



Royal Government of Bhutan
Ministry of Works and Human Settlement
Department of Roads

*Construction, Operation & Maintenance of Dalbari –
Dagapela Secondary National Highway (0.000 - 80.580 km)*

Volume II

**PARTICULAR TECHNICAL SPECIFICATIONS
FOR ROAD WORKS**

Contract Package C-1: Gesarling-Dagapela


PROJECT COORDINATOR
ORIO-RGOB PROJECT
DAGAPELA

ABBREVIATIONS

The following abbreviations are used in the Technical Specifications.

AASHTO	American Association of State Highway and Transportation Officials
ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
ALD	Average Least Dimension
ASTM	American Society of Testing and Materials
BA	Bitumen Affinity
BS	British Standards
BSCP	British Standards Code of Practice
BSR	Bhutan Schedule of Rates
CBR	California Bearing Ratio
CR	Crushing Ratio
Cum	Cubic meter
dia	diameter
DoR	Department of Roads
DES	Department of Engineering Services
FI	Flakiness Index
FSD	Forestry Services Division
hr	hour
IRC	Indian Road Congress Recommended Code of Practice
IS	Indian Standards
ISO	International Organisation for Standardization
LAA	Los Angeles Abrasion Value
LS	Linear Shrinkage
MC	Moisture Content
MDD	Maximum Dry Density
min	minute
no	Number
No	Number (order) as in No 6
OMC	Optimum Moisture Content
OPC	Ordinary Portland Cement
PI	Plasticity Index
PL	Plastic Limit
PM	Plasticity Modulus (PI x % passing 0.425 mm sieve)
SE	Sand Equivalent
sec	second
SG	Specific Gravity
SI	International Standard Units of Measurements
SSS	Sodium Sulphate Soundness test, loss on 5 cycles
STV	Standard Tar Viscosity
Sqm	Square meter
TS	Tensile Strength
UC	Uniformity Coefficient
UCS	Unconfined Compressive Strength
VIM	Voids in Mix
w/c	Water cement ratio
QA	Quality Assurance
QC	Quality Control

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100. GENERAL REQUIREMENTS

101. INTRODUCTION

These specifications cover the construction of the Works, as shown on the Drawings, in the Bill of Quantities and in the General Conditions of Contract, and shall be read in conjunction with all other contract and tender documents including the Environmental Codes of Practice. . In the event of any discrepancy or assumed discrepancy being found between them, the Contractor shall immediately inform the Project Manager of the matter in writing and the Project Manager will issue his instructions in the matter in accordance with the Conditions of Contract including the Environmental Codes of Practice for Highways and Roads of Department of Roads.

102. SCOPE OF WORKS

The work to be carried out under the Contract shall consist of the various items as generally described in the Tender Documents as well as in the Bill of Quantities furnished in the Tender Documents which includes but not limited to the following:

Earthwork

Structures including bridges

Permanent works

Base course

Black top

Bio-engineering works

Slope Protection & stabilization works

All works shall be undertaken on the basis of an item rate contract.

103. QUALITY OF MATERIALS AND WORKMANSHIP

The materials and workmanship shall be of the best of their respective kinds and shall be to the approval of the Project Coordinator or his representative on Site, the Project Manager. In reading these Specifications, the words to the approval of the Project Manager shall be deemed to be included in the description of all materials incorporated in the works, whether manufactured or natural, and in the description of all operations for the due execution of the works.

All works or parts thereof shall be in accordance with the latest edition of the Indian Standards (IS), or International Standards Organisation (ISO) Specification and the Bhutanese Environmental Codes of Practice (ECP), Highways and Roads.

104. EQUIVALENCY OF STANDARDS AND CODES

Wherever reference is made in the Contract to specific standards and codes to be met by the goods and materials to be furnished and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the Contract. Where such standards and codes are national, or relate to a particular country or region, other authoritative standards that ensure a substantially equal or higher quality than the standards and codes specified will be accepted subject to the Project Manager prior review and written consent. Differences between the standards specified and the proposed alternative standards shall be fully described in writing by the Contractor and submitted to the Project Manager at least 28 days prior to the date when the Contractor desires the Project Manager consent. In the event of the Project Manager determines that such proposed deviations do not

ensure substantially equal or higher quality, the Contractor shall comply with the standards specified in the documents.

All materials shall be of approved manufacture and origin, equal to sample and delivered to the site a sufficient period before they are required to be used in the works to enable the Contractor to take such samples as the Project Manager may require for testing or approval, and the Contractor shall provide any information required by the Project Manager as to the quality, weight, strength, constituents, description, etc. of the materials.

No materials of any description shall be used without prior approval by the Project Manager and any condemned as unfit for use in the works, shall be removed immediately from the site by, and without recommendation to, the Contractor.

Where specification for a particular item of work is not available, the relevant specification for that item from the current Specification for Building and Road Works- 2012 published by the Department of Engineering Services (DES), Ministry of Works & Human Settlement, Thimphu (Particular Technical Specifications- Part II) shall be followed. If the DES specification do not cover these items then the relevant IS codes and latest edition of IRC specifications shall be applicable. Where no reference is found in the above specifications for an item of work then sound engineering practice as decided by the Project Manager shall be applicable and the decision of the Project Manager in respect to all such matters relating to specifications shall be final and binding on the contractor.

105. CONTRACT DRAWINGS

The Contract Drawings provided for tendering purposes shall be as contained in the Tender Documents and shall be used as a reference only. The Contractor should visualize the nature and type of work contemplated and to ensure that the rates and prices quoted by him in the Bill of Quantities have due consideration of the qualitative and quantitative variations, as may be found at the site and complexities of work involved during actual execution/construction.

Examination and/or approval by the Project Manager of any drawings or other documents submitted by the Contractor shall not relieve the Contractor of his responsibilities or liabilities under the Contract.

106. TEMPORAY ROADS AND TRAFFIC

The Contractor shall provide, maintain, remove and bring back in original condition on completion all temporary roads, bridges and other work required for the construction of the works including access to quarries, borrow-pits, accommodation, etc. All temporary access facilities need to be kept trafficable (for 4WD car) during the construction and liability period in order to enable DoR to monitor the construction activities and to assess maintenance requirements during the Defects Liability Period.

The Contractor shall provide and in his rates allow for all necessary temporary traffic control signs, barricades, beacons, flagmen, lighting and watching required for the normal control of traffic.

107. SIGNBOARDS

The Contractor shall erect signboards in prominent positions adjacent to the works to the satisfaction of the Project Manager.

108. OFFICE OF THE CONTRACTOR

The Contractor shall erect an office near the works at the site to be approved by the Project Manager. The office shall be kept open all hours during which the work is in progress. The standard of the contractor's Office shall be at least as described in the Project Office/accommodation below, the space and the size shall depend upon the contractor's requirement.

Any notice to be given to or served upon the Contractor shall be deemed and taken to be effectually given or served upon by the delivery thereof at such office.

109. OFFICE OF THE PROJECT MANAGEMENT UNIT AND SUPERVISING CONSULTANTS

The Project Management Unit (PMU) of the Department of Roads, headed by the Project Manager, will be established at Gesarling. In addition to the PMU office at Gesarling, there will be one Project Coordination Office (PCO) at Dagapela established, furnished and maintained by the Employer. The PMU for Section-B1 and B2 will operate from the PMU office at Gesarling while the PMU for Section C1 and C2 will operate from the PCO at Dagapela.

110. FIELD LABORATORY

There will be two Field Laboratories – one at Gesarling and another at Dagapela. These two field laboratories will be constructed, furnished and maintained by the Employer. The contractors of Section B1 and B2 shall use the Gesarling Field Laboratory while the contractors of Section C1 and C2 shall use the Dagapela Field Laboratory for testing of materials and workmanship to be incorporated in the work.

The material testing equipments for the Gesarling Field Laboratory shall be procured and supplied by the contractor of Section B2 and the same shall be used by the contractors of both Section B1 and B2. Similarly, the material testing equipments for the Dagapela Field Laboratory shall be procured and supplied by the contractor of Section C2 and the same shall be used by the contractors of both Section C1 and C2. The list of material testing equipment to be procured and supplied is given below.

Schedule of material testing equipment for Field Laboratory

Item Description	Quantity
1. Grain Size Analysis (coarse sieves)	
a) 450 mm dia G.I. Sieves for coarse aggregates	
150mm	2 No.
100 mm	2 No.
75.0 mm	2 No.
63.0 mm	2 No.
50.0 mm	2 No.
40.0 mm	2 No.
37.5 mm	2 No.
28.0 mm	2 No.
25.0 mm	2 No.
20.0 mm	2 No.
19.0 mm	2 No.

16.0 mm	2 No.
14.0 mm	2 No.
13.2 mm	2 No.
12.5 mm	2 No.
10.0 mm	2 No.
9.5 mm	2 No.
6.30 mm	2 No.
5.00 mm	2 No.
4.75 mm	2 No.
b) G.I. Pan (450 mm dia)	2 No.
c) G.I. Cover (450 mm dia)	2 No.
d) Wire Sieve Brushes	4 No.
2. Grain Size Analysis (fine aggregate)	
a) 200 mm dia Span Brass Wire Sieve for file aggregate	
4.75 mm	2 no.
2.36 mm	2 no.
2.00 mm	2 no.
1.18 mm	2 no.
1.00 mm	2 no.
0.60 mm	2 no.
0.425 mm	2 no.
0.300 mm	2 no.
0.212 mm	2 no.
0.150 mm	2 no.
0.075 mm	2 no.
b) Brass Pan (200 mm dia)	2 no.
c) Brass Cover (200 mm dia)	2 no.
d) Wire Sieve Brushes	4 Nos.
e) Sieve Shaker motorised, 220 V, 50 Hz, single phase supply	2 sets
3. Specific Gravity and Bulk Density	
Pycnometer preferred with capillary opening 50 ml	6 nos.
Pycnometer preferred with capillary opening 250 ml	6 nos.
Pycnometer preferred with capillary opening 1000 ml	6 nos.
Wire Basket (4 mm mesh size)	2 nos.
Bucket for Immersing Aggregate	2 no.
Bulk Density Measures (20 ltr., 10 ltr)	2 sets each
Tamping Rod (16 mm dia.)	2 nos.
4. Liquid Limit Device with Counter Number	
Grooving tool and Gauge	2 Nos.
Removing Counter Kit	2 Nos.

Spatula (Flexible with round tip, 80 mm long and 20 mm wide blade)	2 Nos.
Sample Container (steel) with cover	2 Nos.
Glass plate (Absorbent type) [300 mm x 450 mm]	2 Nos.
Plastic Limit Rod Compactor	2 Nos.
Porcelain Dish, 120 mm dia.	2 Nos.
<u>5. Proctor Compaction Apparatus</u>	
- Compaction moulds 150 mm dia.	2 Nos.
- Compaction moulds 100 mm dia.	2 Nos.
- 4.5 kg. Rammer	2 Nos.
- 2.5 kg. Rammer	2 Nos.
- Gauging Trowel	2 Nos.
- Straight edge (steel)	2 Nos.
- Vernier Calliper, 0-200 mm x 0.05 mm (equivalent to Mitutoyo)	2 Nos.
- Sample trays (600 mm x 600 mm x 75 mm)	6 no.
- Sample trays (450 mm x 270 mm x 45 mm)	6 no
- Sample trays (270 mm x 210 mm x 4500 mm)	6no
- Sample tray (220 mm x 175 mm x 45 mm)	6no
- Sample extruder (Hydraulic)	2 Nos.
- Rubber Gloves as required	12 Nos.
<u>6. California Bearing Ratio (CBR) Apparatus</u>	
- CBR Moulds	6 Nos.
- Spacer Disc	6 Nos.
- Swell Plate	6 Nos.
- Tripod Attachment	6 Nos.
- Dial Indicator	6 Nos.
- Surcharge Weight	12 Nos.
- Filter Paper, Boxes	4 Nos.
- Filter Screen	4 Nos.
- CBR test mould soaking tank	2 Nos.
- Mechanical Loading Press	2 Nos.
<u>7. Field Density Test (Sand Cone Method)</u>	
- Sand Pouring Cylinder 150 mm dia.	4 Nos.
- Sand Pouring Cylinder 200 mm dia.	4 Nos.
- Calibrating Container 150 mm dia.	2 Nos.
- Calibrating Container 200 mm dia.	2 Nos.
- Metal Trays (400 mm x 400 mm x 50 mm) with central hole	2 Nos.
- Density Spoon (medium)	2 Nos.
- Metal dibber tools	2 Nos.
- Scoops	2 Nos.
- Brush (different sizes)	2 sets.

- Chisel	2 Nos.
- 1 kg Hammer	2 Nos.
- Trowels	2 Nos.
- 1 kg Rubber Mallets	2 Nos.
- Covered Containers (moisture sampling)	12 Nos.
- Standard Density Sand 850 /600	500 kg
<u>8. Concrete Test and Slump Cone Apparatus</u>	
- Cube Moulds (150 mm)	24 Nos.
- Slump cone apparatus	2 Nos.
- Tamping rod (16 mm dia)	2 Nos.
- Steel ruler (calibrated, 1 metre length)	2 Nos.
<u>9. Compression Testing Machine</u>	
- Compression Testing machine set (electric and hand driven), 100 t	1 set
<u>10. Flakiness Index</u>	
- Flakiness Sieves 10 mm - 5.0 mm	2 Nos.
- Flakiness Sieves 14 mm - 10 mm	2 Nos.
- Flakiness Sieves 20 mm - 14 mm	2 Nos.
- Flakiness Sieves 28 mm - 20 mm	2 Nos.
- Flakiness Sieves 37.5 mm - 28 mm	2 Nos.
- Flakiness Sieves 50 mm - 37.5 mm	2 Nos.
<u>11. Specific Gravity and Water Absorption Test</u>	
- Gas Jar (75 mm dia x 300 mm high with glass cover)	2 Sets
- Tamping Rod	2 Nos.
<u>12. Bulk Density of Aggregates</u>	
- Bulk density measure, 10 dm ³	2 Nos.
- Bulk density measure, 7 dm ³	2 Nos.
- Tamping Rod	2 Nos.
- Straight edge	2 Nos.
- Balance 10 kg capacity	2 Nos.
<u>13. Balances: (as specified)</u>	
a) Digital Pan balance, 300 - 500 g, 0.1 accuracy	2 Nos.
b) Digital or Triple Beam Balance with carrying case, 10 kg, 0.1 g accuracy (equivalent to OHAUS)	2 Nos.
c) Heavy Duty Solution Balance, 20 kg, 1 g accuracy (equivalent to OHAUS)	2 Nos.
<u>14. Glassware: (as specified)</u>	
a) Flat bottom flasks 500 ml	8 Nos.

b) Volumetric Flask, 500 ml	8 Nos.
c) Graduated glass beakers (100 ml - 1000 ml)	12 Nos.
d) Measuring cylinder (100 ml - 1000 ml)	8 Nos.
e) Glass rod dia 10 mm x 400 mm long	8 Nos.
f) Reagent bottles (500 ml - 1000 ml)	12 Nos.
g) Spare corks for bottles	12 Nos.
15. Miscellaneous Equipment: (as specified)	
- Air circulated laboratory oven, 220 V, 50 Hz, single phase, 250 dm ³	2 Nos.
- Hydrometer set (consisting of 1 hydrometer and 6 hydrometer jars, 1000 ml)	2 Sets.
- Speedy moisture tester	2 Nos.
- Pocket type thermometer, 0-250°C	2 Nos.
- Metal thermometer, 0-25°C	2 Nos.
- Armoured Thermometer, 0-100°C x 1°C	2 Nos.
- Stopwatch	2 Nos.
- Sample splitter, 25 mm, 19 mm, 12 mm size or as specified	2 Nos. Each
- 10 litre buckets, stainless steel or equivalent	4 Nos.
- 10 litre jerry cans	4 Nos.
- Spades	4 Nos.
- Hammer 1KG, 5KG	2 Nos. Each
- Calcium carbide reagent for speedy moisture testing	6 packets
- Dynamic cone penetrometer (DCP) apparatus with 60 deg cone	2 Nos.
- 60 deg cone for DCP tests	6 Nos.

Upon completion of the project the above material testing equipment procured and used in the field laboratory shall be handed over to the Employer to the full satisfaction of the Project Manager.

Each individual contractor shall provide, operate and maintain all necessary services and consumables to the field laboratory including computer, printer, copier, registers, files, stationeries, conduct of quality control tests on works and materials to be incorporated in the works, preparation and submission of test reports and other submittals, etc. as required. Each individual contractor shall also deploy a Lab Technician and a Lab Boy to the field laboratory on fulltime basis throughout the contract duration. The Lab Technician should have minimum class 10 level education with minimum 3 years of experience in laboratory testing. The contractor shall also arrange for additional technicians and lab boys if such additional resources are deemed necessary and or as directed by the Project Manager.

The contractor shall also provide the services of his technicians to the project management and Supervision Consultant promptly as and when required. The services of the Lab technicians provided by the contractor shall be used to collect material samples, dispatch material sample to the central laboratory, assist supervision consultant conduct additional field and laboratory tests.

Measurement and Payment

The payment shall be made at the contract unit rates as per the priced BoQ which shall be the full and the final payment to the Contractor. For the items of works which are not specifically provided in the BoQ but which are necessary for complying with the provisions of the Contract, for instance, deployment of a Lab Technician and a Lab Boy on fulltime basis, the payment shall be deemed included in other related work items in accordance with the Section 118, sub-section (xi) of this Technical Specification.

111. ENVIRONMENTAL MANAGEMENT PLAN

The Contractor's bid shall contain an Environmental Management Plan, where the Contractor explains how the site shall be organized, how he shall proceed with the works, and how the activities shall be executed to comply fully with the rules explained in the Bhutanese Environmental Codes of Practice. An example format of the Environmental Management Plan is provided in EA report.

112. MAINTENANCE OF NEW CONSTRUCTION ROADS

The Contractor shall be responsible for undertaking all routine maintenance of the completed works of new road construction including bridges and structures during the Defect Liability Period (DLP) and till the end of the maintenance period as specified in the Contract Agreement.

The Contractor shall also maintain roads that the Contractor uses for construction or access and the use of such roads shall be identified in advance to the Project Manager for inspection prior to use.

The routine maintenance of the road shall include besides other protection of plants and vegetation; cleaning of culverts, road side drainage (including reshaping/restoring in case of unlined drains) and drainage channels; and clearing any other obstructions including minor landslide (up to 20 m³ at one spot, with unlimited number of spots) and maintaining all completed road features to allow free flow of traffic. The material removed from the cleaning and clearing as above shall be disposed off at safe places as directed by the Project Manager.

The Contractor shall carry out reinstatement of works (pavement, pavement surface, shoulder or any other works) washed out or damaged due to poor routine maintenance of drains, drainage channels, culverts, shoulders; lacking clearance of obstructions such as landslides etc other than those occurred due to earthquake.

The routine maintenance of newly constructed bridges shall include, cleaning including removal of obstructions of bridge decks and bridge deck of drainage elements, cleaning and checking of expansion joints and bearings, cleaning bearing shelves and weep holes, removing accumulated debris and vegetation around and between piers and abutments, repairing parapets, and protection of adjoining works.

The Contractor shall perform the maintenance works as often as required to keep the carriageway, pavement, shoulders, and adjoining structures in proper working order to the satisfaction of the Project Manager. The Contractor shall mobilize labour, equipment and materials to carry out the routine maintenance of the road. The location and scope of the maintenance work shall be as directed by the Project Manager.

Should at any time the Project Manager gives any instruction for the up keep of a section of the road/site and the Contractor does not respond in 48 hours, the Project Manager shall be empowered to instruct others to carry out the works. Any costs involved by this action shall be deducted from any money due to the Contractor.

The department shall carryout reinstatement of works washed out or damaged due to act of god such as earthquake, or land slide due to heavy rainfall. All damages resulting from poor quality of works, materials or workmanship shall be the responsibility of the contractor under defect liability period.

113. NOTES ABOUT MEASUREMENT AND PAYMENT

(1) General Rules for the measurement of Works and Payment

General

All measurements shall be made in the metric system. Different items of work shall be measured in accordance with the procedures set forth in the relevant sections read in conjunction with the General Conditions of Contract.

All measurements and computations, unless otherwise indicated, shall be carried nearest to the following limits.

i	length and breadth	10 mm
ii	height, depth or thickness of earthwork, sub-grade, bases, surfacing and structural members	5 mm
iii	Areas	0.01 sq.m
iv	cubic contents	0.01 cu.m

In recording dimensions of work, the sequence of length, width and height or depth or thickness shall be followed.

114. MEASUREMENT OF LEAD FOR MATERIALS

Where lead is specified in the Contract for construction materials, the same shall be measured as described hereunder:

Lead shall be measured over the shortest practicable route and not the one actually taken and the decision of the Project Manager in this regard shall be taken as final. Lead up to 50 m shall be deemed to be included into the respective items of works, hence shall not be paid separately. Measurements shall be carried out in sections in blocks of 50 to 500 m, 501 to 1000 m and beyond 1000.

Measurements for transport of spoil materials: -The transport of spoil materials shall be done as directed by the Project Manager. The transport of materials includes loading, unloading, levelling and re-vegetation. Length, breadth and height of stacks shall be measured correct to 10 mm. The quantity shall be worked out in cubic metres correct to two places of decimal. The quantity shall be reduced by percentages as shown against each for looseness (voids/bulking) to arrive at the net quantity for payment:

1. Earth

- i) In loose stacks such as cart loads, lorry loads etc 20%
- ii) In Consolidated fills 10%
- iii) In fills consolidated by heavy mechanical machinery but not under O.M.C (optimum moisture content) 5%
- iv) In fills consolidated by heavy mechanical machinery at O.M.C NIL
- v) Consolidated fills in confined situation such as under floors NIL

2. Manure 8%

3. Sand NIL
4. Stone metal 40mm gauge and above 7.5%
5. Course aggregate/stone metal below 40mm gauge NIL
6. Soling stone/boulder 100mm and above 15%
7. Excavated rocks 50%

Note: - No deduction shall be made in respect of articles or materials for which mode of payment is by length, weight or number.

115. MEASUREMENT OF PAVEMENT THICKNESS FOR PAYMENT ON VOLUME BASIS

The finished thickness of sub-base, base and bituminous courses to be paid on volume basis shall be computed in the following manner:

Levels shall be taken before and after construction, at grid of points 10 m centre to centre longitudinally in straight reaches but 5 m at curves. The levels shall be taken at positions transversely, as specified by the Project Manager.

Suitable references for the transverse grid lines should be left in the form of embedded monument on either ends or by other means so that it is possible to locate the grid points for level measurements after each successive course is laid.

For pavement courses laid only over widening portions, at least one line of levels shall be taken on each strip of widening, or more depending on the width or widening as decided by the Project Manager.

Notwithstanding the above, the measurements may be taken at closer intervals also, if so desired by the Project Manager, the need for which may arise particularly in the case of estimation of the volume of the material for profile corrective course (levelling course). The average thickness of the pavement course in any area shall be the arithmetic mean of the difference of levels before and after construction at all the grid points falling in the area, provided that the thickness of finished work shall be limited to those shown on the Drawings or approved by the Project Manager in writing.

As supplement to level measurements, the Project Manager shall have the option to take cores/make holes to check the depth of pavement construction. The holes made and the portions cut for taking cores shall be made good by the Contractor by laying fresh mix/material including compacting as required at no extra cost immediately after the measurements are recorded.

116. CHECKING OF PAVEMENT THICKNESS FOR PAYMENT ON AREA BASIS

Where payment for any bituminous course is allowed to be made on area basis, the Project Manager may have its thickness checked with the help of a suitable penetration gauge at regular intervals or other means as he may decide.

117. MEASUREMENT OF BITUMINIOUS COURSES FOR PAYMENT ON WEIGHT BASIS

Plant-mixed bituminous materials for pavement courses where designated to be paid on weight basis shall be weighed on accurate scales approved by the Project Manager. Approved scales shall mean scales that are of size, capacity, kind and type suitable for the weighing to be done, and these shall be properly and adequately

installed and maintained. Prior to the use of the scales and as frequently thereafter as the Project Manager may deem necessary to ensure accuracy, the scales shall be checked and approved by the Project Manager, or the Project Manager may direct the Contractor to have the scales checked by other competent agency at the cost of the contractor.

Location of the scales shall be as designated by the Project Manager. Trucks used for hauling the material to be weighed shall be weighed empty daily at such times as the Project Manager directs, and each truck shall bear a plainly legible identification mark.

For materials specified to be measured by weight, the Project Manager will have the option to make measurements of the finished work by which in accordance with Sub-clause 114 of the Technical Specifications and such volumes shall be converted into weight for payment purposes. The factor for conversion from volume measurement to weight measurement shall be computed from the representative density of the compacted material at site determined at locations approved by the Project Manager.

118. SCOPE OF RATES FOR DIFFERENT ITEMS OF WORK

For item rate contracts, the contract unit rates for different items of works shall be payment in full for completing the work to the requirements of the Specifications including full compensation for all the operations detailed in the relevant sections for these specifications under "Rates". In the absence of any directions to the contrary, the rates are to be considered as the full inclusive rate for finished works covering all labour, materials, wastage, transportation, temporary work, plant, equipment, overhead charges and profit as well as the general liabilities, obligations, insurance and risks arising out of General Conditions of Contract.

The item rates quoted by the contractor shall, unless otherwise specified, also include compliance with/supply of the following:

- (i) General works such as survey and setting out, clearance of site before setting out and clearance of works after completion;
- (ii) A detailed Program for the construction and completion of the works (using CPM/PERT techniques) giving, in addition to construction activities, detailed network activities for the submission and approval of materials, procurement of critical materials and equipment, fabrication of special products/equipment and their installation and testing, and for all activities of the Employer that are likely to affect the progress of work, etc., including updating of all such activities on the basis of the decisions taken at the periodic site review meetings or as directed by the Project Manager as per Clause 102 of the Technical Specifications.
- (iii) Samples of various materials proposed to be used on the Work for conducting tests thereon as required as per the provisions of the Contract;
- (iv) Design of mixes as per the relevant Clauses of the Specifications giving proportions of ingredients, sources of aggregates and binder along with accompanying trial mixes as per the relevant clauses of the Technical Specifications to be submitted to the Project Manager for his approval before use on the Works.
- (v) Detailed design calculation and drawings for all Temporary Works (such as formwork, staging, centring; specialised constructional handling and launching equipment and the like);
- (vi) Detailed drawings for templates, support and end anchorage, bar bending and cutting schedules for reinforcement, material lists for fabrication of structural steel, etc.

- (vii) Mill test reports for all mild and high tensile steel and cast steel as per the relevant provisions for the Specifications;
- (viii) Testing of various finished items and materials including bitumen, cement, concrete, bearings as required under these Specifications and furnishing test reports/certificates;
- (ix) Inspection Reports in respect of form work, staging, reinforcement, and other items of work as per the relevant Specifications;
- (x) Any other data which may be required as per these Specifications or the conditions of Contract or any other annexes/schedules forming part of the contract;
- (xi) Any other items of works which is not specifically provided in the Bill of Quantities but which is necessary for complying with the provisions of the Contract;
- (xii) All temporary works as per (v) above;
- (xiii) Cost of in-built provisions for Quality Assurance;
- (xiv) Cost of safeguarding/protection of the environment;
- (xv) Cost of monthly progress reports, construction and as-built drawings and other submittals;
- (xvi) Cost of accommodation of traffic;
- (xvii) Cost of all taxes, duties and royalties;
- (xviii) Cost of site commissioning
- (xix) Cost of all operations like storing, erection, moving into final position, etc. necessary to complete and protect the work till handing over to the Employer; and
- (xx) All incidental costs including maintenance of services as described under Section 119.

Portions of road works beyond the limits of the contract and/or any other work might be constructed by the Employer through other contractors. Accordingly, other contractors employed by the Employer may be working in the vicinity of the Works being executed by the Contractor. The Contractor shall liaise with such contractors and carry out activities for the completion of work accordingly and no claim or compensation due to any reason whatsoever will be entertained on this account. The Employer will be indemnified by the Contractor for any claims from other agencies on this account. The requirements of Clause 8, Additional Clauses in Particular Conditions of Contract shall also apply in this regard.

119. MAINTENANCE OF SERVICES

- (1) If any government, publicly and privately owned service for drinking water, electricity, drainage, irrigation channels, sewers, telecommunication cables/lines and other services and structures, passing through the site is affected by the works, the Contractor shall provide a satisfactory alternative service in full working order to the satisfaction of the owner of the services and of the Project Manager before terminating the existing service.
- (2) Drawings and scheduling the affected services like water pipes, sewers, cables, etc. owned by various authorities including government and public undertakings and local authorities shall be verified by the Contractor for the accuracy of the information prior to the commencement of any work.

- (3) The Contractor must also allow for any effect of these services and alternations upon the works and for arranging regular meetings with the various bodies at the commencement of the contract and throughout the period of the works in order to maintain the required co-ordination.
- (4) No clearance or alterations to the utility shall be carried out unless ordered by the Project Manager.
- (5) Any services affected by the works shall be restored immediately by the Contractor who must also take all measures reasonably required by the various bodies to protect their services and property during the progress of the works.
- (6) The Contractor may be required to carry out the permanent removal or shifting or diversion of certain services/utilities on specific orders from the Project Manager for which payment shall be made to him. Such works shall be taken up by the Contractor only after obtaining clearance from the Project Manager and ensuring adequate safety measures.

Measurement and Payment

No separate measurement and payment shall be made for the work of temporarily supporting; maintaining and protecting the government, publicly and privately owned services. All costs in connection with the work specified herein shall be considered to be included with other related items of the work in the Bill of Quantities.

120. ENVIRONMENTAL PROTECTION WORKS

The environment has been defined to mean surrounding area including human and natural resources to be affected by execution and after completion of works.

The Contractor shall take all precautions for safeguarding the environment during the execution of the contract. He shall abide by all prevailing laws, rules and regulations governing environmental protection. In particular, the Contractor shall fully comply with the Environmental Codes of Practice for Highways and Roads. The Contractor shall follow the requirements specified in the Environmental Management Plan for the environmental protection and management of the works carried under the contract. The Contractor shall be responsible to implementation of Environmental Management Plan (EMP) and compliance to it. As part to this the Contractor shall follow the guidelines and submit the required information on monthly basis for monitoring of the EMP implementation by the Project Manager. The Contractor at all-time shall ensure that requirements of EMP are fulfilled.

The Contractor shall prohibit employees from unauthorized use of explosives, poaching wildlife, fishing and cutting trees. Where possible the workers must be provided with kerosene for cooking. Where it is not possible to get kerosene firewood must be provided by purchasing it through the local firewood contractor. Where there is no local firewood contractor, proper forestry permits must be obtained for collection of firewood. The Contractor shall be responsible for the action of his employees.

Environmental protection works, among others, shall also include the following:

(1) Provision and Maintenance of Camps, Offices, Stores, Equipment Yards and Workshops

Various works defined under this item are related to provision and maintenance of camps for workmen and employees, Contractor's site offices, temporary accommodation to the supervision Project Manager, stores, equipment yards and workshops. These camps must be adequate, rain-proof, spacious, airy and hygienic with proper lighting and materials storage facilities. The area shall be kept neat and clean. Space allocated for storage of materials such as cement, gabion wire, reinforcing wire etc. shall in general be damp-free, rain-proof and away from petroleum products storage. Permission may be granted by the Project Manager to erect

temporary suitable camps within the right of way free of charge, if such establishments do not cause obstructions to traffic, nuisance to works execution and adverse effect to the environment. Camps must be located in stable areas where there are no possibilities of landslides or erosion. To prevent disturbance to nearby communities the labor camps must be located at least 500 m away from the nearest settlement.

Written information must be given to and approval be taken from the Project Manager regarding proper establishment and maintenance of such camps. Failure in compliance with Project Manager's instruction in respect of overall standard will lead to reduction or with holding of any payment to the Contractor.

The Contractor shall ensure that proper drinking water, waste disposal and toilet facilities are provided to the camps. This arrangement shall be enforced to avoid proliferation and generation of various water borne diseases. The Contractor shall inform the Project Manager regarding sources, installation and operation of supply of potable water within a week after the supply is commenced.

Provision of toilets for labour and employees and supervision team shall be made to avoid public nuisance as well as pollution of water courses and air. Toilets shall not be located near streams or rivers. The Contractor shall construct suitable septic tanks and/or soak pits along with room of pit-type latrines. Sufficient water must be provided and maintained in the toilets. Proper methods of sanitation and hygiene should be employed during the whole project duration. The contractor shall provide waste disposal facilities such as dustbins and waste disposal pits.

A first aid kit along with proper medical supplies must be available in the camps for treating injuries or common health problems. Services shall also include on-the-way service and other arrangements required for taking them to the nearest hospital in case of emergency. If imported laborers are required for construction, proper medical tests of the laborers shall be carried out to prevent the spread of diseases such as STD and HIV/AIDS amongst the communities near the construction sites. The scope of work shall include service of at least one part-time experienced health worker/health assistant with a minimum of once a week full time site visit as work assignment. The Contractor shall also supply and provide adequate medicines and facilities required for standard first aid. The Contractor shall inform the Project Manager regarding the medical facility within a week after its establishment and operation.

All workers shall be provided with adequate safety wear such as, water boot, gloves, face masks, ear plugs, helmets, safety jackets and safety belts to prevent injuries and health hazards.

During shifting of the camp all trash and unwanted material must be burnt or disposed off properly. Pit latrines must be adequately covered. Areas without any vegetation must be re-vegetated carrying out appropriate bioengineering works.

The Project Manager shall have the power to order basic facilities put in place through days work or local laborers and or procure such basic facilities to maintain adequate safety and hygiene for the contractors workers/employees and deduct the same from the contractor's running bill in the event the contractor does not comply the requirement as per environmental code of practice and or as per labour laws of the kingdom.

(2) Site Clearance and Removal of Top Soil

Loss of trees and vegetative cover is a permanent impact that cannot be avoided. However, the Contractor shall take all measures to minimize removal of vegetation and remove only what is necessary. During clearing activities the Contractor shall make efforts to not to disturb or destroy the vegetation surrounding the road alignment. Proper clearing and grubbing procedures shall be followed in accordance with the Technical Specifications. The contractor shall store top soil of the cleared area and reused for carrying out bioengineering activities, as appropriate.

(3) Borrow/Quarry Sites

The contractor shall use approved borrow/quarry sites in the construction works. The Contractor shall abide by the rules and regulations of the governing bodies while operating, using river side and rock quarries for the construction materials. All new rock quarry sites must be located in stable areas that are away from rivers, streams, settlements, drinking water intakes, cultivable lands and drainage systems.

The Contractor shall obtain the prior approval of the concerning authorities and permission of the Project Manager before opening any borrow pits or quarries. Such borrow pits and quarries may be prohibited or restricted in dimensions and depth by the Project Manager where they might:

- (i) affect the stability or safety of the works or adjacent property;
- (ii) interfere with natural or artificial drainage or irrigation;
- (iii) be environmentally unsuitable.

The Contractor shall not purchase or receive any borrow materials from private individuals unless the source of such materials has been approved by the Project Manager.

After completion of quarry operations the contractor shall restore the site properly. Where necessary the quarry site shall be restored immediately after completion of construction works. Restoration will include spreading of top soil and carrying out bioengineering works as per the instruction of the Project Manager.

The Project Manager shall have the power to disallow the method of construction and/or the use of any borrow/quarry area, if in his opinion, the stability and safety of the works or any adjacent structure is endangered, or there is undue interference with the natural or artificial drainage, or the method or use of the area will promote undue erosion.

All areas susceptible to erosion shall be protected as soon as possible either by temporary or permanent drainage works. All necessary measures shall be taken to prevent concentration of surface water and to avoid erosion and scouring of slopes and other areas. Any newly formed channels shall be backfilled.

The cutting of trees shall be avoided or if necessary shall be carried out only after getting approval of Forestry authority. Temporary ditches and/or settling basins shall be dug to prevent erosion. The undesirable ponding of water shall be prevented through temporary drains discharging to natural drainage channels.

Earthworks operations shall be strictly limited to the areas to be occupied by the permanent works and approved borrow areas and quarried unless otherwise permitted by the Project Manager. Due provision shall be made for temporary drainage. Erosion and/or instability and/or sediment deposition arising from earthwork operations not in accordance with the Technical Specifications shall be made good immediately by the Contractor.

At least 14 days before the Contractor intends to commence opening up any approved borrow pit or quarry, the Contractor shall submit to the Project Manager the intended method of working and restoration. These shall include but not be limited to:

- (i) the location, design and method of construction of any access track;
- (ii) the volume and nature of materials to be removed;
- (iii) the sequence and method of excavation of materials;
- (iv) measures for controlling runoff and sediment from the site during operations;
- (v) proposals for site restoration including approximate finished levels, drainage, erosion and sediment control, slope stabilization and revegetation, including reinstatement of any access track.

Operation of borrow pit or borrow area shall not be permitted until the method of working for that particular pit or area has been approved by the Project Manager in writing. Restoration shall be to the satisfaction of the Project Manager.

(4) Disposal of Spoil and Construction Waste

Materials in excess of the requirements for permanent works and unsuitable materials shall be disposed off in locations and in the manner as agreed with the Project Manager. The locations of disposal sites shall be such as not to promote instability, destruction of properties and public service systems. Exposed areas of such disposal sites shall be suitably dressed and be planted with suitable vegetation. The top soil of the tipping sites must be stored and reused for restoring the tipping site and carrying out bioengineering works. Provisions shall be made to facilitate proper drainage around the site. Tipping sites shall be restored as per the drawing.

(5) Crushing Plants

Crushing plants shall be located away from communities and water sources. Suitable dust control device shall be fitted to the crusher to control emission of dust from the plant. The plants shall be operated only during the day time to minimize disturbance to nearby communities and wildlife. Water shall be sprinkled on the crushing plant and surrounding areas to minimize dust. At the same time appropriate drainage measures shall be constructed to drain out excess water from the site in order to keep the area dry.

(6) Hot Mix Plants and Batching Plants

Hot-mix plants and batching plants shall be located away from the population centers. The Contractor shall take every precaution to reduce levels of noise, vibration, dust and emission from his plants. No bituminous material shall be discharged into drains. Nearby trees, vegetation and property shall be protected during spraying of bitumen.

(7) Use of Bitumen including Heating and Storage of Bitumen

Heating of the bitumen will be necessary for use in pavement works. The bitumen will be heated using firewood or kerosene. Where it is necessary to heat the bitumen using firewood, the Contractor shall obtain firewood through local firewood contractor. In locations where there is no local firewood contractor the Contractor shall obtain forestry permits from the local territorial Forestry authorities for collecting firewood from the forests nearby. During application of bitumen improper storage of the bitumen barrels and bleeding of the bitumen shall be avoided to prevent scarring and loss of aesthetic beauty of the landscape.

(8) Hazardous Materials

The Contractor shall not store hazardous materials near water surfaces. The Contractor shall provide protective clothing or appliances when it is necessary to use some hazardous substances. High concentration of airborne dust resulting in deposition and damage to crops and water resources shall be avoided. The Contractor shall take every precaution to control excessive noise resulting in disruption to wildlife and human population. Only controlled explosives methods shall be applied and used in construction works as per the Technical Specifications.

(9) Operation of Vehicles, Machinery and Equipment

The contractor shall regularly maintain all vehicles, machinery and equipment in order to minimize exhaust pollution. Oil and lubricants must be stored properly to prevent any spills and leakage and pollution of the surrounding soil as well as water bodies.

(10) Reinstatement of Environment

The Contractor shall arrange and execute works as well as related activities in such a way that environmental conditions are reinstated. The Contractor shall be required to carry out filling, removal and disposal works along with plantation of grass and trees as directed by the Project Manager at his own costs at identified locations to reinstate environment.

Written instruction/approval shall be given by/sought from the Project Manager regarding reinstatement of environment both during and after completion of works and up to the end of Defects Liability Period.

Measurement and Payment

No separate measurement and payment shall be made for the works described in this Clause. All costs in connection with the work specified herein shall be considered included in the related items of the work specified in the Bill of Quantities.

121. SITE INFORMATION

The information about the site of work and site conditions in the Bidding Documents is given in good faith for guidance only but the Contractor shall satisfy himself regarding all aspects of site conditions.

The location of the works and the general site particulars are as generally shown on the Site plan/index plan enclosed with the Bidding Documents.

Whereas the Right-of-Way to the bridge sites/road works shall be provided to the Contractor by the Employer, the Contractor shall have to make his own arrangement for the land required by him for site offices, labour camps, stores, etc.

It is assumed that the Contractor has inspected any quarries; borrow areas etc., before quoting his rates for the work to assess the availability of construction materials in required quantity and quality.

200. CONSTRUCTION MATERIALS AND TESTING

201. SCOPE

This section covers the general requirements relating to materials, the specific requirements for basic materials, the tests and methods of testing which are required for the selection and quality control of materials.

202. QUALITY OF MATERIALS

The materials supplied and used in the works shall comply with the requirements of the Technical Specifications. They shall be new, except as provided elsewhere in the contract or permitted by the Project Manager in writing. The materials shall be manufactured, handled and used skilfully to ensure completed works to comply with the contract.

203. SOURCES OF MATERIALS

The use of any one type of material from more than one source is prohibited, except by written permission of the Project Manager. Such permission, if granted, shall set forth the conditions under which the change may

be made. The sources or kinds of material shall not be changed without written permission of the Project Manager. If the product of any source proves unacceptable, the Contractor shall make necessary arrangements for the supply of acceptable material. Any claims for compensation associated with such arrangements or changes shall not be considered, unless the source of the unacceptable material is designated in the contract as a source of material.

In the case of borrow pits, gravel, sand, binder, soil deposits and rock quarries, the "source of material designated in the contract" shall be construed to mean:

- (1) any restricted area (within the pit or quarry) which is designated as the source of material; or
- (2) the entire area of the pit or quarry, if no such restricted area is designated.

Movements of equipment within the "source" as above defined shall not be considered as a "change of source."

Selection and exploitation of material sources as well as use of the materials shall follow the DOR, 'Environmental Codes of Practice Highways and Roads' and 'Blasting Manual and comply with other pertinent environmental specifications including those detailed in Section 100 and other Sections. Prior approval of the material sources shall be required from concerning authorities as per the prevailing rules and regulations of Royal Government of Bhutan.

204. INSPECTION AND ACCEPTANCE OF MATERIALS

Final inspection and acceptance of materials shall be made only at the site of the work. The Project Manager reserves the right to sample, inspect, and test the materials throughout the duration of the Works and to reject any materials which are found to be unsatisfactory. The Contractor/Engineers representative shall strictly follow the system of joint sampling and testing for material/ works as per format provided under section 2200.

A preliminary inspection of materials may be made at the source for the convenience and accommodation of the Contractor, but the presence of a representative of the Project Manager shall not relieve the Contractor of the responsibility of furnishing materials complying with their Specifications.

The representative of the Project Manager shall have free entry at all times to those parts of any plant which concern production of the materials ordered. The contractor shall strictly follow System of Request for Inspection (RFI) as per format provided under section 2200.

205. MATERIALS AND MANUFACTURED ARTICLES

(1) Order for Materials and Manufactured Articles

The Contractor shall, before placing any order for materials and manufactured articles for incorporation in the Works, submit to the Project Manager the names of the firms from whom he proposes to obtain such materials and manufactured articles, giving for each firm a description of the materials and manufactured articles to be supplied, their origin, the manufacturer's specification, quality, weight, strength and other relevant details. The Contractor shall submit the samples of such materials and manufactured articles when requested by the Project Manager and when appropriate, manufacturer's certificates of recent test carried out on similar materials and manufactured articles shall also be submitted.

(2) Storage

All materials and manufactured articles shall be stored on site in a manner acceptable to the Project Manager. The Contractor shall carefully protect all work, materials and manufactured articles from the weather and vermin.

(3) Test Certificates

When instructed by the Project Manager, the Contractor shall submit to him all Test Certificates from the suppliers/manufacturers of the materials and/or manufactured articles to be used for the contract. Such certificates shall certify that the materials and/or manufactured articles concerned have been tested in accordance with the requirements of these Specifications. All Test results shall be enclosed along with such certificates. The Contractor shall provide adequate means of identifying the materials and/or manufactured articles delivered on the site with the corresponding certificates.

206. DEFECTIVE MATERIALS

All materials not conforming to the requirements of the contract shall be rejected whether in place or not. They shall be removed immediately from the site unless otherwise permitted by the Project Manager. Even after rectification of the defects no rejected material shall be used in the work unless approved by the Project Manager in writing. Upon failure of the Contractor to comply promptly with any order of the Project Manager given under this Clause, the Project Manager shall have authority to cause the removal and replacement of rejected material and to deduct the cost thereof from any monies due to the Contractor. The Project Manager/Engineers representative shall strictly follow the system of Non-conformance Report (NCR) in case of Non-conformance of materials/works as per formats provided under section 2200.

207. TRADE NAMES AND ALTERNATIVES

For convenience in designation in the contract, certain articles or materials to be incorporated in the work may be designated under a trade name or the name of a manufacturer and his catalogue information. The use of an alternative article or material which is of equal or better quality and of the required characteristics for the purpose intended shall be permitted, subject to the following requirements:

- (1)** The proof as to the quality and suitability of alternatives shall be submitted by the Contractor. The Contractor shall also furnish all information necessary as required by the Project Manager. The Project Manager shall be the sole judge as to the quality and suitability of alternative articles or materials and his decision shall be the final and binding upon the Contractor.
- (2)** Whenever the specifications permit the substitution of a similar or equivalent material or article, no tests or action relating to the approval of such substitute material shall be made until the request for substitution is made in writing by the Contractor accompanied by complete data as to the equality of the material or article proposed. Such request shall be made well in advance to permit approval without delaying the work.

Foreign materials

Materials which are manufactured, produced or fabricated outside Bhutan shall be delivered at a point in Bhutan as specified in the contract where they shall be retained for a sufficient time to permit inspection, sampling, and testing. The Contractor shall not be entitled to an extension of time for acts or events occurring outside Bhutan and it shall be the Contractor's responsibility to deliver materials obtained from outside Bhutan to the point of delivery in Bhutan. The Contractor shall supply the facilities and make necessary arrangement at his own cost. All testing by the Contractor shall be subject to witnessing by the Project Manager.

The Contractor shall furnish to the Project Manager a “Certificate of Compliance” with the specifications from the manufacturer, producer or fabricator of foreign material where required.

208. SIEVES

IS sieves shall be used for all tests. Based on IS-460 the standard sieves series shall be as follows:

125; 90; 75; 63; 50; 45; 40; 37.5; 31.5; 25; 22.4; 20; 19; 16; 12.5; 11.2; 10; 9.5; 8; 6.3 ;5.6; 4.75; 4.00; 2.8; 2.36; 2; 1.7; 1.4; 1.18; 1; 0.85; 0.71; 0.6; 0.5; 0.425; 0.400; 0.300; 0.250; 0.212; 0.180; 0.150; 0.125; 0.090; 0.075 mm.

In addition, sieves of other test standards shall be used as required in the Technical Specifications.

209. SOILS AND GRAVELS

(1) Sampling and Samples

Sampling of soils and gravels shall be carried out as specified or as directed by the Project Manager.

Samples shall be prepared for testing as indicated in IS 2720 part I, except that:

- (a) mass (in g) of a sample required for sieve analysis is about 400D, D being the maximum particle size (mm).
- (b) sample containing particles larger than 19 mm size shall be prepared for compaction and CBR tests as described hereunder, provided the proportion in weight of such particles is less than 30%:

An adequate quantity of representative material shall be sieved over the 50 mm and 19 mm sieve. The material passing the 50 mm sieve and retained on the 19 mm sieve shall be weighed and replaced with an equal mass of material passing the 19 mm sieve and retained on the 4.75 mm sieve. The material for replacement shall be taken from the remaining portion of the main sample.

When preparing gravel samples, the aggregations of particles shall be broken with a wooden or rubber hammer or pestle. Care shall be taken that no individual particles are crushed in the operation.

(2) Standard Methods of Testing

Tests on soils and gravels shall be performed in accordance with the standard methods given in Table 2.1. The type of tests shall be as directed by the Project Manager.

Table 2.1: Tests Procedures Applicable to Samples of Soils and Gravels

Tests	Test procedure	
Determination of: Moisture Content	IS 2720	Part 2 (Oven-drying method)
Liquid Limit	IS 2720	Part 5 (Cone Penetrometer or by Casagrande Apparatus)
Plastic Limit	IS 2720	Part 5
Plasticity Index	IS 2720	Part 5
Linear Shrinkage	IS 2720	Part 20
Specific Gravity of Particles	IS 2720	Part 3
Particle Size Distribution	IS 2720	Part 4
Organic Matter Content	IS 2720	Part 22
Total Sulphate Content	IS 2720	Part 27

Density-Moisture Content relationship (2.5 kg rammer)	IS 2720	Part 7
Density-Moisture Content relationship (4.5 kg rammer)	IS 2720	Part 8
California Bearing Ratio	IS 2720	Part 16
Sand Equivalent	IS 2720	Part 37 (Mechanical Shaker or Manual Shaker method)
Field Dry Density	IS 2720	Part 28/Part 29
Hydrometer analysis	IS 2720	Part 4

It is further specified that:

- (a) Wherever in the text of these Specifications the term "x% of the MDD (IS 2720 Part 27 or IS 2720 Part 28) is used it shall mean that a standard of compaction shall be achieved such that the dry density of the compacted material is x% of the maximum dry density determined from the respective tests mentioned in Table 2.1. Samples for the compaction tests shall be taken before compaction of the layers begins unless in the opinion of the Project Manager the compaction effort proposed or applied by the Contractor is such that the material characteristics have changed in which case the samples for the tests shall be taken after all compaction is complete.
- (b) Compaction tests: when the material is susceptible to crushing during compaction, a separate and new sample shall be used in the determination of each point on the moisture/density curve.
- (c) The dry density of material placed in the works shall be determined by the Sand Replacement Method unless the Project Manager directs to other method. In the case of nuclear method, tests shall be done at least at the same frequency required when using the Sand Replacement Method, but at each nuclear densometer test location the average of three readings taken at positions rotated by 90° shall be used. A check/comparison test using the Sand Replacement Method shall be carried out at 10 test interval.

Initial calibration of the nuclear density testing equipment shall be done by carrying out at least fifty tests in parallel with the Sand Replacement Method for each different material encountered. The check tests shall be used to update the initial calibration of the nuclear density testing equipment.

210. STONE, AGGREGATE, SAND AND FILLERS

(1) Sampling and Preparation of Samples

Sampling shall be carried out as per ASTM-D75 and the samples shall be prepared in accordance with IS 2386 or according to sampling procedures specified for the Standard Methods of testing given in Table 2.2.

(2) Standards Methods of Testing

Tests on stone, aggregate, sand and filler shall be performed in accordance with the standard procedures given in the Table 2.2. The type of tests shall be as directed by the Project Manager.

Table 2.2: Tests Procedures Applicable to Stone, Aggregate and Fillers

Tests	Test Procedure	
Determination of:		
a) Particle Size Distribution (Gradation)	IS 2386	Part 1

b)	Clay, Silt, Dust in Aggregates	IS 2386	Part 2
c)	Flakiness Index	IS 2386	Part 1
d)	Specific Gravity	IS 2386	Part 3
e)	Moisture Content	IS 2386	Part 3
f)	Bulk Density, Voids & Bulking	IS 2386	Part 3
g)	Soluble Chloride Content	BS 812	Part 117
h)	Mica Content	Manual mineralogical counting	
i)	Water Absorption	IS 2386	Part 3
j)	Crushing Ratio	Manual counting & weighing	
k)	Los Angeles Abrasion	IS 2386	Part 4
l)	AIV – ACV	IS 2386	Part 4
m)	Polished Stone Value	IS 2386	Part 4
n)	Sodium Sulphate Soundness	IS 2386	Part 5
o)	Alkali Aggregate Reactivity Test	IS 2386	Part 7
p)	Bitumen Stripping Test	IS 6241	
q)	Deleterious Substances	IS 2386	Part 2
r)	Sand Equivalent	IS 2720	Part 37
s)	Crushing Strength of stone	IS 2386	Part 4

211. CEMENT

Ordinary Portland Cement (OPC) shall be sampled according to IS 3535 and tested according to IS 4031. The requirements on their physical characteristics shall be as given in Table 2.3.

Table 2.3: Requirements on the Physical Characteristics of Cement

S.N.	Physical characteristics	OPC	Test Procedure
i)	Fineness, m ² /kg: (by Blaine's Air Permeability method)	225	IS-4031, Part 2
ii)	Setting Time :		
	(a) Minimum Initial Setting Time (minutes)	45	IS 4031 Part 5
	(b) Maximum Final Setting Time (minutes)	600	
iii)	Soundness by Lechatelier method, mm, maximum	10	IS 4031 Part 3
iv)	Compressive Strength :		
	Minimum Average Compressive Strength of three mortar cube(N/mm ²)		
	(a) 3 days	16	
	(b) 7 days	22	IS 4031 Part 6
	(c) 28 days	33	

212. CONCRETE

Sampling and testing on concrete shall be carried out in accordance with the standard methods given in the Table 2.4. The type of tests shall be as specified by the Project Manager.

Table 2.4: Tests Procedures Applicable to Concrete

Tests	Test Procedures
Determination of :	
(i) Compressive strength of concrete cubes	BS 1881-116
(ii) Water absorption	BS 1881-122
(iii) Mixing and sampling fresh concrete in laboratory	BS 1881-125
(iv) Normal curing of test specimens (20° C method)	BS 1881-111
(v) Making test cubes from fresh concrete	BS 1881-108

The test specimens shall be cured at a temperature of 27°C ± 2°C. Water to be used in concrete shall be tested as specified in BS 3148.

213. BITUMINOUS BINDERS

(1) Sampling and Samples

Sampling of straight-run and cut-back bitumen shall be carried out in accordance with ASTM D 140.

Sampling of bitumen emulsion shall be carried out in accordance with BS 434, Part 1, except that where a delivery is made in drums or barrels, the number of samples shall be as indicated in AASHTO sampling method, T40

(2) Standards Methods of Testing

(a) Straight-run Bitumen

Test on straight-run bitumen shall be carried out in accordance with the standard methods given in Table 2.5. The type of tests shall be as instructed by the Project Manager.

Table 2.5: Tests Procedure Applicable to Straight run Bitumen

Tests	Test Procedure
Determination of :	
i) Penetration	ASTM D 5
ii) Softening point (Ring and Ball)	ASTM D 36
iii) Flash and fire points (Cleveland open cup)	ASTM D 92
iv) Loss of heating	ASTMD6/D1754
v) Ductility	ASTMD113
vi) Water Content	ASTM D1461/D95
vii) Solubility in Trichloroethylene	ASTM D 2042
viii) Specific gravity	ASTM D70
ix) Penetration of residue from loss on heating	ASTM D5

(b) Cut Back Bitumen

Test on cut-back bitumen shall be carried out in accordance with the standard methods given in Table 2.6. The type of tests shall be as directed by the Project Manager.

Table 2.6: Tests Procedure Applicable to Cutback Bitumen

Tests	Test Procedure
Determination of :	
i) Kinematic viscosity	ASTM D 2170
ii) (a) Flash point (Tag open cup) (RC-MC)	ASTM D 3143
(b) Flash point (Cleveland open cup) (SC)	ASTM D 92
iii) Penetration	ASTM D 5
iv) Specific gravity by hydrometer method	ASTM D 3142
v) Asphalt residue of 100 pen (SC)	ASTM D 243
vi) Water content	ASTM D 95
vii) Distillation	ASTM D 402
viii) Penetration of residue from distillation	ASTM D 5
ix) Ductility of residue from distillation	ASTM D 113
x) Solubility of residue from distillation	ASTM D 2042

(c) Bitumen Emulsion

Test on bitumen emulsion shall be carried out in accordance with the standard methods given in Table 2.7. The type of tests shall be as directed by the Project Manager.

Table 2.7: Tests Procedure Applicable to Bitumen Emulsion

Test	Test Procedures
Determination of :	
(i) Residue on 0.710 mm sieve	BS 434 Part I, Appendix C ₁
(ii) Residue on 0.150 mm sieve	" " " C ₂
(iii) Stability to mixing with coarse aggregate	" " " D ₁
(iv) Stability to mixing with cement	" " " D ₂
(v) Binder content	" " " E
(vi) Engler viscosity	" " " F ₁
(vii) Redwood II viscosity	" " " F ₂
(viii) Storage stability (short period)	" " " H ₁
(ix) Storage stability (long period)	" " " H ₂
(x) Particle charge	" " " J

(3) Requirements

(a) General

Before any bituminous binder is delivered to the site, the Contractor shall provide the Project Manager with a certificate from the manufacturer that the material to be supplied complies in all respects with the relevant specifications.

Any bituminous binder delivered in leaking or deteriorated containers shall be rejected.

(b) Straight-run Bitumen

Straight run bitumen shall comply with all the requirements give in Table 2.8.

Table 2.8: Specification for Straight run Bitumen

S.N.	Specifications	Penetration Grade
		80/100
i)	Penetration, at 25°C (100g-5s), in 0.1 mm	80-100
ii)	Softening point (Ring and Ball), °C	41-51
iii)	Flash point (Cleveland open cup), °C (min)	225
iv)	Ductility at 25°C, cm (min)	100
v)	Loss on heating (5 h at 163°C) % (max)	0.5
vi)	Penetration of residue from loss on heating at 25°C (100 -5s) % of initial pen (min)	80
vii)	Specific Gravity at 25°C	1.00-1.05
viii)	Water, % by weight (max)	0.2
ix)	Solubility in trichloroethylene, % by weight (min)	99.5

The number of tests and criteria for conformity shall be as per IS 73.

(c) Cut Back Bitumen

Slow curing, medium-curing and rapid curing cut-backs bitumen shall comply with all the requirements of ASTM Standard Specification D2026, D2027 and D2028 respectively and the number of tests and criteria for conformity shall be as per IS 217.

(d) Bitumen Emulsion

Bitumen emulsions shall comply with all the requirements of BS 434, Part 1.

214. BITUMINOUS/ASPHALT CONCRETE MIXTURES

(1) Sampling and Samples

Sampling of bituminous mixtures shall be carried out in accordance with ASTM Method D 979.

(2) Standards Methods of Testing

Tests on bituminous mixtures shall be carried out in accordance with the standard methods given in Table 2.9.

Table 2.9: Tests Procedure Applicable to Bituminous Mixtures

Tests	Test Procedure
Determination of :	
i) Moisture and volatile distillates	ASTM D 1461
ii) Quantitative extraction of bitumen	ASTM D 2172
iii) Specific gravity of compacted mixture	ASTM D 1188 & D 2726
iv) Recovery of bitumen from solution	ASTM D 1856
v) Coating and stripping	ASTM D 1664, IS 6241
vi) Degree of particle coating	ASTM D 2489
vii) Maximum specific gravity	ASTM D 2041
viii) Degree of pavement compaction	AASHTO T230
ix) Marshall stability	ASTM D1559

215. REINFORCING STEEL

All reinforcement for use in the Works shall be tested for compliance as specified in Section 1700 [Sub section 1714] in a Laboratory acceptable to the Project Manager and two copies of each test certificate shall be supplied to the Project Manager. In addition to the testing requirements described above, the Contractor shall carry out additional testing as instructed by the Project Manager.

216. BRICKS

Bricks shall conform to the requirements of IS 1077.

217. MORTAR

Mortar shall comply with IS 2250–1981.

218. REINFORCED CONCRETE PIPES

Reinforced concrete pipes shall comply with the requirements of IS 458:1988.

219. HIGH DENSITY POLYTHENE PIPES

High density polythene pipes shall be as approved by the Project Manager.

220. GEOTEXTILES

Geotextiles used for sub-surface drains shall be continuous fibre non-woven, needle punched; UV stratified such as “polyfelt TS 30 or equivalent” Geotextiles. Geotextiles used in masonry structures and French drain shall be ‘Polyfelt TS 30’ unless otherwise directed by Project Manager.

Geotextiles used for reinforced gabion facia walls shall be non-woven, needle punched; UV stratified such as “polyfelt TS 70 or equivalent”.

Unless otherwise shown on the Drawing or directed by the Project Manager, the geotextiles shall meet the following specifications:

Table 2.10 Requirement of geotextiles

Property	Test standard	Unit	10KN geotextile	24KN geotextile
Tensile strength(Av)	ISO 10319	KN/m	9.5 min	24
CBR puncture strength	ISO 12236	N	1200	3000
Vertical water flow (100mm head)	ISO 11058	l/m2/s	217	117
Rod Puncture resistance	ASTM D 4833	N	255	650
Apparent opening size (O95)	ASTM D 4751	mm	0.26	0.18
Permittivity	ASTM D 4491	l/s	3.0	1.70
Nominal mass	ISO 9864	g/m2	125	325
Thickness 2Kpa	ISO 9863	mm	1.2	2.9
Weight of roll		Kg	135/60	140

- (a) Geotextiles shall have a grab strength more than 475/420 N for 10 KN and 1500/1400 for 24 KN and grab elongation corresponding to this limit in accordance with ASTM D4632.
- (b) Have apparent opening size as shown on the Drawing or as mentioned under table 2.10.
- (c) Allow vertical water to flow through it at right angles to its principal plane, at a rate of not less than 217 litres/sq.m./sec for 10KN geotextiles and 117 litres/sq.m./sec for 24 KN geotextiles under a constant head of 100 mm, determined in accordance with BS: 6906 (Part 3) or ASTM D4491, or ISO 11058, unless otherwise shown on the Drawing. The flow rate determined in the test shall be corrected to that applicable to a temperature of 15°C using data on variation in viscosity of water with temperature.

- (d) have a minimum dynamic drop cone puncture (diam) of 30 mm when determined in accordance with ISO 13433.

221. TIMBER FOR STRUCTURAL WORKS

Timber used for structural works shall comply with IS: 883.

222. PAINT FOR ROAD MARKING

The paint for road marking shall be manufactured for road markings and suitable for use in the climatic conditions of Bhutan. Paint colors shall be as shown on the Drawings. The paints shall be to the approval of the Project Manager.

223. MANHOLE COVERS AND FRAMES

Manhole covers and frames shall be of cast iron and shall comply with IS: 1726-1991. For manholes constructed in carriageway and shoulders, heavy duty circular covers and frames shall be used. In footpaths, medium duty circular covers shall be used. In other locations light duty covers and frames shall be used.

224. PRECAST CONCRETE CHANNELS

Precast concrete channels, kerbs, edging, quadrants and gutters shall comply with the requirements of IS: 5758 - 1984.

225. CAST IRON DRAINAGE GRATINGS

Cast iron gratings shall comply with the requirements of IS: 5961 – 1970.

226. GABION

Gabion materials used in the works shall comply with the requirements of Section 1602 of this Technical Specification.

227. MEASUREMENT AND PAYMENT

If otherwise not specified in the contract, no separate measurement and payment shall be made for sampling, samples and testing of materials, site trials and construction control/process control testing. It shall be deemed to have included in the rates of the relevant items for complying with the requirements of this Section 200.

228. SETTING OUT, GEOMETRIC TOLERANCES AND RECTIFICATION

229. SCOPE

All excavation and works to be performed shall conform to the lines, grades, cross-sections, side slopes and levels shown on the drawings or as directed by the Project Manager, subject to the permitted tolerances described hereinafter.

300. SETTING OUT

- (1) During the period of Commencement of works the Contractor shall resurvey the Base Lines, Traverse Points, Bench Marks and confirm the co-ordinates and levels of the stations. He shall immediately notify the Project Manager of any discrepancies and shall agree with the Project Manager any amended values to be used during the contract, including replacements for any stations missing from the original stations.
- (2) The Contractor shall check, replace and supplement as necessary the station points and agree any revised or additional station details with the Project Manager.
- (3) All stations and reference points shall be clearly marked and protected to the satisfaction of the Project Manager.
- (4) Where a survey station point is likely to be disturbed during construction operations, the Contractor shall establish suitable reference stations at locations where they will not be disturbed during construction. No old station shall be covered, disturbed or destroyed until accurate reference stations have been established and details of such stations have been approved by the Project Manager.
- (5) The Contractor shall establish working Bench Marks tied with reference stations soon after taking possession of the site. The coordinates and the elevations of the reference stations shall be obtained from the Project Manager. The working Bench Marks shall be at the rate of four per kilometer and also near all major/medium structure sites. Regular checking of these Bench Marks shall be made and adjustments, if any, got agreed with the Project Manager and recorded.
- (6) The Contractor shall be responsible for the accurate establishment of the center lines based on the Drawing and data supplied. The center lines shall be accurately referenced in a manner satisfactory to the Project Manager. The reference points shall be established at every 25 m interval or as instructed by the Project Manager, with marker pegs or/and chainage boards set in the right of way. A schedule of reference dimensions shall be prepared and supplied by the Contractor to the Project Manager.
- (7) The existing profile and cross-sections shall be taken jointly by the Project Manager and the Contractor. These shall form the basis for the measurements and payments. If in the opinion of the Project Manager, design modifications of the center lines and/or grade are advisable, the Project Manager shall issue detailed instructions to the Contractor and the Contractor shall perform modifications in the field, as required, and modify the levels on the cross-sections accordingly.
- (8) Accurate control of lines and levels shall be provided by the Contractor at all stages of the construction. In respect of road, control shall be at least 10 m interval or such interval as may be directed by the Project Manager. The lines and levels of formation, side slope, drainage works, etc. shall be carefully set out and frequently checked. Care shall be taken to ensure that correct gradients and cross-sections are obtained everywhere. Wherever necessary, but particularly on completion of sub grade, sub base and base, the Contractor shall re-establish center line pegs at sufficiently close intervals to determine the edges of base and surfacing accurately.
- (9) The Contractor shall provide the Project Manager with all necessary assistance for checking the setting out, agreement of levels and any other survey or measurement which the Project Manager needs to carry out in connection with the contract during the entire period of contract. Such assistance shall include:
 - (a) provision of suitably qualified surveyors to work under the direction of the Project Manager as required.

- (b) provision of all necessary support for these surveyors including field assistants, , labours, hand tools, pegs and materials.
- (c) provision of survey equipment (total station) as required by the Project Manager for survey works.

Measurement and Payment

No separate measurement and/or payment shall be made for this work. All costs in connection with the work specified herein shall be considered included in the related items of the work specified in the Bill of Quantities.

301. GEOMETRIC TOLERANCES

(a) Horizontal Alignment

Horizontal alignments shall be determined from the centreline of the pavement surface as shown or calculated from the Drawing. The centreline of the pavement surface as constructed, and all other parallel alignments, shall be correct within a tolerance of ± 10 mm there from.

(b) Thickness of Pavement Layers

The average thickness of any pavement layer measured at five conjugative points at every 20m in any Section shall not be less than the thickness specified nor more than 120% of the thickness specified or ordered by the Project Manager. The thickness of the pavement layer measured at any point shall have tolerance of +/-25 % of the thickness specified.

(c) Surface Levels of Pavement Layers and Formation

The level measured at any point on the surface of a pavement layer to the formation level shall not deviate from the corresponding level calculated from the Drawing by more than the tolerances shown in the table 3.1 below.

For checking compliance with the given tolerances, measurements of surface levels shall be taken at points to be selected by the Project Manager at 12.5m centres longitudinally and at 2m centres transversely. At junctions, the grid point spacing shall be determined by the Project Manager.

(d) Surface Regularity

The surface regularity of pavement layers and the formation shall be tested at points decided by the Project Manager with a rigid, steel straight-edge of 3 m length placed parallel to or at right angles to the centreline of the road. The maximum allowable deviation of the surface below the straight-edge shall not deviate from that shown on the Drawing by more than the tolerances shown below.

In addition the longitudinal slope or transverse cross fall shall not deviate from that shown on the Drawing by more than the tolerances in Table 3.1. If tolerances given below for level and straight edge are not in agreement, in that case the tolerances given for straight edge shall prevail.

Table 3.1: Tolerances for Level and Surface Regularity

Layer	Level Mm	Straight edge mm	Slope or Crossfall %
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Bituminous Wearing Course	± 10	6*	± 0.25
Bituminous Binder Course	± 10	6	± 0.25
Base	± 10	6	± 0.25
Subbase	± 15	10	± 0.50
Gravel Wearing Course	± 15	15	± 0.50
Formation (subgrade)	+0 -25	20	± 0.50

* In case of asphalt concrete surface it shall be 4mm.

(e) Shoulders

Shoulders shall be constructed to the same requirements of thickness, level and surface regularity as for the adjacent pavement layers.

(f) Cuttings and Embankment Slopes

In the final trimmed slope of cuttings or embankment a tolerance of +0.25 shall be permitted, i.e. if a slope of 1 in 2 is specified, the acceptable slope shall be not steeper than 1 in 2 or slacker than 1 in 2.25.

(g) Width of Cuttings and Embankments

The tolerance permitted in the width of the bottom of cuttings shall be 200 mm between the centreline of the road and the toe of the cutting slope.

The width of embankments measured horizontally and perpendicular to the centreline of the road at the top of the embankment shall not be less than shown on the Drawing or more than that shown on the Drawing plus 50 mm.

(h) Depth of Side Drains

The difference between road level measured at the centre line of the road and that of the bottom of the side drain measured perpendicular to the centre line of the road shall not deviate from the specified in the drawing by ± 25 mm.

302. RECTIFICATION OF EARTHWORKS AND PAVEMENTS OUTSIDE PERMITTED GEOMETRIC TOLERANCES

Where any tolerances in Sub-clause 303 (3) are exceeded, the Contractor shall assess the full extent of the area which is out of tolerances and shall make good the surface of the pavement course, earthworks or formation in the manner described below.

(a) Earthworks

Where a cutting slope is steeper, and an embankment slope is slacker than the specified slope, then the slope shall be trimmed to the specified slope. When the cutting slope is slacker, the natural ground slope above top of the cutting and the adjacent cut slopes in the both sides of the slacker slope shall be so trimmed that the entire cut slopes match together and they are environmentally stable. Where an embankment slope is

steeper than the specified slope, then the slope shall be benched and fill material shall be placed and compacted. Subsequently the slope shall be trimmed all in accordance with the requirements of Section 700.

Where the width of a cutting is less than, and the width of an embankment is more than the specified width, then the cutting or embankment shall be trimmed to the specified width. Where the width of the cutting is more than the specified width but cut slope is slacker than the specified slope, the slope shall be trimmed as described in the preceding paragraph. If the cut slope is steeper, it shall be trimmed to specified slope. The adjacent slopes shall be also trimmed to make them in harmony. Where the width, of an embankment is less than the specified width, the embankment shall be benched and filled with suitable material and compacted. The slopes shall be trimmed all in accordance with the requirements of Section 700.

Where the depth of a side drain is less than that specified, the side drain shall be excavated to the specified depth and grade. Where the depth of a side drain is more than the specified depth, the side drain shall be backfilled with suitable material, compacted to a dry density of at least 95% of MDD (Heavy compaction) up to the specified depth or the extra excavated depth shall be made good by the same material of lining of the drain as directed by the Project Manager.

(b) Subgrades

Where the levels and or widths are out of tolerance, the full depth of the layer shall be reworked to the Specification. The area to be treated shall be as determined by the Project Manager necessary for compliance with the Specification.

Where the results of the construction control tests are less than specified the full depth of the layer in the area representing the test shall be reworked to the Specifications. However, if needed, more tests shall be conducted to ascertain the extent of the area required to be reworked.

(c) Base and Subbase

Where these consist of unbound (i.e. natural or graded stone) material the full depth of the material shall be replaced by the material complying with the Specifications. The area treated shall be at least 30m long and 3m wide or such area determined by the Project Manager necessary for compliance with this Specification.

For bituminous bases the material of the full depth of the layer shall be replaced with fresh approved material laid and compacted to specification. Any area so treated shall be at least 5m long and the full width of the paving laid in one operation.

(d) Wearing Course

The method of rectification shall be adopted depending upon the nature of the failure. Rectification shall be effected either by removing base and replacing with approved material and doing wearing course or redoing wearing course alone. The Project Manager shall instruct appropriate method of rectification. The area rectified shall be the full width of the paving laid in one operation and at least 15m long.

(4) Measurement and Payment

The Contractor shall be deemed to have allowed in his general rates and prices for the cost of complying with the requirements of Clause 303.

Notwithstanding the provisions of Sub-clauses 303 (2) and 304, measurement and payment for earthworks and pavement works shall be made on the basis of the net-cross-Section ordered by the Project Manager or as shown on the Drawing. No additional payment shall be made for any variation. If the executed work is within the limit of tolerance, but is less than the specified on drawing or ordered by the Project Manager, the

payment shall be made for actual quantity executed, if the executed work is more, the payment shall be made for as shown on the drawing or ordered by the Project Manager.

400. QUALITY CONTROL

401. SCOPE

This Section covers the Quality Control System and procedures, Quality Assurance Plan, program of tests, trials, and general procedures for acceptance as well as laboratory arrangements and related facilities which are required for the selection and control of the quality of materials and workmanship.

402. CONTRACTOR RESPONSIBLE FOR THE QUALITY OF THE WORKS

All materials incorporated and all workmanship performed shall be strictly in conformity with the requirements of the Technical Specifications and the Contractor shall be responsible for the quality of the works in the entire construction within the contract. All Contractor's bills for the materials and works incorporated in the works shall be supported with test reports, inspection reports, supplier's/manufacturer's certificates and any other documents as appropriate and acceptable to the Project Manager.

The Contractor shall use and maintain on the Site, throughout the period of execution of the contract, a field laboratory operated by competent Lab Technician and a Lab Boy for carrying out tests required for the selection and control of the quality of materials and for the control of workmanship in accordance with these Specifications. The field laboratory shall be established by the Employer where as the laboratory equipments shall be procured and supplied by the contractor as described under Section 411 of this Technical Specification. The Contractor shall assume that tests shall be required on all materials to be used in the works and on all finished works or part of works.

403. QUALITY CONTROL SYSTEM

The Quality Control System comprises the methods, procedures and organisation for the Quality Control of the works. The Contractor shall implement the Quality Control System in the following sequences:

(1) Sequence

- (a) Compliance testing for materials including laboratory trials,
- (b) Compliance testing for methods and equipment prior to the commencement of the work, including site trials or trials sections,
- (c) Control testing during construction,
- (d) Acceptant testing on completed works or parts of the works.

The Contractor shall carry out all necessary tests and shall report to the Project Manager the results of such tests before submitting materials and/or finished works or part of works to the Project Manager for approval in accordance with this Specification. In certain circumstances, tests may be carried out at the place of manufacture as per the Conditions of Contracts.

For satisfying himself about the quality of the works, quality control tests shall be conducted by the Project Manager himself or by any other agencies deemed fit by the Project Manager. Additional tests may also be conducted where in the opinion of the Project Manager such tests are needed.

Before commencement of the work, the Contractor shall demonstrate a trial run of all construction equipment for establishing their capability to achieve the laid down Specifications and tolerances to the satisfaction of the Project Manager.

(2) The supply, testing and monitoring shall be in compliance with a Quality Assurance Plan, Clause 404 and the provisions in the contract.

404. QUALITY ASSURANCE PLAN

The Contractor shall submit to the Project Manager for his approval, the Quality Assurance Plan (QAP) which shall be based on the detailed Program of the Works as per Clause 102 of the Technical Specifications. A sample copy of the Quality Assurance Plan is provided under section 2200.

The Quality Assurance Plan shall include the following:

- (1) The Quality Control Schedule Comprising of:
 - (a) The recapitulative test schedule and testing program detailing the list of tests for compliance, laboratory trials, site trials and trials sections, construction control tests and their frequencies, tests for acceptance of the completed works with their dates.
 - (b) Recapitulative list of "critical" acceptance testing procedures, for equipment or parts of the works which corresponds to the tasks on the Critical Path according to the construction Program.
 - (c) Estimate of the number of tests to be carried out, list and number of appropriate equipment to conduct them, list of tests to be conducted outside the site laboratory, if any, identification of the outside laboratory where proposed to carry out the test.
 - (d) List of staff assigned to the laboratory, their position and responsibilities in the quality control procedures, their qualification and experience, general description and detailed organisation of the laboratory activities.
- (2) The list of sources of materials and/or of manufactured articles, their main characteristics, their identification mode as provided by the supplier when required; the programme of supply and procurement of material and/or manufactured articles in accordance with the Programme pursuant to Clause 102.
- (3) The list of tests and quality control procedures to be implemented by the Sub-contractors, if any, pointing out the "critical" acceptance testing procedures relating to the Sub-contracted works, which correspond to the tasks on the Critical Path included in the Sub-contracted works.

The Contractor shall implement the Quality Control in compliance with the approved QAP.

The Project Manager's approval of the QAP shall not relieve the Contractor from his responsibility of the quality of the Works as per the Conditions of Contract and these Specifications nor shall the Project Manager's approval of the QAP exempt the Contractor of any procedure to inform the Project Manager in writing or request for the Project Manager's approval or re-approval as specified in the Conditions of Contract and/or in these Specifications

The Contractor shall monitor and update the QAP on the basis of the decisions taken at the periodic review meetings or as directed by the Project Manager and in accordance with the program of the works as per Clause 102 and the Conditions of Contract.

405. TESTING PROCEDURES AND SET OF TESTS

For ensuring the quality of the work, the materials and the workmanship shall be subjected to testing in accordance with procedures, sets of tests and frequencies as specified in Section 200 and respective Sections of these Specifications. The specified testing frequencies are not restrictive. The Project Manager shall direct for the tests to be carried out as frequently as deemed necessary that the materials and workmanship comply with their Specifications.

Sets of tests to be carried out on the materials and the workmanship as specified in these Specifications are recapitulated in Clause 410. Where no specific testing procedure is mentioned in the Specifications, the tests shall be carried out as per the prevalent accepted engineering practice or directions of the Project Manager.

406. LABORATORY TRIALS TO CONFIRM COMPLIANCE WITH SPECIFICATIONS

(1) Filling and Pavement Materials

Laboratory trials shall be carried out by the Contractor on filling and pavement materials proposed to be used in the works in their natural state. The laboratory trials shall establish a relationship between their specified requirements of the end product and properties which can be determined in the field for construction control purposes. Laboratory mixes and site trials for bituminous mixes shall be carried out in accordance with the requirements of the Section 200.

The mixed materials, the composition of which meets the specified requirements and is accepted by the Project Manager, shall then be used in the site trials carried out in accordance with Clause 407 to ensure that all specified requirements of the completed pavement courses can be achieved.

The Contractor shall submit the proposals for the site trials to the Project Manager at least two weeks before he intends to use the mixed materials in the site trials in accordance with Clause 407.

(2) Concrete

Laboratory trials for concrete mixes as specified in Section 1700 shall be carried out by the Contractor to demonstrate that the composition of the mixes proposed for the concrete meets the requirements of the Technical Specifications.

The compositions of concrete mixes which meet the specified requirements and are accepted by the Project Manager shall be then used in the site trials carried out in accordance with Clause 407.

407. SITE TRIALS OR TRIALS SECTIONS

(1) Earthworks and Pavement Materials

Site trials for laying and compaction shall be carried out by the Contractor on all earthworks and pavement materials proposed for the works, using the same constructional plant and methods proposed by the Contractor for use in the works. The trials shall demonstrate the suitability of the method and equipment for laying and compaction of the material to the specified density and confirm that other specific requirements of the completed earthwork or pavement work can be achieved.

Each trial area shall be at least 100 metres long and to the full construction width and shall be laid to the specified depth for the material. It may form a part of the works provided it complies with the required

Specifications. Any areas, which do not comply with the Specifications, shall be removed and new trial shall be made.

The Contractor shall allow in his Program for conducting such site trials and for carrying out the appropriate tests on them in accordance with the Quality Assurance Plan. The trials on each pavement layer shall be undertaken at least 21 days ahead of the commencement of the related work.

The Contractor shall compact each section of the trial over the range of compaction effort the Contractor is proposing. The data in respect of the following shall be recorded for each level of compaction effort at each site trial:

- (a) The composition and grading of the material before the site trial.
- (b) The composition and grading of the material including the lime or bitumen content.
- (c) The moisture content at the time of compaction and the optimum moisture content for the specified compaction.
- (d) The type, size, tyre pressures, frequency of vibration and the number of passes made by the compaction equipment.
- (e) The maximum dry density or target density as appropriate measured on a sample before and at intervals through the site trials.
- (f) The density achieved.
- (g) The compacted thickness of the layer.
- (h) Any other relevant information as directed by the Project Manager.

At least, eight sets of tests shall be made by the Contractor on each 100 metres length of trial section for each level of compaction effort. If all eight sets of results over the range of compaction effort proposed by the Contractor meet the specified requirements for the material, the site trial shall be deemed successful. The above data recorded in the trial shall become the agreed basis on which the particular material shall be provided and processed to achieve the specified requirements. If required, the QAP shall be updated or modified on the basis of these data.

If, during the execution of the works, the construction control tests indicate that the requirements for a material are not being consistently achieved, then work on that layer shall be stopped until the cause is investigated by the Contractor. Such investigation may include further laboratory and site trials on the materials to determine a revised set of data as stated above which when agreed, shall be the basis on which all subsequent material shall be provided and processed to achieve the specified requirements.

(2) Concrete

Site trials for concrete mixes as specified in Section 1700 shall be carried out by the Contractor to demonstrate the suitability of his mixing equipment. During the site trials, compliance with the Specifications for weighing equipment, storage of ingredients, means of transport for concrete, placing, compaction and curing shall be checked by the Project Manager.

During the site trial a full scale sequence including placing and compaction of concrete shall be carried out on a part of the works which will represent particular difficulties due to the presence of reinforcement, obstructions or others.

The Contractor shall allow in his Program for conducting the site trials and for carrying out the appropriate tests, including the time required to obtain compressive strength test results at 28 days. The Contractor shall inform in writing the Project Manager at least two weeks before the date he proposes to use the concrete mixes in the site trials with all relevant data including the trial program, the results of the laboratory trial tests for the proposed concrete mixes and compliance tests results of all constituents i.e. cement, aggregates, water and admixtures, if any.

(3) Production of Materials and Crushing Plant

Full scale site trials corresponding to one day production shall be carried out by the Contractor on all type of materials to be processed using the crushing plant, related devices and methods to demonstrate the suitability of the equipment to provide materials of the characteristics and performances specified in these Specifications.

At each stage of the processing, materials shall be sampled, and the following characteristics shall be determined in the laboratory and recorded:

- (a) the grading of the material
- (b) characteristics of the fine fraction: Sand Equivalent (SE); Mica Content; and if SE<40, Plasticity Index.
- (c) characteristics of the coarse fraction : LAA, AIV, ACV, FI, stripping test, Crushing Ratio.

At least three sets of tests shall be conducted by the Contractor at each stage of the production. If all the three sets of results over the full sequence of production proposed by the Contractor meet the specified requirements for the materials, the site trial shall be deemed successful.

408. CONTROL TESTING DURING CONSTRUCTION

(1) Earthworks and Pavement Materials, Backfill to Drainage and Other Structures

All earthworks, pavement layers, and backfill to drainage and other structures shall be subject to control testing (process control) including, if required, testing by the Project Manager in accordance with the Conditions of Contract and Clause 403. The Contractor shall allow in his programme or sequence of operations for any disturbance or delays occasioned by such control and testing.

(2) Other Works and Equipment

Testing and quality control procedures are detailed in the relevant Sections of the Technical Specifications.

409. ACCEPTANCE TESTS FOR COMPLETED WORKS OR PARTS OF THE WORKS

(1) Earthworks and Pavement Materials, Backfill to Drainage and Other Structures

The Contractor shall request, in writing using standard Request for Inspection sheet (RFI) for the Project Manager's approval for each layer of each section of earthwork, pavement construction and backfill to drainage and other structures. Such requests shall be made only when the Contractor is fully satisfied that the section of the works concerned is in the condition required by the relevant Specifications. Such request shall be accompanied by the tests results required by the Sub-clause 403 (1) (a), (b), (c) and the relevant Sections of the Technical Specifications.

The Project Manager shall thereupon, without undue delay, inspect the Section for any visible defects including, heaving material (visible during compaction or on proof rolling) segregation, and for the uniformity of the mixing and compaction. If the visual aspects are satisfactory the Project Managers shall test the Section of the works submitted and inform the Contractor in writing of the results of the tests specifying acceptance or rejection of the Section or the layer concerned. The Project Manager/Engineers representative, for this purpose, shall use the standard Non –Conformance Report form (NCR).

Work on a layer shall in no circumstances commence until the preceding layer has been approved and accepted by the Project Manager in writing. The Contractor shall be fully responsible for protecting and maintaining the condition of the work which has been submitted for approval.

Should any layer be left unprotected for more than 24 hours subsequent to approval, the Contractor shall request for re-approval of the layer and the layer shall again be subject to proof rolling, construction control testing, and tolerance checks in accordance with these Specifications.

Notwithstanding the Project Manager's approval of a layer, the Contractor shall be responsible for making good any subsequent damage due to traffic, ingress of water or any other reason and should any damage occur the layer shall again be subject to proof rolling, construction control testing and tolerance checks in accordance with these Specifications.

(2) Other Works and Equipment

Acceptance tests for other works and equipment are detailed in the relevant Sections of the Technical Specifications.

410. RECAPITULATIVE SCHEDULE OF TESTS

The tests to be carried out and their frequency for the quality control of the works are detailed in the relevant Sections of the Technical Specifications.

The following Table 4.1 recapitulates the testing schedule for the main types of works.

Table 4.1: Testing Schedule

PART OR COMPONENT OF THE WORKS	Section/ Clause No	TESTS	FREQUENCY
PRODUCTION OF MATERIALS natural and crushed materials	500	Site Trails: Other tests on materials	Before starting production According to the relevant component of the works
EARTHWORKS FILL MATERIAL COMPACTION	700	Material Identification, MDD, OMC, CBR MC Field Density	For each new source and in every 1500 m ³ or part of it For each new source and in every per 250 m ³ or part of it One set per 500m ² of each layer with a minimum 3 test per Section

SUBGRADES MATERIALS COMPACTION	900	Material Identification, MC MDD, OMC, CBR Field Density	For each new material and not less than once per 3000 m ² of each layer Once per 250 m ² of each layer or part of it
MECHANICAL STABILISATION IN-SITU MATERIAL STABILISER MIXED MATERIAL COMPACTION	906	Material Identification, MC MDD, OMC, CBR Grading, se (for sand) MDD,OMC,CBR,MC Field Density	One test for each new material and one test per 3000 m ² of each layer or part of it. One test for each new source and one test per 500 m ³ of additive material or part of it. One test for each new material and one test per 400 m ² of each layer or part of it. Once per 250 m ² of each layer or part of it.
SUBBASE MATERIALS COMPACTION	1000	Material Identification, MC, Gradation, Plasticity Index, MDD, OMC Field Density and moisture content	Once per 200 m ³ or part of it and change in source with a minimum of 2 tests per section Once per 1000 m ³ or part of it and change of source, with a minimum of 2 tests per section. Once per 500 m ² of each layer with a minimum of 2 tests per section.
WET MIX CRUSHED STONE BASE COURSE MATERIALS COMPACTION	1100	Material Identification, Gradation, Plasticity Index, FI LAA,AIV, Crushing Ratio, SSS, CBR MDD, OMC Field Density and moisture content	Once per 200 m ³ or part of it and change in source with a minimum of 2 tests per section Once per 200 m ³ or part of it and every change of source Once per 500 m ³ or part of it and every change of source Once per 1000 m ³ or part of it & every change of source, with a minimum of 2 tests per section. Once per 500 m ² of each layer with a minimum of 2 tests per section.

GRAVEL WEARING COURSE MATERIALS COMPACTION	1100	Material Identification, Gradation, Plasticity Index, CBR, LAA, AIV MDD,OMC Field Density and moisture content	Once per 300 m ³ or part of it and for each new source Once per 400 m ³ or part of it and for each change in sources Once per 200 m ² of each layer with a minimum of 3 tests per Section.
BITUMINOUS SURFACE AND PAVEMENT COURSES PRIME COAT - TACK COAT MATERIALS CONSTRUCTION	1300 1302	Quality of Binder Binder temperature for application Rate of spread of binder	Certificates from suppliers. One set of tests for each 50,000 litres of supply or part of it At regular close intervals 2 tests per run
SURFACE DRESSING MATERIALS CONSTRUCTION	1303	Material Identification, Gradation, FI LAA, AIV, CR SSS Striping Value Quality of Binders Rate of application of Chippings Binder temperature for application Rate of application of Binder.	Once per 50 m ³ or part of it and change in source Once per 250 m ³ or part of it and change in source Once per 500 m ³ or part of it and change in source One set of 3 specimens for each source of supply. Then, when warranted, by change in the quality of aggregates. Certificates from suppliers. One set of tests for each 50,000 litres or part of it of supply. Two per day At close intervals Two per run
ASPHALT CONCRETE MATERIALS	1305	Material Identification, Gradation, LAA, ACV, SSS, SE Flakiness Index Quality of Filler	Once per 100 m ³ and change in source Once per 500 m ³ and change in source Once per 100 m ³ " " Per 50 tonnes " "

CONSTRUCTION		Quality of Binders Penetration test Mixture Grading and Bitumen Content Marshall stability, flow & voids Control of Temperature	Certificates from suppliers. One set of tests for each 50,000 litres of supply or part of it Daily Each 100t of mix or part of it Each 100t of mix or part of it As required
STONE MASONRYWORK MATERIALS	1402	Quality of cement and sand	As required
MORTAR	1402(2)	Control tests Compressive strength of mortar	Every 10m ³ of masonry of part of it
BRICKWORK MASONRY WORK MATERIALS	1502	Quality of Bricks Quality of cement and sand	As required
MORTAR	1512	Control tests Compressive strength of mortar	Every 10 m ³ of brick work or part of it.
GABIONS MATERIALS	1601	Gabion wires : Tensile Strength, Mass, Uniformity and adhesion of Zinc coating Water absorption of stones	Sub-clause 1501 Every 50 m ³ or part of it
CONCRETE MATERIALS	1700	Cement : Acceptance Tests: Control Tests : Chemical composition Physical properties	Conservative samples for each supply and not less than every 200 t or part of it. Testing in case of non compliance of the mixes or storage on site for longer than 1 month
		Aggregates: Acceptance Tests :	Sub-clause 1703 (5) Each delivery and every 100 t or part of

		Control Tests : Grading Silt & clay content Organic Impurities Chloride content, sulphate content, Alkali reactivity Water, Admixtures	it for fine aggregate and 250 t or part of it for coarse aggregate As frequently as required. Sub-clause 1703 (7) and (8)
		Concrete Lab. Trials Site Trials Control tests Compressive strength Reinforcement	Sub-clause 1504 (3) Sub-clause 1504 (4) Early work: every 6 m ³ of each class. When compliance is established: every 20 m ³ or part of it. Clause 1614
CROSS DRAINAGE WORKS	1800		
MATERIALS FOR RE-FILLING THE TRENCHES		Identification : Gradation, Plasticity Index, CBR , In- Situ Density (95% MDD)	As specified or required by the Project Manager
MISCELLANEOUS STRUCTURES	1900	Gradation of backfill material	Minimum one test for every 250 m ³ or part of it and for each source of material
BUS SHELTER	1903	Gradation Analysis	One set of test for every 50 m ³ and or part of it and for each change in source of material
HDPE PERFORATED PIPES	1905		

411. FIELD LABORATORY

(1) Establishment of Field Laboratory

The establishment and operation of field laboratory including supply and use of material testing equipment, manning of the laboratory with Lab Technician and a Lab Boy on full-time basis, supply and use of consumables and stationeries, conduct of requisite tests and production and submission of test reports, etc. have been covered under Section 110 of this document.

(2) Laboratory Equipment and testing of materials and workmanship

The list of material testing equipment to be procured and supplied by the contractor is provided in Section 110. The equipments shall be delivered to the site in accordance with the schedule of requirements of such

equipment and materials described in Section 226 of this document. However the non-inclusion of any item of such equipment in the schedule of requirements shall not relieve the Contractor of the responsibility to supply it if it is required for the proper control of the quality of the materials and/or workmanship, notably when identified in the list of appropriate equipment to be supplied.

The Contractor shall keep the laboratory in a well maintained, clean and habitable condition. The Contractor shall keep all laboratory equipment in good working condition throughout the period of the contract at his own expense. Testing apparatus shall be maintained in serviceable condition and all measuring and control equipment will be checked and calibrated from time to time, as required by the Project Manager, and immediately adjusted or replaced if it is found that correction is not possible. Any equipment, which becomes unserviceable during use shall be immediately reported to the Employer for replacement/repair. However, malfunctioning or non-availability of required laboratory equipment in the field laboratory shall not relieve the Contractor of the responsibility to conduct requisite quality control tests and produce test reports on materials and workmanships incorporated in the works. For all testing which cannot be carried out in the field laboratory, the Contractor shall be responsible for arranging for such testing to be carried out at an independent laboratory to be approved by the Project Manager. The Contractor shall be responsible for all attendance on staff from these approved testing laboratories, including if necessary the provision of transport for personnel, equipment and test specimens. No testing by external laboratories shall be carried out without the approval of the Project Manager.

Without relieving the Contractor of any of his responsibility for the testing of materials the Project Manager may as and when he desires carry out any of the tests specified above using the facilities. The Project Manager may also order the Contractor to carry out additional laboratory tests in independent laboratory, as deemed necessary, at the risk and cost of the contractor.

The Contractor shall provide all tools, accessories, services for utility, communication, consumable items for testing and operating, and all the assistance as may be required by the Project Manager and his staff for measuring and checking the works.

(3) Measurement and Payment

- (a) Supply and maintain laboratory equipment as per schedule to Field Laboratory –payment shall be as per priced BOQ on the basis of fifty (50) percent after supply of all laboratory equipment and rest fifty (50) percent on equal monthly installments of contract period since completion of the supply.
- (b) Supply, operate/use and maintain all office equipment, consumables, stationeries, etc. as required to the Field Laboratory – payment shall be as per the priced BoQ.

500. QUARRIES, BORROW PITS, STOCKPILE AND SPOIL AREA

501. GENERAL

Unless otherwise stated in the contract, it is the responsibility of the Contractor to select the sources of rock/stone for pavement materials (such as subbase, base course, asphalt concrete/bituminous base/binder and wearing courses, chippings for surface dressing and other wearing courses); stones for masonry works, aggregates for mortar and concrete; natural/suitable materials, such as fill material, for the construction of embankments; gravel for road subbase and shoulder. Such sources shall be designated as rock quarries, river quarries/alluvial deposits, quarries and borrow pits and are defined in Clause 402. Certain rock quarries, quarries, alluvial deposits, borrow pits may have or have been identified and permission received from concerning authorities prior to the commencement of the contract and the Project Manager shall instruct the

Contractor as to which of these shall be utilized for the extraction as natural or suitable materials to be used in the works.

Provisions are included in subsequent clauses of this section of the Technical Specifications for additional rock quarries, quarries, alluvial deposits, borrow pits to be identified and located by the Contractor during the contract. The Contractor during execution of the contract can explore further suitable material sources and get approval on their extraction from concerning authorities, and materials from such sites could be permitted by the Project Manager depending upon their suitability to meet the requirements of the Technical Specifications.

Stockpile and spoil areas shall be located by the Contractor subject to the approval of the Project Manager.

502. DEFINITIONS

(1) Rock Quarry

A rock quarry is an open surface working in massive rock from which stone is removed by drilling, blasting for use in the works.

(2) Quarry

A quarry is an open surface working from which stone or aggregates for subbase, base and surfacing are extracted for use in the works.

(3) Alluvial Deposit

An alluvial deposit is a site where gravel and aggregates of alluvial origin are extracted for use in the works.

(4) Borrow Pit

A borrow pit is a site from which loose material, other than stone, is removed for use in the works.

(5) Stockpile Area

A stockpile area is an area where material such as topsoil, fill material, gravel or aggregate is stockpiled prior to use in the works.

(6) Spoil Area

A spoil area is a site upon which surplus or unsuitable materials arising out of the works are dumped within or beyond the road reserve as indicated on the Drawing or directed by the Project Manager.

503. LOCATING MATERIAL SOURCES

- (1) The Contractor shall be responsible for locating all material sources and for obtaining approval, the acquisition or renting of all land required for rock quarries, quarries, alluvial deposits, borrow pits, spoil and stockpile areas and for access thereto in accordance with the Conditions of Contract. The location and size of rock quarries, quarries, alluvial deposit, borrow pits, spoil and stockpile areas proposed by the Contractor shall be subject to the approval of the Project Manager.

The Project Manager shall withhold his approval, if in his opinion the rock quarry, quarry, alluvial deposit, borrow pit, spoil and stockpile area, or access into them

- (a) is not approved from the concerning authorities;
- (b) will have a detrimental effect on the environment;

- (c) would be very difficult to acquire;
 - (d) is in or near an urban centre;
 - (e) will require an access road which is excessively long;
 - (f) has excessively thick layers of overburden;
 - (g) covers too large an area; and
 - (h) would constitute a danger to the public
- (2) The Contractor shall submit for the Project Manager's approval full information regarding the proposed location of the material source not later than 30 days after issue the order to commence the works of all rock quarries, quarries, alluvial deposits, borrow pits, spoil and stockpile areas that the Contractor will require for the whole of the works.

The Contractor's written notice shall include the following for each rock quarry, quarry, alluvial deposit, borrow pit, spoil and stockpile areas:

- (a) A plan at 1:500 scale giving details of:
 - (i) type of land (government, community, private), details and plot/land boundaries
 - (ii) government land including required details and permission from concerning government authorities
 - (ii) private land including land owners names and addresses, and other details, as required.
 - (iii) Dzongkahn, Geog, village, Land Record registration (i.e. Tharm number) for each plot;
 - (iv) local details such as buildings, fences, types and areas of cultivation and services, all agreed with the concerning land owners; and
 - (v) areas to be used for working areas, stockpile areas, safety blasting zones etc.
- (b) Cadastral maps covering the areas to be acquired, as available.
- (c) Details of the proposed access road route.
- (d) Technical supporting information relevant to rock quarries, quarries, alluvial deposits, borrow pits, including:
 - (i) Summary of material investigation, indicating for alluvial deposits the thickness of layers, thickness of overburden, lenticular beds, depth and configuration of the bedrock, etc., and in addition for rock quarries, the discontinuities thickness and nature of the infilling, the Weathering Index,
 - (ii) Laboratory results including petrographic identification, and for alluvial deposit material, grading, tests on the fine fraction (PI, Mica content, Organic matters), tests on the coarse fraction (LAA, AIV, ACV, FI, Bitumen Adhesive test), CBR test, or for

quarry material, LAA, AIV, ACV, Bitumen Adhesive test, Specific Gravity, Water Absorption, as appropriate

(iii) Conclusions on qualities and quantities.

- (3) Where the Contractor uses an approved rock quarry, quarry, alluvial deposit, or a borrow pit identified or instructed by the Project Manager he shall obtain the Project Manager's approval of the areas required for the rock quarry, quarry, alluvial deposit, or borrow pit and of the siting of the access roads into the rock quarry, quarry, alluvial deposit, or borrow pit. The Project Manager may require the Contractor to modify his requirements for any of the reasons outlined in Sub-clause 503(1) (b), (c), (d), (e), or (g).

Where rock quarries, quarries, alluvial deposits, or borrow pits, available for inspection at the time of the bidding, are instructed by the Project Manager the Contractor shall satisfy himself as to the quality and quantity of materials available before providing the information required in this Clause. Should such investigations reveal that there is insufficient suitable material for the use for which such material sources were intended, the Contractor shall immediately inform the Project Manager in writing and the Project Manager shall either direct that such sources are extended or that new sources shall be used.

- (4) When a rock quarry, quarry, alluvial deposit, borrow pit spoil or stockpile area has insufficient suitable material or area for the use for which it was intended the Contractor shall propose in writing that either any existing rock quarry, quarry, alluvial deposit, borrow pit, spoil or stockpile area be extended or that a new rock quarry, quarry, alluvial deposit, borrow pit spoil or stockpile area shall be used. The approval and acquisition of such new or extended rock quarries, quarries, alluvial deposits, borrow pits, spoil or stockpile areas shall be in accordance with all the above provisions of this Clause for the acquisition of the original rock quarries, quarries, alluvial deposits, borrow pits, spoil or stockpile areas.

504. SAFETY AND PUBLIC HEALTH REQUIREMENTS

The Contractor shall comply with the prevalent laws and Regulations including those of the Local Authority regarding public health and safety in respect of the operation of rock quarries, quarries, alluvial deposits, borrow pits, spoil or stockpile areas, and in the absence of, or in addition to such Regulations, shall comply with the following conditions:

- (1) All areas of work, if they are not naturally under water, shall be drained and kept drained. Where a quarry or borrow pit has been excavated such that it will not drain naturally, it shall be kept pumped dry while being used.
- (2) The Contractor shall confine his operations solely to the areas provided and shall demarcate the boundary of the area and erect temporary or permanent fencing as instructed by the Project Manager.
- (3) Where the height of any face exceeds 1 metre, the Contractor shall provide, erect and maintain at his own expense stock proof fencing and gates to prevent unauthorised access to the top of the working face.
- (4) On completion of the work all faces shall be neatly trimmed to a slope flatter than 1:4. Where this is impracticable or where the working face is to be left exposed, the edge shall be permanently fenced, as instructed by the Project Manager.

- (5) On completion of work temporary fences and all temporary structures shall be demolished and removed. All latrine pits shall be filled in and drained. The site shall be topsoiled and left neat and tidy.

505. ACCESS ROADS AND TRAFFIC CONTROL

The Contractor shall comply with the provisions of Clause 106 and with the Conditions of Contract with regard to the construction and maintenance of access roads to rock quarries, quarries, alluvial deposits, borrow pits spoil and stockpile areas and with regard to traffic operations thereon.

506. SITE CLEARANCE AND REMOVAL OF TOPSOIL AND OVERBURDEN

Unless otherwise specified in the contract or instructed by the Project Manager, the Contractor shall clear the sites of all rock quarries, quarries, alluvial deposits, borrow pits, spoil and stockpile areas in accordance with Section 600 but measurement and payment shall be made in accordance with this Section.

All existing fences, trees, hedges and other features which the Project Manager shall instruct shall not be removed or otherwise dealt. They shall be protected in accordance with Section 600.

Unless otherwise directed by the Project Manager, the Contractor shall remove topsoil and/or overburden from rock quarries, quarries, alluvial deposits, borrow pits and spoil and stockpile areas. The Project Manager shall direct whether topsoil shall be stripped and stockpiled separately or shall be excavated and spoiled together with the overburden. If suitable, the Project Manager may direct for the use of overburden in the works.

On completion of the work in any rock quarry, quarry, alluvial deposit, borrow pit, spoil or stockpile area the overburden and/or topsoil which has not been used in the works shall be pushed back, spread and landscaped over the area of the rock quarry, quarry, alluvial deposit, borrow pit, spoil or stockpile area. Where topsoil has been stockpiled separately, it shall be pushed back and spread over the rock quarry, quarry, alluvial deposit, borrow pit, spoil or stockpile area after landscaping unless the Project Manager has instructed that it shall be used for topsoiling in accordance with Section 2000.

507. SELECTION, MIXING AND STOCKPILING OF MATERIALS

Before a quarry, alluvial deposit or borrow pit is opened, the Project Manager shall instruct the Contractor as to the type of material to be excavated and the areas and depth to be worked. The Project Manager may require specific operations of equipment according to the characteristics of the raw material and the characteristics of the final product to be obtained in accordance with Clauses 508 and 509 or other relevant Sections of those Specifications.

The Contractor may be required to mix the selected materials by bulldozing into stockpiles and/or face loading by shovel. The stockpiles shall be formed at least six weeks before intended use of the materials which are to be treated and at least three weeks before intended use for materials which are not to be treated.

The Contractor shall ensure that oversize material, clay humus or unsuitable material encountered in the working operations is separated from the materials proposed for use in the works and such inferior material shall be removed to spoil.

A separate stockpile shall be used for each type and grading of material.

When removing material from stockpiles, none of the underlying material shall be mixed with it, and generally at least the bottom 100 mm layer shall be left behind.

Should any stockpile prove surplus to requirements, the Contractor shall spread the material over the area of the quarry or borrow pit unless directed otherwise by the Project Manager.

508. PRE-SELECTION OF MATERIALS

When necessary to meet requirements of the Specifications for materials extracted from quarries or alluvial deposits the Contractor shall carry out a preliminary size selection or screening of the raw materials as instructed by the Project Manager.

509. PROCESSING

The Contractor shall use adequate processing equipment and methods to achieve the characteristics and performances of the aggregates to be produced.

The processing methods may include successive steps such as primary crushing, screening for elimination of fine and soft materials, secondary crushing and recycling, washing.

The Contractor shall carry out site trials in accordance with Clause 407 using the Constructional Plant and methods proposed for selecting and processing the materials to demonstrate their suitability to achieve the materials requirements specified in the Technical Specifications.

(1) Crushing

The crushing process shall include all crushing stages, such as primary crushing, secondary crushing or grinding (after primary screening) tertiary grinding (after secondary screening), as necessary to meet the requirement of the final product specified in the Technical Specifications. The feeding hoppers shall be equipped with appropriate devices, such as drawer or vibrating metallic desk, to allow for a regular and full charge supply of the materials to the crushers.

(2) Screening

The Contractor shall eliminate polluted or soft materials after the primary crushing by screening the crushed materials through a 50 mm mesh screen.

The Project Manager may instruct the Contractor to modify the above mentioned size for the elimination of soft materials according to the results of the laboratory trials.

In case of materials sensitive to crushing, the Project Manager may instruct the Contractor to carry out a secondary screening after the secondary crushing.

(3) Recycling and Sand Production

According to the type and quality of materials to be produced, and notably the sand materials, the Contractor shall include in the crushing process the recycling of the coarse fraction resulting from the primary crushing through the secondary crusher or through the secondary or tertiary grinder.

(4) Washing

Where the washing of aggregates is required to meet the cleanliness requirements, and notably for the chippings for surface dressing, the Contractor shall incorporate to the processing plant an appropriate washing station including adequate equipment such as vibratory washing machine, a washing screw, washing tube etc. and of adequate capacity.

Sands with too high mica content shall be washed using appropriate equipment such as screw classifiers, paddle wheel etc.

(5) Testing

Each type of final products shall be tested in accordance with the tests and frequencies of testing as specified in the relevant Sections of these Specifications.

(6) Records

The Contractor shall maintain records in respect of the following data throughout the production period:

- (a) daily production
- (b) testing results, in accordance with the test schedules specified in the relevant Sections of these Specifications.
- (c) Incident occurred during the production, if any.

510. MATERIAL UTILISATION

All materials from rock quarries, quarries, alluvial deposits, borrow pits as instructed by the Project Manager shall only be used for permanent works shown on the Drawing or instructed by the Project Manager and any other use shall be subject to the Project Manager's approval.

511. MEASUREMENT AND PAYMENT

No separate measurement and payment shall be made in respect of all items in this Section, if otherwise not specified in the contract. The Contractor shall be deemed to have allowed the cost of complying all requirements of this Section elsewhere in his rates including all site clearance, overburden and topsoil removal, access roads to rock quarries, quarries, alluvial deposits, borrow pits, spoil or stockpile areas and reinstatement including landscaping and spreading topsoil.

600. SITE CLEARANCE

601. CLEARING AND GRUBBING

(1) Scope

This Section covers the clearing and grubbing necessary for the construction of the works covered by the contract. Conservation of the top soil and flora is also covered under this Section.

(2) Description of Work

(a) Clearing

Clearing shall consist of the cutting, removing and disposal of all trees, bushes, shrubs, grass, weeds, other vegetation, anthills, rubbish, fences, top soil of thickness approximately 200 mm and all other objectionable material, resulting from the clearing and grubbing. It shall also include the removal and disposal of structures that obtrude, encroach upon or otherwise obstruct the work.

The moving of a certain amount of soil or gravel material may be inherent to or unavoidable during the process of clearing and no extra payment shall be made for this. Clearing shall include the removal of all rocks and boulders of up to 0.15 m³ in size exposed or lying on the surface.

(b) Grubbing

In the roadway all trees up to 300 mm girth, stumps and roots shall be removed to a depth of not less than 150 mm below the sub-grade level or a minimum of 600 mm below the original ground level whichever is lower.

Except in borrow areas the cavities resulting from the grubbing shall be backfilled with approved material and compacted to a density not less than the density of the surrounding ground.

(c) Conservation of Top Soil

Where suitable topsoil exists within the limits of the area to be cleared and grubbed, the Contractor shall, if ordered by the Project Manager, remove the topsoil together with any grass and other suitable vegetation. If not used immediately, the topsoil shall be transported and deposited in stockpiles for later use.

(d) Conservation of Flora

Where provided for in the contract, certain designated flora encountered in the road reserve and borrow areas shall be carefully protected by the Contractor. In his contract price, the Contractor shall include for the careful removal and planting of the flora in a protected and fenced-off area and, on completion of the road, for the replanting of the flora in suitable positions in the road reserve in accordance with the Project Manager's instructions.

(3) Execution of Work

(a) Areas to be Cleared and Grubbed

Stumps, embedded logs, roots and all other vegetable growth and accumulated rubbish of whatsoever nature and all other objectionable material shall be completely removed to a depth as specified in Sub-clause 601 (2) (a) and (b).

Normally the portions of the road reserve that fall within the limits of the road prism, as well as certain borrow areas shall be cleared and/or grubbed. Where the road reserve is to remain unfenced, the full width of the road reserve shall be cleared and/or grubbed except for such trees designated by the Project Manager to be left standing and uninjured.

The Contractor shall mark the boundaries of the area for clearing and grubbing and seek the approval of the Project Manager before commencement of the work. The Project Manager shall designate in detail the exact areas to be cleared and grubbed and the time at which it shall be done.

(b) Cutting, Felling of Trees

The Contractor shall take the necessary precautions to prevent damage to structures and other private or public property.

The Contractor shall carry out felling and cutting of trees above 300 mm girth manually or using bulldozer. Such individual trees shall be approved and marked at the site by the Project Manager.

Authority for cutting trees must be obtained from the Department of Forestry Services who may require that trees be numbered, measured and marked in the presence of officials from the Department of Forestry Services. Cutting of such trees shall then be carried out by the Contractor and the timber stored at designated locations within the Right of Way.

Felling and cutting of trees on the site and piling them off the site shall conform to the requirements of the Department of Forestry Services.

Wood, branches, twigs of trees and other useful material shall be property of the Government. The serviceable materials shall be stacked at sites in the manner as directed by the Project Manager. All unserviceable materials shall be disposed off as per the instructions of the Project Manager.

All timber except such timber as can be used and all brush, stumps, roots, rotten wood and other refuse from the clearing and grubbing operations shall be completely removed from within the Right of Way. The roots of trees shall be dug at least up to 600mm from the ground level or 150mm below sub-grade level whichever is lower. All holes or hollows formed by digging up roots shall be carefully filled up with earth and properly compacted.

If felling of trees is carried out by bulldozer, power chain or any other suitable equipment shall be used to minimize any damages including environment.

(i) Blasting for Removal of Trees

The blasting operation, if any, for felling of trees shall be carried out strictly as per the guidelines given in DoR, Blasting Manual. All blasting work shall only be done under careful supervision of trained personnel and the contractor shall take all precautions as per rules for blasting operations.

The contractor shall be responsible for any damage arising out of accident to the workmen, public or property due to storage, transportation and use of explosive during blasting operation.

For felling of trees, the holes shall be drilled inclined downward with a 30 mm auger. The location of holes shall be in parallel section of the trunk just above the butt. For trees up to 450mm in girth one drill hole will be generally sufficient. For larger trees a series of equally spaced radial holes drilled within about 25 to 50 mm center to center shall be used.

The placing and quantity of explosives required shall vary with each tree and is governed by the age, type and girth. As general rule 1.2kg to 1.52 kg of explosives per square meter of cross section will be sufficient.

For removal of stumps or standing trees, placing of drill holes and quantity of explosives required shall vary with each tree and is governed by the size, type of stumps or tree, and the root system. Sandy or loose soil will require heavier charges than clay soil. The charge shall be placed centrally under the butt. But if there is only one taproot the explosives shall be placed under the fork formed by two of the largest surface roots. In stumps 900mm in girth or over, the charge shall be split and placed at two or more places around the tree.

(c) Dealing with Anthills

Where anthills are encountered within the limits of the road prism, they shall be excavated to a depth of not less than 750 mm below the finished road level and the material carted to spoil. Cavities resulting from the clearance of anthill material shall be backfilled with approved material and compacted to a density not less than that of the surrounding ground.

Where directed by the Project Manager, the area covered by anthills shall be treated, after excavation and before backfilling of cavities, with an approved ant control chemical. Payment for such treatment shall be made in the manner specified in the contract.

(d) Disposal of Material

Material obtained from clearing and grubbing shall be disposed off in borrow pits or other suitable places and be covered up with soil or gravel as directed by the Project Manager. The burning of combustible material shall not, normally, be permitted and may only be done with the prior written approval of the Project Manager.

Where fences have to be taken down, fencing wire shall be neatly wound into reels and all such wire, together with all fence posts and other serviceable material from structures, etc., shall be stacked at sites indicated by the Project Manager.

Rock dumping shall be carried out at the places identified by the Project Manager. The dump site shall be made good by placing soil layer and planting vegetation. Alternatively, the dump sites may be shotcreted if in the opinion of Project Manager such operation is warranted by the site condition. The Project Manager shall implement this operation using the provision of days work.

(e) Re-clearing of Vegetation

When portions of the road reserve, borrow or other areas have been cleared in accordance with the Technical Specifications, but in the course of time, vegetation grows again during construction, the Project Manager may, if he considers it necessary, order that the area be re-cleared.

Before the bottom layer of the embankment is made, the Contractor shall grub up and remove any vegetation that may in the meantime have grown on the surfaces previously cleared and grubbed.

Such re-clearing of areas previously cleared include the removal and disposal of grass, shrubs and other vegetation in the same manner as for the first clearing operation. No separate payment shall be made for re-clearing of vegetation.

(4) Measurement and Payment

Clearing and grubbing executed as per this Specification shall be measured in square meter.

Cutting trees including removal of stumps and their roots of girth above 300 mm and backfilling to required compaction shall be measured in number according to the sizes given below:

- (a) above 300 mm to 600 mm
- (b) above 600 mm to 1200 mm
- (c) above 1200 mm

For this purpose girth shall be measured at a height 1 meter above ground. No separate measurement shall be made for blasting for removal of trees.

Cutting of trees up to 300 mm girth including removal of stumps and roots and backfilling of holes with compaction shall not be measured separately.

Clearing and grubbing and cutting trees shall be paid at their respective contract unit rates which shall be the full and the final compensation to the Contractor as per Clause 114. The contract unit rate for cutting of trees of girth above 300 mm shall also include handling, salvaging, piling and disposing off the cleared materials with all leads and lifts.

700. EARTHWORKS

701. SCOPE

This Section covers the works related to the roadway excavation, roadway filling, excavation for foundation, backfilling, excavation for drains, channels, intercepting drains etc. The works shall consist of hauling and disposing of all unsuitable and excess materials and excavating, hauling, placing and compacting suitable

materials, from areas of excavation or borrow, all as required to construct the graded areas, embankments, roads, drainage, building construction sites and parking, or other fill area. The work shall be done in accordance with these specifications and in conformity with the lines, grades, dimensions and typical cross-sections shown on the Drawings and directed by the Project Manager.

Suitable materials taken from excavation shall be used in the formation of embankment, subgrade, or for backfilling, or construction of structures all as indicated on the Drawings or as directed by the Project Manager. When the volume of suitable excavated material exceeds that required to construct the works to the grades indicated, the excess shall be hauled, disposed with proper soil management at safe tipping sites as directed. When the volume of excavation is not sufficient for constructing the works to the grades indicated, the deficiency shall be supplied from the borrow areas.

702. DEFINITIONS AND GENERAL REQUIREMENTS

- (1) Earthwork includes two types of operations i.e. (i) earth excavation and disposal of the excavated materials (ii) earth excavation and use of excavated materials. The use of excavated materials may be in the form of filling embankment, backfilling (including grading and obtaining graded and structural backfill material) and filling other areas as required.

Earth excavation and disposal implies excavation of all types of materials including part of the structures below ground level within and outside of the limit of the right of way except for otherwise specified, shaping the exposed surface of excavation as specified or directed by the Project Manager, removal, hauling and disposal of the excavated material at the locations and in the manner as specified or directed by the Project Manager.

Excavation and filling implies excavation of materials and shaping the exposed surface of excavation as stated above, removal, hauling and use of the excavated material at the location and in the manner as specified or directed by the Project Manager.

Excavation and disposal shall include:

- (i) Excavation and disposal of any type of material indicated on the Drawing.
- (ii) Excavation and removal or partial removal of existing pavement.
- (iii) Excavation and disposal of landslides, breakages and caving-ins.
- (iv) Excavation and disposal for stream channel, trenches and drains etc.
- (v) Excavation required in cuts or under embankments below the lowest normal limit of excavation as indicated on the Drawing or below ground line.
- (vi) Excavation and disposal of unsuitable materials.
- (vii) Removal or partial removal of existing embankments and disposal of the materials as shown on the Drawing or as directed by the Project Manager.
- (viii) Excavation for foundation and disposal of materials.

Excavation and filling shall include:

- (i) Filling for embankment
- (ii) Backfilling in trenches, foundation pits etc.

- (iv) Any type of other filling or backfilling whereby the ground level is raised or a hole is filled up.
- (2) The following definitions of earthwork materials shall apply to this and other Clauses of these specifications, if otherwise not specified.
- (i) "Topsoil" shall mean the top layer of soil that can support vegetation. It shall include turf acceptable for turfing.
- (ii) "Suitable Material" shall comprise all that is acceptable in accordance with the Contract for use in the Works and which is capable of being compacted in the manner specified in Clauses 709 and 710 to form a stable fill having side slopes as indicated in the Drawing. The material used in fill (except for rock fill) shall not contain rock fragments with dimensions of more than 75 mm.
- (iii) "Unsuitable Material" shall mean other than suitable material and shall include:
- (a) Material from swamps, marshes or bogs;
- (b) Peat, logs, stumps, perishable material, organic clays;
- (c) Material susceptible to spontaneous combustion;
- (d) Material in a frozen condition; materials classified as such, if otherwise suitable, shall be classified as suitable when unfrozen.
- (e) Clay of liquid limit exceeding 70 and/or plasticity index exceeding 45;
- (f) Any such materials unless otherwise permitted in the contract
- (iv) "Rock Fill" shall consist of hard material of suitable size for deposition and compaction as given in Clause 709 and also may comprise rock as defined in Clause 703 and broken stones.
- (v) "*Cohesive Soil*" is defined as fine grained soil, which is plastic within a moderate to wide range of water content. Dry specimens are very hard, and no powder can be detached by rubbing the surface of dried pots with the fingers. Cohesive soils are formed due to chemical weathering of rocks. Example: clay, plastic silt, etc.
- (vi) "*Cohesionless Soil*" is defined as fine or coarse grained aggregates of rounded subangular or angular fragments of more or less unaltered rocks or minerals, which are formed due to physical disintegration of rocks and which is non-plastic in nature. Example: sand, gravel etc.
- (vii) "Well Graded Granular Material" consisting of gravel and/or sand shall conform to Clause 709.
- (viii) "Uniformly Graded Material" includes sands and gravels with an uniformity coefficient of 10 or less.
- (3) Prior to the commencement of any excavation, the Contractor shall satisfy himself as to the circumstances at the site and of all and the various materials, obstructions, strata, water streams including the possibility of floods, etc., and of all other items and things liable to affect or be encountered in the excavation necessary for the proper construction of the works. The rates priced in the Bill of Quantities shall provide for these circumstances.

- (4) The Contractor shall ensure that earthwork operation do not cause interference to the public. If excavations are carried out within 5 m of buildings, the Contractor shall execute the work in a way that will minimize damage and disturbances. In general, vertically sided excavation will be required in such places and all necessary timbering or other support shall be provided. Under-excavation of excavation sides will not be permitted.
- (5) No excavated suitable material other than surplus to requirements of the contract shall be removed from the site except on the direction of the Project Manager. Should the Contractor be permitted to remove suitable material from Site to suit his operational procedure, then he shall make good at this own expense any consequent deficit of filling arising therefrom.
- (6) Material in surplus to the total requirements of works, and all unsuitable materials shall, unless the Project Manager permits otherwise, be run to spoil dumps.
- (7) Where the excavation reveals a combination of suitable and unsuitable materials the Contractor shall carry out the excavation in such a manner that the suitable materials are excavated separately for use in the works without contamination by the unsuitable materials.
- (8) The Contractor shall make his own arrangements for the stockpiling of top-soil and/or suitable material.
- (9) At all times the Contractor shall ensure that earthworks are not damaged by weather or traffic. In the event of such damage occurred, the Project Manager may withdraw approval from the affected works until the Contractor has carried out repairs to restore the works to their original condition.

The cost of all such repairs and any additional testing shall be borne by the Contractor without extra cost to the Employer.
- (10) Prior to commencement of any earthwork, the work shall be set out where required as specified in Clause 107 following the clearing and grubbing as per Section 600 and a survey of the existing ground shall be conducted jointly by the Contractor and the Project Manager. The survey records shall serve as initial measurements for the determination of the final quantities of earthwork performed under the contract.
- (11) Work on embankments and/or cuttings in areas required for the construction of bridges and other structures shall not be carried out until the Project Manager agrees that construction of such structures is sufficiently advanced that there is no interference or damage to them.
- (12) The Contractor shall get approval of the Project Manager in respect of method of earthwork, type of equipment to be used, disposal and other details before commencement of the earthwork.

703. CLASSIFICATION OF EXCAVATED MATERIALS

The Definition and Classification of materials for purpose of excavation shall be as follows:

Ordinary Soil (Normal Excavation) – Generally any soil which yields to the ordinary application of pick and shovel, rake or any other ordinary digging equipment; such as vegetable or organic soil, turf gravel, sand, silt loam, clay, peat etc.

Hard Soil (Intermediate Excavation)– Generally any soil which requires close application of picks or jumpers or scarifiers to loosen; such as stiff clay, gravel, cobble stone, water bound macadam and soling of roads

Ordinary Rock (Intermediate Excavation): Generally any rock which can be excavated by splitting with crow bars or picks and does not require blasting, wedging or similar means of excavation such as lime stone, sand stone, hard laterite, hard conglomerate and un-reinforced cement concrete below ground level. If required light blasting may be resorted to, for loosening the materials but this will not in any way entitle the material to be classified as “Hard Rock”

Hard Rock (Hard Excavation) : Generally any rock or boulder for the excavation of which blasting is required such as quartzite, granite, basalt, reinforced cement concrete (reinforcement to be cut through but not separated from concrete) below ground level and the like.

Hard Rock (Hard Excavation where blasting prohibited) : Hard rock requiring blasting as described above but where the blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging or any other agreed method.

The PETTIFER point load index graph as per BS:5930 shall be used to classify the material type (soil or rock) in case of any misunderstanding and or disputes between the contractor and the Project Manager in the classification of soil.

The classification requires testing of the rock lumps of 5 representative samples in the laboratory using point load test apparatus to obtain point load Index (I_{c50}). The discontinuity spacing index (I_i) shall be noted jointly by the contractor and the Project Manager. Using these two parameters the ‘soil’ or ‘rock’ type shall be classified. All easy to moderately hard digging shall be classified as soil and easy ripping to material requiring use of rock breaker or controlled blasting shall be classified as ‘rock’.

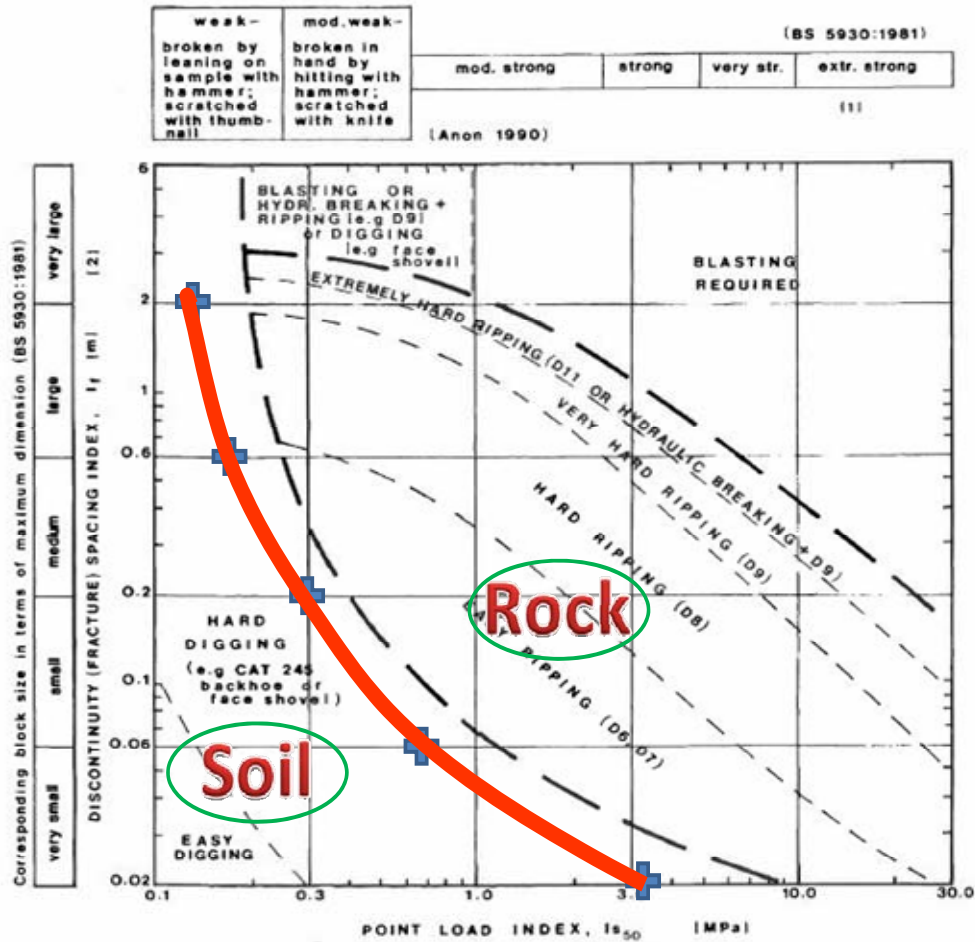


Figure 7.1 : PETTIFER point load Index graph

Marshy Soil: This shall include soils like soft clays and peat excavated below the original ground level of marshes and swamps and soils excavated from other areas requiring continuous pumping or bailing out of water.

All Kinds of Soil: Generally any strata, such as sand, gravel, loam, clay, mud, black cotton soil, moorum, shingle, river or nallah bed boulders, soiling of roads, paths etc. and hard core macadam surface of any description (water bound, grouted tarmac etc.), lime concrete, mud concrete and their mixtures which for excavation yields to the application of picks, shovels, jumpers, scarifiers, ripper and other manual digging implements.

Authority for classification: Project Maager shall decide the classification of excavation and his decision shall be final and binding on the Contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of the Project Manager.

Setting out: After the site has been cleared, the limits of excavation shall be set out true to lines, curves, slopes, grades and sections as shown on the drawings or as directed by the Project Manager. The

Contractor shall provide all labour, survey instruments and materials such as strings, pegs, nails, bamboos, stones, lime, mortar, concrete, etc., required in connection with the setting out of works and the establishments of bench marks. The Contractor shall be responsible for the maintenance of the benchmarks and other marks and stakes as long as in the opinion of the Project Manager, they are required for the work.

The ground levels shall be taken at 5m to 15m intervals in uniformly sloping ground and at closer intervals where local mounds, pits or undulations are met with. The ground levels shall be recorded in field books and plotted on plans. Plans shall be drawn to a suitable scale and North direction and position of benchmark shall be shown on the plans. The contractor and the Project Manager shall sign the plan before the earthwork is started. The contractor at his own cost shall supply the labour required for taking levels.

Stripping and storing topsoil: When so directed by the Project Manager, the topsoil existing over the sites of excavation shall be stripped to specified depths and stockpiled at designated locations for re-use in covering embankment slopes, cut slopes, and other disturbed areas where re-vegetation is desired. Prior to stripping the topsoil, all trees, shrubs etc. shall be removed along with their roots, with the approval of the Project Manager.

Excavation: All excavations shall be carried out in conformity with the directions laid herein-under and in a manner approved by the Project Manager. The works shall be so done that the suitable materials available from excavation are satisfactorily utilized as decided upon beforehand.

While planning of excavations, the Contractor shall take all adequate precautions against soil erosion, water pollution etc. and take appropriate drainage measures to keep the sites free of water.

The excavations shall conform to the lines, grades, side slopes and levels shown on the drawings or as directed by the Project Manager. The Contractor shall not excavate outside the limits of excavation. Subject to the permitted tolerances, any excess depth/ width excavated beyond the specified levels/dimensions on the drawings shall be made good at the cost of the Contractor with the suitable material of characteristics similar to that removed and compacted.

All debris and loose materials on the slopes of cutting shall be removed. No backfilling shall be allowed to obtain required slopes excepting that when boulders or soft materials are encountered in the cut slopes, these shall be excavated to approved depth on instructions of the Project Manager and the resulting cavities filled with suitable materials and thoroughly compacted in an approved manner.

After excavation, the sides of the excavated areas shall be trimmed and the area contoured to minimize erosion and ponding, allowed for natural drainage to take place. If trees were removed, new trees shall be planted, as directed by the Project Manager. The cost of planting new trees shall be deemed to be incidental to the work.

Methods, tools and equipment: Only such methods, tools and equipment as approved by the Project Manager shall be adopted/used in the work. If so desired by the Project Manager, the Contractor shall demonstrate the efficacy of the type of equipment to be used before the commencement of the work. Methods, tools and equipment to be adopted for the work shall be such which will not affect the property to be preserved

Rocks excavation: Rocks, when encountered in the road excavation, shall be removed up to the formation level or as otherwise indicated on the drawings. Where, however, unstable shale or other unsuitable materials are encountered at the formation level, these shall be excavated to the extent of 500 mm below the formation level or as otherwise specified. In all cases, the excavation operations shall be so carried out that at no point on cut formation the rock protrudes above the specified levels.

rocks and large boulders which are likely to cause differential settlement and also local drainage problems should be removed to the extent of 500 mm below the formation level in full formation width including drains and cut through the side drains.

Slopes in rock cutting shall be uniform lines corresponding to slope lines shown on the drawings or as directed by the Project Manager. Notwithstanding the foregoing, all loose pieces of rock on excavated slope surface, which move when pierced by a crowbar, shall be removed.

Where blasting is to be resorted to, the same shall be carried out as per the RGOB blasting manual and all precautions indicated therein observed.

Marsh excavation: The excavation of soils from marshes/swamps shall be carried out as per the programme approved by the Project Manager. Excavation of marshes shall begin at one end and proceed in one direction across the entire marsh immediately ahead of back filling. The method and sequence of excavating and back filling shall be such as to ensure, to the extent practicable, the complete removal or displacement of all muck from within the lateral limits called for on the drawings or as staked by the Project Manager, and to the bottom of the marsh, firm support or levels indicated.

Blasting: The contractor shall obtain a licence from the competent authority for obtaining and storing the explosives. The contractor shall procure the explosives, fuses, detonators etc. from the Government or as per the provision in terms and condition of the contract. The Project Manager or his representative shall have the right to check the contractor's store and accounts of explosives. The contractor shall provide facilities for this.

All blasting work shall only be done under careful supervision of trained personnel and the contractor shall take all precautions as per rules for blasting operations.

The contractor shall be responsible for any damage arising out of accident to the workmen, public or property due to storage, transportation and use of explosive during blasting operations.

Cutting: In firm soil, the sides of the trench shall be kept vertical up to a depth of 2m from the bottom. For a greater depth, the excavation profiles shall be widened by allowing steps of 500mm on either side after every 2m from the bottom. Alternatively the excavation can be done so as to give slopes of 1:4.

Where the soil is soft, loose or slushy, the width of steps shall be suitably increased or side sloped or the soil shored up as directed by Project Manager. It shall be the responsibility of the contractor to take complete instructions in writing from Project Manager regarding the stepping, sloping or shoring to be done for excavation deeper than 2 metres.

The bed of excavation shall be made to the correct level or slope and consolidated by watering and ramming. Soft/defective spots shall be dug out and filled with levelling concrete as directed by the Project Manager. The excess depth shall be made good by the contractor at his own cost with the concrete of the same mix as levelling concrete.

Where hard rock is met with and blasting operations are considered necessary, the contractor shall obtain the approval of the Project Manager. For an ordinary rock, in general, the blasting operation is not adopted but if the contractor wishes to resort to blasting, he can do so, with the permission of the Project Manager but nothing extra shall be paid for this blasting

Measurements and Payment:

In general, excavation for roadway including rock excavation shall be measured by taking cross sections at suitable intervals in the original position before the work starts and after its completion and computing the

volumes in cu. m. by the method of average end areas for each class of material encountered. Where it is not feasible to compute volumes by this method because of erratic location of isolated deposits, the volumes shall be computed by other accepted methods.

The payment shall be as per the priced BoQ and it shall cover the cost for carrying out all the required ploughing operations including cost of labour, materials, equipment hired/owned, tools and plants, and incidentals necessary to complete the work. The rate shall include, where necessary, disposing of the cleared materials with all lifts and lead up to 50m.

704. EXPLOSIVES AND BLASTING

(1) General

The procurement, transportation, storage, use, account and disposal of balance and defective explosive materials shall be strictly in accordance with DoR "Blasting Manual", which is available at DoR Head Office and the by-laws issued by the Ministry of Home Affairs, RGoB and ordinances applicable to the work site. Should there be any discrepancy found between procedures described hereunder and the prevalent laws and ordinance, the later shall supersede.

Blasting shall be carried out in a controlled manner that completes the excavation to the lines indicated on the Drawing or as directed by the Project Manager, with the least disturbance to adjacent material. It shall be done only with the written permission of the Project Manager.

The Contractor shall adopt such method that is consistent with the safety and job requirements. Prior to starting any phase of the operation, the Contractor shall provide information describing pertinent blasting procedures, dimensions and notes.

(2) Materials, Tools and Equipment

All the materials, tools and equipment used for blasting operations shall be of approved type. The Project Manager may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be water-resistant and shall remain unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as shall permit sufficient time to the firer to reach to a safe place before explosion takes place. Detonators shall be capable of giving effective blasting of the explosives. The blasting powder, explosives, detonators, fuses, etc., shall be fresh and not damaged due to dampness, moisture or any other cause. They shall be inspected before use. The damaged articles, if any, shall be discarded totally and safely removed from the site immediately.

(3) Personnel

The blasting operation shall remain in the charge of competent and experienced blaster with legal license and thorough knowledge of handling explosives and blasting operations. The Contractor shall employ blasters experienced in controlled blasting and these blasters must be in possession of a current blasting certificate or should recently have participated in training for Controlled Blasting organized by Department of Roads.

(4) Blasting Operations

Explosives shall be used in the quantities and manner recommended by the manufacturers. The written permission of the Project Manager shall be obtained for each location or series of locations where the Contractor wishes to use more than 5 kg of explosives in one series of blast. Such permission shall not in any way relieve the Contractor of his liabilities under the Conditions of Contract.

The blasting shall be carried out during fixed hours of the day as ordered in writing by the Project Manager. The hours shall be made known to the people in the vicinity. All the charges shall be prepared by the blaster only.

The Project Manager must be notified at least 24 hours in advance of any blasting operation. When blasting is to be carried out, the Contractor shall determine the danger zone likely to be created, and shall ensure that all personnel, vehicles and livestock are clear of the zone before and during the blast. In settlement areas, the Contractor shall take steps to avoid damage to property from flying rock by using blasting mats or other suitable blanketing materials.

The Contractor shall notify each public utility organization/company having structures in proximity to the site of the work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury.

Danger red flags shall be displayed prominently in all directions during the blasting operations. The flags shall be planted 200 m from the blasting site in all directions. People, except those who actually light the fuse, shall be prohibited from entering this area, and all persons including workmen shall be excluded from the flagged area at least 10 minutes before the firing, a warning siren being sounded for the purpose.

The charge holes shall be drilled to required depths and at suitable places. Blasting shall be as light as possible consistent with thorough breakage of the material necessary for economic loading and hauling. Any method of blasting which leads to overshooting shall be discontinued.

Not more than 10 charges shall be prepared and fired at a time. The man in charge shall blow a siren in a recognized manner for cautioning the people. The charges shall be lighted by the blasters only. The blaster shall count the number of explosions. He shall satisfy himself that all the charges have been exploded before allowing the workmen to go back to the work site.

After blasting operations, the Contractor shall compact the loose residual material removed below sub-grade and replace the material removed below sub-grade with suitable material.

When forming final cut faces, pre-split blasting techniques as recommended in the Specification for Road and Bridge (IRC) shall be carried out to ensure that blasting damage to the cut face is minimized. Details of the pre-splitting technique to be used shall be notified to and approved by the Project Manager at least 24 hours in advance of the blasting operation.

(5) Account

A careful and day to day account of the explosive shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Project Manager at all times. Records must be kept by the Contractor of all drilling and blasting operations showing hole diameters and depths, drilling pattern, explosive charge and type per hole, detonator delay times and total charge per blast. These records must be submitted to the Project Manager on completion of charging.

705. EXCAVATION IN CUTTING

- (1) Clearing and grubbing shall be performed as specified in Section 600.
- (2) While executing excavations, the Contractor shall take adequate precautions against soil erosion and water pollution.
- (3) All suitable excavated materials shall be used in construction of the roadway to the extent as required.

- (4) Hauling of material from cuttings or borrow pits to embankments or other areas of fill shall proceed only when sufficient plant or labour is operating at the place of deposition to ensure that adequate spreading and compaction of material can take place.
- (5) Over-excavation shall not be permitted. Any excess depth excavated below the formation levels as specified shall be made good by the Contractor at his own expense by backfilling with suitable material of similar characteristics to those of moved materials with compaction as specified in Clauses 709 and 710.
- (6) The slopes of cutting shall be cleared of all rock fragments which move when pricked by a crow-bar, unless otherwise directed by the Project Manager. Where the Project Manager considers that the slope, immediately after dressing, shall not be permanently stable, he shall direct the Contractor as to the stabilization measures required. The Contractor shall carry out these measures soon after Project Manager's instruction.

When completed, the excavation slopes shall be true to the lines and levels as shown on the Drawing or directed by the Project Manager. When completed, no point on slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock, no point shall vary more than 300 mm from the designated slope.

- (7) If slips, slides, overbreaks or subsidence occur in cutting, they shall be removed. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction.
- (8) If water is encountered in excavations due to seepage, springs, or other causes, it shall be removed by suitable diversions or bailing out and the excavation shall be kept dry. The drained water shall be discharged into suitable outlets as not to damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore to the original condition at his own cost or compensate for the damage.
- (9) General excavation of rocks such as in steep slopes or failed slopes, fragmented rocks etc shall be carried out by manual labour using jack hammer, chiseling, pre-splitting and controlled blasting with utmost care and diligence to avoid cracks, fissures, etc. such as on strip footing for steel arches or precast RCC box culvert or similar structures.

706. EXCAVATION BELOW EMBANKMENTS AND BELOW FORMATION LEVEL IN CUTTINGS

- (1) Where any unsuitable material below the natural ground level under proposed embankments or below formation level in cuttings is required to be excavated, it shall be removed to such depth and over such areas as shown on the Drawing or as directed by the Project Manager. The excavated materials shall be disposed off as indicated on the Drawing or directed by the Project Manager. The resultant excavation shall be backfilled with suitable material and shall be leveled and compacted to the density as specified for forming of the embankments. Nevertheless, if such backfill has to be carried out in standing water, the Contractor shall use only an approved non-plastic well-graded granular material having maximum size of not greater than 75mm. Such materials may be deposited in water without use of compaction equipment.
- (2) Where shown on the Drawing, approved, graded stones having size from 380 mm to 150 mm and containing not more than 10 percent, below 150 mm in size shall be placed directly on the natural occurring unsuitable material. This type of rock fill material shall be deposited in accordance with the requirements of Clause 709 and compacted as per Clause 710.

- (3) If after the removal of material as specified in Sub-clause 706 (1), the Contractor allows the materials so exposed to reach a condition where compaction of back filling is impracticable, he shall make good at his own expense either by additional excavation and filling in the manner specified in this Clause, or by waiting until the condition of the exposed material is fit to receive the approved backfill.

707. EXCAVATION FOR FOUNDATION, DITCHES, PAVEMENT, SLOPES, LANDSLIDES

1. Excavation for Foundation

(1) Scope

Excavation shall consist of the removal of material for the construction of foundations for drainage structures, retaining walls, head walls, cut off walls, culvert, bridges and other similar structures to the lines and dimensions shown on the Drawing or as instructed by the Project Manager in accordance with the requirements of these Specifications. The work shall include construction of protection and subsequent removal of all necessary sheeting, shoring, bracing, diversion of water/flow, draining and pumping, the removal of all logs, stumps, grubs and other deleterious matters and obstructions necessary for placing the foundations; trimming bottoms of excavations; and clearing up the site and the disposal of all surplus material.

(2) Excavation

Excavation shall be taken to the length and width of the lowest step of the footing and the sides shall be left to plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench does not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Project Manager.

The depth to which the excavation is to be carried out shall be as shown on the Drawing or as directed by the Project Manager.

Where blasting is to be resorted to, the same shall be carried out in accordance with Clause 704.

(3) Dewatering, Diversion of Flow and Protection

Normally, open foundations shall be laid dry. Where water is encountered in excavation due to stream flow, seepage, springs, rain or other reasons, the Contractor shall take adequate measures such as bailing, pumping, constructing diversion channels, drainage channels, bunds, cofferdams and other necessary works to keep the foundation pit or trenches dry, when so required and to protect the green concrete/masonry against damage by erosion, failure of cut slopes or sudden rising of water level. The methods to be adopted in this regard and other details thereof shall be left to the choice of the Contractor, but subject to approval of the Project Manager. Approval of the Project Manager shall, however, not relieve the Contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works.

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping shall be permitted during the placing of concrete or for a period of at least 24 hours thereafter, unless it is done from a suitable sump and is separated from the concrete work by a watertight wall or other similar means.

At the discretion of the Contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the area of excavation.

The Contractor shall take all precautions in diverting flow and in discharging the drained water as not to cause damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore to the original condition at his own cost or compensate for the damage.

(4) Preparation of Foundation Base

The bottom of the foundation pit shall be leveled both longitudinally and transversely or stepped as directed by the Project Manager. Before footing is laid, the surface shall be slightly watered and rammed, if surface is not wet. In the event the Contractor carries out excavation deeper than that shown on the Drawing or as otherwise ordered by the Project Manager, the Contractor shall make up the extra depth with concrete or masonry at the cost of the Contractor. Ordinary filling shall not be allowed for the purpose to bring the foundation to level.

When rock or other hard strata is encountered, it shall be freed of all soft and loose materials, cleaned and cut to firm surface either leveled or stepped as directed by the Project Manager. All seams shall be cleaned out and filled with cement mortar or grout to the satisfaction of the Project Manager. In the case of rock excavation, annular space around footing shall be filled with concrete of grade M10 up to top level of rock or as instructed by the Project Manager.

After the excavation is completed, the Contractor shall inform the Project Manager to that effect and no footing, bedding materials or structures shall be placed until the Project Manager has approved the depth and the suitability of foundation material.

If, at any point, in any foundation excavation, material unsuitable for foundations is encountered, the Contractor shall, if so instructed by the Project Manager, shall remove all such materials and refill with suitable materials thoroughly compacted by tamping or rolling in layers of not more than 150 mm thick each.

(5) Slips and Blows

If there are any slips or blows in the excavation, these shall be removed by the Contractor at his own cost.

(6) Public Safety

Where required, trenches and foundation pits shall be securely fenced, provided with proper caution signs and marked with red lights at night to avoid accident as per Sub-clause 105 (5).

The Contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures.

(7) Removal of Shoring and Protection

All shoring, sheeting, bracing used in the foundation and protection shall be removed by the Contractor after the completion of the substructure unit. The removal shall be carried out in such a manner as not to disturb or damage the finished work.

2. Excavation for Ditch, Clearing of Existing Drains and Channels

Ditch excavation shall consist of excavation for drains, channels, or any other type as designated on Drawings or as directed by the Project Manager. The work shall be performed in the proper sequence with other construction. The location of all ditches shall be established on the ground before starting construction of

adjacent works. Suitable excavated material shall be placed in fills or stockpiles while unsuitable or surplus material shall be placed in spoil areas or as directed by the Project Manager. Intercepting ditches shall be constructed prior to the starting of adjacent excavation operations. Handwork shall be performed as required to secure a finish true to line, elevation and cross section, as designated.

Ditches constructed in the works shall be maintained to the required cross-section and shall be kept free from debris or obstructions until completion of the contract. As necessary, sufficient openings shall be provided through spoil banks to permit drainage from adjacent lands. No extra payment shall be made for ditches constructed in the works.

Existing drains and channels where shown on the Drawings or as directed by the Project Manager, shall be cleared by removing vegetation growths and debris deposits. The sides shall be trimmed throughout and the bottoms uniformly graded and the ditches kept clean and trimmed and maintained for the period of the Works. Unsuitable material removed from existing drains, channels shall be disposed off in spoil areas designated by the Project Manager.

3. Excavation (Scarification) for Pavement

Where shown on the Drawings or as directed by the Project Manager the existing pavement surfacing or pavement layers in carriageway and shoulders shall be scarified, transported and stockpiled at designated area for reuse or disposed to spoil. The surface after scarification shall be prepared to meet the requirements of Section 900 of the Technical Specifications. It will be broken, if needed, mixed to achieve required grading of base, subbase including adding extra base, subbase materials as required, watered and laid to required profiles and compacted in its final position as directed by the Project Manager.

4. Excavation for Slopes and Removal of Landslides

Where shown on the Drawings or as directed by the Project Manager the excavation shall be carried out for slopes in widening of road or curves, removal of unstable slopes/landslide, trimming of slopes, etc. The earthwork for removal of landslides shall be other than those encountered in routine maintenance of road of the Specifications. Suitable excavated material shall be placed in fills or stockpiles while unsuitable or surplus material shall be placed in spoil areas or as directed by the Project Manager.

708. REFILLING OF FOUNDATION PITS AND TRENCHES, REMOVAL OF SUPPORTS AND FILLING TO STRUCTURES

Refilling of foundation pits and trenches shall consist of common backfill and/or pervious backfill as shown on the Drawing or as directed by the Project Manager.

1) Materials **(a) Common Backfill**

Common backfill materials other than pervious backfill shall be suitable material approved by the Project Manager.

(b) Pervious Backfill

Unless otherwise specified in the contract, it shall consist of gravel, crushed gravel, crushed rock, natural sands, manufactured sands or combinations thereof. It shall conform to the grading limits set out in Table 7.1.

Table 7.1: Grading Limits of Pervious Backfill

Sieve Size (mm)	Percentage Passing by Weight		
	Class 1, Fine Grade	Class 2, Medium Grade	Class 3, Coarse Grade
40	-	-	95-100
20	-	90-100	50-100
10	100	40-100	15-55
4.75	90-100	25-40	0-25
2.36	80-100	18-33	0-5
1.18	50-95	-	-
0.60	30-75	5-15	-
0.300	10-30	0-7	-
0.150	1-10	-	-
0.075	0-3	0-3	0-3

D₁₅ (filter)

Piping ratio ----- <5

D₈₅ (soil)

D₁₅ (filter)

Permeability ratio ----- >5

D₁₅ (soil)

D₅₀ (filter)

Mean ratio ----- <25

D₅₀ (soil)

Where D₁₅ and D₅₀ (filter) are used to designate the size of sieve passing 15 percent and 50 percent respectively size of filter material (i.e. the size of the sieve that allows 15 percent and 50 percent respectively by weight of the filter material to pass through it).

(c) “Critical” or structural Backfill

‘Critical’ or structural backfill is a non-cohesive backfill and shall be used for steel arches, RCC inverted ‘U’ Box culverts and soil reinforced walls with Gabion Facia. The material and construction methodology shall comply with section 1906.

(2) Method of Filling

Backfilling material shall not be permitted under water unless specifically described in the contract or approved by the Project Manager. It shall be placed and compacted in layers in compliance with the requirements of Clause 610. Any support structures for the excavation shall be withdrawn as the filling proceeds unless described in the contract or ordered by the Project Manager to be left in. The backfill shall be placed in by such methods which shall avoid loading the structure in any manner which may affect its stability or overload its underlying foundation material or substructure. The backfill in front of abutments and wing walls shall be placed first to avoid the possibility of forward movement. Precautions shall be taken to prevent any wedge action against upright surfaces, and the slopes bounding the excavation shall be stepped as directed by the Project Manager before backfill is placed. The backfill material around box culverts, piers and curtain walls shall be placed simultaneously on both sides of the structure.

709. FORMING OF EMBANKMENT AND OTHER AREAS OF FILL

- (1) The work shall consist of the construction of embankment, filling on other areas and backfill not specified elsewhere by providing materials as specified or approved by the Project Manager, placing, compacting and shaping to lines, levels, grades and cross sections as shown on the Drawing or as directed by the Project Manager. The maximum size of the coarse material in the mixture shall not exceed 75mm for general earth fill.
- (2) The limits of embankment shall be built sufficiently wider than the design dimension to facilitate in achieving required compaction nearby outer faces of the embankment. The surplus material shall be trimmed to the specified side slopes and width of the embankment.
- (3) Where necessary, the original ground shall be scarified, mixed with water, leveled and then compacted so as to achieve the density mentioned in Clause 710. Where the height of embankment, as measured from formation level to the original ground level, is less than 200 mm, the embankment foundation shall be compacted in accordance with the requirements of Clause 710 such that the required compaction is achieved within the upper 300 mm below formation level. Where necessary, embankment foundations shall be excavated/furrowed and brought under optimum moisture content and re-compacted in layers of 150 mm each in order to achieve the required level of compaction.
- (4) Embankments shall be built up evenly over the entire width and shall be maintained at all times with a sufficient camber to enable surface water to drain rapidly from them. Damage to compacted layers by constructional or other traffic shall be made good by the Contractor.
- (5) The natural moisture content and the optimum moisture content of the material to be placed in the embankment shall be checked before start of placing material. If these parameters are found to be out of the specified limits, the same shall be made good. Where water is required to be added in such construction, it shall be sprinkled uniformly and thoroughly mixed in soil by blading or harrowing until uniform moisture content as specified is obtained.

Moisture content, checked in accordance with IS 2720 (Part 2), at the time of compaction shall be between 90% and 105% of the Optimum Moisture Content as determined in accordance with IS 2720 (Part 8).

If the material delivered for fill/backfill is too wet, it shall be dried by aeration and exposure to sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced by the above procedure, compaction work shall be suspended.

If the material deposited as fill subsequently reaches a condition such that it cannot be compacted in accordance with the requirements of the specifications the Contractor shall

- (i) Make good by removing the material off the embankment and placing suitable material; or
 - (ii) Make good by tipping it elsewhere until it is in a suitable physical condition for re-use; or
 - (iii) Make good the material by mechanical or chemical means to improve its properties acceptable to the Project Manager.
- (6) Where fill is required to be constructed across water logged or soft clayey ground that displays excessive movement under normal constructional equipment, it may be necessary to construct a capping layer in accordance with Clause 804.
 - (7) Rock used in rockfill embankments shall be deposited in horizontal layers not exceeding 450 mm each extending up to the full width of the embankment.

Material shall be spread, leveled and compacted in accordance with Clause 710. Each layer shall consist of reasonably graded rock and all surface voids shall be filled with broken fragments before the next layer is placed. The top surface and side slopes of embankments so formed shall be thoroughly blinded with approved well graded material to seal the surface.

- (8) Isolated boulders each within the range of 0.05 cubic meters in size may be incorporated in embankments, not of rock fill, at the discretion of the Project Manager provided that the specified compaction requirements are met and it shall not be placed less than 1 m below formation level of carriageways or shoulders.
- (9) While filling embankments up to or over culverts or pipe drains, and where required in the contract, up to bridges, the Contractor shall bring the embankments up equally on both sides. In rock fill embankments the rock shall be carefully packed for such distance from the structure as is described in the contract.

Where provision of filter membrane is specified behind structures, the same shall be laid in layers simultaneously with the laying of fill material.

- (10) If the Contractor wishes to continue to use the surface of embankments including shallow filling for constructional traffic before trimming to formation level, he shall bring up and maintain the area between the extremities of the carriageways including (if any) central reserve and hard shoulders to a level not less than 150 mm above formation level whereupon constructional traffic shall be allowed to use the surface and shall be made good by the Contractor at his own expense. When it is necessary to complete the formation level and this has been done, the movement and use of construction equipment thereon shall be in accordance with Clause 903.

710. COMPACTION OF EMBANKMENTS AND OTHER AREAS OF FILL/BACKFILL

- (1) The Contractor shall obtain the Project Manager's approval of all fill layers before covering with subsequent layers.
- (2) All fill shall be compacted to the depth and degree of compaction as specified in Table 7.2 or as shown on the Drawing. This requirement applies whether the specified zone is in fill or in existing ground, except for any part which may fall within rock or rock fill. Formation level in this context shall mean top of sub grade.

Table 7.2: Depth and Degree of Compaction

Location	Depth below Formation Level (mm)	Minimum Compaction (% MDD Heavy Compaction)
Roadway Embankment including roadway embankment over rock fill	0-300	95
Roadway Cut	0-300	95
All other roadway fill and backfill not separately specified	-	90

- (3) Compaction shall be undertaken to the requirements of Table 7.3 by approved compaction equipment.

Table 7.3: Compaction Requirements

Type of Compaction Equipment	Category	Cohesive Soil		Well Graded granular and Dry cohesive soils		Uniformly Graded materials	
		Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes
Smooth Wheeled Roller	<u>Load per mm. width or roll</u>						
	2.14 - 2.67 kg.	130	8	130	10	Unsuitable	
	2.68 - 5.35 kg.	130	6	130	8	Unsuitable	
	More than 5.35 kg.	130	4	150	8	Unsuitable	
Grid Roller	<u>Load per mm. width of roll</u>						
	2.65 - 5.35 kg.	150	10	Unsuitable		150	10
	5.36 - 8.00 kg.	150	8	130	12	Unsuitable	
	More than 8.00 kg.	150	4	150	12	Unsuitable	
Pneumatic Tyre Roller	<u>Wheel Load</u>	130	6	Unsuitable		Unsuitable	
	1000 – 1500 kg.	150	5	Unsuitable		Unsuitable	
	1500 – 2000 kg.						
	2000 – 2500 kg.	180	4	130	12	Unsuitable	
	2500 – 4000 kg.	230	4	130	10	Unsuitable	
	4000 – 6000 kg.	305	4	130	10	Unsuitable	
	6000 – 8000 kg.	355	4	150	8	Unsuitable	
	8000 – 12000 kg.	405	4	150	8	Unsuitable	
	More than 12000 kg.	455	4	180	6	Unsuitable	
	Vibratory Roller	<u>Static Load per mm. width of Vibratory roll</u>					
0.27 - 0.44 kg.		Unsuitable		75	16	150	16

Type of Compaction Equipment	Category	Cohesive Soil		Well Graded granular and Dry cohesive soils		Uniformly Graded materials	
		Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes
	0.45 - 0.71 kg.	Unsuitable		75	12	150	12
	0.72 - 1.25 kg.	100	12	130	12	150	6
	0.26 - 1.78 kg.	130	8	150	8	200	10
	1.79 - 2.32 kg.	150	4	150	4	230	12
	2.33 - 2.86 kg.	180	4	180	4	255	10
	2.87 - 3.56 kg.	200	4	200	4	280	8
	3.57 - 4.28 kg.	230	4	230	4	305	8
	4.28 - 5.00 kg.	225	4	225	4	305	6
Vibrating Plate Compactor	<u>Static Pressure under base plate</u>						
	0.088 - 0.105 kg/sq.cm	Unsuitable		Unsuitable		75	6
	0.106 - 0.123 kg/sq.cm	Unsuitable		75	10	100	6
	0.124 - 0.141 kg/sq.cm	Unsuitable		75	6	150	6
	0.142 - 0.176 kg/sq.cm	100	6	130	6	150	4
	0.177 - 0.211 kg/sq.cm	150	6	150	5	200	4
	More than 0.211 kg/sq.cm	200	6	200	5	255	4
Vibro-tamper	<u>Weight</u>						
	50 - 63 kg.	100	3	100	3	150	3
	64 - 75 kg.	130	3	130	3	200	3
	Mote than 75 kg.	200	3	150	3	230	3

Type of Compaction Equipment	Category	Cohesive Soil		Well Graded granular and Dry cohesive soils		Uniformly Graded materials	
		Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes
Power Rammer	<u>Weight</u>						
	100 kg. - 500 kg.	150	4	150	6	Unsuitable	
	More than 500 kg.	280	8	280	12	Unsuitable	

- (4) Each layer of rock used to fill in embankments shall be spread and leveled in accordance with Sub-clause 709(7) and systematically compacted.
- (5) Layers of material other than rockfill shall not exceed 150 mm compacted depth unless and until the Contractor can demonstrate to the satisfaction of the Project Manager that he can successfully compact layers of a greater thickness.
- (6) Each layer shall be constructed in lengths suitable to the compaction and working methods used. Materials of each layer shall be thoroughly mixed with water as necessary to facilitate its compaction to the specified density.
- (7) In cut areas, the subgrade shall be processed as necessary and compacted to the depth and compaction requirements as given in Table 7.2. In the event that the Contractor is unable to achieve the minimum compaction requirements below formation level he shall excavate and recompact in layers as necessary.
- (8) Where it may be impracticable to use conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory rollers, power rammers or plate compactor. Track rolling can be used where specified in the drawing with the approval of the Project Manager. Care shall be taken to ensure that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to it.

711. COMPACTION TRIALS

- (1) Before commencing filling embankment and from time to time as may be considered necessary by the Project Manager, the Contractor shall carry out compaction trials in the presence of the Project Manager on each of the main types of soil and rockfill to be used and compacted in the Works. The Contractor shall carry out all necessary laboratory and field testing as required by the Project Manager and shall submit the results of all tests to the Project Manager. The trial procedure shall include the compaction of trial areas selected by the Project Manager. The surface of each area shall first be well compacted to the satisfaction of the Project Manager. Each type of material being used shall be compacted in equal layers at uniform but differing moisture contents to a predetermined number of passes using the Contractor's proposed compaction equipment.

- (2) Following completion of the compaction trials, the Contractor shall submit to the Project Manager, for his approval, his proposals for the compaction of each type of material to be encountered in the Works and its degree of compaction specified. The Contractor's proposals shall include reference to the types of equipment, the operating weights and tyre pressure, the methods of adjusting the moisture content, the number of passes and the loose depth of each layer.
- (3) If, in the opinion of the Project Manager, the results of the compaction trials indicate that the Contractor's proposed plant and methods shall achieve the densities as specified, the Project Manager shall approve the same. Otherwise the Contractor shall submit, in writing, proposals for modifying the plant and/or methods and shall, if the Project Manager so requires, compact further trial areas in accordance with these modified proposals until the Project Manager approves of Contractor's proposals.
- (4) When compaction of earthworks is in progress, the Contractor shall adhere to the compaction procedures approved by the Project Manager.
- (5) Notwithstanding the Project Manager's approval of any of the Contractor's plant or methods, the Contractor shall at all times be solely responsible for executing the earthworks in accordance with the Specifications and the Drawing.

712. BENCHING

- (1) Where embankments are to be constructed on hill slopes or slopes with more than or equal to 1 vertical to 4 horizontal slopes, benches with vertical and horizontal faces shall be cut into the existing slope (including rock) and the embankment shall be built up in successive layers. Where the cross slope is less than 1 vertical to 4 horizontal slope (other than rock) shall be loosened by scarifying to a depth of not less than 100 mm measured perpendicular to the slope, to ensure a good bond between the embankment and the embankment foundation. Material which has been loosened shall be covered with the first layer and compacted to the specified density simultaneously with the first layer of embankment material placed.
- (2) Where existing embankments are to be widened or included in a new embankment and slopes are not more than 1 vertical to 4 horizontal, the slope of the existing embankment shall be scarified to a depth of not less than 100 mm to ensure bond. Where the slope is less than 1 vertical to 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut in existing slopes and the widened embankment shall be built up in successive layers of thickness of 150 mm to the level of old road.

Where the width of the widened portions is insufficient to permit the use of heavy rollers, compaction to the specified density shall be carried out with the help of small vibratory roller/plate compactor/rammer or other approved methods.

713. FINISHING OF SLOPES

The slopes of cuttings shall be trimmed to neat line and to a standard that is attainable with proper care and workmanship in the type of material concerned. All loose rocks, stones and nests of loose material shall be removed especially in solid rock cuts which must be completely free of such material. The final surface batters must not be absolutely smooth, but shall have a slightly rough surface that would be suitable for subsequent grassing or for the natural vegetation to be established on the surface.

Fill slopes shall be finished to neat lines with all loose rocks and non compacted material removed. The degree of finish required shall depend on the nature of the material used for the fill slopes but shall be as

smooth as in consistent with the material involved and good workmanship. No boulders in excess of 150 mm in size will be permitted and isolated large boulder in otherwise smaller size material shall not be allowed to project out of the surface. In the case of rock fill soft material shall be worked into the interstices between the rock on the surface of the slope.

Except in solid rock the tops and bottoms of all slopes, including the slopes of drainage ditches, shall be rounded as indicated on the Drawings or as directed by the Project Manager. Slopes at the junctions of cuts and fills shall be adjusted and warped to flow into one another, or into the natural ground surfaces, without any noticeable break.

Cut and fill slopes shall be finished to a uniform appearance without any noticeable break readily discernible from the road. The degree of finish required for all fill slopes and for cut slopes flatter than 1 in 4 shall be that obtainable by motor grader.

The slopes of cuts and fills which are designated for grassing shall, after finishing, be prepared for grass planting and /or top soil for grass planting.

All trimming of side slopes of cuttings shall be completed before any work on the subbase is commenced inside such cuttings.

714. EARTHWORKS TO BE KEPT FREE OF WATER

By providing temporary water course, ditches, drains, pumping or other means the Contractor shall arrange for the rapid dispersal of water from the areas of earthworks. Where practicable the water shall be discharged into the permanent outfall for the drainage system. Adequate means for trapping silt shall be provided on temporary systems while discharging into permanent drainage systems.

715. WATERCOURSES

Excavations carried out in the diversion, enlargement, deepening or straightening of watercourses shall include the operations of any necessary trimming of slopes, grading of beds, disposal of excavated materials and pumping, tampering works and materials necessary for dealing with the flow of water.

716. FILLING EXISTING WATERCOURSES

Where watercourses have to be diverted from the sites of embankments or other works, the original channels shall be cleared of all vegetable growths and soft deposits and filled in with suitable materials deposited and compacted as specified in Clauses 709 and 710.

717. PROCESS CONTROL

- (1) Throughout the works the Contractor shall perform tests to determine the suitability and compaction characteristics of soils to be used in roadway. The compaction test shall be conducted in accordance with IS 2720 Part 8 in every 1500 cum of fill material and every change in material type. The moisture content test shall be conducted in accordance with IS 2720 Part 2 in every 250 cum of material.
- (2) In addition to the foregoing tests, the Contractor shall carry out field density tests on the compacted fill materials in accordance with IS 2720 Part 28/29. At least one set of density determination consisting of three tests per 500 sqm (or any lesser area) shall be carried out in each layer, including original ground surface on which embankment is to be constructed. If the result of any test shows that the minimum specified density has not been achieved, further compaction shall be executed to the

area concerned and the layer re-tested. Unless the test results are satisfactory, the addition of another layer shall not be allowed.

- (3) The Contractor shall carry out tests for determination of moisture content at frequent intervals on all materials during the course of compaction as per Sub-clause 709(5) to ensure that the requirements of Clause 710 are met with.

718. MEASUREMENT

- (1) The quantities of the various classes of earthwork to be measured for payment under the contract shall be limited to the lines, grades, slopes and dimensions shown on the Drawing or as determined by the Project Manager.

- (2) All roadway excavation including road formation, foundations, side drains, landslides, filling and backfilling compacted in place shall be measured in cubic metres, or in running meters if specified in the Bill of Quantities, by the average end area method as computed from the original and final cross-sections of the completed work. The distance between two end areas shall be the distance measured along central line of the road. Where due to changed conditions, or the nature of a particular operation, or for any other reason, it is impossible or impractical to measure the quantities by means of average end areas, the Project Manager shall compute the quantities by a volumetric method, if in his opinion, it is the best suited method to obtain an accurate determination.

No separate measurement for payment shall be made for excavation made on borrows, quarries, temporary works or in places outside the scope of permanent works specified in the contract.

No measurement shall be made for any excavation other than the limited excavation described above. Excavation over increased width or length, cutting of slopes, shoring, shuttering and planking shall be deemed as convenience for the Contractor in executing the work and shall not be measured and paid for. Backfill to be measured shall be limited to this void only with due consideration of the nature of the structure.

Foundation excavation in rock shall be deemed to be covered by the rate for rock excavation.

No separate measurement shall be made for any quantities of finishing of slopes and preparatory work for formation of embankment and other areas of fill.

Measurement for scarifying, processing, laying, profiling and compaction of existing pavement, and preparation of resultant for laying pavement layers will be made in number of square meters of accepted work. The quantity shall be determined by volume of material in its original position prior to excavation. Quantities shall be computed to the neat lines shown on the Drawings, or to such limits as may be stacked out and approved for scarification by the Project Manager. No separate measurement shall be made for any extra subbase material required including reworking, placing, and compaction to final position.

- (3) Consumption of explosive materials, leveling, watering and compaction of original ground, construction of coffer dams, pumping out water and other ancillary and incidental works necessary to complete the item as per this Specification shall not be measured for payment. They are deemed included in the measurement of the concerned item.
- (4) If the excavated materials are disposed beyond 10m length and more than 1.5m height from the place of excavation and if filling materials are brought from beyond 50m and/or 1.5m below the place of filling, additional leads and lift shall be measured separately for payment. However initial lead of 50m and lift of 1.5m shall not be measured separately. They are deemed included in the measurement of the item itself. However, the measurement of foundation excavation shall be

inclusive of all leads and lifts (i.e. no separate leads and lifts shall be measured in foundation excavation).

The measurement of leads and lifts shall be based on mass diagram of the haulage wherever applicable. All leads and lifts shall be measured as per the contract. If the material obtained from roadway excavation is used fully or partially in roadway filling, the quantities for roadway excavation and roadway filling shall be computed as below.

The quantities of roadway excavation and roadway filling of the distances under reference shall be calculated separately adopting the method described as above in this Section. The computed quantity of roadway filling shall be measured in roadway filling while difference between quantities of roadway excavation and filling shall be measured in roadway excavation. The same excavated material shall not be measured both in roadway excavation and roadway filling.

719. PAYMENT

- (1) Various classes of earthworks i.e. roadway excavation, roadway filling, backfilling, additional leads and lifts, and others measured as described above shall be paid at contract unit rate of the respective item.

The contract unit rates shall be the full and the final compensation to the Contractor as per Clause 114 and for the cost of:

- (i) Arrangement of land as a source of supply of materials as much as needed.
 - (ii) Process Control tests.
 - (iii) Execution of all relevant operations described above in this Section and necessary to complete the item as per this specification.
- (2) Foundation excavation for structures, measured as described above, shall be paid for at the contract unit rate for all classes of excavation. The contract unit rate for foundation excavation shall be the full and the final compensation to the Contractor as per Clause 114 of the Technical Specifications. No payment shall be made for the disposal of the excavated materials irrespective of all leads and lifts, preparation of foundation base, cofferdams, cribs, sheeting, shoring and bracing, foundation sealing, dewatering including pumping, removal of logs and stumps, cleaning and grubbing, diversion of flow/channel, if required and all incidentals works necessary to complete the item in accordance with this Specification.
- (3) Payment for scarifying, processing, laying, profiling and compacting existing pavement, and preparation of resultant surface for laying of pavement layers shall be made at the contract unit rate, which shall be the full and the final compensation to the Contractor as per Clause 114. No separate payment shall be made to the Contractor for any extra base, subbase material required to be added to scarified subbase material to prepare it to comply the requirements of the specifications; reworking; placing and compacting for the final position.
- (4) Payment for excavation of landslide clearance (other than those in routine maintenance as per Clause 109) shall be made at contract unit rate. The contract unit rate shall be the full and the final compensation to the Contractor as per Clause 114 of the Specifications.

800. PROCESS CONTROL TESTING

801. CONSTRUCTION CONTROL TESTING/PROCESS CONTROL TESTING

Unless otherwise directed, values given in these Specifications are minimum values for the properties of materials and the workmanship. They shall be considered satisfactory, if all results of the tests, taken at the frequencies specified, are at least equal to the values given in the relevant Section of the Technical Specifications.

802. ADVERSE WEATHER WORKING

- (1) No material in frozen condition shall be incorporated in the works, but it shall remain on site for use, if suitable when unfrozen.
- (2) Laying of materials containing bitumen, or mixture thereof, shall cease under the following adverse conditions:
 - (a) during foggy and rainy weather;
 - (b) when rain is imminent.
- (3) While the air temperature is rising, work may be performed at the temperatures of:
 - 6 degree Celsius with a wind velocity of 25 km/hr
 - 10 degree Celsius with a wind velocity of 55 km/hr
- (4) When the air temperature is falling, works must be stopped as soon as the temperature reaches 6 degree Celsius, regardless of wind velocity. It shall not be resumed until the temperature is definitely rising.
- (5) When strong wind is blowing and this is likely to interfere with the proper execution of the work, no surfacing, especially spraying of binder shall be done.
- (6) Concrete shall not be placed during falling temperatures when the ambient temperature falls below 7 degree Celsius or during rising temperatures when the ambient temperature is below 3 degree Celsius. The temperature of the placed concrete shall not be allowed to fall below 5 degree Celsius until the concrete has thoroughly hardened. When necessary, concrete ingredients shall be heated before mixing but cement shall not be heated.

When the ambient air temperature exceeds 40 degree Celsius during the concreting operation, the Contractor shall take measures to control the temperature of the ingredients. Such measures shall include spraying the aggregates stockpile with water to promote cooling down by evaporation and, where feasible, shading of stockpiles and the area where concreting is carried out, reducing time between mixing and placing, and restricting concreting as far as possible to early mornings and late evenings. Curing shall commence after placing of the concrete in order to prevent excessive loss of moisture.

803. USE OF SURFACES BY CONSTRUCTION TRAFFIC

- (1) The loads and intensity of construction traffic used on pavements under construction shall be regulated so that no damage is caused to sub-grade and pavement layers already constructed.
- (2) The wheels and track of plant moving over various pavement courses shall be kept free of deleterious materials.

- (3) Bituminous base course shall be kept clean and uncontaminated as long as it remains uncovered by a wearing course and surface treatment. Should the base course or tack/prime coat becomes contaminated, the Contractor shall make good by cleaning it to the satisfaction of the Project Manager, including removal of the contaminated layer and replacing it as per the requirements of these Specifications which shall be done by the Contractor at his own risk and cost.

804. CARE OF WORKS

The general obligations for “Care of the Works” shall inter-alia include the following:

- (1) Materials shall not be spread on a layer that is wet and may damage it during compaction of subsequent layer or when opened to traffic.

When material is spread out on the road, it shall, be given a good cross-fall and a light compaction on the surface with a steel-tyre roller, in order to facilitate run-off during rainy weather.

- (2) All completed works in a layer shall be protected and maintained until the subsequent layer is placed. Maintenance shall include immediate repairs to 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.

- (3) Before priming any completed layer or placing a subsequent layer thereon, any damage to the existing layer shall be repaired so that after repair or reconstruction if necessary, it shall conform in all respects to the requirements specified for that layer. All repair work other than repairs of minor surface damages shall be inspected and tested before covering up.

The previously constructed layer shall also be thoroughly cleaned of all foreign material before construction of a succeeding layer. In the case of bituminous work, the existing layer shall be thoroughly broomed and all dung, clay, mud and other deleterious and loose material shall be removed. Where necessary, the surface shall be sprayed with water before, during and after brooming to remove all foreign material.

Roads shall not be made dirty as a result of construction of works, transportation of equipment, plants, labour and/or materials. In the case of becoming dirty, they shall be cleaned immediately.

805. MEASUREMENT AND PAYMENT

No measurement and payment shall be made for the works required under this Section. All costs in connection with the requirements specified herein shall be deemed included in the rates and prices of the related items of works in the Bill of Quantities.

900. SUBGRADES

901. SCOPE

This section deals with the treatment of the upper layers of earthworks including preparation and surface treatment of the formation, the addition of layers of selected materials, the improvement of in-situ materials by addition and mixing of selected materials.

902. DEFINITIONS

The following definitions shall apply to this section and other relevant sections of these Specifications:

(1) Formation Level

The top surface of the subgrade, which supports the construction of pavement

(2) Subgrade

Up to 300 mm below formation level is designated as "subgrade".

(3) Capping Layers

Capping layers are layers of specified materials to be laid and compacted in the subgrade and below, as required, in replacement of in-situ materials to achieve CBR conforming to Clause 804 (2).

(4) Stabiliser

The selected natural or crushed material, lime, cement and other similar materials to be mixed into the in-situ material of the subgrade is defined as the "stabiliser".

(5) Mechanical Stabilisation

The addition and mixing of natural or crushed material to improve the in-situ material of the subgrade.

(6) Treated Materials

Following the addition of stabiliser to the in-situ materials, the material is referred to as "treated material." Treated materials shall be mechanically stabilised.

**903. PREPARATION AND SURFACE TREATMENT OF FORMATION
(SUBGRADE)**

Preparation and surface treatment of formation (subgrade) shall be carried out only after completion of all drainage works unless otherwise agreed by the Project Manager and prior to laying the subbase or the base where no subbase is required. The sequence of operations shall be as follows:

(1) Formation of Loose Untreated Materials

Materials for use in the subgrade shall not contain particles larger than 60 mm. In addition the material shall have a CBR of not less than 5% measured after a 4-day soak on a laboratory mix compacted to 95% MDD (heavy compaction), a swell of less than 1%, a plasticity index of less than 40% and an organic matter content less than 3%. In-situ material in the subgrade in cutting that does not meet these requirements shall either be spoiled or, if suitable, placed in the embankment. The spoiled material shall be replaced with material meeting the requirements for loose material in the subgrade.

In fill areas, and in cuttings except otherwise instructed by the Project Manager, according to the material encountered, loose materials of the embankments and cuttings shall be deposited in the layers of 150 mm compacted depth. Each layer shall extend reasonably more than the full width of the embankments or cuttings and shall be compacted in accordance with the requirements as specified hereunder:

- (a) The material shall be broken down to the above specified grading and any oversize material which cannot be broken down to the required size shall be removed and disposed off. The material shall be scarified and the moisture content shall be adjusted by either uniformly mixing in water or drying out the material such that the moisture content during compaction is between 95% and 100% of the Optimum Moisture Content. The moisture content shall be kept within these limits until compaction is complete except where otherwise instructed by the Project Manager.

- (b) Each layer shall be compacted to a dry density equal to at least 95% MDD (heavy compaction).
- (c) In accordance with Section 300, the Contractor shall submit to the Project Manager his proposals for the compaction of the material to be used in the subgrade. The proposal shall be based on the type of plant, the range of passes and the loose depth of the layer.

The Contractor shall carry out site compaction trials, supplemented by necessary laboratory investigations, and shall satisfy the Project Manager that all the specified requirements regarding compaction shall be achieved. Site compaction trials shall be completed and approved by the Project Manager before the permanent Works commences.

- (d) Testing to be carried out during the construction of subgrade shall include the following:

The MDD (heavy compaction) and OMC shall be determined for each new material encountered and in every 3000m² or part of it of each layer of compacted subgrade.

The field dry density shall be determined at least once per 250m² or part of it of each layer of compacted subgrade. The test of field density shall be conducted in staggered manner i.e. at left, at crown and at right in the carriageway.

The soaked CBR of material in the subgrade shall be determined at least in every 3000m² or part of it of each layer.

The Contractor shall request in writing for the Project Manager's approval for each layer in accordance with Sub-clause 409 (1) and such request shall be accompanied by the tests results of the above described testing and all additional relevant information required. If the results are as specified, he will approve for addition of another layer or will ask for further tests or rework to meet the requirements.

904. PREPARATION AND SURFACE TREATMENT OF FORMATION

Preparation and surface treatment of the formation, that is top of the subgrade, shall be carried out only after completion of any specified subgrade drainage and unless otherwise agreed by the Project Manager, immediately prior to laying the sub-base or the road base where no sub-base is required. The sequence of operations shall be as follows:

- (a) All surface below carriageway, lay-bys, footways and hard shoulders shall, after reinstatement of any soft areas to the required Specifications be well cleaned and freed of mud and slurry.
- b) The surface shall be compacted by 4 passes of a smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required, before the commencement of rolling
- (c) The foundation shall, wherever necessary, be regulated and trimmed with motor grader.
- (d) The trimmed formation shall be rolled by one pass of smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required, before the commencement rolling.

Where the completed formation is not immediately covered with sub-base or road base material, its moisture content shall be maintained to prevent cracking in the formation by suitable measures as approved by the Project Manager. The entire work of surface treatment of formation shall be deemed as incidental to the work of sub-base/base course to be provided on the subgrade and as no extra payment shall be made for the same.

(2) Formation of Loose Treated Materials

The sequence of operation shall be as described in Clauses 705 to 706 of this Specification.

(3) Formations in Rock Cuttings

The subgrade in rock cuttings shall be regulated after trimming the rock excavation by a regulating course of minimum 150 mm compacted depth of natural materials complying with the requirements of natural material for subbase as specified in Sub-clause 1000 (3).

The regulating course shall be laid, compacted and tested in accordance with Clause 1001 and the surface regularity shall meet the requirements of Clause 900.

(4) Preparation of Formation for Rehabilitation Works

The formation (subgrade) shall be graded and compacted for construction of pavement in carriageway, shoulders, footpath, and lay-bys. Any soft areas shall be corrected as directed by the Project Manager. The prepared surface shall be well cleaned and free from mud and slurry.

(5) Proof Rolling

All subgrade shall be proof rolled with a loaded scraper or truck with a minimum axle load of 8 tonnes. Proof rolling shall be satisfactorily completed before the layer is submitted to the Project Manager for approval and shall be carried out in the presence of the Project Manager. All proof rolling shall be at the Contractor's expense.

(6) Surface Regularity and Tolerances

The surface regularity and tolerances of the subgrade shall meet the requirements of Clause 901.

When each layer is completed the Contractor shall comply with the requirements of Clause 410 for requesting the Project Manager's approval and protecting the layer.

905. CAPPING LAYER

Where shown on the Drawing or where in-situ material in the subgrade in cuttings does not meet the requirements, in-situ materials shall be replaced with selected material from cuttings or borrow pits.

Where materials of differing quality are available for placing in the embankments, the Project Manager may also instruct that certain materials should be excluded from the subgrade and that certain materials should be set apart, or obtained from borrow pits for use in the upper layers.

When materials for subgrade are extracted from borrows to form the capping layers they shall be natural material complying with the following requirements:

(1) Material Classification

Materials used in capping layers shall be selected among soils classified as GW, GP, GC, SW in the Unified Soil Classification of Soils.

(2) Material Requirements

Materials for use in the capping layers shall not contain particles larger than 60 mm and their percentage passing by weight the 0.075 mm sieve shall be less than 15%. The grading requirement for capping layer materials shall be as shown in Table 9.1

The material for use in the capping layers shall have a CBR of not less than 15% measured after a 4-day soak on a laboratory mix compacted to 95% MDD (heavy compaction), a swell of less than 1%, a plasticity index of maximum 6 %.

Table 9.1: Grading Requirements for Capping Layer Materials

Sieve Size (mm)	Percent passing by dry weight
50	100
37.5	80 – 100
20	60 – 100
4.75	30 – 100
1.18	15 – 75
0.3	9 – 5
0.075	5 – 15

(3) Laying and Compaction

The material shall be deposited in the layer of 150 mm compacted depths. Each layer shall extend over the full width of the embankments or cuttings and shall be compacted in accordance with the requirements specified in Sub-clause 303 (1) (a) to (d)).

(4) Proof rolling and Tolerances

Proof rolling and tolerances of capping layers shall be in accordance with Sub-clause 303 (5) and (6).

When each layer is completed the Contractor shall comply with Clause 310 for requesting the Project Manager's approval and protecting the layer.

906. MECHANICAL STABILISATION

(1) General

The extent of the mechanical stabilisation shall be shown on the Drawing or as directed by the Project Manager.

In-situ subgrade materials subject to mechanical stabilisation shall be generally soils classified as SM, ML, CL, MH, CH in the Unified Soil Classification with a CBR less than 5% or a moisture content close to saturation or too high moisture content to meet the compaction requirements as set out in Sub-clause 303 (1).

(2) Material Requirement

(a) Stabiliser (Additive Material)

Additive material shall be gravel, crushed stone/gravel or sand, according to the type and characteristics of the in-situ soil as shown in Table 9.2.

It may be crushed stone/crushed gravel (CS) discarded material from primary crushing, or screened stone (SS) from debris.

Sand may be soils classified as SP, SW in the Unified Soil Classification system or Sand obtained by screening the discarded fine fraction of primary crushing.

Gravel 12/40 shall have a percentage in weight passing the 12 mm sieve less than 20% and a percentage in weight passing the 40 mm sieve more than 85%.

Sand shall have a Sand Equivalent more than 60.

Table 9.2: Types of Additive Material

In-situ soil	Stabiliser (Additive material)	
	Gravel	Sand
SM	CS, SS, 12/40	-
ML	CS, SS, 12/40	-
CL	CS, SS, 12/40	-
MH		SP, SW
CH		SP,SW

(b) Stabilised Material Requirements

The amount of stabiliser shall be determined by the Project Manager after laboratory test. The mechanically stabilised materials after mixing and compacting shall conform to the following requirements:

- maximum size of particles : 60 mm
- Uniformity Coefficient : min 5
- CBR at 95 % MDD (heavy compaction) measured after 4 days soak : min 25%
- Swell : max. 1%

(3) Amount of Stabiliser to be added

The amount of stabiliser to be added shall be generally between 15% and 25% in weight of the in-situ materials and shall be determined by the Project Manager following laboratory trials, and site trials to be carried out by the Contractor in accordance with Section 400.

During the site trials, the control testing requirements shall be in accordance with Clause 407 and in addition, each set of test shall include the following:

- The MDD (heavy compaction) and OMC determined on the mixed material before compaction,
- The CBR at 95% MDD (heavy compaction) after 4 days soak.

(4) Mixing

(a) Mixing Equipment

The equipment for scarifying the in-situ material and mixing it with the stabiliser, such as scarifiers and graders, shall be capable of scarifying the materials and mixing it with the stabiliser to the full depth of the loose layer necessary to give the specified thickness of compacted material mixed and compacted in accordance with this Clause.

The equipment shall be only acceptable, if during the site trials carried out in accordance with Section 300, it produces the material to the specified requirements.

(b) Preparation of the Layer

Before the stabiliser is applied, the material to be treated shall be scarified. If required or instructed by the Project Manager, oversize material shall be removed or broken down so that the maximum size of the particles is not more than specified.

(c) Spreading the Stabiliser

After the layer to be treated has been prepared, the stabiliser shall be uniformly spread over the width to be worked at the specified rate.

(d) Mixing and Watering

After the stabiliser has been spread, it shall be thoroughly and intimately mixed into the material for the full depth of the layer. Mixing shall continue until the resulting mixture forms a homogeneous mass.

Care shall be taken both during mixing and subsequent watering operations so that the underlying layer is not disturbed. No material from the underlying layer is mixed with that being processed.

If watering is necessary to bring the mixture to the required moisture content, this shall be done after spreading and mixing with the stabiliser. Water shall be added in an uniform and controllable manner and, where necessary, in successive increments. Each increment shall be mixed in as a separate mixing operation. Concentration of water at any point or a flow of water over the surface shall be avoided.

Any part of the mixture which becomes too wet for compaction shall be allowed to dry out until its moisture content is satisfactory for compaction.

Throughout the process of mixing the stabiliser and watering, a uniform thickness of the mixture shall be maintained and, if necessary, the mixture shall be graded to maintain the correct loose thickness and shape. Any part of the mixture that becomes segregated shall be removed and replaced.

(5) Compaction and Finishing

(a) Thickness of Layers

The subgrade shall be constructed in the compacted layer of 150 mm thickness.

(b) Compaction Requirements

The minimum density for mechanically stabilised materials shall be 95% MDD (Heavy compaction). The moisture content at the time of compaction shall be between 97% and 103% of Optimum Moisture Content.

(c) Finishing

The surface finish after compaction of any treated layer shall be free from ridges, compaction planes, laminations, loose and segregated material and other surface irregularities and shall be to the line and the level within the tolerances as specified in Clause 801. If the surface fails to meet the requirements of this Specification, the Contractor shall take the action set out in the appropriate part of Section 800 or such other action as the Project Manager may instruct or agree.

(6) Construction Control Testing

(a) In-situ Material

For each new material encountered and in every 3000 m² or part thereof of the subgrade the following properties shall be determined:

- Grading,
- Moisture Content,
- Atterberg limits,
- MDD (heavy compaction) and OMC,
- CBR at 95% MDD (heavy compaction) after 4 days soak.

(b) Stabiliser

The following properties of the additive material shall be determined on opening up of a new source, in every 500 m³ or part thereof and when in opinion of the Project Manager the nature of the material is changed.

- Grading,
- SE (sand equivalent)

(c) Control of Mixing

Prior to compaction in every 400 m² or part thereof the following properties shall be determined on each new treated material used after mixing for subgrade of each layer:

- MDD (heavy compaction) and OMC,
- CBR at 95% MDD (heavy compaction) after 4 days soak.

(d) Control after Completion of Each Layer

The field dry density shall be determined in every 250 m² or part of it of each layer of compacted subgrade in staggered manner i.e. at left, at crown and at right in the carriageway.

(7) Tolerances

(a) Geometric Tolerances

As specified in Clause 801.

(b) Amount of Stabiliser

The average amount of stabiliser, measured before mixing, over a length of 100m, shall not be less than the amount specified. The average amount of stabiliser, in the treated material, measured at five points over a length of 100m, shall not be less than the amount specified.

907. MEASUREMENT

- (1) Earthwork in formation cutting shall be carried out using excavator for 7.5 m clear formation width as per design drawings including uprooting of vegetation and trees, stacking of useful materials for re-use and disposal of surplus earth within 50m lead and lift for all types of soil and rock with or without blasting including excavation of earthen drain with adequate slope as per typical cross sections. The construction methodology shall follow EFRC technique using controlled blasting, half tunnelling/and quarter tunnelling as per design or as directed by the Project Manager. All excavation shall be carried out as per the plans and sections of the alignment and minor adjustment as directed by the Project Manager to arrive at the best possible alignment, gradient and at the same time to achieve most economical cutting.

- (2) Before mixing the stabiliser (i.e. gravel, crushed stone/gravel sand) quantity to be used shall be measured in stacks or in the body of transporting trucks/trippers, if it can be measured.
- (3) In a length of 100m five standard holes at the equal distances shall be dug up and materials shall be collected separately from the each hole. The average percentage of stabiliser obtained from each hole shall be worked out. Based on average percentage of stabiliser and volume treated total quantity of stabiliser used shall be computed.

Least of the quantities computed in (a) and (b) above shall be accepted for payment.

908. PAYMENT

The subgrade construction with loose untreated/treated materials, formation in rock cutting, additive materials and stabilisers, preparation of formation (subgrade), capping layer, mechanically stabilised subgrade, and lime stabilised material shall be paid at their respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 114 and also for the cost of:

- (1) Arrangement of land as a source of supply of material required.
- (2) Compacting the ground supporting subgrade where removal and replacement of unsuitable material or loosening and recompacting is involved.
- (3) Watering or drying of material in the subgrade as required.
- (4) Mixing, spreading in layers brining in appropriate moisture content and compacting to the requirement of Clause 703.
- (5) Proof rolling and testing.
- (6) All other operations including incidental costs necessary to complete the item as per this Specification.

1000. SUB_BASE

1001. GENERAL

This section covers the construction of mechanically stable subbase with suitable material.

The specification and requirements are based on the recommended criteria given by the UK Transport Research Laboratory's Overseas Road Note 31 – A Guide to the Structural Design of Bitumen-surfaced Roads in Tropical and Sub-tropical Countries.

1002. SOURCES OF MATERIALS

Subbase materials shall be obtained from approved roadside excavation in borrow or cut or from such other sources of supply as may be specified or approved from time to time for use.

The Contractor shall comply with all requirements of Section 500 in respect of borrow pits.

1003. MATERIAL REQUIREMENTS AND POTENTIAL PROCESSING

The subbase material for this purpose shall be material from an approved source. The source may be as river bed or pit gravels, rock quarry, alluvial deposits, crusher-run, or other naturally occurring granular materials meeting the requirements of these Specifications.

Partial processing may include such measures as; the use of a bar “grizzly”, or mechanical screening to separate oversize material; crushing or use of a grid or cleated roller to reduce oversize; and/or blending or mechanical stabilization.

The subbase material after placing and compaction shall conform to the following requirements:

The grading of the subbase material after placing and compaction shall be a smooth curve within and approximately parallel to the envelope given in Table 10.1.

Table 10.1: Grading Envelope for Granular Subbase

Sieve size (mm)	Percentage Passing by Weight
50	100
37.5	80 – 100
20	60 – 100
5	30 – 100
1.18	17 – 75
0.3	9 – 50
0.075	5 – 25

The fraction passing 0.425 mm sieve shall have a Liquid Limit not more than 45, a Plasticity Index not more than 12 % and Linear Shrinkage not more than 6%.

The CBR of the material, after 4 days soaking, shall not be less than 30% at 97% MDD (Modified Compaction).

1004. COMPACTION TRIALS

Before commencing construction and from time to time as may be considered necessary by the Project Manager, the Contractor shall carry out compaction trials in the presence of the Project Manager on each main type of materials to be compacted in the Works. The length of the trial section shall be minimum 100 m unless otherwise specified by the Project Manager. The Contractor shall carry out all necessary laboratory and field testing and supply the Project Manager with the copies of the results of all tests.

Following completion of the compaction trials, the Contractor shall submit to the Project Manager, for his approval, proposals for the compaction of each main type of material. The Contractor's proposals shall include reference to the type of equipment, the operating weights and tyre pressures and the method of adjusting moisture content.

If, in the opinion of the Project Manager, the results of the compaction trials indicate that the Contractor's proposed plant and methods achieve the densities specified, the Project Manager shall approve the same. Otherwise the Contractor shall submit in writing proposals for modifying the plant and/or methods and shall compact further trials in accordance with these modified proposals until the Project Manager approves the Contractor's proposals.

1005. PREPARING UNDERLYING COURSE

The subbase shall only be constructed provided that the underlying subgrade layer conforms to the requirements specified in Section 800 of the Technical Specifications. Immediately before placing the material, the subgrade shall be checked for any damage or deficiencies, which shall be made good.

1006. LAYING AND COMPACTION

The material shall be deposited in such quantity and spread in a uniform layer across the full width required, so that the final compacted thickness is nowhere less than shown on the Drawings or instructed by the Project Manager. Every reasonable effort shall be made to prevent segregation during mixing, dumping, spreading, trimming and compacting operations.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 150 mm and when a greater compacted thickness is required, the material shall be laid and processed in two or more layers. The minimum layer thickness shall be 100 mm.

The material shall be broken down to the grading specified in Clause 1003. Any oversize material which cannot be broken down to the required size shall be removed and disposed off. The material shall be scarified and the moisture content adjusted by either uniformly mixing with water or drying out the material such that the moisture content during compaction is between 95% and 100% of the Optimum Moisture Content (IS 2720 Part 8). It shall be graded and trimmed to final line and level.

The final trim shall be in cut and the Contractor shall ensure that material from the trim is neither deposited in low areas nor spread across the section but graded clear of the works. Following the final trim the material shall be compacted to a dry density of at least 95% of MDD (IS 2720 Part 8). During the grading, trimming and compaction of the material the Contractor shall ensure that the surface and/or the material does not dry out. If so, the Contractor is required to apply fog sprays of water or other approved means sufficient to maintain the surface and/or material within the specified limits of moisture content.

On completion of compaction, the surface shall be tight and free from movement under compaction plant and free from compaction planes, ridges, cracks, loose or segregated material. If the surface fails to meet the specified requirements, the Contractor shall take the action set out in the appropriate part of Section 800 or such other action as directed by Project Manager.

1007. PROOF ROLLING

Unless otherwise directed by the Project Manager, the Contractor shall proof roll the completed layer with a steel three wheeled roller applying a load of not less than 5 tonnes per metre width of roll and the layer shall be free from visible movement under the proof roller. Approval of the layer shall only be given after the satisfactory completion of the proof rolling and any remedial measures shall be at the Contractor's expense.

1008. SETTING OUT AND TOLERANCES

The layer shall be set out and constructed to the appropriate tolerances specified in Section 300.

1009. DRAINAGE OF SUBGRADE AND SUBBASE

The subgrade and subbase shall be kept continuously drained and any damage caused by water accumulating on or running off the surface shall be made good at the Contractor's expense.

Water accumulated on any part of the subgrade or subbase, shall be removed and disposed off. Any material which becomes saturated, or cannot then be compacted to the required density, shall be replaced as specified at Contractor's own expense.

1010. TESTING

(1) Process Control

The minimum testing frequency for the purpose of process control shall be as given in Table 10.2.

Table 10.2: Granular Subbase - Minimum Testing Frequency

Tests	One test in Every:	Minimum no of tests per section
Material:		
Gradation	200 m ³ or part thereof, and change in source	2
Atterberg Limits, Shrinkage	" " " "	2
Maximum Dry Density and Optimum Moisture Content	1000 m ³ " " "	2
Field Density and Moisture Content	500 m ² of each layer	2
Construction Tolerances:		
Surface Levels	10 m	-
Thickness	25 m	-
Width	200 m	-

(2) Routine Inspection and Testing

Routine inspection and testing shall be carried out by the Project Manager to test the quality of materials and workmanship for compliance with the requirements of this section.

Any materials or workmanship not complying with the specified requirements shall be replaced with materials and/or workmanship complying with the specified requirements or be repaired to comply with the specified requirements.

1011. MEASUREMENT

Payment for granular subbase will be on the basis of cubic metres of compacted volume. Compacted volume shall be measured in cubic metre by taking cross Sections at intervals of 10 metres or as directed by the Project Manager in the original position before the work starts and after its completion and computing the volumes in cubic metres by average end area method.

1012. PAYMENT

The granular subbase construction shall be paid at the respective contract unit rate for the applicable haul/lead from the approved source and shall be full and final compensation to the Contractor as per Clause 114 to complete the work as per the Technical Specifications. In addition to stated in Clause 114, the contract unit rate shall be also the full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Sections 400 and 500.

1100. BASE

1101. GENERAL

This section covers the construction of mechanically stable or cement modified natural gravel base with suitable material.

The specification and requirements are based on the recommended criteria given by the UK Transport Research Laboratory's Overseas Road Note 31 – A Guide to the Structural Design of Bitumen-surfaced Roads in Tropical and Sub-tropical Countries.

1102. SOURCES OF MATERIALS AND POTENTIAL PROCESSING

Natural gravel base materials shall be obtained from roadside excavation in borrow or cut, or from such other sources of supply as may be specified or approved from time to time for use.

Necessary processing may include crushing or screening to reduce oversize and/or blending to achieve the specification gradation. Where crushing is required, crusher run operations shall be permitted. **For separation of oversize, application of an inclined bar “grizzly” screen may be used.**

Blending of different materials or sizes shall be performed by means of a stationary pug mill plant.

The Contractor shall comply with all requirements of Section 400 in respect of borrow pits.

1103. MATERIAL REQUIREMENTS

The base material for this purpose shall be material from an approved source. The source may be as river bed or pit gravels, rock quarry, alluvial deposits, crusher-run, or other naturally occurring granular materials meeting the requirements of these Specifications.

a) Gradation

The base material after placing and compaction shall conform to the following requirements:

The grading of the base material after placing and compaction shall be a smooth curve within and approximately parallel to the envelopes given in Table 11.1

Table 11.1: Grading Envelope for Road base

Sieve Size (mm)	Percentage passing by weight	
	Nominal 37.5mm maximum size	Nominal 20mm maximum size
50.0	100	-
37.50	80 – 100	100
20.0	60-80	80-100

10.0	45 – 65	55-80
5	30 – 50	40-60
2.36	20 – 40	30-50
0.425	10 – 25	12-27
0.075	5 – 15	5 - 15

At least 40% of particles retained on a 10 mm screen must be angular, irregular or crushed faces.

b) Aggregate Hardness Criteria

Aggregate shall have a minimum soaked (overnight) Ten Percent Fines Value of 50KN or a maximum soaked Aggregate Impact Value of 40.

c) Plasticity of Fines

The fraction passing the 0.425 mm sieve shall have Plasticity Index (PI) not more than 6 %. As an alternative to testing of PI, a maximum Linear Shrinkage of 3% is applicable.

If the PI approaches the upper limit of 6% ($4.5 < PI < 6.0$), the fines content shall be restricted to the lower end of the grading range given in a) in accordance with the following criteria:

- i) A maximum PP (PI x percentage passing the 0.075mm sieve) of 60, and
- ii) A maximum PM (PI x percentage passing the 0.425mm sieve) of 90.

d) California Bearing Ratio (CBR)

The CBR of the material, after 4 days soaking, shall not be less than 80% at 98% MDD (Heavy Compaction).

e) Processing

The crushing, screening, proportioning, mixing, and transportation of crushed stone materials for Roadbase shall be as specified in Sub-Clause 1101(3) of the Technical Specifications.

1104. COMPACTION TRIALS

Before commencing construction and from time to time as may be considered necessary by the Project Manager, the Contractor shall carry out compaction trials in the presence of Project Manager on each main type of materials to be compacted in the Works. The length of the trial section shall be minimum 100 m unless otherwise specified by the Project Manager. The Contractor shall carry out all necessary laboratory and field testing and supply the Project Manager with the copies of the results of all tests.

Following completion of the compaction trials, the Contractor shall submit to the Project Manager, for his approval, proposals for the compaction of each main type of material. The Contractor's proposals shall include reference to the type of equipment, the operating weights and tyre pressures and the method of adjusting moisture content.

If, in the opinion of the Project Manager, the results of the compaction trials indicate that the Contractor's proposed plant and methods shall achieve the densities specified, the Project Manager shall approve the same. Otherwise the Contractor shall submit in writing proposals for modifying the plant and/or methods and shall compact further trials in accordance with these modified proposals until the Project Manager approves the Contractor's proposals.

1105. PREPARING UNDERLYING COURSE

The subbase shall only be constructed provided that the underlying subgrade layer conforms to the requirements specified in Section 800 of the Technical Specifications. Immediately before placing the material, the subgrade shall be checked for any damage or deficiencies, which shall be made good.

1106. LAYING AND COMPACTION

The material shall be deposited in such quantity and spread in a uniform layer across the full width required, so that the final compacted thickness is nowhere less than shown on the Drawings or instructed by the Project Manager. Every reasonable effort shall be made to prevent segregation during mixing, dumping, spreading, trimming and compacting operations.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 150 mm and when a greater compacted thickness is required, the material shall be laid and processed in two or more layers. The minimum layer thickness shall be 100 mm.

The material shall be broken down to the grading specified in Clause 1003. Any oversize material which cannot be broken down to the required size shall be removed and disposed off.

The material shall be scarified and the moisture content adjusted by either uniformly mixing with water or drying out the material such that the moisture content during compaction is between 95% and 100% of the Optimum Moisture Content (IS 2720 Part 8). It shall be graded and trimmed to final line and level. Light compaction may be applied before the final trim is carried out, but once 25% of the compaction effort has been applied no further trimming or correction of surface irregularities shall be allowed.

The final trim shall be in cut and the Contractor shall ensure that material from the trim is neither deposited in low areas nor spread across the section but graded clear of the works. Following the final trim the material shall be compacted to a dry density of at least 98% of MDD (IS 2720 Part 8). During the grading, trimming and compaction of the material the Contractor shall ensure that the surface and/or the material does not dry out. If so, the Contractor need to apply fog sprays of water or other approved means sufficient to maintain the surface and/or material within the specified limits of moisture content.

On completion of compaction, the surface shall be well closed, free from movement under compaction plant and free from compaction planes, ridges, cracks, loose or segregated material. If the surface fails to meet the specified requirements, the Contractor shall take the action set out in the appropriate part of Section 900 or such other action as directed by Project Manager.

1107. PROOF ROLLING

Unless otherwise directed by the Project Manager, the Contractor shall proof roll the completed layer with a steel three wheeled roller applying a load of not less than 5 tonnes per metre width of roll and the layer shall be free from visible movement under the proof roller. Approval of the layer shall only be given after the satisfactory completion of the proof rolling and any remedial measures shall be at the Contractor's expense.

1108. SETTING OUT AND TOLERANCES

The layer shall be set out and constructed to the appropriate tolerances specified in Section 300.

1109. DRAINAGE OF SUBGRADE, SUBBASE and BASE

The subgrade, subbase and base shall be kept continuously drained and any damage caused by water accumulating on or running off the surface shall be made good at the Contractor's expense.

Water accumulated on any part of the subgrade, subbase or base, shall be removed and disposed off. Any material which becomes saturated, or cannot then be compacted to the required density, shall be replaced as specified at Contractor's own expense.

1110. TESTING

(1) Process Control

The minimum testing frequency for the purpose of process control shall be as given in Table 11.2.

Table 11.2: Minimum Testing Frequency

Tests	One test in every	Minimum no of tests per section
Materials:		
Gradation	200 m ³ or part, and change in source	2
Plasticity Index/Linear Shrinkage	" " " "	2
10% Fines Value (soaked)	2,000 m ³ " " "	2
Maximum Dry Density and Optimum Moisture Content	1,000 m ³ " " "	2
Field Density and Moisture Content	500 m ² of each layer	2
Construction Tolerances:		
Surface Levels	10 m	-
Thickness	25 m	-
Width	200 m	-

(2) Routine Inspection and Testing

Routine inspection and testing shall be carried out by the Project Manager to test the quality of materials and workmanship for compliance with the requirements of this section.

Any materials or workmanship not complying with the specified requirements shall be replaced with materials and/or workmanship complying with the specified requirements or be repaired to comply with the specified requirements.

1111. MEASUREMENT

Mechanically stable Road base shall be measured in cubic metre by taking cross Sections at intervals of 10 metres or as directed by the Project Manager in the original position before the work starts and after its completion and computing the volumes in cubic metres by average end area method. No separate measurement shall be made to prepare base, if required, as a filter or separating layer.

1112. PAYMENT

The mechanically stable Road base construction shall be paid at their respective contract unit rate which shall be full and final compensation to the Contractor as per Clause 114 to complete the work as per the Technical Specifications. In addition to stated in Clause 114, the contract unit rate shall be also the full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Sections 400 and 500.

Payment is to be made on the basis of compacted volume of Road base, with consideration of the haul/lead distance from the applicable approved source. Two rates are to be provided;

- i) Haul/lead from 0 to 10 Km from the sources
- ii) Haul/lead greater than 10 Km from the source

Payment to cement modification base shall be made at their respective contract unit rate which shall be full and final compensation to the Contractor as per Clause 114 to complete the work complying with the requirement of Sections 400 and 500 unless otherwise directed by the Project Manager.

1200. GRAVEL WEARING COURSE AND SHOULDER

1201. GRAVEL WEARING COURSE

(1) General

(a) Definitions

The term "gravel" used throughout in this Clause means any material used as a wearing course, and shall include crushed rock and natural or crushed gravel.

A "gravel wearing course" means a top surfacing course constructed from one or a combination of the materials stated above and may be a course placed on the formation of a new road where final pavement surface is not included in the Contract, or placed on the formation of a service, diversion or access road.

(b) Sources of Material

Material for gravel wearing course may be obtained from any of the sources described hereunder.-

- (i) Borrow pits, alluvial deposits, etc.
- (ii) Spoil areas

- (iii) Excavation in cuttings, widened if necessary.

The source for material may be as river bed or pit gravels, rock quarry, alluvial deposits, crusher-run, or other naturally occurring granular materials meeting the requirements of the Technical Specifications.

The Contractor shall comply with all the requirements of Section 500 in respect of borrow pits, alluvial deposits, etc. and spoil areas.

(2) Material Requirements

Particle Size Distribution

The grading of the gravel after placing and compaction shall be a smooth curve within and approximately parallel to the grading envelope given in the Table 12.1.

Table 12.1: Particle Size Distribution of Wearing Course Material

Sieve size (mm)	Percentage passing by weight	
	Class 1	Class 2
37.5	-	100
25.0	100	85-100
20.0	95-100	85-100
14.0	80-100	65-100
10.0	65-100	55-100
4.75	45-85	35-92
2.00	30-68	23-77
1.00	25-56	18-62
0.425	18-44	14-50
0.075	12-32	10-40

In addition, following specification for materials for unpaved roads are recommended as per Table 12.2.

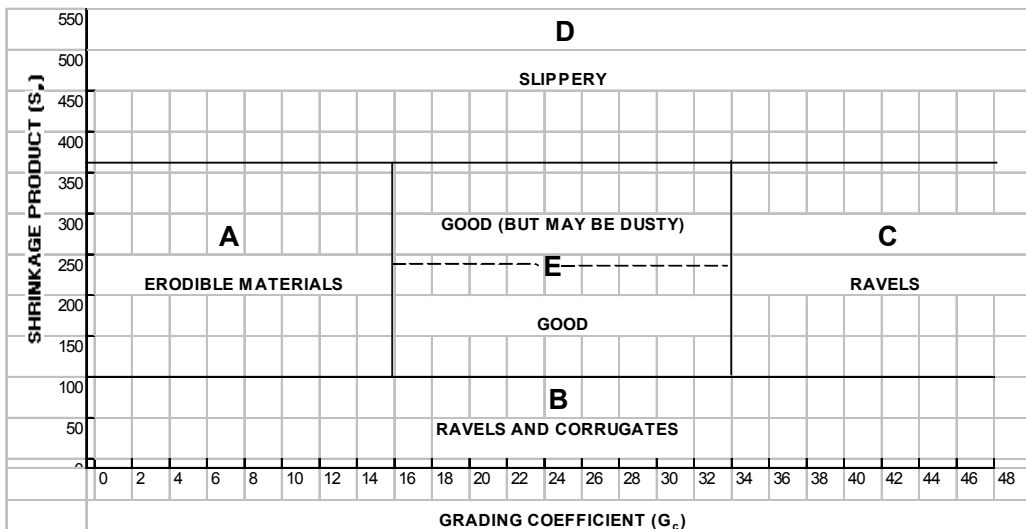
Table 12.2: Special recommendation for unpaved road

Maximum size	37.5 mm
Oversize index (I_o)	≤ 5 percent
Shrinkage product (S_p)	100 to 240 (preferably 240)
Grading coefficient (G_c)	16 to 34
CBR	$\geq 30\%$ soaked 4 days at 97% of the Modified AASHTO compaction and OMC

where, I_o = percent retained on 37.5 mm sieve.

S_p = Linear shrinkage x percent passing 0.425mm sieve.

G_c = (percent passing 26.5mm - percent passing 2.0mm) x percent passing 4.75mm / 100



The relationships between shrinkage product and grading coefficient are shown schematically in Figure 12.1.

Figure 12.1: Relationship between Shrinkage Product, Grading Coefficient and Performance of Unpaved Wearing Course Gravels

By plotting the shrinkage and grading properties of potential unpaved wearing course gravel on the figure, an indication of the suitability and any potential problems will be obtained. However, personal judgment should be used. In flat, dry areas, materials falling into zones A and D may be acceptable if the site-specific potential to erode or become slippery is not excessive.

The following conclusions can be drawn about each zone as defined in the figure:

- Zone A: Materials in this zone generally perform satisfactorily but are finely graded and particularly prone to erosion by water. They should be avoided if possible, especially on steep grades and sections with steep cross-falls and super-elevations. Most roads constructed from these materials perform satisfactorily but may require periodic labour-intensive maintenance over short lengths and have high gravel losses due to water erosion.
- Zone B: These materials generally lack cohesion and are highly susceptible to the formation of loose material (raveling) and corrugations. Regular maintenance is necessary if these materials are used and the roughness is to be restricted to reasonable levels.
- Zone C: Materials in this zone generally comprise fine, gap-graded gravels lacking adequate cohesion, resulting in raveling and the production of loose material.
- Zone D: Materials with a shrinkage product in excess of 365 tend to be slippery when wet.
- Zone E: Materials in this zone perform well in general, provided the oversize material is restricted to the recommended limits.

Plasticity Index

The Plasticity Index of fines passing 0.425 mm sieve shall be in the range of 12 to 18 percent.

California Bearing Ratio

The material shall have a minimum CBR of 30% after 4 days soaking at 95% MDD (heavy compaction).

(4) Sequence of Works

Unless otherwise instructed by the Project Manager, the Contractor shall commence laying wearing course starting as close as possible to the source and shall work away from it so that the maximum amount of compaction is given to the wearing course by the Contractor's vehicles. The Contractor shall route/regulate his vehicles to give even wear and compaction over the whole width of the wearing course.

(5) Preparation of Formation

For new road construction, the formation shall be prepared in accordance with Section 800.

For existing roads the minimum requirements for preparation of the formation are as follows:

The formation shall be cleaned of all foreign matter and loose materials. Any potholes, ruts, corrugations, depressions and other defects which have appeared due to improper drainage, traffic or any other cause shall be corrected. If considered necessary by the Project Manager, the Contractor shall scarify, spray water and mix, grade and recompact the subgrade to line and level all at his own expense. The Project Manager may require the formation to be proof rolled by a loaded truck, scraper or other approved means prior to dumping of the wearing course material. The cost of all such proof rolling shall be at the Contractor's expense.

(6) Setting Out

The gravel wearing course shall be set out to the tolerances given in Section 900.

(7) Laying and Compacting

The gravel wearing course material shall be deposited in such quantity and spread in a uniform layer across the full width required, so that the final compacted thickness is nowhere less than shown in the Drawing or instructed by the Project Manager. Every reasonable effort shall be made to prevent segregation during the loading, hauling, dumping, spreading, mixing, trimming and compacting operations.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 150 mm and where a greater compacted thickness is required, the material shall be laid and processed in two or more equal layers.

The oversize material shall be broken down in the pavement to the grading specified in Sub-clause 1103 (3). Any oversize material which cannot be broken down to the required size shall be removed and disposed off by the Contractor.

The material shall be scarified and the moisture content adjusted by either uniformly mixing with water or drying out the material such that the moisture content during compaction is between 95% and 102% of the Optimum Moisture Content determined as per IS 2720 Part 8. It shall be graded and trimmed to final line and level. Light compaction may be applied before the final trim is carried out but once 25% of the compaction effort has been applied no further trimming or correction of surface irregularities shall be allowed.

The final trim shall be in cut and the Contractor shall ensure that material from the trim is neither deposited in low areas nor spread across the section but graded clear of the works.

Following the final trim the material shall be compacted to a dry density of at least 98% MDD (Heavy compaction). During the grading, trimming and compaction of the material the Contractor shall ensure that the surface and/or the material does not dry out by applying fog sprays of water or other approved means sufficient to maintain the surface and/or material within the specified limits of moisture content.

Vibratory rollers for the final compaction shall not be allowed.

(8) Proof Rolling

The Contractor shall proof roll the completed layers in accordance with Sub-clause 1102 (5).

(9) Tolerances

The gravel wearing course shall be constructed to the tolerances specified in Section 900.

(10) Testing

(a) Process control

The minimum testing frequency for process control shall be as given in Table 12.3.

Table 12.3: Minimum Testing Frequency

Tests	One test in every	Min no. of test per section
Materials :		
Gradation	300m ³ or part of it and change in source	Clause 300
Plasticity index	" " "	-
CBR	" " "	-
LAA	" " "	-
AIV	" " "	-
Maximum Dry Density and Optimum moisture content	400m ³ " "	-
Field Density & moisture content	200m ² of each layer	3
Construction Tolerance:	10m	
Surface Levels	25m	
Thickness	200m	
Width	40m ²	
Smoothness		

(b) Routine Inspection and Testing

Routine inspection and testing will be carried out by the Project Manager to test the quality of materials and workmanship for compliance with the requirements of this Section.

Any materials or workmanship that do not comply with the specified requirements shall be replaced with materials and /or workmanship complying with the specified requirements or be repaired so that after being repaired it shall comply with the specified requirements.

(11) Maintenance

The wearing surface shall be maintained by the Contractor in its finished condition and shall be watered, graded, dragged, reshaped, or re-compacted as necessary, until the Certificate of Completion is issued, or until the Project Manager instructs that the road shall be opened to public traffic, whichever is the sooner.

(12) Measurement

Gravel wearing course shall be measured in cubic metre by taking cross Sections at intervals of 10 metres or as directed by the Project Manager in the original position before the work starts and after its completion and computing the volumes in cubic metres by average end area method.

(13) Payment

Gravel wearing course shall be paid at their respective contract unit rate. In addition to stated in Clause 114, the contract unit rate shall be also the full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Sections 400 and 500.

1202. SHOULDER

(1) Definition

The term "shoulder" means the part of the road falling between the edge of the pavement and the side ditch or embankment slopes above the formation level.

(2) Material for Construction of Shoulders

Material for construction of shoulders shall be as shown on the Drawing or as instructed by the Project Manager. At the minimum, it shall consist of sub-grade or subbase material as described below.

(b) The shoulder material shall be from the source approved by the Project Manager. The source may be as river bed or pit gravels, rock quarry, alluvial deposits, crusher-run, or other naturally occurring granular materials meeting the requirements of these Specifications.

The grading of the shoulder material shall be a smooth curve within and approximately parallel to the envelopes given in the Table 12.4 below.

Table 12.4: Grading Envelope for shoulder material

Sieve size (mm)	Percentage passing by weight
63.0	100
40.0	70 - 100
20.0	50 - 85
10.0	40 - 75
4.75	30 - 60
2.36	20 - 45
1.18	15 - 35
0.075	4 - 15

The fraction passing 0.425 mm sieve shall have Plasticity Index not more than 6 %.

(3) Construction of Shoulders

Shoulders shall be constructed concurrently with construction of the adjacent pavement layers. Shoulders shall not be constructed ahead of adjacent pavement layers and the Contractor shall ensure that the method of construction is such that at no time water gets prevented from draining off the pavement layers. The method of laying and compacting shoulder material and the compaction requirements shall be in accordance with the relevant Clauses of Section 1000 and Clauses 1101 and 1103 of the Technical Specifications.

(4) Setting out and Tolerances

Shoulders shall be set out and constructed to the tolerances given in Section 900.

(5) Surface Treatment of Shoulders

Surface treatment of shoulders shall be as shown on the Drawing or instructed by the Project Manager. Materials for bituminous surface treatment shall be in accordance with Sub-clause 1102(2) and the method of construction shall be in accordance with the relevant Clauses of Section 1300.

Where topsoil and grassing is shown on the Drawing or instructed by the Project Manager, 50 mm of humus or topsoil shall be spread on the completed shoulder and lightly rolled. Grass seeds shall be planted in accordance with the relevant Clauses of Section 2000 and kept watered until growth is established. Top soiling and grassing shall be in accordance with relevant Clauses of Section 1900.

(6) Measurement and Payment

Where shoulders are constructed with the same material as the adjacent pavement layers no separate items shall be included in the Bill of Quantities for shoulder construction and the measurement and payment shall be in accordance with the relevant Clauses of Sections 1000 and 1100.

Where shoulder construction differs from that of adjacent pavement layers the method of measurement and payment shall be in accordance with the relevant Clauses relating to the type of material shown on the Drawing or instructed by the Project Manager for shoulder construction.

Bituminous surfacing shall be measured and paid in accordance with relevant Clauses of Section 1300. Seeding, Top soiling and grassing shall be measured and paid in accordance with relevant Clauses of Sections 2000 and 21000.

Hard shoulder constructed different from that of adjacent pavement layers shall be measured in cubic metre by taking cross Sections at intervals of 10 metres or as directed by the Project Manager in the original position before the work starts and after its completion and computing the volumes in cubic metres by average end area method.

(7) Payment

Hard shoulders constructed different from that of adjacent pavement layers shall be paid at their respective contract unit rate. In addition to stated in Clause 114, the contract unit rate shall be also the full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Sections 400 and 500.

1300. BITUMINOUS SURFACE

1301. GENERAL REQUIREMENTS FOR PRIME COAT AND TACK COAT, SURFACE DRESSING

(1) Scope

This Clause comprises general requirements for bituminous binder, aggregate and trial sections common to Clauses from 1302 to 1304.

(2) Bituminous Binder

All bituminous binders used in the works shall be **Viscosity Grade – 10 (VG-10) bitumen** and the same shall be supplied by the Employer. Accordingly, the quality control requirements of the bituminous material and the workmanship of the bituminous works to be incorporated in the works shall be that of the VG-10 bitumen.

(3) Storage and Handling of Bituminous Binder

When carried in bulk containers, records of binder temperature during and at the time of storage shall be kept in a manner acceptable to the Project Manager. During storage the temperature of the bituminous binder shall be kept as low as possible, consistent with reasonable pumping ability. Any bituminous binder not conforming to the requirements of Sub-clause 1301 (4) shall be rejected by the Project Manager as unsuitable for use.

Where bitumen emulsions are stored on site in drums, the drums shall be regularly "rolled" to ensure mixing of the contents. Prior to using, all bituminous emulsion drums shall be "rolled" just before opening and use. Emulsions shall be protected against frost and temperatures below 3^o C.

The bitumen storage area and heating station shall be cleared of vegetation, kept neat and tidy. The drums shall be stacked on their sides in small quantities with gaps between each stack to reduce fire risk.

Bitumen distributors and boilers shall be kept clean at all times. When changing the grade of bitumen and at the end of each day's work, all boilers and distributors shall be thoroughly cleaned out with a solvent. The flushing from boilers and distributors shall not be poured anywhere indiscriminately, but shall be led by drainage channels to disposal pits. Care shall be taken that flushing do not find their way into storm water ditches or streams. All boilers, pre-heating pits, tools, and plant shall be kept scrupulously clean.

When filling the bitumen distributor from the boilers or bulk containers, the bitumen shall be passed through a filter of fine wire mesh having opening of not more than 0.6 mm.

On completion of the works, the disposal pits and drainage channels shall be filled in and top soiled. The site shall be left clean and tidy.

(4) Weather Limitations

No bituminous work shall be done during foggy or rainy weather. Strong wind may interfere with the proper execution of the work. Therefore, no surfacing, especially spraying of binder, shall be done when strong wind is blowing.

Bituminous material, except for bitumen emulsions and certain types of prime coat if instructed by the Project Manager shall not be applied on a damp surface.

(6) Adhesion Agent

Where required the adhesion agent shall be of an approved type and shall be used in accordance with the manufacturer's instructions and as instructed by the Project Manager. As a guide the adhesion agent shall be amine based anti-stripping agent and the application rate shall be 1% by weight

(8) Safety Precautions

The Contractor shall take every precaution to avoid fire or health hazards. He shall always ensure that:

- (a) bitumen is heated only to the temperature required for the particular application;
- (b) hot bitumen never comes in contact with water;
- (c) suitable protective clothing, foot wears and gloves are used when handling bitumen; and
- (d) dust is reduced to the minimum.

Care is required when using rapid-curing cut-back, because of the highly flammable nature of the solvent.

(9) Trial Sections

The Contractor shall carry out trial sections at location instructed by the Project Manager to demonstrate to the Project Manager that his surfacing operation is capable of executing the works in accordance with the Specification.

Prior to the commencement of trials the Contractor shall submit in writing to the Project Manager his proposals for applying binders and aggregate. On receipt of the Project Manager's approval, the Contractor shall proceed with the trials, but in absence of such approvals the Contractor shall submit fresh proposals to the Project Manager.

In the course of such trials the Project Manager may call upon the Contractor to modify his method of working, to employ other items of equipment and to amend the rates of spread at which various materials are applied.

When the Project Manager is satisfied that the Contractor is capable of constructing surfacing that complies with the Specification after trial Section or Sections, the Contractor shall receive permission to commence the works. No variation in the approved procedures shall be made without the Project Manager's prior consent in writing.

None of the foregoing provisions prevent the Project Manager from requiring the Contractor to vary his materials, equipment or methods of working at any time during the execution of Works, if he considers this to be essential for execution of the works in accordance with this Specification.

(10) Measurement and Payment

No separate measurement and payment shall be made for complying with the requirements of Sub-clauses from 1301 (1) to 1301 (9). The Contractor shall include related costs of complying with the requirements of Clause 1301 in his rates of the items covered in Clauses from 1402 to 1406.

1302. PRIME AND TACK COAT

(1) Scope and Definitions

This Clause covers the application of a bitumen prime and tack coat to be applied on a prepared pavement layer.

A prime coat means a thin layer of low viscosity bituminous binder applied to an absorbent non-bituminous surface. If the prime coat is to be trafficked, it shall be covered with blinding material.

A tack coat means a thin layer of bituminous binder applied to a bituminous surface.

(2) Preparation of Surface

The surface to be sprayed shall be thoroughly cleaned by sweeping with mechanical brooms and/or washing or other approved means. All laitance of soil or binder material, loose and foreign material shall be removed.

All loose material shall be swept clear of the layer to expose the full width of the layer upon which prime/tack coat shall be applied. The surface to be sprayed shall be checked for line, camber and level, and the surface corrected, made good as necessary and approved by the Project Manager before any bituminous spray is applied. The Project Manager's approval, or otherwise, of the surface shall be given immediately prior to the Contractor's intention to start spraying.

Unless otherwise directed by the Project Manager, immediately prior to the application of prime coat, the surface of the layer shall be lightly sprayed with water to dampen the surface, but in no case the surface shall be made saturated. If the water is over applied, the surface shall be allowed to dry until dampness is uniform over the entire surface.

In order to bring the surface to be primed to the condition required, water shall be applied in small increments by a distributor. Any water on the surface after spraying shall be allowed to drain away before the prime coat is applied.

No traffic shall be allowed on the prepared surface.

(3) Spraying of Prime Coat and Tack Coat

Soon after the surface to be sprayed has been prepared as specified in Sub-clause 1302 (3) and approved by the Project Manager, the edges of the area shall be marked out with a line of string or wire pegged down at intervals not exceeding 15 m on straights or 7.5 m on curves. The prime or tack coat shall be sprayed on to it at the specified rate. Spraying shall be carried out not later than 12 hours after the surface has been prepared.

The quantity of binder used shall give complete coverage of the surface with a slight trace of run-off in places. If the specified rate of spray appear to be incorrect; the Contractor shall immediately stop spraying, inform the Project Manager and amend the spray rate as instructed by the Project Manager.

Bitumen shall be sprayed from a pressure distributor complying with the requirements of Sub-clause 1303 (7) and no hand spraying shall be permitted except in small areas, or to make good a defective area caused by a blocked nozzle.

The nozzles shall be arranged to give a uniform spray and shall be tested prior to spraying by discharging on to suitable material (such as building paper, metal sheets, etc..) or into special troughs made for this purpose. Testing shall not take place on the road, and any bitumen spilt on the ground shall be cleaned off.

If during spraying, a nozzle becomes blocked or develops a defect, the spraying shall be made good with a hand sprayer, and the machine repaired before further spraying is commenced.

When commencing and stopping spraying, sheets of building paper or metal at least 2m wide shall be spread across the full width to be sprayed to give a clean sharp edge.

The metal sheets used for stopping and starting work shall be cleaned after each run and the troughs used for testing shall be cleaned at the end of each day's work.

During spraying all kerbs, road furniture, culvert headwalls, tree boles and the like which are liable to be disfigured by splashing of bitumen shall be protected, and any such feature which is accidentally marred by bitumen shall be cleaned off with a suitable solvent or made good.

(5) Curing and Blinding of Prime Coat

If, after the application of the prime coat, the bituminous material fails to penetrate within the time specified or if the road must be used by traffic, blinding material shall be spread in the amount required to absorb any excess bituminous material and to protect the primed surface.

Blinding material shall be spread from trucks in such a manner that no wheel shall travel on uncovered bituminous material.

Unless the Project Manager permits otherwise, all loose material on the sprayed surface, including any blinding material shall be removed before any further layer of the pavement is laid.

(6) Tolerances

The actual rate of application of bituminous binder across the width of each spray run shall not vary by more than $\pm 5\%$ of the rate ordered and the actual rate of application of binder for each single run of the spray shall not vary from this specified rate by more than 0.03 litre per square metre.

If, after the application of the prime coat, the bituminous material fails to penetrate within the time specified or if the road must be used by traffic, blinding material shall be spread in the amount required to absorb any excess bituminous material and to protect the primed surface.

Blinding material shall be spread from trucks in such a manner that no wheel shall travel on uncovered bituminous material.

Unless the Project Manager permits otherwise, all loose material on the sprayed surface, including any blinding material shall be removed before any further layer of the pavement is laid.

(7) Testing

Tray tests shall be taken at least twice a day during priming operation to check calculations based on dipping of spray trucks.

The minimum testing frequency for the purpose of process control shall be as given in the Table 13.5.

Table 13.5: Minimum Testing Frequencies

Test	Minimum number of tests
Quality of binder	The Contractor shall produce certificates from concerned suppliers to the effect that all materials supplied by them comply with the relevant Specifications. In addition, one set of tests for each 50,000 litres of supply of binder
Binder temperature for application	At regular close intervals
Rate of application of binder	Two tests per run

(8) Measurement

The quantity of prime coat, tack coat shall be measured in litre. For computation of the quantity following methods shall be adopted. The measured quantity shall be calculated as actual consumption in the specified area sprayed measured in litres by dip stick reading of the distributor.

(9) Payment

Bitumen shall be supplied by the Employer/Client. Therefore, the contractor shall be paid for the work at the respective contract unit rate which shall be exclusive of the cost of the bitumen.

1303. GENERAL REQUIREMENTS FOR ASPHALT CONCRETE

(1) Scope

This Clause comprises all the general requirements for bituminous mixes which shall apply to Clause 1204.

(2) Construction Plant

(a) General

The Contractor shall submit to the Project Manager full details of the construction plant the Contractor proposes to use and the procedures the Contractor proposes to adopt for carrying out the permanent works.

The Project Manager shall have access at all times to construction plant for the purposes of inspection. The Contractor shall carry out regular calibration checks in the presence of the Project Manager and shall correct forthwith any faults found.

All construction plant used in the mixing, laying and compacting of bituminous mixes shall be of adequate capacity, in good working condition and shall be acceptable to the Project Manager.

(b) Mixing Plant

Bituminous materials shall be mixed in a plant complying with ASTM Designation D995 and shall be located on the Site unless otherwise agreed by the Project Manager. It shall be equipped with at least three bins for the storage of heated aggregates and a separate bin for filler. All bins shall be covered to prevent the ingress of moisture.

Sufficient and separate storage space shall be provided for each size and type of aggregate. Different aggregates sizes shall remain separated until they are delivered to the cold elevator feeding the drier. The storage yard shall be neat, orderly, and stockpiles readily accessible for sampling by the Project Manager.

The plant may be either batch-mix type of the continuous-mix type and shall be capable of regulating the composition of the mixture to within the tolerances specified in clause 1300. The plant shall include truck scales and a recorder.

The bitumen tank shall be capable of maintaining its contents at the specified temperature within a tolerance of plus or minus 5°C and shall be equipped with a thermostat to prevent the temperature rising above 180°C and a fixed thermometer easily read from outside the tank. Any bitumen which has been heated above 180°C or has suffered carbonisation from prolonged heating shall be removed from the plant and disposed off.

The Project Manager or his authorized representative shall have access at all times to all parts of the plant for checking adequacy of equipment; inspecting operation of the plant, verifying weights, proportions and character of materials; and checking the temperatures maintained in the preparation of the mixtures.

(c) Hauling Equipment

Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds. To prevent the mixture from adhering to them, the beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather, and an insulated bed to maintain the mixture at the specified temperature.

(c) Laying Plant

Bituminous materials shall be laid by a self propelled paver capable of laying bituminous materials with no segregation, dragging, burning or other defects and within the specified width, level and surface regularity tolerances. It shall be equipped with a receiving hopper of sufficient capacity to permit uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The screed or strike - off assembly shall effectively produce a finished surface of the required evenness and texture, without tearing, shoving, or gouging the mixture. The paver shall be capable of operating at forward speeds consistent with satisfactory paving of the mixture.

(d) Compaction Plant

The Contractor shall provide sufficient rollers of adequate size and weight sufficient to compact the mixture to the required density while the mixture is still in workable condition. Rollers shall be capable of reversing without backlash, and operating at slow speeds to avoid displacement of the asphalt concrete mixture. The use of equipment which results in excessive crushing of the aggregate shall not be permitted. Prior to commencing the laying of bituminous mixes in the permanent works the Contractor shall carry out site trials in accordance with Section 300 to demonstrate the adequacy of his plant and to determine the optimum method of use and sequence of operation of the rollers.

(3) Preparation of Surface

Immediately before placing the bituminous mix in the pavement, the existing surface shall be cleaned of all loose materials and foreign matter with mechanical brooms or by other approved methods. The debris shall be deposited well clear of the surface to be covered.

Any defect of the surface shall be made good and no bituminous mix shall be laid until the surface has been approved by the Project Manager.

If instructed by the Project Manager tack coat shall be applied prior to laying the bituminous mix or between layers of the bituminous mix, in accordance with Clauses 1301 and 1302. In case asphalt concrete is to be provided on new pavement as wearing course, binder course, prime coat shall be applied in accordance with Clauses 1301 and 1302.

(4) Job Mix Formula

The Contractor shall produce aggregates meeting the grading requirements of the Specification.

No work shall be started on the project nor any mixture accepted until the Contractor has submitted samples of the materials intended for use and the Project Manager has approved a satisfactory job mix formula for each required material grading.

At least one month prior to commencing work using a bituminous mix, the Contractor shall submit samples of each constituent of the mix to the Project Manager.

The maximum size of the aggregate for wearing course shall equal to or less than the thickness of wearing course divided by 2.5 and that for binder course shall equal to or less than thickness or binder course divided by 2 unless otherwise specified or directed by the Project Manager.

The Contractor shall then carry out laboratory tests in order to propose the proportions of each constituent of the initial mix or mixes to be used for site trials to be carried out in accordance with Sub-clause 1025 (5). The Contractor shall submit his proposed job mix formula to the Project Manager for approval, together with copies of all supporting laboratory test data to show that the mix complies in all respects with the requirements of this Specification.

Shall the Project Manager conclude from the site trials that the mix proportions or aggregate grading are to be changed; the Contractor shall submit further samples of the constituents, carry out further laboratory and site trials as directed by the Project Manager to produce an acceptable job mix formula.

The Project Manager may instruct the alteration of the composition of the aggregates passing through 0.075 mm by the addition or substitution of mineral filler.

The Contractor shall make the necessary adjustments to his plant to enable the revised mix to be produced.

Following laboratory and site trials the determined proportions of the mix agreed by the Project Manager shall become the basis of the working mix and the Contractor shall maintain this composition within the tolerances given in clause 1300.

Any changes in the nature or source of the materials, the Contractor shall inform the Project Manager accordingly. The procedure set out above shall be followed in establishing any new mix design subsequent to that.

(5) Site Trials

Full scale laying and compacting site trials shall be carried out by the Contractor on all asphalt pavement materials proposed for the works using the construction plant and methods proposed by the Contractor for constructing the works. The trials shall be carried out at a location approved by the Project Manager in his presence.

The trials shall be carried out to enable the Contractor to demonstrate the suitability of his mixing and compaction equipment to provide and compact the materials to the specified voids content and confirm that the other specified requirements of the completed asphalt pavement layer can be achieved.

Each trial area shall be at least 100 metres long and to the full construction width and depth for the material. It may form part of the Works provided it complies with this Specification. Any areas which do not comply with this Specification shall be removed.

The Contractor shall allow in his program for conducting site trials and for carrying out the appropriate tests on them. The trial on any pavement layer shall be undertaken at least 21 days ahead of the Contractor proposing to commence the permanent work on that layer.

The Contractor shall compact each section of trial over the range of compaction effort the Contractor is proposing. The following data shall be recorded for each level of compaction effort at each site trial:

- (a) The composition and grading of the material including the bitumen content and type and grade of bitumen used.
- (b) The moisture content of aggregate in the asphalt plant hot bins.
- (c) The temperature of bitumen and aggregate immediately prior to entering the mixer, the temperatures of the mix on discharge from the mixer and the temperature of the mix on commencement of laying, on commencement of compaction and on completion of compaction. The temperatures of the mixture are to be measured in accordance with BS 598, Part 109.
- (d) The type, size, mass, width of roll, number of wheels, wheel load, tyre pressures, frequency of vibration and the number of passes of the compaction equipment, as appropriate for the type of roller.
- (e) The target voids and other target properties of the mix together with the results of the laboratory tests on the mix.
- (f) The density and voids achieved.
- (g) The compacted thickness of the layer.
- (h) Any other relevant information as directed by the Project Manager.

At least eight sets of tests shall be made by the Contractor on each 100 metres of trial for each level of compaction effort and provided all eight sets of results over the range of compaction effort proposed by the Contractor meet the specified requirements for the material then the site trial shall be deemed successful. The above data recorded in the trial shall become the agreed basis on which the particular material shall be provided and processed to achieve the specified requirements.

During the execution of the Works, if the construction control/process control tests indicate that the requirements for a material are not consistently achieved, then work on that layer shall be stopped until the cause is investigated by the Contractor. Such investigation may include further laboratory and/or site trials on the material to determine a revised set of data as described above which, when agreed, shall be the basis on which all subsequent material shall be provided and processed to achieve the specified requirements.

Agreement of the Project Manager to a set of data recorded in a site trial shall not relieve the Contractor of any responsibility to comply with the requirements of this Specification.

(6) Preparation of Mineral Aggregate

The aggregate for the mixture shall be dried and heated in the plant before entering the mixer. When introduced into the mixer, the combined aggregate shall contain not more than 0.5% moisture. Water in the aggregate shall be removed by heating to the extent that there is no subsequent foaming in the mixture prior to the placing of the material. The aggregate shall be heated to the temperature designated by the job mix formula within the job tolerance specified. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. Particular care shall be taken that aggregate high in calcium or magnesium content is not damaged by overheating.

(7) Mixing of Aggregates and Bitumen

The bitumen shall be heated so that it can be distributed uniformly. Care shall be taken not to overheat it.

The dried aggregates shall be combined in the mixer in the amount of each fraction of the agreed mix and the bitumen shall then be introduced into the mixer in the amount specified. The quantity of aggregate for each batch shall be determined, measured, and conveyed into the mixer. In case of volumetric proportioning, the size of the gate opening shall be determined, and the gates locked in position.

The quantity of bituminous material for each batch or calibrated amount for continuous mixer shall be determined by the Project Manager. It shall be measured by weight and introduced into the mixer at the specified temperature, using the lowest range possible for adequate mixing and spreading. For batch mixing, all mineral aggregates shall be in the mixer before the bituminous material is added. The exact temperature within the specified range shall be fixed by the Project Manager. In no case shall aggregates be introduced into the mixture at a temperature more than 11 ° C above the temperature of the bituminous material.

The materials shall then be mixed until a complete and uniform coating of the aggregate is obtained. The mixing time shall be the shortest required obtaining a uniform mix and thorough coating.

This time is dependent upon the mix design and the type of mixing equipment used. To compute the mixing time in a continuous mixer, the weight of its contents at operating level is divided by the weight of the mixture delivered per second by the mixer.

Mixing time in Seconds = Pugmill dead capacity in kilograms

Output in Kilograms per Second

(8) Transportation of the Mixture

The asphalt concrete mixture shall be transported from the mixing plant to the point of use in vehicles described in Sub-Clause 1204(2) of this specification. The bituminous mix shall be kept free of contamination and segregation during transportation. Each load shall be covered with canvas or similar covering to protect it from dust and adverse effect of the weather.

(9) Laying of the Mixture

Immediately after the surface has been prepared and approved, the mixture shall be spread to line and level by the laying plant without segregation and dragging. The mixture shall be placed at a temperature between 126 °C and 150 °C. When the mixture is being placed during warm weather and the Project Manager has determined that satisfactory results can be obtained at lower temperatures, he may direct that the mixture be delivered at a temperature within the tolerance allowed in the approved job mix formula.

The mixture shall be placed in widths of one traffic lane at a time, unless otherwise agreed by the Project Manager. The compacted thickness of any layer shall be as shown on Drawings or directed by the Project Manager. The compacted thickness of any layer shall be at least 2.5 times the maximum size of the aggregate for wearing course and at least 2 times the maximum size of the aggregate for binder course.

Only on areas where irregularities or unavoidable obstacles make the use of mechanical laying impracticable, the mixture may be spread and compacted by hand using equipment approved by the Project Manager.

The bituminous mixture shall not be placed during rainfall, foggy and cold weather, when the air temperature in the shade is 10 °C or lower, unless so directed by the Project Manager. The Project Manager may permit work to continue when overtaken by sudden rains only to provide for laying that material which is in transit

from the plant, provided the mixture is in transit from the plant, and provided the mixture is within the temperature limits specified.

(10) Compaction

Immediately after the bituminous mixture has been spread, it shall be thoroughly and uniformly compacted by rolling.

The layer shall be rolled when the mixture is in such a condition that rolling does not cause undue displacement or shoving.

The number, weight and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. The sequence of rolling operations shall be as agreed with the Project Manager.

Initial rolling with a steel tandem or three-wheeled roller shall follow the laying plant as closely as possible. The rollers shall be operated with the drive roll nearest the laying plant, at a slow and uniform speed (not exceeding 5 km/h).

Rolling shall normally commence from the outer edge and proceed longitudinally parallel to the centreline, each trip overlapping one half of the roller width. On super elevated curves, rolling shall begin at the low side and progress to the high side. Where laying is carried out in lanes care must be taken to prevent water entrapment.

Intermediate rolling with a pneumatic tyred or vibratory roller shall follow immediately. Final rolling with a steel wheeled roller shall be used to eliminate marks from previous rolling.

To prevent adhesion of the mixture to the rollers, the wheels shall be kept lightly moistened with water.

In areas too small for the roller, a vibrating plate compactor or a hand tamper shall be used to achieve the specified compaction.

(11) Finishing, Joints and Edges

Any mixture that becomes loose and broken, mixed with dirt or foreign matter or is in any way defective, shall be replaced with fresh hot mixture, which shall be compacted to conform to the surrounding area.

Spreading of the mixture shall be as continuous as possible. Transverse joints shall be formed by cutting neatly in a straight line across the previous run to expose the full depth of the course. The vertical face so formed shall be painted lightly with hot bitumen just before the additional mixture is placed against it.

Longitudinal joints shall be rolled directly behind the paving operation. The first lane shall be placed true to line and level and have an approximately vertical face. The mixture placed in the abutting lane shall then be tightly crowded against the face of the previously placed lane. The paver shall be positioned to spread material overlapping the joint face by 20 - 30 mm. Before rolling, the excess mixture shall be raked off and discarded.

When the abutting lane is not placed in the same day, or the joint is destroyed by traffic, the edge of the lane shall be cut back as necessary, trimmed to line and painted lightly with hot bitumen just before the abutting lane is placed.

Any fresh mixture spread accidentally on the existing work at a joint shall be carefully removed by brooming it back on to uncompacted work, so as to avoid formation of irregularities at the joint. The finish at joints shall comply with the surface requirements and shall present the same uniformity of finish, texture and density as other sections of the work.

The edges of the course shall be rolled concurrently with or immediately after the longitudinal joint. In rolling the edges, roller wheels shall extend 50 to 100 mm beyond the edge.

(12) Sampling of Bituminous Mixtures

The sampling of bituminous mixtures shall be carried out in accordance with ASTM Designation D979.

(13) Quality Control Testing

During mixing and laying of bituminous mixtures, control tests on the constituents and on the mixed material shall be carried out in accordance with Section 200 and relevant Clauses of Section 1200.

If the results of any tests show that any of the constituent materials fail to comply with this Specification, the Contractor shall carry out whatever changes may be necessary to the materials and/or to the source of supply to ensure compliance.

If the results of more than one test in ten on the mixed material show that the material fails to comply with this Specification, laying shall forthwith cease until the reason for the failure has been found and corrected. The Contractor shall replace any faulty material laid with material complying with this Specification all at his expense.

(14) Tolerances

Surfacing and base shall be constructed within the geometric tolerances specified in Section 900.

The Contractor shall maintain the composition of the mixture as determined from the laboratory and site trials within the following tolerances, per single test:

- (a) Bitumen content : $\pm 0.3\%$ of (Total weight of bitumen in total mix)
- (b) Aggregates
 - (i) Passing through 10 mm sieve and larger sieves: $\pm 6\%$ of (Total weight of dry aggregate)
 - (ii) Passing through 10 mm sieve and retained on 1mm sieve: $\pm 4\%$ of (Total weight of dry aggregate)
 - (iii) Passing through 1 mm sieve and retained on 0.075 mm sieve: $\pm 3\%$ of (Total weight of dry aggregate including mineral)
 - (iv) Passing through 0.075 mm sieve : $\pm 2\%$ of filler)

The average amount of bitumen in any length of any layer, calculated as the product of the bitumen contents obtained from single tests and the weight of the mixture represented by each tests, shall not vary beyond the limit of tolerance of the amount specified.

The average amount of bitumen for each day's production calculated from the check weights of mix shall not vary beyond the limit of tolerance of the amount specified.

The final average overall width of the upper surface of a bituminous mix layer measured at six equidistant points over a length of 100 m shall be at least equal to the width specified. At no point shall the distance between the centreline of the road and the edge of the upper surface of a bituminous mix layer be narrower than that specified by more than 13 mm.

(15) Measurement and payment

No separate measurement and payment shall be made for complying with the requirements of the Clause 1304. The Contractor shall allow compensation for compliance of the Clause 1304 in the rates of items covered by Clause 1304.

1304. ASPHALT /BITUMINIOUS CONCRETE

(1) Scope

This Clause covers the materials, method of construction and requirements for the construction of asphalt concrete. The asphalt concrete shall be composed of mineral aggregate and bituminous material, mixed in a central hot mix plant and placed on a prepared course in accordance with these Specifications and shall conform to the dimensions and typical cross section shown on the Drawings and with lines, levels and grades instructed by the Project Manager. The asphalt concrete shall be used for pavement overlay courses, laid in single layer or more than one layer comprising wearing and binder courses.

As specified on the Drawing or as directed by the Project Manager, each course shall be constructed to the depth, typical section, or elevation required by the plans and shall be rolled, finished and approved before the placement of the next course.

(2) Definition

Asphalt concrete means a thoroughly controlled, hot-mixed, hot-laid, plant mixture of well graded dried aggregate and penetration grade bitumen, which, when compacted, forms a dense material.

(3) Materials

(a) The Bitumen used in the work shall be Viscosity Grade-10 (VG-10) bitumen and the same shall be supplied by the Employer. Accordingly, the quality requirements of the works and workmanships incorporated in the works shall be in conformity to the requirements of the VG-10 bitumen.

b) Primer coat / Primer seal shall be as per sub-section 1302.

(c) Aggregate

The aggregate shall consist of crushed stone, or crushed gravel, with or without sand or other inert finely divided mineral aggregate. The aggregate shall be clean; composed of sound, tough, durable stone/rock particles; free from weathered or decomposed stone, shale, clay, silt, organic matter, and other deleterious substances. The coarse aggregate shall be entirely crushed.

The coarse aggregate shall comply with the requirements given in the Table 13.6.

Table 13.6: Physical Properties for Coarse Aggregates for Asphalt Concrete

Property	Test	Specification
Particle shape	Flakiness and Elongation Index	Maximum 25%
Strength*	Los Angeles Abrasion Value	Maximum 30%
	Aggregate Crushing Value	Maximum 25%
Durability	Sodium Sulphate Soundness	Maximum 12%
Water Absorption	Water Absorption	Maximum 2%
Stripping	Bitumen Stripping	Minimum retained coating 95%

* Aggregate may satisfy requirements of either of these two tests unless otherwise agreed by the Project Manager.

Fine aggregate (passing a 4.75 mm sieve) shall be free from clay, silt, organic and other deleterious matter and shall be non-plastic. It shall consist of entirely crushed rock produced from stone having a Los Angeles Abrasion

of not more than 30 percent. The Sand Equivalent of the fine aggregate shall be not less than 60 and the Sodium Sulphate Soundness of not more than 12 percent.

(c) Mineral Filler

If additional filler is necessary, it shall consist of stone dust, Portland cement, or other approved mineral matter. The filler material shall meet the requirements of Clause 8 of BS 594. It shall be thoroughly dry and free from lumps. At least 75% (by weight) shall pass a 0.075mm sieve and 100% shall pass a 0.425mm sieve. It shall have a bulk density between 0.5 and 0.9 g/ml measured in accordance with BS 812-2.

(4) Grading Requirements

The grading of the mixture of coarse and fine aggregate shall be within and approximately parallel to one of the grading envelopes given in Table 13.7 or as specified in the Bill of Quantities.

Table 13.7: Gradation Requirements of Aggregate for Asphalt Concrete

Sieve Size (mm)	Percent Passing by weight		
	Type I Aggregate size 25 mm max.	Type II Aggregate size 19 mm max.	Type III Aggregate size 12.5 mm max.
25.0	100		
19.0	80-90	100	
12.5	70-90	80-100	100
9.5	60-82	68-90	80-100
4.75	42-70	50-79	60-90
2.0	30-60	36-67	40-60
0.425	15-40	17-44	25-40
0.180	8-26	9-29	10-30
0.075	3-8	3-8	3-8
Bitumen Content ¹	6.0-7.5	5.0-6.0	5.0-7.5

¹percent by mass of total mix as determined by the Marshall method

The aggregate shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa. Selection of gradation shall be such that the maximum size aggregate used shall not be more than one - half the thickness of the layer of the bituminous course being constructed.

The bitumen content of the working mix shall be instructed by the Project Manager following laboratory and site trials.

(5) Requirements for Asphalt Concrete

Asphalt concrete i.e. the mixture of binder, coarse and fine aggregates and mineral filler, if any, shall comply with the requirements given in the Table 13.8.

Table 13.8: Requirements for Asphalt Concrete

Asphalt Concrete	Wearing Course	Binder Course, Regulating/Levelling Course
Marshall Stability (75 blows/face, N)	Min 8000	Min 6000
Flow Value (mm)	2 – 3	2 - 3
Voids in total Mix (%)	2 - 4	3 - 7
Compression/Immersion Ratio ²	>0.75	>0.75

² as per ASTM D1075

(6) Construction Operations

The laying and compaction of asphalt concrete mixture shall be as specified. Grade control between the edges of the pavement shall be accomplished by grade stakes or steel pins placed in lanes parallel to the centerline of the pavement and at intervals sufficiently close that string lines may be stretched between stakes or pins.

Placing shall be in accordance with the agreed staging sequence as jointly determined by the Project Manager and the Contractor. Hauling over new bituminous material already placed shall not be permitted until the material has been thoroughly compacted as specified, then allowed to cool to atmospheric temperature.

The mixture shall be dumped into paver as specified and immediately spread to the full width required. It shall be struck off in a uniform layer of such depth that, when work is completed, it will have the thickness and will conform to the grade and surface profile required. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat.

The mixture shall be placed in strips width as may be approved by the Project Manager. To ensure proper drainage, the spreading shall be along the centerline of the pavement on a crowned section or on the high side of the pavement with a one - way slope. After the first strip or width has been compacted, the second width shall be placed, finished, and compacted in the same manner as the first width. After the second strip has been placed and rolled, a 3 meter straightedge shall be placed, across the longitudinal joint to determine if the surface conforms to grade and profile requirements.

Exposed vertical edges of paved strips shall be free of all accumulations of dirt or other foreign material before any mixture is spread in an adjacent lane. If joint faces become dry or dusty, the contact surfaces should be given a brush coat of asphalt tack coat. In lieu of tacking cold contact surfaces, the Contractor may use a joint heater approved by the Project Manager. If the spreading machine should drift from an adjacent lane during construction, the unfilled space shall be carefully filled with fresh hot mixture obtained from the truck or the hopper of the spreading machine. Use of mixture already spread to fill up these areas shall not be permitted.

In areas where the use of mechanical spreading and finishing equipment is deemed impractical, owing to irregularities or obstructions, bituminous premix may be hand spread. When hand spreading is permitted, the mixture shall be dumped on approved dump sheets outside of the area upon which it is to be spread, and then distributed into place immediately with hot shovels. It shall be spread with hot rakes in a uniformly loose layer to the full width required and of such depth that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour shown on the plans.

After spreading, the AC mixture shall be thoroughly and uniformly compacted with power rollers, as directed by the Project Manager. Rolling of the mixture shall be as soon after spreading, as it will bear the roller without undue displacement or hair cracking. On the first strip spread, rolling shall start in the center and continue toward either edge. On subsequent strips laid, rolling shall start on the edge adjacent to previously laid material and continue toward the opposite edge.

Initial rolling shall be done longitudinally. The roller shall overlap on successive trips. Alternate trips of the roller shall be of slightly different lengths. The mixture shall be subjected to diagonal rolling; crossing the lines of the first after three or more lanes are constructed, but cross rolling shall not exceed more than one half the width of the pavement on crowned section.

The speed of the roller shall, at all times, be slow to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by rakes, and the addition of fresh mixture.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until all roller marks are eliminated, the surface of uniform texture and true to grade and cross section, and a density of 98 % of the maximum laboratory density of the job mix.

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but excessive water will not be permitted.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers.

Any mixture, which becomes loose or broken, mixed with dirt, or in any way defective shall be removed to full depth and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work will be done at the Contractor's expenses. Skin patching shall not be allowed.

The mixture at the joints shall comply with the surface requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the adjacent course for the specified depth of the course. Joints shall be formed by saw - cutting the previously placed bituminous course to expose the full depth of the course; the exposed edge shall be given a light coat of asphalt cement or bitumen as specified by the Project Manager. The fresh mixture shall be raked against the joint and thoroughly tamped and rolled.

While the surface is being compacted and finished the Contractor shall carefully trim the outside edges of the pavement to the proper alignment. Edges so formed shall be leveled while still hot with the back of a rake or a smoothing iron and thoroughly compacted by tampers or by other satisfactory methods.

At the end of day work ramps shall be provided longitudinally and transversally on asphalt concrete paving lanes as shown on Drawings or as directed by the Project Manager, to facilitate easy roll of vehicles. To start the next laying operation, the ramp shall be removed by saw - cutting to create a vertical joint face at the end of the paving lane (before the ramp was placed) and removing and disposing of ramp material to the cut line. The joint will be painted with hot bitumen before laying mixture and paving shall start from its interface.

(7) Testing

(a) Sampling

Prior to use the Contractor shall supply the Project Manager with samples of all materials proposed to be used. The Contractor shall carry out all the specified tests as the Project Manager may require satisfying himself that the materials and proportions satisfy this Specification. No material shall be used, nor job mix adopted until they are approved in writing by the Project Manager.

Sampling of mixes shall normally be carried out at the mixing plant or from lorries conveying the materials from the mixing plant to the paver, but the Project Manager may direct for sampling to be carried out from the paver, if there is any danger of segregation of the mix during transportation and spreading process.

The Contractor shall remove 100 mm minimum diameter core samples of the completed pavement from locations designated by the Project Managers so that the composition, compaction and density of the pavement may be tested. Samples for each day or fraction thereof shall be taken at a rate of one core per 1000 m². The Contractor shall at his own expense replace the bituminous pavement in the core holes with new mixture meeting this specification. Pavement deficient in composition, compaction, or thickness, shall be corrected by the Contractor at his own expenses to the satisfaction of the Project Manager.

(b) Process Control

The minimum frequency of testing required for process control shall be as provided in the Table 13.9.

Table 13.9: Minimum Testing Frequency

Test	Minimum number of tests
AGGREGATE:	
Grading	One test for every 100 m ³ or part of it and change of source
Los Angeles	" " " " " "
Aggregate Crushing Value	" 500 m ³ " "
Flakiness Index	" "" " "
SSS	" 100 m ³ " "
Sand Equivalent	" 500 m ³ " "
Quality of Filler	" "" " "
	" 50 tonnes " "
BITUMEN:	
Quality of Binder	<i>The Contractor shall produce certificates from all suppliers to the effect that all materials supplied by them comply with the relevant Specifications.</i> In addition, one set of tests for each 50,000 litres or part of it of supply of binder
Penetration Test	Daily
MIXTURE	
Grading and bitumen content	One test for each 100 tonnes of mix or part of it
Marshall stability, flow and voids	" " "
Control of Temperature	As required
CONSTRUCTION TOLERANCES:	
Compaction	One test per 500 m ² or part of it
Surface levels	Every 10 m or at close intervals
Smoothness	" 50 m ² "

8) Measurement

Asphalt concrete shall be measured in cubic metre calculated as the product of the length and the compacted cross-sectional area of the asphalt concrete laid as per Drawing or as instructed by the Project Manager.

Tack coat and prime coat shall be measured in litre as per Clause 1202.

(9) Payment

The asphalt concrete shall be paid as per contract unit rate which shall be the full and the final compensation for the cost of compliance of all requirements of Clauses 1204 and traffic management according to Clause 106 in addition to those specified in Clause 112.

Tack coat and prime coat shall be paid at the respective contract unit rate which shall be the full and the final compensation for compliance of all requirements specified in Clause 1201 and 1202 and traffic management according to Clause 106 in addition to those specified in Clause 114.

1400. STONE MASONRY WORK

1401. SCOPE

This Section covers furnishing of materials and construction of different types of stone masonry works in accordance with the Drawing and this Specification or as directed by the Project Manager. These works will be required for retaining structures, drains and channel lining, slope and drainage protection works or other works as directed by the Project Manager.

Activities involved will include supply of stones, dressed bond stone, cement, sand, water, equipment, tools, preparation of mortar, placing and joining stones dry/with mortar, curing, collection and testing of specimens, etc.

1402. MATERIALS

All requirements in respect of stones and cement sand mortar described herein shall be applicable in all Clauses of this Section, if otherwise not specified.

(1) Stone

The stones to be used shall be durable and angular in shape. If boulders are used they shall be broken into angular pieces. The stones shall be sound, hard, and free from iron bands, spots, sand holes, flaws, shakes, cracks or other defects. The stone shall not absorb water more than 5 per cent. Stones for coursed or uncoursed stone rubble masonry shall have broken face on three sides. Stones for dressed rubble masonry shall have dressed face on all sides. Except otherwise described in the contract, the length of any stone shall not exceed three times its height. The breadth of the stone on the bed shall not be less than 150 mm nor greater than 3/4th thickness of the wall. At least 80% of the stones used in masonry, except those used for chinking as chips or spalls of stones shall have individual volumes of more than 0.01 m³. The chips or spalls used including voids in the dry stone masonry shall not be more than 20% of the stone masonry by volume. In case of mortared masonry the total volume of mortar and spalls taken together shall not be more than 30% of the mortared masonry. Representative samples of the stones intended for use in the works shall be submitted to the Project Manager for prior approval. Further representative samples shall be submitted for approval whenever there is a change in the type or strength of the rock that the Contractor intends to use in masonry work.

(2) Mortar

Mortar shall comply with IS 2250–1981; Code of Practice for preparation and use of masonry mortar. The mortar used in work shall have the strength not less than 5 N/mm² or 7.5 N/mm² at 28 days as specified. For example class MM5 means cement sand mortar in the ratio to attain compressive strength not less than 5 N/mm² at 28 days. The grade of cement sand mortar shall be as specified in the Bill of Quantities.

Sand shall comply with IS 2116. Cement shall be ordinary Portland cement as per IS 8112 or IS 12269.

Water shall be clean and free from detrimental concentration of acids, alkalis, salts, and other organic or chemical substances. If instructed by the Project Manager the Contractor shall prove the suitability of the water by tests carried out by an approved laboratory. Such tests shall comply with the requirements of IS: 3029-1964.

The mixing shall be done in a mechanical mixer unless hand-mixing is permitted by the Project Manager. If hand-mixing is allowed, the operation shall be carried out on a clear watertight platform. In the required proportion cement and sand shall be first mixed dry to obtain uniform colour. Then required quantity of water shall be added and the mortar shall be mixed to produce workable consistency. The mortar shall be mixed for at

least three minutes after addition of water in the case of mechanical mixing. In the case of hand mixing, the mortar shall be hoed back and forth for about 10 minutes after addition of water in order to obtain uniform consistency.

Only that quantity of mortar shall be mixed at a time which can be used completely before it becomes unworkable. Any mortar that has become unworkable due to loss of water before elapsing the initial setting time of cement shall be rewet to make it workable and shall be used in the works. On no account mortar shall be used after elapsing the initial setting time of cement.

1403. CONSTRUCTION

The method of construction described herein shall hold good in all Clauses of this Section, wherever applicable.

(1) General

Construction shall be carried out in accordance with I.S. 1597-1992, Code of Practice for construction of stone masonry, Part 1 Rubble stone masonry or Part 2 Ashlar Masonry as appropriate. All stratified stone possessing bedding planes shall be laid with its natural bed as nearly as possible at right angles to the direction of load. In the case of arch rings, the natural bed shall be radial. Facework groins shall be built to a height not exceeding one metre in advance of the main body of the work and adjacent walling stepped down on either side. Masonry face work between the groins shall then be built to a height not exceeding 500 mm above the backing which shall then be brought up level with the completed facework. At no time shall the backing be built up higher than the facework.

Except for dry rubble walling, all joints (gaps) shall be sufficiently thick to prevent stone to stone contact and the gaps shall be completely filled with mortar. Stones shall be clean and sufficiently wetted before laying to prevent absorption of water from mortar.

Placing loose mortar on the course and pouring water upon it to fill the gaps in stones shall not be allowed. Mortar shall be fluid, mixed thoroughly and then poured in the joints. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all its faces completely covered with mortar of the thickness as specified for joints.

The bed which is to receive the stone shall be cleaned, wetted and covered with a layer of fresh mortar. All stones shall be laid full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet immediately after placement and solidly embedded in mortar before it has set. Clean and wet chips and spalls shall be wedged into the mortar joints and bed whenever necessary to avoid thick joints or bed of mortar. When the foundation masonry is laid directly on rock, the bedding face of the stones of the first course shall be dressed to fit into rock snugly when pressed down in the mortar bedding over the rock. For masonry works over rock, a levelling course of M15/40 or M15/20 concrete 100mm thickness shall be laid over rock and then stone masonry work shall be laid without foundation concrete block.

In case, any stone already set in mortar is disturbed or the joints broken, it shall be taken out without disturbing the adjoining stones and joints. Dry mortar and stones shall be thoroughly cleaned from the joints and the stones shall be reset in fresh mortar. Sliding one stone on top of another which is freshly laid shall not be allowed.

Shaping and dressing of stone shall be done before it is laid in the work. Dressing and hammering of the laid stones which will loosen the masonry shall not be allowed.

Building up face wall tied with occasional through stones and filling up the middle with stones spalls and chips or dry packing shall not be allowed. Vertical joints shall be staggered. Distance between the nearer vertical joints of upper layer and lower layer in coursed rubble masonry shall not be less than half the height of the course.

Masonry in a structure between two expansion joints shall be carried up nearly at one uniform level throughout but when breaks are unavoidable the masonry shall be raked in sufficiently long steps to facilitate jointing of old and new work. The stepping of raking shall not be more than 45 degrees with the horizontal.

Masonry shall not be laid when the air temperature in the shade is less than 3°C. Newly laid masonry shall be protected from the harmful effects of weather.

The holes left in the masonry work for supporting scaffolding shall be filled and finished with M150 grade concrete.

The masonry work in cement mortar shall be kept constantly moist for a minimum period of 7 days, unless otherwise specified.

(2) Concrete Capping

Where masonry structures are constructed to receive a concrete capping the joints to the upper surface of the masonry shall be raked out to a depth of 10 mm prior to placing of the concrete to the capping. The concrete for capping shall be as per the Drawing or as directed by Project Manager and shall conform to Section 1700.

(3) Pointing

Where external faces of the mortared masonry work will be backfilled or otherwise permanently covered up, the mortared joint shall be finished flush to the faces of the adjacent stonework.

Where mortared masonry faces will remain exposed, the mortar joints shall be pointed to a consistent style as shown on the Drawing. Pointing shall be carried out using mortar MM7.5 cement mortar or as shown on the Drawing or as shown on the Drawing or as directed by the Project Manager. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing, if not otherwise mentioned, shall be ruled type for which it shall, while masonry work is still green, be ruled along the centre with half round tools of such width as may be specified by the Project Manager. The excess mortar shall, then, be taken off from the edges of the lines and shall not be unnecessarily plastered over the exposed stone works. The thickness of the joints shall not be less than 3mm for Ashlar masonry.

However, the maximum thickness of joints in different works shall be as follows:

- Random Rubble : 20mm
- Coursed Rubble : 15mm
- Ashlar Masonry : 5mm

(4) Weep holes

Weep holes shall be provided in solid plain concrete/reinforced concrete, brick/stone masonry, abutment, wing wall or other structures as shown on the Drawing or as directed by the Project Manager. Weep holes shall be provided with 100mm dia polythene pipe for structures in plain/reinforced concrete or brick masonry. In case of stone masonry, weep holes shall be 100 mm wide, 100 mm high or circular with 100 mm diameter. Weep holes shall extend through the full width of concrete/masonry with a slope of 1 vertical 20 horizontal towards the draining face. The spacing of weep holes shall generally be 1 m in either direction or as shown on the drawing with the lowest at about 150 mm above the low water level or ground level whichever is higher or as directed by the Project Manager. Surfaces of the weep holes shall be smooth and it shall be ensured that the water is properly drained from the backfill.

1404. ASHLAR

All stones shall be dressed to accurate planes on the beds and joints and they shall be fair and neatly or fine tooled on the face unless otherwise described in the contract.

1405. BLOCK-IN-COURSE

Beds and joints shall be squared and dressed for a distance of at least 220 mm from the exposed face. Bond stones shall form at least one sixth of the area of the exposed face and shall extend at least 900 mm into the wall or for the full thickness of the wall whichever is minimum. Unless described in the contract as tooled or drafted, the exposed face of all stones shall be blocked and left rough. Arises shall be dressed square at all beds and joints.

1406. SQUARE RUBBLE- COURSED OR BROKEN COURSES

All stones shall be truly squared and dressed for a distance at least 120 mm from the face of the wall. Bond stones shall be provided at the rate of at least one to every 0.5 m² of exposed face and shall measure not less than 150 mm x 150 mm on the face and not less than 450 mm in length or the full thickness of the wall, whichever is the less. Vertical joints in any layer shall be broken in the next layer and the horizontal lapping of the stones shall not be less than 100 mm.

1407. RANDOM RUBBLE - COURSED OR UNCOURSED

All stones shall be carefully set with bond stones running right through the thickness of walls up to 600 mm thickness and in case of walls above 600 mm thickness a set of two or more bond stones overlapping each other by minimum 150 mm shall be provided in a line from face to back. At least one bond stone or a set of bond stones shall be provided for every 0.5 m² of the wall surface. If the bond stone of sufficient length is not available then plain cement concrete (M150 grade concrete) block of cross-section not less than 200x150 mm shall be provided.

In case of highly absorbent types of stones (porous lime stone and sand stones etc) the bond stone shall extend about two third into the wall. The bond stones in such cases may give rise to damp penetrations therefore, for all thickness of such walls, a set of two or more bond stones overlapping-each other by at least 150 mm shall be provided.

For random rubble masonry, the quoins shall be of selected stones neatly dressed with the hammer chisel to form the required angle, and laid header and stretcher alternately.

In case of coursed rubble masonry, the face stones shall be dressed on all beds and joints so as to give them approximately rectangular block shape. The bed joint shall be dressed for at least 80 mm back from the face and side joints for at least 40 mm such that no portion of the dressed surface is more than 10 mm from a straight edge placed on it. The remaining portion of the stone shall not project beyond the surface of bed and side joints. The bushing on the face shall not project more than 40 mm on exposed face and 10 mm on a face to be plastered. The face stones shall be laid alternate headers and stretchers without pinning on the face. Bond stones shall be provided as specified above except that the spacing of a bond stone or set of bond stones shall be about 1.5 m or as directed by the Project Manager. The quoins shall be of same height as the course. These shall be minimum 380 mm long and laid alternate header and stretcher.

1408. DRY RANDOM RUBBLE

Dry random rubble masonry(DRM) shall be constructed generally to the requirements of coursed random rubble masonry as specified in Clause 1407 but with the omission of mortar and in accordance with the drawing. All stones shall be carefully shaped to obtain as close a fit as possible at all beds and joints, any interstices between the stones being filled with selected stone spalls. No round stones shall be used in dry stone masonry work. The stones in courses shall be laid perpendicular to the batter face. Bond stones shall be provided at the

rate of at least 10 percent of volume of dry stone masonry structure. Bond stones shall measure not less than 150 mm x 150 mm and not less than 450 mm in length or full thickness of wall, whichever is less. The exposed tops or capping of dry rubble structures shall be formed as shown on the Drawing or as directed by the Project Manager. Generally DRM shall be constructed only to fill up gaps between RRM walls and the side earthen slope and in gulleys or as directed by the Project Manager.

1409. COMPOSITE RANDOM RUBBLE

Materials for composite random rubble shall comply with Clause 1402 and construction with Clause 1403. Mortar masonry shall be coursed and comply with Clause 1407 and the dry stone insets with Clause 1408. The dry stone insets shall be constructed when the level of the surrounding mortared masonry surround has reached the top of the dry stone inset.

1410. STONE PITCHING

(1) General

Stone pitching work shall be required for lining of drains and channels.

(2) Material

The stones to be used shall be durable and angular in shape. If boulders are used they shall be broken into angular pieces. The stones shall be sound, hard, and free from iron bands, spots, sand holes, flaws, shakes, cracks or other defects. The stone shall not absorb water more than 5 per cent. Stones for pitching shall not be less than 150 mm in minimum dimension. Rounded stones shall not be used in stone pitching. The mortar shall comply with Sub-Clause 1402(2).

(3) Mock-Up

Prior to commencement of any stone pitching work the Contractor shall construct a stone pitching panel of approximately 2000 mm x 1000 mm as a trial. The trial if accepted by the Project Manager shall be the sample for actual work.

(4) Construction

Stone pitching shall be done on surface prepared to specified requirements. Stones shall be laid in mortar with their longitudinal axis across to the direction of flow. Thickness of mortar in bed shall be 25 to 35 mm. They shall be well set into the surface. Thickness of pitching will be as shown on Drawings or as directed by the Project Manager. Spaces between stones shall be filled with spalls. Finished surface shall present an even, tight and neat appearance with no stones varying by more than 20 mm from specified grades and lines. Joints between the stones shall be completely filled with MM 7.5 mortar. Finished surface shall present an even, tight and neat appearance with no stones varying by more than 20 mm from specified grades and lines.

1411. STONE SOLING

Stone soling are required in the construction of foundation beds for various structures as directed by the Project Manager. Stones shall comply Sub-Clause 1401 (1) of this specification. Stone soling shall be done on foundation surface prepared as specified. They shall be well rammed into the surface. Spaces between stones shall be filled with spalls or smaller stones securely rammed into voids. The completed work shall present an even, neat and tight surface.

1500. BRICK MASONRY WORKS

1501. SCOPE

This Section covers the furnishing of materials and construction of brick works for structures in accordance with the detail shown on the Drawing and these Specifications or as directed by the Project Manager.

1502. MATERIALS

(1) Bricks

Burnt clay bricks shall conform to the requirements of IS 1077 and IS 2180 and shall be of the best quality locally available as approved by Project Manager. The bricks shall be free from cracks, flaws, grit and other impurities such as lime, iron and deleterious salts. All bricks shall be well burnt, sound and hard with sharp edges giving a ringing sound when struck with a mallet.

Bricks shall not show any signs of efflorescence when dry or subsequent to soaking.

The bricks shall not absorb water more than 7% of its weight after the 5 hour boiling test.

The standard brick sizes shall be 9 ¼" x 4 ¼" x 2 ¼" (230mm x 110mm x 55mm). The dimensions for sizes of bricks may be amended by the Project Manager to suit the local condition.

The bricks shall have a minimum average compressive strength of 100 kg/cm² and transverse strength of 32 kg/cm². Random compressive strength testing shall be done as prescribed by the Project Manager.

Where bricks are to form fair face construction, they shall be individually selected for colour, size, shape, and quality and if required shall match bricks in existing construction. Bricks shall be inspected by the Project Manager who may reject any or all bricks before incorporation in the works.

Where the Project Manager requires bricks to be classified by their intended use in construction, bricks of each classification shall be stored separately and apart and be clearly identified as instructed. Rejected bricks shall be immediately removed from the site.

Bricks shall not be dumped on the site. Bricks shall be carefully stacked in regular layers and otherwise handled and stored at all times so as to avoid damage.

(2) Mortar

The mortar for brickwork and plastering shall comply with Sub-Clause 1402(2) of the Technical Specifications.

1503. SOAKING OF BRICKS

Bricks shall be soaked in water for a minimum period of one hour before use. When bricks are soaked they shall be removed from the tank sufficiently in advance so that at the time of laying they are skin dry. Such soaked bricks shall be stacked on a clean place where they are not spoilt by dirt, earth, etc.

1504. LAYING OF BRICKS

All bricks work shall be laid in English bond, even and true to line, plumb, level and all joints accurately kept. Whole bricks used on the face shall be selected ones of uniform size and true rectangular face.

Bricks shall be laid with frogs up, if any, on a full bed of mortar. When laying, bricks shall be slightly pressed so that the mortar gets into all the surface pores of bricks to ensure proper adhesion. All joints shall be properly flushed and packed with mortar so that no hollow spaces are left.

Before laying bricks in foundation, a layer of not less than 12 mm of mortar shall be spread to make the surface on which the brick work will be laid even. Immediately thereafter, the first course of bricks shall be laid.

The brick work shall be built in uniform layers. Corners and other advanced work shall be raked back. Brick work shall be done true to plumb or in specified batter. No part of it, during construction, shall rise more than one metre above the general construction level, to avoid unequal settlement and improper jointing.

Toothing may be done where future extension is contemplated but shall be used as an alternative to raking back.

The weep holes shall be provided as per Clause 1403 of the Technical Specifications.

1505. JOINTS

The thickness of joints shall not exceed 10 mm.

1506. JOINTING WITH EXISTING STRUCTURES

When fresh masonry is to be placed against existing surface of structures, the surface shall be cleaned of all loose materials, roughened and wetted as directed by the Project Manager so as to effect a good bond with the new work.

1507. CURING

Green work shall be protected from rain by suitable covering. Masonry work in cement mortar shall be kept constantly moist on all faces for a minimum period of seven days. The top of the masonry work shall be left flooded with water so as not to disturb or washout the green mortar.

During hot weather, all finished or partly completed work shall be covered or wetted in such a manner as to prevent rapid drying of the brick work.

1508. SCAFFOLDING

The scaffolding shall be sound and strong to withstand all loads likely to come upon it. The holes which provide resting space for horizontal members shall not be left in masonry under one metre in width or immediately near the skew backs of arches. The holes left in the masonry work for supporting the scaffolding shall be filled and made good.

1509. CONDITION OF EQUIPMENT

All equipment used for mixing or transporting mortar and bricks shall be clean and free from set mortar, dirt or other injurious foreign substances.

1510. FINISHING OF SURFACES

(1) General

The surfaces can be finished by 'jointing', 'pointing' or 'plastering', as specified. For a surface which is to be subsequently plastered or pointed, the joints shall be squarely raked out to a depth of 15 mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted.

The mortar for finishing shall be prepared as per Sub-Clause 1402(2).

(2) Jointing

In jointing, the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick-work. The faces of brick-work shall be cleaned to remove any splashes of mortar during the course of raising the brick-work.

(3) Pointing

For pointing, the mortar shall be filled and pressed into the raked out joints, before giving the required finish. The pointing shall then be finished to proper type given on the Drawing. If type of pointing is not mentioned on the Drawing the same shall be ruled pointing. For ruled pointing after the mortar has been filled and pressed into the joints and finished off level with the edges of the bricks, it shall while still green be ruled along the centre with a half round tool of such width as may be specified by the Project Manager. The superfluous mortar shall then be cut off from the edges of the lines and the surface of the masonry shall also be cleaned of all mortar.

(4) Plastering

The grade and thickness of mortar for plastering shall be as specified on Drawing or as directed by the Project Manager. Plastering shall be started from top and worked down. All holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. Wooden screeds 75 mm wide and of the thickness of the plaster shall be fixed vertically 2.5 to 4 metres apart to act as gauges and guides in applying the plaster. The mortar shall be laid on the wall between the screeds using the plaster's float and pressing the mortar so that the raked joints are properly filled. The plaster shall then be finished off with a wooden straight edge reaching across the screeds. The straight edge shall be worked on the screeds with a small upward and sideways motion 50 mm or 75 mm at a time. Finally, the surface shall be finished off with a plaster's wooden float. Metal floats shall not be used.

When recommencing the plastering beyond the work suspended earlier the edges of the old plaster shall be scraped, cleaned and wetted before plaster is applied to the adjacent areas.

No portion of the surface shall be left out in a condition to be patched up later on.

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required by the Project Manager.

The average thickness of plaster shall not be less than the specified thickness. The minimum thickness over any portion of the surface shall not be less than the specified thickness minus 3 mm.

Any cracks which appear in the surface and all portions, which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and re-done as directed by the Project Manager.

(5) Curing of Finishes

Curing shall be started as soon as the mortar used for finishing has hardened sufficiently not to be damaged when watered. It shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages.

1511. BRICK SOLING

(1) General

This Clause shall consist of the provision and placing of all materials for the construction of brick soling in foundation to the dimensions and locations shown on the Drawings or as directed by the Project Manager. It shall also include preparation of surface to the specified requirements.

(2) Materials

Brick for soling shall be as described in Sub-Clause 1502(1).

(3) Construction

- (a) Foundation bed for brick soling shall be trimmed to the required level and compacted by hand or suitable mechanical equipment to a density of not less than 95% of the maximum dry density of the material as determined by the method described in IS2720-Part 8. The Contractor shall not be permitted to place the brick soling until the Project Manager has tested and approved the levels and compaction of the surface.
- (b) Brick for soling shall be laid on edge or flat as shown on Drawings or as directed by the Project Manager on foundation bed prepared as above. Shoulder coursing shall be provided at all edge conditions and elsewhere shown on the drawings.
- (c) After completion the brick paving shall have a true and level surface to the required slope. The finished level of the soling at any point shall be within plus or minus 10 mm of the levels shown on the Drawings or as directed by the Project Manager.

1512. TEST AND STANDARD OF ACCEPTANCE

Before laying any mortar, the Contractor shall make three sets of mortar test cubes from each source of sand to demonstrate the compliance of the mortar to the specified strength. Each set shall comprise two cubes, one to be tested at 7 days and the other to be tested at 28 days. Testing shall be in accordance with IS 2250. During construction the Contractor shall make and test mortar cubes at the rate of three for every 10m³ or part of the brick work to assess the strength of the mortar subject to a minimum of 3 sample cubes for a days work. The brick shall be tested for compressive strength and water absorption and shall meet the requirement of this Specification. The surface of the brick soling shall show no depression in excess of 5 mm when tested with a 3m straightedge placed anywhere on the completed surface. The Contractor shall remove and replace any work outside the tolerances stated above.

1513. MEASUREMENT

All brick work shall be measured in cubic metres. The work of plastering and pointing shall be measured in square metres separately.

1514. PAYMENT

The brick works, plastering and pointing shall be paid at their respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work as per these Specifications.

1600. GABION WORK

1601. SCOPE

This Clause covers the furnishing of materials and construction of gabion works that may be required to act as buttresses, retaining walls, catch walls, stream or river training structures, check dams within gullies, or where placed as mattresses, to prevent stream or gully erosion.

1602. MATERIALS

(1) Stones

Stones used for filling the gabion boxes or mattresses shall be clean, hard, sound, un-weathered and angular rock fragments or boulders. The specific gravity of the stone shall be not less than 2.50 and the stones shall not absorb water more than 5 percent when tested as per IS1124. The length of any stone shall not exceed three times its thickness. The smallest dimension of any stone shall be at least twice that of the longer dimension of the mesh of the crate. However smaller size of stones as spalls shall be allowed for filling voids and its volume including voids shall not be more than 20 percent of the total volume of the stones.

Before filling any gabion boxes and mattresses the Contractor shall submit representative samples of the rock he proposes to use in the gabions for approval by the Project Manager. Further representative samples shall be submitted for approval each time when there is a change in the type and strength of the rock.

(2) Gabions

- i) The wire mesh used for the gabion work shall be in conformity to IS 16014-2012. The mesh shall be mechanically woven double twisted 10x12 type as shown in Figure-1 below. The dimension "D" of the hexagonal mesh opening shall be 100 mm with a tolerance of -2% to +2%.

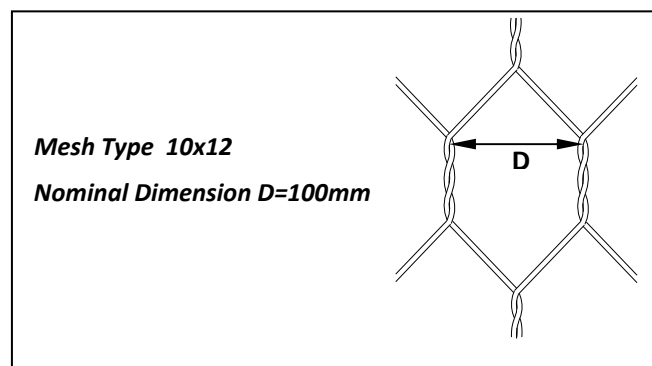


Figure-1

- ii) The mild steel wires used in the mesh shall have minimum diameters and zinc coating as given in the

table below in accordance with the requirements of IS 4826:1979.

	Mesh wire	Selvage wire	Lacing and bracing wire
Wire diameter (mm)	2.7	3.4	2.2
Tolerance in wire size (\pm mm)	0.07	0.09	0.06
Minimum quantity of zinc coating (g/m^2)	260	270	240

The standard sizes (Length x Breadth x Height) of gabion baskets along with number of diaphragms in each type are as given in the table below. Tolerance of $\pm 5\%$ shall be allowed in all dimensions (length, breadth and height) of gabion units.

Typical Gabion sizes (10 X 12 -mesh type)

Length, m	Width, m	Height, m	Number of diaphragms
4.0	1.0	1.0	3
3.0	1.0	1.0	2
2.0	1.0	1.0	1
1.5	1.0	1.0	0
4.0	1.0	0.5	3
3.0	1.0	0.5	2
2.0	1.0	0.5	1

The gabion wire mesh shall be mechanically woven. The front, base, back and lid of the gabions shall be woven into a single unit as shown in Figure-2 below. The lid may also be a separate piece made of the same type mesh as the basket. All perimeter edges of the mesh forming the basket and top, or lid, shall be selvaged with wire having a diameter of 3.4 mm. The gabion boxes shall be divided into cells by means of diaphragms positioned at approximately 1m centre to centre.

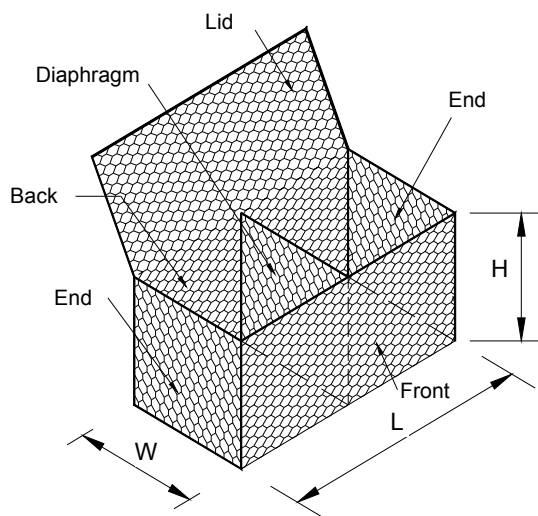


Figure-2

iii) The contractor shall obtain client's approval for the supplier/manufacturer before the start of the supply

of the material to the site in accordance with the provisions of Section 226 of this document. For this purpose, the contractor shall submit manufacturer's test certificate for the material, a copy of the certificate of accreditation from Bhutan Standards Bureau and a copy of an ISO 9001:2008 accreditation from an internationally accredited organization for manufacture and supply of the gabion materials. The performance and quality of the material shall be equivalent to or superior to the Maccaferri gabions and it shall also have a history of having been satisfactorily used in similar road projects in Bhutan in the recent past.

- iv) The material shall be new, except as provided elsewhere in the contract or permitted by the Project Manager in writing (Refer Section 202 of this Specification). The contractor shall provide to the client the manufacturer's test certificate and supplier's challan/invoice for every lot of the material brought and used in the work. The manufacturer's certificate shall include test reports for tensile strength, zinc coating and elongation strength for every lot of the material brought and used in the work. The tensile strength of the wire used for the manufacture of the mesh shall be not less than 350 N/mm² when tested in accordance with IS 280. Elongation shall not be less than 10%, in accordance with IS 16014:2012 and MoRTH (Fifth Revision) Clause 3100. Zinc coating of the wires shall be as specified under Sl. (ii) above.
- v) The client reserves the right to reject the material at any time without giving any reasons whatsoever if the material or its manufacturer / supplier, in the opinion of the client, does not meet any of the requirements specified in this specification.

1603. CONSTRUCTION OF GABIONS

(1) General Requirements

Before filling any gabion boxes and mattresses, the Contractor shall submit samples of gabion boxes and/or gabion mattresses assembled, erected and filled with stones for approval which, when approved, shall be retained for reference and comparison with the gabions built as part of the permanent works. The size, type and location of the samples shall be as directed by the Project Manager.

Gabion boxes and gabion mattresses shall be assembled, erected and filled with stones in the dry on prepared surfaces except as may be otherwise approved. Approval for assembling and erecting gabions in water shall be given only, if in the Project Manager's opinion such a method will produce work which is otherwise in accordance with the Specification.

(2) Preparation of Foundation and Surface for Bedding

The bed on which the gabion boxes or mattresses are to be laid shall be even and conform to the levels shown on the Drawing. If necessary, cavities between rock protrusions shall be filled with material similar to that specified for gabion filling.

(3) Arrangement of Joints

(a) Walls

In walls, gabion boxes shall be placed such that vertical joints are not continuous, but staggered. Aprons shall be formed of headers. If more than one unit is required to obtain the necessary width, units of unequal length shall be used and the joints between them should be staggered.

(b) Channel linings

In channel linings, gabion box and mattress units shall be laid so that the movement of stone inside the mesh due to gravity or flow of water is avoided. Hence, on side slopes, units shall be placed with their internal

diaphragms at right angles to the direction of the slope and, on inverts, as far as possible, at right angles to the direction of flow.

(c) Assembly

Gabion boxes and gabion mattresses shall be assembled on a hard flat surface. After fabrication, unpacking or unfolding, they shall be stretched out and any kinks shall be removed. Creases shall be in the correct position for forming the boxes or mattress compartments. The side and end panels shall be folded into an upright position to form rectangular boxes or compartments. The top corners shall be joined together with the thick selvedge wires sticking out of the corners of each panel. The tops of all sides and partitions shall be leveled except as may be appropriate to special units. The sides and end panels shall be tied together using binding wire of the thickness given in Table 25.2, starting at the top of the panel by looping the wire through the corner and twisting the wire together. Binding shall continue by looping the wire through each mesh and around both selvedges with three rounds which shall be joined tightly together by twisting and the end shall be poked inside the unit. The diaphragms shall be secured in their correct positions by binding in the same way. The bindings wire shall be fixed using 250mm long nose fencing pliers or equivalent approved tools.

The gabion boxes and gabion mattresses shall be laid in such a manner that the hinges of the lid will be on the lower side on slopes and on the outer side in walls.

Where mattresses are laid horizontally hinges shall not be placed on the downstream side as much as practicable.

(d) Filling

The crates shall be placed in their final position before filling commences. They shall be stretched to their full dimension and securely pegged to the ground or wired to adjacent gabions before filling. The vertical corners shall be kept square and to full dimension by inserting a steel bar of at least 20 mm diameter at each vertical corner, maintaining it in the correct final position throughout the filling process, and removing it when the crate is full. Before filling commences, the selvedges of the crate shall be bound to the selvedges of adjacent crates with binding wire. Where crates are being assembled in position in a wall the binding of the edges of each crate in the assembly process and the binding together of adjacent crates shall be carried out in the same operation.

Before filling with stone, gabions shall be anchored at one end or side and stretched from the opposite end or side by inserting temporary bars and levering them forward, the top and bottom shall be kept stretched by tensioning with tie wires attached to an anchorage or equivalent approved method until the gabion has been filled. The gabions shall be inspected at this stage but before filling with stone to ensure that the tie/wiring has been properly carried out and the gabion boxes or gabion mattresses are not pulling apart. Gabion boxes or gabion mattresses may be tensioned either singly or in the case of a long straight structure by straining a number of units together using an approved tensioning system.

The filling shall be carried out by placing individual stones into the gabion by hand in courses in such a manner that the stones are bedded on each other and bonded as in dry random rubble masonry as per Clause 1308. No loose stones shall be tipped into the crate and the practice of coursing and bonding the outer layer and filling the interior with unlaid stones shall not be permitted.

All 1m deep gabions shall be filled in three equal layers and 0.5m deep gabions in two equal layers. Horizontal bracing wires made with the same bindings wire as used for tying shall be fixed directly above each layer of the stone in the compartments, the wires being looped round two adjoining meshes in each side of the compartment and joined together to form a double tie which shall be tensioned by wind lassing together to keep the face of the gabions even and free from bulges. Bracing wires shall be spaced horizontally along and across the gabions at distances not greater than 0.33m. Where the upper faces of gabion boxes are not

covered with further gabions vertical bracing wires shall be fitted between the top and bottom mesh using two tie wires per square metre of surface.

The ties shall be fixed to the bottom of the units prior to filling and tied down to the lid on completion. Where a double layer of gabion boxes is used to form an apron both upper and lower layers shall have vertical tie wires.

(e) Securing Lids

The gabion boxes and mattress compartments shall be over filled by 50mm above their tops to allow for subsequent settlement. The lids shall then be tied down with binding wire to the tops of all partition panels. The lids shall be stretched to fit the sides exactly by means of a suitable tool but due care shall be taken to ensure that the gabions are not so full that the lids are overstretched. The corners shall be temporarily secured first.

(f) Tolerance

On completion, the crates shall be completely and tightly filled, square, true to dimensions and the line and level shown on the Drawing. However the tolerance limit permitted in the length, height and width of the gabion boxes and mattresses as manufactured shall be ± 3 percent from the ordered size prior to filling.

1604. TEST AND STANDARD OF ACCEPTANCE

The gabion wire shall be tested for mass, uniformity and adhesion of zinc coating and tensile strength of the wire itself. Failure of test results to comply with the specifications shall lead to the rejection of gabion wires.

1605. MEASUREMENT

Generally the measurement is done in cubic meters of gabion crates filled with stones and complete in place and quantity calculated from the dimension of the gabions indicated in the Drawing or ordered by the Project Manager. However, in this contract in particular, the gabion works shall be measured in linear length (running metre) for different heights of walls measured from the bottom of the wall foundation to the top of the wall.

1606. PAYMENT

Payment shall be made as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

1700. CONCRETE WORKS

1701. SCOPE

This Section covers the materials, design of mixes, mixing, transport, placing, compaction and curing of concrete and mortar required in the works. It also covers reinforcement for concrete. This also includes plum concrete work.

1702. DEFINITIONS

Structural concrete is any class of concrete which is used in reinforced or plain concrete construction which is subject to stress.

Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling voids, blinding foundations and similar purposes where it is not subjected to significant stress.

A pour refers to the operation of placing concrete into any mould, bay or formwork, etc. and also to the volume which has to be filled. Pours in vertical succession are referred to as lifts.

1703. MATERIALS FOR CONCRETE

(1) General

The Contractor shall submit to the Project Manager full details of all materials which he proposes to use for making concrete. No concrete shall be placed in the works until the Project Manager has approved the materials of which it is composed. In accordance with Clause 203, approved materials shall not thereafter be altered or substituted by other materials without the consent of the Project Manager.

(2) Cement

Cement shall be ordinary Portland cement as per IS 8112 or IS 12269. The cement shall also meet the requirements of Clause 212. If required use of rapid hardening Portland cement as per IS 8041 shall be made for concrete as directed by the Project Manager.

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk. Bagged cement shall be transported in vehicles provided with effective means of ensuring that it is protected from the weather.

Bulk cement shall be transported in vehicles or in containers built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level not less than 300 mm and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked so as to reduce air circulation with min gap of 500mm from outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. Stack of cement bags shall not exceed 8 bags in height. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stacks. Cement in bags shall be used in the order in which it is delivered.

Cement from broken bags shall not be used in the works.

Bulk cement shall be stored in weather proof silos which shall bear a clear indication of the type of cement contained in them. Different types of cement shall not be mixed in the same silo.

The Contractor shall provide sufficient storage capacity on site to ensure that his anticipated programme of work is not interrupted due to lack of cement.

Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site.

All cement for any one structure shall be from the same source as far as possible.

All cement used in the works shall be tested by the manufacturer. The manufacturer shall provide the results of tests as given in Table 17.1 and 17.2 for each supply and for the last six months of his production. The Contractor shall supply two copies of each certificate to the Project Manager.

Table 17.1: Test Results for Chemical Composition of Cement

Compounds %		Mean	Min	Max.	Standard deviation
Lime	CaO				
Silica	SiO ₂				
Alumina	Al ₂ O ₃				
Iron Oxide	Fe ₂ O ₃				
Magnesia	MgO				
Sulphur Trioxide	So ₃				
Soda, Potash	Na ₂ O,K ₂ O				

Table 17.2: Test Results for Physical Properties of Cement

Characteristics	Requirements	Nominal	Mean	Min	Max	St. Dev.
Fineness, M ² /KG : (by Blaine's Air Permeability Method)	225					
Minimum Setting time (initial), minutes	45					
Maximum Setting time (final), minutes	600					
Soundness (by Le Chatelie method) mm, maximum	10					
Minimum Average Compressive Strength of three mortar cubes, (N/mm ²)						
3 days	16,27*					
7 days	22,37*					
28 days	33,53*					

*denotes the requirements of High Strength Portland Cement.

Each set of tests carried out by the manufacturer on samples taken from cement which is subsequently delivered to site shall relate to no more than one day's output of each cement plant.

The Contractor shall constitute, from each delivery and each type of cement and not less than one samples for every 200 tonnes or part of it, representative samples to be tested when instructed by the Project Manager in a laboratory acceptable to him, in case of the concrete mixes do not comply with the requirements of this Specification.

Cement which is stored on site for longer than one month shall be tested in such laboratory for every 200 tonnes or part thereof and at monthly intervals thereafter.

The Contractor shall keep full records of all data relevant to the manufacture, delivery; testing and the cement used in the works and shall provide the Project Manager with two copies thereof.

(3) Fine Aggregate

Fine aggregate shall be clean hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with IS 383. All the material shall pass through a 4.75 mm IS sieve and the grading shall

be in accordance with IS 383. In order to achieve an acceptable grading, it may be necessary to blend materials from more than one source.

The deviation from the initial fineness modulus shall be no more than ± 0.30 for ordinary concrete and ± 0.20 for high quality concrete.

However, in respect of the presence of deleterious materials the fine aggregate shall not contain iron pyrites, iron oxides, mica, shale, coal or other laminar soft or porous materials or organic matter unless the Contractor can show by comparative tests on finished concrete as set out in Clause 213 and as per the direction of the Project Manager, that the presence of such materials does not affect the properties of the concrete.

(4) Coarse Aggregate

Coarse aggregate shall be clean hard and durable crushed rock, crushed gravel or natural gravel corresponding to the following classes:

Class A : Aggregate shall consist of crushed igneous or quartzite rock from an approved source.

Class B : Aggregate shall consist of crushed quarry rock other than Class A from an approved source.

Class C : Aggregate shall consist of natural or partly crushed gravel pebbles obtained from and approved gravel deposit. It may contain a quantity of material obtained from crushing the oversize stone in the deposit provided such material is uniformly mixed with the natural uncrushed particles.

Class D : Aggregate shall consist entirely of crushed gravel. The crushed gravel shall be produce from material retained on a standard sieve having an opening at least twice as large as the maximum size of aggregate particle specified.

Class E : Aggregate shall consist of an artificial mixture of any of the above classes of aggregate. The use of Class E aggregate and the relative proportions of the constituent materials shall be approved by the Project Manager.

Coarse aggregate shall be supplied in the nominal size called for in the contract and shall be of the grading as single sized aggregate or graded aggregate of nominal size 40 mm, 20 mm, 12.5 mm and 10 mm in accordance with IS 383.

Other properties shall be as set out below:

Flakiness Index: When tested in accordance with IS 2386 Part 1, the Flakiness Index of the coarse aggregate shall be as set out hereunder:

For ordinary concrete : not more than 25

For high quality concrete : not more than 15

If the Flakiness Index of the coarse aggregate varies by more than five units from the average value of the aggregate used in the approved trial mix, then a new set of trial mixes shall be carried out if the workability of the mixes has been adversely affected by such variation.

Water Absorption: The aggregate shall not have water absorption of more than 2 per cent when tested as set out in IS 2386 Part 3.

Los Angeles Abrasion (LAA): The aggregate shall have LAA not more than 45% for ordinary concrete, and not more than 35% for high quality concrete, when tested in accordance with IS 2386 Part 4.

Aggregate Crushing Value (ACV): The aggregate shall have ACV not more than 30% for pavement structure and not more than 45% for other structure when tested in accordance with IS 2386 Part 4.

Alkali Aggregate Reactivity: The aggregate shall comply with IS 383/3.2 notes when tested in accordance with IS 2386 Part 7.

(5) Testing Aggregates

(a) Acceptance Testing

The Contractor shall deliver to the Project Manager samples containing not less than 50 kg of any aggregate which he proposed to use in the works and shall supply such further samples as the Project Manager may require. Each sample shall be clearly labelled to show its origin and shall be accompanied by all information called for in IS 2386 Part 1 to 8.

Tests to determine compliance of the aggregates with the requirements of Sub-clauses 1703(3) and (4) shall be carried out by the Contractor in a laboratory acceptable to the Project Manager. If the tested materials fail to comply with the Specification, further tests shall be made in the presence of the Contractor and the Project Manager. Acceptance of the material shall be based on the results of such tests.

All the materials shall be accepted if the results of not less than three consecutive sets of test executed in accordance with IS 2386 (Part 1-8) show compliance with the Sub-clauses 1703 (3) and (4).

(b) Compliance Testing/Process Control Testing

The Contractor shall carry out routine testing of aggregates for compliance with the Specification during the period that concrete is being produced for the works. The tests set out below shall be performed on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to site provided that the set of tests shall represent not more than 100 tonnes of fine aggregate and not more than 250 tonnes of coarse aggregate, and provided also that the aggregates are of uniform quality.

Grading : IS 2386 Part 1

Silt, Clay Contents and Organic Impurities : IS 2386 Part 2

If the aggregate from any source is variable, the frequency of testing shall be increased as instructed by the Project Manager.

In addition to the above routine tests, the Contractor shall carry out the following tests at the stated frequencies:

Chloride Content: As frequently as may be required to ensure that the proportion of chlorides in the aggregates does not exceed the limit stated in the Specification.

Sulphate Content and Alkali Reactivity: As frequently as may be required according to the variability of sulphate content and alkali reactivity assessed from the laboratory tests carried out during the concrete mix design.

(6) Delivery and Storage of Aggregates

Aggregates shall be delivered to site in clean and suitable vehicles. Different type or sizes of aggregates shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that the contamination of aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes occurs.

The storage of aggregates shall be arranged in such a way that drying out in hot weather is prevented in order to avoid sudden fluctuations in water content. Storage of fine aggregates shall be arranged in such way that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

(7) Water for Concrete and Mortar

Water shall be clean and free from harmful matter and shall comply with the requirements of IS 456.

Brackish water containing more than 1000 ppm chloride ion or 2000 ppm sulphate ion shall not be used for mixing or curing concrete.

The Contractor shall carry out tests in compliance with IS 456 to establish compliance with Specifications.

(8) Admixtures

(a) General

The use of admixtures in concrete may be required under the contract to promote special properties in the finished concrete or may be proposed by the Contractor to assist him in compliance with the Specification.

In all cases the Contractor shall submit to the Project Manager full details of the admixture he proposes to use and the manner in which he proposes to add it in the mix. The information provided shall include:

- (i) The typical dosage, the method of dosing, and the detrimental effects of an excess or deficiency in the dosage.
- (ii) The chemical names of the main active ingredients in the admixture.
- (iii) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by weight of admixture.
- (iv) Whether the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage, and if so the extent to which it does so.
- (v) Details of previous uses of the admixture in Bhutan.

The chloride ion content of any admixture shall not exceed 1 per cent by weight of the admixture nor 0.02 per cent by weight of the cement in the mix.

Admixtures shall not be mixed together without the consent of the Project Manager.

Admixtures may be supplied as liquid or as powder. They shall be stored in sealed and undamaged containers in a dry, cool place. Admixtures shall be dispensed in liquid form and dispensers shall be of sufficient capacity to measure at one time the full quantity required for each batch.

(b) Workability Agents

Workability agents shall comply with BS 5075 and shall not have any adverse effect on the properties of the concrete.

1704. DESIGN OF CONCRETE MIXES

(1) Classes of Concrete

The classes of structural concrete to be used in the works shall be as shown on the Drawing and designated in Table 17.3, in which the class designation includes two figures. The first figures indicates the characteristic strength f_{ck} at 28 days expressed in N/mm^2 and the second figure is the maximal nominal size of aggregate in the mix expressed in millimetres. Letter M in the class designation stands for Mix, letters SM stand for Special Mix.

Consistence of the mix, assessed through the Slump Test where the slump is measured in millimetres, is designated as follows:

S: Stiff consistence, for slump ≤ 40

P: Plastic consistence, for slump > 40 and ≤ 90

VP: Very Plastic consistence, for slump >90 and ≤ 150

F: Flowing consistence for slump > 150

Table 17.3: Concrete Classes and Strength

Classes of concrete	Consistence of Mix	Type of uses	Characteristic Strength f_{ck} (N/mm^2)	Maximum Nominal Size of Aggregate mm	Trial mixes Minimal Target Strength $f_{ct}=1.1 f_{ck}$ (N/mm^2)	Early works test cubes	
						Any one result (aver. of 3 cubes) (N/mm^2)	Average of 3 consecutive results (N/mm^2)
M 10/75	S	Ordinary	10	75	11	10	14
M 10/40	S	Ordinary	10	40	11	10	14
M 15/20	S	Ordinary	15	20	16.5	15	19
M 15/40	S	Ordinary	15	40	16.5	15	19
M 20/20	S	Ordinary	20	20	22	20	24
M 20/40	S	Ordinary	20	40	22	20	24

M 25/20	S	Ordinary	25	20	27.5	25	29
M 25/40	S	Ordinary	25	40	27.5	25	29
M 30/40	S	High Quality	30	40	33	30	34
M 30/20	P	High Quality	30	20	33	30	34
M 35/40	P	High Quality	35	40	38.5	35	39
M 35/20	P	High Quality	35	20	38.5	35	39
SM 30/40	VP	Underwater	30	40	33	30	34
SM 30/20	VP	Underwater	30	20	33	30	34

(2) Design of Proposed Mixes

Concrete mixes shall comply with Clause 212.

The Contractor shall design all the concrete mixes called for in the Drawing using the ingredients which have been approved by the Project Manager in accordance with Clause 1703 and in compliance with the following requirements:

- The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150 micron size.
- The cement content shall be such to achieve the strength called for in Table 17.3 but in any case not less than the minimum necessary as shown in Table 17.4
- The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.
- The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than 0.5 for classes of concrete above M20 taking due account of any water contained in the aggregates. The Contractor shall take into account that this requirement may in certain cases require the inclusion of a workability agent in the mix.

Table 17.4 Minimum Cement Content

Classes of concrete	Minimum cement content in kg per m ³ of compacted concrete		
	Moderate exposure	Intermediate exposure	Severe exposure
M10/75, M10/40	125	150	175
M15/40, M15/20	150	200	225
M20/40, M20/20	250	300	325
M25/20, M25/40	300	325	350

M30/40, M30/20, M30/12			
M35/40, M35/20	325	350	375
SM30/20, SM30/40	400	400	425

Note: The minimum cement contents shown in the above table are required in order to achieve impermeability and durability. In order to meet the strength requirements in the Specification higher contents may be required.

The categories applicable to the works are based on the factors listed hereunder:

- Moderate exposure: Surface sheltered from severe rain, buried concrete.
- Intermediate exposure: Surface exposed to severe rain; alternate wetting and drying; traffic; corrosive fumes; heavy condensation.
- Severe exposure: Surface exposed to water having a pH of 4.5 or less, groundwater containing sulphates

(3) Laboratory Trial Mixes

For each mix of concrete for which the Contractor has proposed a design, he shall prepare the number of concrete batches specified hereunder:

Nominal composition: 3 separate batches

Modified compositions, the quantities of other constituents being unchanged:

- Water :+10% 1 batch
- Water :- 10% 1 batch
- Cement :+15% 1 batch
- Cement :- 15 % 1 batch

Samples shall be taken from each batch and the following action taken, all in accordance with BS 1881:

- (a) The slump of the concrete shall be determined.
- (b) Six tests cubes shall be cast from each batch. In the case of concrete having a maximum aggregate size of 20 mm, 150 mm cubes shall be used. In the case of concrete containing larger aggregate, 200 mm cubes shall be used and in addition any pieces of aggregate retained on a 50 mm IS sieve shall be removed from the mixed concrete before casting the cubes.
- (c) The density of all the cubes shall be determined before the strength tests are carried out.
- (d) All faces shall be perpendicular to each other.
- (e) Three cubes from each batch shall be tested for compressive strength at seven days and the remaining three at 28 days.

For smaller works, the following composition is suggested as a starting basis for the Laboratory trials:

Concrete Class	Characteristic Strength N/mm ²	Cement (kg)	Total aggregates (kg)	Fine aggregate/ Total Aggregate %	Water (max) l	Workability
M 15/40 M 15/20	15	250	1900	35-45	160	Stiff-Plastic
M 20/20	20	300	1875	35-45	165 - 170	Stiff
M 30/40	30	350	1825	35-45	170	Stiff
M 30/20	30	350	1825	35-45	175	Plastic
M 35/20	35	350	1825	35-45	175	Plastic

A "result" being the average strength of the three cubes from one batch, the average of the three results from tests at 28 days for the nominal composition shall not be less than the Minimal Target Strength shown in Table 17.3.

One result from the modified compositions shall not be less than the nominal strength as shown on Table 17.3.

(4) Site Trials

At least six weeks before commencing placement of concrete in the permanent works, site trials shall be prepared for each class of concrete specified.

For each mix of concrete for which the Contractor has proposed a design and successfully tested in Laboratory, he shall prepare three separate batches specified hereunder using the materials which have been approved for use in the works and the mixing plant which he proposes to use for the works. The volume of each batch shall be the capacity of the concrete mixer proposed for full production.

Samples shall be taken from each batch and the action taken similar to the above Sub-clause 1704 (3) (a) to (e).

The average of the three results of tests at 28 days shall not be less than the Minimal Target Strength shown in Table 17.3.

The Contractor shall also carry out tests to determine the drying shrinkage of the concrete unless otherwise directed by the Project Manager.

Based on the results of the tests on the Laboratory trial and site trial mixes, the Contractor shall submit full details of his proposals for mix design to the Project Manager, including the type and source of each ingredient, and the results of the tests on the trial mixes.

If the Project Manager does not agree to a proposed concrete mix for any reason, the Contractor shall amend his proposals and carry out further trial mixes. No mix shall be used in the works without the written consent of the Project Manager.

(5) Quality Control of Concrete Production

(a) Sampling

For each class of concrete in production at each plant for use in the works, samples of concrete shall be taken at the point of mixing or of deposition as instructed by the Project Manager, all in accordance with the sampling procedures described in BS 1881 and with the further requirements set out below.

Six 150 mm or 200 mm cubes as appropriate shall be made from each sample and shall be cured and tested in accordance with BS 1881 three at seven days and the other three at 28 days. Where information samples are required, such as for post-tensioning operations, three additional cubes shall be made.

The minimum frequency of sampling of concrete of each grade shall be as following:

- For 1-5 m³ quantity of work - 1 no. of sample
- For 5-20 m³ quantity of work - 2 no. of sample
- For 20 m³ and more quantity of work - each 20m³ or part thereof

At least one sample shall be taken from each shifts of work.

Until compliance with the Specifications has been established the frequency of sampling shall be three times that stated above; and minimum 3 samples/day for each class of concrete production in each plant or such lower frequency as may be instructed by the Project Manager.

(b) Testing

- (i) The slump of the concrete shall be determined for each batch from which samples are taken and in addition for other batches at the point of production and deposition or at the frequency instructed by the Project Manager.

The slump of concrete in any batch shall not differ from the value established by the trial mixes by more than 25 mm or one third of the value whichever is the less.

- (ii) The air content of air entrained concrete in any batch shall be within 1.5 times of the required value and the average value of four consecutive measurements shall be within the required value expressed as a percentage of the volume of freshly mixed concrete.

- (iii) Early Works: Until such time as sufficient test results are available to apply the method of control described in (iv) below, the compressive strength of the concrete at 28 days shall be such that no single result (average of 3 cubes) is less than the characteristic strength f_{ck} as shown in Table 17.3 under the heading "early works test cubes" and also that the average of three consecutive results is not less than $f_{ck} + 4$ as shown in Table 17.3 under the same heading.

The 7-day cube result may be used as an early strength indicator, at the discretion of the Project Manager.

- (iv) When at least 20 consecutive results on tested batches are available for any class of concrete mixed in any one plant, no single result shall be less than $f_{ck}-4$ (N/mm²) and also the average of any group of three consecutive results shall not be less than $f_{ck}+4$ (N/mm²).

In addition the Coefficient of Variation shall be less than the figure given below:

Number of batches	Maximum coefficient of variation	
	Ordinary concrete	High quality concrete
After 20 tested batches	18%	15%
After 50 tested batches	15%	12%

where, Coefficient of Variation = Standard Deviation of results/Avg value of results

- (v) Failure to comply with Requirements

If any one result in a group of three consecutive results is less than f_{ck-4} (N/mm²), but the other results of group satisfy the strength requirement, then only the batch from which the failed result was obtained shall be deemed not to comply with the Specification.

If the average strength of the group is less than the strength requirement then all the batches between those represented by the first and the last result shall be deemed not to comply with the Specification, and the Contractor shall immediately adjust the production procedure or the mix design subject to the agreement of the Project Manager to restore compliance with the Specification. If adjustment of the mix design is agreed, the Contractor shall again be required to comply with Sub-clauses 1704 (3) and (4).

1705. MIXING CONCRETE

Before any batching, mixing, transporting, placing, compacting and finishing and curing the concrete ordered or delivered to site, the Contractor shall submit to the Project Manager full details including Drawing of all the plant which he proposes to use and the arrangements he proposes to make.

Concrete for the works shall be batched and mixed in one or more plants or concrete mixer unless the Project Manager agrees to some other arrangement. If concrete mixers are used, there shall be sufficient number of mixtures including stand by mixers.

Batching and mixing plants shall be complying with the requirements of IS 1791 and capable of producing a uniform distribution of the ingredients throughout the mass. Truck mixers shall comply with the requirements of IS 4925 and shall only be used with the prior approval of the Project Manager. If the plant proposed by the Contractor does not fall within the scope of IS 1791 it shall have been tested in accordance with IS 4634 and shall have a mixing performance within the limits of IS 1791.

All mixing operations shall be under the control of an experienced supervisor.

The aggregate storage bins shall be provided with drainage facilities arranged so that the drainage water is not discharged to the weigh hoppers. Each bin shall be drawn down at least once per week and any accumulations of mud or silt shall be removed.

Cement and aggregates shall be batched by weight. Water may be measured by weight or volume.

Mixers shall be fitted with an automatic recorder registering the number of batches discharged.

The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by the Project Manager immediately before mixing begins each day and thereafter at least once per hour and for each delivery of aggregates during concreting. When the correct quantity of water, determined as set out in the Specifications, has been added to the mix, no further water shall be added, either during mixing or subsequently.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Mixers shall be cleaned out before changing to another type of cement.

1706. TRANSPORTATION OF CONCRETE

The concrete shall be discharged from the mixer and transported to the works by means which shall prevent adulteration, segregation or loss of ingredients, and shall ensure that the concrete is of the required

workability at the point and time of placing. The loss of slump between discharge from the mixer and placing shall be within the tolerances specified in Sub-clause 1704 (5) (b) (i).

The capacity of the means of transport shall not be less than the full volume of a batch.

The time elapsing between mixing transporting placing and compaction altogether of a batch of concrete shall not be longer than the initial setting time of the concrete. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the works.

1707. PLACING OF CONCRETE

(1) Consent for Placing

Concrete shall not be placed until the Project Manager's consent has been given in writing. The Contractor shall give the Project Manager at least two full working day notice of his intention to place concrete.

(2) Preparation of Surface to Receive Concrete

Excavated surfaces on which concrete is to be deposited shall be prepared as set out in Section 200.

Existing concrete surfaces shall be prepared as set out in Clause 1712. Before deposition of further concrete they shall be clean, hard and sound and shall be wet but without any free-standing water.

Any flow of water into an excavation shall be diverted through proper side drains to a sump or be removed by other suitable method which will prevent washing away the freshly deposited concrete or any of its constituents. Any under drain constructed for this purpose shall be completely grouted up when they are no longer required by a method agreed by the Project Manager.

Unless otherwise instructed by the Project Manager surfaces against which concrete is to be placed shall receive prior coating of cement slurry or mortar. The mortar shall be kept ahead of the concrete. The mortar shall be placed into all parts of the excavated surface and shall not be less than 5 mm thick.

(3) Placing Procedures

The concrete shall be deposited as nearly as possible in its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, other embedded items or formwork. It shall be brought up in layers approximately parallel to the construction joint planes and not exceeding 300 mm in compacted thickness unless otherwise permitted or directed by the Project Manager, but the layers shall not be thinner than four times the maximum nominal size of aggregate.

Concrete shall not be placed during rain which is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete. Means shall be provided to remove any water accumulating on the surface of the placed concrete. Concrete shall not be deposited into such accumulations of water.

In dry weather, covers shall be provided for all fresh concrete surfaces which are not being worked on. Water shall not be added to concrete for any reason.

When it is necessary to place concrete under water the Contractor shall submit to the Project Manager his proposals for the method and equipment to be employed. The concrete shall be deposited either by bottom-discharging watertight containers or through funnel-shaped tremies which are kept continuously full with concrete in order to reduce to a minimum the contact of the concrete with the water. Special care shall be taken to avoid segregation.

During and after concreting under water, pumping or de-watering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

1708. COMPACTION OF CONCRETE

Concrete shall be fully compacted throughout the full extent of the placed layer. It shall be thoroughly worked against the formwork and around any reinforcement and other embedded item, without displacing them. Care shall be taken at arises or other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

Concrete shall be compacted with the assistance of mechanical immersion vibrators, unless the Project Manager agrees another method.

The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing which shall not exceed the distance from the vibrator over which vibration is visibly effective and some extent of vibration is overlapped.

Vibration shall not be applied by way of reinforcement nor shall the vibrators be allowed to touch reinforcement, sheathing ducts or other embedded items.

1709. CURING OF CONCRETE

Concrete shall be protected during the first stage of hardening from loss of moisture and from the development of temperatures differentials within the concrete sufficient to cause cracking. The methods used for curing shall not cause damage of any kind to the concrete.

Curing shall be continued for as long as may be necessary to achieve the above objectives but not less than seven days or until the concrete is covered by successive construction whichever is the shorter period. The curing process shall commence as soon as the concrete is hard enough to resist damage from the process. The Contractor shall keep the exposed surfaces continuously wet by means of water spray or by covering with water absorbent material which shall be kept wet. Water used for curing shall be of the same quality as that used for mixing.

The Contractor shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances.

1710. PROTECTION OF FRESH CONCRETE

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from these causes.

Concrete placed in the works shall not be subjected to any loading including traffic until it has attained at least its characteristic strength as defined in Clause 1604.

1711. CONCRETING IN HOT WEATHER

The Contractor shall prevent damage to concrete arising from exposure to extreme temperatures, and shall maintain in good working order all plant and equipment required for this purpose.

In the event that conditions become such that even with the use of equipment the requirements cannot be met, concrete placing shall immediately cease until such time as the requirements can again be met.

During hot weather the Contractor shall take all measures necessary to ensure that the temperature of concrete at the time of placing in the works does not exceed 30°C and that the concrete does not lose any moisture during transporting and placing.

Surfaces in which concrete is to be placed shall be shielded from direct sunshine and surfaces shall be thoroughly wetted to reduce absorption of water from the concrete placed on or against them.

After concrete has been placed, the selected curing process shall be commenced as soon as possible. If any interval occurs between completion of placing and start of curing, the concrete shall be closely covered during the interval with polythene sheet to prevent loss of moisture.

1712. CONSTRUCTION JOINTS

Whenever concrete is to be bonded to other concrete which has hardened, the surface of contact between the Sections shall be deemed a construction joint.

Where construction joints are shown in the Drawing, the Contractor shall form such joints in such positions. The location of joints which the Contractor requires to make for the purpose of construction shall be subject to the approval of the Project Manager. Construction joints shall be in vertical or horizontal planes except in sloping slabs where they shall be normal to the exposed surface or elsewhere where the Drawing requires a different arrangement.

1713. RECORDS OF CONCRETE PLACING

Records of the details of every pour of concrete placed in the works shall be kept by the Contractor in a form agreed by the Project Manager. These records shall include class of concrete, location of pour, date and duration of pour, ambient temperature and concrete temperature at time of placing and all relevant meteorological information such as rain, wind etc., moisture contents of the aggregates, details of mixes, batch numbers, cement batch number, results of all tests undertaken, part of the structure and place where test cube samples are taken from.

1714. REINFORCEMENT

(1) General

Reinforcement as plain bars and deformed bars and steel fabric shall comply with the following Indian Standards:

IS 1786 for high strength deformed steel bars

IS 432 mild steel and medium tensile steel bars

All reinforcement shall be from an approved manufacturer and, if required by the Project Manager, the Contractor shall submit the ISI certification mark or other test certificate from the manufacturer acceptable to the Project Manager.

All reinforcement not complying with the Specification shall be removed from site.

(2) Storage of Reinforcement

All reinforcement shall be delivered to site either in straight lengths or cut and bent. No reinforcement shall be accepted in long lengths which have been transported bent over double.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. Reinforcement shall be stored at least 150mm above the ground on a clean area free of mud and dirt and sorted out according to category, quality and diameter.

(3) Bending Reinforcement

Unless otherwise shown on the Drawing, bending and cutting shall comply with IS 2502. The Contractor shall satisfy himself as to the accuracy of any bar bending schedules supplied and shall be responsible for cutting, bending, and fixing the reinforcement in accordance with the Drawing.

Bars shall be bent mechanically using appropriate bar benders. Bars shall be bent cold by the application of slow steady pressure. At temperatures below 5°C the rate of bending shall be reduced if necessary to prevent fracture in the steel.

Bending reinforcement inside the forms shall not be permitted except for mild steel bars of diameter less or equal to 12 mm, when it is absolutely necessary.

After bending, bars shall be securely tied together in bundles or groups and legibly labelled as set out in IS 2502.

(4) Fixing Reinforcement

Reinforcement shall be thoroughly cleaned. All dirt, scale, loose rust, oil and other contaminants shall be removed before placing it in position. If the reinforcement is contaminated with concrete from previous operations, it shall be cleaned before concreting in that section.

Reinforcement shall be securely placed and fixed in position as shown in the Drawing or directed by the Project Manager.

Spacer blocks shall be used for ensuring that the correct cover is maintained on the reinforcement. Blocks shall be as small as practicable and of a shape agreed by the Project Manager.

All reinforcement shall be checked of shape, size, diameter and number where necessary. Reinforcement shall be rigidly fixed so that it remains intact during placing of concrete. Any fixers made to the formwork shall not remain within the space to be occupied by the concrete being placed.

No splices shall be made in the reinforcement except where shown on the Drawing or agreed by the Project Manager. Splice lengths shall be as shown on the Drawing or directed by the Project Manager.

The Contractor shall ensure that reinforcement left exposed in the works shall not suffer distortion, displacement or other damage. When it is necessary to bend protruding reinforcement aside temporarily, the radius of the bend shall not be less than four times the bar diameter for mild steel bars or six times the bar diameter for high yield bars. Bars complying with IS 1786 or other high tensile bars shall not be bent after placing in the works.

1715. CONCRETE FOR SECONDARY PURPOSES

(1) Non-structural Concrete

Non-structural concrete shall be used only for non structural purposes where shown on the Drawing or as directed by the Project Manager. This shall be compound of ordinary Portland cement and aggregates complying with this Specification.

The weight of cement mixed with 0.3 cubic metres of combined aggregate shall not be less than 50 kg. The mix shall be proportioned by weight or by volume. The maximum aggregate size shall be 40 mm nominal.

The concrete shall be mixed by machine or by hand in accordance with Sub-clause 1715 (3) to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted where required.

The concrete shall be compacted by hand towels or rammers or by mechanical vibration as approved by the Project Manager.

(2) No Fines Concrete

No Fines concrete is intended for use where a porous concrete is required and shall only be used where shown on the Drawing or instructed by the Project Manager.

The mix shall consist of Ordinary Portland cement and aggregate complying with this Specification. The aggregate size shall be 40 mm to 10 mm only. The weight of cement mixed with 0.3 cubic metres of aggregate shall not be less than 50 kg. The quantity of water shall not exceed that required to produce a smooth cement paste which will coat evenly the whole of the aggregate.

(3) Hand Mixed Concrete

Concrete for structural purposes shall not be mixed by hand. Where non structural concrete is required, hand mixing may be carried out subject to approval of the Project Manager.

For making hand mixed concrete, cement, sand and aggregate shall be batched separately by volume or by weight as applicable. Then cement and sand shall be mixed dry to uniform colour. The aggregate shall be stacked in a proper shape upon which cement sand mix shall be spread and whole mix shall be turned up and down to have uniform mix of all ingredients. Then water shall be added as specified in Sub-clause 1615 (1) and shall be mixed to uniform consistency.

For hand mixed concrete the specified quantities of cement shall be increased by 10% and not more than 0.25 cubic meter shall be mixed at one time. During windy weather precautions shall be taken to prevent cement from being blown away in the process of gauging and mixing.

1716. FORMWORK

(1) Scope and Definitions

This Clause covers the preparation, construction and removal of falsework and formwork for concrete structures. It also covers the quality requirements for surface finish on formed and unformed surfaces.

Definitions used in this Clause and other relevant Sections of these Specifications are as follows:

- Formwork means the surface against which concrete is placed to form a face. All the immediate supports necessary to retain the surface in position while concrete is placed, shall be treated as an integral part of formwork.
- Falsework means the structural elements supporting both the formwork and the concrete until the concrete becomes self supporting.
- A formed face is one which has been cast against formwork.
- An unformed surface means a horizontal or nearly horizontal surface which is not cast against formwork.

- An exposed face is one which will remain visible when construction has been completed.

The Contractor shall be responsible for designing and constructing falsework and formwork so that they will support the loads imposed on them by the fresh concrete together with additional stresses imposed by vibrating equipment and by construction traffic,

(1) Construction of Formwork

Joints in formwork for exposed faces shall, unless otherwise specified, be evenly spaced and horizontal or vertical and shall be continuous in a regular pattern.

All joints in formwork shall be water tight. Where reinforcement projects through formwork, the form shall fit closely round the bars.

Formwork shall be so designed that it may be easily removed from the work without damage to the faces of the concrete. It shall also incorporate provisions for making minor adjustments in position, if required, to ensure the correct location of concrete faces. Due allowance shall be made in the position of all formwork for movement and settlement under the weight of fresh concrete.

Surfaces at slopes less than 20° may be formed by screening. Surfaces at slopes between 20° and 30° shall generally be formed if the Contractor can demonstrate to the satisfaction of the Project Manager that such slopes can be screened with the use of special screed boards to hold the concrete in place during vibration.

Horizontal or inclined formwork to the upper surface of concrete shall be adequately secured against uplift due to the pressure of fresh concrete. Formwork shall also be tied down or otherwise secured against floating within the body of the concrete.

The internal and external angles on concrete surfaces shall be formed with fillets and chamfers of the sizes shown on the Drawing unless otherwise instructed by the Project Manager.

Supports for formwork may be bolted to previously placed concrete provided the type of bolt used is acceptable to the Project Manager. If metal ties through the concrete are used in conjunction with bolts, the metal left in shall not be close to the face of the concrete by less than 50mm.

Formwork shall not be re-used after it has suffered damage which is sufficient to impair the finished surfaces of the concrete.

Where circumstances prevent easy access within the form, temporary openings shall be provided through the formwork for cleaning and inspection.

Shear keys of the size and shape as indicated on the Drawing shall be provided in all construction joints.

Where precast concrete elements are specified for use as permanent formwork, or proposed by the Contractor and agreed by the Project Manager, they shall comply with the requirements of formwork as specified in the Specifications in respect of surface finish, strength and rigidity. Such elements shall be set true to line and level within the tolerances prescribed for the appropriate class of finish in Clause 1806 and fixed so that they cannot move when concrete is placed against them.

(3) Preparation of Formwork

Before any reinforcement is placed into position within formwork, the latter shall be thoroughly cleaned and then dressed with a release agent. The agent shall be either suitable oil incorporating a wetting agent, an emulsion of water suspended in oil or low viscosity oil containing chemical agents. The Contractor shall not use an emulsion of oil suspended in water nor any release agent which causes staining or discoloration of the

concrete, air holes on the concrete surface, or retards the set of the concrete or affects the strength of concrete.

In order to avoid colour differences on adjacent concrete surfaces, only one type of release agent shall be used in any one section of the works.

Before placing concrete all dirt, construction debris and other foreign matter shall be removed completely from within the placing area.

Before concrete placing commences, all wedges and other adjusting devices shall be secured against movement during concrete placing and the Contractor shall maintain a watch on the formwork during placing to ensure that no movement occurs. If any movement noticed, the formwork shall be set right immediately.

(4) Removal of Formwork

Formwork shall be carefully removed without shock or disturbance to the concrete. No formwork shall be removed until the concrete has gained sufficient strength to withstand any stresses safely to which it may thereby be subjected.

The minimum periods which shall elapse between completion of placing concrete and removal of forms are given in Table 16.5 and apply to ambient temperatures higher than 10°C. At lower temperatures or if cement other than ordinary Portland are used in concrete work the Project Manager may instruct longer periods for removal of formwork.

Alternatively, formwork may be removed when the concrete has attained the strength set out in Table 16.5, provided that the attained strength is determined by making test cubes and curing them under the same conditions as the concrete to which they refer.

Compliance with these requirements shall not relieve the Contractor of his obligation to delay removal of formwork until the removal can be completed without damage to the concrete.

As soon as the formwork has been removed, bolt holes in concrete faces other than construction joints which are not required for subsequent operations shall be completely filled with mortar sufficiently dry to prevent any slumping at the face. The mortar shall be mixed in the same proportions as the fine aggregate and cement in the surrounding concrete and with the same materials and shall be finished flush with the face of the concrete.

After removal of the formwork, the date of casting of concrete shall be marked on the surface of related concrete by water proof paint/marker for estimation of curing time.

Table 17.5: Minimum Periods for Formwork Removal

Position of Formwork	Minimum period for temperatures over 10° C	Strength to be attained
Vertical or near vertical faces of mass concrete	24 hours	0.2 f_{ck}
Vertical or near vertical faces of reinforced walls, beams columns	48 hours	0.3 f_{ck}
Underside of abutments, beams and slabs (formwork only)	4 days	0.5 f_{ck}
Supports to underside of arches, beams and slabs	14 days	f_{ck}
Arched linings in tunnels and underground works	24 hours	4 N/mm ²

Note: f_{ck} is the Characteristic Strength for the class of concrete used.

(5) Surface Finish on Formed Surfaces

(a) Classes of Finish

The surface finish to be achieved on formed concrete surfaces shall be as shown on the Drawing and are defined hereunder:-

(i) Class F1 Finish

This finish is for surfaces against which backfill or further concrete will be placed. Formwork may be sawn boards, sheet metal or any other suitable material which will prevent the loss of laitance from the concrete being placed.

(ii) Class F2 Finish

This finish is for surfaces which are permanently exposed to view but the highest standard of finish is not required. Forms to provide a Class F2 finish shall be faced with wrought thickened tongued and grooved boards with square edges arranged in a uniform pattern and close jointed or with suitable sheet material. The thickness of boards or sheets shall be such that there shall be no visible deflection under the pressure exerted by the concrete placed against them.

Joints between boards or panels shall be horizontal and vertical unless otherwise directed. In this type of finish pitting, fins, surface discoloration and other minor defects shall be remedied at the time and by methods agreed by the Project Manager.

(iii) Class F3 Finish

This finish is for surfaces which will be in contact with water flowing at high velocity, and for surfaces prominently exposed to view where good appearance is of special importance. To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood or equivalent material in large sheets. The sheets shall be arranged in an approved uniform pattern. Wherever possible, joints between sheets shall be arranged to coincide with architectural features or changes in direction of the surface.

All joints between panels shall be vertical and horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment in the plane of the sheets. Unfaced wrought boarding or standard steel panels will not be permitted for Class F3 finish. The Contractor shall ensure that the surface is protected from rust marks, spillages and stains of all kinds.

1717. EARLY LOADING

No load shall be applied to any part of a structure until the specified curing period has expired, and thereafter loading shall be allowed after approval by the Project Manager. The Project Manager's decision shall be based on the type of load to be applied, the age of concrete, the magnitude of stress induced and the propping of the structure.

No structure shall be opened to traffic until test cubes have attained the specified minimum 28 days strength as defined in Clause 1604.

1718. PLUM CONCRETE

(1) General

This work shall be required to provide lining of drains and drainage structures or other works as shown on the Drawings or as specified by the Project Manager.

(2) Materials

The concrete shall comply with the requirements of Section 1700. The grade of concrete shall be as shown on Drawings or as directed by the Project Manager. The stone shall comply with the requirements of Section 1400.

(3) Composition

Composition of plum concrete shall be composed of 50 percent of concrete 1:3:6 using 20 mm down aggregate and 50 % percent of stones by volume or as instructed by the Project Manager. About 3% non-shrinking agent by weight of cement shall be added to concrete at the time of mixing.

(4) Mock-up

Prior to commencement of plum concrete the Contractor shall construct a plum concrete panel of approximately 2000 mm x 1000 mm for inspection and approval of the Project Manager. The thickness of mock-up shall be according to use of plum concrete in designated work.

(5) Construction

The place to be filled up with the plum concrete shall be cleaned and chipped for adhesion with the concrete. Following completion of form work a layer of concrete minimum 100mm thick shall be laid upon which clean and moist stones shall be placed at a distance of min 100mm measured from face to face in any direction. The distance between the outer edge of the concrete mass and the nearest face of the stone to the edge shall not be less than 100 mm. Then another layer of concrete having thickness not less than 100mm measured from the top of the stone to the top surface of the layer shall be laid and compacted.

In case the proportion of concrete to stones is to be changed, the clear space between stones shall be adjusted as directed by the Project Manager.

After compaction, again stones shall be placed on the layer as described above and the process shall be continued until the top layer of the concrete is completed. The placing of stones shall be staggered both in horizontal and vertical directions.

(6) Tests and Standards of Acceptance

Stones shall be tested for water absorption test. The test results shall meet the requirements as specified in these Specifications. Concrete shall be tested as specified in Section 1700.

1719. MEASUREMENT

(1) Concrete

Concrete laid in place as specified in the Drawing or directed by the Project Manager shall be measured in cubic metre separately for each class. No deduction shall be made in the measurement for:

- (a) bolt holes, pockets, box outs and cast in components provided that the volume of each is less than 0.15 cubic metres;
- (b) mortar beds, fillets, drips, rebates, recesses, grooves, chamfers and the like of 100 mm total width or less;
- (c) reinforcement

(2) Blinding Concrete/Non Structural Concrete

Blinding concrete laid in place shall be measured in cubic metre. No deduction shall be made for openings provided that the area of each is less than 0.5 square metres. Blinding concrete over hard material shall be measured as the volume used provided that the maximum thickness of 150 mm allowed for overbreak is not exceeded.

(3) Admixtures, Workability and Hardening Agents

No separate measurement of these items shall be carried out.

(4) Reinforcement

All types of reinforcement shall be measured in metric tone in the ranges as given below:

- Diameter equal to or less than 8mm
- Diameter above 8mm up to 16mm
- Diameter above 16mm

Only that reinforcement which is required and placed in work as per Drawing or as directed by the Project Manager shall be measured. Other reinforcement not shown on the Drawing or directed by the Project Manager such as splices, chairs, cap lengths hangers and the like and the reinforcements not conforming to shape, size and length as shown on the Drawing or as directed by the Project Manager shall not be measured.

(5) Formwork

Except as stated otherwise, formwork shall be measured in square metre of formwork actually in contact with the finished face of the concrete. The measurement of formwork shall be inclusive of the measurement for formwork finished surface, shoring, staging, scaffolding and other accessories required for erection and removal of the formwork. No deduction shall be made in the measurement for openings, pipes, ducts and the like, provided that the area of each is less than 0.50 square metres. Unless otherwise stated, if the volume or area of concrete has not been deducted when measuring the concrete, formwork to form box or the void shall not be measured. Formwork less than 300 mm high to edges of slabs shall be measured in linear metre.

(6) Plum Concrete

The plum concrete shall be measured in cubic metre. Form work shall be measured in sq.m separately. Struts, bracing supports etc. shall not be measured separately. They are deemed to be included in the measurement of form work.

1720. PAYMENT

(1) Concrete

Every class of concrete shall be paid as per respective contract unit rate. In addition to those specified in Clause 114 the respective rate shall also include the cost of:

- (a) admixtures and workability agents including submission of details unless specified.
- (b) surface finish as per Sub-Clause 1615(5).
- (c) laying to sloping surfaces not exceeding 15° from the horizontal and to falls.
- (d) placing and compacting against excavated surfaces where required including any additional concrete to fill overbreak and working space.
- (e) complying with the requirements of Clauses 1601 to 1618.

(2) Reinforcement

The reinforcement shall be paid at contract unit rate. In addition to those specified in Clause 114 the rate shall also include compensation for the cost of providing , cutting to length, splice lengths additional to those shown on the Drawing, laps, bending, hooking, waste incurred by cutting, cleaning, spacer blocks, provision and fixing of chairs or other types of supports, welding, fixing the reinforcement in position including the provision of wire or other material for supporting and tying the reinforcement in place, bending reinforcement aside temporarily, and straightening, placing and compacting concrete around reinforcement and for complying with Clause 1714.

(3) Formwork

The formwork shall be paid as per the contract unit rate. In addition to those specified in Clause 114 the rates for formwork shall include the cost of submission of details, transportation and use of all materials for formwork and falsework, erection including provision of supports, fillets and chamfers 75 mm and less in width, bolts, ties, fixings, cutting to waste, drilling or notching the formwork for reinforcement where required, working around pipes, ducts, conduits and waterstops, temporary openings, cleaning, dressing, removal of formwork and falsework, filling bolt holes and any remedial work and for complying with Section 1700 including all incidental works required to complete the work as per Specification.

(4) Plum Concrete

The plum concrete shall be paid at contract unit rate which shall be full and final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

1800. CROSS DRAINAGE WORKS

1801. PIPE CULVERTS

(1) Scope

This Clause covers the works for the construction of concrete pipe culverts and piped drains and concrete channels.

(2) Materials

(a) Reinforced Concrete Pipes

Reinforced concrete pipes shall comply with the requirements of IS 458:1988.

(b) HDP Pipes

HDP pipes shall be to the approval of the Project Manager.

(3) Excavation for Pipes

The foundation bed for the pipe culverts/drains shall be excavated in accordance with Section 600 true to the lines and levels shown on the Drawing or to such other lines and depths as the Project Manager may direct. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embankments, taken down to the levels as shown on the Drawing. The additional width of the trench on either sides of the pipe shall be 150 mm or one-fourth of the diameter of the pipe whichever is more. Should the Contractor desire to use mechanical plant for excavating trenches or for laying pipes he shall submit his

proposals for approval by the Project Manager, but such approval shall not relieve the Contractor from his responsibilities in case of damage to pipes.

The pipe shall be placed where the ground for the foundation is reasonable firm. Where the bottom of the trench as excavated does not provide a suitably firm foundation for the culvert, due to soft, mucky or other unsuitable material being encountered, the unsuitable material shall be excavated to such depth, width and length as directed by the Project Manager. The excavation shall then be backfilled with gravel or other approved granular material which shall be properly shaped and thoroughly compacted up to the specified level.

(4) Timbering of Pits and Trenches

The sides of trenches shall, where required, be adequately timbered and supported to the satisfaction of the Project Manager. All such excavations shall be of sizes sufficient to enable the pipes and concrete to be laid accurately and the formwork withdrawn before refilling and ramming is carried out.

(5) Water in Excavation

Trenches shall be kept free from water until the pipes are installed and the joints have hardened. The Contractor shall, at his own expense, construct any sumps or temporary drains that the Project Manager may consider necessary. The Contractor shall make good at his own expense, any damage caused by prolonged and excessive pumping, and shall take all precautions necessary for the safety of adjoining structures by shoring or otherwise, during the time the trenches are excavated or open.

(6) Laying and Jointing Pipes

Arrangements for handling including lifting, loading, transporting, unloading, storage and lowering the pipes in bed shall be such that the pipes do not suffer any damage.

The pipes shall be laid true to line and level, commencing from the outfall. No pipes shall be laid until the Project Manager has approved by the Project Manager. Pipes shall be laid such that each one is in contact with the bed throughout the length of barrel. The pipes shall be laid closely together against each other so as to obtain tight joints.

Where two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to half the diameter of the pipe subject to a minimum of 450 mm.

Concrete pipe culverts shall be laid on granular bedding or concrete bedding or as shown on the Drawing.

The concrete pipes shall be jointed either by collar joint or flush joint. In case of collar joint, the collar shall be of reinforced cement concrete 150 to 200 mm wide according to the diameter of the pipe and having the same structural strength as the pipes to be jointed. Caulking space shall be between 13 to 19 mm according to the diameter of the pipe as specified by IS: 458:1988. Caulking material shall be slightly wet mix of cement and sand in the ratio of 1:2 rammed with caulking irons. Before caulking, the collar shall be placed such that its centre coincides with the joint and an even annular space is left between the collar and the pipe. In case of flush joint, the ends of the pipes shall be spaced to form a self centering joint with a jointing space of 13 mm side. The jointing space shall be filled with cement sand mortar in the ration of 1:2. Care shall be taken to fill all voids and to see that any excess of cement mortar is neatly cleaned off while each joint is being made and any earth, cement or other material thoroughly cleaned out of the pipes. All joints shall be made with care so that the interior surface is smooth and consistent with the interior surface of the pipes. After finishing, the joint shall be kept covered and damped for at least four days. A properly fitted plug shall be well secured at the end of each pipes already laid and shall be removed only when next pipe is being laid or on completion of the culvert or drain. The trench shall be kept free from water until the joints are thoroughly set.

Jointing of HDP pipes shall be done by heating as prescribed by the manufacturer.

(7) Cement Mortar for Jointing

Cement mortar for jointing pipes shall consist of one part by weight of Portland cement to two parts by weight of sand. Sand shall comply with Sub-clause 1300(2). The materials shall be accurately gauged and mixed in an approved manner. Cement mortar shall be made in suitable small quantities only as and when required, and any mortar which has begun to set or which has been mixed for a period of more than the initial setting time shall be rejected.

(8) Pipe to be left Clean on Completion

On completion, all pipe lines, drains etc., shall be flushed from end to end with water and left clean and free from obstructions.

(9) Pipes Bedding and Encasing

Pipes shall be laid on granular or concrete bedding or as shown on the Drawing.

(a) Granular Bedding

The pipes shall be laid on a layer of fine granular material, 100 mm thick, after the bottom of excavation has been shaped to conform to the lower part of the pipe as shown on the Drawing. The bedding material shall be well graded and suitably compacted granular material passing 5.6 mm sieve.

(b) Concrete Bedding

Where indicated on the Drawing, the pipes shall be laid on grade M10/40 concrete conforming to Section 1700 so that the bottom of the pipe rests on concrete of the specified thickness. The thickness of the concrete below the pipe and the height to which it extends upwards shall be as indicated on the Drawing or as instructed by the Project Manager

(c) Concrete Encasing

Where shown on the Drawing, pipes shall be fully encased in concrete as shown on the Drawing. The grade of the concrete shall be as shown on the Drawing. In carrying out this work the Contractor shall take care to pack the concrete under and around the pipes to ensure even bedding and solidity in the concrete; in no instance shall the concrete be thrown directly on the pipes. The concrete shall be placed in such a way that all spaces around the pipe are completely filled with concrete. Concrete casing shall be cast in one continuous operation until completed. The upper surface of the concrete shall be struck off with a wooden screed and neatly finished off.

(10) Joining New Work to Old Work

Where partial demolition is required for extension to the existing structures, the contact face shall be cut to predetermined lines and levels. The loose and fragmented material shall be removed and projecting steel cleaned and bent as directed by the Project Manager. Where no partial demolition but only extension is required, the contact area shall be roughened and cleaned of all dirt and loose particles.

(11) Refilling Trenches

Backfill for pipes and minor drainage structure shall be obtained from the material excavated in forming the excavation. In the event of there being insufficient excavated material or the culvert is laid close to or above existing ground level then selected backfill shall be obtained from borrow pits. All backfill whether from excavated material or borrow pits shall be suitable material as defined in Clause 602 and shall have a CBR of

at least 5% measured after 4 days soak on laboratory mix compacted to 93% MDD (Heavy Compaction), plasticity Index of less than 35%, maximum particle size of 40 mm and shall be compacted to a dry density of 93% MDD (Heavy Compaction).

For pipe culverts which have been placed and where no concrete haunch or surround is called for, selected fill of suitable material available from the excavation shall be placed in layers not exceeding 150 mm of loose thickness. The material shall be uniformly mixed with water or dried out such that the moisture content at the time of compaction is between 95% and 100% of the Optimum Moisture Content. Then it shall be compacted thoroughly. Similar selected material shall then be laid in layers, not exceeding 150 mm of loose thickness, mixed, dried or watered as necessary and carefully compacted, and brought up uniformly on both sides of the pipe up to a height of not less than 300 mm over the crown. The remainder of the trench shall then be backfilled with suitable materials, placed in layers not exceeding 150 mm of loose thickness, mixed, watered or dried as necessary and carefully compacted. All backfilling material except the top 300 mm below formation level shall be compacted to a minimum dry density of 93% of MDD (Heavy Compaction). The top 300 mm below formation level shall be placed in layers not exceeding 150 mm of loose thickness, mixed, watered or dried as necessary and carefully compacted to at least 95% of MDD (Heavy Compaction).

For pipe culverts which have been constructed close to, above or where the culverts protrudes above the existing ground the backfilling under the flanks and alongside and over the culverts shall be placed and compacted in layers not exceeding 150 mm to a density of at least the density required for the material in adjoining layers of fill. All existing ground under this backfill shall be compacted to 93% MDD (Heavy Compaction) to a depth of 150 mm.

Backfilling shall be carried out simultaneously and equally on both sides of the culvert to avoid unequal lateral forces. In all cases there shall be cover of at least 600 mm over the crown of the culvert before construction equipment is driven over it unless protective measures approved by the Project Manager have been provided.

(12) Inlet and Outlet Structures and Catch pits

Catch pits, headwalls, wing walls, aprons and other ancillary works shall be constructed in accordance with the details shown on the Drawing. Masonry for these works shall conform to Section 1300 or 1400 as applicable. Concrete shall conform to Section 1700 and aprons shall conform to Section 1800.

(13) Opening to Traffic

No traffic shall be allowed to cross the pipeline unless the height of the filling is not less than 600 mm above the top of the pipe line or as shown on the Drawing or as instructed by the Project Manager.

(14) Tests and Standard of Acceptance

The Contractor shall submit manufacturer's test certificates for each lot of pipes supplied. The test results shall meet the requirements of the relevant Specifications.

Backfilling/Refilling shall be tested in accordance with Section 600 and all the test results shall meet the criteria specified. Compaction shall be tested in each layer of backfill/refill. Gradation of granular bedding shall be tested at least once a day and the test results shall meet the specified criteria.

The pipe drains/culverts shall be constructed to the true lines and levels indicated on the Drawing or instructed by the Project Manager.

(15) Measurement

Pipes shall be measured along their centre between the inlet and outlet ends in linear meters of individual pipe element of each size, completed and accepted in place. Collar shall not be measured for payment. Excavation, bedding, concrete for encasing and backfilling works shall be measured separately in cubic meters. Ancillary works such as head walls, wing walls, etc., shall be measured as provided for in the respective Sections of these Specifications.

(16) Payment

Pipes, measured as provided above, shall be paid for at the contract unit rates per linear meter of each particular size which shall be the full and the final compensation to the Contractor as per Clause 114.

Cost for cement jointing shall be deemed to be included in the contract unit rate of pipe.

Ancillary works such as excavation, backfilling; granular bedding and/or concrete for bedding/encasing and masonry shall be paid for separately, as provided under respective Clauses of these Specifications.

1802. CONCRETE CHANNELS

(1) Scope

This Clause covers the works for the construction of concrete channeling for drainage.

(2) Materials

Concrete channels may be pre-cast units or may be cast in-situ. All concrete work and reinforcement shall be carried out in accordance with the requirements of Section 1700.

The material on which concrete is to be bedded shall be granular bedding as provided in Clause 1701.

(3) Construction

(a) Excavation and Bedding

Trenches for channels shall be excavated to the required depth as shown on the Drawing. The bottom and side of the trench shall be neatly trimmed. All loose materials shall be thoroughly compacted. The bedding material shall then be laid on the bottom of the trench and it shall be thoroughly compacted and accurately shaped to the required line and level. No concrete shall be placed on un compacted or disturbed material.

(b) Precast Concrete Channels

Precast concrete channels shall be laid with close joints with 1:2 cement sand mortar at the ends. The joints shall not exceed 10 mm in thickness and shall be neatly pointed with a pointing trowel. Guide lines and straight edges shall be used to ensure that the exposed faces and edgings are set to true lines and levels.

Care shall be taken to protect all precast units against chipping or breakage during handling and laying. Broken or chipped Sections shall not be used and shall be replaced with undamaged units.

(c) Cast in-situ Channels

Channels shall be cast in alternative Sections. The length of Sections shall be uniform throughout and shall be equal to 2 m, except where shorter Sections are necessary for closures or where otherwise shown on the Drawing.

Forms shall be accurately set to line, levels and elevation and shall be firmly held in position during the placing of the concrete. Stops at the ends of Sections shall be placed accurately so as to ensure that the joints are truly perpendicular to the surface of the concrete and right angles to the edge of the road. After concrete has been placed in the forms, it shall be tamped and spaded until the exposed surfaces are entirely covered with mortar. Exposed faces shall then be finished to smooth and even surfaces.

The forms of exposed concrete surfaces shall be removed after 24 hours after the concrete has been placed. Minor defects shall be repaired with a 1:2 cement sand mortar. Plastering shall not be permitted on exposed faces and all rejected portions shall be removed and replaced at the Contractor's expense. Exposed surfaces shall be finished while the concrete is still green, by wetting a soft brick or wooden block and rubbing the surfaces until they are smooth. When the concrete has smoothed by using water, it shall be rubbed with a thin paste of 1:1 cement sand mortar until a uniform colour is obtained. When completed the Sections shall be cured in accordance with the requirements of Section 1700.

After the concrete in alternate Sections has been set, the intermediate Sections shall be cast and finished in accordance with all the requirements specified above. The exposed end surfaces of the alternate Sections cast first shall be painted with a coat of approved bituminous emulsion containing 60% of net bitumen by mass, and the emulsion shall be allowed to set and dry before the intermediate Sections are cast.

Guide lines and straight edges shall be used to ensure that the exposed faces are formed to the true line, level and elevation.

(4) Tests and Standard of Acceptance

All concrete works shall be tested in accordance with Section 1700 and the test results shall meet the specified criteria.

The concrete channel works shall be constructed to the true lines and levels shown on the Drawing or instructed by the Project Manager.

(5) Measurement

Concrete channels shall be measured in linear meter. Formworks and reinforcement shall not be measured separately. Excavation and bedding shall be measured as provided under respective Sections of these Specifications.

(6) Payment

Concrete channels shall be paid as per the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications. Excavation and bedding shall be paid as provided under respective Sections of these Specifications and these shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

1900. DRAINS AND PROTECTIVE WORKS

1901. GENERAL

This Section covers the furnishing of materials and construction of slope stabilization and surface erosion protection, sub-surface drains, horizontal sub-surface drains, scour protection and river training works, log and boulder barriers, boulder wall, rock anchorage for retaining wall, rock bolting and shot creting.

1902. LINE DRAINS

(A) LINED EARTHEN CATCH DRAIN

1. Excavation

The excavation for the lined catch drain shall be done according to the Drawings provided and the surplus cut material placed without compaction as a bund immediately on the valley side of the cut. The bottom of the excavation shall be levelled carefully. Any pockets of unsuitable material or loose rock in the bottom of the excavation shall be removed and the resulting cavities filled with suitable material and compacted.

Catch drains shall be minimum 3m from edge of batter, to prevent local seepage causing collapse. The surface where the drain needs to be constructed shall be prepared to the required levels/slopes with full compaction of the base to prevent future settlement. Ensure that the drain have uniform slope with no ponding. The surface of the drain shall be smooth finish. Catch drains shall lead to French drains at suitable locations to enable water to be transferred to side drain

2. **Measurement:** The length shall be measured in running metre correct to 50 mm.

3. **Payment:** The cost of excavation to the required depth, leveling and or sloping to the required degree, equipment, tools, and incidentals necessary to complete the works as specified must be included in the concerned contract rate.

B) LINED L-SHAPED ROAD SIDE CONCRETE DRAIN

1. SCOPE

This item covers Construction of lined L-shaped side drain depth 300 mm and clear width 800 mm including 150mm thick PCC M20:20, 300mm thick RRM in CM 1:4 hill side, including excavation, leveling and disposal of surplus earth within 50m.

2. EXCAVATION

Trenches shall be made along the edge of the road where the drain is to be constructed. The excavation shall be done exactly to the required profile giving specified slope. The surface shall be levelled to uniform grade/level and rammed.

3. CONSTRUCTION

For the lined drain the relevant specification for concreting, soling and plastering shall be followed. The surface of the concrete shall be finished smooth. Any rough surface shall be made smooth by adding dry mix of cement and sand 1:3 (1 cement: 3 sand) on the surface immediately after concreting when the concrete is still green. No extra shall be paid for such finishes. All work shall be carried out as per the drawing and specification or as directed by the Project Manager. Depending upon the site condition the Project Manager may direct the contractor to increase the height of the masonry wall upto maximum of 1.0m The extra work done shall be measured in cubic meter and paid as per construction of stone masonry works and relevant BoQ item.

The longitudinal slope of the drain shall be uniform to avoid ponding, and not less than 3%. The cross slope shall be as per drawing unless otherwise directed by the Project Manager. All concrete and masonry work

shall be thoroughly cured not less than 28 days before water is allowed to flow in the drain. The clear internal dimension of the drain shall be 800 mm wide and the depth shall conform the drawing.

4. MEASUREMENT: The length shall be measured in running metre correct to 50mm.

5. PAYMENT: The rates shall include the cost of all material and labour involved in the above operation.

C) **LINED TRAPEZOIDAL DRAIN**

1. SCOPE

This item covers construction of lined trapezoidal side drain of depth 450 mm and clear width of 800 mm including 150mm thick PCC M15:20 base, 300mm thick RRM on both sides in CM 1:4, including excavation, leveling and disposal of surplus earth within 50m lead.

2. EXCAVATION

Trenches shall be made along the edge of the road where the drain is to be constructed. The excavation shall be done exactly to the required profile giving specified slope. The surface shall be levelled to uniform grade/level and rammed.

For the lined drain the relevant specification for concreting, soling and plastering shall be followed. The surface of the concrete shall be finished smooth. Any rough surface shall be made smooth by adding dry mix of cement and sand 1:3 (1 cement: 3 sand) on the surface immediately after concreting when the concrete is still green. No extra shall be paid for such finishes. All work shall be carried out as per the drawing and specification or as directed by the Project Manager.

The longitudinal slope of the drain must not be less than 3% and it should be uniform to avoid ponding. The cross slope shall be as per drawing unless otherwise directed by the Project Manager. All concrete and masonry work shall be thoroughly cured not less than 28 days before water is allowed to flow in the drain. The clear internal dimension of the drain shall be 800 mm wide and 450 mm deep.

3. MEASUREMENT: The length shall be measured in running metre correct to 50mm.

4. PAYMENT: The rates shall include the cost of all material, tools & plants and labour involved in the above operation.

1903. FRENCH DRAIN

1. SCOPE

This item covers the construction of French drain, including jungle clearance, earth work in excavation, levelling of excavated earth to the sides, filling drain as per the drawings, filter material and geotextile as Section 200 as per the drawing. Two sizes of French drains, 0.6 x 1.0 m and 1.0 x 1.5 m shall be constructed as required at site.

MATERIALS

The stones used for the filling of the French drain shall be as Filter Material Specification as below:

Table 19.1 : GRADING REQUIREMENTS FOR FILTER MATERIAL

Sieve Designation	Per cent passing by weight		
	Class I	Class II	Class III
53 mm	-	-	100
45 mm	-	-	97-100
26.5 mm	-	100	-
22.4mm	-	95-100	58-100
11.2 mm	100	48-100	20-60
5.6 mm	92-100	28-54	4-32
2.8 mm	83-100	20-35	0-10
1.4 mm	59-96	-	0-5
710 micron	35-80	6-18	-
355 micron	14-40	2-9	-
180 micron	3-15	-	-
90 micron	0-5	0-4	0-3

Geotextile shall be as per Section 200 (10KN/m). The contractor shall provide suppliers test certificate of geotextile materials comprising of tensile and tear requirements before mass supply to BS 6906 part 3 or ASTM D4491

EXCAVATION AND FILLING

The excavation for the drain shall be done according to Drawings and the cut material must be equally distributed to the left and right of the drain over an area of about 1-2 m, without compaction. For the filling of the drain, the stones may be thrown into the drain at random, careful stacking is not required.

2. QUALITY CONTROL

The excavation for the main and tributary drain shall be to the required depth as mentioned in the specification. The sides of the trench shall be excavated slightly inclined to give more stability and to prevent collapse of the vertical trench sides. The excavated earth shall be placed towards the downhill of the drain not to block the water. The excavated earth shall be placed uniformly avoiding heaps and lumps. The stone used for filling shall be filled randomly and comply with table 19.1. The geotextile shall fully cover the base and sides of the excavation, and have sufficient lap between sheets. The alignment of the drain shall be in herringbone pattern for quick collection and drainage of water

3. MEASUREMENT: The length of the French drain shall be measured in running metre correct to 50mm.

4. PAYMENT: The rate shall include for all the operation involved above to complete the work including labour, material, excavation, filling, equipment hired/owned, tools and plants and other incidentals.

1904. GROUND ANCHOR

(1) Scope

This Clause covers the works for construction of ground anchors which are used to retain and stabilize structures such as retaining walls, drains, rock slopes etc. The anchor direction both in plan and zenith shall be more or less perpendicular to the weakened plane as indicated on the Drawing or directed by the Project Manager. However, for the case of gravity grouting, the zenith inclination of anchor bars shall be kept minimum 15° degree below the horizontal.

(2) Materials

(a) Anchors

Ground anchors are used as Permanent DCP (Double Corrosion Protection) anchor tendon and shall be manufactured from standard manufacturer and it shall comply with DIN 4125 and shall be of DYWIDAG or approved equivalent type with tensile strength of 950/1050 with nominal diameter of 32 mm. The required length shall be reached by coupling of individual anchor length.

Depending upon the type of rock soil formation and depth of sound rock strata, the fixed anchor and tendon lengths are subject to vary, so that a minimum anchor design load (anchor testing) can be obtained. The bond length of anchor bars shall, in no case, be less than 6 m and tendon length shall depend upon the thickness of loose and soft layer above, as investigated by the Project Manager during construction. The final decision for the change in anchor lengths lies fully on the rock investigation and judgment by the Project Manager during construction and the result of anchor tests.

(b) Anchor Head

Anchor head consisting of domed hex nuts type as per DIN 1994, pre-stressing steel grade of strength 1080/1230. For the load transfer from the anchor nut to the concrete structure either plate anchorages or conical bearing and wedge washes in connection with shims shall be used. To ensure that the anchor head will be positioned vertical to the steel tendon, angular deviations are to be compensated through wedge plates, mortar bed or similar. Anchor end plates shall be of structural confirming to ASTM A36 or equivalent with minimum dimensions of 250x250x25 mm.

(c) Corrosion Protection

Anchor tendons are likely to corrode easily and severity depends on the nature of the environment in which the tendon is used. Hence care shall be given to protect anchor tendon and anchor head assembly against corrosion. The tendon shall be coated with approved insulating wrapping or other materials, as directed by the Project Manager. The coating shall not brittle or develop crack during load testing. It shall be enclosed by HDP pipe as shown in Drawing or as directed by the Project Manager. In all protection work, the general principle shall be to provide protection against corrosion over the whole anchorage length, partial protection shall be avoided. Therefore, the materials used for corrosion protection system must remain:

- i) crack free and not become brittle or fluid over the anticipated service temperature range and
- ii) chemically stable, non-reactive with adjacent materials and impervious to moisture.

(d) Coupler

The coupler of threaded sleeves type and of strength 1080/1230 shall be used to join anchor tendons of 950/1050. When assembling, the tendon shall be screwed to the tendon until the vent cap is tightly clamped. The couplers shall be coated with corrosion protection material before slipping over the coupler tube.

(e) Grout

The primary function of grout is to attach the tendon to the ground in the fixed anchor length. Its second function is to provide protection against corrosion. The third function is to fill voids in the ground which might allow loss of grout around the fixed anchor length.

The cement shall be of Ordinary Portland Cement and shall comply with IS 8112 or IS12269 as directed by the Project Manager. The cement shall meet the following chemical properties:

- Chlorides content shall be < 0.1 % by weight of cement used
- Sulphate content shall be < 4% by weight of cement in the grout expressed as SO₃

Water shall be clean and free from detrimental concentration of acids, alkalis, salts, and other organic or chemical substances. The use of water with high chlorides content shall be avoided in the preparation of grout. If instructed by the Project Manager the Contractor shall prove the suitability of the water by tests carried out by an approved laboratory. Such tests shall comply with the requirements of IS: 3029-1964.

The water cement ratio shall be chosen to ensure that the grout has sufficient fluidity to be pumped down in the borehole and around the tendon. The water cement ratio of grouting shall be between 0.4 and 0.45. Minimum compressive strength of grout from cylinder testing shall be as follows:

7 days 19 N/mm²

28 days 28 N/mm²

Approved commercial grade of extra fine aluminum powder in an amount not exceeding 0.005 % by weight of cement may be blended with cement to ensure expansion of cement grout at fixed anchor zone. The use of admixture shall be referred to ACI Publication (1971).

(3) Construction

(a) Drilling for Anchor Hole

Drilling for anchor holes shall be made through pre-installed heavy density polyethylene casing across the wall and may require casing pipes at loose overburden material. Borehole log shall be prepared on the basis of fast drilling and shall be submitted to the Project Manager before installation of the anchor system.

Drilling for anchor hole shall be done using rotary core drilling rigs or other as applicable and generally inclined downward from horizontal. The minimum diameter of borehole shall be chosen such that the anchor with spacers (86 mm dia) can be installed without any problems. The drill rods used should be sufficiently rigid to assure a straight drilling and that that the borehole can be properly cleaned.

During advancement of drilling works, the drilling spoil shall be removed efficiently and cleaning of borehole shall be done by flushing water to get better bond with grout. After flushing, care shall be taken that no fall-in of hole walls occur, which may prevent tendon being homed into position.

The tolerance of drilling in inclined position shall be as order of 0° 43'to1°10'.

The core shall be logged by a qualified Geologist for an adequate geological interpretation and are kept in core boxes. The cores in the core boxes shall be photographed in color before they are removed from the drill site. The core boxes shall be adequately stored to protect them against any loss or damage and on completion of drilling delivered to the Employer. The Contractor shall maintain daily record of the drilling in a format acceptable to the Project Manager. The format and contents of information in bore log shall be as approved by the Project Manager.

Water Pressure/Lugeon Test

Water pressure test or Lugeon test shall be carried out in the borehole during drilling using suitable mechanical or pneumatic packers to determine the permeability characteristics of the rock especially in fixed anchor length. Drilling mud or other substances that may affect the permeability of the rock, hence shall not be used. The packer used shall be of double type. In general, water pressure of 3 kg/m² will be used. However, care shall be taken not to create fissures due to high water pressure applied during test.

The water pressure test for each test stage shall be submitted in suitable format. The report shall include, but not be limited to the following information:

- Date, borehole number, test number, location.
- Packer type, borehole diameter.
- Depth of packer setting and the bottom of borehole
- Test length
- Gauge height above the ground
- Depth of water table
- Pressure of water supply
- Test period 10 minutes
- Time of test
- Depth of casing

The Lugeon value will be calculated as: $Lu = (10 * Q)/(P * L)$, where, Lu: Lugeon value; Q: quantity of water injected per minute, l /min; P: pressure, kg/cm²; L: length of test section, m, whereas P will be calculated as: $p = p_0 + 0.1 (H_1 - H_2)$, where p_0 = Pressure gauge, kg/cm² and H1 and H2 are hydrostatic heads between the pressure gauge and the center of test section and the water table and the center of the tests section respectively in meters.

The Contractor shall report the Lugeon values in the drilling report.

(b) Installation of Ground Anchors

The anchors of approved dimension shall be installed into the drill hole. Elastic spacers shall be positioned at least 1.5 m in the area of bond or fixed anchor length. The free end of the anchors shall be fixed with anchor head. The face of anchor head shall be inclined with vertical to the same angle as the anchor bar with the horizontal so that the load transfer to the anchor strip shall be axial. The anchor bar at the anchor head should be fitted to a tolerance of ± 5 mm concentrically with the tendon, which in turn, should not suffer an angular deviation in excess of $\pm 3^\circ$ from the axial position.

(c) Grouting

All earth/rock anchors shall be grouted. Placing and grouting of anchors shall commence only after the approval of Project Manager.

Prior to grouting the grout mix shall be mixed for a minimum time of 3 minutes. The grout body shall be produced with cement grout in accordance with DIN EN 447. The grout shall be used as soon as possible after thoroughly mixing all ingredients. The grouting shall comply with DIN 4125.

The rock must be compact so that a perfection fabrication of the grout body will be assured. Checking will be necessary by special investigation (Lugeon test). The injection for the production of the grout body must always be carried out from the deepest point of the grout body, the venting from highest point. The grouting shall not be stopped until cement grout will emerge through the vent tube without any bubbles. In case of downwardly inclined anchors, the vent tube may be dispensed with, if borehole is filled from the bottom until cement grout will escape at the top.

In each individual case the mortar formula, grouting pressure and grouting operation shall be established by the Project Manager. The amount of cement grout needed for one anchor, its composition and the grouting pressure shall be measured and recorded.

In case of cased borehole, the pipes shall be drawn slowly and step by step after filling the sheathing with cement grout while maintaining grouting pressure. The grouting of anchor shall be carried out in two stages. The first stage of grouting (primary grout) shall be done under high but controlled pressure in fixed anchor length zone so as to make a bulb of strengthened ground at the end. It shall continue to 1 to 2 m in free anchorage zone to ensure no plane of weakness at the end of fixed anchor length. A second stage grouting (secondary grout) shall be carried out after curing; anchor testing and final stressing of the tendon is completed. The secondary grout shall be done in free anchorage zone under nominal grout pressure. However each injection in every stage of grouting shall be a continuous operation. The pressure of grouting shall be such that the operation does not cause damage to the adjacent anchors, structures and services. In general the grout pressure shall be done at 0.2 N/mm² per meter of overburden. The injector pipes shall be taken out gradually during grouting process ensuring that the end point shall at all times remain immersed with minimum 1 m in the grout mass. The check list given below shall be referred during grouting.

Check List of data required for anchor grouting

- Type of cement
- Age of cement
- Water/cement ratio
- Concentration and type of additive (if any)
- Mixing equipment used
- Mixing time
- Size of grout pipe and its length
- Upward or downward sloping anchor hole
- Grouting pressure used in each stage
- Grout quantity injection in each stage
- Test specimen taken
- Test results
- Ground water quality test (if any)
- Method of primary grouting
- Method of secondary grouting
- Time interval between completion of anchor hole drilling and start of grout injection
- pH value
- Bleed characteristics of the grout
- Grout fluidity

Backfill behind the anchored structure shall be made after completion of the anchor system so that they may develop stress due to movement of the structures during backfill compaction.

(4) Pullout Testing of Test Anchors

Prior to establishing anchors, test anchor shall be made in equivalent/similar soil/rock conditions through which the anchors are to be placed with the length similar to the anchors intended to be executed.

Load testing or pull out testing shall be done by accepted method for checking the strength of anchors. The stress-strain characteristic of steel is time and stress dependent. The stress level in the steel shall be checked for its capacity to cover the service conditions expected at site within the permissible limits of design. Irrespective of the method of stressing used, one of the objectives of testing is to provide a load extension

relationship to enable the adequacy of the anchor to be assessed and to this end two main parameters have to be measured (i.e. load and extension).

The method of anchor stressing shall be normally by direct pull from a hydraulic jack, connected to hydraulic pump and pump pressure gauge. Load is derived via calibrations charts from the oil pressure in the jacking system. Care shall be necessary to ensure proper and frequent calibration of the pressure gauges and they meet, various design standards (B.S. 1780). As-measured extensions shall be carefully considered for a gross-extension before lock-off, for occurrence of pull-in of the wedges until the system is tight and in equilibrium, for movements due to bedding down of anchor blocks, for deflection of anchor bearing plate, for local deflection of structure and for some debonding and permanent displacement of the anchor as well as the elastic stretch of the loaded tendon etc. Tables 19.2 and 19.3 show recommended load increments for pull out tests and minimum number of test anchors for a given anchor system and ground type respectively.

Table 19.2: Recommended Load Increments and Periods of Observation for

Pullout Tests (Little John, 1981)

Test Anchors		Period of Observation (minutes)
Load Increment (% TW*)		
1 st Load Cycle**	2 nd & 3 rd Load Cycles	
20	20	5
50	50	5
	75	5
100	100	5
	125	5
150	150	15
100	100	5
50	50	5
20	20	5

* TW = working load

** For this load cycle there is no pause other than that necessary for the recording of extension data

Table 19.3: Minimum Number of Test Anchors for a given Anchor Type and

Ground Type according to Bureau Securities (1972)

Number of Production Anchors in any Soil or Soil Category (n)	Number of Anchor Tests (N)
1-200	2
201-500	3
501- 1000	4
1001-2000	5

If the anchor fails at a lower force, another test anchor shall be established and the bonding length increased as instructed by the Project Manager.

(5) Tests and Standard of Acceptance

The Contractor shall submit manufacturer's test certificate for each lot of anchor bars. The test certificate results shall meet the specified criteria. The Project Manager may ask for testing the bars in independent laboratories and the test results shall meet the specified requirements.

Six sets of test cylinder of grout shall be taken from at least one representative batch of grout each day the grouting is carried out and the results shall meet the requirements shown on the Drawing.

Ten percent of the anchors shall be tested in the field to the specified design load. The sequence of testing shall be decided by the Project Manager. The test shall meet the specified criteria.

(6) Measurement

The ground anchor work and grouting shall be measured per running meter of anchor inside the ground and accepted. The exposed dowels/anchors, steel bearing plates, bolts, anchor heads and other accessories, if any, and provision for drilling shall not be measured separately.

The Lugeon test and pull out test of test anchors shall be measured in number.

(7) Payment

The ground anchor work, grouting, Lugeon test and pull out test of test anchors shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

1905. SHOTCRETE/GUNITING

1. Scope

Shotcreting is proposed (under direction of the Project Manager) for a number of different applications;

Protection of fragmented rock faces (with or without steel mesh and anchors).
Use in half tunneling or soil nail facings.

For applications (a) and (b) the necessary shotcrete thickness is expected to be comparatively less of the order of 15-25 mm.

With varying shotcrete thickness and applications (including access and height variations), the payment quantity is therefore based on cubic metres of shotcrete actually applied in accordance with the following provisions.

2. Materials

Shotcrete

Shotcrete is a mixture of cement, sand and Water. It shall comprise 100 parts by weight of cement, 300 parts by weight quartz sand, 35-50 parts by weight Water and 2 parts by weight approved quick setting compound. In general, dry mix shotcrete shall be used, however, wet-mix will also be permitted with the approval of the Project Manager (based upon satisfactory trials).

Cement

Ordinary Portland cement conforming to IS: 269 shall be used.

Sand

Sand for shotcreting shall comply with the requirements stipulated in IS: 383. In general, sand should neither be too coarse to increase the rebound nor too fine to increase the slump. Sand should preferably have moisture content between 3 to 6 per cent.

The grading of sand shall lie within the limits given below:

Table 19.4: Grading limits of sand for shotcrete

IS Sieve Designation	per cent Passing the sieve
4.75 mm	95 - 100
2.36 nun	65 - 90
1.18 min	45 - 75
600 microns	30 - 50
300 microns	10 - 22
150 microns	2 - 8

For thick sections it may be advantageous to incorporate coarse aggregate in the mix provided adequate guniting equipment is available. Coarse aggregate, when used, shall conform to grading given in Table I of IS: 9012. The percentage of coarse aggregate may normally be kept as 20 to 40 per cent of the total aggregate and the mix shall be suitably designed.

Water–Cement and Strength

Water/cement ratio for shotcreting shall fall within the range 0.35 to 0.50 by mass, wet enough to reduce the rebound. Drying shrinkage may be between 0.06 per cent to 0.10 per cent. The quick setting compound shall be added at the nozzle with Water just before shotcreting.

The minimum strength of shotcrete shall be 25 MPa at 28 days.

4. Workmanship

Only suitably experienced and skilled operators shall be permitted to undertake shotcrete work Where the Project Manager deems that sub-standard workmanship, excessive rebound excessive variation in thickness and/or strength outside specification is occurring, the nozzle operator shall be replaced.

For dry mix concrete, the cement and sand shall be batched and mixed and conveyed through a hosepipe with the help of compressed air. A separate line shall bring the Water under pressure. The cement, sand and Water mix shall be passed through and intimately mixed in a special manifold and then projected at high velocity to the surface being repaired. The density of gunite shall not be less than 2000 kg/cum. The strength of shotcrete shall not be less than 25 MPa. For effective shotcreting, the nozzle shall be kept 60 to 150~cm away from the surface, preferably normal to that surface. While enclosing reinforcement bars or mesh the nozzle shall be held closer at a slight angle and the mix shall be wetter than the normal.

Test panels simulating actual field conditions shall be fabricated for conducting preconstruction testing. The procedure for testing the cubes or cylinders taken from the panels stipulated in clause 6 of IS: 9012 shall be followed.

It should be ensured from tests that a strength of about 25 MPa at 28 days is available for the mortar/concrete mix.

In the case of existing walls, removal of vegetation is paid separately. Before commencing shotcrete operations, loose materials shall be removed and the surface cleaned and lightly damped.

Where shotcreting of mesh or reinforcement is undertaken, sufficient clearance shall be provided around the reinforcement to permit encasement with sound gunite. Care shall be taken to avoid sand pockets behind the reinforcement.

A thickness of 25 to 40 mm of shotcrete can normally be deposited in one operation. If, for some reason, the total thickness is to be built up in successive operations, the previous layer should be allowed to set but not become hard before the application of the subsequent layer. It would always be necessary to apply shotcreting on a lightly damp surface.

The stipulations given in IS: 9012 regarding application gunite should be followed so as to keep the rebound to the minimum. The quality of guniting and workmanship shall be such that the **percentage** of rebound mentioned in IS: 9012 can be adhered to. In no circumstances shall the rebound material be re used in the work.

Green gunite shall be moistened (cured) for at least 7 days. Guniting work shall not be done during windy or rainy conditions.

1. Measurement

Measurement shall be made on the basis of volume of wet shotcrete applied. For standard and approved shotcrete mix, this shall be correlated to number of cement bags used.

At the end of each working day, the Contractor shall certify the volume used and verify by presentation to the Project Manager/Engineer Representative the total of cement bags used.

2. Payment

Payment shall be made on the basis of volume in cubic metres of shotcrete applied of exposed rock faces including half tunneling, quarter tunneling in fractured and weak areas as directed by the Project Manager.

The rate shall be inclusive of all setting up and trial, moist curing costs, surface preparation and path and access requirements.

1906. CRIB WALLS

(1) Scope

This Clause covers the construction of crib walls at locations shown on the Drawing or as instructed by the Project Manager. Crib walls shall be constructed of reinforced concrete or timber as shown on the Drawing and filled with compacted backfill material. The height of wooden crib walls shall not exceed 5 m.

(2) Materials

- (a) Reinforced concrete for headers and stretchers shall comply with the requirements of Section 1700.
- (b) Timber for headers and stretchers shall comply with the requirements of IS: 883. They shall be treated or untreated, sawn or log as shown on the Drawing or described in the contract. Timber shall be straight and free from twist, sapwood, shakes, dead and loose knots, worm holes, other holes,

signs of decay and other defects. The logs shall be of hard wood, durable species with barks removed. The wall shall be constructed with timber sections or diameter of 100 to 150 mm for light and 250 to 300 mm for heavy crib walls.

- (c) Drift pins shall be steel bars of a diameter as shown on the Drawing and shall comply with the requirements of IS: 1786 –1985. The length of drift pin shall be equivalent to the combined thickness of three times the depth of one member plus 100 mm or as shown in drawing.
- (d) Backfill material shall be of such character that it will not sift or flow through the openings in the wall, shall be free from clay and other deleterious fines, and shall conform to the requirements set out in Table 19.5.

Table 19.5: Grading and Compaction Requirement of Backfill Material

Combined height of wall and surcharge (vertical from heel of wall to top of Surcharge)	Sieve size (mm)	Percentage passing by weight	Compaction requirement
0 to 3 m	75	100	Min. 93% of MDD in accordance with IS: 2720 Part 8
3 to 8 m	75 4.75	100 35 – 100	- do -
Over 8 m	75 4.75 0.300 0.075	100 25 – 70 5 – 20 0 – 5	- do -

(3) Construction

(a) Reinforced Concrete Crib Walls

Walls founded on embankment material shall have a minimum depth of 1.5m below the base of the wall which is compacted to a minimum of 93% of MDD (IS 2720, Part 8). If the foundation pressure exceeds 0.27 N/sq.mm; the embankment material shall comply with the grading in Table 18.3 compacted to 93% (minimum) of MDD. When walls are founded on original ground it shall have a bearing value adequate to withstand the foundation pressure of the wall but shall not be less than 0.2 N/sq.mm. If the original ground is unsuitable, it shall be removed and replaced to a sufficient depth as approved by the Project Manager, by material complying with the grading requirements of Table 18.3 compacted to 93% (minimum) of MDD. The foundation stretchers shall be laid true to line, level and slope on a 100 mm thick loose layer of material complying with Table 18.3. The laying of headers stretchers and blocking pieces shall then proceed. Backfilling to the crib wall shall be carried out in lifts not exceeding 150 mm and compacted to the compaction indicated in Table 18.3. The gap between bearing surfaces of headers, stretchers and blocking pieces shall in no place exceed 3 mm. Where the gap is between 1.5mm and 3mm asbestos sheet packing shall be placed between the bearing surfaces. In the case of walls whose height exceeds 10m, asbestos sheet packing shall be placed between all bearing surfaces below the 10m level.

(b) Timber Crib Walls

The requirements in respect of the depths and bearing values of the ground on which the wall is to be founded shall be as for reinforced concrete crib walls. The foundation stretchers shall be laid true to line, level and slope on a 100 mm thick loose layer of material complying with Table 18.3. Headers and stretchers shall be secured with drift pins as shown on the Drawing with a minimum of 4 per joint. Holes for drift pins shall be bored with a bit of the same size as the pin. All holes that are bored in treated timber shall be swabbed with two coats of creosote. Step each layer into the slope, so that the face of the wall is at an angle of 45 to 60 degrees from

horizontal. Back filling shall not commence until all drift pins for the portion of crib to be filled have been driven. Backfill material shall be placed in lifts not exceeding 150 mm and compacted to the required density or as directed by Project Manager,. Backfill above the wall with additional suitable material trimmed to slope. Carry out bioengineering works in the front and at the top.

(4) Tests and Standards of Acceptance

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Project Manager,.

The work shall conform to these Specifications and shall be to the true lines, levels and dimensions as indicated on the Drawing with no bulges or sags. The lines of stretchers and headers shall have a uniform appearance.

Frequency of testing for concrete shall be as specified in Section 1700. Backfill material shall be tested for gradation for each change in source of material, subject to a minimum of one test for every 250 m³ of material or part thereof. Minimum three tests of in-situ density test shall be carried out in each layer of backfill. All the test results shall meet the specified criteria.

(5) Measurement

Crib walls shall be measured in square meter for each type of headers and stretchers placed in their final position and accepted. No separate measurement shall be carried out for excavation and backfilling.

(6) Payment

Each type of headers and stretchers measured as provided above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as set out in Clause 114 to complete the work as per these Specifications. The rate shall also include for excavation and backfilling as required for the construction of crib walls.

1907. SLOPE STABILISATION AND SURFACE EROSION PROTECTION

(1) Scope

This Clause covers the works related to the furnishing of materials and construction of slope stabilising measures in dry stone pitching, grouted stone pitching, gabion, masonry walling, rock dowels and rock anchors/bolts and wire netting on slopes as shown on the Drawing or as instructed by the Project Manager,.

(2) Excavation of Soil and Rock

Excavation of soil for landslide stabilisation and slope protection shall include excavation and removal of existing landslide debris, streambed debris, the trimming of scarp faces and gully sides and excavation required to construct gabion and masonry walls or other structures, in accordance with the lines, levels, grades and dimension as shown on the Drawing or as directed by the Project Manager,. Excavation may be undertaken either by machine or by labour or in combination of the both. However, during any excavation work care must be taken to ensure that the excavation does not endanger the stability of adjacent slopes. In some locations the Project Manager may direct the Contractor to use labour only during excavation, or issue other directions as to the method of excavation.

The cutting of access tracks to enable machines to reach otherwise inaccessible areas shall not be allowed during slope stabilisation works. However, access tracks may be constructed only with the specific approval of the Project Manager where no benching into the hillside is necessary.

Excavation and removal of rock for landslide stabilisation and slope protection shall include removal of individual rock blocks from a rock face, removal of potentially unstable rock masses or isolated individual boulders. Excavation and removal of rock may be undertaken by pneumatic tools, hand tools or other approved methods.

The slopes of cuttings shall be shaped or terraced in accordance with the Drawing and as required by the Project Manager.

(3) Fill Areas

During slope stabilisation work, small areas of fill may be required, such as to infill gullies. Fill material for such purposes shall consist of suitable material as defined in Clause 702 and shall be deposited and compacted by approved plant as defined in Clause 710, in accordance with the lines, levels and grades shown on the Drawing and as directed by the Project Manager.

(4) Dry Stone Pitching

(a) Materials

Stone used for pitching shall be from a quarry or arising from the excavation and be angular in shape. If river boulders are used they shall be broken into angular pieces. The stone shall be sound, hard, and free from cracks or other defects. Not less than 80% of the stones, except those used for chinking shall have individual volumes of not less than 0.01 cubic metres. Waste concrete may be used provided it is sound and meets the size requirements of the stone. The stones, when immersed in water for 24 hours, shall not absorb water by more than 5 percent of their dry weight when tested in accordance with IS: 1124.

(b) Construction

Construction shall comply with Sub-clause 1907 (5).

(c) Tests and Standard of Acceptance

Tests and Standard of Acceptance shall comply with Sub-clause 1907 (5) while the size of the stone which shall comply as per Sub-clause 1904 (4) (a).

(5) Grouted Stone Pitching

(a) Materials

The materials shall comply with Clause 1410 in Section 1400 of the Technical Specifications.

(b) Construction

Method of laying and thickness shall be as for dry stone pitching specified in Sub-clause 1807 (5). After the stones have been laid on the entire slope, all spaces between them shall be filled with clean rock fragments, crushed rock or gravel. More than 15% of the fill materials shall not pass 20 mm sieve. The material shall be carefully hand tamped into place.

Prior to the application of grout the surfaces of the stones shall be thoroughly cleaned of adhering dust and then moistened. The interstices between the stones shall be completely filled with grout throughout the entire

thickness of the stone pitching. Grouting operations shall progress from the bottom of the slope toward the top. Grout shall be placed in a continuous operation for any day's run at any location.

After the grout has been placed, the stones shall be thoroughly brushed so that their top surfaces are exposed. The grouted pitching shall be cured for a period of not less than four days after grouting. Curing shall be done with wet sacking or other approved cover, and shall not be subjected to loading until adequate strength has developed. Where required, or instructed by the Project Manager, weep holes shall be provided in the pitching.

(c) Tests and Standard of Acceptance

Stones shall be tested in accordance with these Specifications and shall meet the prescribed criteria. One set of test (3 tests in a set) shall be carried out for every change in source of materials.

The finished surface of the grouted pitching shall present an even, tight and neat appearance with no stones surface varying by more than 25 mm from the specified surface grades and lines. The average thickness of the pitching, measured at right angles to the surface, shall not be less than the specified average thickness.

(6) Wire Mattress

The materials used shall comply with Clause 1602 in Section 1600 of the Technical Specifications. The mattresses shall be assembled and filled in the same manner as for gabions. Ties and anchorages shall be provided as shown on the Drawing.

(7) Wire Netting

Where required by the Project Manager or shown on the Drawing, slopes shall be covered with wire mesh to prevent small scale reeling and erosion. The wire mesh shall conform to the requirements specified in Clause 1602 in Section 1600 of the technical Specifications.

(8) Masonry/Concrete/Reinforced Concrete Walling

Walls of the specified type(s) shall be constructed in accordance with the Drawing and as directed by the Project Manager to act as retaining structures, as revetment structures or as buttresses.

Materials for masonry walling shall comply with Clause 1402, and construction with Clause 1403. Mortared masonry shall be coursed and comply with Clause 1407. Dry masonry shall comply with Clause 1308. Composite masonry shall comply with Clause 1409.

Materials for concrete/reinforced concrete walling shall comply with Section 1700.

In areas where buttresses are to be constructed, the rockface to be supported shall be thoroughly cleared of all vegetation, and loose or spalling rock fragments prior to construction of the buttress.

(9) Rock Dowels

(a) Materials

Rock dowels shall consist of deformed high tensile steel bars complying with IS 1786. Unless otherwise specified, the dowel bars shall be not less than 20mm in diameter and shall be of 1m in length.

Grout shall consist of either cement slurry or cement-sand mortar or concrete as shown on the Drawing or as instructed by the Project Manager. Water cement ratio shall not exceed 0.45. The grout cover to the dowel shall be at least 6 mm.

Cement, sand, aggregates and water shall comply with the requirements specified in Section 1700.

(b) Construction

The location, direction and length of each hole for rock dowels shall be approved by the Project Manager. After drilling a hole, the Contractor shall clear the hole of all drill cuttings, sludge and debris and shall seal the hole to prevent ingress of foreign matter. Before the rock dowels are installed, the position, inclination, bearing, length and diameter of the drill holes shall be approved by the Project Manager.

The drill hole shall be thoroughly flushed with clean water immediately before installation of the rock dowel. Grouting procedure for rock dowels shall be as directed by the Project Manager.

The free end of the dowel bar shall be securely bolted with steel bearing plate and then covered with concrete capping of grade M30/20 to prevent corrosion.

(c) Tests and Standard of Acceptance

The Contractor shall submit manufacturer's test certificate for each lot of dowel bars. The test certificate results shall meet the specified criteria. The Project Manager may ask for testing the bars in independent laboratories and the test results shall meet the specified requirements.

Six sets of test cylinder of grout shall be taken from at least one representative batch of grout each day the grouting is carried out and the results shall meet the requirements shown on the Drawing. Unless otherwise shown on the Drawing, the minimum compressive strength of test cubes shall be as follows:

7 days - 18 N/mm²

28 days - 30 N/mm²

(10) Rock Bolts

(a) Materials

Rock bolts shall be such that it is capable of permanently sustaining the specified working load as shown on the Drawing.

Grout shall be cement slurry mix. The grout shall have a water/cement ratio not exceeding 0.45. The use of admixtures shall be subject to the Project Manager's approval. Cement and water shall meet the requirements specified in Section 1700.

(b) Construction

Method of installation, rock bolt system, full detail of rock bolt, bearing plate, washer and nut, fixed length, grease and sheathing, bearing rod construction, material and curing period, grout of resin details including additives, bleed pipes, stressing and capping details shall be as specified in the design Drawing or as instructed by the Project Manager.

The holes for the bolts shall be drilled true to the line to the required depth for any particular bolt. The depth of the hole shall be such that the installed bolt is located 150mm from the extremity of the hole. The diameter of the drill hole shall be sufficient to ensure a minimum 10mm annulus of grout or resin and also permit free entry of the bolt together with any required protection. Immediately prior to insertion of the rockbolt, the hole shall be cleaned and blown free of dust. In the event of the drilling encountering any material other than solid rock, this shall be recorded and reported to the Project Manager without delay.

A detailed record of the grouting of each drill hole including the date performed and the identification marks of associated test cubes shall be maintained.

(c) Tests and Standard of Acceptance

Copies of the manufacturer's certificates for the steel bolts to be supplied shall be furnished by the Contractor. The test results shown in the certificate shall meet the specified criteria. In addition, the Project Manager may ask for testing in independent laboratories. All test results shall meet the specified requirements.

Six sets of test cylinder of grout shall be taken from at least one representative batch of grout each day the grouting is carried out and the results shall meet the requirements specified in Sub-Clause 1904 (9).

(11) Measurement

- (a) Excavation for structures, common backfill/previous backfill/filter materials, gabion mattresses, masonry/concrete/reinforced concrete walling and wire netting shall be measured as provided under respective Sections of these Specifications.
- (b) Dry stone pitching and grouted stone pitching shall be measured in cubic meters.
- (c) Rock dowels shall be measured in running meter placed inside the ground and accepted. The exposed dowels, steel bearing plates, bolts, and other accessories, if any, shall not be measured separately unless otherwise specified in the Bill of quantities and drawings.
- (d) Rock bolts shall be measured in numbers as placed and accepted. Bearing plates, washers, nuts, and other accessories shall not be measured separately.

(12) Payment

- (a) The quantity of excavation for structures, common backfill/previous backfill/filter materials, gabion mattresses, masonry/concrete/reinforced concrete walling and wire netting shall be paid as provided under respective Clauses of these Specifications.
- (b) The quantities of dry stone pitching, grouted stone pitching, rock dowels, rock/earth anchors and rock bolts shall be paid as per the respective contract unit rates. The contract unit rate shall be the full and the final payment to the Contractor as per Clause 114 to complete the works as per these Specifications.

1908. SUB-SURFACE DRAINS

(1) Scope

This Clause shall cover the works related to the construction of sub-surface drainage networks in slopes, slides and under road pavement. The drains shall be either main or tributary or of other types as shown on the Drawing or as directed by the Project Manager.

Sub-surface drains shall consist of perforated HDP pipes surrounded by granular material laid in a trench. If specified in the contract, sub-surface drains shall also consist of perforated HDP (high density polyethylene pipes) surrounded by geotextile/geomembrane and granular material laid in a trench.

(2) Materials

The materials used for construction of sub-surface drains shall comply with following requirements:

(a) Stone

Stones used for filling and lining of sub-surface drains shall comply with the specifications for dry stone pitching given in Sub-clause 1904 (4).

(b) Cement

Cement shall be Ordinary Portland Cement complying with the requirements of Section 1700.

(c) Mortar

The mortar used for cement masonry lining shall be as specified in Sub-clause 1904 (5).

(d) Gabion Works

Gabion works shall comply with the requirements specified in Section 1600.

(e) Filter Material

Filter materials used in drains shall comply with the requirements specified in Sub-Clause 708 (1)(a) in Section 700.

(f) Geomembrane

Geomembrane shall be made of PVC or polythene 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 a minimum of 3 m width. The joints of these sheets shall be heatbonded or seamed for effective permeation cut off. While fixing on to a slope, they shall not be punctured or stapled to impair their use.

(g) Geotextile

Geotextiles used for lining of drain trenches shall be as per the requirements of Section 200. The type of geotextile to be used for drains shall be approved by the Project Manager prior to starting the works.

(h) Drain Pipe

Drain pipes shall be made of high density polyethylene, high pressure as approved by the Project Manager. Jointing of pipes shall be done by fine-cutting and heating with equipment complying with the prescription of the HDP pipe manufacturer. Pipes may be jointed with angles to fit the requirements of the terrain, but angles shall not exceed the maximum specified by the manufacturer. The joints shall be watertight and develop the same strength as unjointed HDP material. The method of jointing shall be approved by the Project Manager prior to starting the works. Drain pipes shall be provided with holes of minimum 5 mm diameter. The pipes shall be perforated by drilling minimum 50 holes per meter length on the upper half of the pipe in a staggered pattern uniformly distributed. The Project Manager might adjust these specifications according to the site conditions.

(4) Construction

The detailed layout of the drainage network shall be as instructed by the Project Manager, based on the general layout given in the Drawing.

The work shall start with construction at road side and then go up the slope by using already constructed drains as buttress for new drains.

The main drains shall be placed in naturally existing depressions. The tributary drains shall be at a maximum inclination of 45° to the main drain.

(a) Sub-surface Drains without Geotextile/Geomembrane

Trench for sub-surface drain shall be excavated to the specified lines, grades and dimensions shown on the Drawing. Following considerations shall be made while excavating the drain and dumping excess materials.

- (i) Depth of excavation shall be according to Drawing.
- (ii) Top of structure shall be lower than natural ground.
- (iii) No blasting shall be done in slides.

Wherever required or instructed by the Project Manager, the Contractor shall provide trench struts and shoring as per approved design and shall execute in a manner to resist the earth pressure and in order to protect labour and work.

Where unsuitable material is encountered at the bed of trench, the same shall be removed to such depth as instructed by the Project Manager and backfilled with approved material shall be compacted as specified in Clause 608(a).

Laying of pipe in the trench shall be started at the outlet end and proceed towards the upper end, true to the lines and grades specified. Before placing the pipe, filter material shall be laid for the full width of the trench bed and compacted. Unless otherwise shown on the Drawing, the thickness of this layer shall be 150 mm.

After the pipe installation has been completed and approved filter/pervious material shall be placed over the pipe to the required level in horizontal layers not exceeding 150 mm and thoroughly compacted to 93% of the MDD (heavy compaction).

Pitching shall be done as per Clause 1903. The finished slope shall be reshaped to facilitate proper surface drainage towards drains.

(b) Sub-surface Drains with Geotextile/Geomembrane

Excavation and backfilling shall be carried in the same manner as described above in (a). After excavating the trench for sub-surface drain, the filter fabric shall be placed and then the pipe shall be installed in the position as shown on the Drawing. Surfaces receiving filter fabric shall be free of loose or extraneous material and sharp objects. Adjacent rolls of the fabric shall be overlapped to a minimum width 450 mm. The preceding roll shall overlap the following roll in the direction the material is being spread.

After the installation of pipe, the trench shall be backfilled with the filter material in the same manner as described above in (a).

(5) Tests and Standard of Acceptance

Copies of the manufacturer's certificates for geotextile/geomembrane and drain pipe to be used shall be furnished by the Contractor. In addition, the Project Manager may ask for testing in independent laboratories. All test results shall meet the specified requirements.

Minimum one set of test for gradation analysis and compaction of filter material shall be checked for every 50 cu.m. and/or every change in source of material. The results shall meet specified requirements.

(6) Measurement

Sub-surface drain with/without geotextile/geomembrane shall be measured in running meter which shall be inclusive of earth excavation, backfill/filter, geotextile/geomembrane. Drain pipe shall be measured in running meters separately.

Pitching shall be measure as provided under respective clauses of these Specifications.

(7) Payment

Sub-surface drains with/without geotextiles/geomembranes, drain pipe and pitching shall be paid at the respective contract unit rates. The contract unit rates shall be the full and the final compensation to the Contractor as per Clause 114 to complete the works as per these Specifications.

1909. HORIZONTAL SUB-SURFACE DRAIN

(1) Scope

This Clause covers the works related to the construction of horizontal sub-surface drains in slopes and slides. The horizontal sub-surface drains shall consist of HDP drainpipes covered by geotextile and placed into drilled holes.

(2) Materials

The drainage pipes for horizontal drains shall be High Density Polythene (HDP), high pressure capacity – pipes diameter 76 mm and a minimum thickness of 3 mm unless otherwise specified on Drawings or by the Project Manager.

The pipes shall be perforated by drilling minimum 50 holes per metre length on the upper half of the pipe in a staggered pattern uniformly distributed with a diameter of 3mm (minimum) to 6mm (maximum). Perforation of pipes might be adjusted according to soil conditions as approved by the Project Manager.

The drain pipes shall be covered by a geotextile having following specifications.

- Permeability greater than 0.01 cm/s
- Pore width between 0.09 mm and 0.15mm
- Strength greater conditions encountered.

(3) Construction

Drilling of borehole minimum diameter 110 mm shall be carried out by the Contractor to the depth as shown in Drawing or directed by the Project Manager. The drill hole slope shall be 3 to 7 degrees upward or as directed by the Project Manager. The drain pipes shall be covered by a geotextile.

The length of drains shall be decided by the Project Manager based on hydro-geologist conditions encountered.

The pipes shall be secured in drill holes properly and rigidly in such a way that it prevents tampering and pulling out of the drilled/bored hole.

(4) Tests and Standard of Acceptance

The Contractor shall submit a sample of geotextile and HDP pipe along with manufacturer's certificate for the approval of the Project Manager. It shall be ensured that the geotextile and the pipe meet the specified criteria.

(5) Measurement

The horizontal sub-surface drain shall be measured in running meter. No separate measurement shall be done for drilling and geotextile.

(6) Payment

The horizontal drain shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

1910. SCOUR PROTECTION AND RIVER TRAINING WORKS

(1) Scope

This Section covers the works related to the construction of scour protection and river training works. These works shall include all operations necessary for construction of appropriate structures adjacent to culverts, piers and abutments, at outfalls of drainage, along the road side and elsewhere, where protection is required for ensuring safety of structures against damage by flood/flow of water.

(2) Materials

Stones/rocks used in this section of the specifications shall be hard, dense, unlaminated natural stone, not liable to deterioration in water and of general quality of soundness and abrasion resistance prescribed for concrete aggregates. Broken rocks shall be of regular "cubical" shape and shall not be flaky. Flat or needle shaped rocks shall not be accepted unless the thickness of the individual piece exceeds 1/3 of their length. The specific gravity of the stone/rock shall be not less than 2.50 and when immersed in water for 24 hours, it shall not absorb water more than 5 percent of its dry weight tested in accordance with IS:1124. Unless otherwise specified the minimum size/weight of the stone/rock shall be as specified below:

(a) For Rip Rap in River-Bed and Foundation Protection

At least two thirds of the total weights of the stone/rock used shall be heavier than 75 kg.

(b) For Plum Concrete

The size of the stone/rock shall not be larger than 200mm measured in any direction. The concrete to be used in plum concrete shall be as specified in Section 1700.

(c) Dry Stone Pitching/Revetment on Slopes

The size and weight of individual stone shall conform to Clause 5.5.5.1 of IRC: 89. However in no case weight shall be less than 40 kg except for spalls. The total volume of spalls including voids shall not be more than twenty percent of the total volume of the pitching.

All materials to be used shall be subject to approval of the Project Manager.

(3) Rip Rap

(a) Construction

The surface for rip rap shall be prepared to the line and level as indicated in the Drawing or as directed by the Project Manager. To achieve this necessary excavation, filling with compaction and/or leveling shall be done as per site condition. On the prepared surface stone/rocks shall be placed individually to provide minimum

space among the stones. On inclined surface the stones shall be laid in long length from bottom and not in strips in the slope. Needle like shapes and protrusions on the surfaces of stones shall be chipped off by hammer so that stones are bedded properly and voids are reduced. To avoid sliding of stones/rocks downwards, the placing of stones shall be started from the lower edge to proceed towards upper edge. By driving small stones or spalls into interstices, laid stones shall be tightly wedged so that individual stone shall not be removed easily. The top surface, the lines, levels and depth of rip rap and grade shall be as indicated on the drawing or directed by the Project Manager.

(b) Tests and Standards of Acceptance

Stone shall be tested for water absorption and specific gravity. The test results shall meet the specified criteria. At least 3 set of tests shall be made for every source of material.

(4) Plum Concrete

The plum concrete work shall be as per Clause 1618 in Section 1700 of the Technical Specifications.

(5) Pitching/Revetment on Slopes

(a) Dry Stone Pitching

(i) Construction Operations

The pitching shall be provided as indicated on the drawings. The thickness and the shape of stone pitching shall be as shown on the Drawing.

Before laying the pitching, the sides of banks or surface of the slope shall be trimmed to the required slope and profiles and shall be put up by means of line and pegs at intervals of 3 metres to ensure regular straight work and a uniform slope throughout. Depressions shall be filled and thoroughly compacted.

Where required the filter/granular material shall be laid over the prepared surface starting from bottom and compacted to the thickness specified on the drawing. If not specified, the minimum compaction to be achieved shall be 93% of the MDD (heavy compaction).

The lowest course of pitching shall be started from the toe wall and built up in courses upwards.

Stone shall be placed to the required length, thickness and depth conforming to the Drawing. Stones shall be set normal to the slope, and placed so that the largest dimension is perpendicular to the face of the slope, unless such dimension is greater than the specified thickness of pitching. The pattern of laying shall be such that the joints are broken. The spalls shall be used for tight packing and reduction of voids, which shall not exceed fifteen percent of the total volume of pitching. The top surface of the pitching shall be smooth.

When full depth of pitching can be formed with a single stone, the stones shall be laid breaking joints and all interstices shall be filled in with spalls of the proper size and wedged in with hammers to ensure tight packing.

When two or more layers of stones must be laid to obtain the design thickness of pitching, construction method of dry masonry shall be used and stones shall be well bonded. To ensure regular and orderly disposition of the full intended quantity of stone as shown, template cross walls in dry masonry shall be built about a metre wide and to the full height of the specified thickness at suitable intervals and all along the length and width of the pitching. The stones shall be packed as specified within these walls.

(ii) Tests and Standards of Acceptance

Stones shall be tested for water absorption and shall meet the specified criteria. One set of test (3 tests in a set) shall be carried out for every change in source of material and shall meet the specified criteria.

The finished surface of pitching shall present an even, tight and neat appearance with no stones varying by more than 25mm from the specified surface lines and levels. The thickness of pitching, measured at right angle to the surface, shall not be less than the specified thickness.

(b) Grouted Stone Pitching

Grouted stone pitching shall comply with Sub-clause 1904 (5) and shall be measured as per Sub-clause 1904 (11) and shall be paid Sub-clause 1904 (12).

(c) Gabion Pitching

(i) Construction

The surface on which the gabions are to be laid shall be trimmed to true lines level and grade as described above in Sub-clause 1907(5)(a). On the prepared surface, gabions shall be laid as specified in Section 1600.

(ii) Tests and Standard of Acceptance

The Contractor shall produce manufacturers test certificate of the gabion wires which the Contractor proposes to use. Gabion wires shall be tested as per the provisions of Section 1600. The test result shall meet the specified requirements.

(6) Measurement

(a) Leveling, Filling with Compaction, Trimming and/or Earth Excavation

Leveling, filling with compaction, trimming requiring earth excavation or filling not exceeding 150mm in depth shall be measured in sq.m, whereas excavation or filling exceeding 150mm in depth shall be measured in cu.m. Both types of measurements shall not be allowed at the same place. For computation of quantities initial and final ground levels not exceeding at 5 M in both directions in plan and plan of the area to be covered shall be recorded by joint survey i.e. by the contractor and the Project Manager jointly. Quantities shall be computed based on these levels using standard methods of measurement. Levelling, filling trimming and/or earth excavation other than indicated on the Drawing or instructed by the Project Manager shall not be measured.

(b) Rip Rap

Rip rap shall be measured in cubic meter.

(c) Plum Concrete

Plum concrete shall be measured in cu.m. Form work shall be measured in sq.m separately. Struts, bracing supports etc. shall not be measured separately. They are deemed to be included in the measurement of form work.

(d) Dry Stone Pitching/Revetment on Slopes

Dry stone pitching shall be measured in cubic meter.

Gabion work shall be in cubic meters of gabion crates filled with stones and complete in place and quantity shall be calculated from the dimension of the gabions indicated in the Drawing or ordered by the Project Manager.

(7) Payment

Leveling, filling with compaction, trimming and/or earth excavation, rip-rap, plum concrete, from work, dry stone pitching, gabion boxes, gabion mattress, stone filling shall be paid as per contract unit rate of the respective item which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the works as per these Specifications.

1911. LOG AND BOULDER BARRIERS

(1) Scope

This Clause covers the materials and construction of barriers to be constructed on the valley side of the road in advance of the formation cutting. The purpose of barriers is to stop throw material from falling further down the valley side slopes. As such the barriers need to be constructed as and where possible at distances of about 5-10 m below the road edge. The barriers have no permanent retaining function and their function needs therefore to be taken over in time by bio-engineering works (e.g. deep rooting vegetation), which will have to be taken up on the slopes above the barriers. In principle two different types of barriers are taken up in the contracts- log barrier and boulder barrier.

(2) Log Barriers

Log barriers are ideal support structures in forest covered areas to withhold side carted spoil material. Log barriers consist of logs laid onto each other maximum 2 logs and will be held by placing them against two standing trees. Logs with girth minimum 300 mm shall be used and the total height shall not exceed 1.0 meter. Their inclination against the road alignment shall not exceed 20°.

Log barriers shall be built wherever useful in pairs. The first barrier shall be 5-10 m below the road edge. The same distance shall be kept between the first and second barrier. The exact position of the barrier shall depend on the actual site conditions and shall be determined by the Project Manager. The barriers must form a closed line along the road slope so that all material dipped over the road edge shall be withheld by the barriers.

The slope of spoil material shall be protected by bioengineering as per Section 2000.

(3) Boulder Barriers

In places where boulders are available a rough type of "dry wall" can be constructed by placing boulders in a row and on top of each other. Boulder barriers shall be built where possible in pairs. The first barrier shall be 5-10 m below the road edge. The same distance shall be kept if possible between the first and second barrier. The exact position of the barrier shall depend on the actual site conditions and shall be determined by the Project Manager.

The barriers must form a closed line along the road slope so that all material dipped over the road edge will be withheld by the barriers. The boulders shall be placed in such a way that larger boulders will form the first layer and smaller boulders the layer(s) above. The packing of the boulders shall be done in such a way that the barrier can withstand the pressure of the throw material.

The maximum height of the boulder barrier shall be 1.5 m. The height of barrier shall depend on the size of available boulders and the amount of throw material estimated. The inclination of the row against the road alignment shall not exceed 20°.

The slope of spoil material shall be protected by bioengineering as per Section 2000.

(4) Measurement

Each type of log and boulder barriers shall be measured in running meter.

(5) Payment

The log and boulder barriers shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

1912. BOULDER WALL

1. Scope

These wall are constructed at such locations where excavated boulders are available and where a masonry or gabion walls are likely to be damaged by the falling boulders. The boulder walls shall be constructed as per the drawing as directed by the Project Manager.

(2) Measurement

Each type of boulder wall shall be measured in running meter.

(3) Payment

The boulder wall shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

2000. BIO-ENGINEERING

2001. SCOPE

This Section covers all the component of bio-engineering works such as preparation of surface, spreading of top soil, turfing, sprigging, preparation of seeds and plant cuttings, nursery construction and operation, slope preparation for planting, site planting and sowing, jute netting, gabion wire bolsters and wire netting, site protection and maintenance.

2002. PROVISION OF SEEDS

The Contractor shall provide or collect seeds of the required species and quantities in accordance with the requirements described hereafter, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met in full. It shall be ensured that the seed is of a high quality.

The Project Manager shall give indications as to the expected amounts of seeds required and the time of availability. But it shall be the Contractor's responsibility to ensure that adequate quantities of seeds are obtained in a timely manner.

The weights to be specified shall be for sun-dried seeds separated completely from fruiting bodies and other unwanted parts, and ready for storage and subsequent sowing. There is usually large discrepancy between this weight and that of the freshly collected, untreated fruits.

Should the Contractor be unable to supply the specified seeds, the advice of the Project Manager should be sought. The Project Manager may approve other substitute species, if found appropriate. Seed shall not be obtained commercially without the Project Manager's written authority.

(1) Grass Seed Collection

- (a) The species of grass seeds to be collected shall be determined by the Project Manager. The Contractor shall be responsible for determining seed sources, though these may be specified by the Project Manager's instructions. Seeds shall be collected in or very close to the office of use or the project area as much as possible.
- (b) If the Project Manager does not specify the species, then the current approved list of bio-engineering plants, as determined by the Department of Roads shall be referred to.
- (c) Seeds shall be collected from as many individual plants as possible. Seeds shall be collected from the largest and most vigorous plants.
- (d) The Contractor shall under no circumstances damage or remove the roots of grass plants while collecting seed. The Contractor shall be responsible for safety measures and for making all necessary arrangements with landowners, farmers and the Regional Forest Office, Range Office, as applicable, before the collection of seeds.
- (e) Seeds shall only be collected when fully ripe. Seeds collected early shall not be accepted. The Contractor shall be held liable if the germination rate of seeds is lower than 70%.
- (f) Immediately after collection, seeds shall be separated from flower heads by the method normally used by farmers for other grasses. Once separated, the seeds shall be sun-dried before storage.
- (g) Seeds shall be stored in a cool, dry, ventilated building with adequate precautions taken against pests. Containers shall be raised above the floor. They shall not be kept in the same building in which materials like cement, or any chemicals, fuels or lubricants are stored. Grass shall be stored in bags made of cotton. Seeds shall be carefully inspected on a weekly basis to ensure that there is no deterioration or mould formation, or pest attack. Seeds shall only be stored after they have been properly dried in the sun beforehand.
- (h) **Measurement and Payment:** Works shall be measured on the basis of actual quantity collected, weighed in Kilogram and accepted by the Project Manager. The quantities thus measured shall be paid at the unit rates shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for making arrangements of collection location, provision of safety measures, collection of seeds, separation of seeds, preparation of seeds, sun drying, packing and providing the seeds as per these Specifications.

(2) Tree and Shrub Seed Collection

- (a) The species of tree and shrub seeds to be collected shall be determined by the Project Manager. The Contractor shall be responsible for determining seed sources, though these may be specified by the Project Manager's instructions. Seeds shall normally be collected in or very close to the working area.
- (b) If the Project Manager does not specify the species, then the current approved list of bio-engineering plants, as determined by the Department of Roads shall be referred to.
- (c) Seeds shall be collected from as many healthy individual plants as possible. In any event, they shall be collected from at least ten individual plants. The plants from which the seeds are collected shall show vigorous growth and good form. Mis-shaven and stunted plants shall be discarded.

- (d) The Contractor shall under no circumstances damage plants while collecting seed. The Contractor shall be responsible for making all necessary arrangements with and owners, farmers and the Regional Forest Office, Range Office, as applicable, before the collection of seeds.
- (e) Appropriately trained personnel with appropriate equipment shall be employed while collecting the seeds. It shall be the Contractor's responsibility to ensure safe working conditions for his employees or Sub-contractors.
- (f) Seeds shall only be collected when fully ripe. Seeds collected early shall not be accepted. The Contractor shall be held liable if the germination rate of seeds is lower than 80%.
- (g) Immediately after collection, seeds shall be separated from fruit by the method normally used by farmers and foresters for this purpose; this shall depend on the individual species. Once separated, the seeds shall be sun-dried before storage.
- (h) Seeds shall be stored in a cool, dry, ventilated building with adequate precautions taken against pests. Containers shall be raised above the floor. They shall not be kept in the same building in which materials like cement, or any chemicals, fuels or lubricants are stored. If kept in sealed containers, the seeds shall be carefully inspected on a weekly basis to ensure that there is no deterioration or mould formation or pest attack. Seeds shall only be stored after they have been properly dried in the sun beforehand.
- (i) Measurement and Payment: Works shall be measured on the basis of actual quantity collected, accepted and weighed in Kilogram. The quantities thus measured shall be paid at the unit rates shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for making arrangements of collection, provision of safety measures, collection of seeds, separation of seeds, preparation of seeds, sun drying, packing and providing the seeds as per these Specifications.

2003. PROVISION OF PLANT CUTTINGS

The species of plants to be collected for vegetative propagation shall be determined by the Project Manager. The Contractor shall be responsible for determining plant material sources, though these may be specified by the Project Manager. Plants shall normally be collected in or very close to the working area.

If the Project Manager does not specify the species, then the current approved list of bio-engineering plants, as determined by the Department of Roads shall be referred to.

(1) Provision of Grass Cuttings

- (a) Cuttings of various types shall be taken from grass species, which are known to propagate easily by vegetative means.
- (b) Cuttings shall be made from as many healthy individual plants as possible. The plants from which the cuttings are taken shall show vigorous growth and good form. Grass clumps showing stunted growth shall not be considered as sources.
- (c) Apart from the clumps, which are dug up to make cutting, the contractor shall under no circumstances damage other plants. The Contractor shall be responsible for making all necessary arrangements with landowners, farmers and the Regional Forest Office, as applicable, before the making of hardwood cuttings.
- (d) The type of cuttings to be made shall depend on the species specified in the contract. If the species is still not covered, then stem and root slip cuttings shall be used.

- (e) Where roots are required for the cuttings, grass clumps shall be carefully dug up. They shall not be pulled hard so as to damage the material. They shall be separated carefully by hand, using a sharp knife where necessary. There shall be no tearing of the plant fabric.
- (f) Stem cuttings shall be made using sharp secateurs/scissors. The top cut shall be made at right angles to the stem and the bottom cut shall be made at 45° to the stem.
- (g) Once cuttings have been made, they shall be wrapped in wet Hessian jute immediately. At all times, cuttings shall be kept moist and as cool as possible, and shall be wrapped in wet Hessian between all operations such as digging out of the ground, splitting out, trimming and planting. If the Hessian jute is not easily available, the cuttings shall be covered with the thick blanket of off-cut part of vegetation such as Khempashing/Meringma (*Artemisia spp.*) and (*Eupatorium adenophorum*). For this prior approval of the Project Manager shall be required. Under any circumstances, all cuttings shall be planted the same day that they are made.
- (h) Measurement and Payment: Measurement of grass cuttings shall be made on the basis of actual numbers of slip or cutting prepared, counted on site and accepted. The quantities thus measured shall be paid at the unit rate shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for all arrangements for uprooting of grass clumps, collection of materials for cuttings and preparation and providing the cuttings as per these Specifications.

(2) Provision of Hardwood Cuttings

- (a) Hardwood cuttings shall be taken from shrubs and trees species which are known to propagate easily by vegetative means.
- (b) Cuttings shall be made from as many healthy individual plants as possible. The plants from which the cuttings are taken shall show vigorous growth and good form. Mis-shaven and stunted plants shall not be considered as source.
- (c) Apart from the branches from which cuttings are taken, the Contractor shall under no circumstances damage plants while taking cuttings. The Contractor shall be responsible for taking safety precautions and for making all necessary arrangements with landowners, farmers and the Regional Forest Office, Range Office, as applicable, before the making of hardwood cuttings.
- (d) Hardwood cuttings shall be made from stems which are between 6 and 18 months old. Materials outside this range shall not be used. The Contractor shall be held liable if the success rate of cuttings is lower than 70%.
- (e) Hardwood cutting shall be made using sharp secateurs or a sharp saw. The top cut shall be made at right angles to the stem and the bottom cut shall be made at 45° to the stem. Under no circumstances shall there be any damage to the bark of the cutting.
- (f) Hardwood cuttings, which are to be planted in the nursery for later multiplication, shall be normally 150 to 200 mm in length and 20 to 30 mm in diameter. This size shall not be exceeded for the majority of species unless specified or approved by the Project Manager.
- (g) Hardwood cuttings which are to be used in brush layering, palisades and live stakes shall normally be 450 mm for brush layering on road embankments, 600 mm for brush layering on landslide debris, 600 mm for palisades and 20 to 40 mm in diameter. This length of cuttings shall not be exceeded for the majority of species unless specified or approved by the Project Manager.
- (h) The size of cuttings shall be of a minimum length of 1000 mm and 50 mm of diameter for fascines. All the small branches growing from the main branch shall be preserved. Those small branches contain

the first sprouting buds which will help to keep alive the main branches as they are buried in the ground.

- (i) A number of species can be propagated using large truncheon cuttings. Hardwood cuttings for these species shall be in the range of 2000 to 2500 mm in length and 50 to 80 mm in diameter unless otherwise specified.
- (j) All truncheon cuttings shall be covered with long mulch during transportation and storage. Under any circumstances, all cuttings shall be planted within two days that they are made.
- (k) **Measurement and Payment:** Measurement of hardwood cuttings shall be made on the basis of actual numbers of cutting prepared, counted on site and accepted. The quantities thus measured shall be paid at the unit rate shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for all arrangements for collection of materials and preparation of cuttings and providing the cuttings as per the Specifications.

(3) Provision of Bamboo Cuttings

- (a) Bamboo cuttings shall be propagated by two different methods i.e. traditional method and single node culm cuttings method.
- (b) Cuttings shall be made from as many healthy individual culms as possible. The culm from which the cuttings are taken shall show vigorous growth and good form having plenty of branches. Mis-shaven and stunted plants shall not be considered as source.
- (c) The Contractor shall be responsible for taking safety precautions and for making all necessary arrangements with landowners, farmers and the Regional Forest Office, Range Office, as applicable, before making of cuttings. The traditional method which will be required to take the whole culm and mother rhizome may eradicate the further development of clump. In this case, the contractor shall be responsible to make aware of such probability to the owner before taking the rhizomes from such clump. However, if the sourcing clumps are growing on steep slopes, the contractor shall not take more than 10% culm from the sourcing clump.
- (d) Single node culm cuttings or traditional rhizome cuttings shall be made from the culm, which are between 2-3 years old. Materials outside this range shall not be used without the prior approval of the Project Manager. The Contractor shall be held liable if the success rate of single node culm cuttings is lower than 60% and in the case of rhizome cuttings not surviving 100%.
- (e) Single node cuttings shall be made using sharp log saw. The top and bottom cut shall be made at right angles to the stem. Under no circumstances shall there be any damage to the bud and internodes section of culm.
- (f) The rhizome cuttings shall be made using sharp log saw, axe and secateurs.
- (g) Once cuttings have been made, they shall be wrapped in wet Hessian jute immediately. At all times, cuttings shall be kept moist and as cool as possible, and shall be wrapped in wet Hessian between all operations such as taking from the parent plant, transporting and planting. Under any circumstances, all cuttings must be planted within two days of that they are made.
- (h) **Measurement and Payment:** Measurement of bamboo cuttings shall be made on the basis of actual numbers of cuttings prepared, counted on site and accepted. The quantities thus measured shall be paid at the unit rate shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for all arrangements for purchasing of bamboo and preparation of cuttings and providing the cuttings as per the Specifications.

2004. PREPARATION OF NURSERY

The Contractor shall provide nurseries to contribute stocks of grasses, shrubs and trees for planting operations as required by the Project Manager. This shall be done according to the specifications described hereunder, as and when required by the Project Manager. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

The Contractor shall note that the establishment and effective operation of plant nurseries is a skilled business requiring experienced and trained staff. These specifications alone do not provide all the information needed to set up and run nurseries. The Contractor shall seek the advice of specialist agencies and shall refer to the large number of reference books available on the subject.

The purpose of a nursery shall be to supply good quality, healthy plants of the correct type and species at the precise time they are required.

(1) Nursery Establishment

- (a) The Contractor shall provide nursery facilities adequate to supply all of the stock required for planting operations. Alternatively, he may procure planting stock from elsewhere at the time of site planting, provided it is of a standard acceptable to the Project Manager and as described hereunder.
- (b) In selecting a site for a nursery, if not instructed by the Project Manager, the Contractor shall fulfill the following requirements.
 - (i) Nurseries shall be as close as possible to all the sites to be planted. They shall be at the same altitude and in an identical climatic area to the sites to be planted.
 - (ii) Wherever possible, nurseries shall be established on land owned by the Department of Roads if it is available and biophysically suitable. If it is not, other government land shall be used if it is available.
 - (iii) Nurseries shall have a reliable and adequate supply of water which remains constant throughout the later part of the dry season.
 - (iv) Nurseries shall have all weather vehicular access.
 - (v) Nurseries shall have a perimeter of stock-proof fencing, effective against all domestic animals.
 - (vi) Nurseries shall have a weather and pest-proof office cum seed store and proper storage facilities for seed. Seed shall be kept cool, dry and in sealed containers, as specified in Clause 1902.
 - (vii) All nurseries shall be provided with at least two above-ground compost bays, built of stone, brick or timber.
 - (viii) Where a nursery is established on a slope exceeding 2°, the ground shall be leveled by terracing before beds are constructed.
 - (ix) A qualified and experienced in-charge must be appointed.
 - (x) There shall be adequate space in each nursery location for all operations to be performed in the cycle of work. In particular, all plants shall be spaced out periodically as they grow and there shall be adequate bed area to accommodate them.

(2) Preparation of Nursery Beds

- (a) Nursery beds shall be made in a different way according to their purpose. The Contractor shall ensure that there are adequate beds available for all the operations to be undertaken in the nursery.
- (b) There shall be paths around all beds to ensure the best possible access for operations such as weeding and watering.

- (c) Table 20.1 summarizes the construction details of the five main bed types, which are described in full in paragraphs (d) to (h).

Table 20.1: Construction Details of Nursery Beds

Bed Type	Bed size	Details of construction
Beds for grass seeding, grass slips propagation	Bottom width 1200 mm and top width 1000 mm x 200 mm high	Bottom of the bed should be compacted making a camber to facilitate the drainage; 50 mm washed gravel placed above the ground; then 50 mm of 1:1 mix of soil and compost; and topped with 100 mm of 3:1 mix of sieved forest topsoil and washed sand.
Beds for bare root tree seedlings	Bottom width 1200 mm and top width 1000 mm, 200 mm high	Bottom of the bed should be compacted making a camber to facilitate the drainage; 50 mm washed gravel placed above the ground; then 50 mm of 1:1 mix of soil and compost; and topped with 150 mm of 3:1 mix of sieved forest topsoil and washed sand.
Seed beds for tree / shrub seedlings	1000 mm wide (external), 170 mm high with edging; Shade 900 mm of height on the lower side and 1200 mm higher side.	Bed should be provided with brick, flat stone or plank edging as determined by the Engineer; shade should be provided of waterproof materials or as determined by the Engineer; 50 mm of washed gravel placed above the compacted and cambered ground; then 50 mm unsieved forest soil; 50 mm of 1:3 mix of sieved forest soil and washed sand; and topped with 20 mm of washed, sieved and sterilized sand.
Stand out beds for tree / shrub seedlings	1000 mm wide (external), 150 mm high with edging; Shade 900 mm of height on the lower side and 1200 mm higher side.	Bed should be provided with brick, flat stone or plank edging as determined by the Engineer; shade should be provided of highly porous materials or as determined by the Engineer; 50 mm of washed gravel placed above the compacted and cambered ground.
Beds for the propagation of bamboo culm cuttings and stool bed for tree and shrub cuttings	Bottom width 1200 mm and top width 1000 mm x 300 mm high	Ground below the bed is dug to a depth of 300 mm. Bed is made with 100 mm of unsieved soil (lower) and 200 mm of sieved soil (upper). A bund of 100 mm high is formed around the edge. 1500 mm high shade of bamboo frame structures and Hessian jute is made.

Grass beds shall be constructed to hold grass seeds, grasses being propagated by vegetative means. These can be of any practical length but shall be flat and of 1200 mm base width and 1000 mm of top width on compacted and a cambered ground. They shall rise to a height of 200 mm above the surrounding ground. They shall be made up of 50 mm of washed gravel is placed above the ground; then 50 mm of 1:1 mix of soil and compost; and the bed is topped with 100 mm of 3:1 mix of fertile, loamy forest topsoil and washed sand. All sieving shall be done with a mesh size of 2 mm or smaller.

Bare root beds shall be constructed to hold seedlings transplanted from the seed beds. These can be of any practical length but shall be flat and of 1200 mm base width and 1000 mm of top width on compacted and a cambered ground. They shall rise to a height of 200 mm above the surrounding ground. They shall be made up of 50 mm of washed gravel is placed above the ground; then 50 mm of 1:1 mix of soil and compost; and the bed is topped with 150 mm of 3:1 mix of fertile, loamy forest topsoil and washed sand. All sieving shall be done with a mesh size of 2 mm or smaller.

Seed beds shall be made very carefully for germinating small seeds of shrubs and trees. These can be of any practical length but shall be flat and of one meter in width on compacted and a cambered ground. They shall rise to a height of 170 mm above the surrounding ground and provided with shadings as per the details given in the following paragraph (i). They shall be made up of 50 mm of washed gravel placed on the ground; then 50 mm of unsieved forest soil; 50 mm of 1:3 mixes of forest soil and washed sand; and the bed is topped with 20 mm of washed, and sterilized sand. All sieving shall be done with a mesh size of 2 mm.

Standout beds shall be constructed to hold seedlings in polythene pots. These can be of any practical length but shall be flat and of one metre width. Bed floors shall be above surrounding ground level and they shall have a 50 mm layer of washed gravel on the compacted and cambered ground. They shall have a surround, preferably made from flat stones, plank or bricks. The bed shall then be covered with the highly porous shadings as per the details provided in the following paragraph (i).

Beds for the propagation of bamboo culm cuttings and stool cuttings of trees and shrubs, shall be made specially. These can be of any practical length but shall be flat and of 1000 mm width at top and 1200 mm width at bottom. They shall rise to a height of 300 mm above the surrounding ground. They shall be made up of ground below the bed, dug to a depth of 300 mm; the bed itself is then made with 100 mm of unsieved soil on the original surface, and 200 mm of soil above this. All soil sieving shall be done with a mesh size of 2 mm or smaller. Finally, a bund of 100 mm high shall be formed around the edge.

Shades shall be constructed over the beds and kept in position over delicate seedlings during hours of intense sunlight, according to need. Shades shall be 900 to 1200 mm above the ground, and angled so as to be effective for as much of the day as possible (i.e. with the lower side to the south). Bamboo strips laced together with nylon string are particularly suitable in most cases; but over tree and shrub seed beds, thatched shades with a polythene lining shall be used.

(3) Measurement and Payment: Work to be measured shall be the actual top area in sq.m of beds constructed on site and accepted. Only the finished area of the beds shall be considered after the completion of its shades. However, despite the fact that shades will be covering larger area than the beds, the final measurement shall be governed by the area of the top of the bed for payment. The payment shall be the full and the final compensation to the Contractor for providing all materials to be incorporated, all labor, tools, equipment and incidentals to complete the works of Nursery establishment and construction of Nursery beds as per these Specifications.

2005. NURSERY OPERATION AND MANAGEMENT

- (a) The contractor shall operate the nursery according to a high standard. The nursery shall be staffed well and tended at all times. It shall be maintained in clean, tidy and efficient manner at all times. Plants shall always be healthy and vigorous.
- (b) Due to the nature of bio-engineering works, nurseries shall normally be operated and managed by small local contractors with a range of agricultural skills provided it is specified in the Contract.
- (c) Plants shall be kept properly weeded at all times.
- (d) Watering, as required for good plant growth, shall be carried out regularly in the cool of the evening between sunset and dusk. The Contractor shall ensure that the soil in all beds is kept moist but not saturated at all times. Beds shall be kept moist even when empty, so that the soil is kept in good condition.
- (e) The timing of nursery operations shall be of the utmost importance. Activities such as seed sowing and the taking of cutting shall be carried out within the critical few weeks when they will yield the

desired results. Most other operations, such as spacing out, root pruning and watering, shall also be carried out in a timely manner. The Contractor shall be responsible to keep works to the strict schedule required and under no circumstances to permit delays.

- (f) Measurement and Payment: The basis of measurement shall be the actual numbers of plants counted, certified and accepted by the Project Manager. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(1) Nursery Production of Grass

- (a) Grass shall be propagated in nurseries either by seeding in carefully prepared beds or by vegetative propagation.
- (b) Where grass seeding is required in the nursery, finely sieved fertile soil mixed with clean sand to a texture of sandy loam shall be placed in beds before the seeds are sown. Seeds shall be covered with a sheet of Hessian jute until they have germinated, then it shall be carefully removed. Watering of fresh seedlings shall be done by a fine spray and not by the rose of a watering can.
- (c) Grasses to be propagated by vegetative methods shall be of the species instructed. The Contractor shall obtain adequate quantities of the plant material required, but under no circumstances it shall cause serious depletion of grass stocks in any steep or erosion-prone area.
- (d) Vegetative propagation shall normally be by rhizome cuttings. With this method, the grass shall be treated in exactly the same way as a bamboo being propagated by the traditional farmer's technique. A clump shall be carefully dug up and brought to the nursery, being kept cool and damp at all times. Stems shall be cut above the first or second node above the ground: this usually gives a length of 100 to 200 mm. The clump shall be separated carefully, with the minimum of damage to the rhizomes and fine roots. Slips shall be separated out which keep a length of stem and about 50 mm of the rhizome. Each slip shall have some buds on the rhizome, but in some grasses these can be difficult to see. The slips shall be planted with the soil surface at the same level as it was originally, in rows at 200 mm centres; slips shall be at 200 mm centres within the rows. A sheet of Hessian jute shall be placed over the tops of the cuttings. When the new shoots are about 50 mm long, it shall be removed.
- (e) Every two to three months, all grasses shall be lifted from the beds, split carefully and replanted. It is normal that, once split out, three times the previous bed area is required. This is a standard practice to bulk up the supply of planting stock without having to degrade the natural vegetation cover in the region of the nursery.
- (f) Measurement and Payment: The basis of measurement shall be the actual area of live grasses covered surfaces in sq.m. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be considered the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(2) Nursery Production of Trees and Shrubs in Polypots

- (a) Trees and shrubs shall be seeded either in seed beds or directly in polythene pots ("polypots"). Finely sieved fertile soil mixed with clean sand to a texture of sandy loam shall be placed in well shaded beds for seeding. Watering of fresh seedlings shall be by a fine spray, and not by the rose of a watering can.
- (b) All plants shall be grown in pots of dimensions 100x180 mm (4 x 7 inches) or greater when laid flat. The pots shall be of black, 200 gauge polythene. They shall have adequate drainage holes at the bottom and be filled with fertile forest topsoil mixed with clean sand to a texture of sandy loam.
- (c) Roots protruding from the bottom of pots shall be pruned with a razor blade on regular basis which shall not exceed weekly and may need to be more frequent. Protruding roots shall never be allowed to become more than 25 mm in length.

- (d) When polypot seedlings begin to compete with each other for light, they shall be re-spaced as required. This would typically mean doubling the bed space occupied by the plants.
- (e) To be acceptable for planting on site, trees and shrubs shall be healthy, vigorous and showing no signs of damage, wilt, irregular growth, fungal or pest attack, or nutrient disorders. They shall be at least 300 mm in height above soil surface level and of good form. The roots shall be in good condition and there should be no signs of disturbance to the soil in the polythene pot, even after transport to site.
- (f) Measurement and Payment: The basis of measurement shall be the actual numbers of plants counted, certified and accepted by the Project Manager. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(3) Nursery Production of Hardwood Plants by Vegetative Methods

- (a) Trees and shrubs which can be propagated by vegetative methods may be specified by the Project Manager. The Contractor shall produce these by the appropriate method, as required.
- (b) All cuttings and stools shall be made as specified in Clause 1903 and planted in fertile soil beds of the type specified in Clause 1904.
- (c) Cuttings shall be planted 300 mm apart in holes slightly larger than their diameter. They shall be placed at such a depth that only one bud remains above the soil surface (i.e. about 30 mm of the cutting).
- (d) When plants compete with each other for light, they shall be cut back as necessary.
- (e) To be acceptable for planting on site, trees and shrubs produced in this way must be healthy, vigorous and showing no signs of damage, wilt, irregular growth, fungal or pest attack, or nutrient disorders. They shall be at least 500 mm in height above soil surface level and of good form.
- (f) Measurement and Payment: The basis of measurement shall be the actual numbers of plants counted, certified and accepted by the Project Manager. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(4) Extraction of Plants from the Nursery

- (a) The Contractor shall be responsible for extracting plants from nursery beds and preparing them ready for transport. They shall be extracted from the beds only on the morning that they are required for planting on site.
- (b) Plants shall be hardened off, starting at least two weeks before they are to be taken out of the nursery. This process shall require a gradual reduction in the amount of watering and shading. The aim is to prepare them for transfer to a much more hostile location.
- (c) The night before the plants are to be lifted, they shall be thoroughly watered. This is to make the soil softer and ease the business of extracting the roots.
- (d) Plants growing in soil beds shall be carefully lifted from the soil. There shall be no pulling of stems or roots, but they shall be dug out and extracted with no strain on any part of the plant.
- (e) Plants from soil beds shall be wrapped in wet Hessian jute. Hardwood plants shall have a ball of soil around the roots. Grass clumps can have most of the soil shaken or washed off.
- (f) Polypot seedlings shall be lifted and stacked neatly in metal or wooden trays. They shall always be lifted by the pot and never by the stem or leaves.
- (g) All plants shall to be kept moist, in a cool, shady place, until they are loaded for transport to site. In the vehicle, they shall not be stacked high. For transport on rough roads, they shall be packed in carefully so that they do not fall over or roll around. The vehicle shall be shaded.

- (h) Measurement and Payment: The basis of measurement shall be the actual numbers of plants counted, certified and accepted by the Project Manager. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(5) Compost and Mulch Production

- (a) The Contractor shall produce compost and mulch for nursery or site operations. It shall be produced in a timely manner, in the quantities required. Compost is normally required to sustain the long term fertility of nursery beds. Mulch may also be used in the nursery, but normally produced to enhance site planting works, particularly the direct seeding of grass.
- (b) Compost and mulch shall be made from annual and perennial weeds of poor rooting characteristics, such as *Eupatorium adenopherum*. The greenery shall be collected when there is most material available but before it forms seeds. This is most often in May-September.
- (c) Collected material shall be chopped finely and stored in a mound, compost bay or pit. The maximum size for chopped compost is 50 mm; the maximum size for chopped mulch is 150 mm.
- (d) Both compost and mulch shall be kept moist but not waterlogged and in an aerated condition. They shall be completely turned once a month on a regular schedule. Compost can have cow manure mixed in to assist the process of decomposition.
- (e) Neither compost nor mulch shall be applied until they are fully rotted. By this time they shall be black and the parts of individual plants shall be indistinguishable. Early application shall not be allowed as this can lead to a nutrient loss in the soil if microbes extract nitrogen to decompose the added organic material.
- (f) Measurement and Payment: The basis of measurement shall be the actual quantity of compost and mulch provided, accepted and certified by the Project Manager in cu.m. or kg. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

2006. TOP SOILING

(1) General

This Clause shall consist of preparing the ground surface for top soil application, removing top soil from designated stockpiles or areas to be stripped on the site or from approved sources of the side and placing and spreading the topsoil on prepared areas in accordance with this specification at the locations shown on the Drawings, as specified or as directed by the Project Manager.

Suitable equipment necessary for proper preparation and treatment of the ground surface, stripping of topsoil and for the handling and placing of all required materials shall be in good condition, and approved by the Project Manager before the various operations are started.

(2) Materials

(a) Top soil

Top soil shall not contain refuse or any material toxic to plant growth, and it shall be free from inorganic subsoil, stumps, roots, brush, stones (50 mm or more in any dimension), clay lumps or similar objects. Stripping material stockpiled in earthworks operations shall be free of brush and other vegetation except that ordinary sods and herbaceous growth such as grass and weeds shall not be removed but shall be thoroughly broken up and intermixed with the soil during handling operations. To qualify as top soil, the material shall

contain soil particles of which not less than 20% but not more than 80% of the material passes the 75 micron sieve as determined by the wet sieving in accordance with IS 2720-Part 4.

(b) Source of Top soil

Top soil may be obtained directly from earthwork stripping operations, from stockpiles located at other sites from previous earthwork stripping operations.

Prior to the stripping of top soil from designated areas, any vegetation, briars, stumps and large roots, rubbish or stones found on such areas, which may interfere with subsequent operations, shall be removed using methods approved by the Project Manager. Heavy sod or other cover, which cannot be incorporated into the topsoil by dicing or other means, shall be removed.

When suitable topsoil is available on the site, the Contractor shall remove this material from the designated areas and to the depth as directed by the Project Manager. The topsoil shall be spread on areas already tilled and smooth-graded or stockpiled in areas approved by the Project Manager. The sites of all stockpiles and areas adjacent thereto which have been disturbed by the Contractor shall be graded if required and put into a condition acceptable for seeding or sprigging.

The Contractor shall remove the topsoil from approved areas and to the depth as directed. The topsoil shall be hauled to the site of the work and placed as required.

(3) Workmanship

(a) Preparing the Ground Surface

Immediately prior to dumping and spreading the topsoil on any area, the surface shall be tilled or loosened by discs or spike-tooth harrows, or by other means approved by the Project Manager, to a minimum depth of 50mm to facilitate bonding of the topsoil to the subgrade soil to be covered. The surface of the area to be topsoiled shall be cleared of all stones larger than 50mm in any dimension and all litter or other material which may be detrimental to proper bonding and growth of plants.

Grades on the area to be topsoiled, as shown on the Drawings or as instructed by the Project Manager, shall be maintained in a true and even condition. Where grades have not been established, the areas shall be smooth-graded and the surface left at the prescribed grades in an even and properly compacted condition and shall be free-draining, to the extent practical.

(b) Placing Topsoil

The topsoil shall be evenly spread on the prepared areas to a uniform depth after compaction, as shown on the Drawings or as directed by the Project Manager. Spreading shall not be done when the ground or topsoil is excessively wet, or otherwise in a condition detrimental to the work. Spreading shall be carried on so that turfing operations can proceed with a minimum of soil preparation or tilling.

After spreading, any large clods and hard lumps shall be broken down and all stones or rock (50 mm or more in any dimension), roots, litter, or any foreign matter shall be raked up and disposed by the Contractor. After spreading is completed, the topsoil shall be satisfactorily compacted by rolling. The compacted topsoil surface shall conform to the required lines, grades, and cross-sections. Any topsoil or other dirt falling upon pavements as a result of hauling or handling of topsoil shall be promptly removed.

(4) Measurement and Payment

Measurement for top soil (to the depths shown on the Drawings) shall be made in square meter. Payment for top soiling shall be made at the respective contract unit rates and these shall be the full and the final

compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

2007. FINAL SLOPE PREPARATION FOR BIO-ENGINEERING

- (a) The Contractor shall prepare slopes for planting operations as required by the Project Manager. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.
- (b) In the course of all slope preparation works, it shall be essential that no damage is done to existing vegetation unless the Project Manager's instruction specifically requires certain plants to be removed.
- (c) The timing of bio-engineering operations shall be of the utmost importance. Activities such as planting and seed sowing shall be carried out within the critical few weeks when they will yield the desired results. All other operations shall be carried out in timely manner to permit this to happen. The contractor shall be responsible to keep works to the strict schedule required and under no circumstances to permit delays.
- (d) As slope trimming process can be dangerous and risky to personnel, the Contractor shall be responsible to ensure the safety of his/her and Client's personnel engaged for the same. It shall be essential to have the minimum of safety measures as listed below for a working gang of 10 people. The proportion of the safety harness shall be increased according to the requirements and labours employed on site.

The Contractor shall provide all safety measures as listed in Table 20.2 for his/her workers who will be on site and Employer's personnel who will be supervising the work within the Contractor's working premises.

Table 20.2 : Materials Required for Safety Measures

S. No.	Description	Quantity
1.	Safety rope (mountaineering type or similar make having a minimum of 20 mm diameter and 30 metres in length)	For every workers
2.	Safety belt similar to tree climbers or scaffolding use	For every workers
3.	Goggles and dust proof masks	For every workers
4.	Safety hats	For every workers
5.	Knee pad	For every workers
6.	First Aid Kit with necessary medicines and bandages	1 box per working gang
7.	Stretcher	1 no. per working gang

(1) Cut Slope Preparation for Grass Planting

- (a) The objective of final cut slope preparation shall be to produce a surface adequately prepared for grass planting. Grass lines shall be used to provide a strong surface cover. Grass lines shall be planted over a well prepared surface. The slope shall not be subject to any undue stress from erosion and mass movement in its initial stages.

- (b) All the construction work shall be checked prior to slope trimming. The site shall be clear of people and equipment.
- (c) The Contractor shall ensure that the slope under instruction is trimmed to a straight angle, according to the Project Manager's instructions. Cut slopes to be planted with grass shall normally be 3 vertical to 2 horizontal, unless otherwise shown on the Drawing or instructed by the Project Manager. In any event, a straight profile shall be obtained. Concavities shall be filled with well compacted material or dry stone dentition as instructed by the Project Manager. Convexities shall be removed and it shall be ensured that the general profile does not have a shape giving over-steep segments.
- (d) All loose material shall be removed from the slope and tipped elsewhere in an approved location.
- (e) Measurement and Payment: Work shall be measured in square meters on the basis of actual area of trimmed surface. The payment shall be the full and the final compensation to the contractor for making arrangements for traffic control, trimming, and removal of loose materials, all labour, tools, equipment, safety harness and incidentals to complete the work as specified herein.

(2) Final Preparation of Fill Slopes for Bio-Engineering

- (a) The objective of the final preparation of fill slopes shall be to produce a surface adequately prepared for shrub or tree planting or grass sowing, or a combination of these. Vegetation shall be used to provide a strong surface cover. Vegetation shall be planted over a well prepared surface. The slope shall not be subject to any undue stress from erosion and mass movement in its initial stages.
- (b) The Contractor shall ensure that the slope under instruction is trimmed to a straight angle, according to the Drawing or instruction of the Project Manager. In any event, a straight profile shall be obtained. All masses of loose debris, especially where it has previously been tipped at the head of the slope, shall be removed. Concavities shall be filled with well compacted material or dry stone dentition as shown on the Drawing or instructed by the Project Manager. Convexities shall also be removed and it shall be ensured that the general profile does not have a shape giving over-steep segments.
- (d) All loose material shall be removed from the slope and tipped elsewhere in an approved location.
- (e) Measurement and Payment: The work shall be measured in square meters on the basis of actual area of trimmed surface as shown on the Drawing or instructed and approved by the Project Manager. The quantities measured shall be paid at the unit rates shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, trimming, and removal of loose materials, all labour, tools, equipment, safety harness and incidentals to complete the work as specified herein.

2008. SITE PLANTING AND SOWING

- (a) The Contractor shall plant or sow grasses, shrubs and trees as shown on the Drawing or required by the Project Manager. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.
- (b) Due to the nature of bio-engineering works, they may also be undertaken by small local contractors with a range of agricultural skills, if so provided in the Contract.
- (c) It shall be the Contractor's responsibility to ensure that all planting stock, whether provided from a nursery under a separate contract or through a separate instruction, is of high quality and is vigorous enough to grow on the site to be planted.

- (d) All seeds and other planting stock shall be of species indigenous to Bhutan unless otherwise specified. All species shall be covered in the current approved lists of species produced from time to time by the Field Division Offices of the Department of Roads. They shall be appropriate for the precise site conditions in which they are to be planted and the Contractor shall ensure that they apply to the specific altitude and other environmental characteristics of the site in question.
- (e) Activities such as planting and seed sowing shall be carried out within the critical few weeks when they will yield the desired results. All other operations shall be carried out in a timely manner to permit this to happen. The Contractor shall be responsible to keep works to the strict schedule required and under no circumstances to permit delays.

(1) Sowing of Grasses on Site

- (a) The Contractor shall be required to carry out the sowing of grass seeds according to the Project Manager's specific instructions.
- (b) If the site for sowing is to be prepared under a separate contract, then it shall be assumed that the site will already have been prepared for seed sowing. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of grasses.
- (c) The Contractor shall be required to supervise all field operations very closely. The sowing of grass seeds is a delicate business and shall be approached in the same way as for agricultural crops. The Contractor shall employ experienced agricultural labourers for this work.
- (d) If seeds have to be provided under a separate contract, then they shall be properly stored. However, it shall be the Contractor's responsibility to check that it has been carefully stored and remains fully viable.
- (e) Immediately before sowing, the ground surface shall be lightly scarified using a rake to ease early root penetration. Seeds shall then be laid thinly over the surface. Under no circumstances shall they be broadcasted, because the lightness of perennial grass seeds and the steepness of the slopes to be treated give a poor cover using such a technique. The Contractor shall be responsible for ensuring that the correct quantities of seeds are used, while giving a good, even cover.
- (f) A cover of 25 g of grass seed per square metre of surface shall be achieved unless otherwise specified.
- (g) After sowing, a mulch of prepared and dried cut herbs shall be laid over the whole seeded area in a thin layer. If the mulch is too thick it will prevent light from getting to the seed and will inhibit germination. The Contractor shall identify local herbs suitable for this. However, freshly cut herbs shall not be used because of the danger of re-sprouting and weeding.
- (h) If specified, the mulch should be secured with jute netting of mesh size 300x 500 mm and the netting fixed in place using suitable live pegs or hardwood cuttings (e.g. Jhakrikath, *Vitex negundo*) at one metre c/c.
- (i) Measurement and Payment: Work shall be measured in square meters on the basis of actual area of grass seeded and covered surface. The payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, providing seeds, collection and application of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as specified herein. If the seeds and mulch are supplied through a separate contract, costs for the supply of the

same shall not be included herein. However, if the Contractor is responsible for the supply and storage of seeds and mulch no separate payment shall be made for these items.

(2) Direct Seed Sowing of Shrubs and Trees on Site

- (a) The Contractor shall be required to carry out the sowing of shrub and tree seeds according to the Project Manager's specific instructions.
- (b) It is assumed that the site will already have been prepared for seed sowing, if this item has to be executed under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of shrubs and trees.
- (c) The Contractor shall be required to supervise all field operations very closely. As the sowing of any seeds is a delicate business and, therefore, shall be approached in the same way as for agricultural crops. The Contractor shall employ experienced farmers for this work.
- (d) Seed shall be collected and stored well before the time of sowing, if they have to be supplied under a separate contract. However, it shall be the Contractor's responsibility to check that it has been carefully stored and remains fully viable.
- (e) Sowing shall start at the top of the slope and the labourers shall work downwards. Care shall be taken not to disturb areas already seeded.
- (f) To sow the seeds, a small hole shall be made in the slope. The tool used to do this shall depend on the size of the seed. For some seeds, a piece of gabion wire will be adequate; for others, a piece of mild steel with a flattened end is required. The hole shall be in the best soil available but if there is little real soil, then a crevice between two stones is acceptable. Two seeds should be placed in each hole and a covering of soil or whatever fines are available shall be placed over them. This covering shall never exceed 10 mm and shall preferably be about 5 mm; it shall never be less than this. Seeds shall be placed at 200 to 250 mm centres, as ground conditions dictate.
- (g) In some cases the seed can be broadcast starting at the top of the site and working down slope as evenly as possible so that the whole site is lightly covered. This shall be used where the site is still active and only warrants minimum expenditure, or where the site is naturally rough, providing plenty of niches in which the seed can catch. Quantities of seed shall depend on the type of seed involved but are generally half that of the quantities used in the nursery unless otherwise instructed by the Project Manager. With Gawashing/Saonshing (*Alnus nepalensis*) seed it shall be at a rate of 1g of seed per square metre.
- (h) Measurement and Payment: Work shall be measured in square meters on the basis of actual area of grass seeded and covered surface. The payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, providing seeds, collection and application of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as specified herein. If the seeds and mulch are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply and storage of seeds and mulch no separate payment shall be made for these items.

(3) Site Planting of Grass Slips and Cuttings

- (a) The Contractor shall be required to carry out the planting of grass seedlings or rooted cuttings, according to the Project Manager's specific instructions. The configuration of planting shall be determined according to individual site conditions. It shall be either random, contoured or downslope, as instructed by the Project Manager.
- (b) It is assumed that the site shall already have been prepared for planting, if this is to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of grasses, and complies with the specifications given in Clause 2006.

- (c) Using appropriate tools (such as tape measures and spirit levels), planting lines shall be marked out with string as required. Unless specified differently, the row spacing to be marked out shall be as shown in Table 20.3.
- (d) The Contractor shall be required to supervise all field operations very closely. Since the planting of grass slips is a delicate business and therefore shall be approached in the same way as the transplanting of millet seedlings. The Contractor shall employ experienced farmers for this work.

Table 20.3 : Row Spacing Details

Planting configuration	Slope steepness	Spacing
Random lines	All slopes	100 mm planting drill to drill
	Slope less than 30°	100 mm planting drill to drill and 1000 mm between the lines
Contour lines	Slope 30°- 45°	100 mm planting drill to drill and 500 mm between the lines
	Slope more than 45°	100 mm planting drill to drill and 250 mm between the lines
Diagonal	Slope less than 45°	100 mm planting drill to drill and 500 mm between the lines
	Slope more than 45°	100 mm planting drill to drill and 250 mm between the lines
Downslope lines	All slopes	100 mm planting drill to drill and 250 mm between the rows

- (e) The plants supplied to the Contractor from nursery (if so provided in the Contract) shall be prepared for planting by the Contractor. The Contractor shall transport them from the nursery wrapped in Hessian jute. At all times, plants shall be kept moist and as cool as possible, and should be wrapped in wet Hessian between all operations such as extraction from the bed, pruning and planting. Under any circumstances, all plants supplied shall be planted within two days from the time they are lifted from the nursery.
- (f) Grass slips or cutting shall be carefully separated from the clumps to give the maximum viable planting material. Preparation of slips, cuttings or rhizomes shall be strictly followed as mentioned in Clause 2003.
- (g) Planting shall be started at the top of the slope and under no circumstances shall new plants be walked on or otherwise disturbed. Using a small bar (usually made of mild steel and with a flattened end), a hole shall be made that is just big enough for the roots. The slip or cutting is inserted; care shall be taken that the roots are not tangled or bent back to the surface. Soil shall then be replaced around the roots and firmed with the fingers. The spacing of plants within rows shall be 100 mm unless otherwise specified. Two grass slips shall be planted in each drill.
- (h) If the soil is dry and there is no rain within 16 to 24 hours of planting, the site shall be watered carefully with a fine spray. The Contractor shall be required to water for the first two weeks after planting in the event of inadequate rainfall.
- (i) If it is provided in the Contract that the plants are to be collected from locations other than nurseries then utmost care shall be taken to minimize disruption to neighboring land, in the event that species are collected from areas surrounding the road. It shall be the Contractor's responsibility to collect the stock required from a wide area and not to give rise to any soil erosion through the excessive removal of plants in one locality.
- (j) Measurement and Payment: The measurement shall be the actual area of grass planted and covered surface in square meters for the random planting and any other patterns of planting up to 300 mm between the lines. The contour line planting in 500-1000 mm in any slopes shall be measured in linear meter. The payment shall be the full and final compensation to the Contractor for making arrangements for traffic control,

providing grass slips or rhizome, collection of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as per these Specifications. If the grass slips and mulch are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply slips and mulch, no separate payment shall be made for these items.

(4) Site Planting of Shrubs and Trees raised in Polythene Pots

(a) The planting of trees and shrubs is intended to replace or restore something of the natural vegetation on the slope to be treated. The Contractor shall be required to carry out the planting of seedlings to the Project Manager's specific instructions.

(b) It is assumed that the site will already have been prepared for planting if it has to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

(c) The spacing of plants shall be determined according to individual site conditions. However, it shall normally be at 1.5 meters interval unless otherwise specified or instructed by the Project Manager.

(d) The Contractor shall be required to supervise all field operations very closely. As the planting of trees and shrubs is a delicate business and should be approached in the same way as the planting of horticultural seedlings. The Contractor shall employ experienced agricultural or forestry labourers for this work.

(e) If the plants are to be supplied to the Contractor from a nursery under a separate contract, the plants should be ready for planting. They shall be at least 300 mm in height above the soil surface and hardened off in the normal way. The Contractor shall collect the plants from the nursery and transport them to site with all due care. The plants will normally be supplied in polythene pots, which shall not be removed until the moment of planting. Plants shall be lifted by the pots, never by the stem or leaves. At all times they are to be kept as cool as possible. The Contractor shall be responsible for ensuring that the soil around the roots does not dry out. Under any circumstances, all plants supplied must be planted within three days of removal from the nursery.

If it is provided in the Contract that the Contractor is responsible for the supply of plants, he shall maintain the same workmanship and standard as specified herein.

(f) Planting shall be started at the top of the slope and under no circumstances shall new plants be walked on or otherwise disturbed.

(g) A planting pit wide and deep enough for the main root to be buried in without bending it and wide enough for all the roots and surrounding soil ball shall be dug at the time of planting. Some compost if available shall be mixed with the soil from the slit prior to backfilling around the roots. The polythene pot must be removed from the seedling by cutting it away with a razor blade. The plant should then be carefully placed into the hole, the compost and soil packed in, and all surrounding soil firmed up, taking care not to cause any damage to the plant or its roots. The surface over and around the pit shall then be mulched using any appropriate, locally available material, such as manure, compost, dead leaves or cut herbage. The use of freshly cut *Eupatorium adenophorum* shall be avoided, since it can re-sprout from the buds after being cut.

(h) The Project Manager may specify bigger seedlings for specific areas, such as those to be used intensively for amenity purposes. These will normally have been growing in a nursery for at least a year and should have well developed roots as well as aerial parts. They will be provided either as bare root stock with a substantial root ball, or in pots of a minimum of 100 x 180 mm laid flat dimensions. When these larger seedlings are planted, the pits shall be of 300 mm diameter and 300 mm depth. In addition, well-rotted compost shall be mixed with the soil backfill in a ratio of at least one part compost to ten parts soil.

(i) **Measurement and Payment:** The measurement shall be made in number of seedlings planted, counted and accepted by the Project Manager at site. The quantities measured shall be paid at the unit rates shown in the Bill of Quantities. This payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, providing seedlings, collection and application of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as per these Specifications. If the seedlings and mulch are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply of seedlings and mulch, no separate payment shall be made for these items.

(5) Site Planting of Hardwood Cutting

Certain trees and shrubs can be planted on site by means of hard wood cuttings. Where these are specified, the Contractor shall be required to carry out the planting of cuttings as per the Project Manager's instructions.

It is assumed that the site will be prepared for planting, if it is to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

The spacing of hardwood cutting shall be determined according to individual site conditions. However, it will normally be at 500 mm centres unless otherwise specified.

The Contractor shall be required to supervise all field operations very closely. The planting of tree and shrub cuttings is a delicate business and shall be approached in the same way as the planting of horticultural cuttings (e.g. those of tea). The Contractor shall employ experienced agricultural or forestry labourers for this work.

The cuttings supplied to the Contractor will normally be from a nursery as arranged separately. If these cuttings are to be provided by the Contractor himself, he shall make such arrangements so as to make the cuttings ready for planting. The size of the cuttings shall be prepared as specified in Clause 1903 unless otherwise instructed by the Project Manager. The Contractor shall collect the cuttings from the nursery (if provided in the Contract) and transport them from the nursery wrapped in Hessian jute. At all times, cuttings shall be kept moist and as cool as possible, and shall be wrapped in wet Hessian between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied shall be planted the same day that they are lifted from the nursery.

Planting shall be started at the top of the slope and under no circumstances shall new plants be walked on or otherwise disturbed. Using a small bar (usually made of mild steel and with a pointed end), a hole shall be made that is just big enough for the cutting. The cutting shall be inserted and the soil shall be replaced around it and firmed with the fingers. The cutting shall be inserted to depth such that two-thirds to three-quarters of it is buried.

If the soil is dry and there is no rain within 16 to 24 hours of planting, the site shall be watered carefully with a fine spray. The Contractor shall be required to water for the first two weeks after planting in the event of inadequate rainfall.

If it is provided in the Contract that the cuttings to be used are to be from elsewhere other than nurseries then the Contractor shall obtain them in the manner described in Sub-clause 2003 (2).

The Project Manager may specify bigger cuttings for specific areas, using large truncheon cuttings. Cuttings of these species should be planted at 1000 mm centres burring up to 500 mm. A large crowbar shall be used to make the planting hole, but otherwise the technique shall be as described above for smaller cuttings. Under no circumstances shall these cuttings be hammered into the ground.

Measurement and Payment: The measurement shall be made on the basis of per number of cuttings planted, counted and accepted on site by the Project Manager. The quantities measured shall be paid at the unit rates shown in the Bill of Quantities. This payment shall be the full and final compensation to the Contractor for making arrangements for traffic control, providing and delivering seedlings, all labour, tools, equipment, safety harness and incidentals to complete the work as per these Specifications. If the seedlings are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply seedlings, no separate payment shall be made for this item.

(6) Brush Layering, Palisades and Fascines

Under certain conditions, the Contractor shall be required to construct vegetation structures using hardwood cuttings. Where these are specified, the Contractor shall be required to carry out the necessary preparation and planting works as required in the Project Manager's instructions.

It is assumed that the site will be already prepared for planting, if it has to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

The cuttings supplied to the Contractor may be from a nursery as arranged under a separate contract, and will be ready for planting. If the cuttings have to be arranged by the Contractor, he shall ensure that they are ready for planting. The cuttings shall be prepared as specified in Clause 1903 or as instructed by the Project Manager. The Contractor shall collect the cuttings from the nursery and transport them from the nursery wrapped in Hessian jute. At all times, cuttings shall be kept moist and as cool as possible, and shall be wrapped in wet Hessian or in the thick blanket of mulch material (i.e. *Eupatorium adenophorum*) between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied shall be planted the same day that they are lifted from the nursery.

If the instruction to the Contractor includes the provision of cuttings, then the Project Manager shall specify the species and expected sources, and the Contractor must then obtain the cuttings required. This shall be done in the manner described in Clause 1903 except that the size of cuttings will be of a minimum length of 450-600 mm for brush layering, 600 mm for palisades and 1000 mm for fascines, and minimum diameters of 20-30 mm for brush layering and palisades and 40-50 mm for fascines.

Cuttings of the following species, if specified for the truncheon cuttings planting, shall be a minimum of 2500-3000 mm in length.

The Contractor shall be required to supervise all field operations very closely. The planting of tree and shrub cuttings is a delicate business and shall be approached in the same way as the planting of horticultural cuttings (e.g. those of tea). The Contractor shall employ experienced agricultural or forestry labourers for this work.

Planting shall always be started at the top of the slope and under no circumstances shall new plants be walked on or otherwise disturbed.

Brush layering on road embankment slopes shall be planted as given below, unless specified differently.

Starting at the top of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out. From 1.5 meters below the road edge, a precise contour line should be marked out on every 1 meter down the slope.

After the line marking is completed, starting at the bottom of slope, a back sloped terrace (1:10) of approximately 300 mm in width x 100 mm inner depth and 300-400 mm outer depth should be excavated

along the lines. The terrace must not be allowed to open more than 5 metres length at a time before planting work is completed.

Topsoil or agricultural soil of maximum depth of 100 mm from the ROW should be collected and laid on the terrace. The minimum thickness shall be 50 mm unless otherwise instructed by the Project Manager.

Cuttings should then be placed into the terrace at 100 mm centres, the correct way up and angled so that they are at right angles to the maximum slope angle. All cuttings should be inserted to a depth such that two-thirds of their length is buried.

The terrace should then be partially backfilled with another 50 mm thick layer of topsoil and another line of cuttings placed (pushing into the soil) along the terrace at 100 mm centres, and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line. This results in cuttings at 50 mm final gap on each brush layer (i.e. 21 cuttings per linear metre).

When a practical working length is completed, formation of second terrace is then started. As the excavation is undergoing, the partially backfilled brush layering terrace below should be fully backfilled using the material that comes out of the second terrace and gently compacted. Any loose or excess material is cleared down the slope making the complete daylight upon the completion of whole slope.

- (i) Brush layering on the landslide debris shall be planted as given below, unless specified differently.
- (i) Starting at the bottom of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked following a precise contour line at 1 metre interval.
- (ii) After the line marking is completed, starting at the bottom of slope, a back sloped terrace (1:10) of approximately 450 mm in width x 100 mm inner depth and 300-400 mm outer depth shall be excavated along the lines. The terrace shall not be allowed to open more than 5 metres length at time before planting work is completed.
- (iii) Cuttings shall then be placed into the terrace at 100 mm centres, the correct way up and angled so that they are at right angles to the maximum slope angle. All cuttings shall be inserted to a depth such that two-thirds of their length is buried.
- (iv) The terrace shall then be partially backfilled with 50 mm layer of soil and another line of cuttings placed (pushing into the soil) along the terrace at 100 mm centres, and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line. This results in cuttings at 50 mm final gap on each brush layer (i.e. 21 cuttings per linear metre).
- (v) When a practical working length is completed, formation of second terrace shall then be started. As the excavation is undergoing, the partially backfilled brush layering terrace below shall be fully backfilled using that material that come out of the second terrace and gently compacted. Any loose or excess material shall be cleared down the slope making the complete daylight upon the completion of whole slope.
- (vi) Brush layering is often done in diagonal or chevron pattern. If it is instructed so, the procedure given above shall be followed except setting out lines, which shall be changed accordingly.
- (j) Palisades shall be constructed as given below, unless specified differently.

Starting at the top of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked out. From 1 metre below the top of the slope, a precise contour line shall be marked out every 1 metre down the slope.

Starting at one end and using a small bar (usually made of mild steel and with a pointed end), a hole shall be made that is just big enough for the first cutting. The cutting shall be inserted and the soil shall be replaced around it and firmed with the fingers. The cutting shall be the correct way up and angled so that it is vertical. The cutting shall be inserted to a depth such that two-thirds of it is buried.

This process shall be repeated along the entire line, with a series of cuttings placed at 50 mm centres.

If a double line is specified, then a second line of cuttings shall be placed in the same way, 100 mm behind the first and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line.

The soil around the single or double line shall then be completely backfilled into any remaining gaps and gently compacted. Any loose or excess material shall be cleared down the slope before the next line is planted.

(k) Fascines shall be bundles of hardwood cuttings laid horizontally in trenches, and parallel to the line of the trench. The bundles shall be thereby completely buried. Fascines shall be constructed as given below, unless specified differently.

Starting at the top of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked out. From 1 metre below the top of the slope, a precise contour line shall be marked out every 1 metre down the slope.

Starting at the bottom as the marking is completed; trenches approximately 200 mm x 200 mm in depth shall be excavated along the lines.

600 mm long cuttings of same material that is going to make fascine shall be planted on the lower side of trench in vertical position as a peg at 1000 mm interval.

Cuttings shall then be laid along each trench, so that they lie horizontally along the trench. There shall be a minimum of six cuttings together. They shall be overlapped so that no two ends coincide. All the small branches growing from the main branch shall be protruding on slope. Under no circumstances, the branches and buds shall be damaged. The cuttings shall then be tied using jute or coir (coconut fiber) string at 500 mm intervals to form a bundle. As the fascine is created, it thereby forms a continuous bundle right across the slope.

The trench shall then be backfilled and gently compacted. The top of the fascine shall be 50 to 100 mm below the surface. Any loose or excess material shall be cleared down the slope before the next line is planted.

The Project Manager may specify that orientations other than along the contour of the slope are used. In this event, the Contractor shall alter the laying out of lines accordingly and meet the precise angle required.

If the soil is dry and there is no rain within 16 to 24 hours of planting, the site shall be watered carefully with a fine spray. The Contractor shall be required to water for the first two weeks after planting in the event of inadequate rainfall.

(l) Measurement and Payment: Brush layering, Palisades and Fascines shall be measured separately as per the accepted final product in linear metre. The payment shall be the full and final compensation to the Contractor for making arrangements for traffic control, collecting and transporting of cuttings to the site, all labour, tools, equipment, safety harnesses and incidentals to complete the work as per these Specifications. If the cuttings are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the cuttings, no separate payment shall be made for this item.

(7) Live Check Dam Construction

- (a) Under certain conditions, the Contractor shall be required to construct vegetation structures using hardwood cuttings. Where these are specified, the Contractor shall carry out the necessary preparation and planting works as directed by the Project Manager.
- (b) The site preparation shall be completed for planting in advance; but the Contractor shall ensure that the condition of the site is good enough for the successful establishment of delicate plants.
- (c) The cuttings shall be at least 4000 mm long and 5 cm in diameter made from woody material that is 6 to 30 months old. The Contractor shall collect the cuttings from local area and transport them from there wrapped in Hessian jute. At all times, the cuttings shall be kept moist and cool as much as possible, and thus should be wrapped in wet Hessian. Under any circumstances, all plants supplied shall be planted the same day.
- (d) If the instruction to the Contractor includes the provision of cuttings, then the Project Manager will specify the species and expected sources, and the Contractor shall obtain the cuttings required.
- (e) Cuttings of dabdabe (*Garuga pinnata*), kavro (*Ficus lacor*), phaledo (*Erythrina spp*) and *Gliricidia sepium* shall be a minimum of 2000 mm in length. Apart from these other species shall be used as directed by the Project Manager.
- (g) Live check dams shall be constructed as given below, unless otherwise specified:
- (i) Make a hole deep and big enough to insert vertical hardwood cuttings of the largest size available. Use a crowbar if necessary to extend the hole.
- (ii) Insert the vertical cuttings by carefully pushing them into the hole and firming the soil around them. Do not damage the bark. They shall protrude about 300 mm above the ground.
- (iii) Place long hardwood cuttings on the uphill side of the vertical stakes.
- (iv) Key these horizontal members into the wall of the gully
- (v) Backfill around the check dam and compact the soil
- (h) Measurement and Payment: The live check dam shall be measured in linear meter. The Live check dams shall be paid at the respective contract unit price which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

(8) Site Planting of Bamboo

- (a) The planting of bamboo is intended to replace or restore the natural vegetation on the slope to be treated. The Contractor shall carry out the planting of seedlings as directed by the Project Manager.
- (b) The site preparation shall be completed for planting in advance and the Contractor shall ensure that the condition of the site is good enough for the successful establishment of delicate plants.
- (c) The spacing of plants shall be determined based on site conditions. Unless otherwise specified the spacing shall be two meters across the slope and five meters up and down the slope.
- (d) Select a suitable culm of the parent clump and dig out the rhizome carefully. Cut off the culm about two meters above the ground level. Cut the rhizome where it branches from the main plant, taking care not to damage the buds and small roots.

- (e) Wrap the root ball in damp hessian and transport the cuttings to site for planting on the same day.
- (f) Dig a hole (at least five times the size of the cutting's rhizome) and plant the rhizome either upright or at right angles to the slope. Carefully backfill the hole and firm the soil as much as possible.
- (g) The Contractor shall supervise all field operations very closely. The planting of bamboo is a delicate task, thus the Contractor shall employ only experienced agricultural or forestry laborers.
- (h) Measurement and Payment: The measurement shall be made in number of plants planted. The bamboo planting shall be paid at the respective contract unit price which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

(9) Use of Fertilizer

- (a) Under certain circumstances, the use of chemical fertilizers may be specified in place of farmyard manure or mulching.
- (b) Levels of fertilizer application shall vary according to soil type and nutritional content. However, if nutritional data are not available, the following figures shall be used as a rough guide:

Nitrogen (N) : 10 g/m²;
Phosphorus (P) : 5 g/m²;
Potassium (K) : 4 g/m².

2009. SPRIGGING

(1) Scope

This Clause shall consist of planting sprig of living grass plants at the locations shown on the Drawings or as directed by the Project Manager in accordance with these specifications.

Suitable equipment necessary for proper preparation of the ground surface and for the handling and placing of all required materials shall be in good condition, and shall be approved by the Project Manager before the various operations are started. The Contractor shall demonstrate to the Project Manager, before starting the various operations that the planting and application of required materials will be made at the specified rates.

Unless otherwise directed sprigging shall be done on all embankment slopes greater than 3.5 horizontal to 1 vertical, and on drainage berms.

(2) Materials

(a) Sprigs

Sprigs shall be healthy living stems (stolons or rhizomes), of the grass species approved by the Project Manager, harvested without adhering soil and obtained from sources where the sod is heavy and thickly matted. Sprigs containing weeds or other material which might be detrimental to the proposed planting will be rejected.

(b) Water

All water used shall be sufficiently free from oil, acid, alkali, salt, or other harmful materials that would inhibit the growth of grass. Brackish water shall not be used at any time. Water shall be subject to the approval of the Project Manager prior to use.

(3) Soils for Repairs

Soil for fill and topsoiling of areas to be repaired or made up shall be at least of equal quality to that which exists in areas adjacent to the area to be worked in. The soil shall be free from large stones, roots, stump or other materials that will interfere with subsequent sprigging, compacting, establishing turf or grass cutting operations, and shall be approved by the Project Manager before being placed.

(4) Construction

(a) Advance Preparation and Cleanup

After grading of areas has been completed the areas to be sprigged shall be raked or otherwise cleared of stones larger than 50 mm in any one dimension, sticks, stumps, and other debris which might interfere with sprigging, growth of grasses, or subsequent maintenance of grass-covered areas. If any damage by erosion or other causes has occurred after grading of areas and before the planting of sprigs the Contractor shall repair such damage. This may include filling gullies, smoothing irregularities, and repairing other incidental damage.

(b) Obtaining Sprigs

The sprigs obtained from sources off the site shall be from suitable areas as close as practical to the planting site. Regardless of the source, sprigging material to be harvested shall be mowed to a height of 75 mm, and the clippings raked and removed before harvesting begins. Harvesting may be performed by any method acceptable to the Project Manager, including crisscross cultivation, shallow ploughing or other acceptable methods to thoroughly loosen the sprigs from the soil and to bring them to the surface. After loosening the sprigs from the soil, they shall be gathered in small piles or windrows, watered, and kept moist until planted.

Not more than 24 hours shall elapse between harvesting and planting sprigs, except that, when weather or other uncontrollable conditions interrupt the work, a time extension may be granted, provided the sprigs are still moist and viable. Springs that have heated in stockpiles, dried out, or otherwise been damaged during harvesting or delivery shall be rejected and shall be disposed of as directed by the Project Manager.

(c) Planting Sprigs

Sprigging shall be completed such that the turf is well established at the coming of the monsoon season to minimize risk of damage due to rain erosion. Sprigging shall not be done during windy weather, or when the ground is dry, excessively wet, or otherwise untillable. If the soil is not moist when the sprigs are being set, water shall be applied until the soil is moist and in a workable condition. Sprigs shall be broadcast by hand or by suitable equipment in a uniform layer over the prepared surface with sprigs spaced not more than 150 mm apart. The sprigs shall then be forced into the soil to a depth of 50 to 100 mm with a straight spade or similar tool, or with a disc harrow or other equipment set to cover the sprigs to the required depths.

After planting has been completed, the surface shall be cleared of stones larger than 50 mm in any dimension, large clods, roots, and other litter brought to the surface during sprigging.

(d) Compacting

The sprigged area shall be compacted within 24 hours from the time sprigging has been completed. If weather and soil conditions permit, compaction shall be carried out by rollers operated at right angles to the slope. Compaction shall not be done when the soil is in such condition that it is picked up by the equipment.

(e) Care of the sprigs until Final Acceptance

The Contractor shall be responsible for the proper care of the sprigged areas during the period when the plants are becoming established and he shall protect the sprigged areas against traffic by warning signs or barricades approved by the Project Manager. Surfaces eroded or otherwise damaged following sprigging shall be repaired by grading and resprigging as directed. The Contractor shall mow, water as required to promote sprig development, and shall otherwise maintain sprigged areas in a satisfactory condition until final inspection and acceptance of the work.

(1) Measurement and Payment

Measurement for sprigging shall be made in square meter. Payment for sprigging shall be made at the respective contract unit rates and these shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

2010. TURFING

(1) Scope

This Clause consist of furnishing, hauling, and placing approved live turfs on prepared areas in accordance with this specification at the locations shown on the Drawings or as directed by the Project Manager.

Areas to be soiled, stripped or spot sodded shall be as shown on the Drawings or as directed by the Project Manager.

Suitable equipment necessary for proper preparation of the ground surface and for the handling and placing of all required materials shall be in good condition, and shall be approved by the Project Manager before the various operations are started. The Contractor shall demonstrate to the Project Manager before starting the various operations that the application of required materials will be made at the specified rates.

(2) Materials

(a) Turfs

Turfs furnished by the Contractor shall have a good cover of living or growing grass. This includes grass that may be seasonally dormant during the cold or dry seasons but capable of renewing growth after the dormant period. All sod shall be obtained from areas where the soil is reasonably fertile and contains a high percentage of loamy topsoil. Sod shall be cut or stripped from living, thickly matted turf with fewer than 5% weeds or other undesirable foreign plants. Obvious large stones, roots, or other materials which might be detrimental to the development of the sod or to future maintenance shall be removed from sod at the point of harvesting. At least 70% of the plants in the cut sod shall be composed of species approved by the Project Manager. Grass shall be mowed to a height of 75 mm before turf is lifted. Turfs, including the soil containing the roots and the plant growth stated above, shall be cut uniformly to a thickness not less than 50 mm.

(b) Water

Water shall be sufficiently free from oil, acid, alkali, salt, or other materials that would inhibit the growth of grass. It shall be subject to the approval of the Project Manager prior to use.

3) Soil for Repairs

The soil for fill and topsoiling of areas to be repaired or made up shall be at least of quality equal to that which exists in areas adjacent to the area to be worked in. The soil shall be free from stones larger than 50 mm in any dimension, toots, stumps, or other materials that will interfere with subsequent placement, leveling, compacting, and establishment of the sod, and shall be approved by the Project Manager before being placed.

(4) Workmanship

(a) Preparing the Ground Surface

After grading of areas has been completed the areas to be sodded shall be raked or otherwise cleared of stones larger than 50 mm in any dimension, sticks, stumps, and other debris which might interfere with sodding, growth of grasses, or subsequent maintenance of grass-covered areas. If any damage by erosion or other causes occurs after grading of areas and before placing of turf, the Contractor shall repair such damage. This may include filling gullies, smoothing irregularities, and repairing other incidental damage.

(b) Obtaining and Delivering Turfs

After inspection and approval of the source of turfs by the Project Manager, the turfs shall be cut with approved turf cutters to such a thickness that after it has been transported and placed on the prepared bed, but before it has been compacted, it shall have a uniform thickness of not less than 50 mm. Turf sections or strips shall be cut in uniform widths, not less than 250 mm, and in lengths of not less than 450 mm, but of such length as may be readily lifted without breaking, tearing, or loss of soil. Where strips are required, and turf must be rolled without damage with the grass folded inside. Turfs shall be mowed if required to meet this specification.

The turf shall be transplanted within 24 hours from the time it is stripped, unless circumstances beyond the Contractor's control make storing necessary. In such cases, turfs shall be stacked, kept moist, and protected from exposure to the air and sun. Turfs shall be cut and moved only when the soil moisture conditions are such that favorable results can be achieved. Where the turf and soil to be cut is too dry, permission to cut turfs may be granted subject to sufficient watering to moisten the turfs and soil to the full depth the turfs is to be cut.

(c) Laying

Turfing shall be performed only during the seasons when satisfactory results can be achieved. Turfs may be transplanted during periods of drought with the approval of the Project Manager, provided the turfing bed is watered to moisten the soil to a depth of at least 100 mm immediately prior to laying the turfs.

The turfs shall be moist and shall be placed on a moist earth bed. Pitch forks shall not be used to handle turfs. Turfs shall be carefully lifted, loaded and unloaded to prevent tearing or loss of dirt. Turfs shall be carefully laid by hand, edge to edge and with joints staggered a nominal 100 mm, in rows at right angles to the slopes, commencing at the base of the area to be turfed and working upward. The sod shall immediately be pressed firmly into contact with the turf bed by tamping or rolling with approved equipment to provide a true and even surface, and ensure knitting without displacement of the sod or deformation of the surfaces of turfed areas. Where it is likely that the turfs may be displaced during turfing operations, workers when replacing it shall work from ladders or treaded planks to prevent further displacement. Screened soil of good quantity shall be used to fill all cracks between sods. The quantity of the fill soil shall not cause smothering of the grass. Where the grades are such that the flow of water will be from paved surface or road shoulders across sodded areas, the surface of the sod after compaction shall be set approximately 40 mm below the pavement edge. Where the flow will be over the turfed areas and onto the paved surfaces around manholes and inlets, the surface of the turf after compaction shall be placed flush with pavement edges and inlets.

Newly turfed areas on slopes of cuttings and embankments shall be pegged down in a manner approved by the Project Manager.

(d) Watering

Adequate water and watering equipment must be on hand before turfing begins, and turf shall be kept moist until it has become established and its continued growth is assured. In all cases, watering shall be done in a manner which will avoid erosion from the application of excessive quantities and will avoid damage to the finished surface.

(e) Care and Maintenance of Turfing until Final Acceptance

The Contractor shall be responsible for the proper care of the turfed areas during the period when the turf is becoming established and he shall protect the turfed areas from traffic by warning signs or barricades approved by the Project Manager. Surfaces eroded or otherwise damaged following turfing shall be repaired by regrading and returfing as directed by the Project Manager. The Contractor shall water as required to promote turf development, and shall otherwise maintain sodded areas in a satisfactory condition until final inspection and acceptance of the work.

The Contractor shall mow the turfed areas with approved mowing equipment, depending upon climatic and growth conditions and the needs for mowing specific areas. In the event that weeds or other undesirable vegetation are permitted to grow to such an extent that, either cut or uncut, they threaten to smother the sodded species, they shall be mowed and the clippings raked and removed from the area.

When the surface has become eroded or otherwise damaged during the period covered by this Contract the affected area shall be repaired to re-establish the grade and the condition of the soil as directed by the Project Manager, and shall then be returfed as specified above.

(5) Measurement and Payment

Measurement for turfing shall be made in square meter. Payment for turfing shall be made at the respective contract unit rates and these shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

2011. SEEDING

(1) General

This Clause shall consist of furnishing, sowing and maintaining turf growth in landscaped areas, as an alternate to turfing, in accordance with this specification at the locations shown on the Drawings or as directed by the Project Manager.

Suitable equipment necessary for proper preparation of the ground surface and for the handling and placing of all required materials shall be in good condition, and shall be approved by the Project Manager before the various operations are started. The Contractor shall demonstrate to the Project Manager before starting the various operations that the application of required materials will be made at the specified rates.

Unless otherwise directed seeding shall be done only on central reserve areas designated landscape areas and upon approval of the Project Manager.

(2) Materials

(a) Seed

Seed shall be the best quality seed available in Bhutan and suitable for use in the project area.

(b) Fertilizer

Fertilizer shall be added to topsoil after placement in accordance with these specifications. The Contractor shall submit a list of the composition of the proposed fertilizer mixture together with a 2 kg sample to the Project Manager for approval. The fertilizer shall contain amounts of nitrogen, phosphorus and potash appropriate to the soil and growing conditions, as recommended by the Department of Agriculture, Bhutan.

(c) Water

Water shall be sufficiently free from oil, acid, alkali, salt, or other materials that would inhibit the growth of grass. It shall be subject to the approval of the Project Manager prior to use.

(3) Soil for Repairs

Soil for making topsoil repairs shall be of equal quality to that which exists in areas adjacent to the area to be worked in. The soil shall be free from stones larger than 50 mm in any dimension, roots, stumps, or other materials that will interfere with subsequent placement, leveling, compacting, and establishment of the turf, and shall be approved by the Project Manager before being placed.

(4) Construction

(a) Preparing the Ground Surface for Seeding

After grading of areas has been completed the areas to be seeded shall be raked or otherwise cleared of stones larger than 50 mm in any dimension, stick, stumps, and other debris which might interfere with seeding, growth of grasses, or subsequent maintenance of grass-covered areas. If any damage by erosion or other causes occurs after grading of areas and before seeding, the Contractor shall repair such damage. This may include filling gullies, smoothing irregularities, and repairing other incidental damage.

(b) Approval of Seed

Seed shall contain only varieties of grasses considered acceptable for the areas to be seeded. The Contractor shall submit a list of the proposed seed mixture together with a 1 kg sample of the seed mix proposed to the Project Manager for approval. Seed shall be 95% weed-free.

(c) Seeding

Seed shall be applied by mechanical rotary spreader so to evenly distribute the seed over the surface at the specified rate of application of 1 kg per 125 square meters. Manual seeding shall be permitted only if the Contractor is able to demonstrate and prove uniform spreading to the approval of the Project Manager. Seeding shall be performed only during the seasons when satisfactory results can be achieved. Seed may be sown during periods of drought with the approval of the Project Manager, provided the seed is constantly kept moist until two weeks after germination, and then is watered sufficiently frequently to ensure growth of the seed.

Immediately prior to seeding, fertilizer shall be applied to the topsoil at the specified application rate of a minimum 8 kg per 100 square meters. The top 100 mm of soil shall then be mixed by light tilling. Following this the surface shall be bladed and rolled lightly to consolidate and level the loose soil. After rolling, the surface shall be hand-raked so as to slightly loosen the surface of the rolled ground. Seed shall then be applied at the specified rate of application.

Immediately after seeding, the surface shall again be lightly raked in order to barely cover the seed in the top of the soil. The surface shall be lightly rolled.

(d) Watering

The method proposed for use by the Contractor to keep the seed bed moist during the germination period and beyond shall be approved in advance by the Project Manager. Adequate water and watering equipment must be in place at all times after seeding. Seed shall be kept moist until it has become established and its

continued growth is assured. In all cases, watering shall be done in a manner which will avoid erosion from the application of excessive quantities and will avoid damage to the finished surface.

(e) Care and Maintenance of Seeded Area until Final Acceptance

The Contractor shall be responsible for the proper care of the seeded areas during the period when the turf is becoming established and he shall protect the seeded areas from traffic by warning signs or barricades approved by the Project Manager. Surfaces eroded or otherwise damaged following seeding shall be repaired by regrading and reseeding as directed. The Contractor shall water as required to promote turf development, and shall otherwise maintain seeded areas in a satisfactory condition until final inspection and acceptance of the work.

The Contractor shall mow the seeded areas with approved mowing equipment, after new grass reaches a height of 100 mm to 150 mm. The grass shall be cut to a height of 75 mm, and shall be further cut to that height so that it at no time exceeds 150 mm in height prior to final acceptance. In the event that large weeds or other undesirable vegetation becomes established in the new turf, they shall be removed by hand or chemical means. Any dead plant material shall be raked and removed from the area.

When the surface has become eroded or otherwise damaged during the period covered by this Contract the affected area shall be repaired to re-establish the grade and the condition of the soil as directed by the Project Manager, and shall then be reseeded as specified above.

(5) Measurement and Payment

Measurement for seeding shall be made in square meter. Payment for seeding shall be made at the respective contract unit rates and these shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

2012. JUTE NETTING WORKS

- (a) The Contractor shall provide and install jute netting as shown on the Drawing or as required by the Project Manager. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.
- (b) The Project Manager may instruct that jute netting applications be used in conjunction with other techniques, particularly the sowing or planting of grasses. In this event, the netting shall be applied before the plants are introduced. When planting, the labourers shall take care only to hold or stand on the pegs and not to disturb the netting except when carefully placing grass seed underneath on the soil surface.

(1) Supply of Jute Nets

- (a) The Contractor shall manufacture or obtain supply of jute net to the Project Manager's specification.
- (b) The detailed specifications for standard jute net shall be as follows. "Standard" jute netting is used for placing on bare slopes and is normally planted with grasses. (Note: warp ends are the length-ways threads and weft strands are the cross-ways threads)
 - (i) Material: High quality, 100% natural jute fiber from the latest harvest, properly treated and dried.
 - (ii) Yarn: Handspun 5 to 8 mm.
 - (iii) Strip size: minimum 1.0 x 10.0 metres; maximum 1.1 x 11.5 metres.
 - (iv) Warp ends: 27 ends per 1000 mm.
 - (v) Weft strands: 20 to 24 strands per 1000 mm.
 - (vi) Mesh size: 40 mm square mesh holes.

- (vii) Weight: 1.1 to 1.2 kg per square metre.
- (c) The detailed specifications for wide mesh jute net shall be as follows. "Wide mesh " jute net is used for holding on to slopes which have been sown with grass seed. (Note: warp ends are the length-ways threads and weft strands are the cross-ways threads)
- (i) Material: High quality, 100% natural jute fibre from the latest harvest, properly treated and dried.
 - (ii) Yarn: Handspun 3 to 5 mm.
 - (iii) Strip size: minimum 1.0 x 5.0 metres;
maximum 1.1 x 11.5 metres.
 - (iv) Warp ends: 7 ends per 1000 mm.
 - (v) Weft strands: 3 strands per 1000 mm.
 - (vi) Mesh size: 150 x 450 mm rectangular mesh.
 - (vii) Weight: 0.2 kg per square metre.
- (d) Measurement and Payment: No separate measurement and payment shall be made for the supply of jute nets. All costs incurred for the supply of jute nets shall be included in the item rate for the placement of jute nets.

(2) Placement of Small Mesh Size Jute Nets/Standard Jute Nets

- (a) The Project Manager shall normally instruct the placement of standard jute nets on slopes in excess of 45°. It is therefore very essential to place the netting in an effective manner to the satisfaction of the Project Manager.
- (b) It is assumed that the site will already have been prepared for the application of jute netting, if it is to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the optimum effect to be attained. In any event, a smooth profile must be obtained. All loose debris shall be removed. Concavities shall be filled with well compacted material or dry stone dentition as shown on the Drawing or as instructed by the Project Manager. Convexities shall also be removed and it is essential that the general profile does not have a shape giving over-steep segments.
- (c) Starting at one end of top of the site to be treated, a roll of netting shall be pegged 300 mm above the slope to be covered.
- (d) The netting shall be rolled slowly down the slope. Hardwood cuttings, ideally of Jhakrikath (*Vitex negundo*) or pegs (usually made from split bamboo culms) shall be hammered through the netting at 1000 mm centres at 100 mm inside of each edge. They shall protrude about 80 mm on the slope. Labourers shall stand on these cuttings or pegs and not hang on to the netting. As the full length of the jute netting is unrolled down the slope, a second round of the pegs shall be added in between. This will make total allowable spacing of not more than 500 mm interval. Another strip shall then be started to unroll from the top. This shall overlap by 100 mm and under no circumstances the pegging is done through both layer of jute net instead it shall be pegged separately. Each strip of jute netting shall be pegged down on the slope individually.
- (e) The tension of the netting shall now be reduced so that it hugs the slope surface precisely. This is done by pulling up about 200 mm at the bottom of the netting and hooking it on to the pegs a little higher up. This process shall be repeated up and across the slope until the netting rests snugly against the surface and is nowhere tight or pulled away from the surface in minor concavities.

Additional pegs shall be used to hold netting closely against the face of concave slope segments if necessary.

- (f) This process shall be repeated until the entire slope surface is covered. There shall be no lacing of any jute netting whatsoever.
- (g) Finally, the bottom of the netting shall be trimmed to give a tidy finish.
- (h) Measurement and Payment: As the actual quantity of jute net and area covered on slope differ from each other due to the overlapping, payment shall be made on the basis of final area covered on slope and measured in square metre (not the quantity of jute net). The payment shall be the full and the final compensation to the Contractor for making arrangements for safety to traffics, purchasing of jute, arrangement for looms and shades, fabrication of jute netting and transportation to the site, all labour, tools, equipment, safety harnesses and incidentals to complete the work as per these Specifications.

(3) Placement of Wide Mesh Size Jute Netting

- (a) In the case of wide mesh jute netting, it shall only be specified for use on slopes which have already been treated with grass and mulch. These shall usually be less than 45°. However, the process of placing the netting shall be similar to that for standard netting.
- (b) Unlike the standard mesh jute net, wide mesh jute net is available on shorter length of 5.5 metres and smaller roll in nature. It shall be opened by two people by two end laid flat (same as bed sheet is laid) on seeded and mulched slope.
- (c) The netting shall be pegged with hardwood cuttings, ideally of Jhakrikath (*Vitex negundo*) or pegs (usually made from split bamboo culms) at every 500 mm intervals. The Contractor shall ensure that his/her labourers do not damage the area of seeding and mulching while placing the jute net.
- (d) This process shall be repeated until the entire slope surface is covered. The strips shall then laced together with lengths of the same jute yarn, to form a continuous net. The lacing shall form joins every 500 mm or less.
- (e) The tension of the netting shall now be reduced so that it hugs the slope precisely and hold the mulch firmly against the surface throughout the area covered. Additional pegs shall be used to hold netting closely against the face of concave slope segments.
- (f) Finally, the bottom of the netting shall be trimmed to give a tidy finish.
- (g) Measurement and Payment: The payment shall be made on the basis of final area covered on slope and measured in square metre (not the quantity of jute net). The payment shall be the full and the final compensation to the Contractor for making arrangements for safety to traffics, purchasing and transporting of jute net to the site, all labour, tools, equipment, safety harnesses and incidentals to complete the work as per these Specifications.

2013. GABION WIRE BOLSTERS, SUB-SOIL DRAINS AND WIRE NETTING

The contractor shall provide and install wire bolsters as shown on the Drawing or instructed by the Project Manager. This shall be done according to the specifications described hereunder, as required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

(1) Fabrication of Bolster Panels

Bolster panels shall be either 5 x 1 metres or 5 x 2 metres in size, according to the type of bolster to be used. If the bolster panels are used for the wire netting, the size of the panel shall be 5.0 m X 5.0 m. They shall be woven with hexagonal mesh in the same way as normal gabion panels. For the panel frame, 10 swg galvanized wire shall be used; for the mesh, 12 SWG shall be adequate. Gabion wire shall comply with the requirements of Clause 1602.

Weaving shall start from one of the long sides. A total of 83 coils of wire shall be spaced evenly along the 5 metre length. This gives a mesh width of about 60 mm. Each weave shall have three twists, as for normal hexagonal mesh. This shall give a length of about 80 mm to each mesh link. In any event, the mesh length shall not exceed 90 mm. The mesh shall be turned on to the larger frame wire at least one and a half turns and made fully secure.

(2) Placement of Contour Bolsters

- (a) A contour bolster treatment shall give a series of stone-filled wire tubes of 300 mm diameter, laid in trenches cut across the slope. The tops of all the tubes shall flush with the surface of the slope in which they are placed. The purpose shall be to check scour of the slope surface by preventing the development of rills and gullies.
- (b) The site to be treated shall be given final preparation immediately before bolster installation. All small protrusions and depressions shall be obliterated by cutting, or by infilling and compaction.
- (c) Starting at the base of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked out. From 2 metres above the base of the slope, a precise contour line shall be marked out every 2 metres up the slope.
- (d) Starting at the bottom, trenches with circular base shall be dug along the lines, adequate to take the final 300 mm diameter tubes.
- (e) Bolster panels shall then be laid along the trenches and shaped to fit neatly into the base of the trenches, as well as into any curves formed as a result of the slope contours; each panel shall be securely joined to the next panel, to form a continuous bolster tube.
- (f) The panels shall be packed with stones, closed over and the edges wired together. All stones must be bigger than the mesh size. The same care shall be taken as when filling a conventional gabion basket, and stones must be carefully placed to give good structural integrity.
- (g) The ends of the bolsters shall be closed over and wired together. The trenches around all the bolsters shall then be filled and compacted with material left from the excavations.
- (h) Once all of the lines are in place, all surplus debris shall be cleaned off the slope. Mild steel bars of at least 16 mm diameter shall then be driven into the slope through the lower sides of the contour bolsters. These shall be at least every 2 metres along the lines. Bars shall be 1-2 metres in length on slopes composed of soft materials, but at the Project Manager's discretion, on slopes comprising hard rocky materials, bars of 1 metre length shall also be adequate. All bars shall be driven home until the tops protrude no more than 25 mm above the slope surface.
- (i) Measurement and Payment: Bolster shall be measured as per the accepted final product in linear metre. The payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, fabrication of bolster panel including cost of wire, collection and transportation of boulder/stone to the site, packing of stones/boulders, wiring, supply and driving of steel bars, excavation and filling, all labour, tools, equipment, safety harnesses and incidentals required to complete the work as specified in these Specifications.

(3) Placement of Herringbone Bolsters

- (a) A herringbone bolster network is in essence a system of wire tubes of between 300 mm to 600 mm in diameter depending on the amount of water flowing through the site, laid in trenches cut into the slope. The main bolster shall run straight down the slope (the spine) with other running into it at an angle of 45° to the fall of the slope (the herringbones or branches) depending on slope angle and

terrain morphology. The purpose shall be to check scour of the slope surface by preventing the development of rills and gullies, and to drain the surface material in a similar way to a French drain. The diagonal components shall be at 2 to 5 metre centres if measured straight down the slope.

- (b) The site to be treated shall be given final preparation immediately before bolster installation. All small protrusions and depressions shall be obliterated by cutting, or by infilling and compaction.
- (c) Starting at the base of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked out; every 7.0 metres across the slope, a line shall run straight up to the top of the slope (these form the main bolster spines). From the base of the line, and every 3 metres above this, other lines of 5 metres length shall be marked at 45° to the main line (these will form the herringbones).
- (d) Starting at the bottom, trenches with circular base shall be dug along the lines, adequate to take the final 300 mm diameter tubes, or 600 mm diameter tubes if large (5 x 2 metre) panels are specified.
- (e) Bolster panels shall then be laid along the trenches and shaped to fit neatly into the base of the trenches, as well as into any curves formed as a result of the slope contours; the panels of the herringbones shall be securely joined to the panels of the main bolster.
- (f) The panels shall be gradually closed together and secured, working up from the bottom of the slope, while stones are passed in from above to fill them. The stones shall be randomly packed so as to allow free drainage, and all stones shall be bigger than 100 mm. The same care shall be taken when filling a conventional gabion basket, and stones shall be carefully placed to give good structural integrity.
- (g) The upper ends of the herringbones shall be closed over and wired together; they should touch the ends of the next herringbones but shall not be secured (hooked) to each other. The trenches around all the bolsters shall then be filled and compacted with material left from the excavations.
- (h) Once all of the lines are in place, all surplus debris shall be cleaned off the slope. Mild steel bars of at least 16 mm diameter shall then be driven into the slope through the sides of the main spine bolsters and the lower sides of the herringbone bolsters. These shall be at least every 2 metres along the lines. Bars shall be 1-2 metres in length on slopes composed of soft materials, but at the Project Manager's discretion, on slopes comprising hard rocky materials, bars of 1 metre length may be adequate. All bars shall be driven home until the tops protrude no more than 25 mm above the slope surface.
- (i) Measurement and Payment: Bolster that are accepted by the Project Manager shall be measured in linear metre. The payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, fabrication of bolster panel including cost of wires, collection and transportation of boulder/stone to the site, excavations and fillings, boulder/stone packing, all wiring, supply and driving of steel bars, all labour, tools, equipment, safety harnesses and incidentals to complete the work as specified in these Specifications.

(4) Wire Netting

- (a) Wire netting shall be a complete cover on the steep rocky slope where heavily shattered rock face is eroding away by surface water. The site shall be prepared as outlined in Clause 2806. A wire mesh panel, normally larger than bolster, of 5 m x 5m shall be placed over the slope and later plant will be grown to replace the wire netting.
- (b) The site to be treated shall be given final preparation immediately before wire netting. All loose bulging shall be trimmed off.

- (c) Starting at the top of the slope to be treated, wire netting shall be placed securing well on to the slope. The wire net shall then be stapled down with a “U” shaped hook.
- (d) The hook shall be made of 16 mm diameter M/S rod and a minimum of 1000 mm in length. The hook shall be driven hammering down with the mason’s hammer at 500 mm interval. This will be effective if driven into the cracked joint. A shorter length may also be used if the rocky face does not permit the bar, but the Project Manager’s approval shall be obtained prior to taking a decision.
- (e) The wire netting shall be well secured. If there are any minor concavity and convexity, the wire shall be secured by hammering down by mason’s hammer. Additional staples could be used as necessary. If some of the staples become weak and loose, they shall be jammed with 1:4 cement sand mortar in slurry form.
- (f) Measurement and Payment: Wire netting shall be measured in square metre. The payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, purchasing of wire net, fabrication and transportation of wire netting to the site, supply and driving of hooks, all labour, tools, equipment, materials, safety harnesses and incidentals to complete the work as specified in these Specifications.
- (5) Construction of Sub-soil Drains (Sub-surface Drains)

Sub-soil drains shall be installed and paid in accordance with the requirements specified in Section 1800.
- (6) Construction of Rip-rap Drain

Rip-rap drains shall be installed and paid in accordance with the requirements specified in Section 1800.

2014. SITE PROTECTION

- (a) The Contractor shall protect a planted site for the period specified in the Contract. Protection shall include the prevention of damage to the site works and plants by people and domestic or wild animals. It shall also include the tending of plants and improving their growth, as specified below.
- (b) The period of maintenance/site protection shall be twelve months unless otherwise specified in the Contract.
- (1) Provision and Role of Site Warden**
 - (a) The Contractor shall be required to provide an adequate number of site wardens to look after the site to fulfill the specified requirements. The function of Warden shall be broader than that of watchman. It shall also involve a number of routine maintenance operations.
 - (b) Warden shall be matured and reliable who need little supervision for the fulfillment of his duties. They shall be active and physically fit. Old people who are losing their strength shall not be employed. They shall be experienced agricultural workers familiar with caring for plants. They shall remain on site through all hours of daylight and through all adverse weather conditions. They shall not leave the site unattended for any reason whatsoever.
 - (c) The role of the Warden shall be primarily to tend the plants. He/she shall take the initiative in weeding, mulching, replanting failed plants, pruning and protecting plants against all pests. This will

require an active role of individuals with considerable energy and initiative. The Warden shall work constantly to maintain and improve the site and its bio-engineering plants.

- (d) The Warden shall also be required to protect plants on the site from damage by local people, domestic and wild animals. In doing this he/she shall use a friendly approach to the people as far as possible so that no conflicts arise between the locals and the Contractor.
- (e) Measurement and Payment: Site Warden employed under the Contract shall not be paid for separately. All costs associated with the employment of warden as well as execution of works specified shall be considered to be included in the item rate of "Site Aftercare and Maintenance".

(2) Fabrication of Bamboo Tree Guards

- (a) The Contractor shall provide bamboo tree guards as shown on the Drawing or specified in the Contract. This shall be done according to the specification described hereunder, as and when required. The Contractor shall supply all necessary supervision, resources and facilities to ensure that these requirements are met.
- (b) The bamboo strips used to make bamboo tree guards shall be made from bamboos (*Bamboos mutants subs copulate*) whilst the uprights are to be made from (*Bamboos mutants subs mutants* or *Bamboos balboa*) from bamboo. Bamboo tree guards shall be a minimum of 450 mm in diameter by 1300 mm in height so that they are able to provide sufficient protection from grazing for the first 18 months after planting the seedling.
- (c) The guard shall be made by cutting 5 bamboo posts which are a minimum of 50 mm wide by 10 mm thick and at least 1600 mm long. The posts shall be cut so that they have a strong spear-like point at the bottom that can be driven into the ground when placing out on site. The bamboo poles used to make the uprights shall be a minimum of 3 years old.
- (d) Bamboo strips, a minimum of 5 mm thick and 50 mm wide shall be cut from poles that are at least 2 years old. The bamboo used shall be split so that the outer wall remains intact. Only lengths with the outer wall intact shall be used. The split bamboo shall be the length of the whole bamboo pole that it is cut from, or as long as possible. The split bamboo shall be woven in and out of the bamboo uprights and pulled tight, so that it is firm and strong. The end of each of the strips shall be woven back into the basket and tied with binding wire to keep it in place. End pieces shall not be left sticking out and unbound, because they quickly get broken and the basket starts to unravel from this point. The split bamboo shall be woven round the poles so that when they are tightly pressed down there are no gaps in the guard.
- (e) Measurement and payment: No separate payment shall be for the fabrication of the bamboo tree guards. All associated costs shall be considered to be included in the item rate for "Site Aftercare and Maintenance".

(3) Placement of Bamboo Tree Guards

- (a) Tree guards shall be installed on site at the time of planting, no later than the second week of July, and shall be placed carefully around the planted seedlings.
- (b) The tree guards shall be placed over the seedling immediately after planting. The upright posts shall be firmly driven at least 300 mm into the ground so that the guard is able to resist bashing and rubbing from cows, buffalo, goats and people. The woven slats shall be pushed down firmly from the bottom upwards so that they touch one another and are free from large gaps.
- (c) Tree guards alone are not adequate protection for small plants. The Contractor shall provide a site Warden in addition, for the time specified, to maintain the tree guards and ensure that local people respect them, and generally fulfill all the requirements of Section 1900.

- (d) Measurement and Payment: No separate payment shall be made for the placement of the bamboo tree guards. All the associated costs shall be deemed to be included in the relevant item rate for "Site Aftercare and Maintenance".

(4) Fencing

Fencing shall be executed as per the instruction of the Project Manager but payment shall be included in the item rate of "Site Aftercare and Maintenance".

2015. SITE AFTERCARE AND MAINTENANCE

- (1) The Contractor shall maintain planted bio-engineering sites as required by the Project Manager. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise and resources to ensure that these requirements are met.
- (2) The Contractor shall carry out weeding as required throughout the site. All annual weeds and other unwanted plants shall be cut just above the ground and the aerial parts will be used to make compost or mulch. Weeds shall not be pulled out by the roots since this disturbs the ground surface.
- (3) Weeding shall be carried out throughout the growing season. It shall be undertaken with particular diligence at the end of the monsoon, so that there is the minimum amount of competition during the subsequent dry season.
- (4) The Contractor shall carry out mulching as required throughout the site. All plants required under the bio-engineering specifications will be mulched using material prepared as specified in Clause 1905, or the aerial parts of weeds cut on the site or brought from elsewhere for the purpose. The desired plants shall be kept mulched at all times but special care shall be taken in the spring, when the soil moisture deficit is at its highest.
- (5) The Contractor shall replace failed, damaged, diseased and very weak plants, using fresh, healthy plants of the same species, at the correct time of year for planting. This replanting operation shall normally be carried out during the monsoon in the year following the first planting works. Vegetation structures shall be enriched by the planting of additional cuttings or seedlings, as instructed by the Project Manager. Failed seeding areas shall be reseeded at the appropriate time of year.
- (6) In replanting and enrichment works, the Project Manager may specify the use of different species. This shall be done where failures or poor performance of plants may be attributed to poor stock or an incorrect initial choice of species.
- (7) All bio-engineering sites shall be maintained so that there are at least the following two storey of vegetation. In certain locations, however, there may be a number of additional vegetation storeys.
 - (a) A dense ground cover of healthy grass plants, in the configuration specified at the time of planting.
 - (b) An open canopy of shrubs or trees with a deeper rooting network.
- (8) In general it shall be necessary to keep the upper canopy thinned in order to maintain the lower ground cover. Most grasses require high light intensities and become degraded if subjected to excessive shade from the overstorey. It shall therefore be the Contractor's responsibility to thin the canopy as necessary to permit adequate levels of light to penetrate for the optimum growth of the grass understorey.

- (9) All thinning and pruning operations shall be undertaken in accordance with the guidelines issued by the Environment Specialist. Since these are skilled silvicultural operation, the Contractor shall take appropriate professional advice and employ suitably skilled personnel.
- (10) All products from thinning and pruning operations shall be disposed off in accordance with the regulation in place. The Contractor shall follow the instructions of the Project Manager in this regard.
- (11) Other maintenance operations shall be undertaken by the Contractor according to the instructions of the Project Manager.
- (12) Measurement and Payment: The works shall be measured in a lump sum basis. The item rate shown in the Bill of Quantities shall be the full and the final compensation to the Contractor for carrying out all works specified herein including provision of site protection specified in Clause 1914.

Should at any time the Project Manager issue any instruction for the proper Site Protection/Aftercare and Maintenance and the Contractor does not respond within 24 hours, the Project Manager shall engage other individuals/parties to carry out the works. Any costs involved by such actions shall be borne by the Contractor.

2100. TRAFFIC SIGNS, ROAD MARKING, SAFETY BARRIERS

2101. PERMANENT TRAFFIC SIGNS

(1) Scope

This Clause covers the supply and erection of permanent road traffic signs along the roadside, over the carriageway and cross roads and at the locations indicated on the Drawing or as directed by the Project Manager.

(2) Materials

(a) Mounting Posts

Mounting post shall be of either 50 mm internal diameter steel tube of “heavy” category or 78 mm by 38 mm C channel. Structural steel shall comply with the requirements of IS 2062. Steel tube shall comply with IS 1161. Posts constructed from wood or reinforced concrete shall not be accepted.

(b) Bolts, Nuts and Washers

Steel bolts and nuts shall conform to IS 1367. All steel bolts, nuts and washers shall have a hot-dip (galvanised) zinc coating.

(c) Back Support Frames

Unless otherwise specified sign plates shall be supplied with a back support frame of a size and design to avoid the plate being deformed due to wind pressure or manipulation by vandals. The frame shall be made of a steel angle riveted or bolted to sign plate and shall incorporate brackets to enable the sign plate to be bolted to the sign plate.

(d) Steel Plate

Steel plate shall be 2.00 mm thick and comply with the requirements of IS: 1079. After any cutting, welding and punching has been completed all sharp edges shall be uniformly rounded off and smoothed down. All physically adhering contaminants shall be removed and then thoroughly cleaned.

(e) Aluminium Plate

Aluminium plates used for signs shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS: 736 – Material Designation 24345 or 19000 and shall be 2.0 mm thick unless otherwise specified. After any cutting, welding and punching has been completed all sharp edges shall be uniformly rounded off and smoothed down. The plate shall be degreased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth and plain surface. After cleaning, metal shall not be handled except by a device or clean canvas glove.

(f) Retro-Reflective Sheeting

The reflective sheeting shall be either high Intensity reflective sheeting, as specified in the contract. The retro-reflective sheeting shall be of the enclosed lens type consisting of microscopic lens elements embedded beneath the surface of a smooth, flexible, transparent, waterproof plastic. The adhesive backing shall be either of pressure-sensitive aggressive tack type requiring no heat, solvent or other preparation for adhesion, or tack-free adhesive activated by heat in a Heat Lamp Vacuum Applicator in a manner specified by the sheeting manufacturer. The adhesive shall form a durable bond to smooth, corrosion and weather-resistant surface of the sign plate such that it shall not be possible to remove the sign sheeting from the sign plate.

The reflective sheeting shall conform to the following requirements:

- (i) The sheeting shall have high reflectivity normal to vehicle headlights dependent on the angle of incidence. The reflective material shall be sharp and glare less and directed towards the light source at an approved angle of incidence.
- (ii) The surface of the sheeting shall be smooth and flexible. No cracking shall occur when bent. Reflective sheeting shall have high durability under all weather conditions, heat and moisture and be strongly fungus-resistant.
- (iii) The sheeting shall not delaminate, blister, crack, peel and chip during the manufacturing process and during its service life.
- (iv) The sheeting supplied shall be free from dirt, solid lumps, scales, ragged edges and non-uniformity of colour.
- (v) The colour of the sheeting shall be even and free from any spots or loss of colour. The colour shall not fade under local weather conditions during its expected service life.
- (vi) Colours of sheeting used must correspond to the colours of the sheeting supplied as samples.
- (vii) The reflective surface of the sheeting shall be durable and remain sharp during its expected service life. Bad weather conditions such as rain, dew, etc. should not reduce the reflectivity.
- (viii) The reflective surface of the sheeting shall be easily cleaned with soap and water with no adverse effect on its reflectivity and durability when used on the roads.
- (ix) The adhesive used on the backing of the sheeting shall give a high quality bonding to clean, smooth and grease free aluminium or other sign plates approved by the sheeting manufacturer. The adhesive shall withstand the conditions without allowing the sheeting to peel.

(g) Paints

Zinc chromate primer shall comply with the requirements of IS: 2074. Other types of primer and enamel paints shall comply with relevant standards as approved by the Project Manager.

(3) Protective Painting

(a) Steel Surfaces

The prepared surface shall be given two coats of a zinc chromate primer conforming to IS 2074. The first coat shall be applied within 12 hours in the case of wash-primed surfaces and within 4 hours, but before any oxidation of the surface takes place, in the case of abrasive blasted surfaces.

(b) Aluminium Surfaces

Part of the sign plate not covered by the sheeting, including the reverse of the plate shall be applied with protective paint, applied by either stove-enameling or powder –coating process.

(4) Signs

The regulatory, warning and information signs shall be of the standards as detailed in the Drawing or prescribed by the Department of Roads. The colour, configuration, size and location of all traffic signs shall be in accordance with the same standards.

The signs shall be either reflectorised or non-reflectorised as shown in the Drawing or instructed by the Project Manager.

(5) Manufacturing of Signs and Posts

(a) Non-reflective Sign Faces

Non-reflective sign faces shall be manufactured from steel plate.

The background shall be painted with air-brush technique. The legends, borders, symbols, designs, etc. shall be screen printed.

(b) Retro-reflective Sign Faces

Retro-reflective sign faces shall be manufactured from aluminium plate. The background, legends, borders, symbols, designs, etc. shall be made by applying cut-outs. All the sheeting, except in black, shall be retro-reflective.

(c) Size and Shape of Signs

The size and shape of the signs shall be manufactured in strict accordance with the details provided in the Drawings or as prescribed by the Department of Roads.

Traffic sign faces shall be manufactured as one unit. Traffic signs too large to be transported as one unit may, with the approval of the Project Manager, be manufactured in sections. The completed sections shall be assembled in the shop prior to delivery to ensure that all sections fit together properly and that the legends are correctly spaced and aligned. Joints in sign faces shall only be provided at locations and to details approved by the Project Manager.

(d) Welding

All welding of steelwork shall be carried out in accordance with the standards approved by the Project Manager. Welding shall be done before painting.

(e) Metal Extrusions

Metal extrusions for sign faces shall be joined together by rivets or bolts. They shall not be joined longitudinally but, if this cannot be prevented without excessive waste, they shall be joined neatly and joints staggered. No sections shorter than 500 mm shall be used.

Where aluminum extrusion are to be faced with retro-reflective background material, it shall be pre-applied to individual sections before assembly with the material taken around the face edges of each extension for at least 10 mm. Retro-reflective material shall be heated to facilitate binding around edges without damaging the material. Unless otherwise instructed by the Project Manager, letters across the joint between two extrusions shall be avoided.

(f) Galvanising

Where the galvanizing of structural steel plates, back support frames and posts are specified, it shall be done after welding. However, if this is not practicable, the steel sections shall be galvanized before assembly and then welded. All welds shall be thoroughly cleaned, loose material removed and dressed after which the welds shall be coated with two coats of an approved zinc-rich paint. Unless otherwise specified in the contract, galvanized steel shall not require painting.

Where details for the construction of sign faces, the framework of the sign faces and the attachment thereof to the supporting framework are not shown in the Drawing, the Contractor shall design these himself and submit the details to the Project Manager for approval before manufacture.

(g) Posts

The total length of the post shall be determined in such a way that the bottom side of the sign is 1.75 m above the carriageway surface. The section of the post shall be as shown on the Drawing or as instructed by the Project Manager.

(6) Painting

(a) Colours, Symbols and Legend

Paint colours, symbols, legend, size of letterings and borders used on road signs shall comply with the standards as prescribed by the Department of Roads.

(b) Preparation of Surfaces and Application of Paint

The preparation of surfaces and painting shall be carried out in a manner to ensure that they are free from rust and scale.

Structural steel for sign face supports and framework shall be given a wire brush surface preparation and painted. Unless otherwise specified, all painting work shall be carried out in accordance with IS:1477.

(c) Time of Painting

Painting shall not be carried out more than six months prior to erection.

(7) Storage and Handling

All sign faces shall be protected by an easily-removable liner after manufacture. The liner shall be removable by peeling without soaking in water or other solvent and shall be suitable for the type of material used as the sign plate.

All traffic signs or portions of traffic signs shall be carefully handled and stored in a weather-proof storeroom to prevent any permanent deformation or damage to painted surfaces.

Package for shipment shall be in accordance with commercially acceptable standard to prevent movement and chafing. Sign faces shall be protected from scratching, rubbing and other damages. Sign shall remain dry during shipment.

(8) Erection of Traffic Signs

(a) Position

Traffic signs shall be erected in the positions and in the manner as shown on the Drawing or instructed by the Project Manager.

(b) Excavation and Backfilling

Excavations for the erection of traffic signs shall be made according to the dimensions shown on the Drawing.

Unless otherwise specified, the foundation for sign mounted on a single post shall be 300 mm X 300 mm and 300 mm deep. The foundation for signs mounted on two or more posts shall be 450 mm x 450 mm and 600 mm deep. The concrete shall be of grade M10/40 as per Section 1700 of these Specifications. The upper surface of the concrete shall be neatly finished with sufficient fall to ensure proper drainage.

(c) Erection

Traffic signs shall be erected as shown on the Drawing or directed by the Project Manager. During erection, the sign faces shall be firmly bolted and protected in order that no buckling or damage is caused during erection, or by the equipment used for erection. Posts to which traffic signs are to be fixed shall be vertical, and the undersides of traffic signs shall be horizontal after completion of erection.

(d) Field Welding

All welding done during erection shall comply with the requirements for welding during manufacture.

(e) On Site Painting

All painting done after erection shall comply with the requirements for painting during manufacture. All places where the painting work has been damaged before or during erection shall be made good by the Contractor at his own cost to the satisfaction of the Project Manager.

(f) Time of Erection

Road traffic signs shall be erected immediately prior to the opening of the road to public traffic unless otherwise decided by the Project Manager.

(9) Tests and Standards of Acceptance

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Project Manager.

The work shall conform to the relevant Specifications and shall be true to the lines, levels and dimensions as indicated on the Drawing or as directed by the Project Manager.

(10) Measurement

The measurement of permanent traffic signs shall be in numbers of each type of signs supplied and erected in accordance with these Specifications. Excavation, concrete for foundations and backfill shall not be measured. They are deemed included in the measurement of the traffic signs.

(11) Payment

The quantities measured as provided above shall be paid at the respective contract unit rates for each type of signs. The contract unit rates shall be the full and the final compensation to the Contractor as per Clause 114 and also for the cost of excavation, concrete for foundation, backfill and all other incidental works required to complete the work as specified.

2102. ROAD MARKINGS

(1) Scope

This Clause covers the permanent marking of the road surface with white or yellow paint as indicated on the Drawing or instructed by the Project Manager. The colour, width and layout of road marking shall be in accordance with the standards prescribed by the Department of Roads.

This also covers the reflective glass beads installed on the pavement surface along the road centerline to identify the course of the carriageway in darkness or bad weather.

(2) Materials

Paint shall comply with the requirements of BS 6044 (1987) or equivalent or as specified by the Project Manager. If specified in the contract, the paint may also be reflectorised paint, in which case the paint shall be reflectorised by the addition of reflecting beads. The beads shall comply with BS 6088: 1981 (1993).

The paint shall be delivered to the site in sealed containers bearing the name of the manufacturer and the type of paint.

The viscosity of the paint shall be such that it can be applied without thinning. Under no circumstances thinning shall be allowed.

The colour to be used shall be bright white or yellow as shown on the Drawing or indicated in the Pavement Markings Manual, DOR.

(3) Weather Limitations

Road marking paint shall not be applied to damp surfaces or when the relative humidity exceeds 80%, or at temperatures lower than 10°C, or when, in the opinion of the Project Manager, wind strength is such that it may adversely affect the painting operations.

(4) Tools and Equipment for Painting

The paint shall be applied by brush or machine. However, before ordering paint, the Contractor shall inform the manufacturer the proposed method of application of paint to ensure that correct type of paint is ordered.

(5) Surface Preparation

Road markings shall be applied to bituminous surfacing only after sufficient time has elapsed to ensure that damage shall not be caused to the painted surface by volatile substances evaporating from the bituminous surfacing. In no case shall road markings be applied until at least 48 hours after the completion of the surfacing or any longer period required by the Project Manager.

Before the paint is applied, the surface shall be clean and dry and completely free from any soil, grease, oil, acid or any other material which shall be detrimental to the bond between the paint and the surface. The portions of the surface where the paint is to be applied shall be properly cleaned by means of watering, brooming or compressed air.

(6) Setting out of Road Markings

The lines or marks shall be set out by means of paint spots of the same colour as the proposed final lines and marks. These spot marks shall be at such intervals as needed to ensure that the road markings can be accurately applied, and in no case they shall be more than 1.5 m from each other.

After spotting, the positions of the proposed road markings such as dotted lines, starting and finishing points shall be indicated on the road. Pre-marking shall be approved by the Project Manager prior to the commencement of any painting operations.

The positions and outlines of special markings shall be produced on the finished road in chalk and shall be approved by the Project Manager before they are painted. The use of approved templates shall be permitted on the condition that the positioning of the marking is approved by the Project Manager before painting is commenced.

(7) Application of Paint

Where the paint is applied by means of a machine, it shall be applied in one layer. Before the road marking machine is used on the pavement, the satisfactory working of the machine shall be demonstrated on a

suitable site which is not part of the pavement. Adjustment to the machine operation shall be followed by further testing. Only when the machine has been correctly adjusted, and the use thereof is approved by the Project Manager after testing, the machine may be used on the pavement. The operator shall be experienced in the use of the machine.

After the machine itself has been satisfactorily adjusted, the rate of application shall be checked and adjusted, if necessary, before application on a large scale is commenced.

Where two or three lines are required next to each other, the lines shall be applied simultaneously by the same machine. The paint shall be stirred before application in accordance with the manufacturer's instructions. Where painting is done by hand, it shall be applied in two layers, and the second layer shall not be applied before the first layer has dried out completely. As most road marking paint reacts with the bitumen surface of the road, the paint shall be applied with only one stroke of the brush or roller at any one point on the road to prevent reaction with bitumen surface.

Ordinary road marking paint shall be applied at a nominal rate of 0.42 litre/sq.m. for painted old surface, and 0.75litre/sq.m. for new surface, or as specified in the contract.

(8) Tolerances Requirements

Road markings shall be constructed to accuracy within the tolerances given below:

(a) Width

The width of the lines and other markings shall not deviate from the specified width by more than 5%.

(b) Position

The position of lines, letters, figures, arrows, and other markings shall not deviate from the true position specified by more than 20 mm.

(c) Alignment of Markings

The alignment of any edge or a longitudinal line shall not deviate from the true alignment by more than 10 mm in 15 m.

(d) Broken Lines

The length of segments of broken longitudinal lines shall not deviate from the specified length by more than 150 mm.

(9) Faulty Workmanship or Materials

If any material not complying with the requirements is delivered on the 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 Project Manager at the Contractor's own cost. Rejected road markings and paint which has been splashed or dripped on 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 split paint shall not show up again later.

(10) Protection

After the application of paint, the road markings shall be protected against damage by traffic or other causes. The Contractor is responsible at his own cost for the erection, placing and removal of all warning boards, flags, cones, barricades and other protective measures which may be necessary.

(11) Tests and Standards of Acceptance

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Project manager.

The work shall conform to these Specifications and shall be true to the lines, levels and dimensions as indicated on the Drawing or as directed by the Project Manager, subject to the tolerances as indicated in these Specifications.

(12) Application of Reflective Glass Beads

The reflective glass beads shall consist of plastic road studs 100x100x17.9 mm in dimension with 29 glass elements per side (2 rows) with two way reflective and 19 degree tilt for maximum reflection. It shall have two finger grips for easy handling on installation and flat base. The beads shall be installed on the road surface along the centerline of the carriageway.

(13) Measurement

The measurement of road marking shall be in linear meter for each type of marking. The measurement of reflective glass beads shall be in number.

(14) Payment

The quantities measured as provided above shall be paid at the respective contract unit rates for each type of road marking signs and reflective glass beads which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

2103. ROAD MARKER STONES

(1) Scope

The work covers the supply, painting, lettering and fixing of road marker stones and shall include Standard (Kilometer) Marker Stones.

The dimensions and other details of each type of marker stones shall be in accordance with the standards in use by Department of Roads.

(2) Materials

The marker stones shall be constructed of reinforced cement concrete of grade M15/20 as per the requirements of Section 1700. The paint shall be of non-reflectorised type.

(3) Construction

(a) Marker Stone Information Details

Each Kilometer marker stone shall contain following road reference and location information:

- Route Number
- Next Important Station
- Kilometrage

(b) Placing and Painting of Marker Stones

The location of the marker stones shall be as shown on the Drawing. They shall be placed at right angles to the centre line of the carriageway. On embankments they shall be located on the edge of the roadway at least 0.5m outside the road shoulder. Where there is no shoulder the marker stones shall be at least 1.5m outside the road edge, if necessary on specially erected platforms. In cut sections they shall be fixed clear of the shoulders as well as the side drains.

Marker stones shall normally be placed on the left hand side of the road as one proceeds from East to West and from South to North. On divided roads with a centre median the marker stones shall be placed on the left hand side of the road in each direction of travel. In hilly areas, where the road has a valley on one side and a hill slope on other, the marker stones shall be placed on the valley side of the road.

Marker stones posts shall be bedded into the ground with concrete foundation of grade M10/40 as shown in the Drawing. Marker stones shall be applied with a coat of primer and two coats of enamel paint.

(4) Tests and Standards of Acceptance

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Project Manager.

The work shall conform to these Specifications and shall be true to the lines, levels and dimensions as indicated on the Drawing or as directed by the Project Manager.

(5) Measurement

Each type of road marker stones shall be measured in number. Excavation, concrete foundation and backfill shall not be measured separately. They are deemed included in the measurement of marker stones.

(6) Payment

The road marker stones measured as provided above shall be paid at the respective contract unit rate for each type of stone which shall be the full and the final compensation to the Contractor as per Clause 114 and also for the cost of excavation, backfilling concrete foundations and all other incidental works required to complete the work as specified.

2104. DELINEATOR POSTS

(1) Scope

The work covers supplying and fixing of delineator posts. The design and painting of the posts shall be in accordance with the standards of Department of Roads.

(2) Materials

The delineator posts shall be constructed of reinforced concrete of grade M20/20 in accordance with Section 1700 or as shown in the Drawing. Paint shall be non-reflectorised paint and shall be as approved by the Project Manager. It shall be fitted with reflective element as shown in the Drawing.

(3) Manufacturing

Posts shall be manufactured to the dimension shown on the Drawing or as per the standards of Department of Roads. Forms shall be smooth and have accurate dimensions. The concrete mix shall be placed in the forms and vibrated. The posts shall be reinforced as detailed in the Drawing.

The posts shall be true to the shape, smooth and without honeycombing or other blemishes. The posts shall be provided with recess.

(4) Erection and Painting

Posts shall be erected after the completion of pavement surfacing. Holes shall be excavated at a distance of 600 mm from the road edge or at locations instructed by the Project Manager. The posts shall be placed vertically and square to the road center line. Backfilling shall be compacted in layers not exceeding 150 mm thick right from the bottom of the hole.

The posts shall be applied with a coat of white cement primer and two coats of synthetic enamel paint. The paint shall be applied in 200 mm wide alternate strips of white and black starting from the top.

The posts shall be painted immediately after placing. If specified in the contract or shown in the Drawing the posts shall then be provided with 100 mm x 80 mm reflective element.

(5) Tests and Standards of Acceptance

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Project Manager.

The work shall conform to these Specifications and shall be true to the lines, levels and dimensions as indicated on the Drawing or as directed by the Project Manager.

(6) Measurement

The delineator post shall be measured in number. Excavation, preparation of foundation and backfill shall not be measured separately. They are deemed included in the measurement of posts.

(7) Payment

Delineator posts measured as provided above shall be paid at the contract unit rate for each type of post. The contract unit rate shall be the full and the final compensation to the Contractor as per Clause 114 and also for the cost of excavation, backfill, painting reflecting elements (where specified) including all other incidental costs required to complete the work as specified.

2105. METAL CRASH BARRIER

(1) Scope

This Clause covers the materials required and construction of metal crash barrier. The barrier shall be single side single W-beam metal crash barrier with related accessories like beam, spacer, channel, post and fastener. The W-metal beam crash barrier shall comprise of 3mm thick corrugated sheet metal beam rail, 312 mm minimum width, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150x 75 x 5mm spaced at 2 m centre to centre, 1.8 metre high, 1.1 m below the ground/road level. The W-beam rails should be fixed on the vertical post with a spacer of channel section 150x75x5mm, 330mm long.

(2) Materials

Unless otherwise specified the materials for the metal crash barrier shall meet the following specifications:

W-Beam: It should be cold rolled formed section, minimum 3 mm thick, hot dip galvanized, 550g/sq.m and raw materials conforming to IS:5986 Gr.Fe 360(ST-37)/Fe.

Post and Spacer: It should be cold rolled formed section, minimum 5 mm thick, hot dip galvanized, 550g/sq.m and raw materials conforming to IS:5986 Gr.Fe 360(ST-37)/Fe.

The Contractor shall provide 12 months manufacturer's warranty for each items of the metal crash barrier from the date of acceptance of each item at site.

(3) Construction

The crash barrier shall be constructed at the locations shown on the Drawings or as instructed by the Project Manager. The W-Beam spacer post shall be cast in M15/20 concrete block (400x400 mm) 700 mm deep. The concrete for the block shall comply with Section 1700 of the Technical Specifications. The related earthworks shall comply with Section 600 of the Technical Specifications.

After the concrete has fully set, the crash barrier shall be erected by assembling beam, spacer channel and other accessories.

(4) Tests and Standards of Acceptance

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Project Manager. The work shall conform to these Specifications and shall be true to the lines, levels and dimensions as indicated on the Drawing or as directed by the Project Manager, subject to the tolerances as indicated in these Specifications.

(5) Measurement

The measurement of metal crash barrier shall be in linear meter.

(6) Payment

The quantities measured as provided above shall be paid at the respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 114 to complete the work in accordance with these Specifications.

2106. RETRO-REFLECTIVE POST

(1) Scope

This Clause covers the materials and construction of retro-reflective post.

(2) Materials and Construction

Unless otherwise specified the materials for the retro-reflective post shall be 40 mm dia MS welded tube, medium grade. The post shall be 1000 mm long with 500mm bottom portion embedded in the stone masonry parapet. The top 500 mm of the post above the parapet surface is painted in 125 mm wide alternate layers of retro-reflective paint and black enamel paint. The specifications of the paints shall be as approved by the Project Manager.

(3) Measurement and Payment

The retro-reflective post shall be measured in number. The payment shall be at the contract unit price, which shall be full and final compensation to the Contractor as per Clause 114 of the specifications.

2200. QUALITY ASSURANCE FORMS

2201. SCOPE

Standard forms for quality assurance have been provided for implementation of quality **assurance** system as per the international code of best practice. Only the selected forms have been added and any additional forms, if required, shall be adopted during the implementation.

2202. REQUEST FOR INSPECTION SHEET (RFI)

The contractor shall submit Request For Inspection (RFI) prior to start of any work activity. Similarly the contractor shall submit the same again after the completion of the same activity. The contractor shall provide adequate time after submission of RFI so that the Project Manager or his representative shall make themselves available at the site for the inspection. The contractor shall not be relieved of his obligations if the quality of works have been found to be sub-standard even after implementation of the RFI.

2203. NON-CONFORMANCE REPORT (NCR)

The Project Manager shall issue Non- Conformance Report (NCR) in the event the material or works are not implemented as stipulated in the technical specification. The contractor shall propose any corrective action and shall implement the same within the time frame agreed between the Project Manager and the Contractor.

2204. QUALITY ASSURANCE PLAN (QAP)

The contractor shall prepare comprehensive Quality Assurance Plan as well as condensed form of QAP as per the sample format and get it approved within a month from the date of award of the contract. The QAP shall be prepared in conjunction with the work schedule. Any updating of the work schedule will require QAP to be updated accordingly to complete the test program within the work schedule.

2205. TEST REQUEST FORM

Test request form is to be used for delivering sample material to the central laboratory or other regional laboratory outside the project. This form shall be used by the contractor to deliver sample material jointly collected by the Project Manager or his representative(s) and the contractor when there are no test facilities in the field laboratory or the central laboratory of the project.

There are two type of forms

- (i) specifically designed for testing the crushing strength concrete cubes and
- (ii) the other form for testing the materials other than concrete.

2206. MONTHLY FIELD/LABORATORY REPORT FORM

Monthly laboratory/field test report shall be submitted by the contractor using sample form. The monthly test report shall cover number of test covered during the period of reporting as well as the cumulative number of test covered since the start of the project.

REQUEST FOR INSPECTION (RFI) SHEET

Appendix: _____

Name of Project _____ Contract Package: _____

To,

Dear Sir,

You are kindly requested to attend the inspection as follows:

Inspection No.	IRS-01							
Site	FC	Subgrade	GSB	B. course	Permanent works	Drainage	Bridge	Others
Inspection date & time								
Location								
Item Description								

Your kind attention will be highly appreciated

Yours sincerely

(Name)

Designation & Co.



Inspection Result Sheet

Work Item	Inspection date:		
Description: Eg. Compaction is satisfactory except the subgrade which does not comply with cross slope			
Inspection Result			
See attached inspection sheet (IS) - 1	Satisfactory	Unsatisfactory	Others
Signature			
Client (PMU): _____	Consultant _____	Contractor _____	

NON-CONFORMANCE REPORT (NCR) FORM

NCR No:	Issued on:	
Name of the project:	Location	
Implementing Agency:		
Name & designation of responsible person:		
What was expected?		
What has been found?		
What is the root cause of non-conformance?		
Tech Examiner (if applicable)	Project Manager's Representative	Date:

Corrective action (to be proposed by Contractor Engineer & agreed by PMU/Consultant)

Tech examiner/Engineer (as applicable)	Contractor Engineer	Corrective action to be completed on :
--	---------------------	--

Recommended recurrent prevention action:

Responsible Agency/person for taking action:

Tech Examiner/Engineer (as applicable)	Action to be completed on
--	---------------------------

(Please tear this part & return to PCO, ORIO not later than the stipulated date for completion of action)

NCR No.:

Issued on:

Corrective action to be completed on:

Completed on:

Recurrence prevention action to be completed on:

Completed on:

(Tech Examiner/Engineer/Engineer's Representative) as applicable

Quality Assurance Plan (QAP)

Project Name:

Contract award date:

Contract package No.

Contract completion date

Chainage

Contract duration

		As per specification				Schedule			
S N	Type of work	No. test(s)	Frequency(ies)	BoQ Qty	Unit	No. of test reqd as per site condition	From	To	Remarks
1	Earth Works								
	1. MDD/OMC								
	2. Field density test								
	3. Deleterious content test								
	4. Moisture content								
2	Sub-Base								
	1. Gradation								
	2. Atterberg limits								
	3. Density of compacted layer								
	4. CBR								
3	Base								
4	Bituminous works								
	A. Aggregate								

1. Aggregate grading									
2. FI (<30%)									
3. LAA (<40%)									
4. Agg. Impact value (AIV)									
5. Rate of application of Agg.									
B. Bituminous Binder									
1. Quality of binder									
2. Binder temperature									
3. Rate of application									

Submitted by:

Contractor's engineer signature _____ Engineer/Engr's rep. signature _____

Date: _____ Date: _____

Sample History Form (For concrete/cement mortar cubes)

Organization/Agency:	Division/Project:
	Date:
To	

Subject: <u>Material testing</u>	
Kindly carry out the compressive strength tests on the concrete cubes with the following details. Necessary tests charges (if any) would be borne by _____.	
Name of work:	Location:
Name of contractor:	
<u>Details of concrete cubes</u>	
1. Date of casting:	_____
2. Mix ratio (by weight/by volume)	_____ (please specify if different material is tested eg. Cement mortar)
3. Required compressive strength for:	<u>M10/M15/M20/M25/M30</u>
4. Specific works/structural member:	_____
5. Cube identification marks	_____

6. Desired date of cube test		
_____	_____ 7 days	Date:
_____	_____ 14 days	Date:
_____	_____ 28 days	Date:
_____	_____ Others	Date:
<p>Note: A minimum of 3 cubes (preferably more) comprising one set shall be submitted for each work/ structural member. Cubes so prepared shall cover the entire concreting operation at any particular period</p>		
_____	_____	
Name & sig. of contractor's engineer	Name & sig. of Engr/Representative	
Date:	Date:	
Delivered to:	Date:	(copy to be retained)

Sample History Form (For General works other than concrete cubes)

Organization/Agency: To _____ _____ _____	Division/Project: Date
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Subject: **Material testing**

Kindly carry out the compressive strength tests on the concrete cubes with the following details. Necessary tests charges (if any) would be born by _____.

Name of work:

Location:

Source of sample material:

Sampled by:

Name of contractor:

Date of sampling

Details of sample material

Sample name/ref. no.	Description of material	Desired test
1. Gravelly clay/ch. 10+240		
2.		
3.		
4.		

Note: In case of doubts contractor shall enquire on the test sample quantity and test type from the laboratory.

_____	_____
Name & Sig. of contractor's Engr.	Name & sig. of engr./representative
Date: _____	Date: _____

Delivered to: _____

Date: _____ (copy to be retained)

2300. ENVIRONMENTAL MANAGEMENT PLAN

2301. GENERAL

This section provides guidelines for the implementation and monitoring of Environmental Management Plan (EMP) during construction.

An Environmental Management Plan (EMP) is a plan for mitigating or minimizing all negative environmental impacts anticipated in the project and monitoring the implementation of the mitigation measures. An EMP can either be general or site specific.

A general EMP includes a plan for mitigating and minimizing negative environmental impacts for all general construction activities which are applicable to all construction works under the project.

A site specific EMP includes environmental mitigation measures that need to be followed and implemented in specific locations that are environmentally sensitive.

The contractor shall be responsible for implementing all general and site specific EMPs and complying with the requirements of these EMPs while executing the works under the contract. The contractor shall abide by any changes in the EMP consequent to change in environmental situation after the initiation of construction work. In such situation the EMP shall be revised by the project and the contractor shall implement and comply as per the revised EMP.

2302. GENERAL EMP DURING CONSTRUCTION

The contractor shall consider the potential negative impacts and carry out the proposed mitigation measures in the implementation of general EMP while executing the works as per the contract. The requirements under general EMP are provided in **Appendix I**.

2303. SITE SPECIFIC EMP DURING CONSTRUCTION

The Contractor shall consider the potential negative impacts and carry out the proposed mitigation measures at site specific level and implement site specific EMP while executing the works at the identified locations. The requirements under site specific EMP are provided in **Appendix II**.

2304. EMP IMPLEMENTATION AND MONITORING

During construction, the Contractor shall comply and implement the EMP on a regular basis. The contractor shall maintain approved EMP Implementation Sheet in order to monitor the progress of implementation of the EMP. All mitigation measures implemented must be included in the EMP Implementation Sheet. The contractor must refer to both general and site specific EMPs and comply with mitigation measures in the EMP Implementation format. A sample format for EMP Implementation Sheet is provided in **Appendix III**. The format for EMP Implementation Sheet shall be as approved by the Project Manager. The location or chainage where the mitigation measures are implemented shall be mentioned in the sheet. Where new environmental impacts or issues not included in the EMP arise it shall be mentioned under the Deficiencies/Remarks/Observations column.

The contractor shall submit the completed EMP Implementation Sheet to the project Manager on a monthly basis. The consultant will cross-check and verify the implementation of EMP according to the approved EMP Implementation Sheet. Any deficiency found in compliance to EMP and to its implementation shall be instructed to the contractor by the Project Manager. The contractor shall immediately undertake and carry out any additional measures required to comply with the requirements of general and site specific EMPs as deemed necessary.

In addition, the contractor should be aware that monitoring visits may be made by other relevant stakeholders such as the officials of the Environmental Unit of the Department of Roads, National Environment Commission and others during the execution of the contract. The Contractor shall be instructed as per the requirements based on observations of such site visits, if any and the contractor shall abide by such instruction from the Project Manager.

2305. MEASUREMENT AND PAYMENT

No measurement and payment shall be made for the works required under this section. All costs in connection with the requirements specified herein shall be deemed included in the rates and prices of related items of works in the Bill of Quantities.

Appendix I : General Environmental Management Plan of Gesarling-Dagapela SNH (Section –C)

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
Impacts on Air Quality and Noise during Construction							
1.	Excavating, grading, finishing	Dust, fumes and noise in the vicinity of the worksite. Temporary damage to adjacent land use and exposure to air and noise pollutants.	Reduce ambient dust levels by regular spraying of water on exposed earth in construction zone and haul routes where there is potential for human exposure. Remove construction debris and spoil piles Impose traffic controls to reduce public exposure. Cover transport vehicles	Settlement Areas	CC	PMO and CSC/ES	Inform public through their geog administration about the timings of road construction activities
2.	Use of quarries and borrow pits	Air and noise pollution	Spraying of water in quarrying areas and proper covering of vehicles carrying quarried materials	Quarries and construction sites	CC	PMO and CSC/ES	
3.	Construction activity near businesses and community areas	Blocks access, disturbs daily life of community and produces noise, dust and congestion	Select haul routes around community areas Operate vehicles during restricted hours in village limits Introduce traffic controls to reduce contact between the public and construction activity. Complete segments passing through populated areas before starting new construction	Business and settlement areas	CC	PMO and CSC/ES	Inform public through geog administration about the timing of road construction works
4.	Cement mixing, hot mix asphalt blending, rock crushing and asphalt curing	Noxious odors and fumes.	Locate facilities at a sufficient distance from human receptors to eliminate the impact. Conduct activities during daylight hours if there are communities nearby.	Construction sites	CC	PMO and CSC/ES	Discussion with the local geog authorities and people living nearby on the location of crushing plant and cement mixer etc.

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
			Water areas where dust accumulates regularly. Locations for facilities jointly approved by the PMO and the local authorities.				
5.	Blasting of rock	Noise and safety hazard	Prepare a blasting procedure requiring area restrictions, prior warning of workers and nearby residents, restrictions on the timing of blasts and worker safety. Utilize control blasting whenever possible. Limit blasting to midday hours in all areas with wildlife. Procedure to be approved by the PMO and applied rigorously in the work environment.	Rock Stretch	CC	PMO and CSC/ES	Discussion with local geog or Drungkhag authorities on the blasting schedules. Geog or Drungkhag shall inform the general public of the agreed blasting schedules.
6.	Operation of construction equipments, machinery and vehicles	Air pollution from generation of harmful gases	Regular maintenance of all machinery, equipments and vehicles.	Construction zone	CC	PMO and CSC/ES	
Impacts on Soil Resources during Detailed Design and Pre-construction							
7.	Finalization of alignments considering topographical, seismic and geological conditions	Seismic events during operation cause damage to the roadway and adjacent property, and loss of life	Conduct topographical and geological studies; propose alignments to avoid landslide prone areas where possible; assess feasibility of alternative designs and alignments; and recommend preferred alignments based on due consideration of seismic risk	Design office	DC	PMO	
8.	Identification of quarries and borrow pit locations and estimates of quantities of materials	Impacts from hauling and degraded roadway surfaces during construction Hazard due to accident or slope failure during	Identify quarry locations, or consider other options, in conjunction with the selected construction contractor. Prepare development plan to estimate quantities and final contours.	Design office	DC CC	NEC PMO and	

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
		construction				CSC/ES	
9.	Recommendation of techniques for excavation and earth cutting works	Excess cutting and use of poor techniques resulting in landslides and slope failures	Incorporate EFRC construction techniques in the detailed design such as use of full cut method instead of box cut.	Design office	CC	PMO	
10.	Identification of site specific bioengineering techniques	Slope failures and erosion problems due to poor bioengineering techniques	Recommend techniques for specific sites based on existing practices within the region and the DOR's Manual on Bioengineering.	Design office	CC	PMO	
11.	Recommendation of drainage structures for wet and unstable areas	Slope failures during operation due to poor drainage in the road site	Identification of appropriate drainage structures such as horizontal drains suitable for specific site conditions	Design office	CC	PMO	
12.	Clearing and grubbing before initiating construction works	Degradation of surface water quality. Soil loss from exposure to rain and flowing water, and increased sediment in rivers and streams.	Stop land clearing and excavation in rainy periods. Use Log or boulder barriers at the base of slopes subject to erosion. Seed and stabilize slopes and embankments. Include costs for sediment control in the contract bid proposal	Construction zones	CC	PMO and CSC/ES	
13.	Identification of disposal sites for construction debris	Improper disposal of construction debris resulting in scarred landscape	Identify suitably located disposal sites for construction debris	Along ROW	CC	PMO and CSC/ES	Discussion with geog administration, Dzongkhag Environment Office and the public about the disposal area locations.
Impacts on Soil Resources during Construction							

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
14.	Cutting and excavation of the roadbed	Unstable slopes lead to soil loss	<p>Use balanced cut and fill method to minimize cut volume.</p> <p>Construction of log barriers on valley side of slope to hold any falling debris.</p> <p>Proper disposal of unearthed spoil to waste disposal site.</p> <p>Appropriate bio -engineering using local plant species to stabilize slopes</p> <p>Construction of retaining walls wherever needed</p>	Construction zones	CC	PMO	
15.	Blasting of rocky areas and slopes	Hazard due to accident or slope failure.	<p>Blasting procedures in effect at quarry and borrow pit. Local government clearance obtained prior to use of the area.</p>	Construction zones	CC	PMO	Discussion with local geog or Drungkhag authorities on the blasting schedules. Geog or Drungkhag shall inform the general public of the agreed blasting schedules.
16.	Geotechnical Risks to the Roadway Environment	Slope failure and landslides halt operation of roadway, require further reconstruction, and cause the loss of life and property	<p>Use balanced cut and fill method to minimize cut volume.</p> <p>Proper disposal of unearthed spoil to waste disposal site.</p> <p>Appropriate bio -engineering using local plant species to stabilize slopes</p> <p>Construction of retaining walls wherever needed</p>	Construction zones	DC	PMO	
17.	Disposal of construction debris	Improper disposal of construction debris over hillside resulting in scarring of landscape and loss of aesthetic beauty	<p>Prohibition of throwing of construction debris in any sites other than the designated disposal sites identified</p> <p>Proper restoration of the waste disposal area by covering with top soil and carrying out appropriate bioengineering works.</p> <p>No disposal of spoil and construction debris in</p>	Construction zones	DC	PMO	Discussion with geog administration, Dzongkhag Environment Office and the public about the location of disposal area.

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
			streams and rivers.				
18.	Operation of equipment storage and repair yards, and fuel depots	Oily waste is improperly disposed of; fuel is spilled and poor housekeeping causes soil.	Install secondary containment around fuel tanks and at fueling stations. Prevent oil and fuel spills, control runoff from contaminated areas.	Equipment yards and fueling stations	CC	PMO and CSC/ES	
19.	Closure of equipment yards and camps	Failure to render a site clean and safe at the end of use poses both a sanitary and safety hazard.	Remove above-grade structures, clean up construction camp debris and backfill latrines; grade, re-vegetate the area and tree planting under the compensatory forest program.	Construction and labor camps	CC	PMO and CSC/ES	
Impacts on Soil Resources during Operation							
20.	Operation of roadways	Landslides and other erosion issues	Adoption of appropriate engineering and bioengineering structures and techniques	Specific road section	DoR field staff	Dzongkhag, DOR	
21.	Operation of Roadways: Impacts due to Location	Seismic events cause damage to the roadway and adjacent property, and loss of life	Take appropriate engineering measures to fix damages.	Specific road section	DoR field staff	Dzongkhag, DOR	
Impacts on Water Resources and Water Quality during Construction							
22.	Excavation and cutting works	Disposal of excavated materials on hillside and nearby streams and rivers causing excess sedimentation, creation of temporary dams (and hence small floods thereafter),	Use of log barriers or boulder barriers at the base of slopes to hold any excavated material that may fall. No dumping of excavated material or construction rubble on hill side and into streams and rivers nearby (in accordance with DOR's EFRC guidelines) Reuse of excavated material as far as possible and disposal of unwanted material in proper designated	Construction zone	CC	PMU and CSC/ES	

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
		disturbances to aquatic ecology	disposal sites				
23.	Operation of equipment storage and repair yards, and fuel depots	Oily waste is improperly disposed of; fuel is spilled and poor housekeeping causes water pollution.	Install secondary containment around fuel tanks and at fueling stations. Prevent oil and fuel spills, control runoff from contaminated areas.	Equipment yards and fueling stations	CC	PMU and CSC/ES	
24.	Construction of road side drainage structures	Insufficient roadside drainage in community areas leads to flooding of adjacent property and buildings	Develop downstream drainage channels to assure continuity of the drainage system	Jobsite	CC	CSC/ES	
Impacts on Water Resources and Water Quality during Operation							
25.	Operation of roads	Plugging of culverts from debris during heavy downpours; channelization and damage to the roadway	Maintain culverts and remove debris that interferes with the flow in culverts	Roadway locations	DOR, Dzongkhag maintenance units	DOR	
26.	Operation of the Raidak - Lhamoizhingkha road	Increased access to the Oyster lake hence, increased disturbance to the lake's ecology through pollution and fishing	Regular monitoring and field surveillance	Around Oyster lake area	Local forestry staff	NCD	
Impacts on Forests during Pre-construction							
27.	Land clearing for roadways	Displacement of forest and destruction of natural	Prepare an inventory and remove marketable timber under a separate contract before construction begins. Clear only unmarketable trees and brush	Construction ROW	PMO/DOR	DOF	

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
		habitat	remaining in the construction right-of-way. Obtain necessary government permits for cutting trees	Dzongkhag Administration	CC	DOF	
28.	Land clearing for roadways	Clearing extends into adjacent forests: loss of habitat	Demarcate right-of-ways and trees before clearing begins.	Construction ROW	CC	PMO and DC/ES	Survey cost included in engineering package
Impacts on Forests during Construction							
29.	Land clearing for roadways	Displacement of forest and destruction of natural habitat	Provide compensatory planting to replace trees removed along the right-of-way. Abandoned camp sites could be potential locations for carrying out the plantations Revegetate of slopes above and below road through appropriate bioengineering techniques where necessary. Revegetate of road shoulders to help recover some of the vegetated area lost	Construction ROW	PMO/DOR	DOF	Discussion with Forestry Officials for jungle clearing and tree felling
30.	Land clearing for roadways	Clearing extends into adjacent forests: loss of habitat	Punish illegal removal of trees from public lands outside construction zone.	Construction ROW	Local Administration	DOF	"
31.	Clearing right-of-way	Excessive width causes unnecessary damage to hillside, increases need for rehabilitation and leads to unstable	Maintain minimum construction right-of-way, remove only trees that interfere with construction and limit access to adjacent land. Widening of the standard width of right-of-way to be approved by the PMO supervisor.	Construction zones	CC	PMU CSC/ES and	"

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
		slopes	Prohibit disposal of spoil materials and any other forms of construction debris over the edge of the hillside.				
32.	Operation of Workers	Workers fish, hunt and gather firewood; destruction of biological resources.	Prohibit fishing, hunting and gathering of firewood among workers. Provide construction camps with food supplies from purchased stores. Provide firewood for warmth from legitimate sources or stockpiled from materials cleared from the roadway construction zone.	Jobsites and labor camps	CC	PMU and CSC/ES/DOF	Discussion with local forestry officials on issue of illegal hunting, fishing and firewood gathering.
33.	Burning plant matter in construction zone.	Conflagrations, habitat destruction and regional air pollution.	Avoid burning plant residue by placement of materials into stockpiles outside the line of construction, preferably in contours along slopes below the roadway grade.	Construction zones	CC	PMU and CSC/ES	
34.	Blasting of rocks and excavation works	Disposal of spoil materials on lower slopes destroys forests and contributes to sediment loss	Construction of log or boulder barriers on hill side to help catch falling debris if any. Dispose of all spoil materials in designated disposal sites.	Construction zone Construction zone	DC CC	NEC PMU and CSC/ES	Discussion with local or geog administration and communities on blasting schedules.
35.	Stone crushing operations	Covering of surrounding areas and vegetation in a white layer of dust causing resultant impacts on the plant life	Regular spraying of water in stone crushing site to minimize dust	Stone crushing sites	CC	PMU and CSC/ES	
Impacts on Forests during Operation							
36.	Operation of roads	Failure in bioengineering	Adoption of alternate bioengineering or engineering	Within respective road	Field DOR staff	PMU/DOR	

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
		structures installed during construction Poor seedling survival rate or regeneration under compensatory tree plantation and revegetation activities carried out in construction stage	measures. Regular watering and monitoring of seedling survival and revegetation and taking of appropriate measures such as fencing, preventing of cattle to eat freshly planted seedlings.	ROW			
Impacts on Wildlife during Construction							
37.	Conduction of construction activities	Generation of noise and disturbances to wildlife	Limit working time to day light hours only	Construction zone	CC	PMU, NCD, CSC/ES	
38.	Operation of construction camps	Hunting, fishing and other activities with negative impacts on wildlife	Prohibition of workers from hunting, fishing and carrying out other activities that will disturb wildlife. CC must provide workers with adequate food, clothing, shelter, fuel to discourage the activities mentioned above.	Construction zone	CC	PMU, NCD, CSC/ES	
Impacts on Wildlife during Operation							
39.	Operation of Roadways: Impacts due to Location	Roadways provide access to forested areas and accelerate animal poaching.	Rangers equipped to perform surveillance of areas affected by wildlife poaching Provide salaries and operating expenses to rangers for performance of duties	DOF office	DOF; NCD RGoB/DOF	DOF, NEC	
40.	Operation of vehicles along roadways	Vehicle collisions with wildlife	Monitor the presence of appropriate sign boards posted during the construction stage	Important wildlife habitat zones	Forestry field staff	NCD	

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
Impacts on Socioeconomic Environment							
Impacts on Land Tenure during Pre-construction							
41.	Land clearing for roadways	Improved access leads to conflicting land claims	Provide grievance mechanisms under the environment and resettlement components of the Project.	Dzongkhag Administration	PMO	NEC	Discussion with local geog administration and affected people.
42.	Land clearing for roadways	Public lands are encroached upon for private use	Review land surveys in the area of roadways to assure completeness. Classify ownership adjacent to roads. Prevent encroachment onto public lands.	Construction ROW	DA	PMU	
Impacts on Land Tenure during Operation							
43.	Operation of roadways	Public lands are encroached upon for private use	Prevent encroachment onto public lands.	Construction ROW	DA	PMU	
Impacts on Labor Rights during Construction							
44.	Employment of labor	Rigorous living and working conditions affect worker health.	Provide laborers and others resident at the site lodging in a camp setting outside of any danger zone, food service facilities, safe drinking water, adequate washing and bathing facilities for maintaining personal hygiene, and access to health care.	Labor camps	CC	PMU and CSC/ES	
45.	Employment of labor: safety	Accident and injury to workers.	Establish/maintain a safety and accident prevention program, provide adequate protective gear and clothing, maintain equipment, and train workers to be skilled in their jobs; record accident frequency, apply corrective measures.	jobsites	CC	PMU and CSC/ES	
46.	Set up of construction camps	Sanitary waste and litter degrade local environment around	Camp facilities should be located at a distance from nearby communities.	Construction and labor	CC	PMU and CSC/ES	

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
		construction camps.	Provide sanitary facilities (dry pit or pour flush latrines) for workers and arrange for disposal of solid waste in accordance with local practice	camps			
47.	Operation of construction camps	Threat of HIV/AIDS and other STDs	Workers hired by roadway contractors should be screened in advance for HIV/AIDS. HIV/AIDS awareness-raising campaign in pilot communities based on need.	Construction and labor camps Local communities	CC PMO	PMU and CSC/ES NEC	
Public Liability of Contractors and Damage to Local Infrastructure during Construction							
48.	Cutting slopes	Unstable slopes cause hazard for workers and nearby people	Assure stable slopes when construction is complete; avoid hazard to workers and adjacent property. Post flagmen to regulate passage of people; restrict access in danger zones. Adjudicate and compensate property damage or injury under the grievance procedures provided in the Resettlement Action Plan	Construction zones Dzongkhag administration	CC PMO	PMU and CSC/ES NEC	
49.	Targeted Impacts during construction	Private property infrastructure has been noted in the field surveys that are in the alignment of roadways.	Infrastructure will need to be relocated, compensation paid under the resettlement and compensation component of the project, or maintained without damage during construction.	Jobsites and local communities	PMO, CC	CSC/ES/NEC	
Impacts during Long term Operation of roads							
50.	General Roadway Use	Accidents involving fuel and hazardous materials damage rivers and streams and pose a community risk.	Incorporate safety features into the design of the roadway such as signage related to hazardous driving conditions and pullouts for runaway vehicles.	Jobsites	DC	PMU	

<u>S No</u>	<u>Action</u>	<u>Resource Impact</u>	<u>Mitigation</u>	<u>Location</u>	<u>Responsibility</u>		<u>Public Participation and Coordination</u>
					<u>Implementation</u>	<u>Monitoring</u>	
51.	General Roadway Use	Litter causes an aesthetic nuisance and environmental health hazard.	Institute an anti-littering campaign in areas affected by the problem. Rubbish bins may be placed at strategic locations in community surroundings to reduce roadway litter.	Local communities	DOR	NEC	Districts/Dzongkhags are mandated to carryout anti littering activities.
		Impacts on Archeological Remains during Construction					
52.	Construction excavation: archeology	Damage to archeological monuments and unearthed evidence.	Halt nearby work upon discovery of archeological relics. Notify the PMO to contact relevant government authority to investigate and undertake recovery. Work to remain halted at the specific location until recovery is complete.	Construction zone	CC	PMU and CSC/ES	

Notes: CC= Construction Contractor, CSC=Construction Supervision Consultant, DGM = Department of Geology and Mines, ES=Environment Specialist, DoF = Department of Forest, DOR=Department of Roads, NEC = National Environmental Commission, PMU=Project Management Unit

Appendix II: Specific Environmental Management Plan

Detailed Environmental Management Plan of Gesarling- Dagapela SNH (Section – C)

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
A. Pre-construction Stage								
Selection of Alignment as per EA Study	Physical, biological, social and cultural adverse impacts	Select the best alignment that minimizes the adverse impacts and maximizes the beneficial impacts	Project area	Review of alternate alignment analysis and incorporation of EA recommendations	Walk through/ along the road corridor (alignment)	ORIO/PMU/HE MC consultants	DoR/MoWHS	Prior to detail survey and design
Implementation of EA recommendation in project, planning and design	Physical, biological, social and cultural adverse impact	Incorporation of EA recommendation in project planning and design	Road Corridor	Incorporation of EA recommendation into project design	Review of final design document, technical specification, bid document	ORIO/PMU/HE MC consultants	DoR/MoWHS	Following the completion of detail design
Inclusion of Mitigation Measures in Project Cost, Bid Documents, and contract	Physical, biological, social and cultural adverse impact	Incorporation of EA recommendation in Bid Documents and Contract	Along the Road Corridors	Incorporation of EA recommendation in Bid Documents and Contract	Review of Bid Documents and Contract	ORIO/PMU/HE MC consultants	DoR/MoWHS	Following the award of contract
Construction Logistics	Adverse impacts on local environment, delay in construction, etc	Arrangement of logistics in time including necessary precautions for storage,	Construction Camps, sites	Status of logistics in terms of equipment, materials, storage facilities, precautions, labor	Field Observation	Contractor/PMU	DoR/Supervision consultants	Prior to the beginning of constructions

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
				camps, etc				
Land and Properties Acquisition	Loss of Land, properties, loss of livelihoods, hardship to affected families	Compensation to 151 affected households	Specific locations (please refer EA main report)	Amount paid to affected family, Other form of compensation paid, Rehabilitation Work	Review of records, interaction with affected families and other stakeholder	DoR/GYT/ Dzongkhag Land Record Office	MoWHS	Prior to construction work
B. Construction Stage								
Site Clearance/removal of vegetation	Loss of 45 ha of vegetation Damage to vegetation. Loss of micro level ecosystem Loss of habitat for Rufous-necked Hornbill (<i>Aceros nipalensis</i>) and other animals Loss of crops 118 ha of agriculture land and orchards Soil erosion Scarring of Landscape	Compensatory plantation within road corridors to restore lost habitat Removal vegetation within 10 m formation width only Bio-engineering with native plants Avoid felling tall & matured trees particularly <i>Ficus benghalensis</i> which is on of the main sources of food for Hornbills Compensation to be made to the affected people Tree felling shall be done parallel to road alignment Installation of log barriers to prevent debris rolling down to protect downhill vegetation.	Along the road alignment	Volume of forest product and species of plant removed, area of compensatory re-plantation, bio-engineering application locations in length	Review of document, Field visit, interaction with contractors, project officials, and local communities	PMU/ CFO/ Forest Beat Office	DoR/NEC/CF O	Every month during construction
Construction, operation and shifting of camps	Deforestation and poaching by labourers. Improper waste disposal and loss of	Briefing labourers/construction workers on local culture and rules and regulations of kingdom on illegal activities such as felling of trees, fishing	Labour camps to be constructed nearby takeoff	Status of Camp site, availability of drinking water, cooking gas or	Field observation of campsite, interaction with	PMU/Contractor/ Forest Beat Office of	DoR/NEC/OR IO PROJECT	Every month during construction

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
	<p>aesthetic beauty</p> <p>Health problems within camps and nearby settlements due to lack of hygiene</p> <p>Damage to construction camps and injury to workers due to unsafe location and lack of safe facilities</p> <p>Disturbance to nearby settlements</p> <p>Resources competition through unfriendly use of water, and non-timber forest products by labourers</p> <p>Leaving dirty site behind after shifting camps from one site to other.</p>	<p>and hunting.</p> <p>Camps to be placed in secure location and be able to protect inhabitants from rain, excessive sunshine and other extreme condition</p> <p>Providing cooking gas or kerosene to discourage use of scarce firewood</p> <p>Waste disposal facilities such as dustbins and garbage to be provided</p> <p>Health screening for labourers</p> <p>Fire fighting equipment to be provided</p> <p>Separate clean drinking water to be supplied to reduce water use competition and for proper sanitation</p> <p>Adequate Pit latrines to be constructed at the campsites</p> <p>Camp areas to be cleaned and bare surface to be revegetated to restore aesthetic value</p>	and at suitable locations	kerosene, waste disposal bin & garbage, pit latrine, fire fighting equipment, illegal hunting and felling of timber	workers, local community and other stakeholders	Gesarling		
Management of Harvested Forest Product	Loss of Forest Resources/generate revenue	<p>Sell/Auction the harvested forest product (timber/fuel wood) if feasible</p> <p>Local should be given opportunity to buy timber at subsidized rural rate</p>	Along Road Corridor where forest is to be cleared	Volume of Forest Product sold/auctioned, amount of revenue generated	Review of documents/records, site visits	ORIO PROJECT/DoFPS	DoFPS/DoR/NEC ¹	During the Site Clearance
Compensatory	Increase in forest area	Planting of 2 trees for every tree	Along alignment after	No of trees planted, area	Review of documents,	ORIO PROJECT/DoFPS	DoFPS/DoR/	Every four

¹ The schedule and frequency of NEC's visit to site during compliance monitoring to be left with NEC.

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
Plantation		felled the project area.	consultation with communities	planted, mode of protection	observation at site	S/PMU/ Contractor	NEC	months
Change in Land Use	Loss of cultivated and forest land, , reduction in income to farmers,	Avoid fertile agricultural land, provide compensation to households that falls within the ROW		Criteria developed for alternate alignment, Criterion for compensation,	Review of alternate analysis, and compensation and rehabilitation criterion	ORIO PROJECT/DoR/ Dzongkhag Land Record Office/ Forest Beat Office, Gesarling	NEC/ MoHCA	Every six months
Spoil Disposal	Damage of farmland, Damage to properties disruption of natural drainage, damages of existing vegetation, water and air pollution	using spoils for reclaiming the degraded land in consultation with local community No disposal shall allowed in the areas of fragile slopes, floodways, farmland, forest areas, natural drainage path, religious and cultural sites, canal and other infrastructures Dispose spoils in the designated sites (refer table 6.1 of the EA report) Build many spoil benches for filling disposal area rather than few larger ones to avoid slope overloading Compact spoil benches at every 0.5 m thickness Disposal Site shall be rehabilitated with appropriate bioengineering works and proper drainage	All along the road corridor. Spoil should be dumped along specified chainage of	Planning for Spoil deposition, Current Practices of Spoil disposal,	Review of planning and practice of spoil disposal, site visit and interaction with contractors, site engineers and other stakeholders	Contractors/PMU	DoR/NEC/ORIO PROJECT	Every 15 days by ORIO PROJECT and Every month by NEC
Earthwork and Excavation	Loss of nutrient rich top soil Soil Erosion and slope failure,	Selection of proper alignment avoiding unstable and fragile zone Top soil shall be scraped and	Along the road alignment.	Arrangement for Slope Stabilization,	Site Visit, Review of design and	Contractors, PMU, ORIO PROJECT	DoR/NEC	Every month during construction

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
	<p>Disruption of the natural flow of streams, rivers etc of the project area due to excavation or construction</p> <p>Air and Noise Pollution, disruption of water bodies disturbance to wild life</p> <p>Damage to properties Injury to people or wildlife passing by</p>	<p>stored for future reuse for bioengineering application</p> <p>Slope cutting activities to be carried out during dry season</p> <p>Slope cutting to done with excavators and spoils to be carried to safe locations to designated site proposed in this EA report.</p> <p>Log barriers/ Check dams to be built to avoid damage of vegetation, properties and injuries to passerby</p> <p>Apply appropriate Bioengineering technique such spreading top soil, broadcasting seeds, grass slips, seedling of local plants such as <i>Alnus nepalensis</i>, <i>Bambusa nutans</i> and transplantation of grasses</p>		design and implementation of bio-engineering, involvement of trained technicians	contract documents interaction with stakeholders			
Slope Instability and Erosion	<p>Soil erosion and land slides due to slope instabilities and thereby damaging or losing entire road</p> <p>Clogging of drains and irrigation canal</p> <p>Loss of fertile top soil</p> <p>Damage to the natural vegetation and the habitat</p> <p>Siltation of streams, river and other water bodies</p> <p>Damage to aquatic lives and downstream users due to siltation</p>	<p>Select an appropriate road alignment as recommended by EA & Geological and Geotechnical studies. In this case, select alignment I of alignment option II.</p> <p>Cut & fill approach shall be applied as far as possible. Slope cutting shall be limited 1:1.</p> <p>Revegetate cut & fill slopes or exposed areas as soon as possible by using local plant species such as <i>Alnus nepalensis</i>, <i>Bambusa nutans</i> and transplantation of grasses</p> <p>Slope cutting to carried out only during dry season</p> <p>Construction of proper drainages</p>	Along the road alignment.	No of slope failures, Arrangement for Slope Stabilization, design and implementation of bio-engineering, involvement of trained technicians	Site Visit, Review of design and contract documents interaction with stakeholders	Contractors, PMU, ORIO PROJECT	DoR/NEC	Every month during construction

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
		as recommended by Geological and Geotechnical Studies shall be adopted Adoption of appropriate bioengineering technique along with civil structures such as breast and retaining wall for slope stabilization. (For detail refer table 6.2 of the EA report)						
Quarries, borrow pits and stock pile Construction materials to be transported from outside road corridor). However, the impacts and mitigation measures are provided.	Instability of slopes Loss of Topsoil Land slides/ rock falls, causing injury to workers Changes in river/stream regime Scarring of landscape Disturbance to wildlife and nearby communities from drilling and blasting activities Dust pollution effecting health of workers, communities and surrounding vegetation	Selection of quarry site away from critical habitat, settlements, cultivated area as far as possible Separate clearance from DGM is necessary for Quarrying activities Quarrying operation to be done from crown of the slope and gradually moving down-slope in a phased manner Scraping topsoil for future use in bioengineering application Provision of appropriate safety gadgets such as gloves, helmets, face masks, ear plugs, goggles, safety ropes to be tied around the waist, etc., to workers Quarrying activities to be carried out during daytime only Spraying of water to control excessive dust produced Restoration of quarry site and access road using appropriate bioengineering measures	Specific location of quarrying and stock piling	Site Selection for quarrying, Protection measures adopted, Rehabilitation of sites	Review of contract document, site visit, and interaction with local communities	Contractors/PMU	DoR/ORIO PROJECT/DGM	Every 15 days by site engineer and every month by DoR/NEC/DGM
Wild life and Habitat	Reduction in forest cover, disturbance to wildlife	Remove/clear vegetation only within 10m corridor to obtain 7.5 m formation width.	All sites wherever	Criteria developed for alternate analysis, planning	Review of alternate analysis, review	PMU/Contractor s/ Forest Beat Office,	DoR/NEC /CFO	Prior to design and planning, and during

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
	<p>habitats by construction activities</p> <p>Loss of endangered species, Rufous-necked Hornbill (<i>Aceros nipalensis</i>) and Great Hornbill (<i>Buceros bicornis</i>) found along the Lhamoizhingkha-Gesarling Road.</p> <p>Disruption of wildlife migratory routes</p> <p>Poaching and trapping of wildlife</p> <p>Fragmentation and isolation of wildlife and plant communities</p>	<p>Log barrier/Check dams to be constructed to avoid further damage on habitat downhill due to spoil/rock sliding</p> <p>Project along with Contractor and Gesarling Forest Beat Officer will make sure that no indiscriminate felling of tall and matured trees especially the Ficus trees (<i>Ficus benghalensis</i>). Fig fruits are one of the main sources of food for Hornbills.</p> <p>Contractor along with Project Office shall be responsible to provide special instruction and training to its staff and workforce on conservation issues and benefits</p> <p>As a compensatory measure, Contractor shall plant locally available plants with particularly emphasis on <i>Ficus benghalensis</i> to help restore the lost habitat.</p>	feasible	of road corridors, measures adopted for avoiding and minimizing forest and wild losses.	of principle adopted for avoidance of forest, endangered species, and habitats of wildlife	Gesarling, Dagana Dzongkhag		construction. Surprise monitoring visit
Handling and Use of Blasting Materials	<p>Creation of excessive noise and vibration, which may weaken the geology, cause damages to community infrastructures, religious places and monuments,</p> <p>Risk of accident, injury to workers and other people living in close vicinity,</p> <p>Disturbance to wildlife</p>	<p>Transportation, handling and storage of explosive should follow the prevailing rules (Explosive rules of the Ministry of Home Cultural Affairs),</p> <p>Store explosive in steel container, which are fire and theft proof,</p> <p>Do not store gelatin, detonators, and cortex, together,</p> <p>Dispose waste safely by burying them in 5-8 feet deep pits,</p> <p>Adopt controlled blasting practice with limited charge where possible,</p>	Almost throughout the road alignment.	Amount of Blasting Material used, handling process, incidences of accidents, and other types of damages	Review of Records, Observation, consultation with stakeholders etc	Contractor/PMU	ORIO PROJECT/DoR/NEC/MoHCA	Every week by DoR, NEC / MoHCA regularly.

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
	<p>particularly Hornbills (Rufous-necked Hornbill and Great Hornbills which are found along Gesarling – Lhamoizingkha road section)</p> <p>Pollution of ground and surface water due to leakage of toxic materials and wastes endangering the health of people as well as aquatic, and wildlife.</p> <p>risk of theft and misuse of explosive by unauthorized or miscreants,</p>	<p>Use Acconex near habitation and protected areas,</p> <p>Make provision of well equipped first aid kits, health facilities, and fire fighting equipment on construction site,</p> <p>Allow only trained or certified blasters to carry out all blasting activities,</p> <p>Maintain coordination with Dagana administration, police, and Gups of Tsendagang, Goshi, Gesarling, Dorona and Senchumthang Gewog on schedule of blasting to ensure that nearby community people are informed,</p> <p>Use appropriate warning signals by using whistles, flags, megaphone to ensure safety of traveling vehicle and people,</p> <p>Adopt appropriate OHS (provision of helmets, gloves, masks, etc),</p> <p>Conduct blasting exercise during day time</p>						
Disruption of Drainage System	Erosion, landslide, creation of new gullies and rills	<p>provide adequate numbers of drainage structures in order to have minimum interference with and impact on natural drainage pattern of the area,</p> <p>Construct side drains, lined drain to tap excessive water and dispose of to natural drain,</p> <p>Planting of fast growing plant species such as <i>Alnus nepalensis</i>, Bamboos and local wetland grass called <i>Peer</i>, with high water absorptive capacity in marshy area which will lower</p>	Along the road alignment - specifically along the chainage 57+040,	Length of water management structures constructed, (drain, culverts, bridges, etc)	Review of design, construction drawings, observation at site	PMU/ORIO PROJECT	DoR/MoWHS/ NEC	Every three months

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
		the water table and reduce surface drainage, avoid surface water discharge into farmland or risky locations,						
Disruption of Community Infrastructures	Damages of irrigation canal and drinking water of Gesarling village and Odalthang village. Damage to foot trails and mule tracks creating inconvenience to local communities	Avoid damaging water supply line for lower Gesarling village Provide temporary/alternative arrangement for drinking water or foot and mule tracks Restore all disturbed infrastructures to the condition before disturbance or improve where appropriate, and Avoid contamination of water resources systems during construction	(Water Supply at 57+700m & 28+720 km., Irrigation canals at 51+500, 57+250, 53+800 Km and in Dalbari village. - foot trails/Mule tracks at several places	Nos of system rehabilitated and restored	Observation, Review of records	PMU/Contractors	DoR/MoWHS/NEC	Every three months
Road Surfacing/gravelling work	Air and noise pollution	Sprinkle water particularly nearby settlements to control dust pollution, maintain equipment and vehicles	Along the road	General observation or Complain of local residents,	Observation	Contractors/PMU	DoR/MoWHS/NEC	Every month by DoR, and in every six months by NEC
Location of Crusher Plant	<ul style="list-style-type: none"> The dusts from the plant can pollute drinking water source and can cause damages to the crops resulting to low yields. Noise pollution created due to excessive noise 	<ul style="list-style-type: none"> Locate and operate the crushing plant (at least 300m) away from the habitation including farmlands. Operate the plant during day time only. Sprinkle water to minimize dust emissions. Provide masks, goggles and earplugs to the workers. 	To be decided at site. (Depends on site conditions and contract packaging.)	General observations and feedback/complain from the communities.	Observation	Contractors/PMU	DoR/MoWHS/NEC	Every month by DoR, and in every six months by NEC

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
	during operation of the plant. <ul style="list-style-type: none"> • Temporary disturbance to the faunal lives due to noise pollution. • High dusts and noise can be annoying and a health hazard to the workers. 	<ul style="list-style-type: none"> • Restore site (including closure of approach road) with appropriate bioengineering measures, such as, spreading top soil, broadcasting seeds, grass slips, seedlings/wildlings planting, for faster vegetation growth. 						
Air Pollution	Problem of human health, vegetation,	Adopt mitigation measures as suggested in earthwork excavation, spoil disposal, quarrying and stock piling	Along the road corridors	Air and noise level measurement	Observation	Contractor/PMU	DoR/MoWHS/NEC	Every three months
Water Quality	Problem of public health, aquatic life, etc	Adopt mitigation measures as suggested in earthwork excavation, spoil disposal, quarrying and stock piling	Along the road corridors, specifically at 57+750 – 57+450 km	Air and noise level measurement	Observation	Contractor/PMU	DoR/MoWHS/NEC	Every three months
Noise Pollution	Problem of public health, aquatic life, etc	Adopt mitigation measures as suggested in earthwork excavation, spoil disposal, quarrying and stock piling	Along the road corridors	Air and noise level measurement	Observation	Contractor/PMU	DoR/MoWHS/NEC	Every three months
Pressure on Community Infrastructures	Inconvenience to local population for water supply, etc	Make separate water supply arrangement if required	Construction Camp site, etc	Complaints from local communities	Observation, interaction with local communities	Contractors	DoR	Every three months by DoR
Adoption of Occupational Health and Safety	Accidents, loss of life, etc	Adoption of OHS	Construction site	Adoption level of OHS, No of accidents	Observation and interaction	Contractor	DoR	Every three months

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
				occurred				
Damages/disregards to cultural sites	Hurting religious sentiments of communities. loss of faith and lack of cooperation towards the project, increase in disputes	Change the road alignment, Develop and improve these sites if possible. Respect the local religious sentiments.	Ch. 47+820 km (Mahadev dham at Gangjab & ch 38+855 km (Bhaley dunga, Chalabji)	Status of restoration, or realignment	Observation and interaction with local communities	ORIO PROJECT/DoR	MoWHS/Dzongkhag/ NEC	Every Six months
By-pass construction	Damages to vegetation Soil erosion Water pollution to Gangjab stream	Obtain necessary clearance prior to construction. Prepare a specific EMP for the by-pass and obtain written approval from the Project. Limit road corridor to only 4m wide. Take all precautionary measures and follow EFRC techniques. Close access and restore site with adequate bio-engineering measures. Check dams, log/boulder barriers to be constructed wherever required, to catch falling debris.. Prevent spoil dumping in the stream Plant 1 tree (<i>Ficus</i> species to improve the habitat of hornbill) every 300m during restoration of the site.	Gangjab (Dhapar) area. The exact location and length will be dictated by site conditions during construction.	<ul style="list-style-type: none"> - Damages to vegetation - Width of the road - Spoil disposals, log/boulder barriers - Bioengineering works after restoration - No. of <i>Ficus</i> trees planted along the road. - Water quality of the stream - Clearance and EMP for the site . 	Observation	Contractor/ORIO Project	DoR/MoWHS/ DoFPS/ Dzongkhag/NEC	Fortnightly.
C. Operation Stage								

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
Slope Instability	Landslide, disruption of road services, etc	correct maintenance of the slope protection measures and drainage works should be adopted, minor landslides, erosion, and mass wasting should be immediately cleared and slope restored with appropriate technology (preferably bioengineering), promote and support soil conservation activities in the right of way and beyond, organize environmental awareness programmes for local communities, road users, and decision makers.	Landslide prone area	Frequency of occurrence of slide, Frequency of maintenance, awareness programs implemented	Review of document, records and observation	DoR	MoWHS/NEC	Every six months
Road Accident	Loss of life and properties	Adoption of Road safety measures, road signals to be places,	Along the road	Frequency of accidents,	Review of records and observation	DoR	MoWHS/NEC	Every six months
Development of Ribbon Settlement	Road Congestion, Accidents	Restriction of development of ribbon settlement through Implementation of Road Act 2004	Along the road corridors	Nos of houses built along the road alignment	Observation	DoR	MoWHS	Every year
Depletion of Forest Area	Inconvenience to local communities, loss of forest resources,	Protection of forest resources by imposing strict rules	Along the road corridors	Incidences of harvesting of forest product, losses of trees, etc	Observation	DoR/DoFPS	MoWHS/MoA F/NEC	Every year
Maintenance of Road	Inconvenience to road users, accumulation of differed maintenance	Adoption of regular maintenance practices	Along the road	Maintenance budgets, progress of maintenance	Review of reports, documents,	DoR	MoWHS/NEC	Every six months

Activities/Issues	Potential Negative Impacts	Mitigation Measures	Location	Monitoring Indicators	Monitoring Methods	Responsible Implementing Agency	Responsible Monitoring Agency	Schedule/Frequency
				works	observation			

Note: The schedule/frequency of NEC's site visits to be left at the discretion of NEC.

Appendix III: EMP Implementation Sheet (Contractor's Monthly Report)

Contract No:

Contractor Name:

Month/Year:

No.	Mitigation Measures proposed in EMP	Mitigation Measures Implemented	Location	Deficiencies/Remarks/Observations
1.	<p>Site Clearance (Forest, trees, top soil)</p> <ul style="list-style-type: none"> Removal of only necessary vegetation. Bioengineering and re-vegetation of the road shoulders and bare slopes above and below the road immediately after construction of the specific road section using local plant species Felled trees should be handed over to Natural Resources Development Corporation (NRDCL). Top soil should be stockpiled and conserved for reuse on the road shoulder 	<ul style="list-style-type: none"> Vegetation only within the road corridor is removed. Bioengineering work was not carried out. Contractor has been permitted to lift or use the felled as the royalty has paid at commercial rate. Collection of top soil has been carried out 	Km 13+703 – Km 14+143	Bioengineering has not been carried because the construction is carried out during the dry winter season.
2.	<p>Operation of Stone Crusher</p> <ul style="list-style-type: none"> Sprinkling of water to minimize of dust pollution Provision of adequate safety wear to the workers such as ear plugs, gloves, helmet etc. 	<ul style="list-style-type: none"> Water sprinkling done daily to minimize the dust pollution All necessary safety gears are provided to the labourers 	Km 17+300	

Verified and Approved by Supervisory Consultant:

Signature:

Name

2306. OPERATION AND MAINTENANCE

2307. GENERAL

The Contractor shall be responsible for undertaking all routine maintenance of the completed works of new road construction including bridges and structures from the end of Defect Liability Period (DLP) for a period of three years. The Contractor shall also maintain roads that the Contractor uses for construction or access and the use of such roads shall be identified in advance to the Project Manager for inspection prior to use.

The routine maintenance of the road shall include besides other protection of plants and vegetation; cleaning of culverts, road side drainage (including reshaping/restoring in case of unlined drains) and drainage channels; and clearing any other obstructions including minor landslide (up to 2 m³ in any 20 m section) and maintaining all completed road features to allow free flow of traffic. The material removed from the cleaning and clearing as above shall be disposed off at safe places as directed by the Project Manager.

The Contractor shall carry out reinstatement of works (pavement, pavement surface, shoulder or any other works) washed out or damaged due to poor routine maintenance of drains, drainage channels, culverts, shoulders; lacking clearance of obstructions such as landslides etc other than those occurred due to earthquake.

The routine maintenance of newly constructed bridges shall include, cleaning including removal of obstructions of bridge decks and bridge deck of drainage elements, cleaning and checking of expansion joints and bearings, cleaning bearing shelves and weep holes, removing accumulated debris and vegetation around and between piers and abutments, repairing parapets, and protection of adjoining works.

The Contractor shall perform the maintenance works as often as required to keep the carriageway, pavement, shoulders, and adjoining structures in proper working order to the satisfaction of the Project Manager. The Contractor shall mobilize labour, equipment and materials to carry out the routine maintenance of the road. The location and scope of the maintenance work shall be as directed by the Project Manager.

Should at any time the Project Manager gives any instruction for the up keep of a section of the road/site and the Contractor does not respond in 48 hours, the Project Manager shall be empowered to instruct others to carry out the works. Any costs involved by this action shall be deducted from any money due to the Contractor.

The department shall carryout reinstatement of works washed out or damaged due to act of god such as earthquake, or land slide due to heavy rainfall. All damages resulting from poor quality of works, materials or workmanship shall be the responsibility of the contractor under defect liability period.

The Contractor shall carry out all works under this Contract as per Performance Requirements applicable. The Specification and Performance Requirements contained herein shall be read in conjunction with other bid documents

2308. WORKS TO BE PERFORMED DURING MAINTENANCE PERIOD

The Contractor shall undertake the routine maintenance and emergency maintenance (together described as the Works):

(j) Contract Management Services

The Contractor shall carry out Contract management services for the duration of the Contract which includes;

1. Undertake regular road patrols and condition surveys and report the condition of all roads under the Contract.
2. Establish programs for all routine maintenance.
3. Schedule maintenance works to meet the required specifications and performance standards
4. Maintain records of all work undertaken
5. Confirm and record an inventory of all road assets which will be maintained or repaired depending on their condition. The inventory will employ a suitable identification and location referencing system so that all assets can be quickly identified and located during maintenance operations and inspections.
6. Confirm and record those assets that require routine maintenance activities to maintain or return the asset to better than Service Quality standard. The Contractor is deemed to have made full allowance for this work in his bid and no additional payment will be made to bring such works up to Service Quality standard
7. Confirm and record those assets where the defects are considered to be excessive and inappropriate for routine maintenance.
8. Confirm and record those sections of road which either are being, or scheduled to be, improved under contracts. Once these works are completed these sections will be returned to and be maintained by the Contractor, except for rectification of the construction defects.

The Project Manager shall provide a written record of the Initial Inventory and Condition Survey, and approval to proceed with the Works, to the Contractor within 14 days of the completion of the survey. The Project Manager's ruling on the condition of any item feature will be final.

(II) Monthly Inspection

The Contractor shall participate in a Monthly Inspection jointly with the Project Manager to validate that maintenance works are being conducted in accordance with the requirements of the Contract. The inspections will be held at intervals not exceeding one month. The Project Manager will provide at 48 hours notice in writing to the Contractor of the intention to conduct such an inspection and its extent. This joint inspection will note and record those items that are below Service Quality standard, those items that have not achieved Response Times and those items that are below Services Quality standard, those item that have not achieved Response Times and those items to be included in the next month's program.

The Project Manager will provide a written record of the monthly inspection to the Contractor within 7days of the completion of the inspection. The Project Manager's ruling on the condition of any item will be final.

(ii) Sectional completion Inspection

The Contractor shall participate jointly with the Project Manager in inspections of completed sections of Emergency Maintenance Works to validate that the works have been completed in accordance with the

Specification and/or instructions from the Project Manager. Any defects shall be noted and recorded and the Contractor shall be required to rectify them according to the conditions of the contract.

(iii) Contract Completion Condition Survey

Not later than 21days prior to the Completion Date of the Contract, the Contractor and Project Manager shall conduct a Contract Completion Condition Survey of the whole of the items to record those items outside the specified Services Quality standard.

The Project Manager will provide a written record of the Contractor Completion Condition Survey to the Contractor within 14days of the completion of the survey. The Project Manager's ruling on the condition of any item will be final.

(v) Works Programs

(a) Annual Works program

The Contractor shall prepare an Annual Works Program for the Routine Maintenance activities contained in the contract identified during the Initial Inventory and Condition Survey and as directed by the Project Manager for the approval within 7days of receiving the Project Manager's report on the Initial Inventory and Condition Survey.

(b) Monthly Works Program

At the end of the each month the Contractor shall prepare a Monthly Works Program for the following month incorporating items identified during the Monthly Inspection. The program shall be forwarded to the Project Manager no later than the third working day of each month for the information and for approval of any additional quantities-based maintenance or Emergency Maintenance works proposed. The Contractor shall modify the program as required by the Project Manager.

(vi) Monthly Maintenance Report

The Contractor shall provide to the Project Manager with a Monthly Maintenance Report containing information and details on the amount work completed and cost of all works conducted during the previous month. The information shall be presented under the following headings:

- | | |
|---------------------|--|
| 1. Date : | end of month date |
| 2. Road section : | section of road |
| 3. Location : | start and end distance of road section |
| 4. Cost: | total Contract expenditure on road section undertaken in month |
| 5. Work completed : | against item included in BOQ |
| 6. Events : | Emergency maintenance completed and outstanding |
| 7. Program: | Works Program for next month |

The format of the report shall be mutually agreed by Contractor and Project Manager.

(vii) Mobile Maintenance Unit

The contractor shall provide, as a minimum, one or more mobile maintenance units as specified in the Schedules each comprising transport, personnel and equipment to carry out the majority of routine maintenance activities. The mobile unit shall have as a minimum requirement.

- | | |
|--------|--|
| 1 no. | Supervisor |
| 4 nos. | Maintenance Workers (or more to suit tasks and implementation methods) |

- 1 no. Truck or tractor and tipper trailer
- 2 nos. "Workman Ahead" sign boards
- 12 nos. 300mm plastic high-visibility coloured traffic cones
- 4 nos. High-visibility vests to be worn at all times by the mobile maintenance crew
- 2 nos. Red and green flags
- 2 nos. Mobile phones
- 2 nos. Rakes
- 2 nos. Long handle shovels
- 2 nos. Long heavy duty brooms
- 2 nos. Picks
- 2 nos. Crowbars
- 1 nos. Wheel barrow
- 1 no. Small vibratory roller

In addition to the above, the truck shall carry adequate supplies of emulsion, aggregate and sand for pothole patching, crack sealing and minor pavement repair. The truck and equipment shall be subject to inspection and approval by the Project Manager and the Contractor shall rectify any deficiencies noted by the Project Manager.

(viii) Quality Control

(a) Contractor's Responsibility

The Contractor shall be responsible for the carrying out of all tests of materials and works required under the contract. The contractor has full access to fully equipped laboratory to carry out all required tests and quality control work. The contractor shall permit full access to the laboratory for staff of the Project Manager to undertake any testing required by the Project Manager.

(b) Payment for Testing

The Contractor shall bear the expense of all establishment, management and incidental cost in carrying out the required tests as part of the lump sum payment and unit prices under the Contract.

(c) Sampling

All sampling whether carried out by the Project Manager or Contractor, shall be carried out in the presence of an authorized representative of the Contractor and the project Manager. At least 24 hours notice is required for both parties to attend any sampling for testing purposes. Where the Contractor's representatives fails to attend, the results of such sampling will be notified to the Contractor and will be deemed authentic.

(d) Test results

The contractor shall furnish all test results to the project Manager as a monthly summary or at a frequency directed by the project Manager. The Project Manager may withhold payment for those works where test results have not been verified.

(e) Identifying Defects:

The Project Manager shall check the Contractor's work and notify the Contractor of any Defects that that are found. The Project Manager shall give notice to the Contractor of any Defects arising from his work which shall be corrected at the contractor's own expense.

(f) Safety:

The Contractor shall be responsible for the safety of the Works, and of the general public on the Works site(s) and the health and safety of his/her workers. The Contractor shall provide and maintain all warning and traffic control signs and measures required for the safety of the Works.

(ix) Contractor's staffing

This Contract has a requirement that an adequate level of engineering management is to be employed to undertake inspections, work's programming and supervision of maintenance and repair works. The Contractor shall engage a qualified professional with a minimum qualification of Bachelor Engineering (Civil) or alternatively a Diploma Engineering (Civil) with at least five years experience to manage the project and act as the Contractor's Representative.

(x) Traffic Management

The Contractor shall plan and execute the Works while keeping the road open to traffic at all times, and shall provide traffic direction at maintenance and construction sites so as to minimize delays to vehicles and pedestrians. In the event of unavoidable road closure, the Contractor shall submit a work plan and schedule to the Project Manager for approval prior to closing any road section.

The Contractor shall provide the necessary temporary signs, cones and flagmen necessary to warn approaching traffic of construction or maintenance works being undertaken, and to direct road and pedestrian traffic safely past the work site. The Contractor's shall execute all Works in accordance with IRC SP: 55 Guidelines for Safety in Constructions Zones or alternative traffic management guidelines approved by the Project Manager. Traffic management measures shall be provided at all Works sites without exception.

2309. ROUTINE MAINTENANCE ACTIVITIES

The Contractor shall unless otherwise directed carry out the Routine Maintenance as follows:

1. Clearing of carriageway including shoulders, drains, culverts, bridge and catch pits:

All the obstacles like boulders, leaves, branches, rubbish, debris and twigs that might interfere with the normal flow of traffic shall be removed from the road and disposed off at approved disposal sites. Under no circumstances shall the cleared materials be thrown down the slope. All grass and vegetation shall be removed from the carriage way and the drains. Vegetation on the shoulders and the earthen drains shall be trimmed.

The drain shall be kept clean and functional at all times. Any deposit of debris, rubbish or landslide deposits shall be cleaned. Catch drains, diversion drains, inlet and outlet drains shall be

cleared of any foreign matters. The Contractor shall clear landslide debris along the road measuring up to 15 cum in volume per instance. With a maximum of 30 cum per annum per km

The contractor shall ensure that:

- The drains are not being damaged to prevent erosion and scouring.
- Scour checks and maintained or will be constructed when needed.
- Culverts and bridges are checked after heavy rain. If scouring is noticed in the vicinity of the structure it shall be rectified immediately.
- All rubbish collected in the process of clearing is disposed off at approved disposal sites.

The bridges shall be checked at least once a month, and loose deck bolts shall be tightened and protruding deck spikes be driven in.

The Project Manager has to be informed immediately of any work beyond the scope of routine maintenance activities that required engagement of heavy equipment.

2. Clearing vegetation/ jungle from drains, road shoulders and road corridor:

The work shall consist of cutting, removing and disposal of all material such as vegetation, grass, brush-wood, shrubs, tree stumps and sapling of girth 300mm measured at a height of 1m above ground level which are in the opinion of the DoR engineer unsuitable for incorporation in the works. Removal shall be done by cutting and shall not be uprooted. The cleared area shall be made clean by removing all rubbish and shall not be workman like state. The road corridor is the area, which lies 15 meter above and below (or left and right) of the centerline.

3. Surface dressing of road shoulders:

Surface dressing shall include trimming vegetation, cutting and filling of ground up to depth of 150mm and leveling the road shoulder/berm to original shape. The undulations shall be leveled by cutting and filling so as to give an even, neat and tidy look. The width of the shoulders on each side of the road shall not be less than 500mm.

4. White washing of Structures:

White washing of structures include parapet, tops of headwalls and retaining walls to be cleaned of dirt, vegetation, mould and graffiti and whitewashed to be visible at all times. Clean and whitewash one time per year. Check condition of surface monthly and remove excessive dirt and graffiti within 30 days.

5. Pothole Patch Repair:

Each pot-hole and patch repair area shall be inspected and all loose material removed. The area shall be cut/trimmed either with jack hammer or hand tools like chisels, pick-axes etc., such that the area is in the shape of a rectangle or square. The edges shall be cut vertically upto the level where the lower layer is stable without any loose material. The area shall be thoroughly cleaned with compressed air or any appropriate method approved by the Engineer to remove all dust and loose particles. The area shall be tacked or primed with cutback or emulsion depending upon whether the lower layer is bituminous or granular in nature. The sides, however, are to be painted with hot tack coat material using a brush. The prime coat and tack coat shall conform to Clause 1200 of specification.

The mix to be filled shall be either a hot mix or a cold storable mix (using bituminous emulsion). Mixing shall be done in a plant of suitable capacity. It shall be placed in thicknesses not more than 100 mm (loose). It shall be compacted in layers with roller/plate compactor/hand roller / rammer. While placing the final layer, the mix shall be spread slightly proud of the surface so that after rolling, the surface shall be flush with the adjoining surface. If the area is large, the spreading and levelling shall be done using hand shovel and wooden straight edge. During the process of compaction with roller or other means, the surface level shall be checked using a 3 m straight edge.

The work shall include providing and crushing of aggregate of size 40-63 mm and laying on the potholes/patches that need repairs. Before laying aggregates the surface shall be prepared by cutting in straight and uniform widths. The aggregates shall be screened and aggregates of size smaller than 20mm and with rounded edge shall be discarded. The contractor shall fill/repair potholes up to 35sqm per annum per km

Nominal size aggregate of 50mm, as required shall be added to the old aggregate and spread over to depth of 75mm. This shall then be consolidated with hand roller or heavy steel rammer as directed first with light sprinkling then with sufficient application of water, till the aggregate has become adequately consolidate and does not get displaced. All undulation shall be loosened by hand picking surplus aggregate removed from high spots and depression filled with surplus new aggregates and the surface compacted again. We thoroughly consolidated, blinding material, freshly collected shall be spread over it in 12mm layer and consolidated with hand roller or heavy steel rammers, with sufficient application of water till a uniform surface is obtained.

The finished surface shall be in conformity with the camber/cross fall of the road and shall have a little projection against the adjoining road surface to allow for any settlement on drying. Material such as aggregate and blinding material shall be obtained locally without disturbance to the road slopes.

6. Pavement Crack Repair

Fog seal shall consist of an application of emulsified bitumen, without any aggregate cover for sealing fine hair-cracks like shrinkage cracks and alligator cracks or rejuvenating oxidised bituminous surfaces. Areas having cracks with less than 3 mm width shall be considered for this treatment. Bituminous emulsion for Fog Seal shall be of a slow setting type. The area to be applied with fog seal shall be thoroughly cleaned with compressed air, scrubbers, etc. The cracks shall be cleaned with pressure air jet to remove all dirt, dust, etc. The fog seal shall be applied at the rate of 0.5 – 1.0 litre/sq.m. using equipment like a pressure tank, flexible hose and spraying bar or lance. Traffic shall be allowed on the surface after the seal has set to a non-tacky and firm condition so that it is not picked up by the traffic.

7. Pavement Marking Renewal

Marking shall be clear, free of foreign and reflective at 30m. 85% of area of markings shall be clearly visible, with no significant discontinues in visibility of line markings. No more than 100m shall be without a marking. All missing pavement centerline reflectors shall be replaced annually. Repaints as per MORTH clause 803 and IRCS:35. Ordinary paint markings shall be repainted as per MORTH Clause 803.3. Thermoplastic markings shall be maintained as per MORTH Clause 803.4. This is a major safety and guidance device. The markings such as lane, edge, transverse, and word messages have to be present, reflective as per IRC803.4.2

8. Road surface clearing and sweeping:

The debris, rubbish or any other foreign matters shall be cleaned off and sweeping shall be done periodically to keep the road surface clean.

9. Cleaning of structures:

All structures like breast wall, retaining wall, catch pits, French drains and parapets shall be cleaned off from growing vegetation. White washing should be applied when necessary.

10. Road signs and distance marker maintenance

Signs must be in place, complete, clean and structurally sound. Signs must be clear and reflective at 37m and clearly legible in day and night conditions. 95% of surface must be free from damage. Visual inspection, daily on regular basis. Distance stones must be intact, complete, clean and structurally sound; surface painted or otherwise covered according to ruling. Reflectivity standards as per MOTH801.3.2 clear of obstruction that prevent passing motorists from viewing the sign have to be rimmed back. The alignment and face of the sign should as per the original design specification, without any distortions, dirt, or external pasting. Any support post damage, which is hazard to the public must be rectified immediately and made safe. Repair as per IRG:26 and IRC:8. Remove and relocate any stone which is a hazard to the public. Clean, paint, make structural repairs and reinstate as needed to restore the stone to original condition.

11. Bioengineering works:

Bioengineering works shall includes carrying out of those activities that will help in the stabilization of the roadside slopes. The following bioengineering methods shall be applied:

- Planting with seeding/wildings
- Live stacking/palisade
- Direct seeding
- Broadcasting
- Brush layer/hedge-brush layering
- Sodding/turfing

Bioengineering shall be applied as per the site condition or as instructed by the project Engineer. eds, seeding and planting material for bioengineering works shall be of locally available species. Bioengineering works shall commence form February – March expect plantation, which shall be done on the onset of monsoon only. Trees that grow into large trees shall not be planted to avoid overburden later on.

All bioengineering area shall be protected from cattle grazing, collection of firewood and fodder. Temporary fence with bamboos/wood shall be constructed to protect the bioengineering sites/area. The contractor should also prevent damages of the existing flora in the road corridor by cattle, illegal cutting or fire. All incidents should directly be reported to the Consultant Engineer or Project Manager.

12. Maintenance of bridges:

The Bridge shall be checked at least once a month, and loose deck both shall be tightened and protruding deck spikes shall be driven in. Greasing should be done when needed. All metal parts of bridge structures shall be clean, free of corrosion intact without missing or badly corroded components. Timber decks shall be intact with no missing or rotting members. Steel decks shall be intact with no missing or badly corroded components. Concrete decks shall be intact without serious

spalling or cracking. Concrete and masonry abutments and piers shall be intact without significant damage and firmly anchored in the surrounding soil and material.

Measurement and Payment

The Bill of Quantities (BoQ) shall contain items for maintenance work to be done by the Contractor. The Contractor is paid for the quantity of the work done at the rate quoted in BoQ for each work item. **The rate quoted by the contractor in mandays should include all other required costs like supervision, road patrolling, material costs, tools & plants etc.**

The work shall be paid on monthly basis for the certified works based on the Contractor’s quote per work item. The Contractor is responsible for the measurements of works and preparation of its bills. The measurement of works shall be carried out jointly by the Project Manager and the Contractor. The mandays produced in a month should not exceed the mandays planned by the Project Engineer. Only after the Engineer’s prior approval the planned number of mandays can be increased if necessary. The Contractor shall record daily the executed work in measurement form which is to be countersigned by the Project Manager.

2310. EMERGENCY MAINTENANCE

Emergency maintenance comprising repairs and other works of the roads in the contract which may become necessary during the period of the Contract as directed by the Project Manager.

The general activities under Emergency Maintenance are:

- (i) Clearing of landslide: landslides comprising of debris, boulders, trees trunks etc. which can block the road carriageway. Materials blocking the road need clearance as early as possible.
- (ii) Repair of drainage systems: serious damage observed on culverts, drains, bridges etc. which needs to be repaired immediately since delay could result in complete failure of structures.
- (iii) Construction of diversion roads: if a washed away road section or a damaged bridge is not pliable, diversion road have to be constructed as temporary solution.

Emergency Maintenance is by definition unforeseeable and therefore outside the scope of the normal routine maintenance works. The quantities in price schedule for Emergency Maintenance are kept as provisional quantities and are likely to change during the operation and maintenance phase. The contractor shall be paid as per the actual damage caused due to Emergency Maintenance based upon the schedules of rates and subject to verification by the Engineer/ Project Manager. Any items not covered in the provisional quantities shall be paid from the Day Works items.

2311. ENVIRONMENT MANAGEMENT PLAN

The Contractor shall execute all Works in compliance with requirements described in the Environmental Management Plan.

Potential Environment Impact	Mitigation Action by the Contractor
1. Interference with Utilities	Provide advance notice to the public about the time and the duration of the utility disruption. Substitute source of water and other utilities during the disruption period, and re-establish public utilities as soon as possible.

<p>2. Temporary Use of Land</p>	<p>Locate the construction facilities at least 500 in away from water bodies, natural flow paths, important ecology habitats and residential areas, Selection the site for these facilities by adhering to local law and regulation and in close consultation with local authorities,</p> <p>Pay owner compensation for using the site in accordance with local laws and regulations. Obtain an official permit from the authorities if any public utilities will be used for its facilities and pay in accordance to local laws and regulations. In establishing these facilities, the contractor should minimize removal of trees and other green cover vegetation as much as possible.</p>
<p>3. Traffic and Pedestrian Safety</p>	<p>Provide advance notice to local communities of maintenance and construction works. Provide traffic warning signs, temporary traffic lights or flagman to ensure safe and convenient passage to the vehicles, passengers and livestock in accordance with <u>IRC SP: 55 Guidelines for Safety in Construction Zones</u> and as instructed by the Project Manager.</p>
<p>4. Worker Safety</p>	<p>Provide protective footwear, helmets, goggles, eye –shields and clothes to the workers depending on their duties (mixing asphalt, blasting, handling equipment’s etc.)</p>
<p>5. Transport of Materials</p>	<p>Obtain all necessary permits from road authorities to use local roads prior for transport of construction materials. Ensure suppliers of construction materials do not exceed the carrying capacity of local roads and bridges. Ensure all trucks transporting materials are adequately covered</p> <p>Be responsible for maintaining and repairing all roads used as access to worksites, or to materials production and storage areas. This will include cleaning, dust control and repair of road assets damaged by heavy truck use</p>
<p>6. Sources and Storage of Construction Materials</p>	<p>Selection of the mining and quarrying sites by Contractor should exclude areas close to residential, commercial or schools. Construction materials should be obtained only from approved mines and quarries. Avoid storage of construction materials near water bodies. Temporary storage of materials is permitted in the road-of- way during maintenance and construction works but all excess materials and construction waste must be removed from the right-of-way after the completion of the works</p>
<p>7. Disposal of Construction Waste</p>	<p>With approval of the Project Manager, reuse construction waste materials wherever possible for the construction activities. Otherwise all construction waste materials will be removed from the work site and transported to a disposal site approved by the Project Manager. Obtain all necessary permits to use any disposal site.</p>
<p>8. Work Camp Waste Disposal and Sanitation</p>	<p>Provide adequate solid waste disposal, sanitation and sewage facilities at all construction labour camps, site offices and works yards to avoid health hazards and environmental pollution. Provide adequate drainage facilities to eliminate stagnation of the water. Provide adequate supply of water to urinals, toilets and wash rooms in construction labour camps. Provide rubbish bins and remove solid waste at regular intervals to an</p>

	approved waste disposal site.
9. Use of Water Resources	Use water from residential areas only after obtaining permit from representative of the local community, during construction; avoid obstruction of flowing water within the project area. While working close or around the water bodies, Contractor will not obstruct or prevent water flow.
10. Impact on Flora and Fauna	Take necessary action to prevent his work force from gathering fire wood from the surrounding habitats, disturbing to the flora, fauna including hunting of animals and fishing in water bodies. All construction materials processing plants, material storage yards and construction vehicle service stations will be located away from environmentally-sensitive protected areas.
11. Removal of Roadside Trees	Obtain all necessary approvals for any trees which need to be removed as part of the maintenance or construction works. Contractor must mark all roadside trees and record the number of tree to be cut in each road section prior to clearing the areas. Contractor must replace the number of trees cut during the land clearing by planting 2 comparable trees for every one tree.
12. Soil Erosion and Surface Runoff	Minimize clearing of green cover vegetation in areas susceptible to erosion and provide replacement turf as soon as possible before rainy season.
13. Air Quality	<p>Locate crushers and hot mix plants at least 500m from residential areas or other social Infrastructures (school/hospital, clinic) and strictly implement National Emission Standards for all construction vehicles, equipment and plant.</p> <p>Take all necessary actions to reduce dust levels from the work site, crushers and hot mixed plants. Dust extraction unit should be fitted to roadside crushers, construction vehicles and hot mixed plants. Watering of work sites and roads use for transport of construction materials should be done at regular intervals, and dust barriers should be placed near schools, clinics and markets.</p>
14. Water Quality	Ensure all construction works affecting the streams have to be undertaken in the dry season, minimize excavation of beds of any streams, irrigation systems, and other water resources, use of silt traps and erosion control measures where the construction carried out close proximity to the water bodies to avoid entering of cement particles, rock, rubbles and waste water to the surrounding water bodies. Ensure the storage for construction materials which are toxic, hazardous and containing other fine partials would be sited at least 500 from water bodies and would minimize its following into any water body.

15. Noise and Vibration	<p>Construction and suppliers of construction materials shall adhere strictly to noise control regulations for all construction vehicles and equipment. Contractor shall equip heavy construction equipment (compactors, loaders, vibrators and cranes) with exhaust silencers to maintain noise levels under 75 db.</p> <p>Work involving equipment and trucks and any other noisy activities, will be limited to the hours of 0600 to 1800. This also applied to roads through settlement areas used by trucks hauling good to a construction site. In this situation Contractors will either have to plan ahead or haul during the daytime. Outside the settlement areas construction will be permitted at any time.</p>
16. Operation of Asphalt and Rock Crushing Plant	<p>Any plant operated or used by the Contractor must be a licensed. Contractor must provide written proof that this is so and if not, either corrects the non-compliance or find a legal supplier.</p>
17. Bridge Maintenance	<p>Maintain one lane open during bridge maintenance works and provide traffic controls to ensure a smooth flow to traffic across the bridge. For any works requiring the closer of both directions to traffic, Contractor will be required to submit a work plan and schedule for review and approval by the Project Manager prior to start of the work.</p>