressible heat resistant paper backed de-bonding strip as per Drawing shall be inserted in to the groove to serve the purpose of breaking the bond between sealant and the bottom of the groove and to plug the joint groove so that the sealant may not leak through the cracks. The width of debonding strip shall be more than the joint groove width so that it is held tightly in the groove. In the case of longitudinal joints, heat resistant tapes may be inserted to block the leakage through bottom of the joint of the concrete slab.

(k)(iii) Sealing with sealant

During the application of sealant, an appropriate primer shall also be used if recommended by the manufacturer and it shall be applied in accordance with their instructions. The sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. When the naturally occurring temperature in the joint groove to be sealed is below 7°C, priming and sealing with applied sealant shall not be carried out.

When hot applied sealant is used it shall be heated and applied from a thermostatically controlled, indirectly heated preferably with oil jacketed melter and pourer having recirculating pump and extruder. For large road projects, sealant shall be applied with extruder having flexible hose and nozzle. The sealant shall not be heated to a temperature higher than the safe heating temperature and not for a period

longer than the safe heating period, as per specified by the manufacturer. The dispenser shall be cleaned out at the end of each day in accordance with the manufacturer's recommendations and the reheated material shall not be re-used.

The sealant of the cold applied type with chemical formulating like polysulphide may be used. These shall be mixed and applied within the time limit specified by the manufacturer. If primers are recommended they shall be applied neatly with an appropriate brush. The Movement Accommodation Factor (MAF) shall be more than 10 per cent.

As the sealant applied at contraction phase of the slabs would result in bulging of the sealant over and above the slab, the Contractor in consultation with the Engineer shall establish correct temperature and time for applying the sealant. A thermometer shall be hung on a pole in the site for facilitating control during the sealing operations.

Sealant shall be applied, slightly to a lower level than the slab with a tolerance of 5 ± 2 mm.

During sealing operation, it shall be seen that no air bubbles are introduced in the sealant either by vapours or by the sealing process.

Manufacturer's certificate shall be produced by the Contractor for establishing that the sealant is not more than six months old and stating that the sealant complies with the relevant standard as in Sub section 901A.2(h). The samples shall meet the requirements of AASHTO M 282 for hot applied sealant or BS 5212: (Part-1) for cold applied sealant.

(l) Surface finish and quality control

The concrete Pavement shall be finished to the requirements given in Section 1601.

The control on the quality of materials and works shall be exercised in accordance with Section 1602.

901A.5 Opening to Traffic

No vehicular traffic shall be allowed to run on the finished surface of a concrete Pavement within a period of 28 days of its construction and until the joints are permanently sealed. The road may be opened to regular traffic after completion of the curing period of 28 days and after sealing of joints is completed including the construction of shoulder, with the written permission of the engineer.

901A.6 Measurement & Payment

(a) Measurement

Cement concrete Pavement shall be measured as a finished work in cubic meters and accepted by the Engineer. The volume to be paid for will be calculated on the basis of thickness and plan areas shown on the project Drawings and adjusted for the deficiency in thickness. No additional measurements shall be taken for extra thickness of the slab.

The unit for measurement for concrete Pavement shall be the Cu.m of concrete placed, based on the net plan areas for the specified thickness shown on the Drawings or directed by the Engineer. No deduction shall be made in measurement for openings, provided that the area of each is less than 0.5 sq. metre.

(b) Payment

Payment for Cement Concrete Pavement

Machine oriented construction shall be made at the Contract unit rate for the item as measured above. The price shall be full compensation for carrying out all provisions of this Specification and shall include the provision of all materials including polythene film, concrete, stock piling, mixing, transport, placing, compacting, finishing, curing together with all form work and including testing and submission of test certificates and records. It shall also include the full costs of contraction, expansion, construction and longitudinal joints. In addition it shall include joint fillers, keys, caulking rods, debonding strips, sealant primer, joint sealants, dowel bars and tie rods.

The full payment will be made for this item only after 28 days strength of the concrete is found to be satisfactory.

The Pay Items and Pay Units shall be as follows:

Pay Item	Description	Pay Unit
901A(1)	Concrete Pavement - Machine oriented method of construction (state thickness)	Cu.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

901B CEMENT CONCRETE PAVEMENT – MANUAL ORIENTED CONSTRUCTION

901B.1 Description

This work shall consist of the construction of un-reinforced cement concrete Pavements where manual techniques, supplemented by suitably improvised equipment, are used for the placing and compaction of concrete.

Where work of a large scale is envisaged necessitating the use of specialised techniques of construction, either of the fixed-form type or of slip-form type, Section 901A for Machine Oriented Construction shall be referred to.

Where the Pavements are reinforced, the requirements are given in special provisions.

The work shall be carried out in accordance with the lines, levels, grades, dimensions and Cross-sections as shown in the Drawings or as instructed by the Engineer.

901B.2 Materials

Materials used shall conform to the requirements of the following, unless otherwise specified.

(a) Cement to Section 1703.

(b) Water for mixing and curing to SLS 522.

(c) Coarse and fine aggregate to Sub section 1701.2.

(d) Admixtures to Section 1704.

(e) Polythene sheeting and other materials used as separation membranes between the Sub-base and concrete slabs and any special materials used for curing of concrete shall be approved by the Engineer prior to their use.

(f) Sand bitumen mix or any other joint filler as approved.

901B.3 Concrete mix requirements and testing for quality

(a) Maximum size and grading of aggregate

The aggregate shall be of nominal maximum sizes 37.5mm as specified and the combined aggregate, normally obtained by mixing of coarse aggregate and fine aggregate, shall be within the grading limits given in Sub section 1701.2, unless allowed otherwise after carrying out suitable trial mixes.

(b) Mix Design for Concrete

The mix design shall be carried out in accordance with Sub section 901A.3(a).

(c) Concrete Strength and Compliance Testing

The measurements of concrete strength shall comply with provisions of Sub section 901A.3 (b).

Unless otherwise specified, in the design of mixes a target average strength value (flexural or crushing) of at least 20 percent in excess of the minimum value shall be achieved during preliminary testing.

(d) Workability

The requirements of workability shall comply with the provisions of Sub section 901A, modified to cater for manual work and as approved by the Engineer.

901B.4 Construction Requirements

(a) Slab dimensions and joints

(i) Widths and thicknesses

Slab widths shall normally be 3.0 to 3.7m, corresponding to the widths of a traffic lane. In any case the slab width shall not exceed 4.5m without the approval of the Engineer.

Slab thicknesses shall normally vary between 150mm and 250mm depending on Subgrade conditions and traffic. However, thicknesses greater than 200mm shall be adopted only where so specified or directed.

(ii) Transverse Joints

Transverse joints shall normally be contraction joints and they shall be expansion joints only where so indicated in Drawings or directed by the Engineer.

They shall be spaced between 4 to 6m depending on the slab thicknesses.

Contraction joints shall be created by making crack inducers in the slab at the top or at the bottom as specified. Top crack inducers shall be made, as indicated in Drawings or as directed, either by moulding a groove in fresh concrete or by sawing a narrow cut in the hardened concrete to depths of ¼ to ⅓ of the thickness of the slab. Where bottom crack inducers are provided there shall be a corresponding shallow groove on the top as well. These top grooves shall later be filled with a suitable mix of sand and bitumen or any other approved joint filler.

Where specified the contraction joints shall be dowelled across and normally these dowels shall be spaced at about 300mm apart. They shall be M.S rods 20 to 25mm in diameter and about 500mm in length and coated with a film of bitumen, a resin based varnish or a plastic sheath, to protect them against corrosion and to facilitate sliding in the concrete.

They shall normally be installed at mid-depth in the slab and parallel to the surface and the centre line of the road either by vibrating in during concreting or by positioning on a suitable metal frame prior to concreting. Where joint spacing is relatively small and the traffic is relatively low the number of dowels may be suitably reduced or they may be totally eliminated, with the approval of the Engineer.

Expansion joints where specified shall be made with the required space maintained uniformly across the slab and dowelled where necessary according to details given in Drawings or established by the Engineer. They shall be subsequently in-filled with a bitumen sand mix or any other approved material.

(iii) Longitudinal joints

Normally there shall be a longitudinal joint at the centre of a two lane road or at the separation lines of lanes in a multilane road, and they shall be formed with or without a key, and with or without tie bars, as specified

A key where specified shall be formed to details given in Drawings or established by the Engineer.

Tie bars shall be of the size and length specified and shall be inserted at the spacing given in Drawings or by the Engineer. The top of these joints shall be suitably grooved and in-filled with a sand bitumen mix or any other joint filler as approved.

(b) Sub grade requirements

The concrete pavement shall be placed on an improved Subgrade or on a Sub-base of approved type and thickness. The Sub-base may be of natural soil conforming to Section 401 or of stabilized soils conforming to Section 402. The Sub-base may

also be of graded granular material similar to that of graded aggregate Base to Section 405.

(c) Separating membrane

Prior to laying of the concrete Pavement the surface of the approved Subgrade or Sub-base shall be cleared of extraneous material and over-laid with a separating membrane of polythene sheeting of the specified thickness, unless otherwise specified.

(d) Laying of Formwork

The formwork within which the concrete is to be laid shall then be positioned and fixed to line and level and to the required lengths.

Unless otherwise directed, the formwork in addition to the requirements of Section 1008 shall be of steel, and shall be made to L-shape section using steel plates of minimum thickness 6mm. The height of the formwork shall be equal to the thickness of the Pavement and the Base width shall be at least equal to 75 percent of the height.

The forms shall be placed on the Base, and over the separating membrane, with full bearing on it, to the required alignment of the Pavement edge. They shall be held down in place by means of steel stakes one at each end of each length of forms and at intermediate points not greater than 1.5m apart. Each form shall be firmly fixed to the adjoining form by suitable edge fasteners which could easily be removed, but will hold them firmly preventing any lateral movement when the concrete is placed and compacted.

(e) Manufacture and Transport of Concrete

As a first step in the manufacture of concrete the Contractor shall ensure that the production capacity of the mixing plant suits the laying equipment and the concreting rate.

The mixing of concrete shall conform to the requirement of Sub section 1001.8.

In the transport of the mix, care shall be exercised to minimize segregation and also delay.

When concrete is transported from within the site or from a mixing place in the vicinity of the site, ordinary trucks or dumpers with suitable tipping arrangements may be used. Preferably, they should be of low bed type and of small capacity, where manual methods of placing and compaction are adopted. Such transport may be done using even wheel barrows provided a sufficient number are employed and an efficient method of tipping the concrete at the required places is arranged.

In central plant mixing the concrete shall normally be transported using suitable truck mixers or truck agitators. In such circumstances the details of transport equipment and the time duration of transport, laying and finishing operations shall be as specified in the Contract or as established by the Engineer.

(f) Laying Operations

The placing compaction and finishing operations of concrete shall normally be made labour intensive, except in large scale work where specified equipment shall be used.

(i) Manual method of laying and compaction

Laying of concrete manually shall use a suitably improvised method of placing the concrete in a uniform and sufficient manner without segregation to suit the desired rate of concreting.

The work shall be carried out by skilled personnel as per methods approved by the Engineer.

For compaction, suitable poker vibrators, plate vibrators and vibrating beams shall be used. Internal pokers shall be at points not more than 500 mm apart over the whole area of the slab, or drawn continuously across the slab in front of the vibrating beams.

The vibrating beams shall be metal with a contact face at least 50 mm wide. They shall be rigid or supported by a frame or truss without sag across the width of slab being paved. The beams shall be supported on rails or forms or an adjacent slab and shall be moved forward at a steady speed of 0.5 m to 2 m per minute. The whole area of the slab shall be regulated by two passes of a scraping edge not less than 1.8 m wide.

To improve the method of placing of concrete an improvised box hopper spreader may be used. Under suitable conditions, use may be made of an asphalt finisher.

(ii) Machine laying, compaction and finishing

For large scale work, where the Pavement needs to meet higher quality criteria. Particularly for evenness, and where higher rates of laying are specified, use of specific concreting equipment such as a concreting train on fixed forms or a small sized slip form pavers (of paving width not exceeding 5.0m) shall be used. In such instances, however, the provisions of Section 901A for Machine Oriented Construction shall be applied.

(g) Finishing Operations

The surfaces shall be textured as per Sub section 901A.4 (h). Where necessary transverse grooves shall be formed by using a vibrating beam or such other mechanism approved by the Engineer. Use of additives to roughen the surface shall be with the prior approval of the Engineer.

(h) Curing of Concrete

Curing of the laid concrete shall be carried out for a minimum period of 14 days as provided for in Sub section 1001.11.

(i) Surface Finish and Quality Control

The cement concrete Pavement shall be finished to the requirements given in Section 1601.

The control on the quality of materials and works shall be exercised in accordance with Section 1602.

901B.5 Measurement & Payment

(a) Measurement

Concrete Pavements shall be measured as finished work in position in Cu.m or in Sq.m of surface area. Joints shall be measured separately in linear metres as specified.

(b) Payment

Payment shall be based on the Contract unit rate for each item of completed and accepted work, which shall include full compensation for materials, labour, equipment, transport, hire charges and incidentals necessary to complete the work.

The Pay Items and Pay Units shall be as follows :-

Pay Item	Description	Pay Unit
901B(1)	Concrete Pavement	Cu.m
or		
901B(2)	Concrete Pavement (state thickness)	Sq.m
and the following		
901B(3)	Joints (state type)	Linear metres

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

1000 BRIDGES & OTHER STRUCTURES

1001 CONCRETE FOR STRUCTURES

1001.1 Description

This work shall consist of the production of cement concrete for use in the construction of bridges, culverts and structures other than those items covered under Chapter 700. The work shall also include proportioning and mixing of materials; transporting, placing and compacting, finishing and protecting and curing for specified periods.

The work shall be carried out in accordance with these Specifications and with the lines, grades and dimensions shown in the Drawings or as instructed by the Engineer.

1001.2 Materials

The constituent materials shall conform to the following, unless otherwise specified.

(a) Cements to Section 1703.

(b) Rapid hardening cement to BS 12.

(c) Water for mixing and curing to SLS 522.

(d) Coarse aggregate and fine aggregate to Sub section 1701.2

(e) Admixtures to Section 1704.

(f) Special cements and aggregates that are used in the special concretes of class S shall be as specified in the Contract.

(g) Pulverized-fuel ash (Pfa) to BS 3892 (for use with Portland cement for durability and reduced heat of hydration.)

(h) Ground Granulated Blast furnace Slag (Ggbs) to BS6699 (for use with Portland cement for durability and reduced heat of hydration.)

1001.3 Classification and uses of concrete

Concrete used in bridge works and other structures shall be classified as given in Table 1001-1, depending on their uses.

1001.4 Proportioning of Materials

(a) General

The basis and the method of proportioning of concrete will depend on the class of concrete and the structural importance of the members being cast.

Concrete shall be proportioned or batched on the basis of nominal mixes, prescribed mixes or on the basis of designed mixes as the case may be and the method of proportioning of materials shall be by volume or by weight.

Table 1001-1 – Classification of Concrete

Class	Description	Uses
A	Concrete made with ordinary Portland cement (OPC) where strength requirements are specified. They shall be of prescribed or designed mix proportions	All pre-stressed concrete items and for all reinforced concrete slabs, beams abutments, piers, columns, piles etc; where strength is a criterion.
B	Concrete made with OPC for small works and ancillary works where strength requirements may or may not be specified. Shall be of nominal mix proportions.	Mainly for ancillary items such as paving slabs, kerbs, handrails, posts facia slabs etc; Also used on small works such as culverts, slabs etc.
C	Low strength concrete made with OPC where strength requirements are not specified. Shall be of nominal mix proportions	Mass concrete foundations, retaining walls, abutments etc; Fillings & Screeds;
S	Special concrete where (a) Cement used or aggregates used or both may be different from that of classes A, B or C above (b) Strength requirements may or may not be a criterion. They may be of nominal, prescribed or designed mix proportions.	1. Concrete for decorative purposes; 2. Concrete resistant to chemicals etc. 3. High strength concretes using additives and/or special cement and aggregates

(b) **Volume proportioning of concrete**

Volume proportioning or batching of constituents shall be limited to concrete of class B and C and to concrete of class S where strength is not a criterion as given in Table 1001-1, of Sub section 1001.3.

For this purpose mix proportions of nominal mixes shall be used and the volumes shall be based on a unit volume of cement.

(i) Nominal Mixes

In nominal mixes the constituents – cement, fine aggregate and coarse aggregate shall be expressed in simple proportions such as 1:2:4 or 1:3:6 in which the relative proportions of fine to coarse aggregates are generally kept constant at 1:2.

Table 1001-2 gives the nominal mixes that are in general use along with the class of concrete to which they belong.

Table 1001-2 - Nominal Mixes

Class of Concrete	Approximate Grade	Nominal Mix Proportions
B	25	1: 1 ½:3 (14) 1: 1 ½:3 (20)
	20	1:2:4 (20) 1:2:4 (28)
	-	1:3:6 (28) 1:3:6 (37.5)
C	-	1:4:8 (37.5) 1:4:8 (50)

Note
Figures within brackets denote the nominal maximum size of aggregate in mm.

(ii) Unit volume of cement

Cement shall be considered to have a nominal weight of 1440 kg per cu.m. On this basis the equivalent volume of 50kg bag of cement shall be 0.035 cu.m which shall be considered as the unit volume of cement for volume batching.

(iii) Measuring boxes for batching of aggregates

In batching aggregates the unit volume of cement shall be considered the unit of volume and unit volume boxes shall be made to internal dimensions of 400mm x 350mm x 250mm which equals 0.035 Cu.m.

These boxes shall be made of timber or any other suitable material and shall be provided with suitable handles for easy handling.

The Contractor may use different dimensions for these boxes with the approval of the Engineer provided the internal volume equals 0.035 cu.m or a convenient fraction of this volume.

(iv) Batching of cement

Batching of cement shall be by the bag unless otherwise allowed by the Engineer, in which case unit volume boxes or boxes of fractional volumes shall be used with appropriate allowances for bulking. The extra to be added for bulking shall be approved by the Engineer but shall not be less than 15 percent by volume.

(v) Batching of Sand

In batching sand bulking of wet sand shall be taken into account. Where field tests are not carried out to assess the permissible bulking of sand a bulking up to 25% may be allowed depending upon the moisture content of sand.

(c) Weight proportioning of concrete

(i) General

Weight proportioning (batching) of constituents shall be used in the production of concrete of class A or concrete of class B or S where strength requirements are specified.

These mixes are for concrete of medium to high strength and shall be of grade 20 or higher. They shall be either prescribed mixes or designed mixes except where nominal mixes in class B are batched by weight.

(ii) Prescribed Mixes

Prescribed mixes shall normally be limited to grades between 20 and 30. (See Sub section 1001.5 for the definition of grades). They shall not normally be used for pre-stressed concrete members and for special concrete of high strengths.

With prescribed mixes, mix proportions, which satisfy the requirements regarding strength and workability, shall be specified and the Contractor is required to produce properly mixed concrete to satisfy these requirements.

However, slight adjustments to the mix proportions, within reasonable limits, shall be permitted at the site, to obtain the required conditions and to accommodate the variations due to the use of local aggregates. Where so directed, the Contractor shall carry out suitable trial mixes to assess the suitability of a given mix.

In specifying prescribed mixes normally the following shall be given.

1. Strength or grade
2. Nominal maximum size of aggregates
3. Minimum cement content
4. Mix proportions
5. Workability – low, medium or high (see Sub section 1001.6)

However, in place of 3 & 4 above the aggregate proportions for a fixed quantity of cement may be given, as in Table 1001-3, in specifying prescribed mixes.

Table 1001-3 gives a few typical prescribed mixes that could be adopted for general use with slight adjustments where necessary. The Engineer, however, may specify other prescribed mixes provided such mixes had been tested for suitability previously.

(d) Designed Mixes

In designed mixes the Contractor shall select mix proportions of constituents to achieve the strength/grade and workability required. In addition he shall conform to the requirements of minimum cement content and size of aggregate specified.

Where mixes are designed for Class S concrete the Contractor shall conform to the special requirements given in Contract documents or by the Engineer, such as type of cement and type of aggregate, in addition to the above.

All pre-stressed concrete and other concrete of grades higher than 30, shall normally be designed. (See Sub section 1001.5 for grades of concrete).

In the design of mix proportions for particular concrete the Contractor shall prepare trial mixes and carry out preliminary tests as specified in Sub section 1001.6, in order to achieve a target mean strength higher than the characteristic strength by such a margin of strength, that the minimum strength requirements of the works cube strengths shall be satisfied.

The Contractor may decide on the required target mean strengths by a process of statistical analysis provided sufficient data is available. Where such data is not available the Contractor shall adopt a margin of strength not less than 10 N/mm^2, over and above the characteristic strength, in deciding on the target mean strengths. Table 1001-4 gives such proposed minimum target strengths and minimum cement contents using aggregates of 20mm nominal maximum size.

Table 1001 –3 - Prescribed Mixes – Proportions per 50 kg. Bag of cement

Grade of Concrete	Nominal max. size of aggregate mm	37.5		20		14	
	Workability	Medium	High	Medium	High	Medium	High
20	Total aggregate (kg)	280	250	255	220	305	270
	Sand %	35	40	40	45	30	35
25	Total Aggregate (kg)	240	215	220	195	265	240
	Sand %	35	40	40	45	30	35
30	Total Aggregate (kg)	210	90	195	170	235	215
	Sand %	35	40	40	45	30	35

Note: 1) Fine aggregate (sand) used shall normally conform to the grading requirements of Zone 2 given in Table 1701-2 of Sub section 1701.2.

If sand of zone 1 is used the mass of sand used shall be increased by 10 kg and if sand of zone 3 is used the mass of sand shall be reduced by 10 Kg. There shall be corresponding variations of mass of coarse aggregate in order to keep the total mass constant.

2) Percentage sand is by weight of total aggregate.

Table 1001-4 - Minimum Cement Contents

Grade	Minimum Cement content in concrete kg/m3	28 days compressive strength N/mm^2	
		Minimum target strength (Preliminary tests)	Characteristic Strength
30.0	315	40.0	30.0
37.5	335	47.5	37.5
45.0	360	55.0	45.0
52.0	405	62.0	52.0

1001.5 Grade of Concrete

Grade of concrete is defined by the number, which denotes the characteristic strength of the concrete in N/mm^2 as given in Table 1001-5.

Table 1001-5 - Characteristic Strengths

Grade	Characteristic Strength – N/mm^2
20	20.0
25	25.0
30	30.0
40	40.0
50	50.0
60	60.0

By characteristic strength is meant the crushing strength of 150mm concrete cubes at 28 days below which not more than five percent of the test results shall fail.

For purposes of these Specifications concrete where strength requirements are not specified, are denoted only by mix proportions.

1001.6 Workability of Concrete

The workability or consistency of fresh concrete shall be such that the concrete is suitable for the conditions of handling and placing so that after compaction it surrounds and grips all reinforcements and completely fills the formwork.

The degree of workability shall depend on the nature of work and the method of placement; whether with vibration or without vibration.

For purposes of these Specifications the degree of workability shall be classified as low, medium and high and shall normally be assessed by means of the slump test.

Where so required or specified the compacting factor test or the VB consistometer test shall also be used to assess workability.

Generally accepted values of slump, in relation to the degree of workability and the aggregate used, are given in Table 1001-6.

Table 1001-6 - Workability of Concrete

Degree of Workability	Nominal max. size of aggregate (mm)	Slump (mm)
Low	14	0 – 12
	20	12 – 25
	37.5	25 – 50
Medium	14	12 – 25
	20	25 – 50
	37.5	50 – 100
High	14	25 – 75
	20	50 – 125
	37.5	100 - 150

Low workability shall normally be confined to high strength vibrated concrete only and particularly for the manufacture of items such as pre-stressed beams, where work is carried out under controlled conditions.

Medium workability shall normally be used for all in-situ works such as in the casting of RCC slabs and beams, foundations, columns, etc., with or without vibration, as determined.

High workability shall normally be used where vibrators are not used in the compaction of concrete.

In general workability shall be increased and nominal maximum size shall be decreased where the sections concreted are thin and/or are heavily reinforced.

1001.7 Testing of Concrete for Acceptance

(a) General

Concrete shall be tested by determining the crushing strength of 150mm cubes at 28 days. Where so required, an early assessment of the 28 days strength shall be made by carrying out tests at 7 days on the assumption that 65% of the 28 days strength is achieved in 7 days. Any other testing procedure to assess the 28 days compressive strength of concrete shall be subject to the prior approval of the Engineer.

All cubes shall be cast, cured and tested in the manner described in Sub section 1001.12.

(b) Preliminary strength tests

In the design of mixes, preliminary tests shall be carried out by the Contractor to ensure that the proposed mix attains the required target mean strengths. For this purpose three trial batches of the proposed mix shall be prepared at the specified workability. From each batch 3 random samples shall be taken and for each sample a cube shall be made, for testing at 28 days and where required 3 more cubes shall be made for testing at 7 days using three more random samples from the same batch.

The mix shall be accepted as suitable if the average strength of the 9 cubes tested after 28 days exceeds the target mean strength in Table 1001-4 or other target strength approved by the Engineer.

Where an early assessment of strength is needed the 7 days test results may be made use of as given in 1001.7(a) with the approval of the Engineer.

(c) Works strength tests

All concrete where strength requirements are specified shall be tested for compliance by carrying out works tests unless otherwise allowed by the Engineer. The frequency of testing, however, shall be determined by the Engineer depending on the nature and the extent of work.

For works of a continuing nature such as casting of pre-stressed beams initially there shall be frequent testing, to confirm the mix, which shall be suitably reduced to a general pattern of testing after the initial period is over.

As a general rule a specified volume of concrete referred to as a lot shall be sampled for testing and from each lot 3 samples shall be taken for each of which a cube shall be made for testing at 28 days. Where required 3 more samples shall be taken and 3 more cubes shall be made for testing at 7 days.

A lot of concrete shall mean any of the following as applicable:

(1) 15 Cu.m of a continuing process of concreting
(2) A day's concreting
(3) A defined item of work such as concreting a beam or a slab, which is carried out in less than a day.

Acceptance criteria shall be that the average 28 days compressive strength of the 3 cubes exceeds the characteristic strength of the concrete and that the difference between the greatest and least strengths is not more than 20 percent of the average.

The 7-day test results shall generally be made use of as an indicator of the strength at 28 days and unless otherwise decided by the Engineer, no decision regarding non acceptance of the concrete shall be made using these results.

1001.8 Mixing of Concrete

(a) General

Concrete shall be mixed at the site of construction or, where so allowed, shall be mixed at a central plant and transported to the site. Concrete may also be mixed in truck mixers when in transit, from a central place to the site.

All site mixing or mixing at a central place, except where hand mixing is allowed, shall be carried out using a suitable mixer of an approved type and capacity. No mixer having a rated capacity of less than a bag-batch shall be used without the prior approval of the Engineer. Mixes which have been out of use for more than 30 minutes shall be emptied and the mixing equipment thoroughly cleaned before putting in a new batch. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

All concrete, irrespective of the method of mixing, shall be uniformly and thoroughly mixed to the required consistency prior to placing and there shall be no evidence of insufficient mixing. The mixing time of a batch of concrete, in any type of mixer, shall not be less than 60 seconds. Any concrete insufficiently mixed shall be rejected and shall be disposed of by the Contractor at his own expense.

(b) Batching of constituents into mixers

The constituent materials of concrete shall be batched by volume or by weight as specified.

In volume batching, as far as practicable, cement shall be measured by the bag and the aggregate shall be measured using standard measuring boxes (see Sub section 1001.4.b). Water shall be measured using measuring devices approved by the Engineer.

For batching by weight of constituents the mixer shall be equipped with the necessary weighing devices specified in the Contract or required by the Engineer. The batching plant shall have separate bins for cement, fine aggregate and coarse aggregate, a weighing hopper and a scale capable of determining accurately the weight of each component of the batch. A properly calibrated water-measuring device shall be attached to the mixer.

(c) Hand Mixing

Hand mixing where permitted, shall be carried out on a smooth watertight platform large enough to allow efficient turning over of the constituents of concrete before and after adding the water. Mixing platform shall be so formed that no foreign material gets mixed up with the concrete and the mixing water does not flow out of the mixing area.

(d) Mixing at central plant and/or in transit

Where concrete is mixed at a central plant and/or in transit, the method of mixing, transport, and the time duration of mixing and transport, shall be as specified in special provisions or as established by the Engineer depending on the equipment used. However, such concrete shall be transported in suitable truck mixers or truck agitators within stipulated periods of time so as to ensure that the concrete is delivered to the site leaving sufficient time for placing and compaction. Also the interval between deliveries of batches shall be less than 30 minutes so as to ensure that the concrete already in place has not started hardening before fresh concrete is placed on it.

(e) Admixtures

No admixtures shall be added to concrete without the prior approval of the Engineer.

1001.9 Placing and Compaction of Concrete

When a truck mixer or agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharged within one and half hours after the addition of the cement to the aggregates. Each batch of the concrete delivered at the job site shall be accompanied by a batch ticket bearing complete batching information. In adverse weather or under other conditions contributing to quick

stiffening of the concrete, or when the temperature of the concrete is 30^0 C and rising, the time between the introduction of the cement to the aggregates and discharge shall not exceed one hour. In any event the temperature of fresh concrete shall not exceed 32^0 C unless otherwise specified. When a truck mixer is used for the complete mixing of the concrete, the mixing operation shall begin within one hour after the cement has been added to the aggregate.

The addition of water after completion of initial mixing shall not be permitted, except that when concrete is delivered in truck mixers, additional water may be added subject to the Engineer's approval to adjust to a specified consistency. In this event, a minimum of 20 additional revolutions of the truck mixer drum at mixing speed shall be required before discharge of any concrete; the maximum allowable time between the addition of the cement to the aggregates and the discharge of the batch shall not be exceeded. Concrete that is not within the specified consistency limits at the time of placement shall not be used.

Prior to placing of concrete all formwork and reinforcements therein shall be cleaned of all extraneous material and dust and made free of any standing water. It shall be ensured that all formwork is made leak proof and that there is no loss of mixing water or grout from the concrete. No concreting shall be started without the prior approval of the Engineer.

All mixed concrete shall be placed and compacted in the formwork, using approved vibrators of the internal, external or screed types, or combinations there of depending on the type of job. Where approved, steel rods may also be used for the purpose in addition to the vibrators. The adequacy of the compacting equipment or the suitability of the compacting method shall be determined by the Engineer depending on the requirements. Use of steel rods only for compaction shall be resorted to only in small jobs and in low strength concretes.

In all cases of continuous concreting, fresh concrete shall be placed before the already laid concrete is less than 30 minutes old and where this time gap is exceeded further placing shall be subject to testing the already placed concrete surface to be live. In the event that the surface is not live, it shall be treated as a construction joint and to be allowed to set.

All concrete generally shall be placed and compacted in horizontal layers normally not exceeding 300mm in depth except where adequately sized internal vibrators are used when the depth may be increased up to a maximum of about 450mm.

No concrete shall be dropped from a height greater than about 1.5 metres except with the prior approval of the Engineer. Where chutes are used for placing of concrete they shall be kept clean and used in a manner to prevent segregation. When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without the use of excessive quantity of water and without any segregation of its ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with water before and after each working period and the water used for this purpose shall be discharged outside the formwork.

When concreting has to be resumed on a surface which has hardened, the surface shall be roughened, swept clean thoroughly wetted and covered with a thin layer of cement grout or cement mortar as approved. Semi-hardened surfaces shall be

well brushed to remove all laitance, cleaned and covered with a thin layer of cement grout prior to overlaying with fresh concrete.

A concrete surface which has hardened shall be treated as a construction joint for further casting after not less than 24 hours. The surface shall be free of laitance and cleaned until the surfaces of the larger aggregate are exposed. The aggregate stones shall not be loose.

1001.10 Underwater Concreting

In all under water concreting the method of placement and handling of tremie pipes, the mix proportions, slump, the surface on which the concrete is to be placed and other necessary details shall be approved by the Engineer prior to starting work. Consideration shall be given to retarding the concrete adequately to ensure that there are no cold joints in the concrete placed including plant/equipment breakdown Before placing the concrete, the surface on which the concrete is to be placed, shall be cleaned using an air ejector.

Where a tremie pipe is used for placing of concrete it shall be ensured that the pipe is of the correct dimensions and that it is provided with a sufficiently large hopper at the top to hold a full batch or requisite volume of concrete. Such batch or volume shall not be less than that required to fill the tremie pipe and submerge the bottom of tremie with the concrete at commencement. Normally the diameter of the pipe shall not be less than 200mm. At all times of concreting the bottom end of the pipe shall be kept within the newly placed concrete although it may become necessary to raise and lower the pipe to ensure uniform flow of concrete. This embedded length of the tremie pipe in the newly laid concrete shall be 1.5 m minimum. The number and spacing of the tremies shall be worked out to ensure proper concreting. The tremie concreting when started shall continue without interruption for the full height of the member being concreted. The concrete production and placement equipment shall be sufficient to enable the underwater concrete to be completed uninterrupted within the stipulated time. Necessary standby equipment shall be available for emergency situation.

A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged with an approved material before delivering the concrete to the tremie pipe through the hopper, so that when the concrete is forced down from the hopper to the pipe, it will force the plug (and along with it any water in the pipe) down the pipe and out of the bottom end, thus establishing a continuous stream of concrete. Initially the tremie lower end will need to be placed as close as possible to the bottom and not exceeding 100mm in any event to allow water from the tremie to discharge as the plug is slowly moving down. The tremie may then be raised a little and very slowly to allow the plug to eject from the tremie bottom and allow the concrete to flow out and submerge the bottom end of the tremie. It will be necessary to raise the tremie slowly in order to allow a uniform flow of concrete, but it shall not be emptied so that water is not allowed to enter above the concrete in the pipe. At all times after placing of concrete is started and until the required quantity has been placed, the lower end of tremie pipe shall be kept below the surface of the plastic concrete. This will cause the concrete to build up from below instead of flowing out over the surface and thus avoid formation of layers of laitance. If the charge in the tremie is lost while depositing, the tremie shall be raised above the concrete surface and unless sealed by a check valve, it shall be re-plugged at the top end as at the beginning, before refilling for depositing further concrete.

In the alternative, for placing of concrete, a suitable drop bucket shall be used which will allow the concrete to be lowered and the bottom slipped out leaving behind the concrete on the surface.

In all cases of under water concreting care shall be exercised to prevent segregation and washing away of the cement. All concrete shall be placed in still water and there shall be no dewatering in the vicinity during concreting and till the concrete is completely hardened.

1001.11 Curing of Concrete

Freshly laid concrete shall be kept undisturbed and protected from the effects of sun and rain and from drying out / loss of moisture till it hardens. Once hardened, the concrete shall continuously be cured in a moist atmosphere for a minimum period of 7 days and for a further period if so specified or required by the Engineer.

The hydration temperatures during curing shall not exceed 75^0 at the core. The temperature differentials between the core and the surface shall not exceed 20^0 C.

The method of curing shall depend on the type of member to be cured. Bridge deck slabs and other slabs shall be kept covered with burlap, jute-hessian or other similar water absorbing material which shall be kept moist throughout the curing period. Such slabs may be kept covered with wet sand or even kept ponding up with water. Sides of such slabs may have to be kept continuously sprinkled with water. Pre-cast beams and other similar large pre-cast items shall also be kept covered with wet burlap and similar material where as small pre-cast items such as kerbs channels etc., could be kept completely immersed in water.

Steam curing and curing by using liquid membrane forming curing compounds shall be carried out only as given in the Contract or as approved by the Engineer.

1001.12 Casting, Curing & Testing of Cubes

Casting, curing and testing of concrete cubes shall be carried out as given in BS 1881 Part 108 of 1983 or as given below.

(a) Casting

The 150mm cube moulds shall be filled in layers approximately 50mm deep and each layer shall be compacted either by hand or by vibration. After the top layer had been compacted the surface of the concrete shall be finished level with the top of the mould by means of a trowel.

When compacting by hand, the standard compacting bar made of steel weighing 1.8 kg, 380mm long and having a ramming face 25mm square shall be used and the strokes of the bar shall be distributed in a uniform manner over the Cross-section of the mould. The number of strokes for each layer shall depend on the type of concrete. However, each layer shall be subjected to a minimum of 35 blows.

When compacting by vibration each layer shall be vibrated using a suitable vibrating table.

(b) Curing

Immediately after they are made the test specimens shall be stored in a place free from vibration in a damp atmosphere and at a temperature of around 25°C, for the next 24 hours. At the end of this period, unless otherwise directed, the specimens shall be marked for later identification, removed from the mould and immediately submerged in a water tank and kept there until taken out just before test. The specimens shall not be allowed to become dry at any time until they are tested where the specimens have to be transported to another place, say from the field to the laboratory, for testing they shall be rapped up in wet sacks or put inside suitable wet bags during transport. At no stage of transport the specimens shall be allowed to dry up.

(c) Testing

The specimens shall be tested in a machine approved by the Engineer and at the time of testing the platens of the Machine shall be wiped clean and any loose grit or other material removed from the surfaces of the cube which are to be in contact with the platens of the compression machine.

The test cube shall be placed in the machine in such a manner that the load shall be applied to two opposite sides of the cube other than the top and bottom as cast.

During loading, the load shall be applied without shock and increased continuously at a rate of approximately 15 MN/m^2 per minute until no greater load can be sustained & the maximum load applied to the cube shall be noted as the crushing load.

1001.12/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1001.13 Measurement & Payment

(a) Measurement

Cement concrete shall be measured in Cu.m of each class of concrete placed and accepted and shall conform to quantities given in Drawings except for amendments approved by the Engineer.

No deductions shall be made for the volume occupied by pipes less than 150mm in diameter or for reinforcing steel, conduits, weep holes and pile heads embedded in the concrete.

The quantities of reinforcing steel and other items shown in the Contract Documents which are included in the completed structure shall be measured for payment as described for the separate items involved unless otherwise specified.

(b) Payment

Payment will be at the Contract unit rate for each class of concrete and shall be full compensation for all materials, labour, formwork, tools, plant and other incidentals required to complete the work.

Reinforcing steel and other items shown in the Drawings which are included in the completed and accepted structure will be paid for as specified in the relevant sections of these Specifications.

The Pay Items and Pay Units will be as follows: -

Pay Item	Description	Pay Unit
1001(1)	Concrete Class A (State grade and max. size of aggregate)	Cu.m
1001(2)	Concrete Class B (State grade and max. size of aggregate)	Cu.m
1001(3)	Concrete Class C (State grade and max. size of aggregate)	Cu.m
1001(4)	Concrete Class S (State grade and max. size of aggregate)	Cu.m

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

1002 STEEL REINFORCEMENT FOR CONCRETE STRUCTURES

1002.1 Description

This work shall consist of furnishing, fabricating and placing of reinforcement of the specified grade and type in concrete structures in accordance with these Specifications and in conformity with the details shown in the Drawings or as approved by the Engineer.

1002.2 Materials

Steel reinforcements used shall meet the requirements of the following: -

(a) Hot rolled MS bars to CS or SLS 26

(b) Cold worked high yield steel bars to CS 375

(c) Steel fabric to CS 95

(d) Hot rolled high yield steel bars to BS 4449

(e) Hard drawn steel wire and wire mesh, if used, shall be of approved manufacture.

1002.3 Construction Requirements

(a) Protection & Storage

Reinforcement shall be clean and free from loose rust and mill scale, dirt, oil, grease and paint at the time of fixing in position and subsequent concreting; Reinforcement for structures shall be handled and stored in a manner that will prevent deformation.

(b) Cutting & Bending

Bars shall be cut and bent cold by applying a slow, even pressure with equipment and methods approved by the Engineer to the dimensions given in the Bar Bending Schedules shown in the relevant Drawings.

Bends and hooks shall conform to the requirements given in the Drawings or established by the Engineer.

(c) Placing & fixing of reinforcement

All reinforcing bars shall be placed in positions shown in the Drawings and shall be firmly held in position, with the specified spacing, prior to concreting operations using necessary wire ties at bar intersections, spacer bars, steel chairs of approved type or by other approved means. Wire ties shall be black annealed M.S or G.I. wire, not less than 1.0mm in diameter and shall be firmly tied and folded so that they do not project into concrete cover region. The adequacy of supports and ties to secure the reinforcement properly shall be subject to the approval of the Engineer. Layers of bars shall be separated by spacer bars, pre-cast mortar blocks or other approved devices. All horizontal and vertical reinforcement shall be supported on mortar blocks, of approved shape conforming to cover requirements, with tie wires embedded in them, made out of 1: 1 ½ or 1:2 cement sand mix. Supports which are in contact with the external face of the concrete shall all be mortar blocks. The use of small stones or wood blocks shall not be permitted. As far as possible, bars of full length shall be used. In case this is not possible splicing of bars shall be done as specified in the Drawings or as directed by the Engineer. (All splices shall have a lap length at least equal to the anchorage length required to develop the stress in the smaller of the bars to be lapped). Lap splicing shall be staggered for different bars and shall generally not be located at points, of maximum tensile stress.

Where welding is specified or approved by the Engineer, as an alternative, the reinforcement shall be butt welded by the metal arc process using covered electrodes, complying with standard Specifications for such work. Where screwed joints are specified for reinforcement they shall be butt joints made by using screwed coupling boxes of approved type capable of developing strength at least 10% more than that of the bar which is to be jointed, and the joint as a whole shall be capable of developing the same strength as the coupling. Before the Engineer approves the welding of reinforcement or screwed joints in reinforcement, the Contractor shall submit such samples as the Engineer may require for testing.

Substitution with different size bars or with different type of steel will be permitted only with the prior approval of the Engineer.

No concreting shall commence until the reinforcements have been inspected and approved by the Engineer.

Reinforcement after being placed in position shall be maintained in a clean condition until completely embedded in concrete. Special care shall be exercised to prevent any displacement of reinforcement in concrete already placed. All bars protruding from concrete and to which bars are to be spliced and which are likely to be exposed for a considerably long period shall be protected by the a thick coat of neat cement grout.

1002.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1002.4 Measurement & Payment

(a) Measurement

The quantity of reinforcement shall be computed by weight in tonnes of each type of material used and accepted as shown in the Drawings, provided that the quantity shall not include the reinforcement in any item of work the basis of payment for which includes the reinforcement. Lengths shall include hooks at ends. Wastage over laps, coupling welded joints, spacer bars and annealed steel wire for binding shall not be measured and cost of these items shall be deemed to be included in the rate for reinforcement.

(b) Payment

This work measured as provided above, will be paid for at the unit rate per metric tonne of reinforcement for each type and size of steel. The payment shall be full compensation for furnishing and placing of steel and for all labour, equipment, tools and incidentals necessary to complete the work prescribed in this section.

The Pay Items and Pay Units will be as following:-

Pay Item	Description	Pay Unit
1002(1)	Steel reinforcement (state type, size and grade)	Tonnes

Note:
Refer Sub section 106.6 regarding sub divisions of pay items.

1003 PRESTRESSING FOR STRUCTURES

1003.1 Description

This work shall consist of pre-stressing of concrete structures or concrete structural units by processes of pre-tensioning or post tensioning as specified. The work shall be carried out in accordance with these Specifications and with the Drawings or as approved by the Engineer.

1003.2 Materials

Materials used shall conform to the requirements of the following, unless otherwise specified.

(a) Concrete used for structures or structural units shall be of class A and of grade 30 or higher, to Section 1001.

(b) Steel for reinforcements of structures or structural units to SLS 375 or CS 26

(c) Pre-stressing Tendons – Pre-stressing tendon shall consists of either high tensile alloy steel bars to BS 4486:1980, or high tensile wire to BS 5896:1980 or strand to BS 5896 : 1980.

(d) Anchorages – Anchorages shall be in accordance with dimensions and sizes given in the Drawings and to Specifications given therein. When stressing system is not specified, anchorages shall be in compliance with the particular stressing system employed.

(e) Grout – Grout used in the grouting of ducts shall meet the requirements of Sub section 1703.1 and the compressive strength of hardened grout shall be not less than 30 N/mm^2 at 28 days.

(f) Sheaths or duct formers – Sheaths or duct formers shall be made from mild or galvanized steel strips wound to form a duct. The ducts so formed shall be free of loose rust, oil, grease & other harmful matter at the time of incorporation in thc works.

(g) Extractable cores – Extractable cores shall be formed with material approved by the Engineer.

(h) Vent tubing – Vent tubing shall be of approved manufacture.

(i) Spacers – Spacers used in multi-wire cables shall be of shape and size as specified in the Drawings or Contract documents or as ordered by the Engineer and shall be made out of approved material.

1003.3 Delivery, handling & storage of pre-stressing tendons

Wires and strands shall be delivered in coils of sizes specified in the Contract document. Bars shall be delivered straight in standard lengths as specified in Bs 4486:1980 or in any other lengths specified in the Contract document. However, if any straightening of bars becomes necessary after handling, it shall be carried out in the cold.

All pre-stressing steel shall be handled with care to avoid any mechanical damage or work hardening or heating that will impair its properties.

They shall all be separately stored clear of the ground and suitably protected from weather and exposures to oxy-acetylene torches and arc welding processes.

The protective wrappings used on all pre-stressed steel shall be chemically inert. Suitable protection shall be provided for threaded ends of bars.

When steel for pre-stressing is stored for long periods it shall be regularly inspected for rusting and pitting and suitable protective measures taken. The Engineer in case of doubt shall cause suitable tests to be carried out by the Contractor to ensure that the quality of the steel has not been significantly impaired.

1003.4 Construction Requirements

(a) Concreting of structures and structural units

Concreting of structures and the structural units to be pre-stressed shall be carried out as given in Section 1001. Their steel reinforcements shall conform to the requirements of Section 1002. Formwork for concreting shall conform to the requirements of Section 1008 and the surfaces shall be finished smooth.

(b) Positioning of sheathing, tendons, anchorages and vent tubes

Prior to concreting all sheaths, tendons, anchorages and vent tubes shall be positioned as per Drawings and maintained in their positions during the concreting.

In post-tensioning, tendons and sheaths shall be positioned and fixed in accordance with the Drawings, within a tolerance of 5mm. The tendons shall be placed in the steel sheaths or duct former, which shall be fixed at sufficiently spaced intervals to maintain them in position during concreting.

In long line pre-tensioning, supports to tendons, in addition to those at end plates, may become necessary for proper positioning.

Anchorages shall be positioned strictly is accordance with the manufacturers instructions and recommendations, depending on the type of anchorages. They shall be positioned and maintained during concreting so that the centre line of the duct passes axially through the anchorage assembly. All bearing surfaces of the anchorages shall be clean prior to concreting and tensioning.

Vent tubes attached to cable ducts shall be positioned as given in Drawings or as directed by the Engineer.

(c) Stressing of steel

(i) General

Tensioning of steel shall be carried out with particular care and in the presence of the Engineer or his assigns. It shall be done by a team of experienced and skilled personnel.

Precautions shall be taken to safeguard personnel from risks of accidents from tendon failure while the tensioning process is in progress. Protective measures, such as stout timber shields in line and behind tendons and jack, shall be employed. Warning bells or sirens shall be used in addition.

(ii) Checks prior to stressing

Following checks shall be carried out by the Engineer before commencement of stressing.

- in multi wire cables, that the wires play loose
- that the concrete has attained required strength as specified in the Drawings
- that the necessary safety precautions are provided

(iii) Stressing System

The stressing system specified in the Drawings or Contract documents has to be employed. Alternative systems shall not be used without the prior approval of the Engineer.

(iv) Stressing Equipment

Stressing equipment shall be compatible with the stressing system employed. They shall be in good condition and shall be capable of safe operation.

The jacking force shall be capable of being measured accurately either by means of load cells or other gauges incorporated in the jack. Such measuring devices shall be calibrated regularly as required by the Engineer. Calibration curves shall be available at the time of stressing.

(v) Stressing Operations

Stressing operations shall be carried out either from one end or from both ends as specified in the Drawings in such a way that the stresses increase progressively to the required values.

In multi cable units' order of stressing given in the Drawing shall be strictly adhered to unless approval of Engineer to deviate is obtained. Where stage stressing is specified no deviation is permitted without approval of the Engineer.

Stressing of steel shall be carried out gradually and smoothly. Jacking force and extensions shall be measured at different stages and compared with theoretical values. They shall be within a tolerance of ± 5%.

Slip at anchorage shall be measured accurately. The total slip at both ends shall not exceed 25% for tendon lengths up to 16m and 50% for lengths above 16m from those allowed in the Drawings.

Above measurements shall be recorded and copy given to the Engineer.

(d) Cutting of Tendons

All cutting to length and trimming of ends of tendons shall be carried out with: -

(i) High speed abrasive cutting wheel, friction saw or any other mechanical equipment approved by the Engineer, or

(ii) Oxy-acetylene cutting flame, using excess oxygen to ensure a cutting rather than a melting action. Care shall be taken that neither the flame nor splashes come into contact with either the anchorage or other tendons.

In pretension units wire shall be cut not more than 5mm from end. The ends shall then be covered with 1:2 cement mortar to protect the steel.

In post-tensioned units, tendons shall be cut at least 10m away from the anchorage. The temperature of the anchorage shall not exceed 200°C during the cutting operations. The anchorage pocket shall be covered as specified in the Drawings or as directed by the Engineer.

(e) Grouting of Tendons

Grout used in the grout of ducts shall be mixed in a grouting machine. Hand mixing shall not be permitted.

Water/Cement ratio shall be kept as low as possible consistent with adequate workability and shall not exceed 0.45.

Admixtures shall be used only with the approval of the Engineer.

Grouting of cables shall be carried out as soon as possible after the stressing operation using machine capable of continuous pumping operation and maintaining delivery pressure up to 0.7 N/mm2 (100 psi).

All ducts shall be cleaned before grouting commences. Those formed without formers (sheaths) shall be flushed with water and surplus water removed before grouting.

Anchorage shall be sealed with cement mortar. The nozzle of grouting machine shall be fixed and sealed to prevent air being drawn in. Grout, shall be pumped continuously at limit rate until the consistency of grout flow out from free end and air vents are the same. Grout pumping shall continue for a further period and opening sealed subsequently in direction of flow.

(f) Handling, storage and transport of pre-cast pre-stressed units

Extreme care shall be exercised during handling, storage and transporting of pre-stressed units. Any shock loading shall be avoided. They shall be supported or slung from positions indicated in the Drawings and any deviations shall be approved by the Engineer.

(g) Testing

Testing of structural units when required shall be done as directed by the Engineer. Acceptance of the unit shall be based on the performance of the unit when subjected to loadings up to one and a half times the designed service load.

1003.4/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1003.5 Measurement and Payment

(a) Measurement

In the case of pre-cast pre-stressed units the quantity to be measured shall be the number of units of each type and size, completed and accepted. Each unit shall include the concrete, reinforcement and pre-stressing steel and grout, ducting, spacer grills, anchorages inclusive of anchorage plates, nuts, and end make up or pocket filling and other material contained within or attached to the unit.

For pre-stressing of cast in-situ concrete structures, the quantity to be measured shall be the number of pre-stressing tendons or cables, fixed in place and stressed, completed and accepted. Each tendon shall include all pre-stressing steel, grout, ducting, anchorages including anchor plates nuts and other material contained within or attached to the tendon.

Concrete and other Contract items which enter the completed and accepted structure shall be measured for payment in accordance with methods prescribed for such items in these Specifications.

Measurement of work involved in connection with launching and installing in place of pre-cast units shall be number of units of each type and size so installed and accepted and shall include for all necessary materials, labour, tools, machinery, plant and other special equipment such as launching trusses, bailey bridges, gantries, jacks etc. It shall include for movement of the unit from place of storage within work site to its final position.

(b) Payment

Payment for work measured as described above will be full compensation for furnishing all necessary labour, materials, tools, equipment and incidentals required to complete the work as shown in the Drawings and described in proceeding sections.

Payment for pre-cast units supplied will be at Contract price per unit as described above. Where units are transported from outside to the work site, cost of handling, transporting, delivering and stacking at site shall deem to be included in the unit price.

Payment for pre-stressing tendon in cast in-situ pre-stressed structure will be at Contract price per each tendon or cable as described above.

Payment for launching and installing in position of pre-cast units from point of storage at site will be at Contract price per pre-cast unit.

The Pay Items and Pay Units will be as follows:-

Pay Item	Description	Pay Unit
1003(1)	Pre-cast pre-stressed beam supplied (State size and type)	Numbers
1003(2)	Pre-cast pre-stressed beams launched into position (state size and type)	Numbers
1003(3)	Miscellaneous pre-cast pre-stressed units supplied (state type, size and other details)	Numbers
1003(4)	Miscellaneous pre-cast pre-stressed units fixed (state type, size and other details)	Numbers
1003(5)	Tendons, supplied, positioned and stressed (State length and size)	Numbers
1003(6)	Cables, supplied, positioned and stressed (State length and size)	Numbers

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

1004 PILE FOUNDATIONS FOR STRUCTURES

1004.1 Description

This work shall consist of construction of pile foundations for structures using driven or cast in-situ (bored) piles.

Driven piles shall be of pre-cast reinforced or pre-stressed concrete, steel or timber, as specified. Cast in-situ (bored) piles shall be of reinforced concrete.

They shall be furnished and installed or constructed in-situ as applicable, in accordance with these Specifications, in conformity with the requirements given in the Drawings or elsewhere in the Contract documents or as instructed by the Engineer.

1004.2 Materials

Materials used for the manufacture of piles shall conform to the following requirements, unless otherwise specified.

(a) Concrete - Concrete for pre-cast or cast in-situ concrete piles shall be of Class A to section 1001 and as specified. Grades of concrete shall not be less than 30 and 40 for pre-cast reinforced concrete and pre-stressed concrete piles respectively.

(b) Reinforcing Steel - Reinforcing steel for concrete piles to section 1002.

(c) Structural Steel - Structural steel for steel piles shall be of the type and grade specified in Contract documents.

(d) Timber - Timber for timber piles shall be of any selected species such as Na, Teak, Hora, approved by the Engineer which will withstand driving and support the load imposed. They shall be of sound wood, straight grained, free from decay, sapwood, weak knots, splits, shakes or any other defects. They shall be peeled of all bark and shall be well seasoned in accordance with CS 159.

(e) Pile Shoes - Pile shoes shall be of "chilled hardened" high duty cast iron or other equivalent suitable for the anticipated driving conditions including hard to very hard driving.

1004.3 Manufacturing and protective requirements for piles

(a) General

Pre-cast reinforced concrete and pre-cast pre-stressed concrete piles shall be manufactured in accordance with the details shown in the Drawings. They shall be of such straightness that a line stretched from tip to butt on any face will not be more than 1/1000 of the length of the pile from the face of the pile at any point. All joints between pre-cast concrete segments shall be capable of developing the full structural strength of the normal pile section.

Steel piles shall be H- columns of the section shown on the Drawings or specified in the special provisions.

For timber piles the minimum diameter at the centre of the pile, that is midway between tip and butt shall not be less than the dimensions shown in the Drawings, Sawn timber used as piling shall conform to the dimensions shown on the Drawings. They shall be such that a straight line drawn from the centre of the butt to the centre of the tip shall lie entirely within the body of the pile.

(b) Pre-cast concrete piles

In the manufacture of pre-cast concrete pile, of reinforced concrete or of pre-stressed concrete the following shall be complied with:-

(i) Formwork

The forms used shall be of steel, unless otherwise specified or allowed by the Engineer, and they shall conform to the requirements of section 1008 in respect of erection, removal and other details such as dressing of surfaces to obtain a smooth finish.

(ii) Reinforcement

Reinforcement shall be positioned as shown in Drawings and shall conform to the requirements of Section 1002. In case of reinforced concrete piles the main reinforcing steel shall be supplied in one complete length as far as practicable. Any splicing necessary shall be carried out as shown in Drawings or as directed by the Engineer.

(iii) Casting finishing and curing

Concreting in casting of piles shall be carried out in accordance with section 1001. However the compaction shall be done by vibration unless otherwise allowed. Special care shall be taken during concreting to produce a pile free from any air

pockets, honey combs or other defects. The top surface shall be finished to an even texture.

Curing shall be carried out in accordance with Sub section 1001.11.

(iv) Pre-stressing operations

All pre-stressing operations in pre-stressed piles shall comply with the requirements of Section 1003.

(v) Pile shoes

Pile shoes of the approved quality and type shall be incorporated in reinforced concrete piles according to details shown in Drawings.

(vi) Handling, Stacking & Storing

When raising or transporting pre-cast concrete piles the Contractor shall provide slings and other equipment necessary to prevent any appreciable bending of the pile or cracking of the concrete. No concrete pile shall be lifted otherwise than by slinging from the lifting holes, the positions of which shall be shown in the Drawings or approved by the Engineer. Piles damaged in handling shall be replaced. Concrete piles shall be so handled at all times to prevent breaking or chipping of the edges.

Piles shall be stored on firm ground free from liability to unequal subsidence or settlement under the weight of the stack of piles. The piles shall be supported at locations shown on the Drawings or as approval by the Engineer. The support positions may be the same as lifting positions unless otherwise specified. They shall be placed on timber supports, which are truly level and spaced, so as to avoid undue bending. The supports shall be vertically one above the other. Spaces shall be left round the piles to enable them to be lifted without difficulty. The order of stacking shall be such that the older piles can be withdrawn for driving without disturbing newer piles. Separate stacks shall be provided for different lengths of piles. Whenever curing is needed during storage, arrangements shall be made to enable the piles to be kept moist.

(c) Steel Piles

(i) Protection

Where corrosion protection is necessary the number of coats and type of protective treatment shall be as specified in the special provisions.

(ii) Storing and Handling

The method of storing and handling shall be such that bending about the weak axis is avoided.

(d) Timber Piles

Storing and handling of timber piles shall be such as to prevent injury to the piles. Special care shall be taken to prevent breaking the surface on treated piles by cant-hooks, dogs, or pike-poles. Any cuts or breaks which may result from the use of chains shall be treated with preservative of approved quality and preservative shall be poured into all bolt holes.

1004.4 Construction requirements of driven piles

(a) Preparation for driving

The method of installing the piles, including details of the equipment shall be submitted by the Contractor to the Engineer and approved by the Engineer, prior to the commencement of such work.

(i) Caps for pile heads

The heads of all concrete piles, and the heads of timber piles, when the nature of the driving is such as to unduly injure them shall be protected by caps of approved design having a suitable cushion next to the pile head and fitting into a casting, which in turn supports a timber shock block. Pile head shall be so held that the slight rotation which normally occurs while driving is not prevented. When the area of the head of any timber pile is greater than that of the face of the hammer, a suitable cap shall be provided to distribute the blow of the hammer throughout the Cross-section of the pile and thus prevent, as far as possible, the tendency to split or shatter the pile.

(ii) Collars for timber piles

Mild steel or wrought iron collars or other devices to protect timber piles against splitting shall be provided when required by the Engineer.

(iii) Pointing of timber piles

Timber piles shall always be pointed unless otherwise required by the Engineer. In addition when deemed necessary by the Engineer piles shall be shod with metal shoes of a suitable design.

(iv) Splicing piles

Full length piles shall be used where practicable. Where extensions are deemed necessary, the method of splicing shall be as shown on the Drawings or as approved by the Engineer. The splice shall develop the full strength of the pile section including those of tension, compression and bending.

(b) Handling, pitching and driving

(i) General

The main setting out for the piles shall be completed prior to commencement of piling and the setting out points, lines, stations and the like shall be maintained safe and undisturbed. Unless otherwise stated in the Contract documents all piles shall be driven from the tentative pile cut off level. Piles may be driven from a different level subject to be Engineer's approval. For piles within a marine environment, the driving level shall be agreed with the Engineer. Piles shall be pitched accurately in the positions and driven to the lines shown on the Drawings or fixed by the Engineer. Piles deflected from the vertical or proper line shall where ordered by the Engineer, be withdrawn and re-pitched until the proper line is obtained. No lateral force shall be used to correct the position or line of any pile.

Any pile damaged by reason of improper driving or driven out of its proper location or driven below the elevation fixed by the Drawing or by the Engineer, shall

be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question: -

- The pile shall be withdrawn and replaced by a new and if necessary longer pile. Any holes from which piles are withdrawn shall be packed with approved non-plastic material before re-driving takes places.

- A second pile shall be driven adjacent to the defective pile or pile driven below the expected level.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

Batter piles shall be driven accurately to the batter shown on the Drawings. The pile frame employed for the driving of the batter piles shall have leads capable of adjustment to the required angle. When piles have to be driven below the level of the bottom of the leads, extension leads shall be fitted. The use of a follower shall not be permitted except with the approval of the Engineer. For piles to be driven to set, the follower shall be calibrated against a pile driven to set without a follower.

(ii) Pilot Piles

The lengths of the piles shown on the Drawings are based on information which it has been possible to obtain from a site investigation prior to the driving of pilot piles.

Before pile lengths are finally determined the Contractor shall construct to the lengths shown on the Drawings such pilot piles as may be found necessary and these piles shall be driven in the positions specified by the Engineer, who shall be notified in advance of the driving. The Contractor shall furnish the Engineer daily with a detailed record of the driving of pilot piles throughout the full depth of driving. After attaining the approved set driving shall be continued until the Engineer directs that it shall cease. Driving of pilot piles beyond the point at which the approved set is obtained will be called for to demonstrate that driving resistance continues to increase. The Contractor shall then furnish the remainder of the piles in the structure. In determining the lengths of piles the Contractor shall base his list on the lengths assumed to remain in the completed structures with due allowance for subsurface strata variability. The Contractor at his own expense can increase the lengths to provide for fresh heading and for such lengths as may be necessary to suit his method of operation.

(iii) Pile Load Tests

Unless otherwise decided by the Engineer or stated in the Contract document pile load tests shall be undertaken to establish and or to confirm the pile safe working load as shown on the Drawings or the Contract documents. Such tests shall be referred to as preliminary pile load test. Preliminary piles shall not be normally incorporated in the Permanent Works. Load tests may also be undertaken on piles which are intended to be incorporated in the Permanent Works. Such tests are referred to as proof load tests. When indicated in the Drawings or specified in Contract documents that the piles are to be test loaded the Contractor shall submit to the Engineer for approval detailed Drawings of the loading apparatus he intends to use. The apparatus shall be so constructed as to allow the various increments of the load to be placed gradually without any shock loading to the piles. If the approved method requires the use of tension piles such tension piles shall be of the same type and size as the permanent piles and shall be driven in the location of permanent piles.

Loads for the load test on concrete piles shall not be applied until the concrete has attained a minimum compressive strength equal to the specified 28 days compressive strength in accordance with test methods described in Section 1001.

Suitable approved apparatus for determining accurately the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor. The apparatus shall have a working capacity of three times the tentative safe working load for a preliminary pile test or two times the safe working load for a proof load test. Reference points for measuring pile settlement shall be sufficiently removed from the test pile to preclude all possibility of disturbance. All pile load settlements shall be measured by adequate devices, such as gauges and shall be checked by means of an Engineer's level. Increments of deflection shall be read just after each load increment is applied and at 15 minute intervals thereafter. The safe working load shall be considered as 50 percent of the load which, after 48 hours of continuous application, has caused not more than 6.5mm of permanent settlement, measured at the top of the pile for piles 350mm or less in diameter or the diagonal width. For piles of larger diameter and or diagonal widths, the corresponding permanent settlement in mm shall be equal to 3.8 + 0.008 times the pile diameter/diagonal width in mm. The test load shall be twice the safe working load shown on the Drawings for preliminary pile load test and one and a half times the design load shown on the Drawings for a proof load test. The test loads shall be applied in 2 cycles. The first cycle of load to be applied to the test pile shall be the pile safe working load in 4 increments. The load shall then be removed. The second cycle shall then commence. The load on the pile shall be increased to the test load in 8 equal increments. A minimum period of 2 hours shall intervene between the applications of each increment except that no increment shall be added until a settlement of less than 0.25mm is observed for a 1 hour period under the previously applied increment. If there is a question as to whether the test pile will support the test load, the load increments shall be reduced by 50 percent, at the direction of the Engineer, in order that a more closely controlled failure curve may be plotted. The full test load shall remain in the test pile not less than 48 hours. The full test load shall then be removed and the permanent settlement read, the double design load in 10 metric tonne increments until the pile fails or the capacity of the loading apparatus is reached, whichever is the lesser. The pile may be considered to have failed when the total settlement under load exceeds 10% of the pile diameter or diagonal width or the permanent settlement exceeds 6.5mm for piles 350mm or less in diameter or the diagonal width. For larger piles the corresponding permanent settlement limit in mm shall be proportionally increased.

After the completion of the loading tests, the load used shall be removed from the site at the Contractor's expense and the piles, including tension piles, shall be utilized in the structure if found by the Engineer to be satisfactory for such use. Test piles not loaded shall be utilized similarly. If any pile, after serving its purpose as a test or tension pile, is found unsatisfactory for utilization in the structure it shall be removed, if so ordered by the Engineer, or shall be cut off below the ground line and footings.

When the safe working load of any pile is found by test to be less than the design load, piles longer than specified in the Drawing or additional piles shall be driven as ordered in writing by the Engineer.

The arrangement/layout for the above load tests shall be as based on ASTM D 1143. Subject to the Engineer's approval the above tests shall be undertaken by the quick test method in ASTM D 1143.

(iv) Driving Equipment

Before any piling work is commenced the Contractor shall submit to the Engineer for approval full details of the pile driving equipment including pile hammer(s), hammer cushion, pile helmets, driving caps etc. and the method he intends to use for carrying out the work and shall obtain the approval of the Engineer. The Contractor shall ensure that the piling equipment and method he proposes to use is capable of driving the piles to the load capacities shown on the Drawings or other Contract documents without damage or overstressing the pile material.

Piles shall be driven with air, diesel hammers, and a combination of hammers with water jets or gravity hammers. When diesel hammers are used, they shall be calibrated by load tests, if necessary.

The plant and equipment furnished for air hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer.

When gravity hammers are used for driving concrete piles, the drop of the hammer shall not exceed 1.2 metres and the hammer shall have a weight of not less than half the weight of the pile. The fall shall be regulated so as to prevent injury to the pile. For timber piles the height of fall shall not exceed 1.5 metres.

(v) Driving

Piles shall be supported in line and position with leads while being driven. Pile driver leads shall be constructed so as to afford freedom of movement of the hammer, and they shall be held firmly in position to ensure rigid lateral support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length to avoid use of a follower and shall be so designed as to permit proper aligning of batter piles. Piles may be driven using a pile follower subject to the Engineer's approval. In such instances the first and every tenth pile shall be driven without using a follower. The follower shall be calibrated for set against the piles driven without the follower.

Where necessary water jets shall be used. Before the required penetration is reached, the jets shall be shut off and the piles shall be driven by hammer to final penetration.

(vi) Specified Set

Piles shall be driven to the specified set shown on the Drawings or as established by a load test in accordance with the Contract documents.

(vii) Cut off and extension

Timber piles which are to be capped shall be accurately cut off so that proper seating is obtained on every pile without the use of shims. Other timber piles shall be cut off square at the elevation specified.

Concrete piles shall be cut off at an elevation so that they will extend into the cap or footing as indicated in the Drawings. Reinforced concrete piles shall be cast to the full length of the reinforcing bars, as specified and the concrete to the extent necessary shall be cut off to expose the steel as shown in the Drawings to provide necessary connection.

(viii) Extensions of RC piles

When it is necessary, after driving, to increase the length of pre-cast reinforced concrete piles, concrete shall be removed to expose sufficient reinforcing steel to permit the required lap. To obviate the need for lapping reinforcing steel butt welding of reinforcing bars will be permitted on the written approval of the Engineer. Only approved and certified welders shall be used for such works Details of the weld, welding procedure, welding consumables and welder certifications shall be submitted to Engineer for approval prior to undertaking the welds on site. Before welding is permitted the Engineer may require the Contractor to submit sample lengths of welded reinforcement for testing. When welding is permitted welds shall be staggered. The pile shall be extended using concrete of specified grade in properly formed and supported moulds to the length required. Mechanical joints may be used with the approval of the Engineer. Where these are used the Engineer may require the Contractor to submit designs and test certifications to support the strength and effectiveness of the joint both vertically and laterally. Care shall be taken to ensure that the alignment of the extended pile across the joint is maintained.

The extra length of pile shall be sufficient to reach the cut-off level including embedment into cap and shall be of the same section and contain the reinforcement as same as in the pile itself or as shown in the Drawings. After piles have been lengthened driving shall not be resumed until the approval of the Engineer has been given. Driving the piles so extended shall not be commenced till the concrete has attained the required 28 day compression strength.

1004.5 Construction requirements of cast in-situ piles (bored piles)

General

This work shall consist of drilling holes; furnishing, installing and removing temporary casing; furnishing and installing reinforcing steel cage; placing concrete; and all other things necessary for installing cast in place concrete bored piles in accordance with these Specifications and with the Drawings and the direction of the Engineer. Where required and as stated on the Drawings and or in the Contract documents, furnishing and installing permanent casing shall be included in this work.

The Contractor shall submit to the Engineer for approval, complete details of the construction methods, which he proposes to use, including a Specification of the materials, testing during construction and all equipment. Prior approval of the Engineer shall be obtained in writing before any piling work is commenced.

A complete record of the construction of each pile shall be kept by the Contractor and these records shall be submitted to the Engineer for inspection when required and shall be approved finally by the Engineer.

The Contractor shall fill the form of piling record being provided commonly by the Engineer, according to the Engineer's requirement. If the Engineer shall require the Contractor to draw up a form of piling record by him, the said form shall be approved by the Engineer.

(a) Boring

In stable soils a casing may be omitted during excavation if agreed by the Engineer. In soils liable to flow into the borehole, a temporary casing shall be used. The bottom of the casing shall be kept sufficiently below the bored depth to prevent

inflow of soil and the subsequent formation of cavities in the surrounding ground. The casings shall be water-tight steel tubes, and the joints in the tubes shall be reasonably water-tight. The metal casing shall be of sufficient thickness and strength to hold its original form and show no harmful distortion after it and adjacent casings have been driven and the driving core, if any has been withdrawn. The inflow of soil and groundwater from the bottom may be controlled by the use of a head of water with the Engineer's approval. The water level inside the casing shall be maintained, a minimum 1.5m to 2.0m above the natural groundwater level. Alternatively, drilling mud, such as bentonite suspension may be used instead of the water. In this case the casing will only be required close to the top when concreting. The relevant Specifications for the drilling mud or slurry shall be as stated in Table 1004-1 and approved by the Engineer prior to its adoption.

Table 1004 -1 - Requirements for Slurry Property Targets

Boring Method	Geological Formation	Slurry Property Targets						
		Relative Density	Viscosity (Secs.)	Static Shear (Pa)	Sand Content Rate (%)	Colloidal Rate (%)	Water Loss Rate (ml/30min)	P_H Value
Positively Circulating Boring Percussion Boring	Clayey Soil	1.05-1.20	16-20	1.0-2.5	<8-4	>90-95	<25	9.5-12
	Sandy Soil, Broken, Stone Soil, Pebble, Boulder	1.10-1.25	19-28	3-5	<8-4	>90-95	<15	9.5-12
Rolling-Push Boring Percussion Grab Boring	Clayey Soil	1.10-1.20	18-24	1.0-2.5	<4	>95	<30	9.5-12
	Sandy Soil, Broken Stone Soil	1.10-1.25	22-30	3-5	<4	>95	<20	9.5-12
Reversibly Circulating Boring	Clay Soil	1.02-1.06	16-20	1.0-2.5	<4	>95	<20	9.5-12
	Sandy Soil	1.06-1.10	19-28	1.0-2.5	<4	>95	<20	
	Broken Stone Soil	1.10-1.15	20-35	1.0-2.25	<4	<95	<20	
Test Method	Not Applicable	Mud density balance	Marsh Cone	Shearo Meter	Sand Screen Set		Fluid loss test	P_H indicator/ paper strips

The frequency of testing the slurry at the very least shall be carried out at the time of mixing the slurry, prior to commencing the daily boring operations and fresh pile bore, during boring, depending on the depth of bore more than once during boring, on completion of boring/cleaning, prior to rebar cage installation, prior to placing concrete and at another fresh pile bare. The slurry samples during boring shall be taken from the pile toe.

Bells or under reams where specified shall be excavated from virgin material and be free from loose crumbs of soil.

The excavation of the bell or under reams shall be carried out immediately prior to concreting. When construction of enlarged Bases involves men going down holes the safety precautions shall be as specified in Contract documents.

Maximum tolerance in positioning the head of the pile shall be100mm. Maximum variation of shaft from vertical shall be 1 in 75.

Unless otherwise stated on the Drawings or specified in the Contract, piles shall be socketed to a minimum of 500 mm into hard bed rock surface if the bed rock is not very steep. Where the rock is steeply sloping, the rock rocket shall be of such a length that the entire Cross-section for the pile is end bearing on hard rock unless otherwise stated on the Drawings or in the Contract.

(b) Cleaning of bore holes

(i) When the boreholes have reached the depth specified on the Drawings, and the quality of the boreholes has met the requirements specified on the Drawings or requirements of the Engineer, cleaning of boreholes shall be carried out promptly. During the cleaning operation, the water level in the bored shaft shall remain 1.5m to 2m above the groundwater table or the water level of river to prevent any falling-in of the borehole.

(ii) The pile toe shall be free of sediment, unless the Drawings show that the piles are fully frictional in which case sediment depth shall not exceed 100mm. For all other piles, the Contractor in his method - statement shall include a method of measuring the sedimentation. The depth of the sediment so established shall be such that it is displaced during the placing of concrete. This depth shall not exceed 40mm in any event.

(iii) Bentonite slurry after cleaning of boreholes shall have the following properties: relative density = 1.05 to 1.2 (as per test method of Founn Viscometer with the sample screened by 0.300 μm sieve); viscosity = 17 to 20; P_H 9.5-12; sand content <4%.

(c) Reinforcement Cage

The cage of all pile reinforcing steel shall be placed in the excavation in one unit immediately prior to concrete placement. If concrete placement does not follow immediately after cage placement, the steel shall be removed from the excavation. Then the integrity of the boring, including the presence of loose material in the bottom of the hole, shall be checked and remedial action taken prior to reinstallation of the cage. The cage of reinforcing steel shall have stiff bracing to prevent distortion during moving and positioning. The reinforcement cage shall be supported from the top by a support system as stated below, so as to prevent the cage from lifting up. The support system shall be concentric to prevent bending and displacement of the cage, with the cage equipped with concrete spacer blocks (provided for keeping a clearance between reinforcement cage and the sides of the boring). These spacers shall be securely tied at equal distances and distributed around the cage perimeter and shall be spaced at intervals not to exceed twice the pile diameter along the length of the pile unless otherwise shown on the Drawings or as directed by the Engineer. The cage bottom shall have an elevation of 300mm with tolerances of 50mm.

(d) Concreting

(i) Before placing concrete, the thickness of sediment shall be inspected. If it does not conform to the requirements of cleaning of boreholes and specified in Sub section 2.06 the bored shaft shall be re-cleaned.

(ii) When concrete mix is supplied to the placing site, uniformity and slump of concrete shall be checked. If it does not conform to the requirements as specified in Table 1001-2 or 1001-3, the remixing of concrete shall be made and checked again for conformance to the requirements. If it does not, the concrete shall be rejected.

(iii) Concrete placing shall commence immediately after Engineer's approval of the bore shaft and bottom, installation of the reinforcement cage and setting up the tremie/hopper. Concrete placing shall continue without interruption to complete the cast in-situ piles.

(iv) Concrete shall be placed by means of suitable tubes or tremie and hopper arrangement. The tremie shall consist of a tube having a diameter of not less than 250mm, constructed in sections having flanged couplings fitted with gaskets or screw joints. The tremies shall be tested to be water tight and joint strength in tension. At the commencement of concreting, the bottom of the tremie shall be placed between *50~100*mm from the bottom of the borehole. The quantity of first lot concrete shall be such that it is sufficient to meet the requirement of initially submerged depth(> 1.0m) for the tremie and the requirement for filling tremie bottom voids. A float/ plug shall be placed in the tremie over the support fluid or water. Concrete shall be discharged slowly onto the plug causing it to move very slowly to the bottom and fill the tremie length. The lower outlet of tremie shall at all times be kept submerged 2m *in concrete* to prevent water and grout from surging into the tube but not greater than 6m in previously deposited concrete. The location of outlet of the tremie tube relative to the surface of deposited concrete shall be kept under close surveillance at all times, and the tube shall be filed in such a way that no water is trapped in the tube. If the concrete is pumped, the pumping pipe shall be equipped with a bottom valve or other device to prevent mixing of water with the concrete in the pipe. The pumping pipe shall be withdrawn slowly as the concrete in the piles rises, but the end shall, at all times, be a minimum of 2 meters below the surface of the concrete. Concrete, delivery to the pile shall proceed in one continuous operation. Prior to initial set, any contaminated concrete shall be cleaned from the top of the pile at the pile cut off level. Records shall be maintained of the full concrete placing. Such records shall include volume of each batch of concrete, times of arrival of concrete trucks and concrete discharge, slump test measurements, depth soundings to top of concrete in the bore and tremie for each batch of concrete placed. The recorded data shall be such that it is sufficient to be able to develop an accurate assessment of bore size for each batch of concrete placed.

(v) On depositing concrete, the overflowing slurry shall be led to a suitable place to be treated to check the ground pollution, river channel and traffic blocking.

(vi) The temporary casing below the ground surface or the pile top shall be withdrawn immediately after concrete placing subject to maintaining a 1.5m-2.0m difference between the support fluid / water within the pile bore and the ground water level / river water level. The removable casing part over ground surface can only be removed after the newly placed concrete reaches 5 MPa in compressive strength. When concrete is placed with the casing throughout the whole pile length, the removal of casing shall be carried out by successively withdrawing it, with the casing bottom remaining 1m to 2m below the surface of newly deposited concrete.

(vii) The Contractor shall continue concreting until the surface of deposited concrete shall have a proper height above the theoretical cut-off level to ensure that all concrete below cut-off level is of a satisfactory quality. Such heights shall be 1.4m minimum and up to 2.2m when pile cut-off level is up to 10m below ground level.

(viii) If the process of concreting deviates from the correct procedure, it shall be remedied in time, as directed by the Engineer.

When concrete can be placed in a dry excavation, it shall be discharged through a funnel with a length of tube so that the flow is directed and does not hit reinforcement bars or the side of the hole. No vibration is required but attention shall be paid to the compaction of the top 1.5m or so of the pile. Where temporary casing is used the casing shall not be withdrawn before a sufficient head of concrete has been cast which can balance the groundwater pressure outside.

When concreting is carried out under water or in drilling mud, an efficient tremie technique shall be used as described in section 1001. The pile shall be concreted wholly by tremie and the method of disposition shall not be changed as the pile is concreted.

The head of the pile shall be cut clean of all laitance.

Care shall be taken during concreting to prevent as far as possible the segregation of the ingredients. The displacement or distortion of reinforcement during concreting and also while extracting the tube shall be avoided.

The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water or other extraneous matter. Special care shall be taken in silty clays and other soils with the tendency to squeeze into the newly deposited concrete and cause necking. The placing of concrete shall be a continuous process from the toe level to the top of the pile. The rate of placing of concrete in the pile shaft shall be sufficient to ensure self compaction. Also for bored holes, the finishing of the bore, cleaning of the bore, lowering of the reinforcement cage and concreting of the pile for full height shall be accomplished in one continuous operation without any stoppage.

Bored cast in-situ piles in soils which are stable, may often be installed with only a small casing length at the top. A minimum of 2.0 m length of top of bore shall invariable be provided with casing to ensure against loose soil falling into the bore. In cases, where the bored hole penetrates through large depths of peaty or any collapsible soil the length of this steel casing shall be of sufficient length to ensure against side collapse. The casing may be left in position permanently especially in cases where the aggressive action of the ground water is to be avoided or in the cases of piles built in water or in cases where significant length of piles could be exposed due to scour.

(e) Testing of cast in-situ piles

(i) Where required in the Contract or as the Engineer directs, load tests shall be undertaken by the Contractor on the selected piles and the method of testing shall be approved by the Engineer. The test load shall be twice or one and a half times the working load on any pile depending on the type and purpose of the test unless otherwise specified. Where piles fail to satisfy the test the Contractor shall take remedial measures in accordance with the Contract or as directed by the Engineer.

(ii) Where required by the Contract or as directed by the Engineer, the Contractor shall undertake Pile Integrity Testing for the piles by way of employing a specialist. Details of the specialist including qualifications, past experience etc. shall be submitted for approval by the Engineer prior to undertaking the test.

1004.6 Pile Records

A detailed and accurate record of driving and or bore pile construction of all piles shall be kept by the Contractor and a copy of the record of the work done each day shall be given to the Engineer within 24 hours, which shall include the details such as, date of driving, details of piles equipment, particulars of pre-casting identification level of the ground at the commencement of operations, details of any circumstances previously notified to the Engineer or occurring during driving / boring and any other information required by the Engineer.

In the case of pre-cast piles, the following also shall be recorded. The dimensions, depth driven, sequence of driving in groups, final set for the number of blows specified, type and weight of hammer used, type and condition of the packing on the pile head and the dolly in the helmet, for a single acting hammer-the final drop, for a double acting hammer-the final frequency of blows, details of any interruption in driving and details of re-driving. In the case of cast in-situ piles the following also to be recorded. The nominal diameter, length of finished pile excluding any enlarged Base, time interval between boring or driving and concreting of any pile not completed in the working day, volume of concrete placed in the pile and enlarged Base, diameter of any under-ream, details of strata penetrated.

In addition to submitting the records the Contractor shall report immediately to the Engineer any circumstances which indicate that the ground conditions differ from those expected from the interpretation of the soil survey.

1004.6/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1004.7 Measurement and Payment

(a) Measurement

The measurement for all types of driven piles shall be:-

(i) Metres of piles supplied, measured from the tip to the cut-off.

(ii) Metres of piles driven, measured from tip to surface of ground, or river-bottom from where the driving of the pile has started.

When concrete piles are extended, the length of the extension from the top of the extensions to the cut off will be considered as pile furnished and will be added to the original length for measurement.

Cast in-situ piles shall be measured in metres from tip to cut-off.

Cut-off lengths shall not be measured for payment. Load tests shall be measured by number completed.

(b) Payment

The payment for the supply and/or installing of piles, by driving except through boulders or soft rock or by casting in-situ, will be at the Contract unit rate for the particular item. The rate shall include, as applicable, full compensation for supplying and placing of all materials including reinforcement and shoes; for cutting, lengthening, splicing, welding and coupling of piles or pile components; for providing rigs, cranes, hammers etc., for driving and boring; and for providing all labour transport, machinery, equipment, tools and other incidentals necessary to complete the work to these Specifications.

When boulders or weathered rock are encountered with in cast in-situ piles are encountered additional payment could be made through provisional sums.

The rate shall also include full compensation for driving of casings in the case of bored piles and in the case of pre-cast piles, stacking them at site.
The pay items and pay units will be as follows.

Pay Items and Pay Units shall be as follows;

Pay Item	Description	Pay Unit
1004(1)	Pre-cast piles, supplied and stacked (State type and size)	Linear metres
1004(2)	Pre-cast piles driven (state type and size)	Linear metres
1004(3)	Cast in-situ piles installed in soil (state size)	Linear metres
1004(4)	Cast in-situ piles installed through boulders	Provisional Sum
1004(5)	Cast in-situ piles installed through weathered rock	Provisional Sum
1004(6)	Load tests on piles (State type and load)	Number

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

1005 WELL FOUNDATIONS FOR STRUCTURES

1005.1 Description

This work shall consist of the construction of reinforced or un-reinforced cement concrete wells, pre-cast or cast-in-situ, sinking in stages to the indicated levels by open dredging of the soil and other materials, plugging the bottom, filling the inside and sealing the top in accordance with these Specifications and with the details shown in the Drawings or as directed by the Engineer.

1005.2 Materials

Materials used shall meet the requirements of the following, unless otherwise specified.

(a) Concrete, for casting and plugging of the wells, shall be of class A or B to Section 1001.

(b) Steel reinforcements to SLS 375 or CS 26.

(c) Formwork used shall be of steel or any other material approved by the Engineer conforming to Section 1008.

(d) Material for kentledge, used in sinking of the wells shall be as approved.

1005.3 Construction Requirements

(a) Cutting Edges (kerbs)

Cutting edges or kerbs shall be pre-cast or cast in-situ to the shapes and sizes as specified in the Drawings. They may also be pre-cast in sections, assembled and completed at site, as directed by the Engineer.

The cutting edge shall be positioned at the exact location shown in the Drawings.

When the cutting edge is to be laid on dry beds, the bed shall be excavated to a depth decided by the Engineer before placing or casting the cutting edge.

For wells, which are to be pitched in water, a temporary earth or sand island, where so decided by the Engineer, shall first be constructed and the cutting edge placed or cast on the island so formed. Alternatively they may be pre-cast, floated and lowered in its final position with the help of suitable equipment.

All in-situ concreting in cutting edges shall be done in one operation.

(b) Steining

Well steining shall be built to dimensions shown in Drawings, using pre-cast concrete units or by casting in-situ in concrete as specified. The concrete used shall be of class A or B conforming to the requirements of section 1001 and shall be either reinforced or un-reinforced.

The stages of steining shall be as previously determined and, as far as practicable; the laps of vertical steining bars shall not coincide with the joints of the separate stages of concreting. The outer surface of the well at the joint shall be finished smooth. Where well steining is built using pre-cast units the joint shall be constructed to the requirements specified in the Drawings.

The height of the steining shall be determined by marks made clearly on four points equally distributed on the outer periphery of the well. The marking shall commence with zero at the bottom of the cutting edge.

(c) Sinking

Sinking of well sections shall commence after allowing concrete in steining to reach minimum strength as required, but only after the concrete has been cured for at least 48 hours. The well shall be sunk, true to vertical, through the varying strata of soils encountered.

They shall be sunk to the depths and levels shown in the Drawings or as directed by the Engineer. The maximum height of the well steining cast at one time shall be 1.2 m.

Sinking shall be done by excavating materials uniformly from the inside of the well. Excavation may be carried out after dewatering or by under water grabbing, as directed by the Engineer.

Water jetting or any other approved method may be used to assist in the sinking with the consent of the Engineer.

Blasting, as a means to penetrate layers of boulders and the like shall be allowed only with the written permission of the Engineer.

Sinking of wells may be allowed to take place under their self-weight. Where necessary, kentledges may be used to assist in the sinking. Kentledges shall be placed in an orderly and safe manner, without causing any unfavourable loading or damage to the steining. However, they shall be placed only after the concrete has been cured for at least 48 hours.

Dewatering of the well shall not be used as a means for sinking the well, without the written permission of the Engineer.

When the clear distance between the wells is less than 1.0m, or the least dimension of the well, or half the diameter in case of cylinders, sinking shall be carried out simultaneously unless otherwise approved by the Engineer.

All necessary precautions shall be taken against any possible damage to the foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

Where the wells are to be seated on hard rock strata the cutting edge shall be taken to a suitable depth in the rock strata. If the rock profile is sloping it shall be suitably benched.

Unless otherwise specified the tilt of any well shall not exceed 1 in 80 and the shift shall not be more than 5 percent of the maximum outside dimension of the well subject to a maximum of 150mm.

(d) Bottom Plugging, Filling and Top Plugging

Before commencing plugging operations, the bottom of the well shall be cleaned by removing all loose material.

Bells and under-reams, where specified in the Drawings, shall be excavated for as required and the excavated area made free of all loose material. Where wells are to be seated on hard rock the surface of the rock strata shall be suitably dressed to obtain proper seating and the dowels, where specified, shall be fixed in accordance with the Drawings or as directed.

Concreting of bottom plug shall not be commenced without the approval of the Engineer. If bottom plugging is done underwater the formation of soft layer at the top of the bottom plug shall be removed after 07 days.

Concrete shall be laid by skip bucket, tremie pipe or by any other method approved by the Engineer. However it shall be ensured that segregation of concrete is effectively prevented.

Dewatering of wells, for purposes of inspection of the bottom plug and also for hearting the wells, shall be carried out only after 7 days of concreting the bottom plug. Prior to hearting it shall be ensured that the bottom plug is properly sealed.

Hearting of the well and concreting of the top plug shall be as specified in the Drawings. Hearting of well shall be carried out using saturated sand with a specified grading.

(e) Test Load

Where test loading is specified or found necessary by the Engineer, the Contractor shall carry out such test loading, on any one or more of the selected wells in an approved manner and to the loading specified.

1005.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1005.4 Measurement and Payment

(a) Measurement

The measurement for cutting edge (or the kerb) shall be in numbers furnished or cast in position.

The well steining concrete shall be measured in Cu.m and steel if used in, these shall be measured as giving in Section 1002.

The measurements for well sinking shall be made in running metres for different ranges of depth as specified. The depth of sinking shall be measured from the level of placing to the final level of the cutting edge.

Excavation in rock shall be measured in Cu.m and any dowels used shall be measured by the number.

The quantity of bottom and top plugging concrete and sand filling and situation, if any, shall be measured in Cu.m..

The steel if used in well steining and in the bottom and top plugs shall be measures in Tonnes.

(b) Payment

The rate for cutting edge shall be for furnishing and placing in position or casting in position or furnishing and assembling pre-cast sections of the cutting edge and completing in position.

The rate for concrete used in reinforced or un-reinforced construction in steining, as specified, shall include all works as given in Section 1001 and formwork as given in Section 1008.

The rate for sinking shall include the cost of all labour, tools and plant and other operations required such as dewatering, excavation and bailing out material, providing and placing kentledges on top of the well and removing same and also other incidental works to sink the well to the level shown in the Drawings or as instructed by the Engineer. It shall also include blasting, or use of divers for removal of obstacles from under the cutting edge of the well. The rate shall be applicable for all types of soils except rock. Excavation in rock shall include all cost of labour tools and equipment required to excavate and for bailing out of the material.

The rate for doweling shall include for drilling and concreting into position and the rate for concrete plugging and sand filling shall include cost of all labour, materials tools and plant required to complete the work and dewatering.

The rate for reinforcement shall include all work as described in Section 1002.

Island formation shall be paid for separately under a Provisional Sum.

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
1005(1)	Formation of island (State number of cylinders and location)	Provisional Sum
1005(2)	Cutting edge in concrete (state class and diameter)	Number
1005(3)	Casting of well steining inclusive of mould/formwork (State size of well and class and grade of concrete)	Cu.m
1005(4)	Steel reinforcement in well steining (State type and grade)	Tonnes
1005(5)	Sink well (state size of well and depth ranges in 10.0m intervals)	Linear metres
1005(6)	Rock excavation	Cu.m
1005(7)	Hot rolled mild steel dowels (State diameter and length)	Number
1005(8)	Steel reinforcement in bottom plug (State type and grade)	Tonne

1005(8/1)	Steel reinforcement in top plug (State type and grade)	Tonne
1005(9)	Concrete in bottom plug (State class and grade of concrete)	Cu.m
1005(10)	Concrete in top plug (state class and grade of concrete)	Cu.m
1005(11)	Sand filling and saturation with water	Cu.m

Note
Refer Sub section 106.6 regarding sub divisions of pay items

1006 RANDOM RUBBLE MASONRY

1006.1 Description

This work shall consist of construction, in Random Rubble (RR) Masonry, of walls, drains and other structures. Work shall be carried out in accordance with these Specifications and with the lines and dimensions shown in the Drawings, or as directed by the Engineer.

1006.2 Materials

Stones used in Random Rubble Masonry shall be obtained from approved quarries, and be approved by the Engineer. They shall be hard, durable, fresh rock free from fractures and other imperfections, and shall generally be of maximum dimension not exceeding 450mm.

Through stones shall be specially made approximately to square Cross-section, 150 x 150mm minimum dimensions, and of minimum length 600mm or the thickness of the wall whichever is less. They may be pre-cast concrete units, if so specified.

Cement mortar used shall conform to requirements of Sub section 1703.2 of the Specifications.

1006.3 Construction Requirements

(a) Random rubble masonry using cement mortar

All stones, chips and spalls used shall have clean surfaces to facilitate adherence of mortar to them and shall be wetted before laying. Every stone shall be set flush in cement mortar of 1:5 or any other approved mix proportions, and there shall be no dry work or hollow spaces left. Smaller stones shall be used to roughly fit the spaces between the larger stones and chips and spalls shall be wedged in where necessary to prevent thick beds of mortar. The stones in each course shall overlay the joints in the preceding course as far as practicable.

A sufficient number of through stones shall be used in building walls. At least one through stone shall be built into walls at intervals of 2m horizontally and 600mm vertically. They shall run through the full thickness of the walls which are up to 600mm in thickness. In case of walls exceeding 600mm in nominal thickness, more

than one through stone shall be used to run through the full thickness of the wall. In such cases the overlaps shall not be less than 150mm.

Where the faces of walls are to be plastered, their mortar joints shall be raked to depths of 12 to 20mm to form a key and the plastering shall be done using cement mortar of specified proportions and to the specified thicknesses. The faces which are not to be plastered shall be provided with struck off mortar joints unless otherwise specified. In the latter case selected stones shall be used with straight edges as far as practicable, to provide close fitting mortar joints of uniform width not exceeding 20mm. The bushings of the stones shall not project more than 25mm from the plane of the joints.

Where pointing of joints is specified it shall be carried out as given in the Drawings or as directed.

Vertical construction joints in walls shall be avoided and at horizontal or sloping construction joints the mortar in the last course at the joint shall be omitted, for at least half the nominal thickness, to be later placed with the succeeding course of masonry.

When placing rubble masonry on or against construction joints all laitance shall be removed from exposed hardened mortar surfaces; and feather edges and hardened mortar shall be removed from exposed stone surfaces.

Where rubble masonry is placed against a fill or excavation, surface irregularities in such surfaces shall be filled with stone chips, spalls or other free draining materials. Drains and formed weep holes shall be constructed as shown in the Drawings or as directed by the Engineer.

All rubble masonry work shall be maintained in constantly wet condition for a period of at least 3 days commencing from the time of final setting of the cement.

(b) Dry Random Rubble Masonry

Larger stones shall be set in such a manner that they are interlocked with adjacent stones and spalls and chips shall be wedged in to the resulting hollow spaces using a hammer where necessary. Bushings of the stones shall not project more than 25mm from the face of the walls. The stones in each course shall overlay the joints in the preceding course as far as practicable. The faces of the wall shall be constructed with stones having straight edges to provide close fitting edges. Through stones where specified shall be used as indicated in Sub section 1006.3(a).

1006.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1006.4 Measurement and Payment

(a) **Measurement**

Dry RR Masonry shall be measured in Cu.m of completed and accepted work.

RR masonry using cement mortar and Dry RR masonry shall be measured separately in Cu.m of completed and accepted work.

Work of plastering and pointing shall be measured in Sq.m of completed and accepted work.

(b) Payment

The unit rate of payment for each item of work shall be full compensation for all materials, labour, tools and incidentals necessary to complete the work.

No separate payment will be made for necessary trimming of local voids in the excavated or filled surface against which rubble masonry is placed.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1006(1)	RR Masonry using cement mortar	Cu.m
1006(2)	Dry RR Masonry	Cu.m
1006(3)	Plastering	Sq.m
1006(4)	Pointing	Sq.m

1007 BRICK WORK AND BLOCK WORK FOR STRUCTURES

1007.1 Description

This work consists of brick work and block work in the construction of walls, drains and other structures, using burnt clay bricks cement sand bricks, cement sand blocks or cement concrete blocks in accordance with these Specifications and with the details shown on the Drawings or as approved by the Engineer.

1007.2 Materials

Materials used shall meet the requirements of the following unless otherwise specified.

(a) Burnt clay bricks to SLS 39

(b) Cement-sand bricks and blocks and cement concrete blocks shall be of the size and strength and of mix proportions specified in the Contract and shall be of approved manufacture.

(c) Cement mortar to Sub section 1703.2.

1007.3 Construction Requirements

(a) Laying of Bricks & Blocks

Bricks or blocks shall be laid to the specified bond on a full bed of mortar and frogged bricks or blocks, if any, shall be laid with the frogs upwards. Hollow blocks may be laid with the hollows downwards, if so directed.

Each brick or block shall be properly bedded and set in position by gently tapping with the handle of the trowel or a wooden mallet. Whole bricks or blocks shall be used in the courses except where parts of bricks or blocks are necessary for closers.

All vertical joints of a course shall be fully filled from top with mortar before the next layer of mortar is laid.

All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in alternate courses shall be positioned directly one over the other as far as practicable and the thicknesses of courses shall be kept uniform.

All brick work and block work shall be built up uniformly and no part of it shall rise more than one metre above the general construction level. They shall be left in steps, according to bond, at an angle not steeper than 45 degrees and shall not be toothed without the prior approval of the Engineer.

Clay bricks shall be completely soaked in water for a minimum period of one hour before use. Immediately prior to their use, however, they shall be taken out of water and allowed to completely surface dry. Cement sand bricks and blocks shall be soaked only where so specified in the Contract.

Mortar used shall be of 1:5 or 1:6 cement sand mix as specified, mixed only in the required quantities and shall be used not later than 45 minutes from the commencement of mixing.

(b) Plastering

Plastering where specified, shall be carried out using cement mortar of the specified proportions and to the specified thicknesses.

(c) Joints

Faces of walls that are to be plastered or where the joints are to be pointed shall have their joints raked out to a depth of 12 – 15mm, using a raking tool when the mortar is still green. When the mortar has hardened the brick work or block work shall be kept constantly moist for a minimum period of 7 days by suitable means approved by the Engineer.

(d) Curing

All brick work and block work shall be protected from rain and sun by suitably covering when the mortar is green. When the mortar has hardened the brick work or block work shall be kept constantly moist for a minimum period of 7 days by suitable means approved by the Engineer.

(e) Scaffolding

Scaffolding, where necessary, shall be provided as directed and in conformity with the requirements of Section 1008.

1007.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1007.4 Measurement and Payment

(a) Measurement

All brick work and block work shall be measured in Cu.m, of completed work.

Work of plastering and pointing of brick and block work shall be measured in Sq.m.

(b) Payment

The unit rate of payment for each item of work shall include full compensation for all materials, tools, equipment, labour and incidentals necessary to complete the work.

Curing of brick work and block work shall be considered incidental to the work.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1007(1)	Brick work (state type)	Cu.m
1007(2)	Cement block work	Cu.m
1007(3)	Pointing of joints	Sq.m
1007(4)	Plastering	Sq.m

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

1008 FORMWORK FOR STRUCTURES

1008.1 Description

This work shall consist of providing all temporary or permanent forms and moulds required for casting concrete, together with all temporary construction required for their support which include props, staging, centring, scaffolding and temporary construction including piles where necessary.

This work shall be carried out in accordance with these Specifications and with the shape, dimensions and surface finish as shown on the Drawings or as directed by the Engineer.

1008.2 Materials

All formwork shall be of timber, metal or any other material approved by the Engineer.

Timber for forms shall generally be of approved quality, well seasoned and of uniform thickness, sound, free from warps, loose knots, twists, wavy edges, saps and shakes or other defects affecting the strength of formwork and appearance of the finished structure. Where so required the surfaces of the timber shall be suitably dressed.

Metal sheets for forms shall be free from rust and dents with no surface blemishes that will impair the concrete surface finish.

Supports and scaffolding shall be of metal, sawn timber, round timber or of any other material approved by the Engineer.

1008.3 Construction Requirements

(a) False work

Temporary staging shall be provided by the Contractor to enable the constructional operations to be performed in the required sequences and in a safe manner.

The false work shall be properly designed and constructed, to provide the necessary rigidity and to carry the loads which it will be required to support. Where necessary, it shall also include safe walkways to enable the Engineer to inspect the formwork, reinforcements and concreting. Complete details of the arrangements proposed shall be submitted to the Engineer for his approval.

(b) Construction of formwork

All formwork shall be so constructed that there shall be no loss of material from the fresh concrete. Forms shall be mortar tight and shall be made sufficiently rigid by the use of ties and bracing to prevent any displacement or sagging and shall be capable of withstanding all incidental loading during concreting.

Formwork shall be such that hardened concrete shall be in the position and of the shape, dimensions and surface finish described in the Contract.

Where internal ties are permitted, they or their removable parts shall be extracted without damage to the concrete to a depth of at least 25mm from the finished concrete surface and the resulting holes filled with mortar. No permanently embedded metal nuts shall have less than 25mm cover from the finished concrete surface.

Formwork shall be constructed so that the side shutters of members can be removed without disturbing the soffit shutters, and if the Contractor wishes to leave some of the props in place when the soffit shutters are removed. These props shall not be disturbed during the striking. When specified the detailed arrangements of the props shall be submitted in advance to the Engineer, for his prior approval.

(c) Formed surfaces and finish

Surfaces shall be finished smooth or rough as specified. Normally, exposed surfaces shall be finished smooth. Where smooth finish is required, the forms shall be made of dressed timber with or without form liner approved by the Engineer or shall be of metal. Where metal forms are used, all bolts and rivets shall be counter sunk if necessary and well ground to provide a smooth, plane surface. For surfaces that are not designated to be finished smooth sawn timber without dressing (rough timber) may be used.

(d) Re-use of formwork

Where formwork has to be re-used the shape, strength, rigidity water tightness and surface smoothness of reused forms shall be maintained at all times. Any warped or bulged timber shall be resized before being reused. Formwork which is unsatisfactory in any respect shall not be reused.

(e) Preparation of formwork before concreting

Immediately before concreting, the forms shall be thoroughly cleaned either by water jetting or by any other suitable method, temporary openings being provided for the purpose. The inside surfaces of the forms shall then, if necessary, be coated with an approved material such as mould oil to prevent adhesion of the concrete. This material must not come into contact with the reinforcement or pre-stressing tendons and anchorages.

Soffit shutters for pre-stressed concrete work shall permit movement of the units when the pre-stress is applied.

(f) Inspection by Engineer prior to placing concrete

No concrete shall be placed until the Engineer has inspected and approved the formwork, false work and reinforcements.

(g) Removal of Formwork

The Engineer shall be informed in advance as to when the Contractor intends to strike any formwork.

The minimum periods between concreting and the removal of forms shall be as follows: -

Sides of beams, walls, columns, wells and piles	-	01 day
Soffit of secondary slabs (props left in)	-	04 days
Soffit of main slabs (props left in)	-	08 days
Soffits of beams (props left in)	-	08 days
Removal of props – secondary slabs	-	10 days
Removal of props - beams and main slabs	-	21 days
Arch centres, wedges cased	-	08 days
Arch centres, struck	-	21 days

The periods in the above table are given as a guide and are based on average weather conditions and the use of ordinary Portland cement. They shall be increased in areas of extremely cold weather unless otherwise directed by the Engineer, and may be changed, if other types of cement or additives are used, subject to the Engineer's approval.

1008.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1008.4 Measurement & Payment

(a) Measurement

Where it is stipulated in the Contract that formwork will be paid for separately, measurement for formwork shall be taken in Sq.m of the area of concrete for each type of finished surface in smooth or rough finish.

Where it is not specifically stated in the description of the items that formwork will be paid for separately, the rate for pre-stressed and or reinforced cement concrete items shall be deemed to include the cost of all formwork.

(b) Payment

The rate for formwork, where this is provided as a separate item, shall include the cost of all materials, labour, tools and plant hire required for construction and removal of forms as described above and also for framing required for properly supporting the members for at least the periods specified under 1008.3(g) unless otherwise specified.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1008(1)	Formwork, smooth finish	Sq.m
1008(2)	Formwork, rough finish	Sq.m

1009 BRIDGE EXPANSION JOINTS

1009.1 Description

This work shall consist of furnishing and installing expansion joints in accordance with these Specifications and details shown in the Drawings or as directed by the Engineer.

They may be an open joint, filled joints or joints provided with steel work, as required.

1009.2 Materials

Steel sections used for joints provided with steel works, shall meet the requirements of SLS 73.

Joint filler material used for filled joints shall be bitumen impregnated felt, elastomer (of natural rubber or synthetic rubber) or any other suitable material as specified.

Wood strips, metal plates or other material used for open joints shall be as approved.

1009.3 Construction Requirements

(a) Open joints

Open joints shall be constructed at the locations shown in the Drawings using a wood strip, metal plate, or other suitable material, which is subsequently removed. When removing the material care shall be exercised to avoid chipping or breaking the corners of the concrete. The edge of the concrete, at the joints, shall be edge finished.

(b) Filled joints

When preformed filler is shown in the Drawings, the filler shall be placed in correct position before concrete is placed against the filler. The filler material shall form part of the joint and while concreting, care shall be taken to prevent the former from being displaced. After the work is completed, the exposed face of the joint shall be cleaned of all loose material sticking to it.

The preformed joint filler shall consist of large pieces. Assembly of small pieces to make up the required size shall not be allowed.

(c) Joints provided with steel work

It shall be ensured that the steel plates, angles, and other steel sections used are kept in correct position during the placing of concrete. Care shall be exercised to avoid impairment of the necessary clearance in any manner. The clearance shall be compatible with the mean bridge temperature at the time of installation. This temperature shall be determined in concurrence with the Engineer.

The position of all bolts anchored in to concrete and holes drilled in plates shall be accurately determined using templates.

(d) Aftercare

Vehicular traffic shall not be allowed over the expansion joint, after its construction, for such a period as may be determined by the Engineer.

1009.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1009.4 Measurement and Payment

(a) Measurement

Unless otherwise specified, measurement shall be by the number of linear metres for each type of expansion joint completed in place and accepted.

(b) Payment

The payment for expansion joints shall include full compensation for furnishing and placing all materials including all labour, tools, equipment, and incidentals necessary to complete the work as specified in the Drawings.

The Pay Item and Pay Unit shall be as follows:-

Pay Item	Description	Pay Unit
1009(1)	Expansion joint (state type)	Linear metres

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

1010 BRIDGE BEARINGS

1010.1 Description

The work shall consist of supplying and installing in position of bearings in accordance with the requirements of these Specifications and details shown in the Drawing or as directed by the Engineer.

1010.2 Type of bearings and materials

Unless otherwise specified or given in the Drawings, bearings as herein specified shall include Elastomeric plain bearings (consisting of elastomer only) and Elastomeric laminated bearings (consisting of layers of elastomer restrained at their interfaces by bonded metal laminates) and for concrete slabs, paper bearings made out of bitumen laminated kraft paper of lead sheets.

The elastomer used in elastomeric bearings shall be of natural or synthetic rubber and their strength and hardness shall confirm to the requirements of the International Standards Organization (ISO). The Contractor shall furnish to the

Engineer a certificate by the manufacturer that the elastomer in the elastomeric bearing pads conforms to all the ISO requirements.

The metal laminates used shall be of mild steel as given in the Drawings or otherwise specified.

Paper bearings and lead sheets shall be of approved manufacture and shall be as given in the Drawings or otherwise specified.

1010.3 Storage

Bearings and material for bearings delivered to the bridge site shall be stored, under cover, on platforms above the surface of the round. They shall be protected at all times from injury and shall be prevented from contamination with dirt, oil grease or other foreign substances.

1010.4 Construction Requirements

The bearings shall be installed to the appropriate setting as shown in the Drawings, or as directed by the Engineer. The bearing shall be maintained in their correct position during the placing of the bridge deck. The contact surface of the bearings shall be kept free from contamination from grout, mould oil etc., and after the deck has been completed each bearing and the area around it shall be left clean.

1010.4/1Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1010.5 Measurement and Payment

(a) Measurement

Bearing pads shall be measured by the number of each type, size and thickness or in linear metres of each width and thickness, completed in place and accepted, as specified.

(b) Payment

Payment for bearings shall include full compensation for furnishing and all labour, tools, equipment and incidentals necessary for fixing in position complete as specified in the Drawings or as directed by the Engineer.

The Pay Item and Pay Unit shall be as follows: -

Pay Item	Description	Pay Unit
1010(1)	Bearing pad (state type, size and thickness)	Numbers
or		
1010(2)	Bearing pad (state width and thickness)	linear metres

Note
Refer Sub section 106.6 regarding sub divisions of pay items.

1011 MILD STEEL DOWELS SUPPLIED, FIXED AND GROUTED FOR BRIDGE APPROACH SLABS

1011.1 Description

The work shall consist of providing mild steel dowels supplied, fixed and grouted at fixed ends as per these Specifications and Drawings or as instructed by the Engineer.

1011.2 Material

The dowels shall be of mild steel having mechanical and physical properties specified in section 1002.

The grouting shall be of Portland cement and shall conform to Subs section 1703.1.

Hardened grout shall have a compressive strength of not less than 25 N/mm^2 at 28 days.

1011.3 Construction Requirements

The fixing of dowels shall be done prior to fixing of approach slabs which shall be carried out either by casting in-situ or pre-casting as shown in the Drawings. The dowels shall be inserted into the holes of the corbel to the depth specified in the Drawing & grouted well.

1011.3/1Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1011.4 Measurement & Payment

(a) Measurement

The dowels will be measured for payment by the number provided in the finished work and as accepted by the Engineer.

(b) Payment

This work measured as provided above will be paid for at the Contract unit price for this item. Such price and payment constitute full compensation for all material, labour (inclusive of drilling), tools, and equipment scaffolding work, platforms and incidentals, needed to complete all works. The complete work includes work associated with the structure indicated in the Drawings, Bill of Quantities or else where in the Specifications.

The Pay Item & Pay Unit shall be as follows.

Pay Item	Description	Pay Unit
1011(1)	Mild steel dowels (State diameter & length)	Numbers

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1011A MILD STEEL DOWELS SUPPLIED, FIXED AND GROUTED TO THE EXISTING SUBSTRUCTURE

1011A.1 Description

The work shall consist of providing mild steel dowels supplied, fixed and grouted to the existing substructure as per these Specifications and drawings or as instructed by the Engineer.

1011A.2 Material

The dowels shall be of mild steel having mechanical and physical properties specified in section 1002 of Standard Specification for Construction and maintenance of roads and Bridges.

The grouting shall be of Portland Cement and shall conform to section 1703.1 of Standard Specification for Construction and maintenance of roads and Bridges.

Hardened grout shall have a compressive strength of not less than 25 N/mm^2 at 28 days.

1011A.3 Construction Requirements

The dowels to the existing sub structure shall be fixed with care without disturbing the structural arrangement of the existing substructure and driven into the depth as shown in the drawings and grouted well.

1011A.3.1 Tests & Standards of Acceptance

The materials shall be sorted in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1011A.4 Measurement & Payment

(a) Measurement

The dowels will be measured for payment by the number provided in the finished work.

(b) Payment

This work measured as provided above will be paid for at the contract unit price for this item. Such price and payment constitute full compensation for all material, labour (inclusive of drilling), tools, and equipment scaffolding work, platforms and incidentals, needed to complete all works. The complete work includes work associated with the structure indicated in the drawings, Bill of Quantities or else where in the Standard Specifications for Construction and maintenance of roads and Bridges.

The Pay Item & Pay Unit will be as follows.

Pay Item	Description	Pay Unit
1011A(1)	Mild steel dowels (State diameter & length)	Numbers

Note : Sub Section 106.6 regarding sub divisions of Pay Items.

1011B MILD STEEL DOWELS SUPPLIED, FIXED AND GROUTED IN THE BED ROCK FOR THE FOUNDATION SLABS

1011B.1 Description

The work shall consist of providing mild steel dowels supplied, inserted and grouted in the bed rock and embedded into the foundation slabs as per these Specifications and drawings or as instructed by the Engineer.

1011B.2 Material

The dowels shall be of mild steel having mechanical and physical properties specified in section 1002 of Standard Specification for Construction and maintenance of roads and Bridges.

The grouting shall be of Portland Cement and shall conform to section 1703.1 of Standard Specification for Construction and maintenance of roads and Bridges.

Hardened grout shall have a compressive strength of not less than 25 N/mm^2 at 28 days.

1011B.3 Construction Requirements

The dowels shall be fixed only to the hard bed rock as directed by the Engineer. The holes for the dowels shall be driven manually or by any other approved methods to the specified depth shown in the drawings. The holes shall be cleaned well before inserting the dowels. The bottom portion of the dowel which is embedded into the bed rock shall be split as shown in the drawing and the top portion which is embedded in the foundation slab shall be bent to the shape as shown in the drawings. The dowels shall be inserted into the holes to the specified depth and spacing as shown in the drawings and grouted well.

1011B.3.1 Tests & Standards of Acceptance

The materials shall be sorted in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1011B.4 Measurement & Payment

(a) Measurement

The dowels will be measured for payment by the number provided in the finished work.

(b) Payment

This work measured as provided above will be paid for at the contract unit price for this item. Such price and payment constitute full compensation for all material, labour (inclusive of drilling), tools and incidentals, needed to complete all works. The complete work includes work associated with the structure indicated in the drawings, Bill of Quantities or else where in the Standard Specifications for Construction and maintenance of roads and Bridges.

The Pay Item & Pay Unit will be as follows.

Pay Item	Description	Pay Unit
1011B(1)	Mild steel dowels (State diameter & length)	Numbers

Note : Sub Section 106.6 regarding sub divisions of Pay Items.

1012 STAINLESS STEEL DOWELS SUPPLIED FIXED AND GROUTED AT FIXED ENDS

1012.1 Description

The work shall consist of furnishing the stainless steel dowels or any other approved steel dowels supplied .fixed and grouted between beams at fixed ends to the required length and diameter as per Drawing and in accordance with these Specifications and Drawings or as instructed by the Engineer.

1012.2 Material

The dowels shall be of stainless steel and shall be non-corrodible, rust resisting chrome steel having mechanical and physical properties not inferior to the mild steel specified in section 1002.

On the sole description of the Engineer any other approved steel dowels could be used after necessary treatment as directed by the Engineer.

The grouting shall be of Portland cement and shall conform to Sub section 1703.1.

Hardened grout shall have a compressive strength not less than 25 N/mm^2 at 28 days.

1012.3 Construction Requirements

The fixing of stainless steel dowels shall be done after launching the beams as per the Drawings. The dowels shall be inserted into the holes of the capping beams of abutments and piers to the depth specified in the Drawing and grouted well.

1012.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1012.4 Measurement & Payment

(a) Measurement

The dowels will be measured for payment by the number provided in the finished work and as accepted by the Engineer.

(b) Payment

This work measured as provided above will be paid for at the Contract unit price for this item. Such price and payment constitute full compensation for all materials, labour (inclusive of drilling), tools, and equipment scaffolding work, platforms and incidentals, needed to complete all works. The complete work includes work associated with the structure indicated in the Drawings, Bill of Quantities or elsewhere in the Specification.

The Pay Item & Pay Unit shall be as follows.

Pay Item	Description	Pay Unit
1012(1)	Stainless steel dowels (State diameter & length)	Numbers

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1013 BITUMINOUS SEALING FELT UNDER BEAMS AT ENDS TO PREVENT GROUT LEAK ON TO CAPPING BEAM

1013.1 Description

This work shall consists of forming bituminous sealing felt underneath the beam ends, as per Drawing to prevent grout leak on to capping beams at beam ends according to these Specifications or as instructed by the Engineer.

1013.2 Material

Material used shall meet the requirements of the following unless otherwise directed by the Engineer.

Binder shall conform to the requirements of Section 1702. Coarse sand shall conform to the requirements of Section 1701.5.

1013.3 Construction Requirements

Bituminous sealing felt shall be formed by mixing bitumen and sand at appropriate proportions and at a suitable temperature to form a flexible filler and laid underneath the beam ends as indicated in the Drawings to prevent grout leaks on the capping beam.

1013.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1013.4 Measurement & Payment

(a) Measurement

The bituminous sealing felt will be measured for payment in Linear metres provided in the finished work as per Drawing or as directed by the Engineer and as accepted by the Engineer.

(b) Payment

This work measured as provided above shall be paid for at the Contract unit price for this item. Such price and payment constitute full compensation for all material, labour, tools, equipment and incidentals needed to complete all Works. The completed Work included, Work associated with the structure and indicated in the Drawings, Bills of Quantities or elsewhere in the Specification.

The Pay Item & Pay Unit shall be as follows.

Pay Item	Description	Pay Unit
1013(1)	Bituminous sealing felt on Capping beams of abutment	Linear metres

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1014 BITUMINOUS SEALING FELT UNDER APPROACH SLABS AT CAPPING BEAM ENDS TO PREVENT BITUMEN RUNNING ON TO CAPPING BEAM

1014.1 Description

This work shall consists of forming bituminous sealing felt under approach slabs as per Drawing to prevent grout leak on to capping beams, according to these Specifications or as instructed by the Engineer.

1014.2 Material

Material used shall meet the requirements of the following unless otherwise directed by the Engineer.

Binder shall confirm to the requirements of Section 1702. Coarse sand shall conform to the requirements of Sub section 1701.5.

1014.3 Construction Requirements

Bituminous sealing felt shall be formed by mixing bitumen & sand at appropriate proportions and temperature from a flexible filler to and laid so as to indicate in the Drawings underneath beam ends as per Drawing to prevent grout leak on the capping beam.

1011.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1014.4 Measurement & Payment

(a) Measurement

The bituminous sealing felt will be measured for payment in Linear metres provided in the finished work as per Drawing or as directed by the Engineer and as accepted by the Engineer.

(b) Payment

This work measured as provided above shall be paid for at the Contract unit price for this item. Such price and payment constitute full compensation for all materials, labour, tools, equipment and incidentals needed to complete all Works. The completed Work included, Work associated with the structure and indicated in the Drawings, Bills of Quantities or elsewhere in the Specification.

The Pay Item & Pay Unit shall be as follows.

Pay Item	Description	Pay Unit
1014(1)	Bituminous sealing felt under the approach slabs	Linear metres

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1015 POLYTHENE DISPLACERS SUPPLIED AND FILLED WITH SAW DUST OR SIMILAR LIGHT MATERIAL IN DECK

1015.1 Description

This work shall consist of supplying and laying in position of polythene displacers in accordance with the requirements of these Specifications and details shown on the Drawing or as instructed by the Engineer.

1015.2 Material

Polyethylene displacers shall be of polythene films of required diameter and normal clarity and high impact strength of minimum thickness 20mm(or 700 Gauge) conforming to SLS 699 of 1985 filled with light materials such as saw dust or paddy husk free from moisture or similar light material approved by the Engineer.

1015.3 Construction Requirements

Polythene Film shall be filled with light dry material and sealed properly at the ends to prevent moisture getting in. Polythene displacer shall be assembled pieces to form the length as found necessary and as directed by the Engineer. These shall be maintained in their correct position during the concreting of the Bridge Deck. Polythene displacer shall be laid in position as shown on the Drawings and as directed by the Engineer.

1015.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1015.4 Measurement & Payment

(a) Measurement

Quantity shall be measured for payment in Linear metres provided in the finished work and as accepted by the Engineer.

(b) Payment

Rate for payment shall include full compensation for furnishing and all labour, tools equipment and incidentals necessary for laying in position complete as specified in Drawings or as directed by the Engineer.

The Pay Item & Pay Unit shall be as follows.

Pay Item	Description	Pay Unit
1015(1)	Polythene displacers supplied & filled with saw dust or similar light material in deck. (State the diameter)	Linear metres

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1016 FORMING OF SERVICE DUCT IN DECK

1016.1 Description

This work shall consists of forming the above duct to the given dimensions in deck as per Drawing and to these Specifications or as instructed by the Engineer.

1016.2 Materials & Formwork

Material used for forming the duct shall be in accordance with the Specification.

1016.3 Construction Requirements

The formwork for providing the ducts shall be such as to give a smooth finish after formation of the duct. The provision for placing the relevant concrete cover slabs shall also be made in the duct formed as per Drawings, Specifications, etc and workmanship shall be such that the slabs when placed on the same are seated properly to provide an even Pavement, for pedestrian use.

1016.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1016.4 Measurement & Payment

(a) Measurement

The service duct formed in place will be measured in Linear metres and as accepted by the Engineer.

(b) Payment

This work measured as provided above shall be paid for at the Contract unit price for this item. Such price and payment constitute full compensation for all materials, labour, tools, equipment and incidentals needed to complete all Works. The completed Work includes. Work associated with the structure and indicated in the Drawings, Bills of Quantities or elsewhere in the Specification.

The Pay Item & Pay Unit shall be as follows.

Pay Item	Description	Pay Unit
1016(1)	Forming of service duct in the deck. (State the depth & width)	Linear metres

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1017 COVER SLABS FOR SERVICE DUCTS

1017.1 Description

This work shall consist of furnishing above size of reinforced concrete cover slabs for service ducts inclusive of light reinforcements and shuttering as per Specifications and Drawings or as directed by the Engineer.

1017.2 Material

Cement concrete shall conform to the requirements of Class B Grade 25/20 concrete of Section 1001 of these Specification. Steel reinforcement shall conform to the requirements of Section 1002 of these Specifications.

1017.3 Construction Requirements

These slabs shall be cast as per Drawings and Specifications. It shall be clearly noted that the above cover slabs shall be placed on the service ducts to form an even Pavement for pedestrian walks. Therefore, it is important that the cover slabs when laid shall give an even surface to achieve the above purposes mentioned.

In view of above, the casting and laying of cover slabs shall be carried out on the direct supervision of the Engineer or his authorized representative. Also, the concrete shall be placed to lines, levels and grades as indicated in the Drawings.

1017.3/1 Tests & Standards of Acceptance

The materials shall be sorted in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1017.4 Measurement & Payment

(a) Measurement

The cover slabs will be measured for payment by the number provided in the finished work and as accepted by the Engineer.

(b) Payment

This work measured as provided above shall be paid for at the Contract unit price for this item. Such price and payment constitute full compensation for all materials, labour, tools, equipment and incidentals needed to complete all Works. The completed Work included, Work associated with the structure and indicated in the Drawings, Bills of Quantities or elsewhere in the Specification.

The Pay Item & Pay Unit shall be as follows.

Pay Item	Description	Pay Unit
1017(1)	Cover slabs for forming of service duct in the deck (State the thickness, length and width)	Numbers

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1018 PRECAST REINFORCED CONCRETE RAILING & UPRIGHTS

1018.1 Description

This work shall consist of furnishing the above hand rails and uprights fixed in position according to Specifications, Drawings or as instructed by the Engineer. This work shall be inclusive of provision of light reinforcements and moulds for casting hand rails and uprights.

1018.2 Material

Concrete hand railings and uprights shall conform to the requirements of Class A Grade 25(20) concrete of Section 1001 of these Specifications. Steel reinforcement shall conform to the requirements of Section 1002 of these Specifications. The Grade of concrete shall be indicated in the Drawings and Bill of Quantities, Mortar shall conform to the requirements of Sub section 1703.2 of these Specifications.

1018.3 Construction Requirements

The pre-cast concrete hand railings and uprights shall be of approved quality manufactured by reputed firms or Government Corporations. If these items are to be cast at site they shall be cast according to the direction of the Engineer. For connecting railings to uprights, they shall be set in approved sockets or holes. The uprights shall be fixed in the holes with cement mortar as shown in the Drawings.

1018.4 Erection

Railing shall be fabricated and erected as indicated in the Drawings and rails shall be parallel to the grade of the road, Uprights shall be vertical .All exposed surfaces shall be thoroughly cleaned in an approved manner as a final operation under the project.

Concrete railings shall be constructed to the lines and grades shown in the Drawings. Unless otherwise specified, all railings and uprights shall not be placed on a structure until centring or false work has been removed and the Engineer approves the railings to be installed.

1018.4/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1018.5 Measurement & Payment

(a) Measurement

This work shall be measured as the completed length of railing in lm each of the particular types as specified in the Drawings satisfactorily completed and accepted.

(b) Payment

This work measured as provided above shall be paid for at the Contract unit price per meter of railings. The price and payment shall constitute full compensation for finishing all railings, uprights and fittings, including delivery, erection and finishing and for all labour, equipment, tools and incidentals necessary for the completion of the work.

The Pay Item & Pay Unit shall be as follows.

Pay Item	Description	Pay Unit
1018(1)	Pre-cast reinforced concrete Railings & uprights (State the class of concrete)	Linear metres

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1019 END PILASTERS IN CONCRETE FOR BRIDGES

1019.1 Description

This work shall consist of furnishing the above end pilastering according to these Specifications, Drawings or as instructed by the Engineer.

1019.2 Material

Concrete end pilasters shall confirm to the requirements of Class A Grade 25(20) concrete of Section 1001 of these Specifications. Steel reinforcement shall conform to the requirements of Section 1002 of these Specifications. The Grade of concrete shall be indicated in the Drawings and Bill of Quantities.

The formwork for casting shall be such that all the exposed surface of the end pilasters shall be smooth finished.

1019.3 Construction Requirements

The end pilasters shall be constructed with approved materials conforming to the details given in the Drawings. The proper bonding of concrete in end pilaster with that of the wing walls shall be increased by roughening of the surface.

1019.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1019.4 Measurement & Payment

(a) Measurement

The end pilasters will be measured for payment by the number provided in the finished work and accepted by the Engineer.

(b) Payment

This work measured as provided above shall be paid for at the Contract unit price for this item. Such price and payment constitute full compensation for all materials, labour, tools, and formwork, scaffolding, shuttering, equipment and incidentals needed to complete all Works. The completed Work included, Work associated with the structure and indicated in the Drawings, Bills of Quantities as elsewhere in the Specification.

Pay Item and Pay Unit shall be as follows;

Pay Item	Description	Pay Unit
1019(1)	End pilasters (State the grade of concrete & type of foundation)	Number

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1020 PVC RAIN WATER OUTLETS SUPPLIED AND FIXED THROUGH DECK & SERVICE DUCTS

1020.1 Description

The work shall consist of providing the above 110mm dia PVC rain water outlet fixed through deck as per Specification and Drawings or as instructed by the Engineer.

1020.2 Material

(1) Type 600 PVC pipe having an external diameter and wall thickness as given in the Drawing.

(2) Cement Mortar and cement concrete class A Grade 20(25) shall conform to Sub sections 1703.2 and 1001 respectively in these Specifications.

1020.3 Construction Requirements

The rain water outlet shall be formed according to the Drawings. The inlets shall not be completed to final grade until the wearing surface of the bridge is laid, finished and all necessary arrangements have been made to ensure suitable connections at proper grade and alignment with Pavement.

The pipe shall be set in full bed of mortar or be otherwise sealed properly as indicated in the Drawings, so as to be held rigidly in place to proper grade and alignment.

The pipe end at the inlet, shall be set or and flush with the inside faces of the surface/walls of the deck and shall extend a sufficient distance beyond the outside faces of the deck as shown in the Drawings or as directed by the Engineer.

The pipe shall be well secured at the inlet in a neat manner with cement concrete and/or cement mortar as may be specified so as to make the joint water tight and facilitate the draining of rain water only through the pipe.

1020.3/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1020.4 Measurement & Payment

(a) Measurement

The rain water outlets shall be measured for payment by the number provided in the finished work and accepted by the Engineer.

(b) Payment

This work measured as provided above shall be paid for at the Contract unit price for this item. Such price and payment constitute full compensation for all materials, labour, tools, formwork, scaffolding, shuttering, equipment and incidentals needed to complete all Works. The completed Work included, Work associated with the structure and indicated in the Drawings, Bills of Quantities as elsewhere in these Specifications.

Pay Item and Pay Unit shall be as follows;

Pay Item	Description	Pay Unit
1020(1)	PVC rain water outlets fixed through deck & service duct. (State the external diameter)	Number

Note : Sub section 106.6 regarding sub divisions of Pay Items.

1021 STRUCTURAL STEEL WORK FOR STRUCTURES

1021.1 Description

This work shall consist of the use of structural steelwork for construction of steel bridges, in accordance with the Drawings or as directed by the Engineer unless otherwise detailed in the Contract.

Unless otherwise described in the Contract, the requirement of the materials, workmanship, inspection and testing, handling, transport and erection, supply, measurement and weighing of structural steelwork shall comply with the Specification

clauses of BS 5400: Part 6: 1999 and this Specification. In the event of conflict between BS 5400: Part 6: 1999 and this Specification, this Specification shall govern.

Unless otherwise described in the Contract the surface preparation and protective treatment of the structural steelwork shall comply with these Specifications.

1021.2 References

The publications to which reference is made in this Specification are listed at the end of this Specification.

1021.3 Documentary Control

Before commencing any work, the Contractor shall submit Documentary Control proposed for the Engineer's approval. The documentary control shall consist of, but not limited to, shop Drawings, work plan, and quality control processes etc

1021.4 Materials

(a) Structural steel

Unless otherwise described in the Contract, the structural steel shall comply with the requirements of the designated standards as listed out in clause 3.1 of BS 5400: part 6: 1999.

The use of the structural steel complying with the requirements of other standards shall only be at the discretion of the Engineer and in accordance with the clause 3.1.2 of BS 5400: part 6: 1999.

The Contractor before placing any purchase order for materials to be incorporated in the permanent works shall submit for the Engineer's approval, a complete description of such items and their material Specifications. When so directed, the Contractor shall submit samples and/or material Specifications inclusive of the source of the material prior to the Contractor making a purchase order.

In addition to the above, where required, the Engineer may at his own discretion select samples of the steel for testing. All the costs of supplying the samples and tests required for the approval of material shall be borne by the Contractor.

(b) Approval of Material

All supplied steel shall be manufactured under the supervision of an internationally accepted third party inspection authority unless otherwise approved by the Engineer. The Contractor shall nominate such internationally accepted third party for the Engineer's approval. The Contractor shall ensure that all material is hard stamped, unless otherwise agreed by the Engineer for identification against the certificates issued by such inspection authority.

(c) Testing of Materials

The Contractor shall supply evidence satisfactory to the Engineer that all materials or parts conforming to the tests required by the specified material Standards or to other tests that may be specified by the Engineer.

No material or part shall be used in the work until it has been identified with the tests to the satisfaction of the Engineer.

The cost of all testing shall be borne by the Contractor.

(d) Identification of Materials

All materials including steel plates and sections upon arrival at site, and before the use, shall be certified by the Engineer as against the certificates issued by the certifying authority mentioned in Sub section 1021.4.(b) All materials not complying with this requirement shall be rejected. This verification shall be for both quantitative and qualitative assessment of the materials upon arrival at site and before use.

(e) Defective Materials

Finished materials shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall be of smooth and uniform finish and shall be straightened in the mill before shipment. They shall also be free from loose mill scale, rust, pits, and other defects affecting the strength and the durability.

The Engineer shall decide whether the material defects, arising from the manufacture of the steel or damages during handling, which become evident at any stage of fabrication shall be repaired by the Contractor or be rejected.

The cost of repairs or replacement shall be borne by the Contractor.

(f) Storage and Handling of Materials

Upon acceptance of the materials, they shall be subjected to surface preparation and an application of a protective coating of prefabrication primer to protect against corrosion in accordance to this Specification or at the discretion of the Engineer.

All steel, whether fabricated or not, shall be stored at not less than 300 mm above the ground, on platforms, or other supports, and adequately protected against corrosion. Excessively rusted, bent or damaged steel shall be rejected, as decided by the Engineer.

1021.5 Construction requirements

(a) Fabrication Programme

The Contractor shall submit details of the procedure for fabrication and assembly with the fabrication programme for the Engineer's approval at least two months before the commencement of fabrication unless otherwise specified. These procedures shall include such items as:

(i) Procedures for marking, cutting, planing and shaping

(ii) Detailed shop Drawings showing details of cambering, part assembling, connection details, and details of temporary attachments and connections where required for erection and handling.

(iii) Welding procedure, welding sequence and welder qualifications

(iv) Complete surface preparation and painting scheme.

(v) Method statement for transport, handling and storage, including measures to prevent distortion and damage to the steelwork and its protective coating.

(b) Shop Drawings

The Contractor shall prepare shop drawings for the fabrication of all members. No work shall be started unless the shop drawings have been approved. Three copies of the shop drawings undersigned by the Contractor shall be submitted to Engineer 14 working days before the fabrication commences. The Contractor shall submit to the Engineer two copies of the "As built" shop drawings within four weeks of the completion of fabrication and erection of the steel members.

The details on the shop drawings shall be complete and consistent with the Contract Drawings.

(i) The marking plan shall show the location, as appropriate, of the abutments, upstream and downstream, north orientation, span numbers, pier numbers, etc.

(ii) All drawings shall carry Standard welding symbols as per BS 499.

(iii) Complete information regarding location, type, size and extent of welds shall be clearly shown on the shop drawings. The shop drawings shall clearly distinguish between shop and field welds.

(iv) Joints or groups of joints in which it is especially important that the welding technique be carefully controlled to minimize residual stresses and distortion, shall be noted on the shop drawings. Weld lengths specified on the drawings shall be the required effective lengths.

(v) Each member shall be clearly identified with the identification marks and each component shall be further identified to readily distinguish it from all other components. The Contractor shall make allowances in the fabrication of the steelwork for the changes in dimension and profile of the steelwork due to the method of connecting together of steelwork during erection.

(vi) For assemblies, all associated bolting, accessories and/or jointing details shall be shown on shop Drawings

(c) Variations from drawings

No variations from approved drawings including changes in joint details and substitution of steel sections differing from those specified shall be made unless a written approval has been obtained from the Engineer.

(d) Dimensional Tolerances for Fabrication

Measurements of length shall be checked with standard steel measuring tape. The steel work dimensions & given on the Drawings are specified for a mean temperature of 30 ^{0}C unless otherwise specified and the Contractor shall make adjustments as necessary to achieve the specified dimension at this temperature.

Dimensions of fabricated members shall be within the tolerances given in accordance with BS 5400: part 6: 1999 and the Table 1021-1, as given below, unless otherwise shown in the Contract.

Table 1021-1 - Fabrication Tolerances

INDIVIDUAL COMPONENTS

No.	Description	
01	Length a) Member with both ends finished for contact bearing b) Individual components of members with end plate connection c) Other members (i) Up to and including 12 m (ii) over 12 m	 ± 1 mm + 0 mm - 2 mm ± 2 mm ± 3.5 mm
02	**Width** a) Width of built-up girders b) Deviation in the width of members required to be inserted in other members	 ± 3 mm + 0 mm - 3 mm
03	**Depth** Deviation in the depths of solid web & open web girders	 + 3 mm - 2 mm
04	**Straightness** a) Deviation from straightness of columns i) In elevation ii) In plan	 L/3000 subject to a maximum of 15 mm where L is length of member + 5 mm - 0 mm L/1000 subject to a maximum of 10 mm
05	Deviation of centre line of web from centre line of flanges in built-up members at contact surfaces	3 mm
06	Deviation from flatness of plate of webs of built-up members in a length equal to the depth of the member	0.005 d to a maximum of 2 mm where d is depth of the member in mm
07	Tilt of flange of plate girders a) At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings b) At other places	 0.005 b to a minimum of 2 mm where b is width of the member in mm 0.015 b to a maximum of 4 mm where b is width of the member in mm
08	Deviation from square-ness of flange to web of columns and box girders	L /1000, where L is nominal length of the diagonal in mm
09	Deviation from square-ness of fixed Base plate (not machined) to axis of column. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the Base plate.	D /500, where D is the distance in mm from the column axis to the point under consideration of the Base plate
10	Deviation from square-ness of machined ends to axis of columns	D/1000, where D is as defined in 09 above
11	Deviation from square-ness of machined ends to axis of beams or girder	D/1000, where D is as defined in 09 above
12	Ends of members abutting at joints through cleats or end plates, permissible deviation from square-ness of ends	1/600 of depth in mm of member subject to a maximum of 1.5 mm

(e) Tolerances not specified:

Any tolerances not specified above shall be mutually determined and agreed between the Contractor and the Engineer before the fabrication commences.

(f) Straightening

All plates shall be flat and all bars and sections made straight and free from twist. Straightening shall be done only with the Engineer's approval, which will not damage, mark or impair the strength of the material. When assembled, adjacent surfaces shall be close in contact throughout as determined by the Engineer, sharp kinks and bends as determined by the Engineer, shall be avoided.

(g) Cutting and Edge Preparation

The structural steel parts, where required shall be sheared, cropped, sawn or flame cut and ground accurately to the required dimension and shape. The Contractor shall submit written procedures for such operations before commencing fabrication.

End/edge planing and cutting shall be done by any one of the following prescribed methods or left as rolled. Surfaces produced by such cutting shall be finished smooth to the required dimensions.

(i) Shearing, cropping, sawing, machining, machine flame cutting

(ii) Hand flame cutting with subsequent grinding to a smooth edge.

(iii) Sheared edges of plates not more than 16 mm thick with subsequent grinding to smooth profile, which are for secondary use such as stiffeners ,gussets etc..

If ends of stiffeners are required to be fitted, they shall be ground, so that the maximum gap over 60 percent of the contact area does not exceed 0.25 mm, as determined by the Engineer.

Where flame cutting or shearing is used, at least one of the following requirements shall be satisfied.

(i) The cut edges shall not be subjected to applied stress

(ii) The edge shall be incorporated in weld

(iii) The hardness of the cut edge shall not exceed 350 HV30 when tested in accordance with BSEN ISO 6507.

(iv) The material shall be removed from edge to extent of 2 mm or minimum necessary.

(v) Edge shall be suitably heated by approved method to the satisfaction of the Engineer and it shall be shown that cracks had not developed by the dye penetration or magnetic particle test.

Hand cutting shall only be used for secondary cuts, repairing and where machine cutting is not possible. Where finish of the cut edges are not satisfactory they shall be ground or machined and repaired at the Contractor's cost.

Carbon arc gouging may be used with the approval of the Engineer in the fabrication of structural steel for removing defective welding, back gouging of butt welds, and preparing plates for butt and fillet welds.

Re-entrant corners shall be smoothly rounded to a radius of not less than 20mm and all corners and exposed edges shall be rounded to a radius of approximately 2 mm.

Flame cutting by hand shall be done only where approved by the Engineer for secondary cuts, repairs and when machine cutting is not possible.

The mill scale on the flame cut edge shall be removed prior to welding. Other methods of cutting steel shall only be used if approved by the Engineer.

(h) Treatment of Edges

After cutting the edges of flanges, webs and exposed edges in general they shall be ground or machined to a smooth even finish. The Engineer may waive this requirement if, in his opinion a smooth and even surface has been obtained in the cutting process.

Distortion caused by the shearing shall be removed by grinding except where otherwise permitted by the Engineer. Sheared or cropped ends of shear connectors need not be ground. Exposed corners shall be machined or ground to radius of approximately 2 mm. Rolled edges need not be ground provided that the corners are rounded.

(i) Welded Splices

All welded splices shall only be at the locations marked in the Drawings unless otherwise approved by the Engineer. Splices in the component parts of welded members shall be made before the parts are assembled. Splices shall be free from sharp kinks and staggered as practical as possible as determined by the Engineer. Contractor shall obtain Engineer's clear approval for site welded splices.

(j) Close-fitted Stiffeners

Where ends of stiffeners are required to be fitted, they shall be ground or otherwise prepared, so that the maximum gap between the end of the stiffener and the surface against which it is fitted does not exceed 0.25 mm over 60% of the fitted area and does not exceed 0.75 mm over the remainder of the fitted area.

(k) Web Stiffeners

Bearing stiffeners of girders, stiffeners at cross frames, and stiffeners at points of concentrated loads shall be milled or ground to bear uniformly against the girder flanges, where they are not welded as determined by the Engineer.

Where intermediate stiffeners are designed to be fitted against flanges and not welded, the fit against the girder flanges shall be sufficiently close to prevent the entry of water after painting, as determined by the Engineer.

(l) Cambering

Steel structures shall be pre-cambered as per the Contract Drawings. Cambering in built-up sections shall be obtained by cutting webs to the shapes shown in the Drawings.

(m) Correction of Distortion

Distortion resulting from welding and fabrication may be corrected by mechanical or thermal means with the approval of the Engineer provided the following requirements are met.

(i) The mechanical or thermal process shall not damage the member

(ii) Hammering shall not be used.

(iii) The temperature of steel shall not exceed the lesser of 600^0 C or the temperature specified in SLS or BS for the steel concerned.

(iv) Artificial cooling shall not be used until the temperature of steel is below 300^0 C. Water jets shall not be used for cooling.

1021.6 Finishing and Shaping

(a) Description

Finished member shall be true to line and free from twists, bends and open joints.

(b) Facing of Bearing Surfaces

The surface finish of bearing and base plates and other bearing surfaces that will come in contact with each other or with concrete shall be surface roughened.

(c) Transporting To Site

The Contractor shall ensure that during transport there shall be no distortion, loss of camber or damage to the steel work and its protective coating. The method of transporting and handling shall be subject to the approval of the Engineer. The rectification or rejection of damage or distorted members shall be subject to the discretion of the Engineer.

1021.8 Welding

(a) General

All welding and welding procedures shall comply with BS 5135: 1984. Unless otherwise specified by the Engineer; metal-arc welding that complies with BS 5135: 1984 shall be used.

Only quaiified welders and approved welding procedures shall be allowed in production of welds. It shall be ensured that welding is done in a manner and sequence so as to minimise and control shrinkage and distortions.

Surfaces to be welded shall be dry and welding shall not be done when surfaces are wet or exposed to rain or excess blowing.

Temporary welded attachments shall be subject to prior approval of the Engineer.

(i) Supervision of welding

All welding supervisors, welding inspectors, welders and testing technician shall be qualified persons as determined by the Engineer. The welders shall be qualified exclusively for the particular job.

(ii) Welding processes and procedure

Welding processes shall be carried out as per BS 5400: part 6: 1999. Contractor shall submit the welding procedure and obtain the Engineer's approval, before starting the welding process.

(iii) Preparation of Material for Welding

Surfaces and edges to be welded shall be smooth, uniform and free from surface irregularities, cracks and other defects, which would adversely affect the quality of the weld. Surfaces within 50 mm of any weld location shall be free from any paint or other surface coating that would prevent proper welding or produce objectionable fumes while welding.

(b) Preheating

Preheating of steel for welding shall comply with the requirements of the material standards as per Sub section 1021.4 and BS 5135 : 1984.

(c) Butt Welding

Unless otherwise specified, all butt welds shall be with full penetration welds made between prepared fusion faces. Butt welds in flanges and webs shall be dressed flush by grinding in the direction of stress. Loss of parent metal in grinding of the butt welds shall be within the limits specified in relevant material standards.

Where the fatigue stresses are proven, permanent-backing strips shall not be used to facilitate the production of butt welds. The preparation for butt welds shall be in accordance with the guidelines laid down in BS 5135 : 1984.

(d) Fillet Welding

The fitting of parts joined by fillet welds shall comply with the requirements of BS 5135: 1984. The root gaps between parts joined by fillet welds shall not exceed 1mm average (measured over 1.0 m or the length of the weld, whichever is smaller). Where this requirement is not achieved, the Contractor shall increase the size of the fillet weld accordingly, unless otherwise agreed by the Engineer.

(e) Weld Continuity

All welds shall be continuous, unless otherwise specified by the Engineer. All fillet welds shall continue over the edges.

(f) Peening

Peening of welds shall not be permitted.

(g) Appearance and Finish of Welds

Butt welds shall be dressed smooth and flush with abutting surfaces where required for correct assembly and/ or where specified on the Drawings. All weld spatter shall be removed from the surface of the weld and parent material. Slag shall be removed from all completed welds and both the weld and the parent metal shall be cleaned of fabrication contamination.

1021.9 Shear Connectors

(a) Materials for shear connectors.

Steel for all types of shear connectors shall, unless otherwise specified by the Engineer, comply with the requirements of BS 5400: Part 6: 1999.

(b) Welding and procedure trials

Welding of stud shear connectors shall be automatic stud welding unless otherwise in accordance with the manufacturers Specifications and discretion of the Engineer.

Site welding shall be carried out according to the clauses of BS 5135 : 1984 and under the supervision of the Engineer or authorised welding inspector.

Before welding any studs shear connectors, operators and equipment and welding procedure shall be qualified exclusively for the work.

No change of operator or of the equipment or of the welding procedure, which have qualified under these clauses, shall be made without the approval of the Engineer. All costs incurred by the Contractor in carrying out qualification tests on operators and equipment and welding procedure shall be borne by the Contractor.

(c) Surface Preparation

The studs shall not be painted or galvanized and shall be free from rust, scale, rust pits and oil at the time of welding.

The surface to which the studs are to be attached shall be cleaned to a surface completely free of mill scale, rust, dirt, paint, grease, moisture and any other material, which might impair the quality of the weld.

(d) Testing of Welded Studs

Testing of shear studs shall be in accordance with clauses of BS 5400: Part 6 1999.

(e) Replacing of defective Studs

When replacing a stud the surface area, after the defective stud has been removed, shall be ground free of any metal from the old weld, in the case of any pocket it shall be filled with weld metal and ground flush. Replacing of studs shall be at the Contractor's expense. Any satisfactory studs shall not be bent back.

1021.10 Inspection and testing of Welds

(a) General

All inspection work shall be in accordance with the quality manual approved by the Engineer. Inspection shall be carried out within 48 hours on completion of the joint and all welds shall have cooled to ambient temperature.

All destructive and non destructive testing of welds in and attached to principle structural steel work shall be in accordance with the BS 5400: part 6: 1999.

(b) Repairing Methods

Where weld defects exceed the limits specified, the weld shall be rejected. If approved by the Engineer the Contractor shall carry out the corrective measures specified. Formal procedures for the repair of welds shall be required.

(c) Cost of Testing

The cost of providing all necessary equipment and operators for any means of inspection and testing shall be borne by the Contractor.

After the repair of any defective weld, further sub-surface inspection of the corrected weld will be at Contractor's expense and the cost of any further corrective measures and subsequent inspection of the weld shall be borne by the Contractor.

1021.11 Bolted or Riveted Connections

(a) General

Unless otherwise specified by the Engineer, assemblies of the structural steel bolts and nuts shall be in accordance with the clause 3.4 of BS 5400: part 6:1999.

(b) Installation of High strength friction grip bolts

Except where otherwise specified by the Engineer, all contact surfaces in high strength friction grip bolted connections shall comply with the requirements of BS 4604;1970 part 1 and part 2 as appropriate. Fraying surfaces of high strength friction gripped surfaces shall be in accordance with the clause 1021.14.(f) of this Specification and the treated surface shall be adequately protected until they are brought together.

When all fasteners in the joint are tightened, each fastener shall be tightened to provide a minimum bolt tension specified by the Engineer.

Where bolts/nuts are tightened by the 'part-turn' method, the value of bedding torque for the preliminary tightening shall be as in the following Table 1021-2 below.

Table 1021- 2 - Bedding Torque for Preliminary Tightening of Nuts

Nominal diameter of bolt in mm	Bedding torque ±10% in Nm
16	80
20	160
22	210
24	270
27	340
30	460
32	580

(c) Inspection

The Engineer shall observe the installation and tightening of bolts to determine that the selected tightening procedure prescribed by the Contractor is properly used and shall determine that all bolts are tightened.

Whatever the method of tightening is adopted, the Engineer shall have the full opportunity to witness the calibration tests prescribed by the Contractor.

1021.12 Trial Erection of Structural Steel Work

On completion of the shop fabrication and prior to blast cleaning, the Contractor shall trial erect all steel work in presence of the Engineer to enable fit and dimension to be verified. The steelwork shall be supported at correct bearing locations and set to the correct relative levels. All cross girders and cross bracing shall be positioned and all splices tightened with temporary bolts sufficient to bring all splice plates to maximum 0.5 mm gaps. Trial erection shall be carried out in sequential portions longitudinally provided that there is an overlap between portions as determined by the Engineer.

The trial assembly shall prove that each element has the shape to fit exactly into the adjoining element and also shall prove that the camber aimed at, or prescribed, actually exists, and that the geometry is correct.

1021.13 Permanent Erection of Structural Steel Work

(a) Description

The Contractor shall erect the superstructure steelwork in such a manner that it remains stable and in the correct position throughout all stages of construction. Any additional temporary bracing required for the stability of the structure during erection shall be in the Contractor's method statement and subject to approval of the Engineer.

Unless otherwise specified, casting of the concrete shall not be commenced until all steel work has been fully assembled; and splices completed and all permanent bearing incorporated into position.

Measurements for the trial erection shall be repeated after all dead loads have been applied to ensure compliance with clause 5.6 of BS 5400 part 6: 1999.

The material shall be carefully handled so that no parts are bent, broken, or otherwise damaged and protective coatings are kept clean and free from damage. Hammering which will injure or distort the members shall not be permitted. Bearing

surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Steel work shall be stored on supports at least 300 mm above the ground. Prefabricated truss segments shall be stored on the horizontal profile.

(b) Site Welding

For site welded joints, the ends of the members and/or segments shall be held in position during welding by suitable temporary devices. On completion of the joints the temporary devices shall be carefully removed and the steel surfaces restored by grinding smooth and flush to the original surface.

1021.14 Protective Treatment of Structural Steelwork against corrosion

(a) Description

This work shall cover the protective treatment against corrosion of structural steelwork used in Bridgework.

(b) Surface Preparation - General Requirements

Shop and Site Work:

Before blast cleaning or abrading steel surfaces or before over-coating painted or galvanised surfaces, contamination by oil or grease shall be removed by wet cleaning the affected areas as described in Sub section 1021.14.c (iii) of this Specification.

Clean water which does not leave harmful residues on the surface shall be used for cleaning and rinsing. Only cleaning agents which do not leave harmful residues on the surface after final rinsing shall be used. Cleaning agents approved by the Engineer shall be used.

Surface preparation shall be continued until the appropriate standard has been achieved or to the satisfaction of the Engineer. The surface shall be free from condensation, oil grease, dust, residues and detrimental contamination such as chlorides and sulphides.

Weld spatter shall be removed from accessible areas which are to be galvanised or protected by metal spray or paint as determined by the Engineer. Firmly adhering weld spatter in the heat affected zone shall be removed before blast cleaning.

After dry surface preparation of internal surfaces and before any wet cleaning, all dust and debris shall be removed from accessible areas as determincd by the Engineer by sweeping and vacuum cleaning.

Immediately before application of each coat of paint, the Contractor shall ensure that the surfaces:

(i) meet the standard specified.

(ii) are free from harmful residues, including mortar, concrete, dust, grit and paint degradation products;

(iii) are free from detrimental contamination;

(iv) are free from moisture detrimental to the coating to be applied.

Joints, plies and fasteners shall be sealed in compliance with Sub sections 1021.14.5 (b)(iii) and (b)(iv) of this Specification.

Coats of paint shall be free from embedded metallic or other foreign particles including metallic dust. Deposits of adherent matter on metallic coatings or painted surfaces shall be cleaned off immediately they occur. Coatings damaged in the process shall be restored.

Unless otherwise described in the Contract the final shop coats on external surfaces shall be wet cleaned on site.

(c) Surface Preparation - Materials and Methods

(i) Dry Blast Cleaning in the Shops:

Abrasives for blast cleaning shall be chilled cast iron grit abrasive complying with BS EN ISO 11124-2 or high carbon cast –steel shot or grit complying with BS EN ISO 11124-3 with a hardness value greater than 650 HV, or aluminium oxide complying with BS 7079-F7 or equivalent approved by the Engineer.

Grades of metallic Abrasives shall not exceed the following:

Abrasive	Profile [as per clause 1021.14 (d)]		
	Fine	Medium	Coarse
Chilled cast iron grit	G050	G070	G100
Steel shot	S060	S100	S120

The particle size of any abrasive shall not exceed the maximum for the relevant grade as specified above.

Before the start of blast cleaning and during blast cleaning the Contractor shall ensure that the abrasive is free from matter which could leave detrimental contamination on the surfaces to be coated.

Alternatively, good quality silica rich sand shall be used as the abrasive up to ISO Sa 2.5 cleaning standards, subject to the approval of the Engineer.

(ii) Abrading in the Shops or on Site:

Any encrusted foreign matter or paint which may be difficult to remove by abrading alone shall, with the Engineer's approval be dislodged by scraping, aided by hand or power wire-brushing. This work shall be completed before abrading the areas so affected.

Abrading shall be carried out using abrasive paper or other material. Abrading tools may be used to remove weld spatter subject to the Engineer's approval. Wet abrading shall be employed for the preparation of finishes over sound undercoats.

All equipment including tools and abrasive sheets shall be of a type, capacity and in a condition that shall be approved by the Engineer.

A burnished appearance caused by rubbing of paint, rust or dirt shall not be acceptable.

Areas of previously corroded steel or unsound metal coatings, except galvanising, which have been prepared by abrading down to bright steel or bright metal coating, and blast cleaned where appropriate, shall be protected by the primer and two coats of paint before any cleaning down or preparation of adjacent surfaces.

(iii) Wet Cleaning in the Shops or on Site:

Wet cleaning shall be carried out by scrubbing with a stiff-bristled brush using water and a cleaning agent. Immediately after cleaning, the surfaces shall be thoroughly rinsed.

(iv) Dry Cleaning in the Shops or on Site:

Surfaces shall be cleaned by scrubbing with a dry stiff-bristled brush

(v) Dry Blast Cleaning on Site:

Metallic abrasives shall comply with Sub section 1021.14.d (i), (ii), & (iii) of this clause. Metallic grit abrasive shall be used for dry blast cleaning of relatively small areas on site which are to be metal sprayed, such as at site welds, at areas prepared to clean steel or areas where a metal spray is to be restored . The Contractor shall ensure that the grade and particle shape of non-metallic abrasives are adequate for the purpose intended. Non-metallic abrasives shall not be recycled.

(vi) Wet Blast Cleaning on Site:

Unless otherwise agreed with the Engineer a low-pressure air/water abrasive system shall be used. The air/water pressure at the nozzle shall not exceed 7.0 kgf/cm2 and shall be fully adjustable below this level.

Within 60 minutes of wet blast cleaning, the whole of the cleaned surface shall be thoroughly washed using the blast cleaning equipment with air and water. Any further deposits of abrasive on already rinsed surfaces shall be removed in a similar manner also within 60 minutes of being deposited. All accumulated deposits of abrasive and debris on other parts of the structure shall be removed by the same method before the end of the working day. After washing, the surface shall be free from all particles of dust and debris. After the washing, examination for detrimental contamination shall be made to the satisfaction of the Engineer

(vii) Combined Wet/Dry Blast Cleaning on Site:

Wet blast cleaning using the low pressure air/water abrasive system shall be followed, at an interval approved by the Engineer, by dry blast cleaning of all the previously wet blast cleaned areas.

The specified standard of surface preparation shall have been achieved in full, initially by wet blast cleaning and washing, before any later dry blast cleaning of the same areas to remove flash rusting or to restore the required standard of surface preparation.

(viii) Other Requirements:

When surface preparation is to be carried out by dry blast cleaning and, on adjacent surfaces, by wet cleaning and or abrading, then unless otherwise agreed or

instructed by the Engineer, the wet cleaning and any abrading shall be carried out first.

Grinding wheels and discs shall be of the size, shape and grade of coarseness appropriate to the particular operation and shall be approved by the Engineer prior to use.

The Contractor shall pay particular attention to his methods of working to prevent contamination of any kind to any watercourses or areas of the site as indicated by the Engineer. Any contamination shall be cleaned to the approval of the Engineer and at the Contractor's cost.

(d) Workmanship Standards for the Surface Preparation of Steel by blast cleaning, Abrading, Grinding and Cleaning

The surface profile to be achieved by blast cleaning, either 'Fine' 'Medium' or 'Coarse', as described in this Specification or described in the Contract, shall be within the limits set by the Surface Profile Comparator for the Assessment of Abrasive Blast Cleaned Surfaces, conforming to BS EN ISO 8503: Part 1: 1988.

Blast cleaned surfaces shall be virtually free from sharp spikes of the parent metal formed by the impact of abrasive particles and which project above the blast cleaning profile. Any of which require above that would be detrimental to the protective system shall be removed, as directed by the Engineer.

'Hackles' and inclusions caused by the rolling process , visible after blast cleaning , which would be detrimental to the protective system, shall be removed. Affected surfaces shall be prepared by grinding and abrading to 'bright steel' in compliance with Sub section 1021.14 (e)

Steel surfaces shall be prepared by any of the methods described in the Contract and shall be such that after surface preparation of the surfaces, they shall be free from 'harmful residues' or 'detrimental contamination'. Surface shall be deemed to be satisfied by this condition when in the opinion of the Engineer; any such remaining matter shall not reduce the required durability of the specified protective system.

Surface preparation by blast cleaning/abrading grinding shall be to one or more of the following standards of visual cleanliness:

(i) Sa 3 to BS 7079 - A1 :1989 (ISO 8501-1:1988)
(ii) Sa 2.5 to BS 7079 - A1 :1989 (ISO 8501-1-1988)
(iii) Sa 2 to BS 7079 - A1 : 1989 (ISO 8501-1:1988)

Additionally, after surface prepared by blast cleaning to Sa 3 or Sa 2.5 quality, the surface profile shall be virtually free from embedded abrasive particles when viewed through a X10 illuminated magnifying glass.

The Surfaces prepared by grinding or abrading shall have an overall bright appearance as determined by the Engineer and defined as 'Bright steel'.

Surfaces assessed by the Engineer, as unsatisfactory in this respect shall be cleaned again to the specified standards.

(e) Workmanship Standards for the Surface Preparation of Coated Steelwork by blast Cleaning, Abrading Grinding and Cleaning

In the opinion of the Engineer, before over coating, surfaces shall be free from;

i. Any visible gloss which may in the opinion of the Engineer, prevent adequate adhesion of the next coat

ii. Any unsound paint down to sound paint or bright steel

iii. Any unsound paint down to Sa3 or Sa2.5 quality steel.

iv. Any unsound paint down to bright steel

v. Any unsound paint down to sound metal coating

vi. Any unsound paint down to bright metal coating

vii. Any unsound metal coating down to sound metal coating

viii. Any unsound metal coating down to bright metal coating

ix. Any unsound metal coating down to Sa 3 or Sa 2.5 quality steel.

x. Any unsound metal coating down to bright steel

xi. Any detrimental contaminations

(f) Procedures for Treatment at Joints

(i) Fasteners, Joint Material and Parent Material in Joints, Before Assembly or Welding, in the Shops or on Site:

(a) Fasteners, Including Bolts, Nuts and Washers:

Surfaces of uncoated fasteners shall be free from all traces of oil or grease before assembly. Fasteners which have become difficult to tighten because of corrosion shall be replaced as instructed by the Engineer.

(b) Joint Material and Parent Material in Joints:

The standard of initial blast cleaning of joint material and parent material in joints shall be equal to that for the parent material. Before a joint is made on Site, contact surfaces shall be restored to clean steel, 2nd Quality medium profile and followed by the same protective coating as the parent material.

(c) At Joints Made with HSFG (High Strength Friction Grip) Bolts:

In steelworks painted only overall, the blast primer applied to the contact surfaces with maximum of 25 microns Dry Film Thickness (DFT). Other paint coats shall be applied 10 mm to 15 mm inside the perimeter of the joints. The outer surfaces and edges of the joint shall be applied a full protective coating.

In steelwork with thermally sprayed metal coatings at joints only, and painted overall, the metal spray shall be applied to the contact surfaces of the joints and to the other surfaces and edges of joint material. The metal spray on the contact surfaces of the parent material shall be taken 10 mm to 15 mm outside the perimeter of the joints. The blast primer applied to the parent material shall be taken 15 mm inside the

perimeter of the joints. The metal spray on the outer surfaces and edges of site joint material shall be given a coat of aluminium epoxy sealer (2 packs).

In steelwork with thermally sprayed metal coatings, overall and sealed only or painted overall, the metal spray shall be applied to the contact surfaces of the joints and to the outer surfaces and edges of joint material. The sealer applied to the parent material shall be taken 10 mm to 15 mm inside the perimeter of joints. The metal spray on outer surfaces of site joint material shall also be given a coat of sealer.

(d) At Welded Joints:

At shop and site joints in all steelwork, surfaces to be welded shall be restored to Sa 2.5 quality or to bright steel and shall be free of any protective or other coating immediately prior to welding.

(ii) Parent Material Shop Treatment Adjacent to Joints which are to be Assembled or Welded Later on Site:

(a) At High Strength Friction Grip Bolted Joints:

The paint coats with the exception of the primer or first coat of paint shall be stepped back at 30 mm intervals commencing 10 mm from the perimeter of the joints.

(b) At non Friction Bolted Joints

Unless otherwise described in the Contract, shop paint coats shall not be required to be stepped back.

(c) At welded joints

Thermally sprayed metal coating shall be kept clear of the weld by a distance of at least 15 times the thickness of the steel in the area to be welded, with a maximum of 300mm from the joint. The restricted area shall be masked during metal spraying. Hot dip galvanizing shall be removed a minimum of 15 mm back from the edge of the weld areas. Paint coats shall be stepped back at 30 mm intervals commencing at least 100mm from the joint, or from the edge of the thermally sprayed metal coating, starting with the 2^{nd} coat of paint.

(d) Surfaces of Fasteners:

Uncoated and temporarily coated fasteners shall be free from all oil and grease and blast cleaned to clean steel, Sa 2.5 Quality, before painting.

(e) Sealing at Joints or Plies:

Bolted joints or built-up sections shall be free from any water which has penetrated the plies. When drying out has been completed to the satisfaction of the Engineer or when surfaces are dry after surface preparation, fine gaps around the perimeter of joints or along plies shall be sealed by successive application of undercoat paint. All wider gaps shall be sealed with a proprietary sealant compatible with the primer or undercoats and approved by the Engineer.

(f) Sealing of Gaps at Nibs of Load Indicating Fasteners or Washers:

Unless otherwise agreed by the Engineer these gaps shall be sealed by brush application of primer and successive undercoats, of the types used on adjacent areas.

(g) Procedures for Treatment for at Areas of Mechanical Damage or Other Surface Defects

In the case of damage to paint coatings only, surface preparation shall be by abrading or by another method agreed with the Engineer. The paint coatings shall then be restored.

In the shop, a damaged metal spray coating, together with any damaged sealer or paint coats, shall be restored.

In all cases where paint coats are to be restored, the edges of paint coatings adjacent to the affected area shall be bevelled back into sound paint.

In the shops exposure and over-coating times shall not exceed those specified in Sub section 1021.15.(m) of this Specification.

On site, unless otherwise agreed by the Engineer, over-coating shall be started immediately after surface preparation of the affected area and continued as soon as each coat is dry enough for over- coating.

(h) Procedures for Treatment of Local Failure in Protective Coating

In the shops, failed paint coatings and failed metal sprayed coatings shall be restored. Abrading down to sound paint shall only be permissible. If a metal spray coating is damaged or reduced to less than 80% of the specified minimum thickness during abrading, it shall be restored.

On Site, failed paint coatings and metal sprayed coatings shall be restored using one of following methods of surface preparation when restoring paint systems over a steel substrate.

(i) abrading down to sound paint or to bright steel, or

(ii) blast cleaning to Sa 2.5 quality standards.

Restoration of protective coatings shall not be started until the standards of surface preparation, including the cleanliness of the surface, has been approved by the Engineer.

(i) Metal Coatings

(i) Hot Dip Galvanized Coatings:

Galvanised coatings shall, unless otherwise described in the Contract, comply with BS EN ISO 1461 : 1999. and with the following:

(a) The surfaces of components to be galvanised shall be dried before immersion in the molten zinc.

(b) Galvanised coating shall be virtually free from imperfections, including porosity, to the satisfaction of the Engineer.

(c) Vent holes drilled in hollow sections prior to galvanising shall be plugged to the satisfaction of the Engineer.

(ii) Thermally Sprayed Metal Coatings:

Sprayed metal coatings shall, unless otherwise described in the Contract, comply with BS EN 22063: 1994 and with following:

(a) The thickness of the coating shall be not less than 100 microns.

(b) The strength of the adhesion of thermally sprayed metal coatings shall not be less than the following:

Aluminium 50 kgf/cm^2
Zinc 50 kgf/cm^2

(c) The application of thermally sprayed metal in separate layers shall not be permitted.

(d) The surfaces to be thermally sprayed metal, including that of the reference panel having equivalent hardness to that of the parent material, shall be blast cleaned to the Sa 2.5 standards unless otherwise specified in the Contract.

(iii) Electroplated coatings:

Electroplated coatings shall, unless otherwise described in the Contract, comply with BS 3382 : part 2.

(j) Testing of Metal Spray Coatings

At the start of the work, and later at intervals as instructed by the Engineer (with the exception of coatings on steel in bearings, curved surfaces, repairs to mechanical damage, local failure of metal spray at site joints and areas restored on site), the Contractor shall demonstrate by means of a tensile test in accordance with BS EN 22063 that the minimum adhesion requirement is being attained as stated in Sub section 1021.14 (I) (ii)(b). The Contractor shall ensure that adhesion tests have been carried out satisfactorily before any further work continues unless otherwise approved by the Engineer.

(k) Paint or similar for Protective Coatings

Paint system or similar protective coatings and the relevant cleaning standards shall be in accordance with the Contract according to the durability requirements, accessibility for maintenance and environmental conditions relevant to the project.

All paints shall be supplied in sealed containers of not more than 25 litre capacity and these shall be used in the order of the delivery unless otherwise agreed with the Engineer. Each container shall be clearly marked on the side to show the name of the manufacturer, registered description of the material (including purpose, e.g. whether primer, undercoat or finish coat), colour, Item No, paint manufacturer's

reference number, batch number and date of manufacture. Where date of manufacture is coded, the Contractor shall provide the Engineer with the code key.

The Contractor shall ensure that the properties of the paints he has selected are suitable for the conditions in the shops and on Site, including temperature and humidity, and that he is able to apply the paints satisfactorily to all parts of the structure in these conditions.

All paints forming any one protective system or overlapping systems shall be obtained from the same manufacturer and shall be to the approval of the Engineer. The disposal of unused or empty paint containers shall be agreed with the Engineer.

(l) Storage Requirements and Keeping Periods for Paints

On delivery to the shops or Site, paint shall be unloaded directly into one or more secure paint stores. The Contractor shall implement any storage restrictions recommended by the paint manufacturer.

Unless otherwise agreed by the Engineer, paint which has not been used within the shelf life recommended by the manufacturer or 12 months with ever is lesser, shall be discarded and not used in Works.

Chemically or moisture cured paints shall not be used after the expiry of the Pot-life stipulated by the paint manufacturer. They shall be discarded on expiry of Pot-life or at the end of each working day whichever is the less. All other paints in opened tins or open containers including painters' kettles, shall be returned to store and kept in sealed containers

(m) Application of Paint

Paint shall be applied onto the surfaces which have been prepared and cleaned as described in this Section of the Specification or as per the Contract.

Unless otherwise described in the Contract a coat of paint in a system shall be applied by one of the following methods or specified by the paint manufacturer:

(i) Brush/Roller
(ii) airless spray
(iii) air pressure spray.

Paint shall not be applied under the following conditions:

(i) when the ambient temperature falls below 5°C or the relative humidity rises above 80% in an enclosed workshop or 90% on site;

(ii) during rain, fog, mist or in a dust laden atmosphere;

(iii) when the amount of moisture likely to be deposited on the surface by condensation or rain before or after painting, may have a harmful effect on the paint.

(iv) when wind-borne dust may have a harmful effect on the paint.

All shop painting of steelwork shall be carried out in a fully enclosed workshop unless otherwise agreed by the Engineer.

Before starting the procedure trials described in Sub section 1021.14.15 of this Specification and as required by the Engineer, the Contractor shall furnish the Engineer with details of the overall wet film thickness for each coat he proposes to apply. He shall also provide information as to the total amount of paint he expects to use for each coat of each system for which procedure trials are required. The calculation of the amount of paint to be used shall be based on the volume of solids plus an allowance for waste.

The following requirements on paint film thicknesses shall apply;

Wet film thickness gauges shall be used where practicable to check that the wet film thickness is not less than:

$$\frac{\text{minimum dry film thickness (mdft)} \times 100}{\text{volume solids \%}}$$

During the application of a paint system the Contractor shall ensure that the progressive total thickness of the applied coats will allow the specified minimum total dry film thickness (Dft) of the system to be attained without exceeding, overall proposed wet film thicknesses by more than 20%.

In no case shall the total dry film thickness (Dft) of a paint system or the mean Dft of the last undercoat or finish be less than that specified.

The local dry film thickness for any primer shall not exceed the specified mean DFT by more than 30% and for other paints by more than 75%.

Each coat of paint of a specified system shall have satisfactory adhesion as demonstrated by an adhesion test approved by the Engineer.

The finished system shall have an even and uniform appearance. When required by the Engineer, the degree of gloss of a finishing coat shall be agreed before the procedure trials. A painted thin plate reference panel, 150 mm x 100 mm, shall be provided by the Contractor for this purpose.

Two pack chemically cured paints shall not be applied when the steel or ambient temperatures are below those advised by the paint manufacturer, nor shall such paints be applied when the temperature is likely to fall below the advised temperatures during the curing period.

Stripe Coats:

Unless otherwise described in the Contract two stripe coats (Hand Brush) using undercoat paint shall be applied to all welds and all fasteners including washers and to all sharp edges and external corners

Exposure Times for Prepared Steel Surfaces and for metal coatings

Unless otherwise specified in the Contract, exposure times for the prepared steel surfaces shall be as per paint manufacturer's instructions. In all other cases following shall be used.

(i) Clean steel prepared by dry blast cleaning or bright steel prepared by abrading or by grinding shall be primed within 4 hours.

(ii) Clean steel prepared by wet blast cleaning only, shall be primed within 4 hours of being dry enough for painting.

(iii) Clean steel prepared by combined wet/dry blast cleaning shall be primed within 4 hours of dry blast cleaning.

(iv) Steel or steelwork blast primed at the mills or in the shops shall be over coated within 8 weeks. The primed surfaces shall only be exposed outside for a maximum of 2 weeks of the 8 week period. Prepared surfaces affected by detrimental contamination or corrosion which in the opinion of the Engineer will reduce the required durability of the protective system shall be restored by the Contractor when required by the Engineer.

(v) Shop steelwork which has been thermally metal sprayed shall be primed and sealed within 4 hours. The next coat shall be applied within 72 hours.

(vi) Shop prepared steel surfaces, unsealed metal spray coatings and undercoats, except final shop undercoat, shall not be exposed outside the shop.

(vii) A first shop undercoat shall be over coated within 72 hours. Unless otherwise agreed with the Engineer, further shop coats shall be applied within 72-hour intervals per coat.

(viii) The application of sealant in gaps, in compliance with Sub section 1012.4 of this Specification, may be carried out either before or after application, as appropriate, of the first coat of paint to be applied to the completed joints or assembled plies.

(ix) Prepared steel surfaces and metal sprayed coatings which have been restored and paint coats which have been prepared after surface damage or deterioration shall be over coated with the sealer primer or first undercoat as appropriate before the surfaces have been affected by moisture and in any case within 4 hours.

(x) On Site, steel surfaces and metal sprayed coatings shall be primed within 4 hours and shall have the following coat applied within 72 hours unless otherwise agreed with the Engineer. The next coat shall be applied within a further 72 hours unless otherwise agreed with the Engineer.

(n) Procedure Trials

Unless otherwise described in the Contract the Contractor shall carry out shop and site procedure trials of the protective system when more than 50 litres of any coat of paint are to be applied to 'Difficult access' Bridge Steel works.

The procedure trials shall be completed at least ten days before the start of application of the systems on the main steelwork. The trials shall be carried out with the labour and equipment to be used for the work.

The Contractor shall provide for the shop trials, samples of steel from 2 m^2 to 10 m^2 representing the main steelwork, as required by the Engineer.

Metal sprayed application and painting of the main steelwork shall not be started in the shops or on Site until procedure trials have been completed to the satisfaction of the Engineer.

Unless otherwise agreed by the Engineer the Contractor shall carry out further procedure trials whenever he employs replacement skilled labour or proposes to use equipment of a different type.

(o) Storage and Transport of Steel and Fabricated Steelwork

Steel awaiting fabrication for the Works and uncoated steelwork shall be adequately protected from contaminants liable to cause heavy rusting and possibly pitting of the surfaces.

Steelwork shall not be loaded for transport until the paint system is sufficiently hard for handling.

During storage, steelwork shall be kept clear of the ground and shall be laid out or stacked to prevent water or dirt accumulating on or against any of the surfaces. Suitable packing shall be placed between layers of stacked steelwork. When cover is provided it shall be ventilated sufficiently to keep condensation to a minimum.

Components weighing less than one tonne shall be kept in a storage area away from their erection point in order to minimise damage to protective coatings.

If in the opinion of the Engineer, damage to coatings is excessive, or may be difficult to deal with satisfactorily after erection, the Contractor shall restore the coatings before erection.

(p) Surfaces in Contact with Concrete

Unless otherwise described in the Contract, thermally sprayed metal coating all shop paint coats shall be returned 25 mm into the concrete/steelwork contact area.

(q) Access and Lighting

The Contractor shall provide access for inspection by the Engineer. The access shall be agreed with the Engineer as being adequate in all respects for inspection purposes.

Manual surface preparation and coating application work shall only be carried out in good lighting. When the light intensity is inadequate the Contractor shall install and maintain temporary lighting at the workface during the work and for inspection when required by the Engineer.

1021.14/1 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards and acceptance.

1021.15 Measurement and Payments

(a) Fabrication of Structural Steelwork

Measurement

Unless otherwise specified, the unit of measurement shall be the computed by weight in tonnes of the finished member comprising plates, rolled sections, shear connectors, stiffeners, cleats, packs, splice plates and all fittings, without allowance for tolerances for rolling margin and other permissible deviations from standard weights or nominal dimensions, and excluding the weights of welds, bolts, nuts, washers, rivets and protective coatings. No deductions shall be made for notches, cope holes, bolt and rivet holes, and the like; which are each less than 0.03 Sq.m.

The computed weight of rolled and cast steel and cast iron shall be determined from the dimensions shown on the Drawing on the following basis:

rolled or cast steel, 7850 kg/m³;

cast iron, 7210 kg/m³

Deck panels shall be measured separately only when the deck panel is not integral with the main member. Bracings, external diaphragms and the like shall be measured separately as subsidiary steelwork only when they are not integral with main members or deck panels.

Main members and deck panels shall be inclusive of connectors, stiffeners, internal diaphragms and other integral components.

Payment

The unit rate for payment shall include full compensation for the procuring and furnishing all materials required for examining and checking steel plate for segregation, laminations, cracks and surface flaws and carrying out any remedial measures required by the Engineer in respect of such defects; cutting, marking off, drilling, notching, machining, treatment of outside arises, smoothing to slopes, form fitting, end and edge preparation and cambering; riveting, bolting, assembling and pre-heating, welds; packing plates, rivets, bolts (including hold down bolts), nuts and washers required to fabricate and to complete the erection and installation on Site, together with spares and service bolts, drifts, draw up cleats and the like specified in BS 5400: Part 6; pre-production procedural trials; approval of welders; destructive and non-destructive production testing of welding, rivets and shear connectors; allowance for rolling margins and other permissible deviations; checking of deviations in rolled and built-up sections and of alignment at joints, including taking measurements and observations and recording and supplying one copy of the records to the Engineer; preparation and supply of marked erection Drawings, marking members for identification and delivery in matching sequence and any other methods and incidentals necessary to complete the work as specified.

(b) Trial Erection of Structural Steelwork

Measurement

Unless otherwise specified, the unit of measurement for trial erection of structural steelwork shall be the tonne as described in Sub section 1021.15 (a) of this Specification.

Payment

The unit rate of payment shall include for temporary bracing or stays to prevent displacement including the provision and removal of temporary attachments; proving dimensions, cambers and profiles and alignment of joints; match-marking members as required for permanent erection; dismantling; modifications and refitting of members as a result of the trial erection; bolts, nuts, washers, sockets, Base plates, anchorage assemblies, drilling or forming holes and pockets and casting in and any other methods and incidentals necessary to complete the work as specified.

(c) Permanent Erection of Structural Steelwork

Measurement

Unless otherwise specified, the unit of measurement for permanent erection of structural steelwork shall be in tonnes as described in Sub section 1021.15(a) of this Specification

Payment

The unit rate of payment shall include for temporary bracing or stays to prevent displacement including the provision and removal of temporary attachments; approval of welders, welding procedural trials; permanent bolted and welded connections including the provision of preheat and shelters for welding; checking of deviations of rolled and built-up sections and of alignment at joints, including taking measurement and observations and recording and supplying one copy of the record to the Engineer; drilling or forming holes and pockets and casting in bars, sockets, Base plates and anchorage assemblies; adhesives and epoxy or polyester mortar, bedding mortar or grout and any other methods and incidentals necessary to complete the work as specified.

(d) Protective Treatment of Steelwork

Measurement

Unless otherwise specified, the unit of measurement shall be the surface area to be treated in Sq.m and as accepted by the Engineer.

Payment

The unit rate of payment shall include for despatching paint samples to testing authority; shop procedural trials; site procedural trials; masking and other measures to protect adjacent untreated steelwork and the removal of masking and other protective measures upon completion; joint fillers and treatment of joints; preparing materials for application; preparation of surfaces and coating of steelwork at the place of fabrication and on Site; complying with any special requirements in respect of ambient conditions for the application of protective treatment and for intervals between successive operations and applications; stripe coats; obtaining the correct dry film thickness of paint or other coating; preparation and supply of system and data sheets; access and illumination for inspection and any other methods and incidentals necessary to complete the work as specified.

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
1021(1)	Fabrication of Structural Steelwork	Tonnes
1021(2)	Trial Erections of Structural Steelwork	Tonnes
1021(3)	Permanent Erections of Structural Steelwork	Tonnes
1021(4)	Protective Treatments of Steelwork	Sq.m

1100 MAINTENANCE OF BITUMEN SURFACED CARRIAGEWAY

1101 COLD MIX FOR PATCHING

1101.1 Description

The work shall consist of the preparation of patch mixes for patching potholes, ruts, depressions, etc., in accordance with these Specifications or as directed by the Engineer.

1101.2 Materials

The provision of Sub section 507.2 shall apply.

1101.3 Proportioning of aggregate and binder

The combined aggregate used shall be of the dense graded type and mix proportioning shall be carried out as given in Sub section 507.3(a). Where approved, the volume batching may be carried out, as given therein.

1101.4 Work requirements

(a) Preparation of the mix using cut back bitumen

The preparation of the mix using cut back bitumen shall be carried out as given in Sub section 507.3 (b).

(b) Preparation of the mix using emulsion CSS-1 & CSS-1h

The preparation of mix using emulsions shall be carried out as given in Sub section 507.3(c).

(c) Stockpiling of mix

Stockpiling of mix shall be carried out as given in Sub section 507.4.

(d) Quality Control

The control on the quality of materials and works shall be exercised in accordance with Section 1602.

1101.5 Measurement and Payment

(a) Measurement

The quantity of cold mix for patching that have been accepted by the Engineer, shall be measured in Cu.m in the loose state/ or by weight in tonnes using a weigh bridge or any other acceptable device.

(b) Payment

The payment shall be based on the Contract unit rate for the item, which shall include full compensation for providing all materials, equipment, machinery, tools and incidentals necessary to prepare the cold mix according to these Specifications. The

rate shall also include the cost of transporting to and stockpiling of the cold mix at designated locations.

The pay items and pay units shall be as follows:-

Pay Item	Description	Pay Unit
1101 (1)	Cold mix for patching (State type of binder)	Cu.m
	OR	
1101(2)	Cold mix for patching (State type of binder)	Tonnes

Note: refer Sub section 106.6 regarding sub divisions of Pay item.

1102 PATCHNG POTHOLES

1102.1 Description

This work shall consist of patching potholes on Pavements in accordance with these Specifications using such combinations of materials as described herein, depending on their depth and also on the availability of material in accordance with these Specifications and as directed by the Engineer. For extreme situations, Section 1105 shall be referred to.

For the purpose of these Specifications, potholes shall be referred to as shallow when they are less than 20 mm in depth, of medium depth when the depth is between about 20 mm and 75 mm, and as deep when the depth is in excess of about 75 mm as visually observed by the Engineer.

1102.2 Materials

(a) Cold mix used for patching shall conform to the requirements of Section 1101

(b) Aggregates used for patching medium and deep potholes shall be crushed stone aggregates of nominal single sizes, 50 mm, 37.5 mm and 20 mm and 14 mm or crushed stone graded aggregates of nominal maximum sizes, 37.5 mm and 20 mm conforming to the general requirements of Sub section 1701.3 (a) and grading requirements given in Tables 1701-4 and 1701-5 respectively of Sub section 1701.3(b).

(c) Aggregates used for patching shallow potholes shall be usually single sized, 14 mm , 10 mm and 6.3 mm conforming to the general requirements of Sub section 1701.3 (a).

(d) Binder shall be 80-100 penetration grade bitumen to Sub section 1702.1, cut back bitumen to Sub section 1702.2 and bituminous emulsion to Sub section 1702.3, as specified.

(e) Gravelly soil as infill for water bound gravel macadam to Sub section 1708.6.

(f) Blotting (blinding) material shall be sand or non plastic gravels to Sub section 1701.4.

1102.3 Work Requirements

(a) Shallow potholes (about 20 mm and less in depth) Using hot bitumen and single sized aggregate

Unless otherwise directed, these potholes shall be patched adopting a method similar to seal coat treatment (SBST or DBST) as given in section 505 A&B, normally using hot bitumen and single sized aggregate of sizes 20 mm, 14 mm, 10 mm or 6.3 mm.

The bitumen shall be heated to the temperatures specified in Sub section 503.3 and where practicable, the aggregate shall be washed, clean and dried prior to application.

Prior to application of the hot bitumen the edges of the potholes shall be cut and the potholes brushed free of dust and other particles.

The approximate rates of application of binder and the aggregate shall be as given in Table 1102-1. These rates, however, shall be used as a guide only as the actual rates could vary depending on the site conditions.

The decision regarding the type of treatment (SBST or DBST) and the sizes of aggregates to be used shall depend on the depths of the potholes.

This work may be carried out using cutback bitumen or emulsions as binder provided the Engineer's prior approval is obtained for the same. The rates of application of the binder, in which case, shall be suitably adjusted.

Table 1102-1 - Approximate rates of application of binder and aggregate for patching shallow potholes:

Nominal Single Size of aggregate in mm	Rate of Application Aggregates cu.m. per 100 sq.m	Binder litres/sq.m.
20	1.7 to 2.1	1.35 to 1.60
14	1.3 to 1.6	1.0 to 1.35
10	0.9 to 1.3	0.85 to 1.2
6.3	0.7 to 1.0	0.70 to 1.0

(b) Potholes of medium depth (about 20 mm to 75 mm)

(i) Using cold mix

The edges of potholes shall be cut to a near vertical shape, unless the engineer decides otherwise, without unnecessary dislodgement of aggregate and the potholes shall be cleaned of all loose material.

Where practicable, the potholes, after cleaning shall be wetted and allowed to dry.

Unless otherwise directed, a tack coat of emulsion shall be uniformly applied at an average rate of 0.75 litres per Sq.m. The tack coat may be of a cut back or of hot bitumen if so approved.

The pothole shall then be uniformly filled with the already prepared premix material sufficiently proud of the adjoining surface to allow for compaction. The patch shall be compacted either by a hand tamper or by use of a light roller or by other means as approved by the Engineer. The patched areas shall be left slightly proud of the surrounding surface to allow for further compaction by traffic. A thin layer of coarse sand, crusher dust or gravel of approved quality shall then be spread over the patched area so as to prevent the premix material from being picked up by traffic.

Care shall be taken to ensure that premix material for patching is transported to the required places on the road before commencing the patching operation. The premix shall not be left unused on the road side for more than 12 hours and it shall be ensured that only the day's requirement of premix material is transported to site.

(ii) Using aggregate and hot bitumen

When cold mix is not available, the pothole shall be filled using aggregate. The size of aggregate used shall depend on the depth of the pothole and shall consist of single sized or graded aggregate as given in Sub section 1102.2. When single sized aggregate is used, ideally, the aggregate shall form a layer of two stones thick.

The aggregate packed into the pothole shall be compacted by hand tamper or by light roller or such other means approved by the Engineer. Also where single sized aggregate of 50 mm or 37.5 mm are used, the top interstices shall be filled using choker stone either of 20 mm or of 14 mm, as appropriate and compacted again.

Hot bitumen shall then be spread at a rate of about 2.0 l/m^2 and the surface shall immediately be covered with blotting material at the rate of about 8 cu.m./1000 sq.m. . Use of cutback or emulsion, as binder shall be previously approved by the Engineer.

(c) Deep potholes (deeper than 75 mm)

(i) Using gravelly soil (if necessary), aggregate and cold premix.

The edges of the potholes shall be cut vertically, unless the Engineer decides otherwise, and the loose and unstable material removed by brushing. Any depth of potholes below the existing Base shall be filled using gravelly soil. The soil shall be compacted at or near the optimum moisture content using a hand tamper or any other means approved by the Engineer.

Then either single sized or graded aggregate shall be laid to a level approximately 40 mm below adjoining surface and shall be well compacted either by a hand tamper or by any other means as approved by the Engineer. When single sized aggregate is used, ideally the aggregate shall form a layer two stones thick. When graded aggregate is used. Ideally the nominal maximum size of aggregate shall be less than one-half of the thickness of the layer.

The remaining depth of the pothole shall be filled as given in Sub section 1102.3b (i).

(ii) Using gravelly soil (if necessary), aggregates and hot bitumen

This work shall be carried out in the same manner as for potholes of medium depth as given in Sub section 1102.3 b (ii), except that any depth of pothole below the existing Base shall be filled using gravelly soil as given in Sub section 1102.3 c (i).

(iii) Using water-bound gravel macadam with or without a seal coat topping, as a wet weather measure

The edges of potholes shall be cut vertically down to sound material, unless the Engineer decides otherwise and shall be cleaned of all loose and unstable material. The pothole area shall be roughened by using pick axes in respect of smaller areas or by scarifying in respect of larger areas. The loose stone aggregate shall then be taken out and the worn out and rounded stone aggregate shall be discarded. The useful stone aggregate shall be refilled into the pothole along with fresh 50 mm or 37.5 mm stone aggregate to the level of the carriageway and shall be compacted with hand tampers, in respect of small areas, or with a light roller or such mechanical means as directed in respect of larger areas.

Gravel of approved quality, with low plastic clay content, shall then be spread to a thickness of 25 mm to 40 mm and tamped or rolled simultaneously watering the surface. The road shall then be opened to traffic.

After a period of time, during dry weather conditions, the surface shall be brushed clean of all soil and gravel on the surface using wire brushes and bass brooms, so that the stone aggregate is exposed. The surface shall then be patched adopting the Specifications for single coat surface dressing as specified under paragraph 1102.3 (a).

Where applicable, prior to the application of surface dressing, the surface shall be watered and allowed to dry or the surface shall be sprayed with a diluted emulsion as directed.

1102.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1102.4 Measurement and Payment

a) Measurement

Measurement of correction of potholes, etc., that have been accepted by the Engineer, shall be carried out by one of the following alternative methods specified.

Alternative 1

For all items of work described in this section, the materials used and the work done shall be measured separately, as given below.

The binder used shall be measured in litres . The aggregate, soil and blotting material used shall be measured in Cu.m. The cold mix shall be measured in Cu.m. The work done in patching shall be measured as finished work in Sq.m.

In patching potholes, shallow, medium and deep potholes shall be measured separately.

Alternative 2

Where extensive patching has to be done and in the opinion of the Engineer, measurement by area is not practicable, the work shall be measured based on the quantities of the material used.

b) Payment

Alternative 1

The payment for the materials will be based on the Contract unit rate for the items, which shall include full compensation for the supplying of the material at site.

The payment for the work done in patching using material supplied shall be based on the Contract unit rate for the items which shall include full compensation for providing all labour, machinery, equipment, tools and all other incidentals necessary to complete the patching work to Specifications.

Alternative 2

The payment for the patching will be based on the Contract unit rate for each type of material and shall include full compensation for providing the materials, labour, machinery, equipment, tools and all other incidentals necessary to complete the work to the Specifications.

The Pay Items and Pay Units shall be as follows :-

Pay Item	Description	Pay Unit
Alternative 1		
1102 (1)	Binder (state type and grade)	Litres
1102 (2)	Cold mix	Cu.m
1102 (3)	Aggregate (state size)	Cu.m
1102 (4)	Soil (state type)	Cu.m
1102 (5)	Blotting material	Cu.m
1102 (6)	Patching of potholes, using materials supplied (state whether shallow, medium or deep)	Sq.m
Alternative 2		
1102 (7)	Binder (state type and grade) inclusive of work	Litres
1102 (8)	Cold mix inclusive of work	Cu.m
1102 (9)	Aggregate (state type) inclusive of work	Cu.m
1102 (10)	Soil (state type) inclusive of work	Cu.m
1102 (11)	Blotting material inclusive of work	Cu.m

Note : Refer sub section 106.6 regarding sub divisions of Pay items.

1103 EDGE CORRECTION

1103.1 Description

This work shall consist of carrying out repairs and restoring the damaged edges of existing road Pavements in accordance with these Specifications, and as directed by the Engineer. For extreme situations, Section 1105 shall be referred to.

For this work, two alternatives are specified, which in their adoption shall be related to the importance of the road; both in terms of the class of road and traffic. (These alternatives, however, may have to be reviewed by the Engineer in situation of poor Subgrade conditions and for roads where the traffic is in excess of about 2000 vehicles per day.)

1103.2 Materials

The materials used shall conform to the requirements of the following, unless otherwise specified.

(a) Cold mix to Section 1101.

(b) General requirements of aggregates of nominal single size, 100 mm , 50 mm , 37.5 mm , 20 mm and 14 mm or blended aggregate 37.5 mm and 20 mm maximum size, shall be to Sub section 1701.3 (a).

The size requirements of 100 mm aggregate shall be as given in 1701.3, and the grading requirements of the other aggregates shall be as given in Table 1701-4 and 1701-5 respectively of Sub section 1701.3 (b).

(c) Binder shall be 80-100 penetration bitumen or emulsion to Section 1702.

(d) Blotting (blinding) materials to Sub section 1701.4.

1103.3 Work Requirements

(a) General

The general procedure adopted requires excavation of the edge to be corrected to form a small trench. In the alternative 1, which is more suited for relatively heavy traffic the overall depth of the trench shall be 225 mm where as in the alternative 2, which is essentially meant for roads with low traffic, the overall depth of the trench shall be 125 mm . The nominal width of both cases shall be minimum 225 mm .

To start with, the outer edge of the area to be corrected shall be demarcated by stretching a string or by other means approved by the Engineer. After excavation for the trench along the demarcated edge as specified, and after suitably trimming the damaged edge of the carriageway to a regular shape as directed, all loose and soft materials in the area in between shall be removed. Then the trench along with the rest of the area to be corrected shall be wetted, allowed to dry up as required, and compacted to an even finish using hand tampers and other approved means.

(b) Alternative 1

In the 225 mm deep trench, a bottom layer of 100 mm aggregate shall first be closely packed with hand laying. Smaller aggregate, 50 mm down grade, shall be added to close the gaps where necessary and the whole layer compacted using a hand tamper. Over this layer a 50 mm aggregate shall then be spread to two stones thick. The rest of the area shall also be spread with a two stone thick layer of aggregate of the appropriate size: 50 mm, 37.5 mm, 28 mm or a combination of these sizes as permitted by depth availability, so that the whole of the aggregate layer after compaction shall be 40 to 50 mm below the level of the adjoining road surface, giving due consideration to the camber of the existing surface. The compaction of this aggregate layer shall be carried out using small vibrating rollers, hand rammers or other approved means, as appropriate.

Over the compacted aggregate shall then be laid a cold mix layer, prepared as given in Section 1101, sufficiently proud of the surface so that when rolled with an 8 –10 tonne steel wheeled roller, the layer will be flush with the existing surfaces and conforming to the requirements of camber and levels of the existing road.

Where cold mix is not available the entire depth above the 100 mm aggregate layer shall be filled either with single sized aggregate of appropriate size fractions or with graded aggregate of nominal maximum size 37.5 mm.

Where single sized aggregate is used there shall not be more than 3 spreads (thickness equal to the nominal single size) nor less than 2 spreads of aggregate. This layer shall be compacted using an 8-10 tonne roller to required levels as necessary. The surface interstices shall be choked with 20 mm or 14 mm aggregate as appropriate. All work shall generally be carried out to details given in Section 403.

Where graded aggregate is used, care shall be exercised to prevent segregation, during spreading of the aggregate. The layer shall be compacted using an 8-10 ton roller, as necessary. All work shall generally be carried out to details given in Section 405.

These compacted surfaces shall be prepared prior to the application of a surfacing by wetting and lightly brushing the surface clean of loose material and dust.

Unless otherwise directed, the single sized aggregate layer shall be surfaced using first and second coat hot bitumen treatment as per Section 503.

The surfacing for the graded aggregate layer shall be first and second coat hot bitumen treatment as above if the aggregate is sufficiently open graded as visually observed or shall consist of a prime coat as per Section 501 and a sand seal or seal coat as per Section 504 or 505 respectively, if the aggregate is dense graded, unless otherwise directed.

(c) Alternative 2

The procedure adopted for alternative 2 with 125 mm deep trench at the edge, shall be exactly similar to that of alternative 1, except for the absence of 100 mm aggregate bottom layer.

1103.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1103.4 Measurement and Payment

(a) Measurement

For edge correction, the materials used and the work done that have been accepted by the Engineer shall be measured separately as given below.

The binder used shall be measured in litres. The aggregate, soil and blotting material used shall be measured in cubic metres as supplied. The cold mix shall be measured as given in Section 1101.

The work done in edge correction shall be measured as finished work in Sq.m.

(b) Payment

The payment for the materials shall be based on the Contract unit rate for the item, which shall include full compensation for stock piling, transport of materials, local transport, if any, in the supplying of the materials at designated locations.

The payment for the work done in edge correction shall be based on the Contract unit rate for each item and shall include full compensation for providing all labour, machinery, equipment, tools and all other incidentals necessary to complete the work to Specifications.

The Pay Items and Pay Units shall be as follows :

Pay Item	Description	Pay Unit
1103 (1)	Binder (state type and grade)	Litres
1103 (2)	Aggregate (state size)	Cu.m
1103 (3)	Soil (state type)	Cu.m
1103 (4)	Blotting material	Cu.m
1103 (5)	Edge correction using available material (State nominal depth of trench)	Sq.m

Note : Refer sub section 106.6 regarding sub divisions of Pay items.

1104 PATCH SEALING (LOCAL SEALING)

1104.1 Description

This work shall consist of sealing patches of the road surface that are:

(a) Lacking in bitumen and/or where hair cracks exist.

(b) Pitted with numerous small potholes.

(c) Having streaking (Broad lines devoid of binder on road surface after application with a binder distributor when its spray bar nozzles are clogged) at initial stages on a seal coat (SBST or DBST) treated road.

All work shall be carried out in accordance with these Specifications and as directed by the Engineer.

1104.2 Materials

Materials used shall conform to the requirements of the following, unless otherwise specified.

(a) Binder shall be 80-100 penetration bitumen or bituminous emulsion to Section 1702.

(b) Sand for sand-binder mix to Sub section 1701.5.

(c) Blotting (blinding) material to Sub section 1701.4.

1104.3 Work Requirements

(a) Surface patches lacking in binder

These surface patches shall be applied with a coating of binder and immediately covered with the blinding material. However, prior to binder application, the surface shall be brushed clean of all extraneous matter and dust.

The binder used shall be hot bitumen or a rapid setting emulsion (CRS-1 or CRS-2) unless otherwise specified, and shall be applied using a mechanical sprayer or using a hand can at the rate of about 0.5 to 0.75 1/m2 . Where hand cans are used for applying, the binder shall be squeegeed as necessary.

The blinding or blotting material shall be spread at the rate of about 0.08 $m^3/10m^2$.

(b) Surface patches pitted with numerous small potholes

Surface patches that are pitted with numerous small potholes shall be covered as necessary with a sand binder mix and compacted as required. Prior to in-filling, however, the surfaces shall be brushed clean of extraneous matter and dust.

The mix shall either be a hot mix of bitumen and sand (1:8) or slurry of slow setting emulsion and sand (1:6).

If hot mix type is specified, sand and the bitumen shall be separately heated to the specified temperatures and mixed on site in a suitable mixer or manually as directed by the Engineer.

The mixed material shall be spread uniformly to completely cover the small potholes and compacted using hand tampers or a suitable roller. The quantity of bitumen added to the mix shall be about 7.5 percent by weight of sand (97 l/ Cu.m). The mixed material shall be spread and compacted before the temperature falls below about 110^0C.

If a slurry seal of slow setting emulsion (CSS-1 or CSS-2) and sand is to be used, they shall be mixed in a suitable mixer or by other approved means.

The quantity of emulsion added shall be about 10 percent by weight of sand (130 l/Cu.m) and where required, an equal amount of water on the emulsion shall also be added prior to mixing. The mixed material shall be spread without delay using a squeegee or other suitable means.

(c) Streaking on a seal coat(SBST or DBST) treated road

Surface areas that show signs of streaking and areas where aggregate particles begin to dislodge, shall be marked. Then they shall be brushed clean of all extraneous material and dust. These areas shall be applied with a coating of binder and immediately covered with blinding material.

The binder used shall be hot penetration grade bitumen or a rapid setting emulsion (CRS-1 of CRS-2) unless otherwise specified, and shall be sprayed using a mechanical sprayer or applied using a hand can at a rate of about 0.5 to 0.75 l/m2. Where hand cans are used for applying the binder, the material shall be spread evenly with squeegees as necessary.

1104.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1104.4 Measurement and Payment

a) Measurement

Patch sealing shall be measured as finished work in Sq.m. The operations (a), (b) and (c) under 1104.3 shall be measured separately.

b) Payment

The payment shall be based on the Contract unit rate for the items and shall be full compensation for providing all materials, labour, transport, equipment, tools and incidentals, necessary to complete the work to Specifications.

The Pay items and pay units shall be as follows:

Pay Item	Description	Pay Unit
1104 (1)	Patch sealing using binder only including Blinding with sand (state type and grade)	Sq.m
1104 (2)	Patch sealing using sand binder mix (State whether mix is sand, penetration grade Bitumen or emulsion slurry).	Sq.m

Note: Refer Sub section 106.6 regarding sub divisions of Pay items.

1105 LOCAL RESTORATION OF ROAD PAVEMENT

1105.1 Description

This work shall consist of restoring the road Pavement that is in extreme condition of

(a) Alligator cracking
(b) Ruts and Depressions
(c) Edge subsidence and ravelling
(d) Edge surface failure
(e) Large pot holes
(f) Shoving and such are beyond repair as given in Section 1102 &1103.

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

1105.2 Material

Material used shall conform to the requirements of the following, unless other wise specified.

(a) Binder shall be 80 – 100 pen to section 1701.1 or bitumen emulsion to Sub section 1701.2

(b) Sand for sand binder mix to Sub section 1701.5

(c) Blotting (Binding) material to Sub section 1701.9

(d) General requirements of aggregate of normal single size 100mm, 50 mm, 37.5 mm, 20 mm or graded aggregate 37.5mm and 20 mm maximum size shall be to Sub section 1705.5(a) the size requirement of 100 mm aggregate shall be as given under Sub section 1701.3 (c) and the grading requirement of the aggregate shall be as given in Tables under Sub section 1701.3(b)

(e) Cold mix used conforming to requirements of Sub section 1101.

(f) Gravely soils as infill for water bound /dry bound macadam gravel to Sub section 1708.6

1105.3 Work Requirements

The area of distress shall be marked out and the edges cut to a near vertical shape. The depth of excavation shall be increased until firm material is found and then the walls of the hole shall be dressed so that they are nearly vertical. All loose material shall be removed within the marked out area. The bottom of the hole shall be dressed and compacted, such that it shall be flat.

Any depth of excavation below the existing Base shall be filled using gravely soil Sub-base material as in Section 401. The soil shall be compacted at or near the optimum moisture content using, a vibrating roller or rammer depending on the size of excavation or by any other means approved by the engineer.

Then either graded aggregate or two spreads (thickness equal to the nominal single size) of single size aggregate shall be laid to a level approximately 40 mm below the adjoining road surface and shall be well compacted either by Vibrator roller, vibrating rammer or any other means as approved by the engineer. When single

size aggregate is used, ideally the aggregate shall form a layer of two stones thick. When graded aggregate is used, ideally the nominal maximum size of aggregate shall be less than one half of the thickness of the layer.

Then the balance left shall be filled as given in Sub section 1102 .3 (b) (i)

1105.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1105.4 Measurement and payment

(a) Measurement

Measurement of local restoration that have been accepted by the Engineer shall be carried out by one of the alternatives given below.

Alternative 1

For all items of work described in the section, the material used and work done shall be measured separately as given below.

The binder used shall be measured in litres. The aggregate, soil and blotting material used shall be measured in Cu.m. The cold mix shall be measured in Cu.m or tonnes. The work done in local restoration shall be measured as finished work as Sq.m.

Alternative 2

In large scale work when local restoration is extremely spread out measurement by quantities is not practicable, the work shall be measured as finished work in Sq.m.

(b) Payment

Alternative 1

The payment for materials shall be based on the Contract unit rate for the items which shall include full compensation for the supplying of material at site.

The payment for patching shall be based on the Contract unit rate for the items which shall include full compensation to provide all labour, machinery, equipment, tools and all other incidentals necessary to complete the patch work with available material to the Specification.

Alternative 2

The payment for local restoration based on unit area and shall include full compensation for providing the materials, labour, machinery, equipment, tools and all other incidental necessary to complete the work to the Specifications.

The pay items pay unit shall be as follows:

Pay Item	Description	Pay Unit
Alternative 1		
1105 (1)	Binder (State type/grade)	Litre
1105 (2)	Cold Mix	Cu.m
1105 (3)	Aggregate (State type)	Cu.m
1105 (4)	Soil (State type)	Cu.m
1105 (5)	Blotting material	Cu.m
1105 (6)	Local Restoration using material Supplied	Sq.m
Alternative 2		
1105 (7)	Local restoration including material supply	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1106 CRACK SEALING

1106.1 Description

This work shall consist of repair of surface cracks in the Pavement, whether they are longitudinal, transverse or alligator cracking, which are not associated with subsidence.

All the works shall be carried out in accordance with these Specifications or as directed by the engineer.

1106.2 Material

Material used shall conform to the requirements of following, unless otherwise specified.

(a) Binder shall be bituminous emulsion CRS-1 to Section 1702

(b) Sand to Sub section 1701.5

(c) Blotting (Binding) material to Sub section 1701.4

1106.3 Work Requirement

(a) Cracks which are up to 3 mm width

The cracks to be sealed shall be brushed and cleared of all extraneous material and dust. Then cracks shall be filled with slow setting emulsion. CSS-1 diluted 1:1 with water at the rate of 1liter/m^2.This shall be carried out using a spray lance or watering can with the sprayer to follow the line of cracks. The nozzle of the spray tank or the spout of the watering can shall be held close to the road surface. The width of the spread shall be kept as small as possible. After the emulsion dries out this procedure shall be repeated with rapid setting emulsion CRS-1 applied at the rate of 1liter/m^2 and blinded with coarse sand. The blinding or blotting material shall be spread at the rate of about 8 Cu.m per 1000 Sq.m.

(b) Cracks which are of 3 to 20 mm width.

The area to be repaired shall be brushed and cleaned of all extraneous matter and dust and the area to be repaired marked out. The marked out area shall be spread with sand binder mix using squeegee. The material shall be spread out in a thin layer, approximately 5 mm thick, allowed to dry out and compacted by suitable means.

The ratio of quantities of bituminous emulsion to dry sand shall be 1:8 by volume.

(c) Cracks which are of 20 to 75 mm wide.

Such cracks shall be patched as per Section 1107.

1106.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1106.4 Measurement and Payment

(a) Measurement

Crack sealing shall be measured as finished work in place in Linear metres as in 1106.3 (a) and (b) and as accepted by the Engineer.

(b) Payment

The payment shall be based on the Contract unit rate, for the item and shall be full compensation for providing all materials, labour, transport equipment, tools materials necessary to complete the work to Specification.

Pay Items and Pay Units shall be as follows;

Pay Item	Description	Pay Unit
1106 (1)	Crack Sealing with cracks up to 3 mm wide	linear metres
1106 (2)	Crack sealing with cracks between 3 to 20 mm wide	linear metres
1106 (3)	Crack sealing with eracks above 20 mm to 75 mm wide	linear metres

1107 FILLING OF SHALLOW SMALL IRREGULARITIES

1107.1 Description

This work shall consist of filling of small irregularities like ruts and depressions on existing road Pavements with these Specifications or as directed by the Engineer.

For the purpose of this Specifications shallow irregularities are those that are less than 75 mm in depth. Those irregularities in excess of 75 mm in depth together with cracks shall be restored in accordance with Section 1105 Local restorations.

1107.2 Material

(a) Binder shall be bituminous emulsion to Sub section 1702.3 or cutback bitumen Sub section 1702.2.

(b) Cold mix used for patching shall conform to the requirements of Section 1101.

(c) Blotting material or blinding material to Sub section 1701.4

1107.3 Work Requirement

The surface area of the depression shall be cleaned of all foreign matter and dust and marked out. All edges trimmed if necessary shall be in level with the rest of the area.

The surface area of the depression shall be applied with tack coat of bituminous emulsion or cut back. Unless otherwise directed, the tack coat shall be uniformly applied at an average rate of 0.25 litre/Sq.m.

The depression shall then be uniformly and sufficiently filled with already prepared premixed material and levelled to an excess thickness of about one third of the depth of the depression, proud of adjoining surface to allow for compaction. The laid premix shall be compacted using a light weight vibrating roller (2 tonnes with vibration) or rammer until the surface is slightly proud of the adjoining surface. A thin layer of coarse sand or crusher dust of approved quality shall then be spread over the patched area so as to prevent premix material being picked up by traffic.

Care shall be taken to ensure that premixed material for covering the depression is transported to the required place on the road before commencing depression correction operation. The premix shall not be left unused on the road side for more than 12 hours and it shall be ensured that only the day's requirement of premix is transported to site and also covered until it is used.

1107.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1107.4 Measurement and Payment

(a) Measurement

Alternative 1

For all items of work described in this section, the material used and work done shall be measured separately.

The binder used shall be measured in litres. The cold mix shall be measured either in Cu.m or tonnes. The work done shall be measured as finished work in Sq.m.

The blotting material shall be measured in Cu.m.

Alternative 2

When extensive work is done in the opinion of the engineer, measurement by area is not practicable, the work shall be measured based on quantity of material.

(b) Payment

Alternative 1

The payment for materials used will be based on the Contract unit rate for the items which shall include full compensation for the supplying of materials at site.

The payment for the work done in filling depression and rate shall be the Contract unit rate for the items which shall include full compensation for providing all labour, machinery, equipment, tools and all other incidentals necessary to complete the filling in depression work to the Specifications.

Alternative 2

The payment for filling and depression will be based on the Contract unit rate for each type of material and shall include full compensation for providing the materials, labour, machinery, equipment, tools and all other incidentals necessary to complete work to the Specification.

The Pay Items and Pay Units shall be as follows:

Pay Item	Description	Pay Unit
Alternative 1		
1107 (1)	Binder (State type & grade)	Litres
1107 (2)	Cold mix	Cu.m
1107 (3)	Filling depressions	Sq.m
1107 (4)	Blotting material	Cu.m
Alternative 2		
1107 (5)	Binder (Specify type & grade) inclusive of work	Litres
1107 (6)	Cold mix inclusive of work	Cu.m
1107 (7)	Blotting material inclusive of work	Cu.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1108 SANDING

1108.1 Description

This work shall consist of treatment of road surfaces where binder has migrated to the road surface causing bleeding due to

(a) Too much binder

(b) Unsuitable binder

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

1108.2 Material

(a) Sand for blotting material to Sub section 1701.9

1108.3 Work Requirements

Sand shall be applied spread evenly with a broom so that the surface is evenly covered at the rate of approximately 8 Cu.m / 1000 Sq.m. This operation shall be repeated until the bleeding is completely diminished. This operation is best commenced in mid day when the binder is melted due to heat of the sun.

1108.4 Measurement and Payment

(a) Measurement

The sanding operation and treatment of bleeding shall be measured in Sq.m of work completed and as accepted by the Engineer.

(b) Payment

Payment will be based on the Contract unit rate for completed work as measured which shall include full compensation for providing all material, labour equipment and incidentals necessary to complete the work to the Specifications

Pay Item and Pay Unit shall be as follows;

Pay Item	Description	Pay Unit
1108(1)	Sanding	Sq.m

1109 ROAD MAINTENANCE OF ANY SECTIONS OF EXISTING ROAD DURING CONSTRUCTION OF OTHER SECTIONS WITHIN THE SITE

1109.1 Description

Before being given possession of any part of Site, a joint condition survey of any roads drainage facilities, right of way clearings, shoulders, structures and footways etc. within that part of Site shall be carried out by the Employer, the Contractor and the Engineer, and a schedule of remedial works, if any, that may be necessary to restore the road to an acceptable agreed condition. If such remedial work is not carried out by the Employer in time to accord with the Contractor's approved programme of work, the Contractor shall carry out such remedial works himself.

The Contractor shall maintain the road to the satisfaction of the Engineer until a Taking-Over Certificate for it, or applicable to it, has been issued. He shall maintain the carriageway, shoulders, structures and drainage facilities to the full extent of his possession of Site in a condition which is at least as good as the condition at the time of handing over and in accordance with the relevant parts of Sections of Chapters 1100, 1200, 1300, 1400 and 1500 herein.

Roads used as diversion routes for traffic due to the Works shall be considered as part of the Site for the purposes of maintenance.

1109.2 Measurement & Payment

(a) Measurement

There will be two categories of Road Maintenance, as follows:

(i) Category 1: Where the final asphalt wearing course is complete, having been laid to the Engineer's satisfaction over the full width of the carriageway and, as applicable, one or both shoulders.

(ii) Category 2: Where the final asphalt wearing course is not complete.

Measurement shall be per linear kilometre of carriageway along the centre line of the road, calculated to the nearest metre.

(b) Payment

Payment shall be per linear kilometre of each maintenance category per month of maintenance or part thereof. The Contract unit rate specified for the work concerned shall be full compensation for furnishing all labour, materials, tools, equipment and incidentals necessary to complete all the work required by the Contract and as directed by the Engineer.

Certification shall require that the Engineer is satisfied that the Contractor has properly discharged his obligations with respect to the work required. If it is the opinion of the Engineer that this is not the case, then:

(i) He may delete the item from any payment certificate or reduce the amount certified in lieu of unattended works on a reasonable proportion assessed by him, and

(ii) The Employer may undertake the work himself, or employ a third party for the purpose, and shall deduct the cost of doing so, from payments due to the Contractor.

Item No	Description	Pay Unit
1109(1)	Road maintenance :	
	- Category 1	km – month
1109(2)	- Category 2	km – month (A minimum rate shall be given in the BOQ)

1200 MAINTENANCE OF SHOULDERS AND ROAD SIDE

1201 REPAIRS AND CORRECTION TO SHOULDERS AND THE ROADSIDE

1201.1 Description

The work shall consist of:

(a) Effecting repairs under routine maintenance to damaged shoulders, verges embankment slopes and other areas within the ROW, caused, traffic, storm water, by construction activity or by other means.

(b) Regrading and gravelling of the shoulder under periodic maintenance.

(c) Reducing high spots.

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

1201.2 Materials

Unless otherwise specified, the soils used for effecting repairs to shoulders and re-gravelling of shoulders shall conform to the requirements of Sub section 409.2 and soils used for repairs of verges and embankment slopes shall conform to the requirements of Sub section 304.2.

1201.3 Work Requirements

(a) Repairs to Damages

All depressions, ruts, holes and erosion paths shall be cleared of all extraneous matter and dressed to a regular shape where necessary. They shall then be filled with approved soil and compacted as required using equipment approved by the engineer. The repaired surfaces shall be grassed or treated otherwise to prevent erosion.

(b) Re-grading & Re-gravelling of Shoulders

In areas designated for re-grading and gravelling of shoulders, the shoulders shall be re-graded to required levels by using grader or manually as approved by the Engineer.

Gravelling to the required thickness shall then be carried out in the areas demarcated for gravelling and compacted as described in Sub section 409.3. Such compaction shall be extended to areas that may not be gravelled but exposed as a result of grading operations, unless otherwise directed.

On all exposed areas not gravelled, grassing shall be carried out as directed and, if so directed, grassing shall be carried out even over the gravelled areas as a measure of erosion prevention.

Material from regrading shall selectively be used, for shoulder filling or gravelling as appropriate, and with the prior approval of the Engineer.

Precautions shall be taken during the above operations to avoid damages to Pavements, foot walks, drive ways, kerbs, drainage, gullies, manholes etc. Any damage caused by negligence shall be repaired at the Contractor's expense.

All unused soil and debris resulting from re-grading operations shall be dumped in approved dumping places.

(c) Reducing high spots

Where isolated high spots along the shoulder are required to be reduced, the work shall be carried out in such a manner, as not to disturb the surrounding area and the cut material shall be removed to suitable dumping grounds.

1201.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1201.4 Measurement and payment

(a) Measurement

Repairs to damage to shoulders and the roadside shall be measured in meters or kilometres of work completed. Fill material if supplied by the Contractor shall be measured separately in Cu.m.

Grading of shoulders shall be measured in Sq.m of completed work. Shoulder fill material if supplied and reducing high spots of shoulders shall be measured separately in Cu.m.

For re-gravelling of shoulder, the shoulder material shall be measured in Cu.m as supplied and the work done in re-gravelling of shoulders shall be measured based on the volume of material used in Cu.m.

(b) Payment

Payment shall be based on the Contract unit price/s for the items/s and shall include full compensation for the components given below for the items.

The prices for the maintenance work in repairs to damages of shoulder and roadside, grading of shoulders and re-gravelling of shoulders shall be full compensation for providing all labour, tools, equipment and incidentals necessary to carry out the work to the Specifications.

The price for fill material (shoulder fill and/or embankment fill) supplies shall include full compensation for the supply and transport of material to site.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1201(1)	Repairs to damages of shoulders and roadside	Kilometres/Metres
1201(2)	Grading of shoulders	Sq.m
1201(3)	Re-gravelling of shoulders	Cu.m
1201(4)	Reducing high spots of shoulders	Cu.m
1201(5)	Fill material supplies (state type of material)	Cu.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1202 GENERAL UP-KEEP OF SHOULDERS AND THE ROAD SIDE

1202.1 Description of Work

This work shall consist of maintaining the shoulders and the road side in a neat condition by trimming, weeding and clearing. Work shall include clearing of drains, drainage structures, scupper drains, filling erosion gullies and also clearing of minor slips.

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

1202.2 Work Requirements

The full width of the right of way including earth drains shall be cleared of all weeds and shrub jungle, including small trees and obstructing branches, which still remain after jungle clearing, had been carried out in accordance with Section 1203. All grassed areas on verges and embankments shall be trimmed and mowed as directed.

Areas adjacent to guard stones, kilometre posts, road signs, guard rails etc., shall be cleared as directed so that their complete visibility is maintained.

All drains and drainage structures shall be cleared of any refuse and litter.

All scupper drains shall be trimmed and cleared of any silt and debris.

All debris from minor slips fallen on to the roadway or to the drainage system shall be cleared and disposed of as directed.

Disposal of debris shall be as directed. Disposal by burning shall be carried out in a manner approved by the Engineer. However, disposal by burying within the right of way shall not be permitted.

1202.2/1 Tests and standards of acceptance

The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1202.3 Measurement & Payment

(a) Measurement

Unless otherwise specified measurement for general upkeep of road sides shall be in kilometres of road side cleared, and as accepted by the Engineer.

(b) Payment

The rate of payment shall include full compensation for materials, labour, plant and incidentals required for the work, and the cost of transport of debris not exceeding 30m haulage distance. Extra transport shall be paid for as actually required.

The pay Item and Pay Unit shall be as follows:-

Pay Item	Description	Pay Unit
1202(1)	General upkeep of road sides	Kilometres

1203 JUNGLE CLEARING ALONG THE ROAD SIDE (Road Side Weeding)

This work shall consist of removal of high growing vegetation within the right of way other than that designated to remain. The work shall include the removal of debris as directed.

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

1203.2 Work Requirements

All high growing plants and trees of girth less than 300mm. other than those designated to remain, shall be removed by uprooting or by cutting and then uprooting the stumps or by cutting only as directed. Any branches of trees, irrespective of the girth, overhanging on to the road or to the right of way and obstructing traffic or visibility of the road user shall also be cut and removed as directed. The girth of trees shall be measured at one metre above ground level.

The debris, prior to disposal, shall be stacked away from the road platform foot walks and drains and in heaps of not exceeding 0.75 m in height. Disposal of any such debris by burning with in the right of way shall be carried out only with the prior approval of the Engineer.

During removal of trees or branches, precautions shall be taken against damage to overhead electrical power transmission and telecommunication lines and other property such as sign boards. Such activities shall not, in any way, be a danger to vehicles and persons using the road and shall not impede the smooth passage of regular traffic.

1203.2/1 Tests and standards of acceptance

The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1203.3 Measurement of Payment

(a) Measurement

Unless otherwise specified jungle clearing shall be measured in Sq.m of roadside cleared and as accepted by the Engineer.

(b) Payment

The rate of payment shall include full compensation for materials, labour, plant and incidentals required for the work and the cost of transport of debris not exceeding 30m haulage. Extra transport shall be paid for as actually required.

Removal of trees less than 300mm girth and cutting and removal of branches of trees shall be incidental to the work, and any trees or branches larger than this shall be paid in accordance with Section 201.

The Pay Item and Pay Unit shall be as follows:-

Pay Item	Description	Pay Unit
1203(1)	Jungle clearing	Sq.m

1204 MAINTENANCE OF FOOTWALKS

1204.1. Description

The work consists of maintaining foot walks free of ruts, depressions, potholes etc., by effecting repairs in accordance with these Specifications.

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

1204.2 Materials

Unless otherwise approved by the Engineer the material shall conform to the requirements of following, unless otherwise specified.

(a) Gravely soil for filling to Sub section 1708.7
(b) Cement mortar for jointing to Sub Section 1703.2
(c) Pre-cast slabs to Section 1705
(d) Binder for priming etc. to Section 1702
(e) Cold mix for patching to Section 1101.

1204.3 Work Requirements

Foot walks shall be maintained free of weeds and grass to full width and repairs affected as follows.

Ruts, depressions and potholes of gravelled surfaces shall be filled with approved gravel and compacted to finished levels using hand tampers or other means as suitable.

Ruts, depressions and potholes on bitumen surfaced foot walks shall be patched in accordance with Section 1102 as appropriate. Gravel surfaces that are primed with bitumen shall be patched using approved gravel and then applied with hot bitumen, cut back or emulsion as approved.

All cracked or broken pre-cast slabs in paved foot walks shall be replaced with slabs of same size and type approved by the Engineer. Slabs that are displaced shall be removed, reset to level, and mortar jointed using 1:2 or 1:3 cement mortar as required. Care shall be exercised not to cause damage to adjoining slabs in this operation and any slabs damaged due to the negligence of the Contractor shall be replaced at his own expense.

1204.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1204.4 Measurement & Payment

(a) Measurement

Unless otherwise specified measurement for maintenance of foot walks shall be as follows:-

(i) Sq.m of surface maintained for gravelled or bitumen surfaces.

(ii) Units of slabs replaced or re-levelled for paved surfaces.

(b) Payment

The Unit rate of payment for items of work defined above shall include full compensation for material, labour, plant and incidentals required for the work and the cost of transport for supply of material and disposal of debris within 30m haulage distance.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1204(1)	Maintenance of foot walks (state type of foot walks)	Sq.m
1204(2)	Pre-cast slabs (state whether replaced repaired or realigned)	Numbers

Note

Refer Sub section 106.5 regarding sub divisions of pay items.

1205 MAINTENANCE OF KERBS AND CHANNELS

1205.1 Description

The work shall consist of maintaining pre-cast kerbs and channels on the edges of carriageway.

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

1205.2 Materials

Materials used shall conform to the requirements of the following, unless otherwise specified.

(a) Pre-cast kerb units or kerb and channel units to Section 1705.

(b) Cement mortar for joint filling to Sub section 1703.2

1205.3 Work Requirements

Kerb and channels shall be maintained true to line and grade.

All defective or broken units shall be repaired or replaced and joints filled with 1:2 or 1:3 cement mortar as specified.

Displaced kerbs and channels shall be reset to proper line and grade on a formed bed as directed, and the joints filled with 1:2 or 1:3 cement mortar as specified. In the case of kerbs and channels cast in situ the repair shall include all necessary chipping of in-situ concrete and replacing with class B concrete of 1:2:4 (20mm) mix, to line and level.

In replacing or resetting units any damage to the carriageway or to the foot walk shall be corrected as directed.

1205.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1205.4 Measurement & Payment

(a) Measurement

Unless otherwise specified repairs and resetting replacement operations shall be in numbers of pre cast units or linear metres of cast in situ kerbs or channels, and as accepted by the Engineer.

(b) Payment

The rate of payment shall include the cost of pre-cast units, other materials, labour, plant and the cost of transport for disposal of material not exceeding 30m haulage distance.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1205(1)	Pre-cast unit (state type of unit and whether replaced, repaired or realigned)	Linear Metres
1205(2)	Cast in situ kerb/channel (state whether replaced or repaired)	Numbers

Note

Refer to Sub section 106.6 regarding sub divisions of pay items.

1206 MAINTENANCE OF CARRIAGEWAY SIDE KERB

1206.1 Description

The work shall consist of maintaining carriageway side of the kerb, free of accumulated soil, sand, silt and obstructions for flow of water, visibility of road marking and optimum use of carriageway at traffic islands, roundabouts, centre medians, and pedestrian refugee islands by traffic.

The work shall be carried out in accordance with these Specifications or as directed by the Engineer.

1206.2 Work Requirements

The carriageway side of the kerb shall be maintained true to line and grades, free of weeds, silts, soil, sand and debris to facilitate flow of water where applicable and maintain visibility of road marking and kerb itself and to encourage the use of full width of carriageway by the traffic.

All silt, mud and other accumulated debris shall be collected manually or by mechanical means and carted well away from road side, as frequently as necessary in order that kerb side is clean, all the time to the satisfaction of the Engineer. Any irregularities in carriageway close to kerb side shall be dealt with separately as per Sections 1102, 1105, 1107.

1206.5 Measurement and Payment

(a) Measurement

Unless otherwise specified measurement for cleaning operation shall be in linear metres per month, and as accepted by the Engineer.

(b) Payment

The rate of payment shall include full compensation for the cost of labour, plant and the transport for disposal of material to any distance.

Pay Item and Pay Unit shall be as follows:-

Pay Item	Description	Pay Unit
1206	Cleaning kerb side	Linear metres per month

1300 MAINTENANCE OF DRAINAGE SYSTEMS

1301 CLEARING AND RESHAPING OF EARTH DRAINS

1301.1 Description

The work shall consist of clearing, de-silting and reshaping of longitudinal side drains and transverse drains to facilitate the disposal of storm water.

1301.2 Work Requirements

The drains shall be kept free of weeds, debris, silt and other extraneous matter by clearing and de-silting regularly. They shall be re-cut, where necessary, to maintain proper shape and gradient. Any minor damages to sides and bottoms shall be corrected by filling with selected material and compacting as appropriate. Where so directed these drains shall be grassed to reduce erosion.

All debris and silt from the drains shall be removed from the roadway area into dumping places approved by the Engineer. Dumping places shall be such that the dumped material shall not be washed back into the drains by action of storm water.

The silt and debris may be temporarily dumped on the shoulder or verges provided that they are removed within the same day, or under exceptional circumstances, within an extended period specified by the Engineer. No extra payment shall be made if this debris etc. gets washed back due to rain, and re-clearing becomes necessary.

1301.3 Measurement & Payment

(a) Measurement

Unless otherwise specified measurement for clearing, de-silting and reshaping shall be in linear metres of drains.

(b) Payment

The rate for payment shall include the costs of all operations, labour, material, plant and transport of debris, to disposal sites.

The Pay Item and Pay Unit shall be as follows:-

Pay Item	Description	Pay Unit
1301(1)	Clearing and reshaping of earth drains	Linear metres

1302 CLEARING AND REPAIRING OF BUILT-UP DRAINAGE SYSTEMS

1302.1 Description

The work shall consist of clearing, de-silting and effecting repairs to masonry drains, pipe drains, catch pits, manholes and inlets to facilitate the disposal of storm water including replacement of any pre-cast units such as cover slabs and gully gratings.

1302.2 Materials

(a) Cement concrete for correction work shall be of class B Grade 20(20) mix, to Section 1001 and other materials used shall meet the requirements of the following Sub sections.

(b) Pre-cast units to Section 1705.

(c) Cement mortar for jointing & plastering to Sub section 1703.2

1302.3 Work Requirements

The drains and specials such as manholes, catch pits etc., shall be kept cleared of silt, debris and other extraneous material. In masonry drains with cover slabs, where it becomes necessary to remove some of the slabs to obtain access for clearing, care shall be taken not to damage the slabs in such operations and any damage caused by negligence shall be repaired by the Contractor at his own expense. Pipe drains shall be cleared from manhole using appropriate tools.

All debris and silt from the above operations shall be removed to approved dumping places and debris temporarily dumped on the foot walks or verges shall be removed within the same day, unless otherwise allowed by the Engineer.

Cracked, spalled or otherwise damaged, plaster or masonry drains and specials shall be chiselled to a regular rectangular shape and re-plastered using 1:3 cement mortars.

Section of damaged random rubble work bridge work or cast in-situ concrete drains and specials that are damaged shall be repaired by cutting to a regular shape and replacing with the original material of construction or with class B grade 20(20) concrete or with cement mortar 1:2 or 1:3 mix, as directed.

All cracked or broken pre-cast units (slabs, channels, pipes etc) shall be replaced with new units of the required sizes and to line and level. Displaced pre-cast units shall be restored to the line and level after re-bedding where necessary.

1302.4 Measurement & Payment

(a) Measurement

Unless otherwise specified measurement for clearing and repair of drains shall be as:

(i) Linear metres of the drain length for clearing operations.

(ii) Sq.m of repaired surfaces of drains etc. for the re-plastering and repair operations.

(iii) Number of displaced pre-cast units restored to original level for pre-cast concrete drains cover slabs catch pits etc.

(b) Payment

The rates of payment shall include full compensation for material, labour, plant and incidentals required for the work and the cost of transport and disposal of debris not exceeding 30m haulage distance.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1302(1)	Clearing of built up drains	Linear metres
1302(2)	Re-plastering and/or repairing surfaces of built up drains	Sq.m
1302(3)	Restoring displaced pre-cast sections to original line and level (state type of unit)	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1303 CLEARING, DESILTING AND REPAIRING OF CULVERTS

1303.1 Description

The work shall consist of clearing, de-silting, painting and effecting repairs to culverts in accordance with these Specifications.

1303.2 Materials

The materials shall meet the requirements of the following, unless otherwise specified.

(a) Cement Mortar to Sub section 1703.2

(b) Cement Concrete of class B to Section 1001.

(c) Paint (Enamel, Emulsion, Anticorrosive & lime wash) to Section 1707.

1303.3 Work Requirements

The culvert shall be kept cleared of silt, debris, and other extraneous matter causing obstructions to the free flow of water. Where access is limited a scoop or any other approved means shall be used for this purpose. Clearing operations shall include removal of under growth, weeds and shrubs from head walls, wing walls, abutments and other parts of the structure. All debris from clearing operations shall be disposed of, to dumping places away from the roadway area.

All components of culverts such as parapets, hand rails, deck slabs, head walls, wing walls, abutments, pipes and catch pits shall be checked for cracks, damages or displacements and repaired as directed. Cracks in walls etc. shall be sealed using 1:2 or 1:3 cement mortar as specified.

Any re-construction work shall be carried out only as directed by the Engineer and after carrying out the necessary investigations.

All inverts and sides immediately adjacent to inlets and outlets shall be regularly checked for erosion or scour and appropriate protective measures such as rip-rap protection, rubble masonry linings or concrete linings, shall be carried out as directed.

Where painting is required, masonry parapets and head walls shall be cleaned free of all dirt and applied with one or two coats of emulsion paint of approved type & colour or lime wash as specified. Metal railings shall be cleaned of rust, by wire brushing and other approved means, and applied with a coat of anticorrosive paint and two coats of enamel paint unless specified otherwise. Where so directed approved rust inhibitor shall be applied prior to the application of the anticorrosive paint.

1303.4 Measurement & Payment

(a) Measurement

Unless otherwise specified measurement shall be as follows:

(i) Numbers of culverts for clearing and repair operations

(ii) Cu.m of concrete, rip rap, etc. for scour protection work.

(iii) Sq.m of painting

(b) Payment

The rate of payment shall be full compensation for all labour materials equipment and transport needed to carryout the work and also for the disposal of debris.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1303(1)	Clearing and repairing of culverts	Numbers
1303(2)	Scour protection work (state material)	Cu.m
1303(3)	Painting of culverts (state material and number of coats)	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1304 PROVIDING SCUPPER DRAINS

1304.1 Description

The work shall consist of providing scupper drains at given locations to facilitate the surface drainage of storm water from the carriageway.

1304.2 Materials

Concrete used for paving of scupper drains shall be of class C to Section 1001 and stabilized soils shall meet the requirements of Section 402.

Any other material used shall, as far as practicable, meet the requirements of the relevant sections and approved by the Engineer.

1304.3 Work Requirements

Scupper drains shall be provided where the gradient and/or the height of the shoulders do not permit the rapid drainage of storm water from the carriageway to the side drains. They shall be located at suitable intervals and at points of lowest depression in each interval. The locations shall be approved by the Engineer before the commencement of work.

The scupper drains shall be cut to widths not exceeding one metre and flared the entrance near the carriageway edge to intercept the storm water flow path along the edge. The drain shall be cut with the drain axis suitably angled to the road axis to suit the flow path from the road. The invert of the drain shall be at level with the carriageway edge at the entrance, and cut to sustain a gradient of 4 to 5% towards the side drains. The exposed surfaces shall be hand tamped to prevent erosion and, where so directed, lined with a layer of stabilized soil, rubble paving, or paving of cement concrete as directed by the Engineer. The paving may also be of bituminous materials where approved.

1304.4 Measurement & Payment

(a) Measurement

Unless otherwise specified the measurement shall be in Sq.m for cutting, and finishing of scupper drains and also for lining, and as accepted by the Engineer.

(b) Payment

The rate of payment for work shall include full compensation for materials, labour, plant and incidentals required for the work and the cost of transport of material and transport of debris to approved disposal sites.

The Pay Item and Pay Unit shall be as follows:-

Pay Item	Description	Pay Unit
1304(1)	Provision of scupper drains (state type of lining)	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1400 MAINTENANCE OF BRIDGES

1401 STEEL BRIDGES

1401.1 Description

This work shall consist of the necessary maintenance operations in respect of bearings; carriageway paving including decking plates and concrete deck slabs, expansion joints and drainage outlets; structural members such as trusses, built up girders, beams, and supporting trestles, protective coatings; and other items such as pilasters and hand rails. Concrete or masonry sub structures shall be maintained as in Section 1404.

1401.2 Materials

The materials used shall meet the requirements of the following, unless otherwise specified.

(a) Anti corrosive paints on structural steel to Section 1021. & other paints to Section 1707

(b) All structural steel sections to Section 1021.

(c) M.S round bars and ribbed bars for deck concrete to CS 26 and SLS 375.

(d) Concrete for deck repair to Section 1001.

(e) Cold mix Surfacing for deck repair to Section 507.

(f) Decking plates and buckle plates to BS 1449 or as approved.

(g) Grease and metallic primer shall be of varieties approved by the Engineer.

1401.3 Work Requirements

(a) Bearings

All bearings of steel bridges which include hard rubber, elastomeric laminated, pot, rocker, roller and sliding types shall be inspected regularly, and particularly after floods, and shall be serviced as per servicing instructions or as directed. They shall be cleared of debris collection, cleaned of any corrosion and their bearing surfaces and pins shall be kept well greased. Their relative movements in longitudinal and transverse direction and any rotation shall be recorded and monitored at regular inspections. In the same bridge all bearings shall be inspected separately and recorded separately with their locations, if the individual bearing functions or the expected bearing functions are known or given. For this purpose the bearing notations and functions prescribed in BS 5400: part 9 shall be used. At the inspection each bearing shall be checked for malfunctioning and action taken as given below.

Conditions shall be recorded for any possible damage of intervals of once a year or after periods of heavy flooding or passages of extra heavy loading.

All components of bearings, which show signs of heavy corrosion or any form of inadequacy, shall be replaced with new component parts of approved quality.

All bearing plates, which are exposed to the elements, shall be suitably covered and protected from the elements.

Servicing of steel bearing shall generally be undertaken at night under floodlit conditions and when the disruption to vehicular traffic is minimized.

When such servicing operations take place during the night, red lanterns or electrically operated warning lights shall be installed on approaches to both side of the bridge at 30 metres and 60 metres to warn traffic. If such operations are to be carried out during the day, warning signs and flags shall be used to warn traffic.

When the servicing of individual components of the steel bearings requires complete release of load from them, no vehicular traffic shall be allowed over the bridge during the period of servicing. Where jacking stiffeners are provided at main structural members for the purpose of upwards jacking of the Bridge deck; their capacity at the time of use shall be verified.

(b) Carriageway Paving, Decking Plates, Expansion Joints and Drainage Outlets

(i) Carriageway Paving

Unless otherwise specified or directed all bituminous carriageway paving shall be repaired or replaced as required by using cold mix Surfacing conforming to the requirements of section 506.

Infill between the decking plates and the surfacing shall be replaced with graded aggregate or with concrete as specified and shall be laid and compacted as directed. Where concrete is used as infill, steel reinforcements shall be incorporated, to arrest cracking and ribbed bars shall be welded to the decking plates to provide the necessary bond, if so directed.

In carrying out replacement work or repair work it shall be ensured that the surfaces of the paving are finished to proper camber to ensure drainage of rain water through the drainage outlets.

(ii) Decking Plates

When replacing corrugated steel decking plates or buckle plates from existing decks of steel bridges, they shall conform to the same dimensions and specifications as the rest of the decking and shall be of whole lengths spanning from one under lying steel girder to the other. Connections between the corrugated plate and the underlying steel girders shall be reinstated to the original condition as directed by the Engineer.

Where only a few isolated places of corrosion of decking plates exist, welding in patches may be permitted with the approval of the Engineer. Such welding, however, shall not be allowed extensively.

All replaced and repaired decking plates shall be treated with an approved metallic primer and two coats of approved anti-corrosive paint on the side of the plates facing the deck girders.

Where it is necessary to replace the paving material, over the decking plates, the decking plates shall be painted with a tack coat of approved bituminous paint before the fill is placed. Where the paving material is concrete the plates shall not be painted but shall be left rough and free of grease and oil.

Field rivets and MS bolts when replaced in fixing steel decking plates and buckle plates, shall conform to standards specified and shall be of the same dimensions as in the rest of the deck.

All holes in decking plates and buckle plates shall be drilled as specified and no punching shall be allowed.

(iii) Expansion Joints

All expansion joints shall be checked and adjusted to facilitate freedom of movement with proper clearance and alignment.

It shall be ensured that finger plate expansion devices and steel expansion plates are firmly anchored to permanent fixtures and have no loose anchorage or cracked or damaged welds.

Expansion joints consisting of angle irons and aluminium sheeting shall be filled with approved bituminous fillers and shall be finished and maintained flush with the topmost line of the angle runners. It shall be ensured that there is no leakage of rain water through the bituminous filler or through the joints.

(iv) Drainage Outlets

Drainage outlets of the bridge deck shall be kept clear of all material and shall be covered with cast iron gratings as per approved design. In case of trusses, where drainage outlet holes are provided from the bottom chord, the holes shall be cleaned well and the water path shall be cleaned without trapping the water within the truss chord at intervals of 3 months. It shall be ensured that the outlets of drainage pipes are directed away from the troughs of steel trusses so as to prevent water collection. All work under this Sub section shall be carried out to the satisfaction of the Engineer.

(c) Structural Members

When structural members are bent, buckled, distorted or sway or deflect excessively in use, it shall be noted, marked with a sketch and repaired if necessary as directed by the Engineer.

Cracks or damage in the deck slab of steel - concrete composite girders shall be repaired as directed by the Engineer. Shear connectors in damaged areas of composite sections shall be reinstated as directed by the Engineer.

(d) Connections

All welded or bolted connections in truss nodes, built up sections; splice joints etc. shall be regularly inspected. They shall be free of corrosion. Any possible failures of connections like bolt shear, bolt bearing, plate bearing, weld cracks shall be noted and repaired as directed. No free bolt or rivet holes shall be left in high tension stress areas. They shall be plugged or stiffened as directed. Black bolts shall not be used for the permanent structural connections in bridge works.

(e) Painting of Steel Members

All structural steel members such as trusses, beams, built up girders supporting steel trestles and other steel items such as pilasters and handrails shall be subject to preventive maintenance as regards corrosion. They shall be de-rusted, old paint removed, cleaned well up to the specified cleaning standards either by hand and power tool cleaning such as pneumatic or electrical scraping, wire brushing, machine-brushing, grinding or by other approved means to expose the bare metal, and followed by cleaning either by air pressure or by other approved means unless otherwise specified by the Engineer. Any repairs shall be completed as necessary prior to cleaning and application of any paint. Use of blasting cleaning methods shall be at the discretion of the Engineer.

After attending to corrosion, all de-rusted parts shall be painted as in accordance with Section 1021 or as directed. No painting shall be carried out in wet or damp weather and the surfaces to be painted shall be properly dry before paint is applied.

Painting on galvanized surfaces shall be carried out with a type of self-adhesive thinner Base (solvent thinner) primer and the primer shall not be completely burn off the zinc layer of the galvanized surface as directed by the Engineer.

All activities in scraping, cleaning and painting shall be carried out by men experienced personnel.

In case of work where workmen are engaged either above or below deck level, safety devices such as netting, platforms, saddles etc. shall be constructed to ensure the necessary safety for the workmen and the public, to the satisfaction of the Engineer.

1401.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1401.4 Measurement & Payment

(a) Measurement

Steel bearings serviced, repaired or replaced shall be measured by the number.

Carriageway infill above decking plates shall be measured as 'finished work in position in Cu.m.

Steel reinforcement in concrete infill in carriageway deck shall be measured in kilograms or tonnes.

The wearing course shall be measured in Cu.m of loose material supplied and laid. Method of measurement shall be as given in Sub section 507.5(a) (ii)

Replacement of steel decking plates or buckle plates including fixing shall be measured in Sq.m. Welding of existing decking plates or buckle plates shall be measured in linear metres of weld.

Replacement of steel rivets, MS bolts, and shear connectors shall be measured by the number.

Expansion joints replaced, repaired or re-fixed shall be measured in linear metres.

Drainage pipes replaced, repaired or re-fixed with iron gratings in position and their clearing shall be measured by the number.

De-rusting of steel surfaces and protective coating of steel members shall be measured in Sq.m.

(b) Payment

Payment shall be at the Contract unit rate for the items which shall include where applicable full compensation for all materials, labour, equipment, tools, plant, transport and other incidentals necessary to complete the work to the Specifications. The rate shall also include the cost of all false work, staging and safety measures and traffic control measures necessary for the execution of the work.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1401(1)	Steel bearing (state whether serviced, repaired or replaced and type of bearing)	Number
1401(2)	Carriageway infill above decking plates (state material)	Cu.m
1401(3)	Steel reinforcement in concrete infill in carriageway deck	kg/Tonne
1401(4)	Wearing course (state material)	Cu.m
1401(5)	Replacement of steel decking plates or buckle plates including fixing (state shape and thickness)	Sq.m
1401(6)	Welding of steel decking plates or buckle plates	Linear metres
1401(7)	De-rusting steel surfaces (state method and the level of cleaning or standards)	Sq.m
1401(8)	Protective coating for steel members,(state paint scheme and application method)	Sq.m
1401(9)	Replacement of steel rivets or M.S bolts or shear connectors	Number
1401(10)	Expansion joints (state whether replaced or repaired or re-fixed and type)	Linear metres
1401(11)	Drainage pipes cleaned of choked material	Number
1401(12)	Drainage pipes (state whether replaced or repaired and re-fixed with iron grating in position)	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1402 TIMBER DECKED BRIDGES

1402.1 Description

This work shall consist of the necessary maintenance operations in respect of timber decks of bridges where the supporting structures for these decks are of steel, concrete or masonry. Maintenance of steel supports shall be carried out as given in Section 1401. Concrete and masonry sub structures shall be maintained as given in Section 1404.

1402.2 Materials

The materials used shall meet the requirements of the following, unless otherwise specified.

(a) Timber for deck planks and runners to Section 1709.

(b) M.S round bars for U bolts to CS 26.

(c) Nuts & bolts and washers to SLS 97 and SLS 238.

(d) Steel chequered plates for wheel traeks to relevant BS or as approved.

(e) Jute hessian and bitumen used shall be of approved varieties.

1402.3 Work Requirements

Timber deck planks and runners shall be replaced where necessary by planks and timber joists of the approved quality and of the required dimensions.

They shall be assembled in position with the space between two adjacent planks to be within 3 to 6mm. The ends of these planks shall be firmly fixed to the longitudinal timber runners, by means of MS U-bolts or holding down bolts at intervals not exceeding 2 metres with suitable locking arrangements to prevent movement and easy removal of planks as shown in Plans or as directed by the Engineer.

When chequered steel plates are to be fixed on wooden decks, they shall be fixed with suitable countersunk bolts in wheel tracks over layers of jute hessian 15mm thick (that had been dipped in hot bitumen), as directed by the Engineer.

Repair to timber decks shall be undertaken when traffic is least over the bridge, especially during night time.

Where repair work is done during the night work site shall be well lit and traffic shall be warned as given in Sub section 1303(a).

When the replacement of a few deck timber planks is undertaken, it shall be done causing the least possible inconvenience to traffic. Not more than one plank should be removed at a time. Traffic, if allowed, should be scheduled at regulated intervals of time and at regulated speeds not exceeding 6 kilometres per hour and should be made to cross over the temporarily provided steel decking plates, with due caution over sections where repair work is carried out.

However, when total replacement of the timber deck is to be carried out prior arrangements to divert traffic shall be made with the approval of the Engineer.

1402.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1402.4 Measurement & Payment

(a) Measurement

Replacement of timber deck planks shall be measured in Sq.m and replacement of timber runners shall be measured in linear metres.

The supplying and fixing of MS U-bolts and holding down bolts with locking arrangements and the supplying and fixing of counter sunk bolts on wheel tracks shall be measured by the number.

Fixing of available chequered steel plates, supplying and fixing of chequered steel plates and supplying and fixing of layered jute Hessian cloth dipped in hot bitumen shall be measured in Sq.m.

(b) Payment

Payment shall be at the Contract unit rate for the items which shall include full compensation for all materials, labour, equipment, tools, plant, transport and other incidentals necessary to complete the work to the Specifications. In the case of replacement of deck planks the rate shall also include the cost of temporary provision of steel decking plates to allow limited traffic when necessary

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
1402(1)	Replacement of timber deck planks (state thickness)	Sq.m
1402(2)	Replacement of timber runners (state Cross-section)	Linear metres
1402(3)	Supplying and fixing of M.S U-bolts and holding down bolts with locking arrangements	Number
1402(4)	Supplying and fixing of counter sunk bolts on wheel tracts	Number
1402(5)	Fixing of available chequered steel plates	Sq.m
1402(6)	Supplying and fixing of chequered steel plates	Sq.m
1402(7)	Supplying and fixing of layered jute Hessian cloth dipped in hot bitumen(state thickness)	Sq.m.

Note

Refer Sub section 106,6 regarding and sub divisions of pay items.

1403 PRESTRESSED CONCRETE AND REINFORCED CONCRETE BRIDGES

1403.1 Description

This work shall consist of the necessary maintenance operations in respect of the super structure of all P.S.C. and R.C.C. bridges. Sub structures shall be maintained as given in Section 1404.

1403.2 Materials

Materials used shall conform to the requirements of the following, unless otherwise specified.

(a) Cement concrete to section 1001 and cement mortar to Sub section 1703.2.

(b) Cold mix and patch mix for wearing course to Section 507 and 1101 respectively.

(c) Paint to Section 1707.

1403.3 Work Requirements

(a) Wearing Course

The asphalt wearing course of bridge decks shall be re-laid where necessary, to proper lines and levels as per Section 507, using cold mix, unless otherwise specified.

Patching up of the wearing course, where necessary, shall be carried out using patch mix, prepared as given in Section 1101, and as directed.

(b) Expansion Joints

These shall be maintained as per Sub section 1401.3 of the Specifications.

(c) Drainage Outlets

These shall be maintained as per Sub section 1401.3 of the Specifications.

(d) Handrails and Uprights

All handrails running over expansion joints, which are meant to be kept loose, shall be loosened where necessary to allow the handrails to slide on the sockets in uprights so that the deck expansion joints on deck function effectively.

Any damaged handrails or pilasters shall be repaired or replaced as required. Repairs shall be carried out using concrete of class B of specified mix proportions and/or 1:2 cement mortar as directed.

(e) Painting

All concrete copings, handrails, uprights, shall be cleaned and painted during dry weather with one or two coats of approved paint as directed. The number of the bridge shall be painted in black on end pilasters conspicuously and the dimensions of he figures so painted shall be of the standard size adopted by the Contractor.

(f) Vegetation of Base of Pilasters and at Exits of Rain-water Outlets

The Base of pilasters and concrete lips of rainwater outlets, situated on concrete facial slabs, shall be cleaned of all vegetation to present a neat and tidy appearance.

1403.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1403.4 Measurement & Payment

(a) Measurement

The wearing course shall be measured in Cu.m of loose material supplied and laid. Measurement shall be as given in Sub section 507.5(a)(ii).

Replacement, repair or re-fixing, along with iron gratings in position, of drainage pipes and their cleaning shall all be measured by the number.

Replacement, repair or re-fixing of expansion joints and the replacement of handrails including uprights shall be measured in linear metres.

Replacement of pilasters shall be measured by the number.

Painting of concrete pilasters, copings, handrail etc. shall be measured in Sq.m.

(b) Payment

Payment shall be at the Contract unit rate for the items which shall include full compensation for all materials, labour, equipment, tools, plant, transport and other incidentals necessary to complete the work to the Specifications. In the case of painting pilasters, copings, handrails etc. the rate shall also include the preparation of the surface on which the paint is applied.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1403(1)	Wearing course (state materials)	Cu.m
1403(2)	Expansion joints (state whether replaced or repaired or re-fixed)	Linear metres
1403(3)	Drainage pipes cleaned of choked material	Number
1403(4)	Drainage pipes (state whether replaced or repaired and re-fixed with iron grating in position)	Number
1403(5)	Replacement of Handrails (state type)	Linear metres
1403(6)	Replacement of pilasters (state type)	Number
1403(7)	Painting (state type of paint and number of coats)	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1404 MAINTENANCE OF SUB STRUCTURES OF BRIDGES

1404.1 Description

This work shall consist of the necessary maintenance operations in respect of concrete and masonry sub structures of steel, wooden decked, pre-stressed concrete and reinforced concrete bridges. Any supporting steel trestles shall be maintained as given in Section 1401.

1404.2 Materials

All materials used shall meet the following requirements unless otherwise specified.

(a) Cement concrete to Section 1001

(b) Cement mortar to Sub section 1703.2

(c) Soils and rubble used for erosion control shall be as approved.

1404.3 Work Requirements

(a) Vegetation on pier and abutment faces

All cracks, crevices and pockets in abutments and piers shall be chipped clean of all vegetation and shall be properly dressed and plugged neatly with Class B cement concrete and /or 1:2 or 1:3 cement mortar as specified. Small trees or shrubs growing in cracks and crevices shall be cut and the roots carefully burnt or destroyed by the use of weed killers removed / cleaned, as approved by the Engineer, prior to carrying out plugging operations.

(b) Debris on pier Base caps and pier Bases

Pier Bases and Base caps shall be cleared of collected debris. Extra vigilance shall be exercised during times of floods to see the debris and other items that float do not collect and impede the smooth passage of water flow.

(c) Earth fillings and rubble packing in front of wing walls abutments

Earth filling or rubble packing in front of wing walls and abutments that are eroded shall be corrected to their original slopes or shapes as directed by the Engineer.

(d) Weep-holes in Abutments and Wing walls

Weep-holes shall be cleared of choked material, as per Sub section 1303.3.

(e) Abutments and Pier Caps.

These shall be cleared of bitumen and debris.

1404.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1404.4 Measurement and Payment

(a) Measurement

Removal or destroying small trees on masonry abutments and piers and clearing of weep-holes shall be measured by the number.

Erosion correction of wing walls and abutments shall be measured in Cu.m of materials placed in position.

Cleaning of weep holes shall be measured as numbers.

Cleaning abutments and pier caps shall be measured in Sq.m.

Clearing light vegetation including sealing of cracks crevices and pockets and the clearing of debris shall be measured as Sq.m.

(b) Payment

Payment shall be at the Contract unit rate for the items which shall include where applicable full compensation for all materials, labour, equipment, tools, plant, transport and other incidentals necessary to complete the work to the Specifications.

Clearing light vegetation and removal of debris shall be paid separately.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1404(1)	Removal or destroying of small trees on masonry abutments/piers	Number
1404(2)	Erosion filling at wing walls, abutments, pier Bases	Cu.m
1404(3)	Cleaning of weep-holes	Number
1404(4)	Clearing abutments, piers	Sq.m
1404(5)	Clearing light vegetation including sealing of cracks, crevices and pockets as required	Sq.m
1404(6)	Clearing of debris	Sq.m

1405 CABLE SUPPORTED FOOT BRIDGES (SUSPENSION BRIDGES)

1405.1 Description

The work shall consist of maintenance operations of foot bridges suspended from steel cables running over pylons and anchored to ground. This work shall be carried out in accordance with these Specifications or as directed by the Engineer.

1405.2 Materials

The materials used shall meet the requirements of the following, unless otherwise specified.

(a) Timber for deck planks to Section 1709

(b) Steel round bars for tie rods to CS 26

(c) M.S Angle irons for deck runners to SLS 73

(d) Nuts & bolts and washers to SLS 97 & 238 respectively.

(e) Anti corrosive paint to SLS 713

(f) Concrete of class B for repair work to Section 1001

(g) Cement mortar for repair to Sub section

(h) Steel wire ropes for main cables to relevant BS or as approved.

1405.3 Work Requirements

(a) Timber Deck Planks & Runners

All planks of foot walks that are loose shall be adequately fixed to the angle iron runners using nuts, bolts etc., as directed. Any runners or sections thereof that need replacement shall be replaced using angle iron of the same size and Cross-section. They shall be welded or bolted into place as directed.

Foot-walk planks which are partly or totally perished shall be replaced with the same approved quality seasoned timber planks, and of the same dimensions, as the rest already fixed.

In replacing the planks the space between adjacent planks shall be kept at a uniform spacing of 3mm, or there about, as far as practicable or similar to the existing space.

(b) Cables and Suspenders

Where the main cable wires have deviated from the designed curve, they shall be corrected by adjusting the turnbuckles at ends.

Suspender tie rods joining the main cables with the foot-walk and which are out of plumb, shall be made vertical by loosening the clips at ends and re-fixing them at the correct places. Suspender rods, where necessary to be replaced shall be fabricated using MS rods or other material approved by the Engineer.

Where the roller assembly on top of pylon heads are loose they shall be corrected, aligned and firmly fixed on their seats to prevent fouling the main cable movement due to passage of pedestrian traffic.

The roller assembly on pylon heads shall be effectively greased and shall function at all times so as not to dislodge the main cables and damage the cable wires running over them.

Drainage for water collecting on roller assembly seats and on pylon heads, shall be cleared and cleaned, by the Contractor every month.

(b) Painting of Steel Members

All steel members of cable supported footbridges including angle iron runners of the deck shall be subject to preventive maintenance against corrosion. They shall be de-rusted and painted as given in Sub section 1301.3(c). In the case of main wire cables, only wire brushes shall be permitted for de-rusting.

(c) Concrete blocks for steel pylons and main anchor blocks

Any growth of vegetation at pylon supports and the main cable anchor blocks shall be cleaned to a distance of 5 metres to the satisfaction of the Engineer.

All cracks, spalls and damaged areas of concrete blocks at pylon bases and anchor points of main cables shall be repaired using concrete of class B and/or cement mortar of 1:2 mix proportions and finished suitably to prevent water collection.

1405.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1405.4 Measurement and Payment

(a) Measurement

Replacement of timber planks shall be measured in Sq.m.

Replacement of angle runners and tie rods shall be measured in linear metres.

Correction to changes in catenaries of main cables and correction and fixing of roller assembly on pylons including greasing shall all be measured by the number.

De-rusting of steel surfaces, painting of steel members and clearing vegetation on pylon supports, anchor blocks and the ground around shall all be measured in Sq.m.

(b) Payment

Payment shall be at the Contract unit rate for the items which shall include where applicable full compensation for all materials, labour equipment, tools, plant, transport and other incidentals necessary to complete the work to the Specifications.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1405(1)	Replacement of timber planks (state thickness)	Sq.m
1405(2)	Replacement of angle runners, suspender (tie) rods (state size)	Linear metres
1405(3)	Correction to changes in catenaries of main cables	Number
1405(4)	Suspender (tie) rods adjustment	Number
1405(5)	Correction and fixing of roller assembly on pylons including greasing	Number
1405(6)	De-rusting steel surfaces	Sq.m
1405(7)	Painting of steel members, (state type of paint and number of coats)	Sq.m
1405(8)	Clearing vegetation of pylon supports anchor blocks and ground around	Sq.m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1406 MAINTENANCE OF CAUSEWAYS

1406.1 Description

This work shall consist of the necessary maintenance operations in respect of causeways of all types.

1406.2 Materials

The materials used shall meet the requirements of the following, unless otherwise specified.

(a) Rip rap for downstream protection to Section 804.

(b) Concrete of class B for carriageway repairs to Section 1001.

(c) Enamel and emulsion paints to SLS 539 and 557.

1406.3 Work Requirements

The ramps and carriageway platform and the openings below the carriageway shall at all times be cleared free of debris, boulders, stones, branches of trees, logs or any other obstructing material.

Erosion on the immediate downstream of the causeway, particularly after a heavy flood flow, shall be arrested by adopting, remedial measures such as rip rap packing.

As a general rule no borrowing of sand shall be allowed within hundred metres of the upstream of the causeway and three hundred metres from the downstream side of the causeway.

When the causeway is not active and carriageway is dry, action shall be taken to clear its carriageway and ramps of all slippery material and all grooves cast on platform shall be cleared of collected silt and other material so as to ensure effective road holding ability for vehicular traffic as well as providing a non slippery surface for pedestrians.

All guide posts, guard stones, flood gauges, constructed along the length of the causeway, shall be cleared free from entangled twigs and debris. Flood gauges shall be painted with black figures on a white background using enamel paint and they shall be so positioned that the flood levels can be seen from positions of safety on both the approaches. The guide posts and the guard stones shall be white washed with lime or painted with emulsion paint as directed.

Warning signs shall be erected and maintained at suitable places on either side of the causeway as directed by the Engineer, to warn traffic, both vehicular and pedestrian, if the flow of water over the causeway is considered dangerous for such traffic.

1406.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1406.4 Measurement and Payment

(a) Measurement

Excavation for rip rap construction measured in its original position and rip rap construction measured as finished work shall be Cu.m.

Concrete construction in repair work shall be measured in Cu.m of finished work.

Clearing carriageway surfaces and ramps of slippery material, silt etc. shall be measured in Sq.m and clearing of debris inclusive of boulders, stones, branches of trees and logs shall be measured as directed.

Cleaning guide posts, guard stones and flood gauges shall be measured by the number.

Painting of flood gauges, warning boards etc., and white washing of posts etc. shall be measured in Sq.m except that painting of figures and letters on them shall be measured by the number.

(b) Payment

Payment shall be at the Contract unit rate for the items which shall include where applicable full compensation for all materials, labour, equipment, tools, plant, transport and other incidentals necessary to complete the work to the Specifications.

The Pay Items and Pay Units shall be as follows: -

Pay Item	Description	Pay Unit
1406(1)	Excavation for rip rap protection	Cu.m
1406(2)	Rip rap construction	Cu.m
1406(3)	Concrete construction in repair work (State class and grade)	Cu.m
1406(4)	Clearing carriageway surface and ramps	Sq.m
1406(5)	Cleaning guide posts, guard stones and flood gauges	Number
1406(6)	Painting of flood gauges, warning board etc. (state type of paint and number of coats)	Sq.m
1406(7)	White washing of posts etc. (state number of coats)	Sq.m
1406(8)	Painting of figures and letters	Number
1406(9)	Clearing of debris	Provisional Sum

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1500 MAINTENANCE OF TRAFFIC SIGNS AND ROAD MARKINGS

1501 MAINTENANCE OF TRAFFIC SIGNS

1501.1 Description

This work shall consist of the maintenance of traffic signs including, cleaning, repairing and replacing components of signs, restoring signs to correct orientation/position and improving the visibility of signs.

1501.2 Materials

Unless otherwise specified all materials used shall meet the requirements specified in Sub section 811.2

1501.3 Work Requirements

(a) Cleaning road signs

The sign face and reverse side shall be washed using clean water, light detergent and cloth. Care shall be taken to avoid scratching the surface of the sign face. After washing out the dirt, all traces of the detergent shall be removed with a cloth or soft bristle brush and rinsed in clean water. Signs contaminated with bitumen or oil shall be cleaned using an approved solvent that will not affect the material of the sign face and/ or its finish.

(b) Repainting or painting components of a sign assembly

(i) General

Surface areas to be repainted shall be cleaned free of rust, dirt and other extraneous matter. Painting shall be done during dry weather and on dry surfaces using soft brushes or rollers. Precautions shall be taken to see that any area which should not receive a coat of paint applied to the surrounding areas is not contaminated with such paint.

Stencils shall be used for painting letters and standard symbols.

A retro-reflective sign face shall not be touched up with paint

(ii) Repainting Metal Surface

Surface to be repainted shall be initially cleaned of any old paint using an approved solvent and any traces of the solvent shall be removed from the sign face. Painting and finishing work of the sign face shall be carried out according to Sub section 811.3(g) and 811.3(h).

(iii) Repainting concrete surfaces

The surface to be repainted shall be cleaned of dust, soil and other extraneous matter by washing thoroughly with water. One coat of emulsion or enamel paint of approved manufacture shall be applied according to the

manufacturer's instructions. Numerals and letter symbols shall be painted using the same type and brand of paint and the specified colour or colours.

(c) Correcting badly oriented/tilted signs/burying mounting posts deeper for stability (for mounting posts without concrete Bases)

The ground around the buried part of the post shall be excavated to a width sufficient to facilitate compaction of backfill. The depth of excavation shall be as specified in Sub section 811.3(i)(b). The sign (assembly) shall be removed from the excavation. The work shall proceed beyond this stage according to Sub section 811.3(f).

(d) Replacing components of a sign assembly

(i) General

Damage caused to any component of a sign assembly due to the Contractor not having taken due care whilst replacing any component of it shall be made good by replacement of the component or repairing or restoring it to meet the requirements of Sub section 811.3(i) at Contractor's expense. Any material rejected for reuse shall be disposed of as directed by the Engineer.

(ii) Replacing screws, bolts and nuts.

Precautions shall be taken to avoid damage to any screws, nuts and bolts during replacement.

(iii) Replacing mounting post or posts

The sign assembly on a sign post or posts requiring replacement shall be dismantled from the post taking due care to avoid damage to the sign or any other component of the sign assembly. In fixing of the new post or posts to the remaining part of the sign assembly and re-erection of the sign assembly, the requirements of the appropriate Sub sections of Section 811.3(b) shall be met.

(iv) Replacing sign plate

The sign plate requiring replacement shall be dismantled from the post assembly taking due care to avoid damage to the other components of the sign assembly. In fixing of the new sign plate to the remaining part of the sign assembly, the requirements of the appropriate Sub sections of Section 811.3(d) shall be met.

(v) Repairing deformed/bent sign plate

A bent or deformed sign plate may be reused after repairs subject to the approval of the Engineer. The sign plate shall be dismantled and re-fixed after repairs according to (iv) above. Any damage caused to the sign face during the process of repair shall be made good to the satisfaction of the Engineer, or the sign restored to its original condition.

(e) Replacing sign assembly

The sign assembly shall be removed. The new sign assembly shall be erected according to Sub section 811.3(i) (a) or (b) , which ever is applicable.

(f) Improving visibility of signs

Vegetation or other objects which obstruct the view of a sign to approaching vehicles shall be removed so that the sign is visible to approaching vehicles or pedestrians from the further most point where it could be clearly seen and understood.

1501.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1501.4 Measurement & Payment

(a) Measurement

Cleaning of surface of traffic signs shall be measured in Sq.m.

Repainting or painting of traffic signs shall be measured in Sq.m.

Correction of sign assembly for alignment, orientation etc., shall be measured by the number.

Replacing of screws, nuts, bolts etc., shall be measured in kilograms.

Replacing mounting post or posts shall be measured by the number.

Replacing sign plates shall be measured by the number.

Repairing deformed / bent sign plate shall be measured by the number

Replacing sign assembly shall be measured by the number.

Improving visibility of sign shall be measured by the number.

(b) Payment

Payment shall be based on the Contract unit rate for items which shall include full compensation for providing all materials, labour, tools equipments and other incidentals necessary to complete the work to the Specifications.

The pay items and pay units shall be as follows:

Pay Item	Description	Pay Unit
1501 (1)	Cleaning of surfaces of traffic signs	Sq.m
1501 (2)	Repainting or painting of traffic signs, (state materials)	Sq.m
1501 (3)	Correcting sign assembles for alignment, orientations, etc. (state type of sign)	Number
1501 (4)	Replacing screws, nuts, bolts etc. (State size and type of material)	Kilograms
1501 (5)	Replacing mounting post or posts (state type)	Number
1501(6)	Replacing sign plates (state type)	Number
1501(7)	Replacing sign assembly	Number
1501(8)	Repairing deformed / bent sign plate (State type)	Number
1501(9)	Improving visibility of signs	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1502 MAINTENANCE OF ROAD MARKINGS

1502.1 Description

This work shall consist of the replacing/repairing or road markings including reflecting road studs (hereinafter referred to as studs) on road surfaces, periodically and as and when required, in accordance with these Specifications.

1502.2 Materials

Materials used for replacing road markings and studs shall be the materials specified for road markings and studs according to the Specifications 810.2. Any other material which may have to be used shall be from an approved manufacturer and recommended by the manufacturer for the type of work and shall be approved by the Engineer.

1502.3 Construction Requirements

All existing road markings, which are required to be replaced or removed, shall be removed from the road surface carefully without causing damage to the road surface by wire brushing or by other approved means without leaving any traces, unless the new road markings completely overlaps the old road markings. Any chemical agent used for the work shall not be injurious to the road and all traces of such a material shall be removed from the road surface after the aforesaid work has

been completed. Any road marking or stud which replaces an existing marking or stud shall be applied or installed on the road surface thereafter according to Sub section 810.3. Any recess or hole in the road which has resulted from the removal of any stud where a replacement of stud will not be installed shall be made good in a manner as approved by the Engineer. Any defective stud shall be replaced in full except in the case of reflective lenses where the design/manufacture permits replacement of a reflective lens or lenses in a stud provided the other components of the stud are in acceptable condition.

1502.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1502.4 Measurement & Payment

(a) Measurement

Road markings removed shall be measured by the area in Sq.m. Road markings in road paint and road markings in thermoplastic material shall be measured separately. Road markings applied shall be measured according to Sub section 810.4

Removal of damaged road studs and making good the surface shall be measured by the number.

The removal and replacement of studs shall be measured in accordance to the following categories:-

(i) Where a replacement stud is installed at the same position.

(ii) Where a replacement stud is not installed at the same position, studs installed shall be measured by the number.

(b) Payment

The work measured as provided above, shall be paid for at the Contract unit price per unit of measurement for each of the items listed.

The payment shall be full compensation for providing and placing or installing the materials including all labour, equipment, tools and incidentals necessary to complete the work.

The Pay Items and Pay Units shall be as follows:-

Pay Items	Description	Pay Unit
1502 (1)	Removal of existing road markings	Sq.m
1502 (2)	Replacement of road marking (state materials)	Sq.m
1502 (3)	Removal of damaged road studs and making good the surface.	Number
1502(4)	Replacement of damaged road studs (state whether in same place or elsewhere)	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1503 MAINTENANCE OF TRAFFIC LIGHT SIGNAL SYSTEM

1503.1 Description

This work shall consist of the maintenance of traffic light signal system in an operational condition in order to provide a reliable traffic light signal system during the required time periods with the provision of flashing amber system during periods other than the required periods of time.

1503.2 Material

Unless otherwise specified all materials used shall meet the requirements specified in Sub section 813.4(a).

1503.3 Work requirements

(a) Cleaning traffic light signal heads, poles, controllers etc.

All sides of the entire traffic light signal heads, poles, controllers, etc shall be washed using clean water, light detergent and cloth.

(b) Repainting or painting components of traffic light signal heads, poles, controllers etc.

This work shall be carried out in accordance with Sub section 1501.3(b) (i) and as directed by the Engineer.

(c) Correcting badly oriented/tilted traffic light signal heads.

This work shall be carried out in accordance with Sub section 1501.3(c) and as directed by the Engineer.

(d) Replacing components of traffic light signal assembly.

(i) General

Damage caused to any component of a traffic light signal assembly due to the Contractor not having taken due care whilst replacing any component, it shall be made good by replacement of the component or repairing or restoring it to meet the requirements of Sub section 813.4(a) and with the approval of the Engineer at the Contractor's expense. Any material rejected for reuse shall be disposed of, as directed by the Engineer.

(ii) Replacing screws, bolts and nuts

Precautions shall be taken to avoid damage to any screws, nuts and bolts during replacement.

(iii) Replacing mounting pole

The traffic light signal head pole or poles requiring replacement shall be dismantled from the traffic signal head assembly taking due care to avoid damage to the signal head and the electrical wiring system or any other component of the head assembly. In installing the new pole or poles or the re -erection of the assembly, the requirements of the appropriate Sub sections of Section 813.9(a) shall be met.

(iv) Replacing the traffic light signal head

All safety precautions shall be taken as this work is carried out with electrical lines. Care shall be taken when replacing the head, the electrical/electronic work to ensure that all necessary requirements shall be satisfied in order to provide the service as per the previous system or the system approved by the Engineer to guarantee the expected service. The requirements of the replacements shall be according to the design and or as directed by the Engineer.

(e) Improving brightness of the traffic light signal

If the brightness of the traffic light signal is not within the required ranges, the bulb or light emitting diode (LED) shall be checked against the expected lumen output, specified in the Sub section 813.9 and shall be corrected by replacement with a new bulb or LED, if found necessary . In addition the inside electrical/electronic circuits shall be checked and corrected or replaced, if necessary.

(f) Push buttons

The push buttons at the pedestrian crossing (Pelican crossing) to be checked frequently at least once a week in order to provide the guaranteed service to the pedestrians. If the push buttons are not effective, immediate action shall be taken to correct or replace the switch component.

(g) Timing

The time set for the traffic light signal system shall be adjusted at least once every six months or whenever it is necessary according to the traffic data, in order to provide an effective and efficient service to the road users.

(h) Flashing amber traffic light signal system

The flashing amber traffic light signal shall be made available to avoid any hazardous situations during the repair/ correction works where the closure of total traffic light signal system is required and during periods of low traffic at night and during early morning.

1503.3/1 Tests and standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standard of acceptance.

1503.4 Measurement & Payment

(a) Measurement

(i) Cleaning of surface of traffic signal system shall be measured in Sq.m

(ii) Repainting or Painting of traffic light signal system, poles, controllers, etc shall be in Sq.m.

(iii) Correcting badly oriented/tilted traffic light signal heads, etc shall be measured by the number.

(iv) Replacing components of traffic light signal assembly shall be measured by the number.

(v) Replacing screws, bolts and nuts shall be measured by the number.

(vi) Replacing mounting poles shall be measured by the number.

(vii) Replacing traffic light signal heads shall be measured by the number.

(viii) General maintenance for items other than those given above and for push buttons, timing and flashing amber traffic light signal system, etc shall be measured by the number of months.

(b) Payment

Payment shall be based on the Contract unit rates for items which shall include full compensation for providing all materials, labour, tools, equipments and other incidental necessary to complete the work to the Specifications.

The pay items and pay units shall be as follows:

Pay Item	Description	Pay Unit
1503(1)	Cleaning of surface of traffic signal system.	Sq.m
1503(2)	Repainting or painting of traffic light signal system, poles, controllers, etc.	Sq.m
1503(3)	Correcting badly oriented/tilted traffic light signal heads, etc.	Number
1503(4)	Replacing components of traffic light signal assembly	Number
1503(5)	Replacing screws, bolts and nuts (State sizes and type of material)	Number
1503(6)	Replacing mounting poles	Number
1503(7)	Replacing traffic light signal heads	Number
1503(8)	General maintenance for items other than those given above and for push buttons, timing and flashing amber traffic light signal system, etc.	Months

1600 QUALITY CONTROL OF WORK

1601 CONTROL OF ALIGNMENT, SURFACE REGULARITY AND PAVEMENT LAYER THICKNESS

1601.1 General

All work carried out shall conform to the lines, grades, Cross-sections and dimensions shown in the Drawings or as directed by the Engineer, subject to the permitted tolerances given hereinafter or as otherwise specified.

The Contractor shall allow for the time taken to carry out testing of materials in his method and programme of working, and no delays shall be considered relating to any materials testing.

Generally as a guide, the Contractor should allow a period of at least 24 hours after the completion of a layer of fill, subgrade, sub-base or basecourse for testing for compliance with the compaction requirements.

Any material, whether naturally occurring, processed, fabricated or manufactured by others which is intended for incorporation in the Works shall be subject to quality control testing before approval is given for its use.

Any material or product which fails to receive approval shall be immediately removed, replaced or otherwise treated to the approval of the Engineer. Any unapproved material or product subsequently covered over or incorporated in the Works shall be removed at the Contractor's expense as instructed by the Engineer.

1601.2 Horizontal Alignment

The horizontal alignment of a road shall be reckoned with respect to the centre line of the carriageway as given in the Drawing. The edges of the carriageway shall be within a tolerance of + 25mm therefrom.

The corresponding tolerances for the edges of the shoulders and the lower layers of the Pavement shall be + 40 mm with no negative tolerance.

1601.3 Longitudinal Profile and Pavement Layer Thickness

The level of subgrade and different pavement courses as constructed shall not vary from the design level calculated at any point with reference to longitudinal and cross-section profile of the road shown on the Drawings or as instructed by the Engineer beyond the tolerances mentioned below;

Subgrade	:	+10 mm / -20 mm
Sub-base	:	+10 mm / -20 mm
Basecourse	:	+15 mm / -10 mm
Asphalt Surfacing	:	+ 6 mm / -6 mm
Cement concrete Pavement	:	+ 6 mm / -6 mm

Notwithstanding the level tolerances given above, thickness of the Pavement layers shall not vary from the specified thickness by more than the following amounts :

Subgrade (Prepared)	:	+10 mm / -20 mm
Sub-base	:	+10 mm / -20 mm
Basecourse	:	+15 mm / -10 mm
Asphalt Surfacing	:	+ 6 mm / - 6 mm
Cement concrete Pavement	:	+ 6 mm / - 6 mm

1601.4 Surface Regularity of Subgrade and Pavement Layers

Surface regularity of the Subgrade and the Pavement shall be within the tolerance indicated in the Table 1601-1.

The longitudinal undulations shall be checked with a 3m long straight edge at the middle of each traffic lane parallel to the centre line of the road. The transverse undulations shall be checked with camber boards at intervals of 10m.

Table 1601-1 - Tolerances of Surface Regularity

TYPE OF CONSTRUCTION	LONGITUDINAL PROFILE WITH 3 m STRAIGHTEDGE					TRANSVERSE PROFILE
	Maximum permitted undulation	Maximum number of undulations permitted in any 300 metre length exceeding :				Maximum permissible variation from specified profile under camber template
	mm	18 mm	12 mm	10 mm	5 mm	mm
Subgrade	24	30				15
Sub-base	15		30			10
Basecourse	12			30		8
Surface Dressing	12			20		8
Asphalt Surfacing	8				30	6
Cement concrete Pavement	8				30	6

Surface regularity requirements in respect of both the longitudinal and transverse profile shall be simultaneously satisfied.

1601.5 Rectification

Where the surface regularity of Subgrade and the different Pavement courses falls outside the specified tolerances, the Contractor shall rectify these in the manner described below and to the approval of the Engineer.

Subgrade

Where the surface is high, it shall be trimmed and suitably compacted to achieve the tolerances. Where the surface is low, the deficiency shall be corrected by scarifying the existing layer and adding fresh material. The degree of compaction and the type of material to be used shall conform to the requirements of Section 304 and Sub section 1708.1 respectively.

Sub-base

The same as for Subgrade except that the degree of compaction and the type of material to be used shall conform to the requirements of Section 401 and Sub section 1708.2 respectively.

Aggregate Basecourse

Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary, and re-compacted. The area of treatment at any place shall not be less than 5 metres long 2 metres wide. The degree of compaction and the type of material to be used shall conform to the requirements of Section 405 herein.

Bituminous Bases and Surfacing Courses

For Bituminous Bases and Surfacing courses, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to Specifications. The area of treatment shall be not less than 5 metres long and not less than one lane wide.

1602 QUALITY CONTROL TESTS DURING CONSTRUCTION

The material supplied and work carried out shall conform to the relevant sections of these Specifications covering each type of work. For ensuring quality of construction, the materials and work shall be subjected to quality control tests prescribed in Table 1602-1. These tests shall be carried out as specified in Chapter 1800. The testing frequencies given in Table 1602-1 are desirable minimum values and the Engineer may direct the Contractor to carry out tests as frequently as he may deem necessary to satisfy himself that the materials and the work comply with the appropriate Specifications.

Table 1602-1 - Quality Control Tests and their Frequencies

TYPE OF MATERIAL	TYPE OF TEST	QUANTITY OF MATERIAL or part thereof for which minimum of one test set is to be carried out
Fill for Embankment (Section 304), preparation of Subgrade (Section 301) and back filling of excavations, drains and trenches (Sections 302 and 305)	- Particle size analysis	1,000 Cu.m
	- Atterberg limits	1,000 Cu.m
	- Modified Compaction	100 Cu.m
	- 4 day soaked CBR [set of 3 specimens for each sample]	1,000 Cu.m
	- Layer thickness	Regularly as required by the Engineer
	- Degree of compaction and field moisture content [embankment and Subgrade]	500 Sq.m subject to minimum of two tests per each layer
	- Degree of compaction [back filling of excavations, drains and trenches] and field moisture content	50 m subject to minimum of two tests per each layer
Lower Sub-base or Capping Layer or Selected Subgrade and for Granular Layers (Sections 301, 304 and 401)	- Particle size analysis	1,000 Cu.m
	- Atterberg limits	1,000 Cu.m
	- Modified Compaction	100 Cu.m
	- 4 day soaked CBR [set of 3 specimens for each sample]	1,000 Cu.m
	- Layer thickness	Regularly as required by the Engineer
	- Degree of compaction and field moisture content	250 Sq.m subject to minimum of two tests per section
Upper Sub-base (Section 401)	- Particle size analysis	200 Cu.m
	- Atterberg limits	200 Cu.m
	- Modified Compaction	100 Cu.m
	- 4 day soaked CBR [set of 3 specimens for each sample]	500 Cu.m
	- Layer thickness	Regularly as required by the Engineer

TYPE OF MATERIAL	TYPE OF TEST	QUANTITY OF MATERIAL or part thereof for which minimum of one test set is to be carried out
	- Field moisture content	250 Sq. m
	- Degree of compaction	500 Sq.m subject to minimum of two tests per section
Stabilized Soil Sub-base / Base (Section 402)	- Lime or cement compliance	As required by the Engineer
	- Soils - Particle size analysis	500 Sq.m
	- Atterberg limits	
	- Modified compaction	
	- Strength tests (UCS/CBR if relevant)	
	- Degree of pulverization	One test per day
	- Layer thickness while spreading	Regularly as required by the Engineer
	- Field moisture content prior to compaction	One test per 250 m^2
	- Degree of compaction of compacted layer	One test per 500 m^2
Single sized aggregate Base (Sections 403 & 408)	- Aggregate impact value	One test per 400 m^3
	- Sieve Analysis of coarse aggregates	
	- Flakiness Index	One test per day
	- Rate of spread of aggregate	One test per day
Water / dry bound macadam Base (Sections 404, 408 & 409)	- Aggregate impact value of coarse aggregate	One test per 400 m^3
	- Sieve analysis of coarse aggregate	One test per 200 m^3
	- Flakiness Index of coarse aggregate	One test per day
	- Sieve analysis of fines	One test per 50 m^3
	- Thickness of layer	One test per day
Aggregate Base Course (Sections 405 & 408)	- Particle size analysis of aggregate	300 Cu.m
	- Plasticity Index	As required
	- Modified Compaction	50 Cu.m
	- Water absorption	500 Cu.m
	- Aggregate impact value	300 Cu.m
	- Los angeles abrasion value	300 Cu.m
	- Flakiness index	1,000 Cu.m
	- Bulk specific gravity	As required by the Engineer
	- Layer thickness	Regularly as required by the Engineer
	- Degree of compaction and field moisture content	500 Sq.m for Section 405 and 100 Sq.m for Section 408 subject to minimum of two tests per section
Penetration Macadam Base (Sections 406 & 408)	- Aggregate impact value	One test per 400 m^3
	- Sieve analysis of coarse aggregate	
	- Flakiness Index	
	- Sieve analysis of key aggregate	One test per 200 m^3
	- Flakiness Index	One test per 200 m^3
	- Depot tray test	At least once in 6 months and when required by the Engineer
	- Acceptance testing of binder	As required by the Engineer
	- Rate of spread of coarse aggregate	One test per day

TYPE OF MATERIAL	TYPE OF TEST	QUANTITY OF MATERIAL or part thereof for which minimum of one test set is to be carried out
	- Rate of spread of binder	Two tests per day
	- Temperature of application of binder	As required by the Engineer
	- Rate of spread of key aggregate	One test per day
Bitumen Bound Base(BBB) (Section 407)	- Acceptance testing of binder	As required by the Engineer
	- Los angeles abrasion value - Aggregate impact value - Sieve analysis of combined aggregate - Coating and stripping test	One test per 400 m^3 However at least one test per each source of Aggregate shall be done
	- Flakiness Index - Bulk specific gravity - Soundness - Water absorption - Temperature of binder - Temperature of aggregate - Temperature of mixing - Temperature of laying	At regular close intervals as required by the Engineer
	- Hot bin grading - Compliance to job mix	One test per 300 tonnes However at least one test per day shall be done
	- Marshall mix design	One for each type of aggregate
	- Core sampling [for checking compaction and determining thickness]	One test per 250 Sq.m or as decided by the Engineer
Earthen Shoulders or Gravel Surfacing (Sections 409 & 601)	- Sieve analysis - Liquid limit - Plastic limit	Each soil type to be tested At least once. Thereafter One test per 300 m^3
	- Standard compaction test	One test for each soil type and thereafter as required
	- CBR	As required by the Engineer
	- Layer thickness while spreading	Regularly as required by the Engineer
	- Field moisture content prior to compaction	One test per 100 m^2
	- Degree of compaction of compacted layer	One test per 200 m^2
Blended aggregate Bases and Surfacing (Section 410)	- Aggregate impact value - Sieve analysis of 37.5, 20 and 14 mm aggregate - Flakiness Index	One test per 400 cu. m
	- Acceptance testing of binder	As required by the Engineer
	- Rate of spread of binder for two coats	Two tests per each coat per day
	- Rate of spread of blended aggregate Base material and choker stone, if applicable	Two tests per day
	- Layer thickness	Regularly as required by the Engineer
Prime Coat or priming cum surface dressing of gravel roads (Sections 501 & 602)	- Depot tray test	At least once in 6 months and when required by the Engineer
	- Acceptance testing of binder	As required by the Engineer

TYPE OF MATERIAL	TYPE OF TEST	QUANTITY OF MATERIAL or part thereof for which minimum of one test set is to be carried out
	- Rate of application	Two tests per day
	- Temperature of application	Regularly as required by the Engineer
Tack Coat (Section 502)	- Depot tray test	At least once in 6 months and when required by the Engineer
	- Acceptance testing of binder	As required by the Engineer
	- Rate of application	Two tests per day
	- Temperature of application	Regularly as required by the Engineer
Hot Bitumen Application (Section 503)	- Depot tray test	At least onee in 6 months and when required by the Engineer
	- Acceptance testing of binder	As required by the Engineer
	- Rate of application of binder	Two test per day
	- Temperature of application of binder	Regularly as required by the Engineer
	- Rate of spread of binding material	Two tests per day
Sand Seal (Section 504)	- Depot tray test	At least once in 6 months and when required by the Engineer
	- Acceptance testing of binder	As required by the Engineer
	- Sieve analysis of cover aggregate	One test per 25 m^3
	- Rate of spread of binder	One test per 500 m^2
	- Rate of spread of cover aggregate	One test per 500 m^2
	- Temperature of binder	Regularly as required by the Engineer
Seal coat treatment (Surface dressing) (Sections 505A & B)	- Depot tray test	At least once in 6 months and when required by the Engineer
	- Particle size analysis of aggregate	200 Cu.m
	- Water absorption	400 Cu.m
	- Aggregate impact value	200 Cu.m
	- Los Angeles abrasion value	200 Cu.m
	- Flakiness index	400 Cu.m
	- Clay, silt and dust fraction of aggregate	400 Cu.m
	- Bulk specific gravity	As required by the Engineer
	- Soundness	As required by the Engineer
	- Coating and stripping test	As required by the Engineer
	- Acceptance of binder	As required by the Engineer
	- Rate of spread of binder	One test per 500 m^2
	- Rate of spread of aggregate	One test per 500 m^2
	- Temperature of binder	Regularly as required by the Engineer
Asphalt Concrete (Section 506)	- Acceptance testing of binder	As required by the Engineer
	- Particle size analysis (coarse aggregate)	200 Cu.m

TYPE OF MATERIAL	TYPE OF TEST	QUANTITY OF MATERIAL or part thereof for which minimum of one test set is to be carried out
	- Particle size analysis (fine aggregate)	100 Cu.m
	- Sand equivalent value of fine aggregate	As required by the Engineer
	- Water absorption	400 Cu.m
	- Aggregate impact value	200 Cu.m
	- Los Angeles abrasion value	200 Cu.m
	- Flakiness index	As required by the Engineer
	- Bulk specific gravity	As required by the Engineer
	- Soundness	As required by the Engineer
	- Coating and stripping test	As required by the Engineer
	- Clay and silt content	As required by the Engineer
	- Acceptance testing of filler material	As required by the Engineer
	- Marshall mix design	One for each type of aggregate
	- Hot bin grading - Compliance to job mix	One test per 300 tonnes However at least one test per day shall be done
	- Temperatures of binder, aggregate, mix and laying	At regular close intervals as directed by the Engineer
	- Core sampling (for checking compaction and determining thickness)	One test per 250 Sq.m or As decided by the Engineer
	- Marshall stability and flow and laboratory compacted density of mix (marshal) voids in mix and voids in mineral aggregate	One test per 300 Tonnes. However at least one test per day
Cold Mix Surfacing (Section 507)	- Acceptance testing of binder	As required
	- Aggregate impact value of aggregate - Flakiness index of aggregate - Grading of combined aggregate	One test per 300 m^3 or 30m^3 for machine or manual mixing respectively. However at least one test per each source of aggregate shall be done.
	- Temperature of binder and aggregate at the time of mixing	To be measured at the commencement of mixing
Slurry Seal Surfacings (Section 508)	- Particle Size Analysis & Aggregate Impact Value Test (aggregates and total mix)	20 Cu.m or 2 tests per day whichever is higher
	- Particle Size Analysis (Mineral filler)	2 Cu.m or 2 tests per day whichever is higher
	- Cement acceptance testing	As required by the Engineer
	- Asphalt emulsion	As required by the Engineer
	- Water for mixing	As required by the Engineer
	- Consistency set time cure time & wet track abrasion test of the mix	20 Cu.m or 2 tests per day whichever is higher
	- Rate of application of mix	Two tests per day

TYPE OF MATERIAL	TYPE OF TEST	QUANTITY OF MATERIAL or part thereof for which minimum of one test set is to be carried out
Cement Incorporated Cold Mix Surfacing (Section 509)	- Particle Size Analysis, Flakiness Index & Aggregate Impact Value Test (aggregates & total mix)	50 Cu.m or 2 tests per day whichever is higher
	- Tests for cement	2 tests per day
	- Asphalt emulsion	As required by the Engineer
	- Water for mixing	As required by the Engineer
Gravelling of earth roads and re-gravelling of gravel roads (Section 601)	- CBR test of gravely soil - Atterberg limits - Standard compaction test - Sieve Analysis	Each soil to be tested at least once, thereafter one test per 300Cu.m
	- Layer thickness while spreading	Regularly as required by the Engineer
	- Field moisture content prior to compaction	One test per 250 m^2
	- Degree of compaction of compacted layer	One test per 500 m^2
Priming cum surface dressing of gravel roads (Section 602)	- Depot tray test	As required
	- Acceptance testing of binder	As required by the Engineer
	- Rate of application of binder	Two tests per day
	- Temperature of application	Regularly as required by the Engineer
Cement Concrete Pavement (Section 901)	- Acceptance testing of cement	1 tests per day per source
	- Acceptance testing of water	One test per source and as required by the Engineer
	- Particle Size Analysis (coarse aggregate)	200 Cu.m
	- Particle Size Analysis (fine aggregate)	100 Cu.m
	- Los Angeles abrasion value or aggregate impact value	200 Cu.m
	- Water absorption of aggregate	As required
	- Soundness of aggregate	As required
	- Alkali Aggregate reactivity	As required by the Engineer
	- Water for concreting	As required by the Engineer
	- Concrete strength	2 cubes and 2 beams per 150 m^3 or part there of (one for 7 day and other for 24 day strength or minimum of 6 cubes and 6 beams per day's work whichever is more
	- Core strength of concrete	As required by the Engineer
	- Workability of fresh concrete slump test	One test per alternate transport equipment
Cold mix for patching (Section 1101)	- Acceptance testing of binder	As required by the Engineer
	- Aggregate impact value - Flakiness Index - Grading of combined aggregate	One test per 30 Cu.m At least one test per each source of aggregate
	- Temperature of binder and aggregate at the time of mixing	To be measured at the commencement of mixing

A fresh series of construction control tests shall be undertaken every time there are changes in the sources of the materials or in the appearance of the materials as visually assessed by the Engineer.

Additional numbers and type of construction control tests shall be carried out if it is considered necessary to do so by the Engineer for monitoring the variability of materials brought to work site or stockpiled by the Contractor.

Moisture content test before compaction of materials shall be carried out on a layer by layer basis for each compaction panel on the following scale:

Table 1602-1b - Moisture Content Testing

TYPE OF MATERIAL	AREA OF LAYER under compaction for which a minimum of one moisture content is to be done
Fill for Embankment	500 Sq.m
Selected Subgrade	250 Sq.m
Sub-base	250 Sq.m
Aggregate for Basecourse	500 Sq.m

A moisture content test shall be repeated whenever the moisture content of the material changes due to drying the wetting or if there is uncertainty (for example, due to variability) in the results of earlier tests.

1603 MATERIAL TESTING

The physical properties and engineering characteristics of the materials mentioned in the Specification shall be established through appropriate tests of representative samples collected in such a manner and at such a frequency as specified and instructed by the Engineer. The tests shall be carried out in accordance with test method mentioned in the Specification after taking into account the appropriateness of the test methods for particular application under consideration.

1700 MATERIAL DETAILS

1701 AGGREGATE

1701.1 Aggregates for bed course materials

(a) For sidewalks, kerbs & channels and pipes

Bed course material for sidewalks, kerbs and channels and for pipe bedding shall consist of sands, natural gravels, crushed stone or other approved non-plastic granular material of such a grading that 100 percent passes through 20mm sieve and at least 90 percent passes through a 14mm sieve and shall be reasonably well graded. It shall be free from vegetable and other deleterious matter. Where required the particle size distribution shall be determined by the sieve analysis test as given in Section 1801.

(b) For filter blankets (filter beds) (Sections 702, 706, 804 and others)

Material for filter blankets in rip rap protection (Section 804), the filter layer behind retaining walls (Section 706) and filter material for sub surface drains (Section 702) shall normally be crushed stone aggregate or non plastic natural gravels with such a grading that 100% of the material passes a 37.5mm sieve and not more than 40% passes a 5mm sieve and it shall be reasonably well graded. It shall also be free from silt, clay and vegetable and other deleterious matter. Where required, the particle size distribution shall be determined by the sieve analysis test as given in Section 1801.

The gradation of the filter material shall satisfy the following requirements :

(i) (D_{15} of filter) / (D_{15} of base material) = 5 to 40 provided that the filter does not contain more than 5% of material finer than 0.075 mm.

(ii) (D_{15} of filter) / (D_{85} of base material) = 5 or less

(iii) The particle size curve of the filter should be roughly parallel to that of the base material.

1701.2 Aggregate for cement concrete (Sections 1001 & others)

Aggregate for concrete shall consist of coarse aggregate (aggregate substantially retained on the 5 mm sieve) and fine aggregate (aggregate substantially passing the 5 mm sieve).

Unless otherwise specified the coarse aggregate shall be crushed rock from an approved quarry and the fine aggregate shall either be crusher fines or river sand.

Aggregate from marine sources shall not be approved. The aggregate shall be free of salt and organic matter. The permissible maximum salt content shall be as follows;

Fine Aggregate	
Sodium Chloride	<0.10%
Soluble Sulphates	<0.25%
Coarse Aggregate	
Sodium Chloride	<0.05%
Soluble Sulphates	<0.25%

The aggregate both coarse and fine shall be hard durable and clean and shall be free from weathered, soft, laminated or elongated pieces, deleterious matter, dust and clay.

The Aggregate Impact Value of the coarse aggregate determined as given in Section 1801 shall not be greater than 45.

The flakiness index of the coarse aggregate when determined by the sieve method described in BS-812 shall not exceed 35%.

Where the concrete is to be used for wearing surface or for concrete of grade greater than Grade 40, the Aggregate Impact Value shall not exceed 30.

Where crusher fines are used as fine aggregate, they shall be derived from rock meeting the requirements of coarse aggregate given above.

The preferred gradings for coarse aggregate, fine aggregate and combined aggregate are given in Table 1701-1, 1701-2 & 1701-3 respectively. The aggregate grading shall be determined as given in Section 1801.

Table 1701-1 - Preferred Grading for Coarse Aggregate for Concrete

SIEVE SIZE mm	PERCENTAGE PASSING					
	Nominal size of graded aggregate mm			Nominal size of single sized aggregate mm		
	37.5 to 5	20.0 to 5	14 to 5	37.5	20.0	14
75.0	100	-	-	-	-	-
63.0	-	-	-	100	-	-
37.5	95-100	100	-	85-100	100	-
20.0	40-72	96-100	100	0-30	87-100	100
14	-	-	95-100	-	-	88-100
10	12-42	35-62	67-88	0-6	0-30	0-58
5	0-5	0-13	0-16	-	0-6	0-13
2.36	-	-	-	-	-	-

Table 1701-2 - Preferred Grading for fine Aggregate for Concrete

SIEVE SIZE		PERCENTAGE PASSING		
mm	µm	Zone 1	Zone 2	Zone 3
10		100	100	100
5		91-100	91-100	91-100
2.36		60-95	75-100	85-100
1.18		30-70	55-90	75-100
	600	15-34	35-59	60-79
	300	5-20	8-30	12-40
	150	0-10	0-10	0-10

Table 1701-3 - Preferred Grading for all-in Aggregate for Concrete

SIEVE SIZE		PERCENTAGE PASSING	
mm	µm	37.5mm Nominal Size	19.0mm Nominal Size
75		100	-
37.5		95-100	100
20		48-82	92-100
5		25-50	35-55
	600	8-30	10-35
	150	0-6	0-6

Note
The equivalent ASTM sieves as given in Sub Section 107 may also be used.

1701.3 Aggregate for the construction and maintenance of Bases and Surfacing of flexible Pavements (Chapters 400, 500, 1100 and others)

(a) General Requirements

The coarse aggregate (aggregate substantially retained on 5mm sieve) used for Road Bases and Surfacing shall be crushed rock from an approved quarry and shall consist of clean hard sound durable particles of angular shape and rough surface texture. They shall be free from weathered, soft, laminated or elongated pieces, deleterious matter and shall be free from clay and excess dust.

The coarse aggregate shall conform to the following requirements :

Unbound Basecourse Aggregates (Chapters 403, 404, 405, 406, 408, 410 and others)

1. The Aggregate Impact Value (AIV) determined as specified in BS-812 shall not be more than 30%.

2. The flakiness index of the coarse aggregate when determined by the sieve method described in BS-812 shall not exceed 35%.

3. Additional requirements for 405 Dense Graded Aggregate Bases

3.1 The crushed stone shall preferably be non-plastic, but in no case shall the PI exceed 6%.

3.2 The minimum soaked CBR value of material in the Basecourse shall not be less than 80% at the specified in-situ density.

Coarse Aggregate Used for Bound Base Course Aggregate - Section 407 Bitumen Bound Bases & Surfacing – Section 506 Asphalt Concrete

1. The Los Angeles Abrasion Value (LAAV) as determined by AASHTO T-96 test shall not be more than 40%.

2. The Aggregate Impact Value (AIV) determined as specified in BS-812 shall not be more than 30%.

3. The flakiness index of the coarse aggregate when determined by the sieve method described in BS-812 shall not exceed 35%.

4. The water absorption of the aggregate shall not be more than 2%.

5. When subject to bitumen coating and stripping as per AASHTO T-182 test the coated area of the aggregate shall not be less than 95%.

6. The loss on the Sodium Sulphate soundness test (5 cycles) AASHTO T-104 shall not exceed 12%.

Cover Aggregate Used for seal coat treatments (surface dressing) (Sections 505A & B)

1. The Los Angeles Abrasion Value (LAAV) as determined by AASHTO T-96 test shall not be more than 40%.

2. The flakiness index determined by the sieve method described in BS-812 shall not exceed 25% for 20 & 14mm chips and 30% for 10 & 6mm chips.

3. The loss on the Sodium Sulphate soundness test (5 cycles) AASHTO T-104 shall not exceed 12%.

4. When subject to bitumen coating and stripping as per AASHTO T-182 test the coated area of the aggregate shall not be less than 95%.

5. The dust content (passing the 75 mm sieve) of the aggregate determined shall not exceed 1.0%.

Fine Aggregates Used for Bases and Surfacings(Chapter 400, 500 and others)

Fine aggregate (aggregate substantially passing the 5 mm sieve) used for Bases and Surfacing shall either be crusher fines or river sand. The fine aggregate shall be non-plastic, clean and free from any organic matter. Where crusher fines are used they shall be derived from rock meeting the requirements of coarse aggregate for Bases and Surfacings.

Fine Aggregate Used for Asphalt Concrete (Section 506)

The sand equivalent value determined in accordance with AASHTO T-176 shall not exceed 45.

Fine aggregate (aggregate substantially passing the 5m sieve) shall either be crusher fines or river sand. Where crusher fines are used they shall be derived from rock meeting the requirements of coarse aggregate for Asphalt Concrete Surfacing.

(b) Grading requirements of aggregates used for Bases and Surfacings

Table 1701-4 - The Grading of Single Sized Aggregates used for Bases and for Maintenance Work. (Sections 403, 408 and others)

SIEVE SIZE mm	PERCENTAGE BY WEIGHT PASSING - SIEVE			
	Nominal size in mm			
	50	37.5	20	14
63	100	-	-	-
50	85-100	100	-	-
37.5	0-30	85-100	-	-
28	0-14	0-52	100	-
20	0-2	0-12	88-100	100
14	-	0-3	0-53	87-100
10	-	-	0-11	0-45
5	-	-	-	0-7
2.36	-	-	0-2	0-2

Table 1701-5 - The Grading of Graded Aggregates used for Base Courses and for Maintenance Work. (Section 405 and others)

SIEVE SIZE mm	µm	PERCENTAGE BY WEIGHT PASSING - SIEVE		
		Nominal size in mm		
		37.5 mm	28 mm	20 mm
50		100		
37.5		95 – 100	100	
28		-	-	100
20		60 – 80	70 – 85	90 – 100
10		40 – 60	50 – 65	60 – 75
5		25 – 40	35 – 55	40 – 60
2.36		15 – 30	25 – 40	30 – 45
	425	7 – 19	12 – 24	13 – 27
	75	5 – 12	5 – 12	5 – 12

Table 1701-6 - The Grading of Coarse Aggregate and Crusher Fines for Water Bound and Dry Bound Macadam Base Courses. (Section 403)

SIEVE SIZE mm	SIEVE SIZE µm	PERCENTAGE BY WEIGHT PASSING - SIEVE		
		Coarse Aggregate		Crusher Fines
		Nominal max. size of agg. in mm		
		63	50	
75		100	-	-
63		90-100	100	-
50		30-70	90-100	-
37.5		0-15	30-70	-
28		-	0-32	-
20		0-6	-	-
14		-	0-7	-
10		-	-	100
5		-	-	86-100
	150	-	-	10-30

Table 1701-7 - Grading of Aggregate for Penetration Macadam Base Courses (Section 406)

SIEVE SIZE mm	PERCENTAGE BY WEIGHT PASSING - SIEVE			
	Nominal Maximum Size of Aggregate in mm			
	50	37.5	20	14
63	100	-	-	-
50	-	100	-	-
37.5	50-73	-	-	-
28	-	46-72	100	-
20	7-26	-	52-68	100
14	-	7-27	-	63-88
10	-	-	7-25	-
5	-	-	-	6-35
2.36	0-3	0-3	0-3	0-3
1.18	-	-	-	-

Table 1701-8 - Grading of Single Sized Aggregate for Seal Coat Treatments (Sections 505 A & B and others)

SIEVE SIZE mm	SIEVE SIZE µm	PERCENTAGE BY WEIGHT PASSING - SIEVE 20 mm	14 mm	10 mm	6.3 mm
28		100	-	-	-
20		85-100	100	-	-
14		0-25	85-100	100	-
10		0-7	0-25	85-100	100
6.3		-	0-7	0-20	85-100
5		-	-	0-10	-
3.35		-	-	-	0-20
2.36		0-2	0-2	0-2	0-10
	75	0-1.0	0-1.0	0-1.0	0-1.0

Table 1701-9 - Grading of Coarse River Sand used for Sand Sealing and as Blotting (Blinding) Material (Section 504 and others)

SIEVE SIZE mm	SIEVE SIZE µm	PERCENTAGE BY WEIGHT PASSING - SIEVE
10		100
5		85-100
2.36		50-95
1.18		25-80
	600	10-40
	300	0-15
	150	0-5
	75	0-2

Table 1701 – 10 - Grading of Graded Aggregate with and without cement for Cement Incorporated Cold Mix (Section 509).

SIEVE SIZE mm	SIEVE SIZE µm	PERCENTAGE BY WEIGHT PASSING - SIEVE Without Cement	With Cement
28		100	100
20		85 – 95	89 – 100
10		56 – 86	59 – 91
5		35 – 68	37 – 72
2.36		25 – 52	26 – 55
	425	7 – 26	07 – 27
	75	2 – 14	5 – 15

(c) Size requirements of 100mm aggregate (Section 403 and others)

The 100mm aggregate shall be such that the maximum dimensions of the pieces of aggregate shall not exceed 150mm and their minimum dimensions shall not be less than 75mm. The aggregate shall in addition be well graded between these two limiting dimensions of maximum and minimum dimensions.

1701.4 Blotting (Blinding) Material (Sections 501, 502, 503 and others)

Blotting (blinding) material shall be coarse river sand or crushed rock conforming to grading given in Table 1701-9. The grading shall be determined by the sieve analysis test as given in Section 1801.The use of other naturally occurring coarse sands or gravels shall be subject to the approval of the Engineer.

The blotting material shall be clean and dry and free of lumps of clay and other deleterious matter.

1701.5 Sand for sand sealing (cover material) (Section 504 and others)

Sand for sand sealing shall be coarse river sand conforming to the grading given in Table 1701-9. The grading shall be determined by the sieve analysis test as given in Section 1801. It shall be clean and dry and free of lumps of clay and other deleterious matter.

1702 BINDER (Chapter 500, Section 406 and others)

1702.1 Penetration grade bitumen

The penetration grade bitumen used for road construction and maintenance work shall be derived by refining petroleum crude and shall conform to the requirements in Table 1702-1 below. In addition it shall not foam when heated to 177°C.

Table 1702-1 Requirements of Penetration Grade Bitumen

Type	60/70	80/100
Property	Requirements	
Penetration 25°C 100 gm 5 secs. 1/10mm	60/70	80-100
Softening point °C	48/56	47-55
Loss on heating for 5 hrs. at 163°C		
(1) Loss in weight percent	Not greater than 1.0	not greater than 0.5
(2) Loss in penetration, percent of original value	Not less than 75	not less than 80
Solubility in trichloroethylene, percent	Not less than 99	not less than 99.5
Flash point (Cleveland open cup) °C	Not less than 232	not less than 232

Each consignment of bitumen delivered to Site must be accompanied by a certificate of testing, as per BS-3690-1:1989 (1997) or AASHTO M20 : 1996, from the supplier. Any extra test instructed by the Engineer whose result proves that the material is out of Specification will be carried out at no extra cost.

Note

The determination of all characteristics in Table 1702-1 shall be carried out in accordance with tests specified in Section 1802.

1702.2 Medium curing cutback bitumen

Medium curing cutback bitumen used for road construction and maintenance shall be prepared at site by fluxing 80-100 penetration bitumen with kerosene oil. The percentage of kerosene added shall be as specified or as directed by the Engineer depending on the purpose for which the binder is to be used. The cutback bitumen prepared shall be designated by the percentage quantity by volume of kerosene present in the binder. (eg. 10 percent cutback bitumen shall contain 10 percent by volume of kerosene and 90 percent by volume of bitumen).

In the alternative medium curing cutback bitumen shall conform to ASTM D 2027 where they are designated as MC 30, MC 70, MC 250, MC 800 & MC 3000. The residue from distillation of these grades when heated to 260°C shall not be less than 50%, 55%, 67%, 75% & 80% respectively.

All acceptance tests shall be carried out as specified in Section 1802.

1702.3 Cationic bitumen emulsion

Cationic bitumen emulsion used for road construction and maintenance shall be the rapid setting CRS-1 & CRS-2, medium setting CMS-2 and slow setting CSS-1 types which shall conform to ASTM D 2397-98.

These emulsions shall conform to the requirements given therein, in respect of the following:-

(a) Viscosity

(b) Settlement

(c) Storage Stability

(d) Particle charge test

(e) Sieve test

(f) Distillation characteristics

(g) Characteristics of the residue of distillation

In addition the rapid setting emulsion shall conform to the requirements of demulsibility, the medium setting emulsion shall conform to the requirements of coating ability and water resistance and slow setting emulsion shall conform to the requirements of the cement mixing test.

All acceptance tests shall be carried out as specified in Section 1802.

1703 CEMENT (Chapters 900, 1000 and others, Sections 402, 509 and others)

Cement used shall normally be Ordinary Portland Cement (OPC) complying with the requirements of SLS 107 or blended hydraulic cement to SLS 1247 or Portland limestone cement to SLS 1253 - 2008. If the concrete or the cement product is subjected to severe exposure such as a substructure is in an acidic medium pH<7(in peaty soils), Portland limestone cement shall not be used. The cement shall conform to the requirements given therein, in respect of the following:-

(a) Fineness

(b) Chemical composition

(c) Compressive strength

(d) Setting time

(e) Soundness

Tests in respect of the above shall be carried out as specified in Section 1803.

Use of Masonry Cement complying with the requirements of SLS 515 or rapid hardening cement complying with the requirements of BS 12 or BSEN 197-1 – 2000 or any other special cement shall be with the prior approval of the Engineer for special uses.

Unless otherwise permitted by the Engineer, only one brand of the approved brands of cement shall be used on one project.

Cement shall be brought to Site in quantity not exceeding three months requirements. Each consignment of cement delivered to Site shall be accompanied by a certificate of testing as per BS or SLS. Any extra tests instructed by the Engineer whose result proves the material to be not conforming to Specification shall be carried out at no extra cost. If for any reason the period of storage of consignment of cement exceeds three months, a representative sample of the cement shall be re-tested to confirm its suitability before use at no extra cost.

The Contractor shall provide suitable means of storing and protecting the cement against dampness. Cement which, for any reason has become partially set or which contains lumps of caked cement shall be rejected.

No additives for cement shall be used unless agreed by the Engineer.

1703.1 Cement Grout

Cement grout for grouting of ducts, jointing of concrete pipes, and other purposes shall consist of Ordinary Portland Cement and water mixed in the proportions necessary for the intended purpose. The grout shall be mixed until a uniform consistency is obtained and shall normally be used within 45 minutes of mixing.

1703.2 Cement Mortar

Cement mortar shall normally consist of Ordinary Portland Cement, sand and water in the proportions specified. Lime shall be added only where specified.

Mortar shall be mixed thoroughly, either by hand or mechanically until its colour and consistency are uniform. It shall be mixed in small quantities only as and

when required and shall normally be used within 45 minutes of mixing. Mortar which had been mixed for more than 1 hour and shows signs of hardening shall be discarded.

The constituent materials shall normally be volume proportioned as accurately as practicable making allowance for bulking of sand and also of the cement. Water shall be added in stages until the required consistency is reached.

1704 CONCRETE ADMIXTURES (Chapter 1000 and others)

Concrete admixtures as retarders, accelerators or as plasticizers shall be used with the prior approval of the Engineer only and they shall be used strictly in accordance with the manufacturer's recommendations.

In the use of additives particular attention should be paid to the accurate proportioning of the additive and its homogeneous introduction in the mix.

1705 CONCRETE PRECAST UNITS (Chapters 700, 800, 1000 and others)

All precast concrete units such as kerbs, slabs, drain sections, catch-pits and manholes shall be manufactured using concrete of class A and of the required grade as given in Section 1001. The manufacturer shall obtain approval for the mix proportions, from the Engineer based on a suitable mix design procedure, prior to starting on production operations.

Class B concrete of nominal mix proportions 1:2:4 or 1:1½:3 and of the aggregate sizes proposed shall be used only with the approval of the Engineer and only on jobs of a small scale, where the units are cast at sites of limited facilities.

The units shall be cast in permanent moulds preferably made of steel. Timber moulds shall be made use of only with the approval of the Engineer. All moulds shall conform to the general requirements of Section 1008.

The precast units shall be reinforced or unreinforced as required. Reinforcement used shall meet the requirements of SLS 375 & SLS 26 or BS 4449.

The Engineer may permit precast units to be supplied from a reputed manufacture. Prior to procuring units for installation in the Works, samples of the units together with documented test results from the manufacture shall be forwarded to the Engineer for his approval. The Engineer shall order tests to be undertaken at no extra cost where insufficient results are available.

1706 FILLER FOR ASPHALT CONCRETE (Section 506)

The filler for asphalt concrete shall be chemically inert crushed stone dust and lime stone dust and chemically active hydrated lime and cement or any other non-plastic inert material approved by the Engineer. It shall also conform to the grading given in Table 1706-1.

Table 1706-1 Grading Requirements for Filler for Asphalt Concrete

SIEVE SIZE µm	PERCENTAGE BY WEIGHT PASSING - SIEVE
600	100
150	90 – 100
75	75 – 100

The grading shall be determined by the sieve analysis test as specified in Section 1801.

1707 PAINTS (Chapters 800, 1400, 1500 and others & Section 1023 and others)

Cement paints shall conform to the requirements of SLS 590. Enamel & Emulsion paints shall be those suitable for exterior use and shall conform to the requirements of SLS 539 and 557 respectively.

Anticorrosive paints shall conform to the requirements of SLS 713.

Spray primers and paints shall be of approved brands.

Lime wash used for painting of guard stones, guide posts etc. shall be of the quality approved by the Engineer.

1708 SOILS

1708.1 Embankment Materials (Section 304 and others)

Soils used as embankment materials shall be naturally occurring soils and shall not include highly plastic clay, silt, peat or other organic soils or any soil that is contaminated with top soil vegetable and other deleterious matter. The material used for the top 500mm of embankment shall conform to the requirements of type I material, and the material for lower layers of embankment shall conform to the requirements of type II material as given below.

Embankment Material

Table 1708-1 : Requirements of Embankment

PROPERTY	TEST METHOD (AASHTO)	EMBANKMENT Type I	Type II
Liquid Limit (LL)	T-90	Not to exceed 50%	Not to exceed 55%
Plasticity Index (PI)	T-90	Not to exceed 25%	Not to exceed 25%
Maximum Dry Density (Modified)	T-180	Not less than 1,600 kg/m^3	Not less than 1,500 kg/m^3
4-day soaked CBR at 95% MDD (Modified)	T-193	Not less than 7%	Not less than 5%

1708.2 Soils for Upper Sub-base and Lower Sub-base (Capping Layer) or Selected Subgrade Material (Sections 301, 304, 401 and others)

The materials used for the upper Sub-base, Lower Sub-base(Capping Layer) or selected Subgrade shall be naturally occurring or blended gravels and sands or mixtures thereof and shall not include highly plastic clays, peat or other organic soils or any soil that is contaminated with topsoil, vegetable and other deleterious matter.

The completed upper Sub-base, Lower Sub-base(Capping Layer) or selected Subgrade shall contain no aggregate having a maximum dimension exceeding two thirds of the compacted layer thickness.

The soil for upper Sub-base material shall have the following characteristics:-

Upper Sub-base

Table 1708-2 - Requirements of Upper Sub-base

PROPERTY	TEST METHOD (AASHTO)	UPPER SUB-BASE		
			Flexible	Rigid
Liquid Limit (LL)	T-90	Not to exceed	40%	25%
Plasticity Index (PI)	T-90	Not to exceed	15%	6%
Maximum Dry Density (Modified)	T-180	Not less than 1,750 kg/m^3		
4-day soaked CBR at 98% MDD (Modified)	T-193	Not less than 30%		

Table 1708-3 - Grading Requirements for Upper Sub-base (Section 401 and others)

SIEVE SIZE mm	SIEVE SIZE µm	PERCENTAGE BY WEIGHT PASSING SIEVE
50		100
37.5		80 – 100
20		60 – 100
5		30 – 100
1.18		17 – 75
	300	9 – 50
	75	5 – 25

Lower Sub-base (Capping Layer) or Select Subgrade (Sections 301, 304, 401 and others)

Materials used for Select Subgrade shall be naturally occurring soils or gravels and shall not include highly plastic clay, silts, peat or other organic or any soil that is contaminated with topsoil, vegetable or other deleterious matter.

Table 1708-4 - Requirements of Lower Sub-base (Capping Layer) or Select Subgrade

PROPERTY	TEST METHOD (AASHTO)	LOWER SUB-BASE (CAPPING LAYER) OR SELECT SUBGRADE
Liquid Limit (LL)	T-90	Not to exceed 40%
Plasticity Index (PI)	T-90	Not to exceed 15%
Maximum Dry Density	T-180	Not less than 1,650 kg/m^3
4-day soaked CBR at 95% MDD (Modified)	T-193	Not less than 15%

1708.3 Soil for cement and Lime-stabilized Sub-base and base (Section 402 and others)

The soil used for cement and lime-stabilized sub-base/base shall be naturally occurring or blended soils and shall not include highly plastic clays, silts or peats or any soil that is contaminated with top soil, vegetation, organic or other deleterious matter which inhibit the chemical reaction with the stabilizer. The soil shall also conform to the following requirements.

(i) The guide to the type of stabilization likely to be effective as given in Fig. 7.2 of TRL, UK Road Note 31 (1993) is tabulated below. [The guide shall be read in conjunction with Sub section 402.3(d)].

Guide to the type of stabilization likely to be effective

Type of Stabilisation	Soil Properties					
	More than 25% passing the 0.075 mm sieve			Less than 25% passing the 0.075 mm sieve		
	PI≤10	10<PI≤20	PI>20	PI≤6 PP≤60	PI≤10	PI>10
Cement	Yes	Yes	*	Yes	Yes	Yes
Lime	*	Yes	Yes	No	*	Yes

Notes 1. * Indicates that the agent will have marginal effectiveness
2. PP = Plasticity Product
=PI* (Percentage Passing 75 μm sieve)

(ii) The soil shall have a stable grading with coefficient of uniformity D_{60}/D_{10} (ratio of percent passing sieve sizes) not less than 5 except where otherwise allowed.

(iii) The desirable properties of material before stabilization

BS test sieve mm	BS test sieve µm	Percentage by mass of total aggregate passing test sieve		
		CB1	CB2	CSB
53		100	100	-
37.5		85 - 100	80 – 100	-
20		60 - 90	55 – 90	-
5		30 - 65	25 – 65	-
2.36		22 - 53	17 – 53	-
	425	10 - 30	10 – 30	-
	75	5 - 15	5 – 15	-
		Maximum allowable value		
LL		25	30	-
PI		6	10	20
LS		3	5	-

Note: CB1 - Stabilised road base1
CB2 - Stabilised road base2
CSB - Stabilised subbase [Also see Section 402.3(d)]

(iv) The sieve analysis test, the liquid limit test, the plastic limit test and shrinkage limit shall be carried out as given in Section 1804.

(v) The soil shall be able to be pulverized to an extent that all of it will pass the 25 mm sieve and not less than 60% will pass through a 4.75 mm sieve.

1708.4 Not used

1708.5 Soil for road shoulders and gravel surfacing (Sections 409, 601 and others)

The soil used for road shoulders and gravel surfacing shall consist of naturally occurring gravels, sands and mixtures thereof with sufficient plastic fines to act as binder or such soil obtained by blending two or more soils and shall conform to the grading requirement given in Table 1708-1 and consistency limits given in Table 1708-2.

The soil shall also have a 4 day soaked CBR value not less than 15% at 100% maximum dry density under standard conditions of compaction.

Table 1708-1 - Grading Requirements for Soils for Road Shoulders and Gravel Surfacing.

SIEVE SIZE mm	SIEVE SIZE µm	PERCENT PASSING
37.5		100
20		77-100
5		41-100
2.36		30-80
	600	18-50
	75	5-25

Table 1708-2 - Consistency Limits for Soils for Earthen Road Shoulders and Gravel Surfacings.

CLIMATIC ZONE		LL	PI
Wet Zone	Lateritic Gravely Soils	< 55	4 – 25
	Other Gravely Soils	< 50	4 – 20
Dry Zone		< 55	6 – 25

The standard compaction test, the CBR test, the sieve analysis test, the liquid limit test and the plastic limit test shall be carried out as given in Section 1804.

1708.6 Natural gravels for water/dry bound macadam (Section 404 and others)

Natural gravels for infilling of aggregate in water/dry bound macadam shall consist of naturally occurring gravels, sands and mixtures thereof having a liquid limit and plasticity index not exceeding 20 and 6 respectively. The soil shall be free of organic and other deleterious matter and shall conform to the grading given in Table 1708-3.

Table 1708-3 Grading Requirements for Natural Gravels for Water Bound Macadam

SIEVE SIZE mm	SIEVE SIZE µm	PERCENTAGE BY WEIGHT PASSING - SIEVE
10		100
5		86-100
	150	10-30
	75	0-10

The sieve analysis test, the liquid limit test and the plastic limit test shall be carried out as given in Section 1804.

1708.7 Soil for patching of deep potholes below base level (Section 1102 and others)

The soil used for patching of deep potholes below base level, shall consist of naturally occurring gravels, sands and mixtures thereof having a liquid limit and plasticity index not exceeding 40 and 15 respectively. The soil shall be free of organic and other deleterious matter and shall not have percentage passing the 75µm sieve greater than 25. It shall have the same CBR requirement as for upper subbase as per Section 1708.2.

1708.8 Porous shoulder material (Section 409 and others)

Porous shoulder material shall be crushed stone aggregate or non plastic natural gravels with such a grading that 100% of the material passes a 37.5mm sieve and not more than 40% passes a 5mm sieve and it shall be reasonably well graded. It shall also be free from silt and clay and vegetable and other deleterious matter.

The sieve analysis test shall be done as given in Section 1804.

1709 TIMBER

Timber for bridge decks (struts and planks) and for guard rails (posts and rails) and for mounting posts for road signs shall be sawn timber of the class and species specified. They shall be completely free of sapwood, cracks, decayed knots and other defects and shall conform to the specified strength requirements.

Timber for fence posts, gate posts and guideposts shall be either round timber or sawn timber as specified. They shall be hardwood of the specified species and shall be free from cracks, wood rot, worm and decayed knots.

All round timber shall be peeled and with the ends sawn or cut as required. They shall be straight and with all knots trimmed flush with the surface.

All timber shall be properly seasoned as required and the seasoning shall be carried out in accordance with SLS 159.

1710 GEOTEXTILES / GEOFABRIC FOR HIGHWAY APPLICATIONS

1710.1 Referenced Documents

These Specifications:

- Section 1804.1 Particle Size Analysis of Soils
- Section 1804.3 Determining the Plastic Limit and Plasticity Index of Soils
- Section 1804.4 Moisture-Density Relations of Soils using a 4.5 kg Rammer and 450 mm Drop

ASTM Standards:

- D 123-00a, Standard Terminology Relating to Textiles
- D 276, Test Methods for Identification of Fibres in Textiles
- D 4354-99(04), Practice for Sampling of Geosynthetics for Testing
- D 4355-05, Test Method for Deterioration of Geo-textiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
- D 4439-04, Terminology for Geosynthetics
- D 4491-99a(04), Test Method for Water Permeability of Geo-textiles by Permittivity
- D 4533-04, Test Method for Trapezoid Tearing Strength of Geo-textiles
- D 4632-91(2003), Test Method for Grab Breaking Load and Elongation of Geo-textiles
- D 4751-04, Test Method for Determining Apparent Opening Size of Geo-textile
- D 4759-02, Practice for Determining the Specification Conformance of Geosynthetics
- D 4833-00, Test Method for Index Puncture Resistance of Geo-textiles, Geomembranes and Related Products
- D 4873-02, Guide for Identification, Storage and Handling of Geo-textiles

- D 5261-92(03), Test Method for Measuring Mass per Unit Area of Geo-textiles
- D 6140-00(05), Test Method for Determining the Asphalt Retention of Paving Fabrics

1710.2 Physical Requirements

(a) Fibers utilised in the manufacture of geo-textiles and the threads used in joining geo-textiles by sewing, shall consists of long-chain synthetic polymers, composed of at least 95 percent by weight of polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns, including selvages, retain their dimensional stability relative to each other.

(b) Subsurface drainage, separation, stabilization, and permanent erosion control applications, geo-textiles shall conform to the physical requirements of Sub section 1710.6. Geo-textiles used as paving fabrics shall conform to the physical requirements of Sub section 1710.7.

(c) All values of properties, with the exception of apparent opening size (AOS), in these Specifications represent minimum average roll values (MARV) in the weakest principal direction (i.e., average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the minimum values provided herein). Values for AOS represent maximum average roll values (MARV).

1710.3 Certification

(a) The Contractor shall provide to the Engineer, a certificate stating the name of the manufacture, product name, style number, chemical composition of the filaments or yarns, and other pertinent information to describe the geo-textile fully.

(b) Contractor shall obtain the supplies of geo-textiles from a manufacturer who shall be responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the Specifications. Documentation describing the quality control program shall be made available upon request from such manufacturers.

(c) Such manufacturer's certificate shall state that the furnished geo-textile meets MARV requirements of the Specification as evaluated under the manufacturer's quality control program. A person having legal authority to bind the manufacturer, shall attest to the certificate.

(d) Either misrepresentation of materials or mislabeling shall be a reason to reject those geo-textile products of the manufacturer.

1710.4 Sampling, Testing and Acceptance

(a) Geo-textile materials shall be subject to sampling and testing to verify conformance with these Specifications. Sampling shall be in accordance with the most current ASTM Standard D 4354, using the section titled, "Procedure for Sampling for Purchaser's Specification Conformance Testing." In the absence of purchaser's testing, verification may be based on manufacturer's certifications as a result of testing by the manufacturer of quality assurance samples obtained using the procedure for Sampling for Manufacturer's Quality Assurance (MQA) Testing. A lot size shall be considered to

be the shipment quantity of the given product, or a truckload of the given product, whichever is smaller.

(b) For the indicated application, testing shall be performed in accordance with the methods referenced in these Specifications. The number of specimens to test per sample is specified by each test method. Geo-textile product acceptance shall be based on ASTM D 4759. Product acceptance is determined by comparing the average test results of all specimens within a given sample to the specimen MARV. Reference shall be made to ASTM D 4759 for more details regarding geo-textile procedures for acceptance.

1710.5 Shipment and Storage

(a) Labeling, shipment and storage of geo-textiles shall follow ASTM D 4873. Product labels shall clearly show the manufacturer or supplier name, style name and roll number. Each shipping document shall include a notation certifying that the material is in accordance with the certificate of the manufacturer.

(b) Each roll of geo-textiles shall be wrapped with a material that will protect the geo-textile, including the ends of the roll, from damage due to shipment, water, sunlight and contaminants. The protective wrapping shall be maintained during periods of shipment and storage subsequently.

(c) During periods of storage, the geo-textile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 71^0C (160^0F) and any other environmental condition that may damage the geo-textile physical property values.

1710.6 Geo-textile Property Requirements for Subsurface Drainage, Separation, Stabilization and Permanent Erosion Control.

(a) General Requirements:

(i) Table 1710-1 provides strength properties for three geo-textile classes. For the indicated application, the geo-textile shall conform to the properties of Table 1710-1 based on the geo-textile class required in Table 1710-2 to 5.

(ii) All numerical values in Table 1710-1 represent minimum average roll value (MARV) in the weaker principal direction. The geo-textile properties required for each class are depended upon geo-textile elongation. When sewn seams are required, the seam strength, as measured in accordance with ASTM D 4632, shall be equal to or greater than 90 percent of the grab strength specified.

(b) Subsurface Drainage Requirements:

(i) Geo-textile Requirements - The geo-textile shall meet the requirements of Table 1710-2. Woven slit film geo-textiles (i.e., geo-textiles made from yarns of a flat, tape-like character) shall not be allowed. All numeric values in Table 1710-2, except AOS, represent MARV in the weaker principai direction. Values of AOS represent maximum average roll values.

Table 1710-1 – Strength Property Requirements of Geo-textiles

	Test Methods	Units	Geo-textile Class [a,b]					
			Class 1		Class 2		Class 3	
			Elongation < 50%[c]	Elongation ≥ 50%[c]	Elongation < 50%[c]	Elongation ≥ 50%[c]	Elongation < 50%[c]	Elongation ≥ 50%[c]
Grab strength	ASTM D 4632	N	1400	900	1100	700	800	500
Sewn seam Strength	ASTM D 4632	N	1260	810	990	630	720	450
Tear strength	ASTM D 4533	N	500	350	400[e]	250	300	180
Puneture strength	ASTM D 4833	N	500	350	400	250	300	180
Permittivity	ASTM D 4491	Sec^{-1}	Minimum values for permittivity, AOS and UV stability are based on geo-textile application. Refer to Table 1710-2 for subsurfaee drainage. Table 1710-3 for separation, Table 1710-4 for stabilization and Table 1710-5 for permanent erosion eontrol.					
Apparent opening size	ASTM D 4751	mm						
Ultraviolet stability	ASTM D 4355	%						

Table 1710-1 : Notes

a For the required application, the required geo-textile class is designated in Tables 1710-2 to 5. The severity of installation conditions for the application generally dictates the required geo-textile class. Class 1 shall be specified for more severe or harsh installation conditions where there is a greater potential for geo-textile damage, and Class 2 and 3 are specified for less severe conditions of installation.

b All numerical values represent MARV in the weaker principal direction. (See Sub section 1710.6(a)(ii)

c As measured in accordance with ASTM D 4632.

d When sewn seams are required, refer to Section 2002-3(a) .

e The required MARV tear strength for woven monofilament geo-textiles is 250 N.

Table 1710-2 – Geo-textile Requirements for Subsurface Drainage

	Test Methods	Units	Requirements, Percent in situ Soil Passing 0.075 mm[a]		
			<15	15 to 50	>50
Geo-textile class				Class 2 from Table 1710-1[b]	
Permittivity[c,d]	ASTM D 4491	Sec^{-1}	0.5	0.2	0.1
Apparent opening size[c,d] (AOS)	ASTM D 4751	mm	0.43 max avg roll value	0.25 max avg roll value	0.22[e] max avg roll value
Ultraviolet stability (retained strength)	ASTM D 4355	%	50% after 500 hours of exposure		

Table 1710-2 : Notes

a Based on particle size analysis of in situ soil carried out in accordance with test given in Sub section 1804.1.

b Default geo-textile selection. The Engineer may specify a Class 3 geo-textile from Table 1710-1 for trench drain applications based on one or more of the following:

1. Class 3 geo-textiles to have sufficient survivability based on field experience of the Engineer.
2. Class 3 geo-textiles to have sufficient survivability based on laboratory testing and visual inspection of a geo-textile sample removed from a field test section constructed under anticipated field conditions.
3. Depth of subsurface drain is less than 2 m; drain aggregate diameter is less than 30 mm; and compaction requirement is less than 90 percent of heavy compaction test on Sub section 1804.4b.

c These property values of default filtration are based on the predominant particle sizes of in-situ soil. In addition to the default permittivity value, the Engineer may require textile permeability and / or performance testing based on engineering design for drainage systems in problematic environments of soil.

d The site specific design for geo-textiles shall be carried out especially if one or more of the following problematic soil environments are encountered: unstable or highly erodible soils such as non-cohesive silts; gap graded soils; alternating sand / silt laminated soils; dispersive clays; and / or rock flour.

e For a plasticity index of cohesive soils as per test given in Sub section 1802.3 greater than seven, geo-textile maximum average roll value for apparent opening size shall be taken as 0.30 mm.

(b)(iii) The values in Table 1710-2 represent default values that provide sufficient geo-textile survivability under most construction conditions. Note 2 of Table 1710-2 provides for a reduction in the minimum property requirements when sufficient survivability information is available. The Engineer may also specify properties different from that listed in Table 2 based on experience in Engineering design.

(c) Requirements of Separation

The requirements of separation geo-textiles shall be taken as those given under Sub section 2003.2 for separation geo-textiles.

Table 1710-3 is not in use.

(d) Requirements of Stabilization

(i) The application of stabilization is appropriate for subgrade soils that are saturated due to a high groundwater table or due to prolonged periods of wet weather. This specification is not appropriate for embankment reinforcement where stress conditions may cause global subgrade foundation or stability failure. Reinforcement of the pavement section is a site specific issue of design.

(ii) Requirements of Geo-textiles – The geo-textile shall meet the requirements of Table 1710-4. All numeric values in Table 1710-4 except AOS represent MARV in the weakest principal direction. Values for AOS represent maximum average roll values.

Table 1710-4 Property Requirements of Stabilization Geo-textiles

	Test Methods	Units	Requirements
Geo-textile class			Class 1 from Table 1710-1[a]
Permittivity	ASTM D 4491	Sec^{-1}	0.05[b]
Apparent opening size	ASTM D 4751	mm	0.43 maximum average roll value
Ultraviolet stability (retained strength)	ASTM D 4355	%	50% after 500 hours of exposure

Table 1710-4 : Notes

a Default geo-textile selection. The Engineer may specify a Class 2 or 3 geo-textile from Table 1710-4 based on one or more of the following;

1. Class of geo-textile to have sufficient survivability based on field experience of the Engineer.
2. The Engineer has found Class of geo-textiles to have sufficient survivability based on laboratory testing and visual inspection of a geo-textile sample removed from a field test section constructed under field conditions that are anticipated.

b Default value. Permittivity of the geo-textile shall be greater than that of the soil ($\Psi_g > \Psi_s$). The Engineer may also require the permeability of the geo-textile to be greater than that of the soil ($k_g > k_s$).

(iii) The values in Table 1710-4 represent default values that provide for sufficient geo-textile survivability under most construction conditions. Note 1 of the Table 1710-4 provides for a reduction in the minimum property requirements when sufficient survivability information is available. The Engineer may also specify properties different from that listed in Table 1710-4 based on Engineering experience and design.

(e) Permanent Control of Erosion

(i) Requirements of Geo-textiles – The geo-textile shall meet the requirements of Table 1710-5. Woven slit film geo-textiles (i.e., geo-textiles made from yarns of a flat, tape-like character) will not be allowed. All numerical values in Table 1710-5 except AOS represent MARV in the weaker principal direction. Values for AOS represent maximum average roll values.

(ii) The values in Table 1710-5 represent default values that provide for sufficient geo-textile survivability under conditions similar to or less severe than those described under Note b of Table 1710-5. Note c of Table 1710-5 provides for a reduction in the minimum property requirements when sufficient survivability information is available or when the potential for construction damage is reduced. The Engineer may also specify properties different from that listed in Table 1710-5 based on engineering experience and design.

Table 1710-5 –Geo-textile Requirements for Permanent Erosion Control

	Test Methods	Units	Requirements, Percent in situ Soil Passing 0.075 mm[a]		
			<15	15 to 50	>50
Geo-textile class					
Woven monofilament geo-textiles				Class 2 from Table 1710-1[b]	
All other geo-textiles				Class 1 from Table 1710-1[b,c]	
Permittivity[a,d]	ASTM D 4491	Sec^{-1}	0.7	0.2	0.1
Apparent opening size[c,d]	ASTM D 4751	mm	0.43 max avg roll value	0.25 max avg roll value	0.22[e] max avg roll value
Ultraviolet stability (retained strength)	ASTM D 4355	%	50% after 500 hours of exposure		

Table 1710-5 : Notes

a. Based on grain size analysis of in situ soil in accordance with the test given in the Sub section 1804.1.

b The default geo-textile selection is appropriate for conditions of equal or less severity than either of the following, as a general guideline.

1. Armour layer stone weights do not exceed 100 kg, stone drop height is less than 1 m, and no aggregate bedding layer shall be required.
2. Armour layer stone weights more than 100 kg, stone drop height is less than 1 m, and the geo-textile shall be protected by a 150 mm thick aggregate bedding layer designed to be compatible with the armor layer. More severe applications require in assessment of geo-textile survivability based on a field trial section and may require a geo-textile with strength properties.

c The Engineer may specify a Class 2 geo-textile from Table 1710-1 based on one or more following:

1. Found Class 2 geo-textiles to have sufficient survivability based on field experience of the Engineer.
2. The Engineer has found Class 2 geo-textiles to have sufficient survivability based on laboratory testing and visual inspection of a geo-textile sample removed from a field test section constructed under anticipated field conditions.
3. Armour layer stone weights less than 100 kg, stone drop height is less than 1 m, and the geo-textile is protected by a 150 mm thick aggregate bedding layer designed to be compatible with the armour layer.
4. Armour layer stone weights do not exceed 100 kg, and stone shall be placed with a drop of zero height.

d These default filtration values are based on the predominant particle sizes of in situ soil. In addition to the default permittivity value, the Engineer may require geo-textile permeability and/or performance testing based on engineering design systems in problematic environments of soil.
See the following:

1. Site specific geo-textile design shall be performed especially if one or more of the following problematic soil environments are encountered: unstable or highly erodible soils such as non-cohesive silts; gap graded soils; alternating sand / silt laminated soils; and / or rock flour.
2. For cohesive soils with a plasticity index greater than seven, geo-textile maximum average roll value for apparent opening size shall be taken as 0.30 mm.

1710.7 Requirements of Paving Fabrics

(a) Requirements of Paving Fabrics - The paving fabric shall meet the requirements of Table 1710-7. All numerical values in Table 1710-7 represent MARV in the weaker principal direction.

Table 1710-7 – Requirements of Paving Fabrics(Note 1)

	Test Methods	Units	Requirements
Grab strength	ASTM D 4632	N	450
Ultimate elongation	ASTM D 4634	%	≥50
Mass per unit area	ASTM D 5261	gm/m^2	140
Asphalt retention	ASTM D 6140	l/m^2	Notes 2 and 3
Melting point	ASTM D 276	^0C	150

Table 1710-7

Note 1 : All numerical values represent MARV in the weaker principal direction. [Refer to Sub section 1710.7(a)]

Note 2 : Bitumen required to saturate paving fabric only. Bitumen retention value shall be provided in manufacturer certification. (Refer to Sub section 1710.3). Values does not indicate the bitumen application rate required for construction. Refer to Sub section 2002.3(e) for discussion of application rate of bitumen.

Note 3 : Product bitumen retention property shall meet the MARV value provided by the manufacturer certification. (Refer to Sub section 1710.3)

1800 TESTS FOR QUALITY CONTROL OF MATERIALS AND WORKS

1801 AGGREGATES AND SOIL – AGGREGATES MIXTURES

1801.1 Sieve Analysis

The sieve analysis test for aggregates shall be carried out in accordance with BS EN 932-1-1997 or ASTM test designation C 136-96a or AASHTO T27-99.

1801.2 Clay, silt and Dust fraction

The clay, silt and dust fraction (fraction passing the 75mm sieve) in aggregates shall be determined in accordance with BS 812 : 103.2 (2000) or ASTM test designation C 117-95 or AASHTO T11-97

1801.3 Aggregate Impact Value (AIV)

The test to determine aggregate impact value (AIV) shall be carried out in accordance with BS EN 1097-2-1998.

1801.4 Not used

1801.5 Los Angeles Abrasion Value (LAAV)

The test to determine Los Angeles Abrasion Value (LAAV) shall be carried out in accordance with ASTM C 131-01or C 535-89 for small size and large size aggregates respectively or BS EN 1097-8 (2000) or AASHTO T96 – 02.

1801.6 Flakiness Index

The flakiness index test shall be carried out in accordance with: BS 812:part 105.1:1989. (2000), Elongation – BS 812 : 105.2 1990 (2000)

1801.7 Specific Gravity of Coarse Aggregate

The specific gravity of coarse aggregate shall be determined in accordance with clause 5.3 of BS 812 : Part 2:1975 or ASTM C 127 – 88(1993) or AASHTO T85 – 91 (2000).

1801.8 Specific Gravity of Fine Aggregate

The specific gravity of fine aggregate shall be determined in accordance with clause 5.5 of BS EN 1097.5 : 1999 or ASTM C 128 – 97 or BS 812 : 1990 (2000) or AASHTO T84 – 00.

1801.9 Soundness of Aggregate

The soundness of aggregate shall be determined by BS 812 – Part 121 – 1989 (2000) or ASTM C 88 – 83 or AASHTO T 104-99.

1801.10 Field Density

The field density of graded aggregate layers shall be determined by test 15 B of BS 1377 : Part 9 Sec. 2.2 1990 or ASTM D 1556 - 82.

1801.11 Sand Equivalent Test

The sand equivalent of aggregate shall be determined by ASTM D 2419 – 1979 or AASHTO T 176-2000.

1802 BITUMINOUS BINDERS AND BITUMEN – AGGREGATE MIXES

1802.1 Penetration Grade Bitumen

(a) Penetration

Penetration test shall be carried out in accordance with ASTM test designation D 5-97, or BS EN 1426 – 2000 or AASHTO T49-97(2001)

(b) Softening Point

The softening point test shall be carried out in accordance with ASTM test designation D 36-95, or BS EN 1427 – 2000 or AASHTO 53-96(2000)

(c) Loss on Heating

The loss on heat test shall be carried out in accordance with BS 2000 : Part 45:1993 or ASTM test designation D 6-95(2000) or AASHTO T47-98.

(d) Flash Point (ASTM or AASHTO)

The flash point test for penetration grade bitumen shall be carried out in accordance with ASTM test designation D 92-96 or AASHTO T48-99.

(e) Solubility

The solubility test shall be carried out in accordance with ASTM test designation D 2042 - 93. or BS EN 12592 : 2000 or AASHTO T44-97(2001)

(f) Coating Ability and Water Resistance

The test shall be carried out as per Section 1802.3(h)

1802.2 Cutback Bitumen

The cutback bitumen shall conform to AASHTO 82 – 75 (2000)

(a) Viscosity

The viscosity test for cutback bitumen shall be carried out in accordance with ASTM test designation D 2170 - 95.

(b) Distillation

The distillation test for cutback bitumen shall be carried out in accordance with ASTM test designation D 402 – 91 or AASHTO T78-96(2000)

(c) Ductility for Residue

The ductility test shall be carried out in accordance with ASTM test designation D 113 – 99 or AASHTO T51-00

(d) Water Percentage

The water percentage of cutbacks shall be determined in accordance with ASTM test designation D 95 – 99 or AASHTO T55-02.

(e) Flash Point

The flash point test for cutback bitumen using the tag open cup shall be carried out in accordance with ASTM test designation D 3143 - 98.

(f) Coating Ability and Water Resistance

The test shall be carried out as per Section 1802.3(h)

1802.3 Bituminous Emulsions

The bitumen emulsion shall conform to AASHTO M208-01 or ASTM D 2397-98.

(a) Viscosity Test

The viscosity test for bitumen emulsions shall be carried out in accordance with Section 22 - 24 of ASTM test designation D 244 – 99 or AASHTO T59-01.

(b) Settlement

The settlement test for bitumen emulsions shall be carried out in accordance with Section 29 - 32 of ASTM test designation D 244 – 99 or AASHTO T59-01.

(c) Storage Stability

The storage stability test for bitumen emulsions shall be carried out in accordance with section 56 - 62 of ASTM test designation D 244-99 or AASHTO T59-01.

(d) Particle Charge

The particle charge test for bitumen emulsions shall be carried out in accordance with section 19 - 21 of ASTM test designation D 244 – 99 or AASHTO T59-01.

(e) Sieve Test

The sieve test for bitumen emulsions shall be carried out in accordance with section 38 - 41 of ASTM test designation D 244 – 99 or AASHTO T59-01.

(f) Distillation

The distillation test for bitumen emulsions shall be carried out in accordance with section 8-10 of ASTM test designation D 244-99 or AASHTO T59-01.

(g) Characteristics of Residue

The characteristics of the residue by distillation shall be examined by carrying out tests in accordance with section 63 - 68 of ASTM test designation D 244-99 or AASHTO T59-01.

(h) Coating Ability and Water Resistance

The coating ability and water resistance test for bitumen emulsion shall be carried out in accordance with section 50 - 55 of ASTM test designation D 244-99 & ASTM D1664 – 80 or AASHTO T59-01 & AASHTO T 182 – 84(1998).

(i) Not in use

(j) Cement Mixing

The cement mixing test for bitumen emulsion shall be carried out in accordance with sections 33 -37 of ASTM test designation D 244 – 99 or AASHTO T59-01.

(k) Demulsibility

The demulsibility test for bitumen emulsions shall be carried out in accordance with sections 25 -28 of ASTM test designation D 244 – 99 or AASHTO T59-01.

1802.4 Bitumen Aggregate Mixes

(a) Marshall Stability and Flow

The test determination of Marshall Stability and flow shall be carried out in accordance with ASTM test designation D 1559 – 89 or for flow with AASHTO T245-97(2001).

The samples shall be compacted using 35, 50 or 75 blows for low, medium or high traffic depending on whether the cumulative number of standard axles for the design life of the surfacing is less than 10^4 or between 10^4 and 10^6 or greater than 10^6 respectively.

(b) Extraction of Bitumen

The test for extraction of bitumen shall be carried out in accordance with ASTM test designation D 2172 – 05 or AASHTO T164-01. The asphalt shall be recovered from solution in accordance with AASHTO Test Method T 170 or ASTM D 1856 – 95a.

(c) Density of compacted bituminous mixtures

The test for determining the density (bulk specific gravity) of compacted bituminous mixtures shall be carried out in accordance with ASTM test designation D 2726 – 96a or AASHTO T230-68(2000).

1802.5 Rate of Spread of Binders

Rate of spread of binder shall be determined by the Tray test as described below.

Three square metal trays, each of area between 0.06 - 0.12 m^2 and of known weight are placed on the surface on which the binder is to be applied. After the binder is applied, the trays are weighed and the rate of application of binder calculated in l/m^2. The specific gravity of the binder to be used in the calculation shall be as determined in the laboratory, which for most purposes may be taken as 1.0. Care shall be taken to ensure that the binder does not drip off the tray prior to weighing.

1802.6 Distributors

Tests for distributors including Depot Tray test shall be carried out as per Section 505.A.3(a).

1803 CEMENT AND CONCRETE

1803.1 Cement

(a) Standard Consistency

The test for standard consistency (normal consistency) shall be carried out in accordance with Appendix E of SLS 107 : 2008 or ASTM test designation C 187 - 04. or BS EN 196-3 – 2005 or AASHTO T129-01.

(b) Setting Times

The tests for the determination of initial and final setting times shall be carried out in accordance with Appendix F of SLS 107 : 2008 or ASTM test designation C 191 – 04b or BS EN 196-3 - 2008 or AASHTO T131-01.

(c) Fineness

The test for the determination of fineness shall be carried out in accordance with Appendix A of SLS 107: 2008 or ASTM test designation C 204 – 00 or BS EN 196-6 – 1992 or AASHTO T152-01.

(d) Compressive Strength

The tests for the determination of compressive strength of cement shall be carried out in accordance with Appendix C or D of SLS 107 : 2008 or ASTM designation C109 / C–109M-05 or BS EN 196-1 – 2005 or AASHTO 106-02.

(e) Soundness Test

The test for the determination of soundness shall be carried out in accordance with Appendix BS 4550 Part 3 Sec. 3.7 or BS EN 196-3 - 2005.

1803.2 Concrete

(a) Casting of Concrete Cubes

The casting of concrete cubes shall be carried out in accordance with BS 1881: Part 108 : 83, BS EN 12390-1 - 2000 or ASTM C31/C31M-03a in the field or ASTM C192C/192M-05 in the laboratory.

(b) Testing of Concrete Cubes

The testing of concrete cubes shall be carried out in accordance with, BS EN 12390 – 3 - 2002.

(c) Casting of Concrete Beams

The casting or concrete beams shall be carried out in accordance with BS 1881 : Part 109 : 83 or ASTM test designation C 192 - C 192M-95 or C 31 - 00 as relevant. ISO 1920, ISO 2736-2 or AASHTO T126-01 or T23-02 as relevant.

(d) Testing of Concrete Beams

The testing of concrete beams shall be carried out in accordance with ASTM test designation C 78 – 94 or BS EN 12390 – 5 – 2000 or AASHTO 97-97(2001).

(e) Casting of Concrete Cylinders

The casting of concrete cylinders shall be carried out in accordance with ASTM test designation C 192 – C 192M-95 or AASHTO T126-01 or T23-02 as relevant or C 31 - 88 as relevant or BS EN 12390 – 2 - 2000.

(f) Testing of Concrete Cylinders

The testing of concrete cylinders shall be carried out in accordance with ASTM test designation C 39 – 86, BS EN 12504 – 1 – 2000 or AASHTO T22-97.

(g) Slump Test

The slump test shall be carried out in accordance with ASTM test designation C 143 / C 143M-05a or BS EN 12350 – 2 - 2000 or AASHTO T119-99.

1804 SOILS AND SOILS AGGREGATES MIXTURES

1804.1 Sieve Analysis Test for soils

The sieve analysis test for soils shall be carried out in accordance with test 7A of BS 1377 – Part 2 – 1990 or ASTM D 422 – 63 (re-approved 1972) or AASHTO T88-00.

1804.2 Liquid Limit

The liquid limit test shall be carried out in accordance with test 2B of BS 1377 – Part 2 – 1990 or ASTM D 4318 – 05 or AASHTO T89-02.

1804.3 Plastic Limit

The plastic limit test shall be carried out in accordance with test 3 of BS 1377 Part 2 – 1990 or ASTM D 4318 – 05 or AASHTO T90-00.

1804.4 Standard / Modified Compaction

The standard / modified compaction tests shall be carried out in accordance with Test 12 or 13 of BS 1377 Part 4 – 1990 respectively or ASTM D 698–00a or D 1557-02 or AASHTO T99-01 or T180-01 respectively.

1804.5 California Bearing Ratio (CBR)

The California bearing ratio test shall be carried out in accordance with test 16 of BS 1377 Part 4- 1990 or ASTM – D 1883 – 99 or AASHTO to T193-99.

1804.6 Field moisture

The field moisture content shall be carried out in accordance with ASTM D2218-98.

1804.7 Field Density

The field density test shall be carried out in accordance with test 15A of BS 1377 – Part 9 – 1990 or ASTM D 1556 – 90 or AASHTO T-191-02.

1805 GEOTEXTILES / GEOSYNTHETICS

All tests pertaining to Geo-textiles / Geo-synthetics are carried out as per Section 1710 & Chapter 2000.

APPENDIX I

(a) ASTM PUBLICATIONS

The following is a list of publications to which reference is made in this book.

Annual Book of ASTM Standards - 2006

Volume 04.01	-	for cement & lime -2006
Volume 04.02	-	for concrete and mineral aggregates - 2006
Volume 04.03	-	for road paving bituminous materials - 2006
Volume 04.08	-	for soils – 2006

(b) PUBLICATIONS OF BRITISH STANDARD INSTITUTION

BS EN 197-1-2000	Ordinary and Rapid Hardening Portland Cement
BS 882 : 1992	Method of Sampling and Testing of Mineral Aggregates Sands and Fillers

BS EN 12620–2002 (2000) Part 101	Guide to sampling and testing aggregate
BS EN 932–1–1997 Part 102	Method for sampling
BS EN 932–1–2000Part 103	Particle size distribution
BS EN 932–1–2000Part 105.1	Flakiness Index Test
BS EN 932–1–2000Part 105.2	Elongation Index Test
BS EN 1097–2–1998 Part 112	AIV Test

BS 1881: 1983 Methods of Testing Concrete

BS EN 12350-1-2000	Part 101	Method of sampling fresh Concrete on Site
BS EN 12350-2-2000	Part 102	Method for Determination of Slump
BS EN 12350-1-2000	Part 108	Method for Making Test Cubes from Fresh Concrete
ISO 1920, ISO 2736-2	Part 109	Method for Making Test Beams from Fresh Concrete
BS EN 12390-3-2002	Part 116	Method for Determination for Compressive Strength of Concrete Cubes
BS EN 12350-5-2000	Part 118	Method for Determination of Flexural Strength
BS 4449: 1997		Hot Rolled Steel Bars for Reinforcement of Concrete
URONORM 138, BS 4486: 1980		Cold worked High Tensile Alloy Steel Bars for Prestressed Concrete
BS 4027 :1996	Part 3	Sulphate - Resisting Portland Cement
BS 4550: 1978		Method of Testing Cement Fineness test Strength test, determination of standard consistency, setting time

BS 3690	-	Bitumen testing
BS – 1707:1989	-	Depot tray test

(c) AASHTO PUBLICATIONS

Reference has been made to part 2A&2B "Tests" of .the "Standard Specifications for Transportation Materials and Methods of Sampling and Testing – Twenty Second Edition – 2002."

(d) PUBLICATIONS OF SRI LANKA STANDARDS INSTITUTION

SLS 26-93	-	Hot Rolled Mild Steel Round Bars for Concrete Reinforcement
SLS 31 : 1972	-	Galvanized Mild Steel Barbed wire
SLS 39 : 1978	-	Common Burnt Clay Building Bricks
CS 68 : 1969	-	Wrought Aluminium Steel and Strip
CS 73 : 1969	-	Steel Channels, Angles and Tee Bars
SLS 107 : Part 1-2008 SLS 107 : Part 2-2008	-	Ordinary Portland Cement
SLS 1253 : 2008	-	Portland Lime Stone Cement
CS 124 : 1971	-	Test Sieves
CS 139 : 1972	-	Mild Steel Wire for General Engineering Purposes
SLS 147 : 1983	-	Rigid PVC Pipes
CS 159 : 1972	-	Code of Practice for Seasoning of Timber
SLS 217 : 1973	-	Reinforced Concrete Fence Posts
SLS 238 : 1973	-	Metal Washers for General Engineering Purposes
SLS 262 : Part 1: 1974	-	Method of Sampling of Fresh Concrete
SLS 262 : Part 2 - 1975	-	Analysis of hardened concrete
SLS 375 : 1976	-	Cold Worked Deformed Steel Bars for the Reinforcement of Concrete
SLS 449 : 1978	-	Glazed Earthen Ware Pipes
SLS 452: 1979	-	Concrete Non Pressure Pipes, Reinforced or unreinforced, for Culverts and Sewers
SLS 481 : 1980	-	Hexagonal Bolts Screws and Nuts
SLS 493 : 1980	-	Galvanized Wire Netting
SLS 522 : 1981	-	Water for Making Concrete
SLS 539 : 1981	-	Enamel Paints for Exterior Use
SLS 552 : 1982	-	Building Lime
SLS 557 : 1982	-	Emulsion Paints for Exterior Use
SLS 713 : 1985	-	Bituminous Anticorrosive Paint
SLS 855 Part 1 - 1989	-	Specification for cement blocks
SLS 855 Part 2 - 1989	-	Cement Blocks – Test methods

(e) TRANSPORT RESEARCH LABORATORY, UNITED KINGDOM

Overseas Road Notes 3, 19 & 31.

1900 SITE INVESTIGATIONS FOR EMBANKMENT CONSTRUCTION, BRIDGES & OTHER STRUCTURES AND CUTTINGS

1901 GENERAL

1901.1

The objectives of soil investigations are to ascertain the suitability or otherwise of the soil or rock in the vicinity of embankments, foundations and cuttings and soil parameters and rock characteristics for the design of the same by identifying the required strata and in-situ testing or testing of samples / cores taken out of explorations. The soil investigation shall be planned in such a way that different types of soils up to the desired depth and their profile for the proposed length of the embankment / bridges / structures / cuttings can be recorded and other information such as mechanical and physical properties like grain-size distribution, sensitivity, any existence of deleterious material in soil or ground water, etc. are determined along with soil parameters and rock characteristics. The site investigations shall also give an indication of the porosity of rock, ground water level, artesian condition, if any, likely cylinder sinking and pile driving effort, likely constructional difficulties, etc.

1901.2 General requirements

a(i) Standards used

All field work including in-situ tests and the laboratory tests shall conform to those given in ICTAD Publication No. ICTAD/ID/11, unless otherwise stated in these Specifications. Alternative British Standards (in particular BS 1377 and BS 5930), or equivalent ASTM Standards may also be allowed.

In Publication No. ICTAD/ID/11 wherever the words "Building/s" & "Foundation/s" appear they shall be taken as "Bridge/s, Structure/s, embankment/s and cutting/s" and "Foundation/s of bridge/s, structure/s and embankment/s" respectively.

a(ii) Inspection of Site

The Contractor shall inspect and examine the Site and its surrounding before submitting his Tender. He shall satisfy himself as to the nature of the Site, the scope and nature of Works, equipment, plant and materials necessary for the completion of the Works. In general, he shall obtain for himself all necessary information as to the risks, contingencies and other circumstances which may affect his Tender.

a(iii) Programme to be Furnished

Within seven (7) days after the Award of Contract, the Contractor shall submit a programme to Engineer, showing the order of procedure and method in which he proposes to carry out the Works. The programme shall include the particulars of plant and temporary works which he intends to supply, use or construct as the case may be. The submission and approval by Engineer of such programme or particulars shall not relieve the Contractor of any of his duties or responsibilities under the Contract.

a(iv) Supply of Plant, Materials and Labour

Except where otherwise specified, Contractor shall at his own expense supply and provide all the plant, labour and materials both for temporary and for permanent Works, including the supervision thereof, transport to or from the Site and in and

about the site and other things of every kind required for the work in accordance with the approved machinery deployment schedule.

a(v) Equipment for Investigations

Before boring or rotary drilling is commenced, Contractor shall obtain Engineer's approval of the equipment he proposes to use and method for supporting the sides of the holes. The equipment shall have adequate power to undertake all the work given in this Specification within the times defined in the Contract. Engineer reserves the right to call for additional rigs and equipment at no extra cost if he considers the programme requirements is not being met.

All equipment which the Contractor proposes to use for the work shall be in good working condition and suitable for the purpose. The drilling machine shall have the capacity suitable for drilling boreholes as specified, into all types of soil and rock to reach various required depths.

a(vi) Watching and Lighting

The Contractor shall in connection with the work provide and maintain at his own cost all lights, guards, fencing and watching when and where necessary or required by Engineer or by any competent statutory body or other authority for the protection of the work or for the safety and convenience of the public or others.

a(vii) Site Access and Temporary Access

The access to the site shall be in accordance with Clause 21 (Possession of the site) and Clause 22 (Access to the site) of Conditions of Contract of ICTAD Standard Bidding Document for Procurement of Works. (ICTAD/SBD/01)

The Contractor shall provide all temporary roads including timber planks on trestles etc. in marshy areas and gangways required for the execution of the work. He shall provide at all times during the progress of the work, proper means of access with ladders, gangways, pontoons, boats etc. and the necessary attendance of Contractor for inspection of the work by Engineer.

a(viii) Care in executing the work

(a) The Contractor shall take full responsibility to ascertain the positions and take all reasonable precautions to avoid damage to services above and below ground, such as sewers, drains, water mains, electricity and other cables, and all structures above and below ground. He shall be fully responsible for any damage and for claims for consequential damages.

The Engineer shall be immediately informed if any of the original locations of the boreholes or other tests coincide with the positions of the mains or services. The Contractor shall propose the revised locations to the Engineer for approval.

The care of works shall be in accordance with relevant Clauses in Conditions of Contract. In case of any damage, clauses pertaining insurance of work of the Conditions of Contract of ICTAD/SBD/01 shall apply.

(b) Upon completion of each borehole, the Contractor shall backfill each borehole as specified in Sub section 1902.9 "Backfilling".

The position of the boreholes shall be marked by concrete monuments or by any other approved method.

(c) All standpipe piezometers shall be adequately protected to allow readings to be continued subsequently.

(d) All barriers breached or otherwise disturbed during the execution of the site operations shall be immediately repaired or replaced to the same standard.

(e) Unless otherwise indicated in Schedule 1, on completion of each borehole; all equipment, surplus material and rubbish of every kind shall be cleared away and removed from the site. Damage to land, property and underground and overhead services in the vicinity shall be made good, at the expense of the Contractor. The whole of the site shall be left in a clean and tidy condition.

a(ix) Removal of Improper Plant and dismissal of Incompetent Personnel

The Engineer shall during the course of the work have the power to order in writing from time to time:-

(a) The removal from the Site of any plant not conforming to the requirements of the Specifications, and the replacement of such plant at the Contractor's own cost,

(b) The dismissal from the Site, any engineer, geologist, technician, supervisor, plant operator, or any workmen of the Contractor found incapable or refusing to follow the proper procedure of work as specified, and replacement of such workmen at Contractor's own cost. Contractor's attention is drawn particularly to his personnel to identify and describe correctly soils and rock samples in the field, and to do survey work including taking reduced levels and setting out.

(b) Geotechnical Personnel

(i) The Contractor shall have on his site staff, a geotechnical engineer or engineering geologist or an engineer as indicated in Schedule 2 fully experienced in site investigation work, and he shall supervise the field work and prepare the daily report indicated in Section 1907. Contractor's assigned personnel shall have a minimum of two (2) years experience in soil investigation works who shall be approved by Engineer. Such approval may be withdrawn at any time by the Engineer depending on the performance of the personnel.

(ii) The Contractor shall engage the services of a Principal Geotechnical Engineer who shall be responsible for reviewing the results of all laboratory and field tests, and write a Final Report with Recommendations. However, this would not relieve the Contractor of any responsibility for the report and recommendations.

(c) Methods of Investigation

(i) The Engineer may require investigations to be carried out by all or any of the methods described in this document.

(ii) The equipment brought to site shall be capable of drilling through all subsoil conditions (including drilling through rock, boulders, logs, sandstone, etc.) which may be encountered at the site. Details of all such equipment which the Contractor intends to use shall be submitted to the Engineer before drilling commences; and the use of equipment shall be subject to the approval of the Engineer.

(d) Extent of Exploration

(i) The provisional number of exploratory holes and the provisional depth of each hole are as described in Schedule 3 for bridges / structures, embankments and cuttings. The minimum extent of exploration / number of field tests shall be as stated under (A) to (C) and as summarized in Table 1901-1 or as directed by the Engineer.

(A) Investigation for embankments including soft soils {such as organic and inorganic clays (soft) and peaty soils} sections

All investigations and laboratory tests shall be carried out as per ICTAD/ID/11, unless otherwise stated in these Specifications.

(i) Core Drilling as per section 1902

Rotary core drilling technique shall be carried out at intervals stated in Table 1901-1 or as directed by the Engineer, to establish the bed rock profile. In this case, drilling through rock shall be carried out to 3½ m depth below the residual soil stratum.

(ii) Wash Boring as per section 1902

Where soft soils are encountered, boreholes using wash boring technique shall be carried out, as per Section 1902, at intervals indicated in Table 1901-1 or as directed by the Engineer. Each borehole shall be continued to a depth at which a hard stratum of very dense residual soil or highly weathered rock is encountered, where the Standard Penetration Test (SPT) spoon's refusal to penetration is observed.

(iii) Hand Augering

Where soft soils are encountered, hand augering shall be carried out, as per ASTM D 1452, at intervals indicated in Table 1901-1 or as directed by the Engineer. In locations where hand augering cannot proceed due to sand layers being encountered, wash borings up to the bottom of the soft soil layers, shall be carried out.

(iv) Standard Penetration Test (SPT)

Standard Penetration Test shall be done at 1.5 m (this can be reduced to 1.0 m if undisturbed samples are not taken) depth intervals within the boreholes (core drilling and wash boring), in the overburden, in order to obtain a continuous strength profile throughout every borehole, as per ICTAD/ID/11.

(v) Sampling

Disturbed and Undisturbed soil samples and rock samples shall be collected for visual classification and laboratory testing purposes. Water samples shall be collected for chemical testing.

Table 1901-1 Minimum Extent of Explorations / Field Tests

Type of Investigation / Test	Minimum Extent of Explorations / Numbers of Field Tests			
	Investigations for Embankments		Bridge and Other Structures	Major Cuttings (>5m) and materials for fillings and crushed rock for concrete and Pavement layers
	Where Soft Soils are Encountered	Where Soft Soils are not Encountered		
	1901.2(d)(i)A.1	1901.2(d)(i)A.2	1901.2(d)(i)B	1901.2(d)(i)C
Core Drilling	One per 1.0 km down to 3½m in bed rock	One per 1.0 km down to 3½ m in bed rock with a minimum of 1 location in every such section	2 minimum per abutment/ piers and other structures down to 3½ m in bed rock but could be reduced to 1 for minor structures	Major cuttings 3 per cutting down to 2 m below final grade or 3½ m into rock when rock is encountered For material survey for rock at quarry site in a grid of 50 m down to the required depths. (minimum of 4 core drillings per site)
Wash Boring	200 m intervals except at core drilling locations	—	—	—
Hand Augering	50 m intervals at an offset of one half of the top width of embankment from centre line in between each boring / drilling	—	—	—
Standard Penetration Test (SPT)	1m depth intervals in each boring / drillings	Same as A.1	Same as A.1	Same as A.1
Undisturbed Samples	Such samples taken in between SPT when they can be taken	Same as A.1	Same as A.1	Major cuttings Same as A.1 In addition, block samples shall be taken for direct shear and permeability tests as per TRL, UK Overseas Road Note 14
Disturbed Samples	Such samples taken at every SPT locations	Same as A.1	Same as A.1	Major cuttings Same as A.1 Material survey for soil at borrow pits. Cutting test pits in a grid of 15 - 30 m down to the required depths - adequate samples for required testing. (minimum of 4 pits per site)
Rock Samples	Taken from core drilling locations	Same as A.1	Same as A.1	Same as A.1
Vane Shear Test	Where required	—	Every drilling where clays are present	—
Static Cone Penetration Test (SCPT)	200 m intervals except at core drilling / wash boring locations	—	—	Major cuttings Adjacent to every drillings where clays are present
Other Tests	As per 1901.2(d) (i) A	Same as A.1	As per 1901.2(d)(i)B	As per 1901.2(d)(i)C

(v)a Undisturbed samples as per section 1904

Whenever soft soils (peaty soils or soft clays) are encountered within the boreholes, undisturbed samples shall be collected in between SPTs as per Section 1904, in order to obtain the strength parameters of the soil for the design of side slopes of the embankments and settlement characteristics for the design of roads founded on soft soil.

(v)b Disturbed samples as per section 1904

Disturbed samples shall be collected at every SPT location as per Section 1904, for visual classification and index property tests, in the laboratory.

(v)c Rock samples as per section 1905

Rock core samples shall be recovered from core drilling locations as per Section 1905 for identification purpose and to establish the weathering conditions of rock.

(v)d Water samples

Water samples from boreholes shall be collected for determining sulphate, chloride and pH value.

(vi) Vane Shear Test

Field vane shear tests shall be carried out at some locations, at 1m depth intervals, where soft layers are encountered by the wash boring operations / core drillings, as per ICTAD/ID/11.

(vii) Static Cone Penetration Tests (SCPT)

Static cone penetration tests (SCPT) shall be done at locations indicated in Table 1901-1 or as directed by the Engineer.

(viii) Ground Water Monitoring

Ground water levels in boreholes shall be monitored before commencement and after completion of drilling / boring operations.

(ix) Laboratory Tests

The disturbed and undisturbed soil samples collected from boreholes shall be used for visual soil classification and on these the following laboratory tests shall be performed.

(ix)a Soil Classification and index property tests

Sieve analysis of all SPT samples and undisturbed samples and Hydrometer analysis tests of all clayey soil SPT and undisturbed samples shall be carried out in order to find the grading of soil samples obtained from boreholes. This will give an indication of permeability of the soils encountered, as well.

Adequate Atterberg Limit tests shall be done on samples as per Section 1804 to classify the soils as well as to obtain compressibility, strength and compaction characteristics.

Adequate Natural Moisture Content and Specific Gravity tests shall be done to determine the classifications of soils and obtaining consolidation characteristics.

(ix)b Strength and Settlement Parameter Tests

Adequate consolidation tests shall be carried out on samples of soft soils in order to obtain settlement parameters.

Strength and stability parameters of soft soils encountered along the trace, shall be obtained by carrying out adequate number of Consolidated Undrained (CU) and Consolidated Drained [(CD), if required] triaxial tests and direct shear tests on block samples (taken as per Section 1903.6), as per BS or ASTM Specifications and Unconsolidated Undrained (UU) triaxial tests.

(ix)c Chemical Tests on Soil and Water

Adequate water samples collected shall be tested for contents of sulphate, chloride and pH value to check the aggressiveness effects of water on construction of structures. They shall be taken from suitable locations, where bridges and other structures are to be constructed.

Soil samples collected from different locations shall also be tested to obtain the content of organic matter as well as the above chemical properties.

(ix)d Shear Strength of Rock Cores

Uniaxial compressive tests on rock cores (taken as per 1905.1), if required, shall be carried out as per BS or ASTM Specifications.

(B) Investigations for bridges and structures

(i) A minimum 2 (it can be taken as 1 for minor structures) core drilling for bridge abutments / structures / bridge pier shall be carried out in the area under investigations.

(ii) SPTs shall be carried out as per A(iv)

(iii) At locations where clay layers, are encountered in core drillings, SCPTs shall be carried out adjacent to such core drillings as per section A(vii).

(iv) Ground water monitoring shall be carried out as per A(viii)

(v) Laboratory tests, if required, shall be carried out as per A(ix)

(C) Investigations for Major Cuttings (>5m) and materials for filling and crushed rock for concrete and Pavement layers

(i) Core drillings at major cuttings shall be carried out at locations where there could be high water table after cutting to a depth of 2 m below final grade of road. Where rock is encountered, core drilling shall be taken down to the rock face and

cores shall be drilled 3½ m into intact rock. In all these boreholes stand pipe piezometers at 3 depths shall be installed and recorded as per Sub sections 1906.3 & 1906.4.

(ii) In the soil over burden, SPTs shall be carried out as per A(iv)

(iii) Same as B(iii)

(iv) In each major cut a minimum of 3 test pits shall be carried out as per Section 1903, where the soils are of lowest strengths to obtain block samples of 0.3x0.3x0.3 m, in order to carry out direct shear and permeability tests, as per TRL UK Overseas Road Note 14 "Hydrological design manual for slope stability in the tropics".

(v) In each major cut, a minimum of another three tests pits shall be excavated to obtain bulk samples of soils to determine the suitability of the material for use as compacted fill, Subgrade and Sub-base.

(vi) For material survey for rock at quarry sites core drilling shall be carried out in a grid of 50 m down to the required depths, to take adequate samples for the required testing for each variation of material. A minimum of 4 core drillings shall be carried out per site.

(vii) For material survey for soils for filling embankments, Subgrade and Sub-bases at borrow pits, cutting test pits in a grid of 15 - 30 m down to the required depths to take adequate samples for the required testing for each variation of material. A minimum of 4 test pits shall be dug per site.

(viii) In order to determine soil and hard rock excavation quantities, where rock is expected to be encountered seismic surveys shall be made on several Cross-sections in each major cutting, in order to extrapolate the bed rock surface identified in the borings.

(ix) Testing for suitability of materials for embankment filling, Subgrade, Sub-base, Base and Surfacing shall be carried out as per relevant sections in Chapters 300, 400, 500 & 600 along with Section 1602 and 1800 at the frequencies of 1 test for each type of required testing, for each sample taken.

1901.2(d)(ii) The Engineer reserves the right to increase or decrease the number of exploratory holes and their depths based on the information obtained from the first few holes.

1901.2(e) Ground elevation of exploratory holes

The Contractor shall establish the Reduced Level at the top of each exploratory hole with reference to a benchmark agreed to with the Engineer.

1901.2(f) Miscellaneous

(i) The Contractor shall make his own arrangements for water required in connection with the work, including the supply and fixing of all fittings, maintenance of the supply, payment of all fees, and removal of all fittings and making good all disturbances after completion of the work.

(ii) The Contractor shall make his own arrangement with the authority concerned for electricity supply and shall comply with all safety regulations and pay all fees in connection with installation and supply.

(iii) All samples of soil, rock and water collected during the site investigations shall be properly stored, protected and retained with the Contractor for a period of 28 days after submission of the Final Report, unless otherwise specified by the Engineer.

(iv) The Contractor shall provide third party liability insurance and shall indemnify the Client against all claims whatsoever, during the course of his work. Clauses 23 and 24 ICTAD Publication No. SCA/1 shall apply.

(v) The requirements of the Specifications shall not limit the Contractor's statutory obligations or liabilities under the laws of the country and under local regulations. Clause 26(2) of ICTAD Publication No. SCA/1 shall apply.

(vi) In general the rates quoted in the Bill of Quantities for an item shall include for all elements of work in connection with that item as required in accordance with this Specification and the Standards referred to in Sub section 1901.2.

1901.3 Measurement and Payment

(a) Measurement

All items measured for payment as given below shall be as Lump Sum items.

(b) Payment

All prices shall include full compensation for all labour, materials, tools, equipment, transport etc. Necessary to complete look to these specifications for the period of the investigation .

Pay Items and Pay Units shall be as follows;

Pay Item	Description	Pay Unit
1901 (1)	Mobilisation and demobilisation	Lump Sum
1901 (2)	Shifting and setting up of drilling rig from one borehole to another to all borehole positions	Lump Sum
1901 (3)	Provision of geotechnical personnel	Lump Sum

1902 BOREHOLES AND HAND AUGER HOLES

1902.1 Method and diameter

(a) The method of advancement and the diameter of a borehole shall be such that the boring can be completed and logged to the scheduled depth, samples of the specified diameter can be obtained, in-situ testing can be carried out, and instrumentation installed as specified in the Contract.

(b) The following methods may be employed for advancement of a borehole unless otherwise stated in Schedule 1 Section (1901):

Rotary drilling; shell and auger boring; wash boring, and percussion drilling (in rock only) and hand augering.

1902.2 Supporting sides of boreholes

All boreholes except for hand auger holes shall be supported with casing, and/or drilling mud; unless the borehole is shallow and is in stiff soils. Casing shall not be driven below any level at which sampling or testing is to be carried out until the latter has been completed.

1902.3 Addition of water to the borehole

(a) In general, water shall not be used to advance a borehole above the water table. Addition of water in such cases may be permitted with the approval of the Engineer when boring in dry granular soils or hard laterites or hard stiff clays.

(b) When the borehole penetrates below the water table, and disturbance of the soils is likely due to artesian pressure, a positive hydraulic head shall be maintained in the borehole.

1902.4 Rotary drilling

Rotary drilling shall be permitted in all cases to advance the borehole.

The drilling fluid shall normally be clean water. However drilling mud could also be used.

1902.5 Shell and auger boring

Shell and auger boring shall be permitted if the Contractor can demonstrate that the validity of in-situ testing and extraction of undisturbed samples is not compromised. This method of boring can be used in sandy soils, lateritic soils, residual soils and completely weathered rock. However, special attention is required when boring in soft clays and peats.

1902.6 Wash boring

Wash boring shall be permitted in all soils provided that care is taken not to unduly disturb the soil at bottom of the borehole especially before in-situ testing or sampling.

1902.7 Encountering of hard stratum or obstruction

(i) Any obstruction encountered during boring shall be brought to the attention of the Engineer.

(ii) If an obstruction in the form of bed rock, boulder, hard layer such as sandstone, concrete, brick, log, or either object is encountered which prevents further progress in boring, the Contractor shall first attempt to break through the obstruction either by chiselling, or by rotary coring methods to drill through and obtain cores of the obstruction.

(iii) If the drilling shows that the obstruction is bed rock, the rotary core drilling shall be continued to a depth of 3½ m or as required by the Engineer to prove the continuity and engineering characteristics of the formation.

(iv) If the obstruction is shown to be a boulder or other object underlain by soil, the Contractor shall consult and agree with the Engineer on the use of one of the following lines of action.

(a) chisel out the cored borehole through the obstruction to allow boring, sampling, and in-situ testing to be carried out beneath the obstruction.

(b) continue the advancement of the borehole by rotary drilling.

(c) abandon the borehole, and drill one additional borehole nearby for which the cost will be borne by the Client.

1902.8 Hand Augering

Hand augering shall be carried out as per Sub section 1901.2(d)(i)(A)iii, at intervals as indicated in the Table 1901-1 or as directed by the Engineer.

1902.9 Backfilling

Upon completion of each borehole, the Contractor shall backfill the holes as the casing is withdrawn. The soil backfilled into the borehole shall be placed in layers, each successive layer being tamped by the boring tools. The surface shall be reinstated to the original condition.

1902.10 Measurement and Payment

(a) Measurement

i The advancement of borehole shall be measured separately in linear metres in soil overburden and rock.

ii The hand augering shall be measured separately in linear metres in soft soil and soil overburden.

(b) Payment

The quantities of advancement of borehole and hand auger holes shall be paid at the Contract unit rates for each class of material encountered.

No extra payment shall be made to the Contractor for either exceeding the number of exploratory holes or the depth of boring and drilling of each hole, unless ordered by the Engineer.

No payment shall be made for holes rejected by the Engineer.

All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these Specifications and in addition shall include

(i) Setting out

(ii) Planking and any other precautionary measures taken to ensure the stability of adjacent areas.

(iii) Removal of obstructions of boulders, road Pavement logs etc.

(iv) Backfilling of the hole after completion of borehole or hand auger work.

Pay Item	Description	Pay Unit
1902(1)	Advancement of borehole [state (i) type of borehole equipment, (ii) type of material drilled through (a) over burden soil (b) rock (iii) depth from(a) 0.0m – 10.0m (b) 10.0m – 20.0m (c) more than 20.0m]	Linear m
1902(2)	Advancement of hand auger hole state type of material augered (a) soft soil (b) overburden soil	Linear m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1903 PITS AND TRENCHES

1903.1 Trial pits and trenches

Trial pits and trenches shall be excavated by hand to a maximum depth of 1.2 m or by machine to the required depth as directed by the Engineer to enable visual examination and sampling from outside the pit or trench as required. Trial pits or trenches deeper than 1.2 m shall not be entered by personnel, unless adequately supported.

Top soil shall be stripped from the pit or trench area at the commencement of the excavation works and the materials stockpiled separately until backfilling as per Sub section 1903.6.

1903.2 Observation pits and trenches

Observation pits and trenches shall be excavated by hand or machine as directed by the Engineer, sides shall be adequately supported to enable personnel to enter safely and to permit in situ examination, soil sampling and testing as required.

1903.3 Pit and trench dimensions

Unless otherwise indicated in schedule 1.

(a) trial pits and observation pits shall have minimum Base dimensions of 1.5mx1.5m

(b) trial trenches and observation trenches shall be 1 m wide.

1903.4 Description

Trial pits and trenches, and observation pits and trenches shall be examined and described by a geotechnical person meeting the requirements of Sub section 1901.2(b) and if required, photographed.

1903.5 Groundwater

The Contractor shall keep pits and trenches free of surface water run-off. Groundwater shall be controlled by pumping from a sump to permit continuous work.

1903.6 Undisturbed block samples

Undisturbed block samples shall be taken from test pits as per BS and ASTM Specifications.

1903.7 Backfilling

Backfilling of the pits and trenches shall be carried out as soon as practicable. The backfilling shall be compacted in such a manner using excavation plant or as specified in Schedule 1 as to minimize subsequent depression of the ground surface. Any surplus excavated material shall be heaped proud over the site and covered with top soil unless otherwise instructed by the Engineer.

1903.8 Protection to pits and trenches left open

Where pits and trenches are required to be left open for a period, the Contractor shall provide fencing together with all necessary lighting and signing. Precautions shall be taken to protect the pits and trenches from the adverse effects of weather during this period. Support and strutting for the sides of the pit shall be provided to prevent the collapse of the sides.

1903.9 Measurement and Payment

(a) Measurement

Pits and trenches excavation for all required and completed work shall be measured in its original position and the volume determined in Cu.m. Trench excavation shall be measured separately in soil.

Pits and trenches reinstatement fill material shall be measured as compacted in position in Cu.m. Reinstatement using suitable material resulting from the excavation and using borrow excavation shall be measured separately.

(b) Payment

The quantities of pit and trench excavation shall be paid for at the Contract unit rates for each class of material encountered.

The reinstatement of the excavation shall be paid at the Contract unit rates for the separate items as measured above.

All prices shall include full compensation for all labour, materials, tools, equipment etc. necessary to complete the work to these Specifications and shall include the following where applicable :-

(i) Setting out

(ii) Planking and any other precautionary measure taken to ensure the stability of adjacent areas.

(iii) Removal of excess or unsuitable material, logs, stumps etc.

(iv) Measures required for working under restricted conditions. Dewatering shall be considered as part of the work.

The Pay Items and Pay Units shall be follows:-

Pay Item	Description	Pay Unit
1903(1)	Pits and Trenches in soil	Cu.m
	Pit and Trench reinstatement	
1903(2)	(a) up to 1.2m	Cu.m
1903(3)	(b) depth for depths greater than 1.2 m	Cu.m

1904 SOIL SAMPLING

1904.1 Undisturbed soil samples

Unless otherwise indicated in Schedule 1, the method of obtaining undisturbed sample from borehole shall be as follows;

(a) use of 75 mm diameter piston samplers for peat and soft clays.

(b) use of 75 mm diameter Thin Walled Samplers for clays which are not too soft and can be retained.

(c) use of 75 mm diameter open tube sampler for medium stiff cohesive soils.

(d) use of 75 mm diameter Denison samplers for lateritic soils

The method of sampling from trial pits and trenches shall be as specified by the Engineer.

1904.2 Disturbed soil samples

In a borehole investigation, when a Standard Penetration Test (SPT) is carried out, the sample from the split spoon sampler shall be retained. Where a sample cannot be recovered from the SPT tube, samples can be collected from either the cuttings brought to the surface in rotary drilling and wash boring, or the boring tools in the shell and auger boring or hand augering.

The method of collecting disturbed samples from hand augering, trial pits and trenches shall be as specified by the Engineer.

1904.3 Sampling frequency

(a) Undisturbed samples of soil shall be obtained from peaty or clayey soils as indicated in Schedule 1, or as otherwise instructed by the Engineer.

(b) SPT carried out in boreholes shall be at depths of 1.5 m intervals; or as otherwise instructed by the Engineer. The SPT may be left out at any depth at which an undisturbed sample is being collected.

1904.4 Description of samples

All samples shall be examined and described by a geotechnical person meeting the requirements of Sub section 1901.2(b).

1904.5 Measurement and Payment

(a) Measurement

Collection of samples shall be measured separately in numbers for disturbed and undisturbed samples for stated weights or sizes respectively, and as accepted by the Engineer.

(b) Payment

The collected numbers of samples shall be paid for at Contract unit rates for each size or weight. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these Specifications and in addition shall include the following where applicable :-

(i) Packaging and proper sealing

(ii) Labelling and storage

(iii) Transportation to the laboratory.

The pay items and pay units shall be as follows:-

Pay Item	Description	Pay Unit
1904(1)	Collection of undisturbed soil samples (state sizes)	Number
1904(2)	Disturbed soil samples (state weight and packaging)	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1905 ROCK SAMPLING

1905.1 Core Samples

(a) Unless otherwise stated in Schedule 1901.1, rock cores shall be obtained by rotary core drilling using a double tube coring system.

(b) Rotary core drilling shall produce cores of not less than 40 mm diameter.

(c) The first core run in each hole shall not exceed 1 m in length. Subsequent core runs shall not normally exceed 3m in length.

(d) In cases where rock cores are to be obtained, hammering of the core barrel or explosive extrusion under high air pressure or water pressure shall not be permitted.

1905.2 Disturbed Samples

The sludge from percussion borings, or from rotary drilling which has failed to yield a core, may be taken as a disturbed sample.

1905.3 Measurement and Payment

(a) Measurement

Collection of samples shall be measured separately in numbers for core and disturbed samples for stated weights or sizes respectively, and as accepted by the Engineer.

(b) Payment

The collected numbers of samples shall be paid for at Contract unit rates for each size or weight. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these Specification and in addition shall include the following where applicable :-

(i) Packaging and proper sealing

(ii) Labelling and storage in core boxes

(iii) Transportation to the laboratory.

The pay items and pay units shall be as follows:-

Pay Item	Description	Pay Unit
1905(1)	Collection of rock core samples (state sizes)	Number
1905(2)	Disturbed rock samples (state weight and packaging)	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1906 GROUNDWATER

1906.1 Groundwater measurement records

(a) When groundwater is encountered in a borehole, the Contractor shall immediately cease boring, and observe and record any movement in the level of the groundwater.

(b) If it is necessary to add water to the borehole to facilitate boring, this shall be used sparingly and not in sueh a manner as to prevent accurate observation of the groundwater conditions in the borehole.

The Contractor shall take all necessary precautions to prevent surface water entering the boreholes.

(c) The Contractor shall take records of the following water levels in each borehole:

(i) the level at which groundwater was first encountered.

(ii) the levels at which ground water was standing at the commencement and termination of each working day.

(d) The cost of above works shall be included in the rates quoted for advancing boreholes.

1906.2 Sampling of groundwater

Samples of groundwater shall be taken as directed by the Engineer, and as specified in Clause 1901.2(d)(i)(A)(v)d.

1906.3 Installation of Standpipes

The Contractor shall install standpipes in boreholes to the numbers and depths required by the Engineer. The Standpipes shall be as specified in Appendix 1906.1.

1906.4 Recording of reading of Standpipes

(a) While on the site, the Contractor shall take daily readings of water levels in all Standpipes. He shall also, where directed by the Engineer return to the site at intervals to make additional water level readings.

(b) The measured water level, elevation of the tip of Standpipe together with dates and time of reading shall be reported to the Engineer and shall also be included in the Final Report.

1906.5 Measurement and Payment

(a) Measurement

Collection of ground water samples shall be measured separately in numbers, and as accepted by the Engineer.

(b) Payment

The collected numbers of ground water samples shall be paid for at Contract unit rates for each size or weight. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these Specification and in addition shall include the following where applicable :-

(i) Packaging and proper sealing

(ii) Labelling and storage

(iii) Transportation to the laboratory.

The pay items and pay units shall be as follows:-

Pay Item	Description	Pay Unit
1906(1)	Collection of ground water samples (state sizes)	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1907 DAILY REPORTS

1907.1 General

The Contractor shall prepare in duplicate for each exploratory hole a daily report, one copy of which shall be submitted to the Engineer at the beginning of the next working day.

1907.2 Information for daily reports

(a) General Information

(i) Name of Project
(ii) Date
(iii) Weather Condition

(b) For boring in Overburden

(i) Borehole number
(ii) Type of plant used and method of boring
(iii) Times of boring
(iv) (a) Depth of hole at beginning of working day
(b) Depth of hole at end of working day
(c) Depth bored during working day
(v) Diameters of boring
(vi) Diameters and depths of casing
(vii) All water levels encountered
(viii) Levels at which ground water was standing as commencement and end of working day
(ix) Levels of water in standpipes
(x) Depths from ground level of each stratum, and a preliminary description of the samples.
(xi) Records of in-situ tests carried out
(xii) (a) Depths at which obstructions are encountered
(b) Extents in vertical direction of obstructions
(c) Time for chiselling through obstructions and weights of chisel
(xiii) Details and depths at which samples were taken and Reference Numbers of samples.

(c) For drilling in rock

(i) Borehole number
(ii) Types of core barrels and bits
(iii) Times of drilling
(iv) (a) Depth of hole at beginning of working day
(b) Depth of hole at end of working day
(c) Depth of hole drilled during working day
(v) Depths of 'start' and 'finish' of each core run
(vi) Core diameters
(vii) Time of drilling each core run
(viii) Total Core Recovery and Rock Quality Designation (RQD)
(ix) Preliminary description of type of rock and degree of weathering of rock at each pull out
(x) Percentage of water return and colour of return of water
(xi) Levels at which ground water were standing at beginning and end of working day

1907.3 For Trial Pits and Trenches

(a) Reference Number of Pit or Trench
(b) Type of equipment used
(c) Times of excavations
(d) (a) Depth of excavation at beginning of working day
(b) Depth of excavation at end of working day
(e) Details of groundwater inflow
(f) Depths from ground level of each stratum, and a description of each stratum
(g) Dip and strike details of each stratum
(h) Records of in-situ tests carried out
(i) Locations and details of buried services encountered
(j) Information on photographs taken

1908 IN-SITU TESTS

1908.1 All in-situ tests shall be in accordance with standards indicated in Sub section 1901.2(a).

1908.2 Measurement and Payment

(a) Measurement

Tests shall be measured separately in numbers, and as accepted by the Engineer.

(b) Payment

The numbers of tests shall be paid for at Contract unit rates for each type of test. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these Specifications.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1908(1)	Carrying out insitu tests (State type)	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1909 LABORATORY TESTS

1909.1 All laboratory tests shall be in accordance with the standards indicated in Sub section 1901.2(d).

1909.2 As soon as the first 2 boreholes have been completed. The Engineer shall in consultation with the Contractor decide on the actual number and types of tests to be carried out.

1909.3 Measurement and Payment

(a) Measurement

Laboratory tests shall be measured in numbers, and as accepted by the Engineer.

(b) Payment

The laboratory tests shall be paid for at Contract unit rates for each type of tests. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these Specifications.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1908(1)	Carrying out laboratory tests (State type)	Number

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

1910 REPORTING

1910.1 Preliminary Logs

The Contractor shall prepare a preliminary log of each borehole using an agreed format, and submit the same to the Engineer within 7 working days of the completion of each borehole. A sample format is given in Appendix 1910.1.

1910.2 Final borehole logs

(a) After the completion of all soil classification tests and a visual examination of all the samples in the laboratory, final borehole logs shall be prepared.

This shall include

(i) Ground level at top of borehole related to a datum.
(ii) Description of each stratum in accordance with the Standards indicated in Sub section 1901.2(d).
(iii) Details of groundwater observations.
(iv) Symbolic legend of strata in accordance with the Standards indicated in Sub section 1901.2(d).
(v) Details of rock cores as given in (b) below.

(b) When rock of cores are obtained by rotary drilling methods, the final borehole logs shall also include

(i) Condition of each core run in terms of percentage of Core Recovery and percentage of Rock Quality Designation, i.e. the percentage of solid core received in pieces larger than 100mm.

(ii) Description of rock type, its alteration state and relative strength; details of the natural discontinuities and rock structures.

(iii) Percentage of water return, and colour of water.

1910.3 Preliminary laboratory test results

Laboratory test results shall be submitted to the Engineer in batches at the completion of each week's testing. Legible photocopies of work sheets shall be acceptable.

1910.4 Form of Report

The report shall be submitted in two sections; the first being the factual report, and the second, if required by the Engineer, the interpretative report.

1910.5 Contents of factual report

The factual report shall contain the following information:

(a) a statement on the purpose and rationale of the investigation.
(b) a description of the work carried out , including reference to Specifications and standards adopted and any deviations from them.
(c) borehole logs
(d) in situ test records
(e) laboratory test plan
(f) plan with location of boreholes and other test locations
(g) site location plan
(h) any additional information that may be required and is included in Schedule 1.

1910.6 Contents of interpretative report

(a) The interpretative report shall contain the following information:

(i) the brief agreed with the procurer for the interpretative work
(ii) reference to the desk study information
(iii) a written appraisal of the ground and water conditions
(iv) analyses and recommendations as indicated in Schedule 1901.1.

(b) When required in the Contract the Contractor shall supply the calculations and analyses on which recommendations are based.

1910.7 Acceptance of report

A draft copy of the factual report and interpretative report shall be submitted to the Engineer for acceptance before submission of the Final Report.

1911 ALTERNATIVE PROGRAMME

The Contractor at the time of tendering may propose an alternative Investigation Programme which would still enable the Contractor to submit the Final Report and Recommendations as required by the Engineer.

The Contractor must however, price the investigation programme included in the Bill of Quantities and submit his alternative separately.

1912 FINAL PAYMENT

The final payment shall be made upon satisfactory completion of the work, and submission of 3 copies of the Final Report accepted by the Engineer.

Appendix 1906.1

Standpipes for groundwater observations

A1.1 Specification of Standpipe

The standpipe shall consist of a rigid polyvinyl chloride (PVC) of about 19 mm in diameter or as specified by the Engineer. The Base of the standpipe shall be plugged and the lower 1.0 m of the standpipe perforated by holes not greater than 5 mm in diameter at intervals of approximately 75 mm.

A1.2 Specification of filter

The filter shall consist of rounded gravel (6-10) mm in diameter and shall be approved by the Engineer.

A1.3 Installation

(i) The drilled hole shall be flushed until return water runs clear. The water from the hole shall be pumped out prior to installation.

(ii) Where the depth of the borehole is greater than the depth to which the filter and standpipe are to be installed, then the borehole shall be backfilled up to the Base of the filter with natural materials approved by the Engineer.

(iii) The gravel filter shall be placed in the borehole up to the level of the proposed Base of the standpipe. The elevation of the top of the filter shall be recorded.

(iv) The standpipe shall be lowered carefully down the borehole to the top of the filter, and the hole backfilled with filter gravel to within 1.0 m of ground level or as recommended.

(v) The top of the PVC tubing shall be covered by plastic caps or similar as approved by the Engineer.

(vi) A small hole shall be made in the side of the standpipe tube near the top to allow air to escape.

(vii) The pipe shall be sealed into the ground at the surface with a 0.5 m deep layer of cement grout or bentonite–cement grout, so that it does not rotate and the ingress of surface water is prevented.

SCHEDULES

Specifications The Specifications shall be "Chapter 1900" Site Investigation for embankment construction, bridges and other structures and cuttings" of the "Standard Specifications for Construction and Maintenance of Roads and Bridges" published by ICTAD with information, amendments and additions as described in the Schedules.

Schedule 1	:	Information
Schedule 2	:	Specification Amendments
Schedule 3	:	Exploratory holes (i.e. Boreholes, Hand auger holes, Pits and Trenches)
Schedule 4	:	Specification Additions.

SCHEDULE 1 (SECTION 1901) INFORMATION

S 1901.1 Name of Contract

(Note. A concise and unique name shall be required for Contract and reporting purposes. The name shall include the nearest town)

S 1901.2 Description of Site

(Note. The description of the site shall include its location, geological setting (if known), and previous use site (if known)

The locations of the underground services (if known) can be provided. In the alternative, information may be provided as to the Authorities from whom the locations of underground services could be obtained. Notwithstanding such information provided, the ultimate responsibility for the location of underground services shall be with the Contractor.)

S 1901.3 Type of development proposed at site

(Note. Type of development shall be indicated; e.g. road embankments, bridges or other structures and cuttings etc. Also, if possible, provide information on number of spans, loading details, etc. for bridges)

S 1901.4 Scope of Investigation

(Note. The text shall state whether the investigation is preliminary, main or supplementary. A brief outline is required of the work to be done under the Contract, stating the type of exploratory holes (boreholes, trial pits, etc). It shall also state whether sampling and testing (in situ and laboratory) are required, and also what types of report are required (factual or factual and interpretative.)

S 1901.5 Schedule of Drawings and documents

(Note. These shall include
(a) Site Plan
(b) Layout Plan, if available
(c) Contour Map, in sloping terrain

S 1901.6 The requirements/restrictions given below shall be included only if necessary.

(a) Requirements for borehole in overburden

(i) The method of advancing the borehole
(ii) Special backfilling requirement

(b) Requirements for borehole in rock

(i) The method of advancing the borehole
(ii) Special backfilling requirement
(iii) Particular photographic requirements

(c) Requirements for Pits and Trenches

(i) any alternative dimensions
(ii) particular photographic requirements
(iii) special backfilling requirements

(d) Requirements for Sampling

(i) Frequency of sampling in overburden
(ii) The method of obtaining undisturbed samples from overburden
(iii) The minimum diameter of undisturbed samples from overburden
(iv) The method of obtaining rock cores
(v) The minimum diameter of rock cores
(vi) Special requirements for retention and delivery of samples.

(e) Requirements for in-situ testing

(i) Frequency of SPT
(ii) In-situ testing requirements other than SPT
e.g. Plate bearing tests, Static Cone Penetration Tests, Vane Shear Tests, Field permeability tests , Degree of compaction Tests, Pressure meter Tests.
(iii) Geophysical investigations.

(f) Requirements for particular instrumentation and monitoring

(i) Installation of piezometers and/or standpipes
(ii) Frequency of readings
(iii) If piezometers and/or standpipes are to be removed.

(g) Requirements for Final Report

(i) Requirements for interpretative report
(ii) Additional information required in factual report
(iii) Analysis and recommendations required in interpretative report
(iv) Calculations required.

SCHEDULE 2 (CLAUSE 1901.2) SPECIFICATION AMENDMENTS

The following clauses are amended:

(Note: 1901.2(b) may be amended (for small jobs) to allow field works to be carried out under the supervision of a person with drilling experience; e.g. Drillers, Drilling Foremen , Soil Testers, etc.

Similarly, this schedule shall contain any other Specification Amendments.

SCHEDULE 3 (CLAUSE 1902) EXPLORATORY HOLES (BOREHOLES, HAND AUGER HOLES, PITS AND TRENCHES)

(Note: The following information shall be provided for each exploratory hole.

Hole No:

Type :

Scheduled depth :

Method of locating hole:

SCHEDULE 4 SPECIFICATION ADDITIONS

The following clauses are added to the Specifications:

BILL OF QUANTITY (TYPICAL)

Item	Description	Quantity	Unit Rate	Amount
1.0	Mobilisation and de-mobilisation of the necessary drilling rigs, and all necessary equipment and labour, including any improvements to access roads.	Lump Sum		
2.0	Shifting and setting up of drilling rig from one borehole to another within the work site, including any improvements to access roads and preparations of working platforms.	Nr.		
3.0	Advancement of borehole through soil overburden including obstructions of boulder, Pavement, log, etc.; and backfilling hole thereafter 3.1 From 0.0 m – 10.0 m depth 3.2 From 10.0 m – 20.0 m depth 3.3 More than 20 m depth 3.4 (a) Drilling through rock including rock coring (b) Collection of rock core samples (state sizes) (c) Collection of disturbed rock samples (state weight and packaging)	 m m Rate Only Nr Nr		
4.0	Carry out Standard Penetration tests and collecting disturbed soil samples at 1.0 m / 1.5 m intervals inclusive of transport of samples to laboratory (state sizes)	Nr. Nr.		
5.0	5.1 Collecting undisturbed soil samples as specified inclusive of transport of samples to laboratory (State sizes) 5.2 Disturbed soil samples (state weight & packaging)	Nr.		
6.0	Installation of standpipes to required depth in the borehole, and monitoring during period of Contract.	Nr.		
7.0	Advancement of hand auger hole state type of material augered (a) Soft soil (b) Overburden soil	Linear m		
8.0 (a)	Excavation of test pits and trenches of plan dimensions 1.5 m X 1.5 m, 8.1 (a) up to 1.2 m depth (b) for depths greater than 1.2 m 8.2 Pit and trench reinstatement	 Cu.m. Cu.m. Cu.m.		
8.0 (b)	Excavation of pit or trench to a depth greater than 1.2 m for purpose of locating underground services.	Rate only		

Item	Description	Quantity	Unit Rate	Amount
9.0	(In-situ test other than SPT)			
	9.1 Vane Shear test	Nr.		
	9.2 Permeability Test	Nr.		
	9.3 Static Cone Penetration test	Nr./m		
	9.4 Plate Bearing Test	Nr.		
	9.5 Pressuremeter test	Nr.		
	9.6 In situ density Tests	Nr.		
	9.7 Other probing tests, as specified	Nr.		
10.0	Collecting groundwater samples (state sizes) (Note the rates for testing of these samples are required separately in 11.11 to 11.13	Nr.		
11.0	Laboratory Tests			
	11.1 Natural moisture content			
	11.2 Bulk density and dry density			
	11.3 Proctor compaction test			
	11.4 Specific Gravity			
	11.5 Particle size distribution			
	- Sieve analysis only			
	- Sieve analysis and hydrometer analysis			
	11.6 Atterberg Limits			
	11.7 Organic content			
	11.8 Consolidation tests with at least loading increments and unloading increments)	Rate only		
	11.9 Triaxial Test (minimum 3 specimens)			
	- UU Test			
	- CU test with Pore water pressure measurements			
	- CD Test			
	- Any other test , as specified			
	11.10 Direct Shear Test (minimum 3 specimens)			
	11.11 Tests for Sulphate			
	11.12 Tests for Chloride			
	11.13 pH Test			
	11.14 Uniaxial compressive Test on rock cores			
	11.15 Any other tests, as specified			
12.0	Provision for complying with other requirements (e.g. Surveying, insurance, etc.) of the Specification	Lump Sum		
13.0	Provision of geotechnical personnel	Lump Sum		

2000 GEO-SYNTHETICS

2001 GEO-SYNTHETICS IN ROAD AND BRIDGE WORKS

2001.1 Description

This Specification describes the various applications of Geo-synthetic materials in road and bridge works including supplying and laying as per Sections 2002, 2003 & 2004 or as directed by the Engineer.

Geo-synthetic is a general classification for all synthetic materials used in geotechnical engineering applications. It includes geo-textiles, geo-grids, geo-nets, geo-membranes and geo-composites as described below.

(a) Geo-textiles : They shall be synthetic textiles confirming to Section 1710 and used with foundations, soils, rock, earth, or any other geotechnical engineering related materials, in performing at least one of five discrete functions,

(i) Separation
(ii) Reinforcement
(iii) Filtration
(iv) Drainage and
(v) Containment barrier when impregnated

Geo-textile for foundations (i) to (iv) shall be permeable.

(b) Geo-grid: A deformed or non-deformed grid of polymeric plastic material used primarily for reinforcement purposes with foundations, soils, rocks, earth, or any other geotechnical engineering related materials. They are stretched in one or two directions for improved physical properties or made on weaving machinery by unique methods.

(c) Geo-nets: Geo-nets are made of polymeric material used for drainage of foundations, soils, rocks, earth or any other geotechnical engineering related material. They are usually formed by continuous extension of parallel sets of polymeric ribs at acute angles to one another.

(d) Geo-membrane: They are essentially thin impermeable membranes of polymeric material used with foundations, soils, rock, earth or any other geotechnical engineering related material, to control fluid migration.

(e) Geo-composite: They are manufactured materials using a combination of geo-textiles, geo-grids, geo-nets and or geo-membranes.

2001.2 Materials

Unless otherwise stated, these Geo-synthetic materials shall conform to requirements as given below:

(a) Geo-textiles: They shall conform to the requirements of Section 1710. The type of geo-textile to be used shall be decided on the basis of design for a particular application.

(b) Geo-grids: They shall be made from integrally jointed, mono or bi-directionally orientated or stretched meshes made from polyethylene or polypropylene or polyester or similar polymer, with high secant modulus, in square, rectangular, hexagonal or oval mesh form. Their junction strength shall be high with high creep resistance, and dimensional stability. Their open structure shall permit effective interlocking with soil,

aggregates, rock etc., they shall be used as a tensile member or reinforcement. Characteristics strength of such Geo-grids varies from 40 kN/m to 200 kN/m peak strength at a maximum elongation of 15 per cent in the direction of the length of the roll length.

(c) **Geo-nets**: They shall be made from a single extruded non-oriented process from polyethylene or polypropylene or similar polymer. It shall have square or rectangular net shape aperture when used for protective works like gabions and mattresses. While in polygonal aperture it shall be used as a separator. It shall not be used as soil reinforcement due to its high creep characteristics, neither as a slope reinforcement or soil retaining wall or asphalt reinforcement. Geo-nets used in protective works for highway structures shall be at least 650 gm/ sq.m. in unit weight. It shall be available in roll form in suitable width and shall be black in colour.

(d) **Geo-membranes**: They shall be made from PVC or polyethylene sheets of at least 0.8 mm thickness, duly protected from ultra· violet exposure with 2.5 per cent carbon black, in black colour, supplied in roll form with 3 m or above width. The joints of these sheets shall be heat bonded or seamed for effective permeation cut off, at site using standard equipment as part of the laying process. While fixing on to a slope, they shall not be punctured or stapled to reduce their effectiveness.

(e) **Geo-composites**: They shall be made from combination of geo-nets, geo-grids or geo-membranes of above description using heat bonded, seamed, stitched or wrap techniques. Their principal use shall be to regulate drainage in cross-plane or in-plane directions. Minimum unit weight of such material shall conform to the requirements given in the Contract Drawing or to the Special Provisions.

(f) **Testing and acceptance**: Geo-synthetics shall be tested in accordance with either ASTM or British Standards or ISO Standards.

2001.3 Application Areas

Some areas of application for geo-textiles and related materials and their functions for performance are given below in Table 2001-1.

Table 2001-1 - Applications and Functions for performance of Geo-synthetics

Number	Application Area	Geo-synthetics Used	Functions for Performance
1.	Embankments on soft soils	GT,GG	R,S
2.	Retaining walls	GG,GT	R
3.	Drainage and Filtration	GT	D, F, S
4.	Drainage-prefab, composite	GC,GN	D,F,S, B
5.	Erosion Control rip rap	GT	F, S
6.	Asphalt overlay	GT,GG	B,R,S

Abbreviations:

Geo-textile = GT	B = Barrier
Geo-grid = GG	D = Drainage
Geo-composite = GC	F = Filtration
Geo-net = GN	R = Reinforcement
	S = Separation

2002 GEO-TEXTILES / GEOFABRICS FOR HIGHWAY & BRIDGE APPLICATIONS OTHER THAN FOR SOFT GROUND TREATMENT

2002.1 Description

The work shall consist of furnishing all materials, labour, equipment and placing of geo-textiles on prepared surfaces to perform one or more of the following functions in accordance with these Specifications or as directed by the Engineer.

(a) As a filter for all drainage systems where there is a possibility of clogging by fine particles of adjacent soil separation and filtration. The geo-textile will allow the seepage water to pass through into a subsurface drain system retaining the particles of soil from passing in whilst.

(b) As a separation to prevent mixing of subsoil and an aggregate cover material (Sub-base, Base, select Subgrade etc.) This may also apply to situations other than beneath Pavements where separation of two dissimilar materials required, where seepage of water through the geo-textile is not a critical function. Separation geo-textiles for soft ground treatment are covered under Section 2003.

(c) For Subgrade stabilization and increasing soil shear strength by providing bonding mechanism of the geo-textile - soil (wet saturated) system to provide coincident functions of separation and filtration.

(d) As a filter element for all bodies of water where the soil of the banks can be eroded by currents, wave action or water level changes.

(e) As a paving fabric, saturated with bitumen between Pavement layers. The function of the paving fabric is to act as a water proofing and stress relieving membrane with the Pavement structure.

2002.2 Materials

(a) Geo-textiles - General

The geo-textile material ultra violet stabilized and shall be resistant to acid and alkaline media in the pH range 2 to 13, resistant to lime cement and concrete, resistant to all naturally occurring bacteria and fungi. A prolonged out side exposure of several months shall have no effect on the Geo-textile properties.

Except for those used with paving fabrics, the geo-textile shall have high water permeability. In order to ensure free drainage, geo-textiles shall offer high retention capability for almost all types of soils. The geo-textiles shall have high resistance against installation damage with optimum stress-strain behaviour even with low unit weight. The geo-textile / geo-fabric shall conform to the requirements of Section 1710.

(b) Geo-textiles to be used with Paving Fabrics

The sealant material used to impregnate and seal the paving fabric, as well as bond it to both the Base Pavement and overlay, shall be penetration grade bitumen recommended by the paving fabric manufacturer, and approved by the engineer.

Uncut penetration grade bitumen is the preferred sealant; however, cationic and anionic emulsion may be used provided the precautions outlined in Section 2002.3e(ii)c are followed. Cutbacks and emulsions that contain solvents shall not be used.

The sealant shall be 60–70 or 80–100 penetration grade bitumen conforming to Section 1702.1.

Blotting (blinding) material to be spread over bitumen saturated paving fabric to facilitate movement of equipment during construction or to prevent tearing or delimitation of the paving fabric shall be coarse sand conforming to Sub section 1701.4.

2002.3 Construction Requirements

(a) Seaming of the Geo-textile

(i) Sewn seam

The thread used shall consist of high strength polypropylene or polyester. Nylon thread shall not be used. For erosion control applications, the thread shall also be resistant to ultraviolet radiation. The thread shall be of contrasting colour to that of the geo-textile used.

The Contractor shall submit the seam assembly description along with the sample of the seam. The description shall include the seam type, stitch type, sewing thread, and stitch density.

(ii) Sewn Seam in the field

The Contractor shall provide at least two-meter length of sewn seam for sampling by the engineer before the geo-textile is installed.

The seams sewn for sampling shall be sewn using the same equipment and procedures as will be used for the production seams. If seams are sewn in both the machine and cross machine direction, samples of seams from both directions shall be provided.

(iii) Sewn Seam in the Factory

The engineer shall obtain samples of the factory seams at random from any roll of geo-textile that is used on the project.

(b) Drainage Geo-textile

(i) a. Excavation of trenches shall be done in accordance with details given in the Drawings or as instructed by the Engineer. In all instances, excavation shall be carried out in such a way so as to prevent large voids from occurring in the sides and bottom of the trench. The excavated profile shall be cut to a smooth surface and shall be free of debris.

b. The geo-textile shall be placed loosely with no wrinkles or folds, and with no void spaces between the geo-textile and the ground surface. Successive sheets of geo-textiles shall be overlapped a minimum of 300 mm, with the upstream sheet overlapping the downstream sheet.

(ii) a. Where the trench is less than 100 mm the geo-textile overlap shall be sewn or otherwise bonded. In trenches less than 300 mm, but greater than 100 mm wide, the overlap shall be equal to the width of the trench. In trenches equal to or greater than 300 mm in width, after placing the drainage aggregate the geo-textile shall be folded over the

top of the backfill material in a manner to produce a minimum overlap of 300 mm. All seams shall be subject to the approval of the engineer.

b. If the geo-textile be damaged during installation or drainage aggregate placement, a geo-textile patch shall be placed over the damaged area extending beyond the damaged area a distance of 300 mm, or the specified seam overlap, whichever is greater.

(iii)a. The drainage aggregate shall be placed immediately following placement of the geo-textile. The geo-textile shall be covered with a minimum of 300 mm of loosely placed aggregate prior to compaction. If a perforated collector pipe is to be installed in the trench, a bedding layer of drainage aggregate shall be placed before the pipe is laid, with the remainder of the aggregate placed to the minimum required depth of construction.

b. The aggregate shall be compacted with vibratory equipment to a minimum of 90 percent density under heavy compaction as per Section 1804.4b unless the trench is required for structural support. If higher compaction effort is required, a Class I geo-textile as per Table 2002-1 shall be required.

(c) Separation (other than for soft ground treatment) / Stabilization Geo-textiles

Please refer to Section 2003 for separation geo-textiles for soft ground treatment.

(i) The site for installation shall be prepared by clearing, grubbing and excavation or filling the area to the design grade including the removal of vegetation and topsoil.

Any soft spots and unsuitable areas shall be identified during site preparation or subsequent proof rolling. These areas shall be excavated and backfilled with select material and compacted using procedures, normally carried out.

(ii) a. The geo-textile shall be laid smooth without wrinkles or folds on the prepared Subgrade in the direction of construction traffic. Adjacent geo-textile rolls shall be overlapped, sewn or joined as required in the Drawings. Overlaps shall be in the direction as shown on the Drawings. Overlap requirements shall be taken as those given in Table 2002-1.

Table 2002-1 – Overlap Requirements

Soil CBR	Minimum Overlap
Greater than 3	300 – 450 mm
1 – 3	0.6 – 1 m
0.5 – 1	1 m or sewn
Less than 0.5	Sewn
All roll ends	1 m or sewn

b On road curves the geo-textile shall be folded or cut to conform to the curves. The fold or overlap shall be in the direction of construction and held in place by pins, staples or piles of fill or rock, in the case of non woven type and piles of fill or rock in the case of woven type.

c The geo-textile shall be inspected prior to covering, to ensure that the geo-textile has not been damaged (i.e., holes, tears, rips) during installation. The inspection shall be done by the Engineer or the Engineer's designated representative.

Damaged geo-textiles, as identified by the Engineer, shall be repaired immediately. The damaged area shall be covered with a geo-textile patch that extends an amount equal to the required overlap beyond the area of damage.

(iii) a The Base / Sub-base shall be placed by end dumping onto the geo-textile from a location beyond the edge of the geo-textile or over previously placed Sub-base aggregate. Construction vehicles shall not be allowed directly on the geo-textile. The Sub-base shall be placed such that at least the minimum specified lift thickness shall be between the geo-textile and equipment tires or tracks at all times. Turning of vehicles shall not be permitted on the first lift above the geo-textile. On Subgrades having a CBR value of less than one, the Sub-base aggregate shall be spread in its full thickness as soon as possible after dumping to minimize the potential of localized Subgrade failure due to overloading of the Subgrade / embankment formation.

b During construction, any ruts occurring shall be filled with additional Sub-base material and compacted to the specified density or as decided by the Engineer.

c If placement of the backfill material causes damage to the geo-textile, the damaged area shall be repaired as previously described in Section 2002.3(b)(ii)(b). The placement procedures shall then be modified to eliminate further damage from taking place (i.e., increase pioneer layer thickness, decrease equipment loads, etc.). In stabilization applications, the use of vibratory compaction equipment shall not be used along with the initial lift of Sub-base material, as it may cause damage to the geo-textile.

(d) Erosion Control Geo-textiles

(i) a The erosion control geo-textile shall be placed in intimate contact with the soils without wrinkles or folds and anchored on a smooth graded surface approved by the engineer. The geo-textile shall be placed in such a manner that placement of the overlaying materials will not excessively stretch so as tear the geo-textile. Anchoring of the terminal ends of the geo-textile shall be accomplished through the use of key trenches or aprons at the crest and toe of slope as shown in the Drawing or as directed by the engineer.

b The erosion control geo-textile shall be placed with the machine direction parallel to the direction of water flow which is normally parallel to the slope for erosion control runoff and wave action, and parallel to the stream or channel in the case of stream bank and channel protection. Adjacent geo-textile sheets shall be joined by either sewing or overlapping. Overlapped seams of roll ends shall be a minimum of 300 mm except where placed under water. In such instances, the overlap shall be a minimum of 1 m. In all instances, overlaps of adjacent rolls shall be a minimum of 300 mm.

During overlapping, successive sheets of the geo-textile shall be overlapped upstream over downstream, and/or upslope over down slope. In cases where wave action or multidirectional flow is anticipated, all seams perpendicular to the direction of flow shall be sewn, as per Sub section 2002.3(a).

c Due care shall be taken during installation in order to avoid damage occurring to the geo-textile as a result of the installation process. If the geo-textile is damaged during installation, a geo-textile patch shall be placed over the damaged area extending 1 m beyond the perimeter of the damage caused.

d The placement of the armour system shall begin at the toe and proceed up the slope. Placement shall be carried out in order to avoid stretching and subsequent tearing of the geo-textile. Riprap and heavy stone filling shall not be dropped from a height of more than 300 mm. Stone with a mass of more than 100 kg shall not be allowed to roll down the slope.

e Materials for slope protection and smaller sizes of stone filling shall not be dropped from a height exceeding 1 m, or a demonstration provided showing that the placement procedures will not damage the geo-textile. In underwater applications, the geo-textiles and backfill material shall be placed the same day. All void spaces in the armour stone shall be backfilled with small stone to ensure full coverage of the area concerned.

f After the placement of the armour stone, grading of the slope shall not be permitted if the grading results in movement of the stone directly above the geo-textile.

g Monitoring in the field shall be carried out to verify that the armour system placement does not damage the geo-textile material.

h Any damaged geo-textile during backfill placement shall be replaced at the Contractor's expense as directed by the Engineer.

(e) Paving Fabrics

(i) Equipment

a. The bitumen distributor shall be capable of spraying the asphalt sealant at the prescribed uniform application rate. No streaking, skipping or dripping shall be permitted. The distributor shall also be equipped with a hand spray having positive shut-off valve and a single nozzle.

b. Manual or mechanical lay down equipment shall be capable of smooth laying of the paving fabric.

c. The following tools and equipment shall be provided: stiff bristle brooms or squeegees to smooth the paving fabric; scissors or blades to cut the paving fabric; brushes for applying asphalt sealant to overlaps of the paving fabric.

d. Rolling equipment of the pneumatic type, to smooth the paving fabric into the sealant and sanding equipment shall be required for certain jobs. Rolling shall be required on jobs where thin lifts or chip seals are being placed. Rolling helps ensure paving fabric bond to the adjoining Pavement layers in the absence of heat and weight associated with thicker lifts of bituminous overlays.

(ii) Installation of Geo-textiles

(a) The bitumen sealant or the paving fabric shall not be placed when weather conditions, in the opinion of the engineer, are not suitable. Air and Pavement temperatures shall be sufficient to allow the asphalt sealant to hold the paving fabric in place. For bitumen, such air temperatures shall be 10^0C and rising and for bituminous emulsion (without solvents), such air temperature shall be 15^0C and rising.

(b) The profile on which the paving fabric is to be placed shall be reasonably free dirt, water, vegetation or other debris, as determined by the Engineer. Cracks exceeding 3 mm in width shall be filled with suitable crack filler as per Section 1105. Potholes shall

be properly repaired as per Section 1102 and as directed by the Engineer. Fillers shall be allowed to cure prior to placing the paving fabric.

(c) The specified rate of asphalt sealant application shall be sufficient to satisfy the asphalt retention properties of the paving fabric and bond the paving fabric and overlay to the old Pavement, as decided by the Engineer.

When emulsions without solvents are used, the application rate shall be corrected by dividing the application rate for penetration grade bitumen by the fraction of bitumen in the emulsion.

(d) The binder application shall be carried out by a distributor spray bar, with hand spraying kept to a minimum. Temperature of the asphalt sealant shall be sufficiently high to permit uniform spray pattern. For bitumen asphalt the minimum temperature shall be 145^0C. However, the distributor tank temperatures shall not exceed 160^0C in order to avoid damage to the paving fabric.

(e) As spraying with bituminous emulsions are improved by heating, temperatures in the 55^0C to 70^0C range are desirable. Since higher temperatures may break the emulsion, temperature of 70^0C shall not be exceeded.

(f) The bituminous binder target width of application shall be the paving fabric width plus 150 mm. The bituminous binder shall not be applied any farther in advance of paving fabric placement than the distance the Contractor can maintain traffic free.

(g) Spills from bitumen distributor shall be cleaned from the road surface to avoid flushing and movement of the paving fabric.

(h) When bituminous emulsions (without solvents) are used, the emulsion shall be cured with essentially no moisture remaining prior to placing the paving fabric and final wearing surface.

(i) The fabric used for paving shall be placed onto the bituminous binder with minimum wrinkling prior to the time the asphalt has cooled and lost tackiness. Wrinkles or folds in excess of 25 mm shall be slit and laid flat, as directed by the Engineer.

(j) Brooming and/or pneumatic rolling shall be required to maximize paving fabric contact with the Pavement surface, on which the paving fabric is laid.

(k) Overlap of paving fabric joints shall not exceed 150 mm and shall be sufficient to ensure full closure of the joint. Transverse joints shall be lapped in the direction of paving to prevent edge pickup by the paver. A second application of bituminous binder to the paving fabric overlaps shall be required when additional bituminous binder is needed to ensure proper bonding of the double paving fabric layer, if required in the judgment of the Engineer.

(l) The Contractor shall be responsible for removal and replacement of paving fabric that is damaged at no cost to the Client, if it is found to be the fault of the Contractor.

The problems associated with wrinkles are related to thickness of the asphalt lift being placed over the paving fabric. When wrinkles are large enough to be folded over, there usually is not enough binder available from the tack coat to satisfy the requirement of multiple layers of paving fabric. Therefore, wrinkles shall be slit and laid flat.

Sufficient asphalt sealant shall be sprayed on the top of the paving fabric to satisfy the requirement of the paving fabric when lapped.

When overlapping adjacent rolls of paving fabric it is desirable to keep the lapped dimension as small as possible and still provide a positive overlap. If the lapped dimension becomes too large, the problem of inadequate tack to satisfy the two lifts of paving fabric and the old Pavement may occur. If this problem does occur, then additional bituminous binder sealant shall be added to the lapped areas. In the application of the additional sealant, care shall be taken not to apply too much since excess will cause flushing and paving fabric movement.

(m) Traffic on the paving fabric shall be permitted for emergency and construction vehicles only.

(n) The hot-mix overlay placement shall closely follow paving fabric lay-down. The temperature of the mix shall not exceed 160^0C. In the event asphalt bleeds through the paving fabric causing construction problems before the overlay is placed, the affected areas shall be blotted by spreading sand. To avoid movement of or damage to the seal-coat saturated paving fabric, turning of the pavers and other vehicles shall be kept to a minimum and gradual.

(o) Before placing seal coat (or thin overlay such as an open-graded friction course), the paving fabric shall be spread with sand at a spread rate of 0.65 to 1.0 kg per m^2, and the paving fabric with sand shall be pneumatically rolled tightly into the bituminous binder.

(iii) Safety

Trafficking of the paving fabric shall not be allowed. However, if the Contractor elects to allow trafficking, the following shall be adhered to.

If authorized by the Engineer, the seal-coat saturated paving fabric may be opened to traffic for 24 to 48 hours prior to installing the surface course. Warning signs shall be placed which advise the motorist that the surface may be slippery when wet. The signs shall also post the appropriate safe speed. Excess sand shall be broomed from the surface prior to placing the overlay. If, in the judgment of the Engineer, the fabric surface appears dry and lacks thickness following the traversing of traffic, a light tack coat as per Section 502 shall be applied prior to the overlay construction.

2002.4 Tests and Standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall be conform to these Specifications and shall meet the prescribed standards of acceptance.

2002.5 Measurement and Payment

(a) Measurement

The quantity of Geo-textile measured to be paid shall be in square meters of work completed in accordance with requirement of this item and the limiting dimensions shall not exceed than those shown on the Drawings or fixed by the Engineer. Measurement shall only be made of area covered without considering any overlap.

(b) Payment

The accepted quantity measured as provided above shall be paid at the Contract unit price per square meter of Geo-textile laid for the pay item as listed below in the BOQ which price and payment shall constitute full compensation for furnishing all materials, labour, equipment and placing of Geo-textile and other works given in these Specifications.

The price of bitumen sealant for sealing paving fabrics or the sand used for blotting (blinding) shall be included in the completed work.

The Pay Items and Pay Units will be as follows:-

Pay Item	Description	Pay Unit
2002(1)	Providing and Placing of Geo-textile, (state type)	Sq. m.

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

2003 SEPARATION / HIGH STRENGTH GEO-TEXTILE CONSTRUCTION FOR SOFT GROUND TREATMENT

2003.1 Description

This work shall consist of the placing of geo-textiles to separate or strengthen the earthworks materials.

2003.2 Materials

Geo-textile fabrics shall be manufactured from non-woven or woven and needle punched synthetic, polyethylene, or polypropylene materials for separation and woven for high strength geo-textiles. They shall be inert to all chemicals found in the soil and ground water and canal water and normally resistant to ultra violet light. They shall also be resistant to acid and alkaline media in the pH range 2 to 13, resistant to lime, cement and concrete, resistant to all naturally occurring bacteria and fungi. They have a life expectancy when used in the conditions anticipated in the Contract in excess of 50 years. In order to ensure free drainage, the geo-textiles shall after high retention capability for all utmost types of soils.

The Contractor shall comply with the provisions of Sub section 1710.3 "Certification", Sub section 1710.4 "Sampling, testing and acceptance" and Sub section 1710.5 "Shipment and Storage".

The following types of geo-textile will be required in the works and the Contractor shall supply manufacturers certified test certificates for the actual materials supplied to demonstrate compliance.

Item	Example-1, For drainage & earthworks separator	Example-2, High strength, woven, for high embankment
Tensile strength (ISO 10319)	9.5 KN/m	MD 800 KN/m CD 100 KN/m
Tensile elongation (ISO 10319, md/cd)	75 %/35 %	10%/10%
CBR puncture strength (ISO 12236)	1500 to 2500 N	-
Effective opening size (ISO 12956)	0.1 to 0.2 mm	-
Vertical water flow, 50 mm head (ISO 11058)	85-130 l/sq.m./s	-
Thickness (ISO 9863)	1.2 to 2.0 mm	-
Long term design strength (120 years creep factor)	-	400 KN/m
Ultraviolet stability (retained strength) as per ASTM D4355-05	50% after 500 hours of exposure	

2003.3 Construction

Geo-textiles shall be stored on site away from direct sunlight in the manufacturers wrapping in covered stores. They shall be carefully laid with minimum laps of 500 mm and any damage shall be patched to ensure at least a 300 mm overlap in all directions.

The layer of material on which the geo-textile is to be placed shall not have protrusions or sharp projections which are likely to damage the geo-textile during installation or service. The method of installation shall ensure that the geo-textile is in continuous contact with the surface on which it is placed and the geo-textile shall not be stretched or bridged over hollows or humps. Operation of construction plant directly on the geo-textile will not be permitted and its covering with material shall take place immediately after its laying.

2003.3/1 Tests and Standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall be conform to these Specifications and shall meet the prescribed standards of acceptance.

2003.4 Measurement

The quantity of geo-textile to be measured shall be the surface area covered in Sq.m of geo-textile completed and accepted in place. Laps will not be measured.

2003.5 Payment

The items for geo-textile shall include for:

- Cleaning, trimming, regulating and preparing surfaces,
- Laps,
- Measures to protect material,
- Cutting, jointing, sealing and fixing,
- Securing material in place,
- Complying with the requirements of strengthened earthworks.

Laying of geo-textiles measured as provided above shall be paid for at the Contract unit price for each type of geo-textile which price and payment shall be full compensation for furnishing and all materials including labour, tools and incidentals necessary to complete the work.

The Pay Item and Pay Unit shall be as follows;

Pay Item	Description	Pay Unit
2003 (1)	Geo-textile (9.5 KN/m)	sq.m

(For other types of Geo-textile, please refer to Section 307: Soft Ground Treatment)

2004 PROTECTION WORKS USING GABIONS / MATTRESSES USING GEO-SYNTHETICS

2004.1 Description

This work shall consist of laying Gabions/Mattresses filled with boulders in wraps of GEO-synthetics in the form of bolsters, on slopes of embankments or in aprons. Gabions or Mattresses are also used for stone spurs or groynes. Geo-textiles are used for prevention of migration of fine soil particles, whilst allowing water to seep through them.

2004.2 Gabions / Mattresses with Geo-grids and Geo-nets

The geo-grids and geo-nets used shall conform to Section 2001.

Mattresses fabricated with Geo-grids or Geo-nets shall be used for thickness of 300 mm or above as shown in the Drawings. While adopting a particular size for gabions or mattresses width of the roll of geo-grid/geo-net may be kept in view to minimize wastage of the geo-synthetic in cutting off pieces. The mesh opening may vary depending on functional requirement but shall have aperture between 35 mm and 100 mm. The mesh/net shall have characteristics as given below:

Aperture	:	Rectangular, square or oval shaped (and not in round, polygonal or diamond shape).
Colour	:	Black
Mechanical	:	Peak strength not less than 10 kN/m at maximum elongation of 15 percent

Properties	:	Not more than 5 per cent elongation at half peak load.
Strands/Fabric	:	Integral joints with junction strength of 100 per cent of plain strands as measured by GRI-GG3 standards. Material shall have ISO 9002 certification.
Life	:	At least 8 years in case of continuous exposure and 5 years for buried applications (life shall be defined as capable of retaining at least 75 per cent of its original strength after the stated life span).

2004.3 Construction Requirements

(a) **Assembly** : Boxes of gabions and mattresses shall be assembled in situ, on a level surface. After fabrication of boxes in situ they shall be correctly filled in layers in a state of dense packing.

The sides, bottom and end panels shall be erected after removal of all kinks, kept in an upright position to form rectangular boxes by joining the sides with connectors of 40 mm x 6 mm size, or by ring staples. The top corners shall be tie tensioned from sides to keep them erect for filling. For gabions of 600 mm or more height, suitable cross internal ties shall be placed in layers of 300 mm connecting opposite sides in lateral braces tied with polymer braids of ultra-violet stabilised variety so as to ensure protection against bulging of the gabions during filling with stones.

(b) **Installation**: The gabion/mattress filling shall be carried out by hand in layers so as to minimise voids and achieve specified density. The stones in contact with the surface of the geo-grids/geo-nets shall be placed in such a way that their sharp edges are kept turned inside so that they do not damage the material of the geo-grids / geo-nets. The opposite panels of the boxes shall be firmly secured with lateral ties to withstand the design forces. The bottom of the gabion mesh shall be secured in a key type excavation for preventing slide. The space between the gabion and earthen sides shall be filled with sand and the filling compacted. In most of the cases design shall be supplemented with a layer of geo-textile under the gabion/mattress to prevent migration of fines, whilst allowing any water to seep through the geo-textile.

(c) **Laying boulder apron in crates**: Mattresses of minimum height 300 mm shall be used. The typical size of a single continuous unit shall be I m x 5 m size with baffles at I m centres. The least dimension of boulders shall be at least 100 mm or double the size of the aperture whichever is larger. The density of boulder filling shall be as stated in the Drawing. Methodology of laying boulders shall be as per the following. Gabions if placed in the apron shall be of size I m x 5 m in plan with height at least 600 mm, with baffles at centres of I m.

The stone size shall also be as large as possible. In no case any fragment shall weigh less than 40 kg. The specific gravity of stones shall be as high as possible and it shall not be less than 2.65.

In order to ensure regular and orderly disposition of the full intended quantity of stone in the apron, template cross walls in dry masonry shall be built about a metre thick and to the full height of the specified thickness of the apron at intervals of 30 metres all along the length and width of the apron. The stones then shall be hand packed, within these walls.

The apron surface shall be leveled and prepared for the length and width as shown on the Drawings. In case this surface is below the low water level, the ground level may be raised 150 mm above the low water level by dumping earth and the apron laid thereon. The quantity of stone required in the apron shall be re-worked out by taking the toe of pitching as this higher level.

Mattresses or Gabions made with polymer geo-grids/geo-nets shall always be laid in situ and shall not be preformed, filled and transported to be dropped in deep waters. Where depth of water is low or dry bed is available, the boxes shall be filled in situ. In streams or water body having running boulders in the bed, the gabions/mattresses shall be armoured with placement of loose large boulders alongside the gabion wall to protect against impact of straying boulders.

Keying or stakes shall always be provided in the founding recess, where the gabion be located, especially in case the ground is assessed to be yielding or sloping type.

(d) Spurs or Groynes with crates: Spurs or groynes of gravity retaining variety shall be constructed using geo-grid/geo-net gabions placed in stable configuration one over the other to form a well. They shall be filled in situ on a shallow depth of water or dry bed with firm founding and level strata. The provision of a layer of geo-textile /geo-composite shall be made while placing the structure if resting over a bed of fine soil to prevent sinking and passage of fines.

2004.3/1 Tests and Standards of acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall be conform to these Specifications and shall meet the prescribed standards of acceptance.

2004.4 Measurements & payment

(a) Measurement: The geo-textile / geo-composite fabric shall be measured in Sq.m of plan area of actual use.

The polymer braids or connecting rods shall be measured in metres. Ring staples shall be measured by numbers provided per linear metre.

The boulder fill shall be measured in Cu.m.

The excavation for keying of gabions in the ground trenches shall be measured in Cu.m.

The backfilling in side trenches shall be deemed to be a part of the excavation work.

(b) Payment: The cost of Geo-synthetic material for fabrication of Gabions / Mattresses shall be full compensation for supply, transportation and storage.

The Contract rate per Cu.m of crate fill shall be full compensation for supply of boulders and their transportation.

The Contract rate for excavation and backfilling of trenches, seating trench up to 150 mm (included in rate), shall include full compensation for cost of labour, tools and plant for completion of the work.

The cost of making a crate shall include preparation of box of geo-grid/ geo-net, tensioning and staking arrangements, tying, internal cross braids, etc., for forming of the crates in an engineered manner and filling the crate by laying boulders. The cost shall include transportation of material from store to site.

Pay Item	Description	Pay Unit
2004(1)	Fabric of geo-textile / geo-composite (state type)	Sq. m.
2004(2)	Connecting rods and polymer braids	Linear metre
2004(3)	Ring stapler	Number
2004(4)	Boulders	Cu. m
2004(5)	Excavation for laying of gabions	Cu. m

Note

Refer Sub section 106.6 regarding sub divisions of pay items.

NEW THARANKE