

HIS MAJESTY'S GOVERNMENT OF NEPAL
Ministry of Local Development
TECHNICAL DIVISION

Technical Specifications

for Agricultural and Rural Roads

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For the use of proposed
DEPARTMENT OF LOCAL INFRASTRUCTURE DEVELOPMENT (DoLID)

GGeneral

G -1 INTRODUCTION These Specifications are for the works carried out in rural and agricultural roads in Nepal and shall apply as required under the contracts with Contractors or as per the agreements with Users' Groups or local labour groups. In all cases, the work shall be executed as per the Specifications or otherwise as directed by the Engineer and shall conform to the location, lines, dimensions, grades and cross-sections shown on the drawings or as indicated by the Engineer. The quality of work and material shall comply with the minimum requirement or higher than what is requisite in the respective Sections of these Specifications. Where the Specifications and the drawings describe a portion of the work only in general terms or in other words do not cover the details, it shall be understood that only the best general practice is to be followed and the materials and workmanship of the best quality are to be employed within the limitations prevailed at site. In such cases, the work shall fully comply with the instructions received from the Engineer at site.

G -2 DEFINITIONS The term "Contractor" is often being used while describing the Specifications. It should be understood as "contractor" or as "users' group" depending upon the party who undertakes or is about to undertake the said work from the office. So, the terms "Contract", "Contractor", "Engineer", "Drawings", "Government", "Works", "Site", "Item Rate Contract", "Provisional Sums" used in the Specifications shall be referred in line with the definition given in the General Condition of Contract/Users' Group Agreement. The following abbreviations shall have the meaning as described below:

ASTM : American Society for Testing and Materials
BS : British Standards published by the British Standards Institution
CBR : California Bearing Ratio
IS : Indian Standards published by the Bureau of Indian Standards

The various elements in the cross-section of a road referred to in these Specifications are shown in **Figure G -2**.
Figure G -2 : Terms used in the Specifications to describe Cross-sectional Elements of a Road

G -3 GENERAL MATERIAL TESTING REQUIREMENTS Materials shall be obtained from the best available sources with due consideration to their cost. Wherever possible, necessary tests shall be carried out in order to determine their suitability. These tests could be conducted at the field or at a laboratory. Conducting field tests may not be feasible in some of the labour-based rural roads projects. In such cases, quality of materials shall be determined based on the judgement made at site by an experienced technical personnel. However, it may be necessary to carry out the conventional tests for material testing in order to ascertain the quality of work. In general, the sieve sizes given in **Table G -4** are being used in the country for material testing purposes. Details are covered in the respective Sections of these Specifications.

G -4 SIEVE SIZES GENERALLY IN USE The sieve designations which are mentioned in these Specifications are given in the table below. The equivalent figures of International Standards (BS and ASTM) are also mentioned to the nearest value against each designation.

Table G -4 Sieve Designation Equivalent

Designation which conforms to	BS	ASTM
100 mm	80 mm	63 mm
50 mm	40 mm	25 mm
20 mm	12.5 mm	10 mm
6.3 mm	4.75 mm	2.36 mm
4 in.	3 in.	2½ in.
2 in.	1½ in.	1 in.
1½ in.	¾ in.	½ in.
¾ in.	3/8 in.	¼ in.
No. 74	3 in.	2½ in.
2 in.	1½ in.	1 in.
¾ in.	¾ in.	½ in.
3/8 in.	¼ in.	No. 4
No. 8	2.00 mm	1.70 mm
1.18 mm	850 micron	600 micron
600 micron	500 micron	425 micron
425 micron	300 micron	180 micron
300 micron	150 micron	75 micron
75 micron	No. 8	No. 10
No. 10	No. 14	No. 18
No. 14	No. 25	No. 30
No. 25	No. 40	No. 50
No. 40	No. 60	No. 80
No. 60	No. 100	No. 200
No. 80	No. 150	No. 200
No. 100	No. 200	No. 250
No. 150	No. 250	No. 300
No. 200	No. 300	No. 350
No. 250	No. 400	No. 450
No. 300	No. 500	No. 550
No. 350	No. 600	No. 650
No. 400	No. 700	No. 750
No. 450	No. 800	No. 850
No. 500	No. 900	No. 950
No. 550	No. 1000	No. 1050
No. 600	No. 1100	No. 1150
No. 650	No. 1200	No. 1250
No. 700	No. 1300	No. 1350
No. 750	No. 1400	No. 1450
No. 800	No. 1500	No. 1550
No. 850	No. 1600	No. 1650
No. 900	No. 1700	No. 1750
No. 950	No. 1800	No. 1850
No. 1000	No. 1900	No. 1950
No. 1050	No. 2000	No. 2050
No. 1100	No. 2100	No. 2150
No. 1150	No. 2200	No. 2250
No. 1200	No. 2300	No. 2350
No. 1250	No. 2400	No. 2450
No. 1300	No. 2500	No. 2550
No. 1350	No. 2600	No. 2650
No. 1400	No. 2700	No. 2750
No. 1450	No. 2800	No. 2850
No. 1500	No. 2900	No. 2950
No. 1550	No. 3000	No. 3050
No. 1600	No. 3100	No. 3150
No. 1650	No. 3200	No. 3250
No. 1700	No. 3300	No. 3350
No. 1750	No. 3400	No. 3450
No. 1800	No. 3500	No. 3550
No. 1850	No. 3600	No. 3650
No. 1900	No. 3700	No. 3750
No. 1950	No. 3800	No. 3850
No. 2000	No. 3900	No. 3950
No. 2050	No. 4000	No. 4050
No. 2100	No. 4100	No. 4150
No. 2150	No. 4200	No. 4250
No. 2200	No. 4300	No. 4350
No. 2250	No. 4400	No. 4450
No. 2300	No. 4500	No. 4550
No. 2350	No. 4600	No. 4650
No. 2400	No. 4700	No. 4750
No. 2450	No. 4800	No. 4850
No. 2500	No. 4900	No. 4950
No. 2550	No. 5000	No. 5050
No. 2600	No. 5100	No. 5150
No. 2650	No. 5200	No. 5250
No. 2700	No. 5300	No. 5350
No. 2750	No. 5400	No. 5450
No. 2800	No. 5500	No. 5550
No. 2850	No. 5600	No. 5650
No. 2900	No. 5700	No. 5750
No. 2950	No. 5800	No. 5850
No. 3000	No. 5900	No. 5950
No. 3050	No. 6000	No. 6050
No. 3100	No. 6100	No. 6150
No. 3150	No. 6200	No. 6250
No. 3200	No. 6300	No. 6350
No. 3250	No. 6400	No. 6450
No. 3300	No. 6500	No. 6550
No. 3350	No. 6600	No. 6650
No. 3400	No. 6700	No. 6750
No. 3450	No. 6800	No. 6850
No. 3500	No. 6900	No. 6950
No. 3550	No. 7000	No. 7050
No. 3600	No. 7100	No. 7150
No. 3650	No. 7200	No. 7250
No. 3700	No. 7300	No. 7350
No. 3750	No. 7400	No. 7450
No. 3800	No. 7500	No. 7550
No. 3850	No. 7600	No. 7650
No. 3900	No. 7700	No. 7750
No. 3950	No. 7800	No. 7850
No. 4000	No. 7900	No. 7950
No. 4050	No. 8000	No. 8050
No. 4100	No. 8100	No. 8150
No. 4150	No. 8200	No. 8250
No. 4200	No. 8300	No. 8350
No. 4250	No. 8400	No. 8450
No. 4300	No. 8500	No. 8550
No. 4350	No. 8600	No. 8650
No. 4400	No. 8700	No. 8750
No. 4450	No. 8800	No. 8850
No. 4500	No. 8900	No. 8950
No. 4550	No. 9000	No. 9050
No. 4600	No. 9100	No. 9150
No. 4650	No. 9200	No. 9250
No. 4700	No. 9300	No. 9350
No. 4750	No. 9400	No. 9450
No. 4800	No. 9500	No. 9550
No. 4850	No. 9600	No. 9650
No. 4900	No. 9700	No. 9750
No. 4950	No. 9800	No. 9850
No. 5000	No. 9900	No. 9950
No. 5050	No. 10000	No. 10050
No. 5100	No. 10100	No. 10150
No. 5150	No. 10200	No. 10250
No. 5200	No. 10300	No. 10350
No. 5250	No. 10400	No. 10450
No. 5300	No. 10500	No. 10550
No. 5350	No. 10600	No. 10650
No. 5400	No. 10700	No. 10750
No. 5450	No. 10800	No. 10850
No. 5500	No. 10900	No. 10950
No. 5550	No. 11000	No. 11050
No. 5600	No. 11100	No. 11150
No. 5650	No. 11200	No. 11250
No. 5700	No. 11300	No. 11350
No. 5750	No. 11400	No. 11450
No. 5800	No. 11500	No. 11550
No. 5850	No. 11600	No. 11650
No. 5900	No. 11700	No. 11750
No. 5950	No. 11800	No. 11850
No. 6000	No. 11900	No. 11950
No. 6050	No. 12000	No. 12050
No. 6100	No. 12100	No. 12150
No. 6150	No. 12200	No. 12250
No. 6200	No. 12300	No. 12350
No. 6250	No. 12400	No. 12450
No. 6300	No. 12500	No. 12550
No. 6350	No. 12600	No. 12650
No. 6400	No. 12700	No. 12750
No. 6450	No. 12800	No. 12850
No. 6500	No. 12900	No. 12950
No. 6550	No. 13000	No. 13050
No. 6600	No. 13100	No. 13150
No. 6650	No. 13200	No. 13250
No. 6700	No. 13300	No. 13350
No. 6750	No. 13400	No. 13450
No. 6800	No. 13500	No. 13550
No. 6850	No. 13600	No. 13650
No. 6900	No. 13700	No. 13750
No. 6950	No. 13800	No. 13850
No. 7000	No. 13900	No. 13950
No. 7050	No. 14000	No. 14050
No. 7100	No. 14100	No. 14150
No. 7150	No. 14200	No. 14250
No. 7200	No. 14300	No. 14350
No. 7250	No. 14400	No. 14450
No. 7300	No. 14500	No. 14550
No. 7350	No. 14600	No. 14650
No. 7400	No. 14700	No. 14750
No. 7450	No. 14800	No. 14850
No. 7500	No. 14900	No. 14950
No. 7550	No. 15000	No. 15050
No. 7600	No. 15100	No. 15150
No. 7650	No. 15200	No. 15250
No. 7700	No. 15300	No. 15350
No. 7750	No. 15400	No. 15450
No. 7800	No. 15500	No. 15550
No. 7850	No. 15600	No. 15650
No. 7900	No. 15700	No. 15750
No. 7950	No. 15800	No. 15850
No. 8000	No. 15900	No. 15950
No. 8050	No. 16000	No. 16050
No. 8100	No. 16100	No. 16150
No. 8150	No. 16200	No. 16250
No. 8200	No. 16300	No. 16350
No. 8250	No. 16400	No. 16450
No. 8300	No. 16500	No. 16550
No. 8350	No. 16600	No. 16650
No. 8400	No. 16700	No. 16750
No. 8450	No. 16800	No. 16850
No. 8500	No. 16900	No. 16950
No. 8550	No. 17000	No. 17050
No. 8600	No. 17100	No. 17150
No. 8650	No. 17200	No. 17250
No. 8700	No. 17300	No. 17350
No. 8750	No. 17400	No. 17450
No. 8800	No. 17500	No. 17550
No. 8850	No. 17600	No. 17650
No. 8900	No. 17700	No. 17750
No. 8950	No. 17800	No. 17850
No. 9000	No. 17900	No. 17950
No. 9050	No. 18000	No. 18050
No. 9100	No. 18100	No. 18150
No. 9150	No. 18200	No. 18250
No. 9200	No. 18300	No. 18350
No. 9250	No. 18400	No. 18450
No. 9300	No. 18500	No. 18550
No. 9350	No. 18600	No. 18650
No. 9400	No. 18700	No. 18750
No. 9450	No. 18800	No. 18850
No. 9500	No. 18900	No. 18950
No. 9550	No. 19000	No. 19050
No. 9600	No. 19100	No. 19150
No. 9650	No. 19200	No. 19250
No. 9700	No. 19300	No. 19350
No. 9750	No. 19400	No. 19450
No. 9800	No. 19500	No. 19550
No. 9850	No. 19600	No. 19650
No. 9900	No. 19700	No. 19750
No. 9950	No. 19800	No. 19850
No. 10000	No. 19900	No. 19950
No. 10050	No. 20000	No. 20050
No. 10100	No. 20100	No. 20150
No. 10150	No. 20200	No. 20250
No. 10200	No. 20300	No. 20350
No. 10250	No. 20400	No. 20450
No. 10300	No. 20500	No. 20550
No. 10350	No. 20600	No. 20650
No. 10400	No. 20700	No. 20750
No. 10450	No. 20800	No. 20850
No. 10500	No. 20900	No. 20950
No. 10550	No. 21000	No. 21050
No. 10600	No. 21100	No. 21150
No. 10650	No. 21200	No. 21250
No. 10700	No. 21300	No. 21350
No. 10750	No. 21400	No. 21450
No. 10800	No. 21500	No. 21550
No. 10850	No. 21600	No. 21650
No. 10900	No. 21700	No. 21750
No. 10950	No. 21800	No. 21850
No. 11000	No. 21900	No. 21950
No. 11050	No. 22000	No. 22050
No. 11100	No. 22100	No. 22150
No. 11150	No. 22200	No. 22250
No. 11200	No. 22300	No. 22350
No. 11250	No. 22400	No. 22450
No. 11300	No. 22500	No. 22550
No. 11350	No. 22600	No. 22650
No. 11400	No. 22700	No. 22750
No. 11450	No. 22800	No. 22850
No. 11500	No. 22900	No. 22950
No. 11550	No. 23000	No. 23050
No. 11600	No. 23100	No. 23150
No. 11650	No. 23200	No. 23250
No. 11700	No. 23300	No. 23350
No. 11750	No. 23400	No. 23450
No. 11800	No. 23500	No. 23550
No. 11850	No. 23600	No. 23650
No. 11900	No. 23700	No. 23750
No. 11950	No. 23800	No. 23850
No. 12000	No. 23900	No.

fuel, water, strutting, timbering, transport, offices, stores, workshops, staff, labour and the provision of proper and sufficient protective measures, diversions, temporary fencing and lighting. It shall also include: safety of workers, first-aid facilities, suitable accommodation for the staff and workmen with adequate sanitary arrangements, the effecting and maintenance of all insurance coverages, the payment of all wages, salaries, fees, royalties, duties or other charges arising out of the erection of works and the regular clearance of rubbish, reinstatement and clearing-up of the site as may be required on completion of works, safety of the public, and protection of the works and adjoining lands. The Contractor shall ensure that all actions are taken to assure the quality in the planning and execution of works. The quality assurance shall cover all stages of work such as setting out, selection of materials, selection of construction methods, selection of equipment and plant, deployment of personnel and supervisory staff, quality control testing, etc. The work of building in quality assurance shall be deemed to be covered in the scope of work. In the case of users' groups, the particular Site-in-Charge shall take necessary actions to assure the quality of works which will be executed by users. The Contractor shall furnish, at least 15 days in advance, his/her programme of commencement of item of work, the method of working he/she intends to adopt for various items of work such as site clearance, construction for embankments, sub-base, base, surfacing, culverts, bridges, causeways, retaining walls, simply supported girders, cantilever construction and such other items for which the Engineer demands the submission of the method of working. He shall provide information regarding the details of the method of working and tools/equipment which are to be employed and shall satisfy the Engineer about the safety and adequacy of the same. The sole responsibility for the safety and adequacy of the methods adopted by the Contractor will, however, rest on the Contractor irrespective of any approval given by the Engineer. In case of users' groups, the particular Site-in-Charge should assist the users' committee to prepare such work programmes before the commencement of activities. Site-in-Charge's assistance in selecting the most appropriate method of working is necessary since most of the users' groups lack the experience in this regard.

G -6 CONSTRUCTION EQUIPMENT In addition to the general conditions indicated in the contract or users' group agreement, the following conditions regarding the use of equipment in works should also be satisfied: The Contractor/Users' Group shall be required to give a trial run of the equipment for establishing their capacity to achieve the laid down Specifications and tolerances to the satisfaction of the Engineer before the commencement of work; All equipment provided shall be of proven efficiency and shall be operated and maintained at all times in a manner acceptable to the Engineer; All the plant/equipment to be deployed on the works shall be approved by the Engineer after ensuring their fitness and efficiency. No plant or equipment shall be used without the prior approval of the Engineer. No plant/equipment shall be removed from site without prior permission of the Engineer.

G -7 ENGINEERING DRAWINGS The Engineering Drawings provided shall be contained in the contract documents and shall be used as a reference. The Contractor/Users' Group shall visualise the nature and type of work contemplated and ensure that the rates and prices quoted/agreed by them in the Bill of Quantities have due consideration to the qualitative and quantitative variations, as may be found at the site or/and as per the complexities of work involved during actual execution/construction. When responsibility of the preparation of drawings lies with the Contractor, the contract unit rates/prices for the work shall be deemed to include the cost of preparation, supply and delivery of all necessary drawings, prints, and tracing which the Contractor is required to provide in accordance with the contract. Two copies of drawings, on the basis of which actual execution of the work is to proceed, shall be furnished free of cost to the Contractor/Users' Group by the Engineer progressively according to the work programme which is accepted in advance by the Engineer upon its submission by the Contractor/Users' Group. Drawings for any particular activity shall be issued to the Contractor/Users' Group in advance of the scheduled date of the start of the activity. Examination and/or approval by the Engineer of any drawings or other documents submitted by the Contractor/Users' Group shall not relieve the Contractor/Users' Group of

their responsibilities or liabilities under the contract.

G -8 SITE INFORMATION The information about the site of work and site conditions in the contract documents is given in good faith for guidance only, but the Contractor/Users' Group shall satisfy themselves regarding all aspects of site conditions. The location of the works and the general particulars of site are as shown on the Site Plan or Index Plan enclosed with the contract documents. The right-of-way to the bridge sites/road works shall be provided to the Contractor/Users' Group by the Engineer whereas the Contractor/Users' Group shall have to make their own arrangements for the land required for their site offices, labour camps, stores, etc. The quarry charts shall be enclosed with the contract documents as a guide to the Contractor/Users' Group. They indicate the location of quarries and other sources from where naturally occurring materials are available. The leads indicated in the said charts may be approximate. It is assumed that the Contractor/Users' Group will inspect the quarries, borrow areas, etc., well in advance to assess the availability of construction materials in required quantity and quality before quoting/agreeing their rates for the work.

G -9 SETTING OUT The Contractor shall establish working Bench Marks tied with the Reference Bench Mark in the area prior to the commencement of work and obtain the approval from the Engineer or a designated consultant who represents the Engineer at site. The reference Bench Mark for the area shall be as indicated in the contract documents and the values of the same shall be made available by the Engineer to the Contractor/Users' Group. The working Bench Marks shall be at the rate of four per km and also at or near all drainage structures, over-bridges and underpasses. In case of Users' Groups, the Engineer shall establish the working Bench Marks tied with reference Bench Marks in the area. Checks must be made on the Bench Marks monthly and adjustments, if any, shall be made by the Engineer. An up-to-date record of all Bench Marks including the adjustments made, if any, shall be maintained by the Engineer. A copy of this record shall be provided to the Contractor/Users' Group on regular basis. The lines and levels of formation, side slopes, drainage works, carriageways and shoulders shall be carefully set out and frequently checked. Care shall be taken to ensure that correct gradients and cross-sections are obtained everywhere. In order to facilitate the setting out of the works, the centre line of the carriageway or roadway must be accurately established by the Contractor and, subsequently, approved by the Engineer or his/her representative. It must then be accurately referenced at every 50 m intervals in the plain and rolling terrain; 20 m intervals in hilly terrain; and as necessary in all curve points. The Engineer shall make the necessary arrangements to highlight the reference points with marker pegs and chainage boards set in or near the fence line. These markers shall be maintained until the works reach to the finished formation level and, finally, are accepted by the Engineer. In case of Users' Groups, the centre line of the carriageway or roadway shall be established by the Engineer or his/her representative. In both cases, a schedule of reference dimensions shall be supplied to the Contractor/Users' Group by the Engineer. When construction reaches the next formation level stage, the centre line shall again be set out in the similar manner and shall be accurately referenced by marker pegs set at the outer limits of the formation. No reference peg or marker shall be moved or withdrawn without the approval of the Engineer and no earthwork or structural work shall be commenced until the centre line has been referenced. The Contractor/Users' Group will be the sole responsible party for safe guarding all survey monuments, bench marks, beacons, etc. The Engineer will provide the Contractor/Users' Group with all data necessary for setting out of the centre line, if disturbed. All dimensions and levels shown on the drawings or mentioned in documents forming part of or issued under the contract shall be verified by the Contractor/Users' Group on the site. They shall immediately inform the Engineer of any apparent errors or discrepancies in such dimensions or levels. The Engineer shall, in connection with the staking out of the centre line, survey the terrain along the road and shall supply a profile along the road centre line and cross-sections at intervals to the Contractor/Users' Group as required. After setting out, work on earthwork can commence and the profile and cross-sections shall form the basis for measurements and payment. The Contractor/Users' Group shall be responsible for ensuring

that all the basic traverse points are not disturbed until the commencement of the work and if any are missing or appear to have been disturbed, the Contractor/Users' Group shall make arrangements to re-establish these points. A "Survey File" containing the necessary data will be made available by the Engineer for this purpose. There will be no separate payment for any survey work performed by the Contractor/Users' Group in such instances. If in the opinion of the Engineer, design modifications of the centre line or grade are advisable, the Engineer shall perform the modifications in the field, as required, and modify the ground levels on the cross-sections accordingly as many times as required. The labour involved in setting out works from the part of Contractor shall be deemed to be a part of general works preparatory to the execution of work and no separate payment shall be made for the same. Automatic levels, having a standard deviation of ± 5 mm per km, shall be used for all double run levelling work. Setting out of the road alignment and measurement of angles shall be done by using theodolite with traversing target having an accuracy of 20 seconds. Measurement of distances shall be done generally by using tape measurements. **G -10**

PUBLIC UTILITIES No clearance or alterations to the utility shall be carried out unless specially ordered by the Engineer. Any services affected by the works must be temporarily supported by the Contractor/Users' Group. The Contractor/Users' Group must take all measures reasonably required by various bodies to protect their services and property during the progress of the works. The Contractor/Users' Group may be required to carry out certain works for and on behalf of various bodies and shall also provide, with the prior approval of the Engineer, such assistance to various bodies as may be authorised by the Engineer. The work of temporarily supporting and protecting the public utility services during execution of the works shall be deemed to be part of the contract and no extra payment shall be made for the same. The Contractor/Users' Group may be required to carry out the removal or shifting of certain services/utilities on specific orders from the Engineer for which payment shall be made to him. Such works shall be taken up by the Contractor/Users' Group only after obtaining clearance from the Engineer and ensuring adequate safety measures. **G -11 PRECAUTIONS FOR SAFEGUARDING THE**

ENVIRONMENT **G-11.1 General** The Contractor/Users' Group shall take all precautions

for safeguarding the environment during the course of the construction of the works. He shall abide by all laws, rules and regulations in force governing pollution and environmental protection that are applicable in the area where the works are situated. **G-11.2 Borrow Pits**

for Embankment Construction Borrow pits shall not be dug in the right-of-way of the road.

The requirements stated in clause 2-5.2.2 shall apply in this regard. **G-11.3 Quarry Operations** The Contractor/Users' Group shall obtain materials from quarries only after the consent is obtained from the Department of Forest or other concerned authorities. The quarry operations shall be undertaken within the purview of the rules and regulations in force. **G-11.4 Control of Soil Erosion, Sedimentation and Water Pollution** The

Contractor/Users' Group shall carry out the works in such a manner that soil erosion is fully controlled, and sedimentation and pollution of natural water courses, ponds, tanks and reservoirs is avoided. The requirements stated in clause 2 -6 shall apply. **G-11.5 Pollution from Hot-Mix Plants and Batching Plants** Bituminous hot-mix plants and concrete batching plants shall be located sufficiently away from habitation, agricultural operations or industrial establishments. The Contractor/Users' Group shall take every precaution to reduce the levels of noise, vibration, dust and emissions from the plant and shall be fully responsible for any claims for damages caused to the owners of property, fields and residents in the vicinity. **G-11.6 Substances Hazardous to Health** The Contractor/Users' Group shall not use or generate any materials in the works which are hazardous to the health of persons, animals or vegetation. Where it is necessary to use some substances which can cause injury to the health of workers, the Contractor/Users' Group shall provide protective clothing or appliances to their workers. **G-11.7 Other Precautions** The Contractor/Users' Group must

take all reasonable steps to minimise dust nuisance during the construction of the works. All existing roads used by vehicle of the Contractor/Users' Group or any of their sub-

contractors/sub-groups or suppliers of materials or plant, and similarly any new roads which are part of the works and which are being used by traffic, shall be kept clean and clear of all dust/mud or other extraneous materials dropped by the said vehicles or their tyres.

Similarly, all dust/mud or other extraneous materials from the works spreading on these roads shall be immediately cleared by the Contractor/Users' Group. Clearance shall be affected immediately by manual sweeping and removal of debris and all dust, mud and other debris shall be removed entirely from the road surface. Additionally, if so directed by the Engineer, the road surface shall be hosed or watered using suitable equipment. Any structural damage caused to the existing roads by the Contractor's/Users' Group's construction equipment shall be made good without any extra cost.

G -12 ARRANGEMENT FOR TRAFFIC DURING CONSTRUCTION (only when necessary)

G-12.1 General Arrangement The Contractor or the Users' Group shall be responsible for carrying out work on the road with minimum interference to the traffic as well as without affecting the satisfactory execution of the construction works. While the improvement works of the rural road are in progress, the construction party shall follow the respective directions issued by the Engineer. A passage of traffic either along a part of the existing carriageway or along a temporary diversion shall be opened prior to the closure of road section for improvements.

G-12.2 Traffic Passage along a part of the Existing Carriageway under Improvement This situation will occur when an existing road is subjected to the following improvements: widening of the carriageway; strengthening of the existing pavement; reconstruction or repair of cross-drainage works, etc. and where a part of the road width provides enough space for such work, leaving the remaining part for traffic. To make room for this passage of traffic, the shoulder is often required to be widened; levelled; dressed and maintained throughout the duration of work. This work needs to be done to the satisfaction of the Engineer. For works in long continuous stretches, passing passage of 20 m X 6 m inclusive of the width of the existing carriageway shall be provided at 500 m intervals or as directed by the Engineer.

G-12.3 Traffic Passage along a Temporary Diversion (only when necessary) Where a passage for traffic on a part of the carriageway is not possible, a temporary diversion closer to the road alignment needs to be opened. The necessary temporary crossings shall be provided on the approval of Engineer.

G-12.4 Traffic Safety and Control (only when necessary) During the construction of road, the party responsible for the construction shall ensure the safety of traffic. In this regard, the construction party shall provide, erect and maintain the necessary barricade signs, markings, flags, lights and flag men, etc. to provide the correct information to the vehicles in order to ensure the safety of approaching and passing traffic. A phased programme for the diversion of traffic shall be drawn up with the Engineer prior to the commencement of work. Where a part of the carriageway becomes inadequate for two lane traffic, one-way traffic operation shall be established. Suitable regulatory or warning signs shall be placed on both approaches to provide necessary guidance to the road users. Upon the approval of Engineer, the signs on each approach shall be placed as follows: one, close to the point where transition of carriageway begins, and the other, 120 m away.

G-12.5 Maintenance of Diversion and Traffic Control Devices All the diversion and traffic control devices which are mentioned in paragraph G-12.4 shall be well maintained to the satisfaction of the Engineer.

G-12.6 Measurements for Payment Measurement of the above works shall be done in the following ways: (a) Incidental to the Contracted Work : The works performed in respect of maintaining an uninterrupted traffic flow through the section of road under improvements shall be considered as incidental to the contracted works with the exclusion of provisional works. (b) Provisional Works :

Temporary diversions, initial dressing of the shoulders and additional passing passages. The former shall be paid from the contracted sum and the latter from the provisional sum.

G -13 GENERAL RULES FOR THE MEASUREMENT OF WORKS FOR PAYMENT

G-13.1 General Measurements of works shall be done in metric system. Procedure for the measurements of works under item rate contract is usually defined

in the general conditions of contract. For lump-sum contracts and turn key contracts, the procedure shall be defined under the special provisions of the contract. The measurements and computations of works shall be carried out to the nearest of the following limits: length and breadth (for each 30 m length or less) height/depth/thickness of earthwork, sub-bases, bases, surfacing and structures (for each 15 m or less) areas (for each 1 m² or less) volumetric quantity (for each 1 m³ or less)⁴. Dimensions of completed works are recorded in the following sequential orders - (i) length; width/breadth; or (ii) height/depth/thickness. G-13.2

Measurement of Lead for Materials Where there is a provision for separate payment with regard to additional lead, the measurement of which shall be taken over the shortest practicable route irrespective of which route has been taken in actual practice. Decision on this regard shall be made by the Engineer of the project. Lead measurements shall be taken along the slope of the route. For additional lead payment purposes, the unit lengths of lead distances shall be as follows: for distances up to and including 200 m **50 m** for distances exceeding 200 m, but not exceeding 1 km **200 m** **Note :** When the distance exceeds 1 km, the norms applicable for transportation shall be used. Refer to Volume IV of **WORK NORMS for Labour-based Construction Works of Agricultural and Rural Roads**

Unit length shall be reckoned as one, if it is half or above. Unit length shall be ignored, if it is less than half of the unit length. The distances mentioned above are to be understood as those in addition to the initial lead covered by the item rate. Source of materials shall be divided into number of blocks. For each block, the lead length for payment shall be measured from the **centre of the block at source** to the **centre of the block at placing**. G-13.3 **Measurement of Pavement Thickness when making the payment on Volume Basis** If the payment for sub-

base/base/pavement is to be made on volume basis, then the measurement procedure shall be as follows: Level measurements shall be taken before and after the construction. Level measurements shall be taken at the points (either side) which are 0.75 m away from the centre line of the carriageway. These points should be at 10m intervals longitudinally. The longitudinal distance may vary as per the decision of Engineer as and when required. Suitable reference lines shall be established along the edges of carriageway in the form of wooden spikes or embedded bricks/stones. This will clearly define the measured sub-base/base/pavement width. In the case of widening, at least one level line shall be taken along each strip of widening. The average thickness of the pavement course (there may be several layers in one course) in any area shall be the arithmetical mean of the level differences (before and after construction) at all grid points falling in that area. Each thickness shall be confirmed with the design or the field-level instructions given by the Engineer. As a cross check to the level measurements, the Engineer is authorised to measure the thickness of any grid point by making cores or holes, if required. G-13.4

Measurement of Pavement Thickness when making the payment on Area Basis

Engineer could use suitable penetration gauge at regular intervals to measure the thickness of the sub-base/base/pavement on ad-hoc basis. He/she may employ any other methods which are in use for the determination of thickness. When the thickness is confirmed with the design, the payment could be made by taking the area measurements. G

-14 SCOPE OF RATES FOR DIFFERENT FORM OF CONTRACTS For Labour

Contract The unit item rate (quoted/agreed) shall be taken as the rate for finished work covering labour component only. Required tools, plant and equipment shall be either provided or compensated by the client as per the Engineer's Cost-estimate. This basically applies for *Users' Groups* and *Local Labour Groups*. **For Item Rate Contract** The unit item rate (quoted or contracted) shall be taken as the rate for completing the work to the requirements of the Specifications. It includes full compensation for all the operations detailed in the relevant sections of these Specifications under the clause-

"Rates". It covers components such as labour, material, wastage, precautionary measures, preparatory work, temporary arrangements, etc. However, the components such as tools, plant, equipment, profits, taxes as well as liabilities, obligations and risks shall be covered separately by respective quotations made in the Contractor's bid. This applies for *Contractors*.

1

Site Clearance

1 -1 CLEARING AND GRUBBING

1-1.1 Description

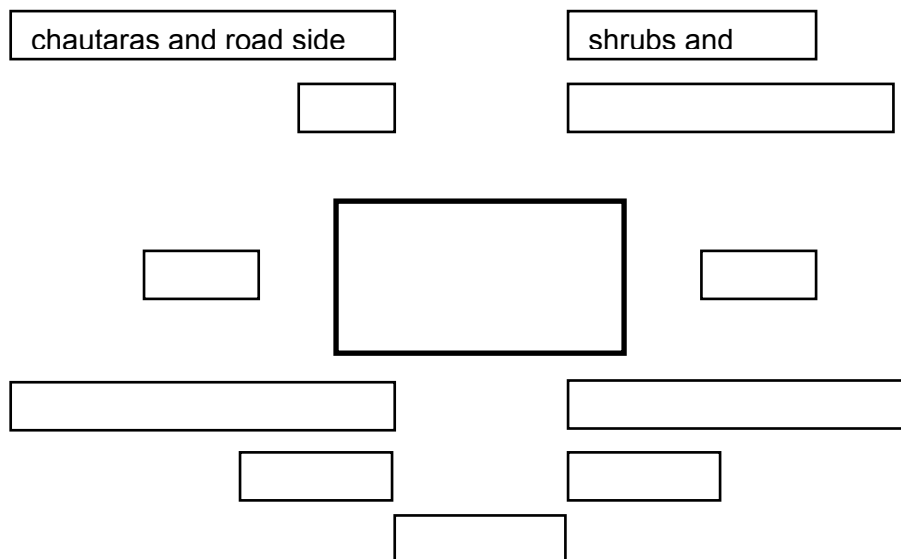
Clearing and grubbing shall be carried out prior to earthwork.

The work includes the removal and disposal of objects such as,
trees
bushes
shrubs
stumps
rubbish
and other obstacles to work.

1-1.2 Preservation of Property/Amenity

The cost required for protecting the property and amenity shall be considered as included in the item rate of the contracted work.

(a) The objects which shall not be disturbed or otherwise be protected are as follows:



(b) The Users' Group/Contractor who will be entrusted the work shall take adequate measures against the environmental degradation such as:

soil erosion and
water pollution of the concerned area.

(c) The Users' Group/Contractor shall submit the following documents to the Engineer for approval prior to the commencement of such work.

work plan and proposed procedure for the disposal of waste materials
schedules for carrying out temporary and permanent erosion control work as stated in clause 2-6.3.

1-1.3 Methods, Tools and Plants

Clearing and grubbing work shall be carried out as per the following guidelines:

- (a) The adopted methods, tools and plants should not affect the property to be preserved while carrying out the activities. are to be approved by the Engineer prior to the commencement of work.
- (b) The roots of trees, stumps, etc. which fall within the cut and fill lines shall be removed up to a minimum depth of 0.5 m below the ground level.
- (c) The roots of trees and stumps which fall immediately beyond the fill lines shall be removed up to 0.15 m below ground level so that they are not noticeable after clearing.
- (d) Such deeply excavated pockets which are created as a result of the removal of trees, stumps, etc. shall be filled with suitable fill material and compacted properly in order to make such surfaces affirmed with the surrounding ground surface.
- (e) Vegetation such as roots, secondary growth, grass and other organic substances which are unsuitable as fill material shall be removed from fill areas to the satisfaction of the Engineer.
- (f) The branches of trees extending above the roadway shall be trimmed as directed by the Engineer.

1-1.4 Disposal of Cleared Materials

The work under this item shall be carried out as per the following order:

- (a) All materials which originated as a result of clearing and grubbing operations shall be considered as the property of the owner of the concerned land. In this case, the owner may be a private (an individual citizen) or a public (Government, VDC, etc.) party.
- (b) Cleared materials shall be disposed by the Contractor/Users' group as directed by the Engineer and in accordance with the consensus of owner.
- (c) Trunks and branches of trees shall be cleared up by cleaning the limbs and tops and stacked neatly within the right-of-way of each place.
- (d) Products of clearing and grubbing which cannot be used or auctioned as determined by the Engineer shall be dumped to a dumping site/pit and burnt or buried. The dumping sites shall be determined as per the direction of Engineer.
- (e) Precautionary measures shall be taken in advance to prevent any mixing up of cleared materials with the materials meant for embankment/road construction.

1-1.5 Measurements for Payment

The measurement of the work "clearing and grubbing" shall be taken by the Engineer for the purpose of payment to the Contractor/Users' Group. The following guidelines shall be followed in this regard:

- (a) Unit of payment for clearing and grubbing shall be in m².
- (b) The item "clearing and grubbing" includes the cutting of trees less than 30 cm in girth measured at 1 m above the ground.

(c) The payment for cutting of trees having the following measurements shall be made separately by counting the number of trees belonging to the concerned range and by measuring the girth of individual tree at a spot 1 m above the ground.

girth of above 30 cm up to 60 cm

girth of above 60 cm up to 90 cm

girth of above 90 cm up to 180 cm

girth of above 180 cm up to 270 cm

girth of above 270 cm up to 450 cm.

If girth is above 450 cm, then the payment shall be made by extrapolating the rate of above range.

1-1.6 Rates

The rates for the item “clearing and grubbing” shall be determined as follows:

(a) The quoted unit rate in the contract shall be paid in full for all operations under the item “clearing and grubbing” which includes full compensation for labour, materials and any other incidentals.

(b) Where a contract does not include a separate item for clearing or grubbing then such work shall be covered as incidental to the earthwork items. In such cases, the quoted unit rate in the contract for earthwork item shall cover the expenses for clearing and grubbing as well.

1 -2 DISMANTLING CULVERTS, BRIDGES, PAVEMENTS AND OTHER STRUCTURES

1-2.1 Description

This item shall consist of operations such as dismantling and removal of the existing structures and utilities which are not suitable to be remained in place, salvaging or/and disposing of the resulting materials from the concerned site, and backfilling the trenches and pits which are created as a result of the removal of such structures.

The following types of structures and utilities shall be considered under this item:

culverts

bridges

pavements

kerbs

guard rails

fences

utility poles

manholes

catch basins

inlets, etc.

Dismantling and removal operations shall be completed prior to the start of new construction.

1-2.2 Dismantling Culverts and Bridges

The dismantling operation shall be carried out as per the following guidelines:

It should be done carefully without causing damages to the materials which can be reused. Resulting materials which cannot be reused shall be removed from the site.

All reusable materials shall be retained and salvaged for future use.

Removal of overlying or adjacent materials, if required, shall be **incidental** to this item.

Where the existing bridges/culverts are to be extended or otherwise incorporated in the new construction, only such part or parts of the existing structure shall be removed as it is necessary to provide a proper connection to the new component. In such cases, connecting edges shall be cut, chipped and trimmed to the required lines and grades while reinforcement bars shall be left to act as dowels.

Particularly in the case of pipe culverts, the hume pipes shall not be damaged during the dismantling operation.

While dismantling the steel framed structure, care must be taken in order to avoid any damages to its members.

If the structure which needs to be removed is in a condition suitable for **re-creation or re-erection** then,

all members shall be match-marked with white lead paint before dismantling.

end pins, nuts and bolts, gusset plates, etc. shall be match-marked to indicate their location.

all pins, pinholes and machined surfaces shall be painted with a mixture of white lead and tallow.

all loose parts shall be securely wired to adjacent members or packed in boxes.

While dismantling timber framed structures, care must be taken in order to prevent any damages to its members. Removed parts shall be salvaged as per the instruction of the Engineer.

1-2.3 Dismantling Pavements and Other Structures

The removal of unnecessary parts or the sections shall be carried out in such a way that the cut face at the joint should be perpendicular to the surface of the existing structure.

If the dismantled concrete structures or base course elements are to be reused then those shall be broken into pieces whose volume shall not exceed 0.02 m^3 . Such pieces shall later be stock piled at the locations designated by the Engineer.

1-2.4 Backfilling

Ditches and cavities caused due to dismantling operations shall be backfilled with suitable fill material as directed by the Engineer. Such fill shall be compacted to the satisfaction of Engineer.

1-2.5 Disposal of Dismantled Materials

All materials which originated as a result of dismantling operations shall be considered as the property of the owner of the concerned structure. In this case, the owner may be a private (an individual citizen) or a public (Government, VDC, etc.) party.

All reusable materials shall be stock piled within the right-of-way at places designated by the Engineer. This includes hume pipes, steel parts, timber members and similar reusable materials.

Unless otherwise specified or directed, all structural steel shall be stored in blocks at locations convenient for loading.

Structures or elements of structures which are specified in the contract for re-erection shall be stored in separate piles.

Timber planks, beams or logs of old structures which are designated by the Engineer as materials to be salvaged shall be stacked in piles at locations convenient for loading. All nails, bolts and nuts should be removed prior to stacking.

All the products of dismantling operations which, in the opinion of the Engineer, cannot be reused or auctioned shall be disposed as waste materials. Such waste shall be kept away from the right-of-way of the road.

1-2.6 Measurements for Payment

The dismantling operations shall be measured in the respective units as follows:

Dismantling brick/stone/concrete (plain and reinforced) masonry : in cubic metre.

Dismantling flexible and cement concrete pavement : in cubic metre.

Dismantling steel structures : in tonne.

Dismantling timber structures : in cubic metre.

Dismantling pipes, guard rails, kerbs, gutters, fencing : in linear metre.

Utility poles : in numbers.

1-2.7 Rates

The quoted/agreed unit rates in the contract for the items of dismantling works shall be paid in full for carrying out the required operations including full compensation for labour, materials, protective measures and other incidentals.

Various operations included in each rate shall be dismantling, excavation, backfilling, piling, disposing, handling, hauling up to 100 m and related protective measures.

2

Earthwork and Drain Construction

2 -1 ROADWAY AND DRAIN EXCAVATION

2-1.1 Description

This work which consists of excavation, removal and satisfactory disposal of all materials shall be necessary for the construction of
roadway (carriageway and shoulders)
side drains and
other cross drainage structures

and shall be performed in accordance with the
requirements of the Specifications
lines, grades and cross-sections given in the construction drawings
or
directions given by the Engineer.

Roadway and drain excavation work shall also include
hauling and stacking of cut and fill materials wherever necessary, and
trimming and finishing of the roadway surface and slopes.

2-1.2 Classification of Excavation Material

2-1.2.1 *Authority for Classification*

The classification of excavated material shall be decided by the Engineer or his representative. The decision of the Engineer shall be regarded as final within the scope of the contract (in case of Contractor) or the agreement (in case of Users' Group). Mere use of explosives shall not be entertained as the basis for higher classification.

2-1.2.2 *Classification*

All materials involved in excavation are classified below. At the field, these materials shall be identified and determined by the Engineer or his representative before or during the earthwork operation.

(a) Ordinary soil shall comprise of organic soil, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale, loose moorum, mixture of the above and similar material which could be excavated by ordinary application of picks and shovel, kodalo or any other ordinary digging tool.

Gravel or any other nodular material having maximum diameter not exceeding 75 mm in any direction shall also be covered in this category.

(b) Hard soil shall include:

material like stiff heavy clay, hard shale, compact moorum which could be excavated by extensive application of grafting tool or pickaxe or both and shovel,

gravel and cobble stones having maximum diameter between 75 mm and 300 mm in any direction,

existing soling surfaces of roads, paths, etc. when these surfaces are to be dismantled.

(c) Ordinary rock shall include:

lime stone,
sand stone,
laterite,
soft conglomerate when the blocks could be detached from the matrix by simply using the pickaxes,
soft or fissured rock which can be split/quarried with crowbars,
boulders having maximum diameter between 300 mm and 500 mm in any direction which are lying loosely on the ground or embedded in the river bed,
any rock which in dry state may be hard but in wet state becomes soft and manageable without much effort.

(d) Medium rock shall include:

rocks which do not necessarily require blasting but do require some efforts in breaking by chisels and hammers,
hard conglomerate,
boulders having maximum diameter above 500 mm in any direction which are lying loosely on the ground or embedded in the river bed,
any rock which in dry state may be hard but in wet state becomes comparatively manageable with a focused effort.

(e) Hard rock shall include:

rocks which require either blasting or intensive chiselling or use of mechanical plant.

When uncontrolled blasting is prohibited due to environmental reasons then the excavation of hard rock shall be carried out by

chiselling,
wedging,
tempering and any other standard method.

(f) Marshy soil shall include materials below ground level of marshes, swamps and other areas where continuous dealing with water is required.

2-1.3 Construction Operations

2-1.3.1 *Setting Out*

Limits of excavation shall be as per the construction drawings or as directed by the Engineer. The boundaries for excavation shall be set out as per the lines, curves, slopes, grades and sections given in the construction drawings.

Responsibility of carrying out this task shall be in accordance with the Clause **G-9**.

2-1.3.2 *Stripping and Storing Top Soil*

The layer of top soil (generally 150 mm) shall be stripped and stored at designated locations for reuse in roadside/embankment slopes, cut slopes, berms and disturbed areas where vegetation is desired. It should be confirmed that the entire organic substances are stripped out from the area under excavation or filling.

2-1.3.3 Excavation (General)

Excavation shall be carried out in conformity with the contract (Contractors) or the agreement (Users' Groups) and as per the directions of the Engineer. Wherever possible, the excavated material shall be stock piled if they are found suitable for future use. Adequate precautions against soil erosion and water pollution shall be taken while planning or executing excavation.

The excavation shall be conformed with the lines, grades, side slopes and levels as given in the construction drawings or as directed by the Engineer. No excavation shall be carried out outside the slopes and below the established grades by loosening any materials outside the limits of excavation.

Such excess excavation beyond the permissible limits shall be recovered from the Contractor/Users' Group or from their payment. Debris and loose materials on the slopes of cutting surfaces shall be removed.

No back filling shall be allowed to obtain the required slopes except when boulders or soft materials are encountered in cut slopes. The resulting cavities left over by the excavation of unsuitable materials shall be filled with suitable fill material and compacted as directed by the Engineer.

2-1.3.4 Rock Excavation

Rock in roadway excavation shall be removed up to the sub-grade level or as indicated in the construction drawings. Where unstable shales or other similar materials appear at the sub-grade level, they shall be excavated to the extent of 500 mm below the sub-grade level or even more to the satisfaction of the Engineer.

The rock excavation shall be carried out in such a manner that the rock protrudes shall not exist above the specified levels at any point. However, a negative tolerance of 150 mm could be allowed for the over-excavated portions.

Such over-excavated portions shall be recovered by hand packing of rubble and chips and by compacting them to the designed level. Slopes in rock cutting shall be finished to a uniform surface corresponding to the designed slope.

Where blasting is required, it shall be carried out in confirmation with clause 2 -2 and all necessary precautions shall be observed as indicated therein.

Where pre-splitting blasting is prescribed, it shall be carried out in confirmation with clause 2 -3.

2-1.3.5 Excavation of Marshy Land

Excavation of marshes/swamps shall be carried out as per the programme laid down by the Engineer.

Excavation of marshes shall begin at one end and shall proceed towards a single direction across the entire marsh. Back filling shall be carried out immediately after this operation.

All muck shall be completely removed and displaced, from the area shown on the drawings or staked by the Engineer and up to the firm base of the marshy land or to the level indicated by the Engineer.

2-1.3.6 Excavation of Road Shoulders for the purpose of pavement widening

During the widening of existing pavements,

The shoulders shall be excavated to the required width and level as shown on the drawings or as indicated by the Engineer.

The existing pavement which is supposed to be retained shall not be loosened or disturbed under any circumstances.

2-1.3.7 Excavation of Surface/Sub-surface Drains

Where the contract provides provisions for constructing surface/sub-surface drains (refer to clause 2 -9) the excavation shall be carried out according to the sequence which complies with the other works or is approved by the Engineer.

2-1.3.8 Removal of Slides

Slides, if occurred in cut slopes during construction, shall be removed at the cost of Contractor/Users' Group as per the instruction of Engineer.

If finished slopes slide into the roadway then such slides shall be removed by the Contractor/Users' Group at the contract rate/agreed rate for the class of excavation involved. This could be done only if the slides occurred due to a factor other than the low quality workmanship of the Contractor/Users' Group.

The classification of the slipped material shall be determined as per its condition at the time of removal. The payment shall be made accordingly regardless of its condition earlier.

2-1.3.9 Dewatering

If water is found during the excavation due to springs, sub-surface runoffs, rainfall or other causes then it shall be removed by suitable diversions, pumping or bailing out. However, the excavation shall be kept dry whenever required by the work or as directed by the Engineer.

Care shall be taken to discharge the drained water without causing damages to the completed works, crops and any other private or public property.

2-1.3.10 Disposal of Excavated Material

All the excavated materials shall be the property of either the government or DDC or VDC or the community.

Where the excavated material is identified for re-use for the construction of embankment then it shall be safely stored/piled up at a location as per the requirements given in clause 2 - 5.

Excavation and disposal operations shall be arranged in such a way that the moisture content of soil should not be lost adversely during the process of cutting, hauling and compaction.

All hard materials such as hard moorum, rubble, etc. which are not intended for use in earth filling shall be stacked neatly for other uses such as pitching.

All excavated materials shall be disposed/piled up/stacked on the land owned by the government/DDC/VDC/community or in a location shown by the Engineer.

Unsuitable and surplus materials which are not intended for re-use shall be disposed as directed by the Engineer.

2-1.4 Plying of Construction Traffic

Construction traffic shall not use the cut formations without prior permission of the Engineer.

Any damage arising as a result of unauthorised traffic shall be re-built by the Contractor/Users' Group at their own expenses.

2-1.5 Preservation of Property

The Contractor shall undertake all reasonable precautions for the protection and preservation of any or all existing roadside trees, drains, sub-surface drains, pipes, conduits and any other structures under or above the ground which may be affected by construction operations and which, in the opinion of the Engineer, shall be continuously used without any change.

Contractor/Users' Group shall take adequate measures to safeguard the property and shall obtain prior approval of Engineer in such events.

Any damage caused by the negligence of Contractor/Users' Group shall be recovered or restored at their cost.

2-1.6 Preparation of Cut Formation

The cut formation shall be prepared as a foundation to sub-base/base course. It shall be carried out as per the drawings or as directed by the Engineer.

At sub-grade level, if the material is found with poor compaction then it shall be loosened to a depth of 500 mm and compacted in two layers (each of 250 mm) in accordance with clause 2 -5.

In rocky formation, the irregularities in the surface shall be corrected up to the specified elevation as shown in the drawings or as directed by the Engineer.

2-1.7 Finishing Operations

This work shall include proper shaping and dressing of all excavated surfaces. At no point, the finished surface shall vary from the designed slope by more than:
150 mm (measured at right angles to the slope) in the case of earth excavation and
600 mm (measured at right angles to the slope) in the case of rock excavation.

In no case, any portion of the side slopes shall encroach the roadway. The finished cut formation shall satisfy the surface regularity tolerances described in clause 5 -1.

The top soil removed earlier and conserved for re-use (as per clauses 2-1.3.2 and 2-5.3.2) shall be spread over cut slopes, filled slopes and other disturbed areas as directed by the Engineer.

If required, such slopes shall be roughened and moistened prior to the application of top soil. The top soil shall be spread as a layer of 75 mm to 150 mm thick.

2-1.8 Measurements for Payment

The quantities of roadway and drain excavation shall be measured by comparing the cross sections taken before the commencement and after the completion of works. These cross-sections should represent the same locations established in suitable intervals as per the ground profile.

Volumes are computed by the method of average end areas and are in cubic metres. At inaccessible and erratic locations, the volumes shall be computed by using other accepted methods. The Contractor/Users' Group could leave depth indicators during the excavation in order to indicate the original ground level as per the direction of the Engineer. The indicators shall not be disturbed until the final measurements are taken.

To determine the quantities of rock excavation, the cross-sections shall be taken after removing the overburden. Where the surface is irregular and when the material is admixed with other classes, the volumes shall be computed on the basis of stacked volume of material. In case of rock, 40% deduction of volume shall be made for the voids. In case of materials other than rock, this deduction shall be only 16% .

Quantities of work in the preparation of cut formation shall be measured in units indicated below:

loosening and re-compaction at sub-grade level : m^3

removal of unsuitable materials : m^3

replacement with suitable materials in place of removed unsuitable materials : m^3

preparing rocky sub-grade : m^2

stripping and storing of top soil : m^3

reapplication of top soil : m^2 .

2-1.9 Rates

2-1.9.1 *Contract Unit Rate for Roadway and Drain Excavation*

The contract unit rate for roadway and drain excavation shall be paid in full for carrying out the operations required for the individual items including full compensation for:

setting out

transporting and depositing/stacking the excavated materials on sites of embankments or spoil banks (up to a lead of 50 m along the slope of lead route)

trimming of excavated surfaces

dewatering

all labour, precautionary measures, incidentals which are necessary for the completion of work as per the Specifications.

wherever necessary a separate provisional rate shall be defined for pre-splitting work in rock excavation. It shall be worked out and paid as per clause 2-3.5.

2-1.9.2 Contract Unit Rate for Loosening and Re-Compacting at Sub-Grade Level

The unit rate for this work shall include full compensation for:
loosening of sub-grade soil to specified depth
breaking clods
spreading in layers
watering and
compaction.

2-1.9.3 Contract Unit Rates for Removal of Unsuitable Materials and Replacement with Suitable Materials

Unit rates for these items shall be the same as indicated in clauses 2-1.9.1 (for excavation) and 2-5.7.1 (for filling).

2-1.9.4 Contract Unit Rate for Preparing Rocky Sub-Grade

The unit rate for this item includes full compensation for:
providing, laying and compacting sub-base/base material as directed and
labour, incidentals and lead up to 50 m along the slope of lead route.

2-1.9.5 Contract Unit Rate for Stripping, Storing and Re-Application of Top Soil

It shall include full compensation for all necessary operations including lead up to 100 m along the slope of lead route.

2-1.9.6 Contract Unit Rate for Transporting Material from Excavation Sites

It shall include full compensation for all labour and incidentals on account of additional haul beyond the initial lead of 50 m along the slope of lead route.

2 -2 BLASTING OPERATIONS

2-2.1 General

2-2.1.1 Carrying and Storing of Explosives

In this respect, all HMGN statutory laws, regulations, rules which are pertaining to acquisition, transport, storage, haulage and use of explosive materials shall be followed.

Blasting shall be carried out:

with the written approval of the Engineer.

in the presence of police personnel.

as per the prior arrangement made with the security authorities of the area.

The Contractor/Users' Group shall be responsible for:

any damage to property

any accident to workers

any accident to public

on account of transportation, storage, handling and use of explosives.

2-2.1.2 Magazine

Magazine for the storage of explosives shall be built to the design Specifications and to the satisfaction of the concerned authority. It shall be located at a nearer site or in the premises of:

Royal Nepal Army or
Nepal Police Department

or

any other place which satisfies the requirements of the Government.

No unauthorised person shall be allowed to enter the magazine. No matches or inflammable materials shall be allowed in the magazine. The magazine shall be provided with an effective lightning conductor.

The following items shall be displayed in the lobby of the magazine.

a copy of relevant rules on safe storage,
a statement of up-to-date stock in the magazine,
a certificate showing the last date of testing of the lightning conductor, and
No Smoking sign.

2-2.1.3 Methods of Blasting

Methods of blasting need to be approved by the Engineer. These shall be in consistent with the safety and job requirements.

2-2.2 Materials, Tools and Equipment

All the materials, tools and equipment for blasting operations shall be approved in advance by the concerned authority. Engineer shall specify the type of explosives to be used for special blasting operations.

Fuse to be used in wet locations shall be fully water resistant for at least 30 minutes after immersing into water. The burning rate of fuse wire shall be:

uniform and
definitely known

in order to decide the safe length of cut pieces.

Fuse wire, gelatine or detonators shall:
be capable of producing an effective blast.
be fresh.

not easily be damaged due to dampness or any other reason.

Damaged blasting materials shall not be used and, later, be destroyed by the designated authority.

2-2.3 Personnel

The blasting work shall be conducted by a licensed blaster under the supervision of a trained or experienced blasting foreman/engineer. The storekeeper, overseer, sub-overseer or any other personnel who is involved in blasting shall be well acquainted with the details of handling and use of explosives.

2-2.4 Blasting Operations

2-2.4.1 Precautionary Measures to be taken during the Blasting Operations

Blasting shall be carried out during fixed hours of the day:
at lunch hour,
at the close of day's work,
at a time ordered in writing by the Engineer.

All blasting charges shall be prepared by the designated In-charge only.

People other than the one who lights the fuse shall be prohibited to enter the area.

During blasting operations, red danger flags shall be displayed 200 m away from the blasting site, in all directions.

All persons including the workers shall be excluded from the flagged area at least 10 minutes before the firing. A warning siren shall be blown for this purpose.

2-2.4.2 Preparation for Blasting

The charge holes shall be located in suitable places and drilled to the depth as per the requirement.

The use of blasting should be as minimum as possible. However, it should break the material up to an extent where loading and hauling of the broken pieces are made easier.

Any method that leads to overshooting shall be discontinued immediately.

2-2.4.3 When Blasting is conducted with Explosive Powder

The fuse shall be cut to the required length.

The cut piece of the fuse shall be inserted into the hole.

Powder shall be dropped in the hole and gently tamped with copper rods with rounded ends.

The explosive powder shall be covered with sticky material (clay). This material shall also be tamped lightly but firmly.

2-2.4.4 When Blasting is conducted with Dynamite or Other Higher-quality Explosives

Dynamite cartridge shall be prepared by

inserting the square cut end of a fuse into the detonator;

finishing it with nippers at the open end;

pushing the detonator gently into the primer leaving 1/3 of the copper tube exposed outside;
and

closing the paper of cartridge securely by binding with wire or twine.

The prepared primer cartridge shall be inserted into the explosives.

Bore holes shall be of adequate size to accommodate the cartridge. The holes shall be cleared of all debris before inserting the explosives. A minimum space of 20 cm shall be kept above the charge in order to be filled with dry clay. Clay shall be pressed gently but firmly.

Rest of the space above the clay layer could be filled with any available material. This material shall also be tamped gently with a wooden hammer.

2-2.4.5 Firing of Explosives

At a time, not more than 10 charges shall be prepared and fired.
Blasting-in-Charge shall blow a siren in a recognised manner in order to alert the people.
All the people shall move to a safe haven.
Blasting-in-Charge shall light the charges.
Before allowing the workers to be back in blasting site, he shall count the number of charges exploded and disconnect all the charges which have not been exploded.

2-2.5 Misfire

Sufficient time shall be allowed for delayed blasting.
Blasting-in-Charge shall inspect all the charges individually and determine the missed charges.

2-2.5.1 If the Charge is Blasting Powder

In the case of misfire, the sequence and procedure adopted shall be as follows:
Misfired charges shall be completely flooded in water.
A new hole shall be drilled at about 45 cm away from the old hole and fired.
If the old charge is still not fired then the prescribed procedure shall be repeated until the old charge gets blasted.

2-2.5.2 If the Charge is Gelignite/Dynamite/etc.

Two methods adopted in this regard shall be as follows:

Blasting-in-charge shall gently remove the tamping material and the primer with the detonator; Use a fresh detonator/primer and blast the charge.
Alternately, the tamping material shall be cleared up to a depth of 30 cm (ascertain by placing a stick in the hole); Another hole shall be drilled 15 cm away from the old one; The new hole shall then be charged and fired.

It is assured that the misfired charge explodes with the new one at the same time.

Blasting-in-charge shall, at once, report all cases of misfires and the remedial measures taken

to the Contractor's office and
to the Engineer.

If a misfire has been found as a result of defective detonator or dynamite, then the whole quantity in the box must be returned to the authority for further inspection with the approval of the Engineer.

2-2.6 Account of Explosives

A careful day to day account of the explosives shall be maintained by the Contractor or the In-charge of store at site. The records shall be kept in approved format.

Account of explosives shall be inspected by the Engineer periodically.

2 -3 PRE-SPLITTING ROCK EXCAVATION

2-3.1 General

Pre-splitting is defined as the creation of a specific excavation/cracked line in rock by controlled use of explosives. It shall be done by arranging drill holes in properly aligned and spaced pattern.

The pre-split blasting technique shall be used to form exact slopes or shapes in rock as per the engineering drawings. Generally, Users' Groups may not be capable enough to perform pre-split blasting since it requires special skills.

2-3.2 Construction Operations

The Contractor shall furnish the Engineer with an operational plan outlining the position of all drill holes,
depth of drilling,
type of explosives to be used,
loading pattern, and
sequence of firing.

The drilling and blasting plan is basically necessary for record purposes. However, submission of such plan shall not relieve the Contractor from his responsibilities on proper drilling and safe blasting practices.

2-3.2.1 *Controlled Blasting*

Controlled blasting begins with a short test section of a length approved by the Engineer. The proposed plan of Contractor is tested here. First, the test section shall be separated by pre-split blasting. Then, the separated portion shall be removed by mass (production) blasting. If the proposed plan (method) works to create an acceptable slope/shape according to the drawings, then the Engineer shall determine whether the same plan could be implemented or other alternative will be tested.

2-3.2.2 *Preparation for Drilling of Pre-splitting Holes*

All the over burden soil and weathered rock along the top of the excavation for a distance of 5 to 15 m beyond the blasting limits shall be removed before the commencement of drilling operation. In cases where such removal is not required, the Engineer shall provide the necessary instructions.

Care and attention shall be given, particularly to the beginning and end of excavation to ensure the complete removal of all overburden soil and weathered rock,
to ensure the exposure of fresh rock, and
to drill the holes at an elevation equal to the bottom of the adjacent lift where the pre-splitting holes have already been drilled.

Slope holes for pre-splitting shall be drilled along the line of the planned slope within the specified tolerances.

Diameter of the drill holes shall be within the range of 60-75 mm. Drilling operations shall be carried out by using proper equipment and techniques.

2-3.2.3 *Drilling Operations*

No hole shall deviate more than 300 mm from its position in the plan.

No hole shall deviate from being parallel to an adjacent hole by more than $\frac{2}{3}$ rd of the horizontal spacing between them.

The length of pre-split section for any individual lift shall not exceed 9 m.

The spacing of pre-split holes shall not exceed 900 mm c/c.

Auxiliary drill holes along the pre-split line, not loaded or stemmed, may be ordered by the Engineer.

Except spacing, the auxiliary drill holes shall satisfy all other requirements for pre-split holes.

The line of production holes shall be placed inside the pre-split lines in such a manner that it avoids any damage to the pre-split face.

The first line of production holes shall be drilled parallel to the slope line at the top of the cut at each bench level.

If the pre-split surface is damaged by the adopted production blasting technique, then other alternative technique should be tested.

Production holes shall be drilled within 2.5 m of a pre-split plane or as directed by the Engineer.

The bottom of the production holes shall not be lower than the bottom of the pre-split holes.

The maximum permissible width (offset) of a construction working bench for use in drilling shall be 600 mm.

Drilling operations shall be organised in such a way that any drift in previous level should be compensated or corrected at the start of next level. Similarly, the working space (offset) used for drilling of lower lift shall also be compensated or corrected. However, the specified slope line shall be maintained while adjusting the drilling operations.

The maximum diameter of explosive capsules used in pre-split blasting shall not be greater than $1\frac{1}{2}$ times the diameter of the pre-split holes.

Only standard cartridge explosives which are prepared and packaged by explosive manufacturing firms/agencies/or the Royal Nepal Army shall be used for pre-split blasting.

Ammonium Nitrate will not be permitted in pre-splitting blasting.

For a satisfactory pre-split face, stemming is required.

Stemming material should be dry and free running. It should pass through 10 mm sieve and 90% of it should retain on 2.36 mm sieve.

Stemmed pre-split holes shall be completely filled with collar.

All charges in each pre-splitting pattern shall be detonated simultaneously.

2-3.3 Tolerances

Deviation of the pre-split face from the finished adjacent plane shall not be more than 300 mm. However, excess deviation could be approved by the Engineer for the occasions where such irregularities are unavoidable.

After completion, the average plane of the slope should conform with the slope indicated on the engineering drawings.

No point on the completed slope shall vary from the designed slope by more than 300 mm.

All tolerances shall be measured perpendicular to the plane of the slope line.

No portion of the slope shall occupy the space needed for side drains.

If satisfactory pre-split slopes could be ensured by the adopted technique then either the slope face may be pre-split before the production blasting

or

both the pre-splitting of slope face and the production blasting could be done at the same time. For this, the production blasting should be delayed at least 50 milliseconds in sequential order starting from the furthestmost row of holes of the slope and progressing in steps to the row of holes nearest to the pre-split line.

The pre-splitting line shall be extended either to the end of the excavation or to a distance not less than 15 m beyond the limits of the production holes.

2-3.4 Measurements for Payments

Measurements for pre-split blasting shall be in square metres whereas for production blasting in cubic metres.

2-3.5 Rates

The contract unit rate for pre-split blasting shall be paid in full for carrying out the required operations for obtaining acceptable pre-split slope surface. It shall be paid on the basis of pre-split area.

The quantity of rock excavated through the production blasting shall be paid on the basis of volume.

2 -4 EXCAVATION FOR STRUCTURES

2-4.1 Description

Excavation for structures shall include the removal of materials from the foundation of bridges, culverts, retaining walls, head walls, cut off walls, pipe culverts and other similar structures.

Excavation for structures shall be carried out in accordance with the requirements of these Specifications and the lines and dimensions as shown on the drawings or as indicated by the Engineer.

Such excavation work shall include,
the construction of cofferdams and cribs,
sheeting and shoring for earth retaining purposes,

the subsequent removal of the water/debris/spoil by bailing, draining and pumping, the removal of logs, stumps, grubs and other deleterious matter, trimming the base of excavation, backfilling, clearing up the site, and disposal of all surplus materials.

2-4.2 Classification of Excavation

All materials involved in such excavation shall be classified as per clause 2-1.2.

2-4.3 Construction Operation

The site shall be cleared as per clause 1 -1.

2-4.3.1 *Setting Out*

The limits of excavation shall be set out as per the lines, curves, slopes, grades and sections given in the construction drawings. This work shall be carried out as per clause 2-1.3.1.

2-4.3.2 *Excavation*

Excavation shall be carried out to the width of the lowest step of the footing by keeping the sides vertical as far as possible. If the nature of soil does not permit it, then the Contractor/Users' Group at their own expenses shall put up necessary shoring, strutting, planking; or shall make the cut slopes to a safer angle; or both in order to assure the safety of workers and works. However, it should be done to the satisfaction of the Engineer.

Depth of excavation shall be according to the construction drawings or otherwise as directed by the Engineer. If blasting is required, it shall be carried out as per clause 2 -2.

2-4.3.3 *Dewatering and Protection from Water*

When water is found in excavation due to stream flow, seepage, springs, rainfall or other reasons, then the Contractor/Users' Group shall take adequate measures first, to protect the excavation from in coming water (constructing diversion channels, bunds, cofferdams) and secondly, to remove the collected water from the excavation (bailing and pumping).

The Contractor/Users' Group shall keep the foundation trenches as dry as possible. When required, laid screed concrete and masonry should be protected against the damages caused by erosion or sudden rise of water level.

Measures to be adopted to address the problems mentioned above shall be left to the choice of the Contractor/Users' Group but subjected to the approval of the Engineer. However, such approval shall not relieve the Contractor/Users' Group from the responsibilities for the extent of dewatering, the protective arrangements, the quality and the safety of the works.

When required, cofferdams having adequate width and height/depth shall be constructed as per a safe design. Such cofferdams should be watertight enough to carry out construction work without any obstructions.

The area enclosed by the cofferdam shall be spacious enough for the construction and supervision as well as for the installation of pumps and other machinery.

The rate of pumping shall be controlled to avoid any possibilities of water seeping through the fresh concrete.

No pumping shall be permitted during the placing of concrete and for at least 24 hours there after, unless it is done from a suitable sump which is away from the concrete work.

The Contractor/Users' Group shall take all precautions in relation to diversion of water. Diverted water should not damage the works, crops and any other property.

2-4.3.4 Preparation of Foundation

Foundation base shall be levelled both longitudinally and transversely or as directed by the Engineer. The surface shall be slightly watered and rammed before the screed concrete or footing is laid.

When the excavation is made deeper than the level shown on the drawings, the extra excavated depth shall be filled with concrete or masonry having the same grade as of foundation at the cost of the construction party (Contractor/Users' Group). No ordinary filling by soil shall be allowed in such cases.

When rock or hard strata is encountered in foundation excavation, then the base shall be cut to a firm and level/stepped surface or as directed by the Engineer. The base shall be cleaned and kept free from all soft and loose materials. Rock seams shall be cleaned and filled with cement mortar or grout to the satisfaction of the Engineer.

2-4.3.5 Slips and Blows

All slips or blows in the excavated trench, if do exist, shall be removed by the Contractor/Users' Group at their own cost.

2-4.3.6 Public Safety

Particularly at public and unsafe, sporadic places, the trenches and foundation pits shall be securely fenced with proper caution signs, fixed with red light at night to avoid accidents. Similarly, adequate protective measures shall be taken to protect the adjoining structures and public property.

2-4.3.7 Back filling

Back filling shall be carried out with approved material after the concrete is fully set or the masonry is hardened. It should be carried out in such a manner which does not cause any thrust or pressure to any part of the structure.

Space between the sides of excavated trench and the erected structure shall be backfilled with approved material in 250 mm layers; watered and compacted until the original ground level is reached.

2-4.3.8 Disposal of Surplus Excavated Materials

This work shall be carried out as per clause 2-1.3.10.

2-4.4 Measurements for Payment

Excavation for structures shall be measured in cubic metres for each class of encountered materials. However, the measurements are limited to the dimensions shown on the drawings or directed by the Engineer.

Any over-excavation, trimming of slopes to avoid collapses and work such as shoring, shuttering and planking which are considered as measures taken by the Contractor/Users' Group for executing the work with ease shall not be measured and paid separately.

Preparation of rock foundation shall be measured in square metres.

Works related to foundation sealing and dewatering (including pumping) shall be considered as incidental to the item of work unless a separate provision is made in the contract. In such case, the payment shall be made on lump sum basis. However, it shall be mentioned in the Bill of Quantities.

2-4.5 Rates

2-4.5.1 Rates for Earth Foundation

The contract unit rate for the items of excavation for structures shall be paid in full for carrying out the required operations including compensation for setting out, construction of necessary coffer dams, cribs and sheeting, shoring & bracing, subsequent removal of logs, stumps, grubs and other deleterious matter, trimming of bases of foundation trenches, unless separate provision is made in the contract, the works such as foundation sealing and dewatering (including pumping), back filling, clearing up the site, disposal of all surplus material up to a lead of 50 m along the slope of lead route, and all labour, materials, precautionary measures and incidentals required to complete the work to the Specifications or to the satisfaction of the Engineer.

2-4.5.2 Rate for Rock Foundation

The contract unit rate for preparation of rock foundation shall be paid in full for carrying out the required operations such as cutting, trimming, clearing the foundation base and filling/sealing of all seams with cement mortar or grout. This includes the full compensation for labour, materials, protective measures and other incidentals.

2 -5 EMBANKMENT CONSTRUCTION

2-5.1 Description

These Specifications shall apply to the construction of embankments, shoulders and other miscellaneous filling and backfilling with approved materials obtained either from excavation of road construction or borrow pits or other sources.

All embankments shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades, cross sections shown on the construction drawings or as directed by the Engineer.

2-5.2 Materials

2-5.2.1 *Physical Requirements*

The materials used in embankments shall be earth, moorum, gravel, a mixture of these materials or any other material approved by the Engineer. The filling materials shall be free from logs, stumps, roots, debris and any other organic materials which affect the stability of the embankment.

Maximum particle size of the coarse material in the mixture of earth shall not exceed 75 mm. The Engineer may permit coarse material of larger sizes if he/she finds no difficulty as regards to the compaction of such material according to the Specifications.

In ordinary case, the filling materials shall satisfy the following requirements:

For the construction of embankment having a height of up to 3 m, the dry density shall not be less than 1.44 g/cm³.

For the construction of embankment having a height of over 3 m and if a part of its height is subjected to inundation for longer periods, the dry density shall not be less than 1.52 g/cm³. For the construction of top 0.5 m of the embankment (or the road formation), the dry density shall not be less than 1.65 g/cm³.

However, the Engineer may waive these requirements depending upon the availability and the involved cost of such materials.

Clay materials which exhibit the properties like swell and shrinkage shall be filled at the bottom of the embankment so that it prevents any seepage through the embankment. No such material shall be placed or permitted at the top 0.5 m range which forms the sub-grade of road.

2-5.2.2 *Source of Supply*

The materials for embankment filling shall be obtained from the approved sources. Such sources could be nearby road excavation sites or any other excavation sites under the contract.

All borrow pits shall be approved by the Engineer. When obtaining the approval, the Contractor/Users' Group shall submit all required information such as location, expected quantity, quality of material, hauling distance and means of transportation to the Engineer. No borrow pit shall be opened without the permission of the Engineer.

Borrow pits shall not be opened continuously. At least every 300 m interval, there shall be a ridge of not less than 8 m width unopened. Small drains shall be excavated to facilitate drainage through the ridges.

The depth of the pits shall be regulated so that the maximum depth shall be limited to 1.5 m. No excavation shall be made below the imaginary slope line of 1:4 which connects the bottom of the borrow pit to toe of the embankment under construction.

The minimum distance between the borrow pit and the toe of the final section of the road embankment shall be 5 m.

2-5.3 Construction Operations

2-5.3.1 *Setting Out*

The site shall be cleared as per clause 1 -1. The work shall be set out as per clause 2-1.3.1.

Borders of the embankment shall be set out and pegged before the commencement of the earth filling. Batter pegs shall be fixed on both sides at regular intervals. The border pegs, desirably, shall be fixed about 0.5 m outside the actual limits of the fill and painted in a distinctive colour.

2-5.3.2 *Stripping and Storing Top Soil*

All top soil materials existing over the embankment foundation which are suitable for plant growth shall be stripped to specified depths not exceeding 150 mm and shall be stored for later use such as covering of embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired.

2-5.3.3 *Compacting Original Ground*

The original ground shall be consolidated by rolling or effective ramming to the satisfaction of Engineer.

Where the height of the proposed embankment is less than 0.5 m and the original ground does not have a relative compaction of at least 95%, the original ground shall be loosened to a depth of 0.35 m (in addition to 0.15 m top soil layer), watered and compacted to achieve 95% relative compaction. In normal circumstances, the required compaction could be achieved by a 8-10 t roller with a maximum of 6 passes or by a 1.5 t concrete roller with 12 passes. However, the Engineer shall confirm the final level of compaction.

Any unsuitable materials existing in the embankment foundation shall be removed and replaced by an approved material prior to compaction. Further filling work shall not be commenced until the foundation for embankment has been inspected by the Engineer.

2-5.3.4 *Spreading the Materials in Layers and Maintaining the Optimum Moisture Content*

The filling material shall be spread uniformly over the entire width of the embankment or the stretch under construction in layers not exceeding the loose thickness of 250 mm. Successive layers shall not be placed until the layer under construction has been well compacted to the requirements spelled out in these Specifications or contract document.

Moisture content of the filling material shall be checked at the source of supply. If it is found less than the *Optimum Moisture Content (OMC)*, then the material shall be watered up to the

required level at the source or after spreading as a loose layer at the construction site. The latter shall be recommended to follow since it spreads the water better than the former.

When sprinkling water over the loose soil layers, care should be taken to avoid any isolated flooding which makes the compaction operation difficult.

If the filling material is over-saturated than the OMC then it shall be dried by aeration or by exposing it to the heat of sun. However, the optimum moisture content shall be reached in order to achieve the desired compaction with lesser effort.

Owing to wet weather if the moisture content cannot be reduced to the required amount by the above procedures then all compaction operations shall be suspended.

Moisture content of each layer shall be checked and adjusted by compensating for evaporation losses. Generally, at the time of compaction the moisture content shall be kept within the range of 98% - 101% of the optimum moisture content.

In case of highly expansive soil, the moisture content shall be maintained at a value 2%-4% higher than the optimum moisture content.

After sprinkling the required amount of water, the soil shall be mixed by using harrows, rotary mixers or any other appropriate tools until the layer becomes equally wet.

Clods or hard lumps of earth shall be broken into pieces having maximum size of 150 mm, when being placed in the lower layers of the embankment.
60 mm, when being placed in the top 0.5 m range of the embankment.

Hauling vehicles and construction equipment shall be moved uniformly over the entire surface of the previously compacted layer in order to minimise rutting or uneven compaction. When the embankment is required to be constructed across a low swampy area, the base of the fill shall be constructed by dumping successive loads of fill material consisting of larger soil particles. The thickness of the layer shall be uniform and just enough to hold the weight of hauling vehicles.

2-5.3.5 Compaction

The compaction equipment shall be approved by the Engineer after a demonstration exercise or trial compaction test which has been carried out by the Contractor in order to indicate the efficiency of the plants.

Each layer of the fill material shall be thoroughly compacted to the following degree of compaction (field dry density as a percentage of laboratory dry density at OMC) values:
not less than 98% for the top 0.5 m range of embankment.
not less than 95% for other portion of embankment.
85%-90% for highly expansive clay materials.

Subsequent filling shall be carried out only after the finished layer has been tested and accepted by the Engineer. When dry density measurements reveal any less compacted areas, further compaction shall be carried out as directed by the Engineer.

If the specified degree of compaction could not be achieved, then the material in the soft areas shall be removed; replaced by other suitable material and compacted again to achieve the required degree of compaction.

Consolidation : As an alternative to compaction operation, the filled embankment may be left for consolidation by nature. For this, the embankment shall be kept for at least one monsoon.

When no roller is available for compaction, manual ramming could also be used as another alternative.

2-5.3.6 Drainage

During construction time, the surface of the embankment shall be kept free from stagnated water by providing adequate cross-falls and other drainage facilities.

2-5.3.7 Finishing Operations

The finishing operations shall include the work of shaping and dressing of shoulders, road base, side slopes in accordance with the levels, cross-sections and dimensions given in the drawings or as directed by the Engineer. However, the surface tolerances shall be observed as per clause 5 -1.

To improve the appearance and to merge the embankment with the adjacent terrain both the upper and lower ends of the side slopes shall be rounded off.

The top soil, removed and conserved earlier (refer to clause 2-1.3.2 and 2-5.3.2) shall be spread over the fill slopes in order to facilitate the growth of vegetation. Prior to the application of top soil, the side slopes shall be roughened and slightly moistened in order to have a satisfactory bond between the layers. The depth of the top soil shall be sufficient enough to sustain the plant growth. The usual thickness of top soil spread is 75 - 150 mm.

Wherever possible, the slopes shall be turfed with sods in accordance with clause 2 -7. If prescribed in the contract, the seeding and mulching of slopes shall be done as per the requirements of clause 2 -8.

When earthwork operations have been substantially completed, the roadway area shall be cleared of all debris and ugly scars.

2-5.4 Embankment Construction under Special Conditions

2-5.4.1 Earthwork for Widening of Existing Road Embankments

If the slopes of the existing embankment are steeper than 4:1 then, horizontal benches of 0.3 m width shall be cut across slope line starting from toe of the embankment. Filling shall be carried out in 250 mm thick layers progressing from the toe level up to the top level of the embankment. All layers shall be watered and compacted to achieve the required degree of compaction. The material obtained from cutting of benches could also be utilised for this operation.

When the existing slopes of the embankment are flatter than 4:1 then the slope surface may only require ploughing or scarifying and no bench cutting is necessary. However, filling shall be carried out in 250 mm thick horizontal layers as described above.

Where the width of the widened portion is insufficient for the use of roller, mechanical or manual tampers shall be used for compaction. Wherever possible, end dumping of material from hauling vehicles shall be avoided.

2-5.4.2 Construction of Earth Embankments on Sloping Ground

Where an embankment needs to be constructed on sloping ground, the ground surface shall be appropriately benched or ploughed and scarified as indicated in clause 2-5.4.1 before the commencement of filling. If required, the construction of lateral sub-surface drains shall be carried out at the cut-fill interface as per clause 2 -9.

2-5.4.3 Earthwork over Existing Road Surfaces

If the existing road surface is granular or bituminous and a new road surface is supposed to be constructed within 1 m range of height above the old one, then the existing road surface shall be scarified to a minimum depth of 50 mm for proper bondage between fill and the old formation.

If the existing road surface is of cement concrete and a new road surface is supposed to be constructed within 1 m range of height above the old one, then the existing pavement shall be removed completely prior to filling operation.

If the level difference between the existing and the new road surface is more than 1 m, then the existing surface may not be required to be scarified or removed.

2-5.4.4 Embankment filling around Structures

Earth work on embankment shall be suspended at points forming approaches to structures such as abutments, wing wall, return walls until the structure is fully set.

The filling around culverts, bridges and other structures up to a distance of twice the height of the embankment at abutment shall be carried out independently from the filling on main embankment. Such back filling shall not be carried out near to any structural component until such component is being cured for 14 days.

The embankment shall be raised simultaneously in equal layers placed on either side of the structural component. The sequence of such work shall be approved by the Engineer in advance.

The material used for back filling shall not be organic or high plastic clay having plasticity index of more than 20 and liquid limit of more than 40. The fill material shall be deposited in horizontal layers not exceeding a loose thickness of 150 mm. These layers shall be compacted as per clause 2-5.3.5.

If specified in the contract, a filter medium material could be used behind the structural component in order to reduce the pore water pressures on it. Such filter material shall be laid in layers simultaneously, in line with the other layers of fill material.

The compaction can be carried out by mechanical or manual tampers or by other methods approved by the Engineer. Care shall be taken to avoid any damages to the built structural components.

2-5.5 Plying of Construction Traffic

Construction traffic shall not use the prepared surface of the embankment without prior permission of the Engineer. Any damage caused as a result of such use shall be rectified by the Contractor/Users' Group at their own cost.

2-5.6 Measurements for Payment

Earth embankment construction shall be measured by taking cross sections in the original position before the work starts and in the final position after its completion.

Volumes of earthwork shall be computed by the method of average end areas and be given in cubic metres.

The measurement of fill material from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material brought from road way and drainage excavation. It shall be assumed that one cubic metre of suitable material brought to site from roadway and drainage excavation forms one cubic metre of compacted fill if the measurement has already been done under the item of excavation. Since the measurement was taken for undisturbed earth prior to excavation, no allowance for any shrinkage/bulging shall be made.

Stripping of top soil including its storing and reapplication shall be measured in cubic metres.

Work which involves loosening and re-compacting of original ground surface shall be measured in square metres.

In preparing foundations for embankments, works such as removal of unsuitable material from the base, its replacement with suitable material shall be measured as individual items in cubic metres.

Scarifying existing granular/bituminous road surfaces shall be measured in square metres. Dismantling and removal of existing cement concrete pavement shall be measured in cubic metres as per clause 1-2.6.

Preparation of filter media adjacent to the structural components shall be measured as finished work in cubic metres.

2-5.7 Rates

2-5.7.1 *Contract Unit Rate for Construction of Embankment or Filling of Sub-Grade*

The contract unit rate for the items of construction of embankment and filling of sub-grade shall be paid in full for carrying out the required operations including full compensation for:
setting out,
compacting original ground,
scarifying or cutting continuous horizontal benches of 0.3 m width on side slopes of existing embankments where required,
compaction to specific requirements,
shaping and dressing the top and slopes of embankment including rounding off the corners,
back filling at structures,
widening works of embankments,
excavation of all materials from designated borrow areas and transporting them to site up to a lead of 50 m along the slope of lead route, and

all labour, materials and incidentals necessary to complete the work as per the Specifications.

2-5.7.2 Contract Unit Rate for Transporting Materials Required for Embankment Construction

This unit rate shall be paid in full to compensate for labour and incidentals necessary on account of the additional haul or transportation involved beyond the initial lead of 50 m.

2-5.7.3 Contract Unit Rate for Stripping and Storing or Reapplication of Top Soil

This contract unit rate covers either storing or reapplication. Refer to clause 2-1.9.5 in this regard.

2-5.7.4 Contract Unit Rate for Loosening and Re-Compacting the Embankment Foundations

Clause 2-1.9.2 shall apply.

2-5.7.5 Contract Unit Rates for Removal of Unsuitable Materials and Replacement with Suitable Materials

Clauses 2-1.9.1 and 2-5.7.1 shall apply for removal and replacement, respectively.

2-5.7.6 Contract Unit Rate for Scarifying Existing Granular/Bituminous Road Surfaces

This rate shall cover the carrying out of required operations including full compensation for all labour, materials, safety precautions and incidentals necessary to complete the work as per the Specifications. It shall also cover handling, salvaging, stacking and disposing of the dismantled materials up to a lead of 100 m along the slope of lead route.

2-5.7.7 Contract Unit Rate for Dismantling and Removal of Cement Concrete Pavements

Clause 1-2.7 shall apply.

2-5.7.8 Contract Unit Rate for Preparing Filter Media adjacent to Structural Components

This rate shall cover the carrying out of required operations including full compensation for materials, labour and incidentals required to complete the work as per the Specifications.

2 -6 SOIL EROSION

2-6.1 Description

This work shall include temporary or permanent control measures shown in the engineering drawings or/and directed by the Engineer during the construction period in relation to soil erosion and water pollution. Such works shall be carried out in the form of berms, dykes, sediment basins, fibre mats, mulches, grasses, slope drains and other erosion control devices.

The temporary erosion control measures shall be made in conjunction with the permanent erosion control features which are specified on the drawings or directed by the Engineer. Such works shall ensure economical, effective and continuous control of erosion throughout the construction and post construction periods.

2-6.2 Materials

All materials shall comply with the quality standards spelled out in the contract or otherwise shall be approved by the Engineer prior to the commencement of work.

2-6.3 Construction Operations

Prior to the start of relevant construction, the schedule of work shall be approved by the Engineer. This schedule shall detail, all temporary and permanent erosion control works which are applicable to construction items such as
clearing and grubbing,
roadway and drainage excavation,
embankment construction,
bridges and other structures,
structure related water courses,
road pavement and
shoulders;
proposed methods of erosion control on service roads and borrow pits; and
plan for disposal of waste materials.

The surface area of earth material which is liable to erosion shall be minimised. The Contractor/Users' Group shall be directed to provide immediate temporary or permanent control measures to prevent soil erosion and its effects on construction operations and adjacent properties as well as subsequent contamination and damage to nearby streams, lakes, reservoirs, etc.

The erosion control measures may involve the construction of berms, dykes, sediment basins, slope drains and use of temporary control devices and methods such as mulches, mats, seeding, etc. Cut and fill slopes shall be seeded and turfed as per the engineering drawings.

The Contractor/Users' Group shall be required to incorporate all permanent erosion control features into the project at their earliest as outlined in the approved schedule in order to minimise the need for temporary control measures.

Temporary erosion and pollution control measures shall be used to deal with the conditions developed during construction but which were not foreseen during the design stage. However, some of these measures may not necessarily be associated with permanent control features of the project.

Where erosion is likely to be a problem, the permanent erosion control measures shall be carried out soon after the completion of clearing, grubbing and stripping of top soil operations. Otherwise, temporary erosion control measures shall be carried out after each relevant construction activity. In such cases, entire construction area shall not be exposed at once by any earthwork operation without the prior approval of Engineer.

The Engineer may, further, limit the operations in progress for the areas of excavation, borrow and embankment filling. Such limits shall be fixed by the Engineer by considering the Contractor's/Users' Group's capability in adhering to the approved schedule and their progress made in finishing, mulching, seeding and constructing the permanent measures of erosion and pollution control.

If the above mentioned schedule becomes unrealistic due to climatic reasons, then temporary control measures shall be taken immediately to the extent of their feasibility.

When the temporary erosion and pollution control measures become necessary due to the Contractor's/Users' Group's negligence at work or as a result of failure in timely installation of permanent controls according to the contract, such activities shall be carried out at their own cost.

Temporary erosion and pollution control works which are required due to reasons other than the above shall be carried out as directed by the Engineer. The cost of such works shall be covered by the provisions made in the contract.

Temporary erosion and pollution control measures may be required even outside the right-of-way where supplementary operations such as borrow pit excavation, service road construction, tipping of excavation spoils, parking of equipment, storing of tools/materials and camping are continuing as a result of roadway construction.

The temporary erosion control measures made by the Contractor/Users' Group shall be adequately maintained by them until such measures are found no longer required.

2-6.4 Measurements for Payments

The soil erosion and pollution control works shall be measured by the units specified for respective items in the contract. When the items are difficult to quantify, payments shall be made on lump sum basis as per the provisions made in the contract.

2-6.5 Rates

The contract unit rates for different items of soil erosion and pollution control works shall be paid in full for carrying out all required operations including full compensation for all labour, materials and incidentals necessary to complete the works as per the Specifications.

2 -7 TURFING WITH SODS

2-7.1 Description

This work shall include furnishing and laying of live sod of perennial turf which forms grass on the slopes of embankment, shoulders and other locations shown on the drawings or directed by the Engineer.

Unless otherwise specified, such works shall be carried out immediately after the completion of relevant construction items provided that the season is favourable or facilities are available for turfing.

2-7.2 Materials

The sod shall be dense and have well-rooted growth of permanent and desirable grasses which are indigenous to the locality where it is supposed to be used. It shall be practically free from weeds or other undesirable matters.

When the sod is cut for re-use, the thickness of the grass layer on sod should be approximately 50 mm and free from debris. The overall thickness of the sod should be as

uniform as possible with 5-8 cm thick cover of soil containing grass roots. Practically, the entire root system of the grasses shall remain intact in the sod strip.

The sods shall be cut in rectangular strips having dimensions of not less than 25 cm x 30 cm. However, the sods shall not be in excessively large size which may cause inconvenience in handling and transportation.

During wet weather, the sod shall be allowed to dry sufficiently in order to avoid any tearing during handling. During dry weather, the sod shall be watered in order to prevent the separation of soil during handling. Furthermore, watering keeps the grass alive.

2-7.3 Construction Operations

2-7.3.1 *Preparation of Earthen bed for Turfing*

The area to be turfed shall be constructed in advance to the required slope and cross-section. Soil on the area shall be loosened and made free from all stones larger than 50 mm diameter, sticks, stumps and undesirable hostile matters. Soil on the area shall be prepared to a reasonably fine granular texture up to a depth of not less than 25 mm.

Where required, top soil shall be spread over the locations to be turfed. Prior to spreading of top soil, the slopes shall be scarified to the depths shown in the drawings. While spreading top soil, required allowances shall be provided for the settlement. The depth after settlement shall comply with the required nominal depth shown in the drawings.

Where top soil is not available for spreading, fertiliser and ground limestone shall be spread uniformly at the rate indicated in the drawings.

If the sod bed is not sufficiently wet, then the prepared sod bed shall be moistened to the loosened depth prior to turfing. The sod shall, however, be placed within 24 hours of its detachment from the original ground.

Each sod strip shall be laid edge to edge. Each strip, when placed tightly against the other, shall be tamped with wooden or metal tampers in order to eliminate air pockets and to press it into the underlying soil layer.

On side slopes steeper than 2:1, the laying of sods shall be carried out from the bottom to the top. At places where water may flow over the turfed area, the top edge of the lower strip shall always be inserted into the down edge of the higher strip and a layer of soil shall be placed over the joint followed by its compaction.

2-7.3.2 *Staking the Sods*

Where the slope is 2:1 or steeper and the distance along the slope is more than 2 m, the sods shall be staked with pegs or nails spaced approximately 50 to 100 cm along the longitudinal axis of the sod strips. The stakes shall be driven approximately perpendicular to the sod surface.

2-7.3.3 *Top Dressing*

After the sods have been laid in position, the surface shall be cleared of loose sods, excess soil and other hostile materials. A thin layer of top soil shall be spread over the turf and the turfed area shall be moistened by sprinkling water.

2-7.3.4 *Watering and Maintenance*

The turf shall be watered regularly by the Contractor/Users' Group for a period of at least four weeks after its laying. Watering shall be carried out without damaging the turf by erosion or flooding. The turfed areas shall be, further, protected from any damage caused by wheels of water bowsters or by people walking over it. To this effect, the Contractor/Users' Group shall erect necessary warning signs and barriers.

The Contractor/Users' Group shall repair or replace turfed areas by new sods if any area fails to show uniform growth of grass. If such situation occurs as a result of the Contractor's/Users' Group's negligence then it shall be rectified at their cost.

2-7.4 Measurement for Payment

Turfing with sods shall be measured as finished work in square metres.

2-7.5 Rate

The contract unit rate for turfing with sods shall be paid in full for carrying out all relevant operations detailed in clause 2 -7 including full compensation for all labour, materials, precautionary measures and incidentals required to complete the work as per the Specifications.

2 -8 SEEDING AND MULCHING

2-8.1 Description

This work shall include furnishing of seeds, chemical fertiliser, other organic manure and mulching materials; and placing and incorporating the above on embankment slopes and other locations shown on the drawings or as designated by the Engineer.

2-8.2 Materials

The seeds shall be of approved quality and type and be suitable for the soil on which they are to be applied. The seeds shall be pure enough to ascertain the germination process. If provided, seeds shall comply with the requirements indicated in the contract.

The chemical fertiliser shall be of standard quality having acceptable commercial identity. The organic manure shall be fully putrefied organic matter such as cow dung. The mulching material shall be preferably straw, hay, wood shaving or saw dust. It shall be reasonably free from weed seeds and other hostile matters which may lower the effectiveness of mulch or be harmful to the plant growth. To this effect, mulching material shall be delivered in dry state.

2-8.3 Seeding Operations

2-8.3.1 *Preparation of Seed Bed*

The area to be seeded shall be brought to the required shape by refilling of eroded areas and refinishing of slopes, berms, etc. The preparation of seed bed shall include removal of all live plants by using appropriate agricultural tools; loosening of soil up to a depth of 10 cm;

breaking and spreading of clods which are larger than 25 mm in diameter; and application of water as per the requirement.

2-8.3.2 Sowing of Seeds

All seeds shall be sowed uniformly according to the approved rate. Immediately after sowing, the area shall be raked and dragged or otherwise covered by a layer of top soil of 6 mm thickness.

The sowing of seed shall not be carried out when the ground is muddy or the weather condition is not favourable for such operation.

2-8.3.3 Soil Moisture

Soil moisture shall exist throughout the zone at a depth from 2.5 cm to 12.5 cm below the surface at the time of planting. Watering of the seeded area shall be carried out as directed by the Engineer.

2 -8.4 Mulching and Application of Fertiliser/Organic Manure

Within 24 hours of seeding, mulching material mixed with organic manure shall be placed as a continuous, uniform cover having an approximate thickness of 25 mm. Mulching material shall be protected from being blown away by wind as directed by the Engineer.

If required, chemical fertiliser could be applied later as described in the contract or as directed by the Engineer.

2-8.5 Maintenance

Each seeded and mulched area shall be maintained by the Contractor/Users' Group until its final acceptance. Maintenance shall include protection of seeded areas from traffic by installing approved warning signs and barricades; and repeating the seeding and mulching operations in failed areas.

2-8.6 Measurements for Payment

Seeding and mulching operations shall be measured as finished work in square metres.

2-8.7 Rate

Contract unit rate for seeding and mulching shall be paid in full for carrying out all relevant operations including full compensation for all labour, materials, precautionary measures and incidentals required to complete the works as per the Specifications.

2 -9 SURFACE/SUB-SURFACE DRAINS

2-9.1 Introduction

This work shall include construction of surface drains and sub-surface drains in accordance with the requirements of these Specifications and as per the lines, grades, dimensions and other particulars shown on the drawings or as directed by the Engineer.

Schedule of works shall be approved by the Engineer in order to ensure the completion of such drains as per the operational sequence of other activities such as roadway and pavement works. While preparing the schedule, it should be ensured that no excavation of other completed works becomes necessary and no damage to other completed works is caused as a result of scheduled time lag of this work.

2-9.2 Surface Drains

Surface drains shall be excavated as per the requirements of clause 2 -1. If found suitable, the excavated materials shall be utilised in the adjoining embankment construction.

2-9.3 Sub-surface Drain

2-9.3.1 *General*

Sub-surface drains shall be either close-jointed perforated pipes or open-jointed non-perforated pipes which are laid in trenches and packed with granular materials according to a specified grading. When such drains are constructed to drain out the water in pavement courses, it shall be in the form of aggregate drain which is placed in transverse direction to the road pavement at specific intervals.

2-9.3.2 *Materials*

Pipe : Perforated pipes for the drains are usually made out of metal, asbestos cement, cement concrete or PVC. Non-perforated pipes are generally made out of vitrified clay, cement concrete or asbestos cement. The type, size and grade of the pipe shall be specified in the contract. However, minimum internal diameter of the pipe shall be 150 mm. Holes of perforated pipes shall be made on one half of the circumference as per the spacing indicated on the drawings. Size of the hole shall either be within the range of 3 mm - 6 mm or be closer to D 85 size of the aggregate which will be packed around the pipe. D 85 stands for the size of the sieve that allows 85% of the particles by weight to pass through.

Filter Material : Filter material shall consist of particles which are sound, tough, hard and durable. It shall be either sound-gravel or broken stone which is free from organic matters and other undesirable materials. When the contract does not specify any particular grading for filter material, the filter material shall be provided according to the following guidelines.

when the soil in the trench is fine grained (e.g. fine silt, clay or a mixture of both), the filter material shall be of Class I grading as given in **Table 2 -9**.

when the soil in the trench is a type ranging from coarse silt to medium sand, the filter material shall correspond to Class II grading of **Table 2 -9**.

when the soil in the trench is gravel mixed sand, the filter material shall correspond to Class III grading of **Table 2 -9**.

The thickness of filter layer around the pipe shall be maintained as shown on the drawings but it shall always be at least 150 mm.

Table 2 -9 : GRADING REQUIREMENTS OF FILTER MATERIAL

Sieve Designation

Percentage by Weight Passing the Sieve

Class I
Class II
Class III

50 mm

-

-

100

40 mm

-

-

95-100

25 mm

-

100

-

20 mm

-

90-100

50-100

10 mm

100

40-100

15-55

4.75 mm

90-100

25-40

0-25

2.36 mm

80-100

18-33

0-5

1.18 mm

50-95

-

-

600 micron

30-75

5-15

-

300 micron

10-30

0-7

-

150 micron

0-10

-

-

75 micron

0-3

0-3

0-3

2-9.3.3 Trench Excavation

Trench for sub-surface drain shall be excavated as per the specified lines, grades, dimensions on the construction drawings and in accordance with the requirements of clause 15 -3, provided that the width of trench at pipe level shall not be less than 450 mm.

The excavation shall begin at the outlet end of the drain and proceed towards the upper end. When unsuitable material is found at the trench bed, such material shall be removed to the satisfaction of the Engineer. Such excavation shall be backfilled with an approved material and the back fill shall be thoroughly compacted prior to the laying of pipes.

2-9.3.4 Laying of Pipes and Backfilling

Laying of pipes in the trench shall be carried out according to the specified lines, grades shown in the drawings. The laying works shall start from the outlet end and proceed towards the upper end. Longitudinal gradient of the pipe shall not be less than 0.01 (1:100).

Before laying the pipe, filter material of the required grading shall be placed on full width of the trench bed in a layer not more than 150 mm thickness (or as shown on the drawings) and compacted to the satisfaction of the Engineer. The pipe shall then be firmly embedded on the bed.

Perforated pipes, unless otherwise specified, shall be placed with perforated holes facing downwards in order to minimise clogging at the mouth. Pipes shall be joined securely with appropriate couplings, fittings or collars.

Non-perforated pipes shall be laid with not less than 150 mm spacing between the adjoining ends. Such open joints shall be wrapped with suitable pervious material like double layer of hessian or similar material in order to permit entry of water but not the finer particles. In this case, the number of pipe segments shall be increased so that there are more open joints available to receive seepage water.

In case of non-perforated pipes with bell end, the pipes shall be laid with the bell facing upgrade direction. Upper end of the pipe shall be closed either by concrete plugs or plugs

fabricated from the same material as of the pipe in order to prevent entry of any soil particles.

When the pipe laying is completed, an approved filter material of the required grading (refer to clause 2-9.3.2) shall be placed over the pipe to the required level in layers having maximum thickness of 150 mm. Each layer shall be compacted to the satisfaction of the Engineer.

Unless otherwise specified, the segments of sub-surface drains which are not directly below the road pavement shall be sealed at the top by a sealing material (clay) having a minimum thickness of 150 mm in order to prevent percolation of surface water. However, the minimum thickness of overburden layer (filter material + sealing material) above the pipe shall be 300 mm.

2-9.3.5 Drain Outlets

Outlets of pipes shall be carefully positioned to avoid any possible blockage. The projected portion of the outlet pipes shall be protected with a cover of approved gratings or screens which are securely fastened to the place.

For a length of 0.5 m from the outlet end, the trench shall not be filled with filter material. Instead, such section shall be backfilled with excavated soil. Further, the pipe in this section shall not have any perforations.

2-9.3.6 Aggregate Drains

Aggregate drains shall be placed within the shoulders. It shall be carried out after the completion of road pavement. Depth, thickness and spacing of the aggregate drains shall be generally shown on the construction drawings. Trenches for aggregate drains shall be excavated to a minimum width of 300 mm and to a depth specified in the drawings or as directed by the Engineer.

The base of the trench shall be kept free from loose particles and sloped enough to drain the seepage water. Face of the trench at the edge of road pavement shall be made in such a manner that all granular pavement courses to be drained shall be exposed clearly.

Aggregate used in such drains shall be durable and free from organic matter and other undesirable substances. In general, gravel stones or any other hard stones shall be filled in aggregate drains. The filter materials recommended for aggregate drains shall have the following grading:

Sieve Designation Percentage by Weight Passing the Sieve

12.5 mm
10 mm
4.75 mm
2.36 mm
1.18 mm
100
85-100
10-30
0-10
0-5

Thickness of aggregate layer shall be according to the construction drawings. However, in no case, it shall be less than 200 mm.

The remaining depth of the trench shall be filled with suitable fill material in accordance with clause 2 -5.

2-9.4 Measurements for Payment

Excavation of surface drain shall be measured and paid as per clause 2 -1.

Dressing the sides and bed of the surface drain shall be measured in square metres.

Lining of surface drain shall be measured in square metres.

Excavation of trench for sub-surface drain shall be measured and paid as per clause 2 -4.

Removal of unsuitable material and its replacement with suitable material in the trench bed shall be measured as a single item in terms of filled volume in cubic metres.

Laying of pipes for sub-surface drains shall be measured as completed length in linear metres.

Joining of pipes shall be considered incidental to the work and covers

the provision of hessian wrappings at open joints;

plugging the upgrade end of pipe;

providing grating/screen at the outlet end; and

providing impervious clay cover wherever required.

Backfill material and aggregates for aggregate drains shall be measured as laid in position in cubic metres.

2-9.5 Rates

2-9.5.1 *Surface Drains*

The contract unit rates for the dressing of bed and sides and the lining of surface drains shall be paid in full for carrying out the required operations including full compensation for all labour, materials, precautionary measures and incidentals required to complete the work as per the Specifications.

2-9.5.2 *Sub-surface Drains*

The contract unit rate for the removal of unsuitable materials and its replacement with suitable material shall be paid in full for carrying out the required operations including full compensation for all labour, materials, precautionary measures and incidentals required to complete the work as per the Specifications. It includes a lead up to 50 m along the slope of the lead route.

The contract unit rate for the laying of pipes for sub-surface drains shall be paid in full for providing, laying and joining the pipes to the requirements of these Specifications including full compensation for all labour, materials, loading, unloading, handling and other incidentals required to complete the work.

The contract unit rate for the placing of backfill material and aggregates in aggregate drains shall be paid in full for providing, laying and compacting the material to the requirements of these Specifications including full compensation for all labour, materials and other incidentals required to complete the work.

3

Sub-base, Base and
Shoulders

3 -1 GRANULAR SUB-BASE

3-1.1 Description

This work shall include laying and compacting of well-graded material on prepared sub-grade in accordance with the requirements of the Specifications. The sub-base material shall be laid in one or more layers as necessary according to the lines, grading and cross-sections as shown on the drawings or as directed by the Engineer.

3-1.2 Materials

The material to be used for such works shall be any individual or combination of natural sand, moorum, gravel, crushed or broken stone, crushed or broken slag, crushed or broken concrete, over burnt brick aggregates, laterite, etc. depending upon the approved quality and the grading. The material shall be free from organic or undesirable substances and shall conform with one of the three grading given in **Table 3 -1**.

Table 3 -1 : Grading for Granular Sub-base Materials

Sieve Designation
Percentage by Weight Passing the Sieve

Grading I
Grading II
Grading III

80 mm
63 mm
4.75 mm
75 micron
100
90-100
35-70
0-20
100
90-100
40-90
0-25
100
90-100
50-100
0-30

CBR Value (minimum)
30
25
20

Note : For all three gradings, the material passing 425 micron sieve shall have a liquid limit of not more than 25% and a plasticity index of not more than 6%.

3-1.2.1 *Physical Requirements*

The fraction of material passing 20 mm sieve shall give a CBR value as indicated in **Table 3 -1** or more (if specified in the contract), when tested in accordance with IS : 2720 (Part XVI) after preparing the samples at maximum dry density and at optimum moisture content corresponding to IS : 2720 (Part VII) and soaking the same in water for 4 days.

3-1.3 Construction Operations

3-1.3.1 *Preparation of Sub-grade*

Immediately prior to the laying of sub-base, the sub-grade previously completed as per clause 2 -1 or 2 -5 shall be prepared by removing all vegetation and other extraneous matter; by sprinkling lightly with water, if necessary; and by compacting it with one pass of 8-10 ton smooth wheeled roller or with relatively increased number of passes of 1.5 ton concrete roller.

3-1.3.2 *Spreading and Compacting*

The sub-base material of specified grading shall be spread on the prepared sub-grade. The thickness of loose layers shall be regulated in such a manner that the attained thickness of each layer does not exceed 150 mm after consolidation.

Moisture content of the loose material shall be checked and suitably adjusted by sprinkling additional water. At the time of compaction, the moisture content of the loose material shall be within the range of 98%-101% of the optimum moisture content. While adding water, due allowances shall be made for evaporation losses. After moistening, each layer shall be scarified or mixed by suitable means in order to make the materials uniformly wet.

Immediately after making the material uniformly wet to the satisfaction of Engineer, rolling shall be started with 8 to 10 ton smooth wheeled rollers or with any other labour-based means or plants such as 1.5 ton concrete roller. Rolling shall be done longitudinally commencing at the edges and progressing towards the centre except on super-elevated positions.

Rolling on super-elevated positions shall commence from the lower edge and progress towards the upper edge by moving the equipment parallel to the centre line of the pavement. Each pass of the roller shall uniformly overlap with not less than one third of the adjoining track made during the preceding pass. During rolling, the grade and camber shall be checked and any high spots or depressions which become apparent shall be corrected by removing or adding fresh material. Rolling shall be continued till the density attained is at least 100% of the maximum dry density for the material.

The surface of any layer of material on completion of compaction shall be well closed; free from any surface movement due to the load of compaction plants; and free from ridges, cracks and loose materials. All loose, segregated, defective areas shall be completely re-laid and re-compacted.

3-1.4 Finishing of Surface and Quality Control Works

The finishing work of surfaces shall conform with the requirements of clause 5 -1. Effective quality control of materials and works shall be exercised by the Engineer as per the clause 5 -2.

3-1.5 Arrangement for Traffic

During the period of construction, the flow of traffic shall be maintained in accordance with clause G -12.

3-1.6 Measurements for Payment

Granular sub-base shall be measured as finished work in position in cubic metres.

3-1.7 Rate

The contract unit rate for granular sub-base shall be paid in full for carrying out the required operations including full compensation for making arrangements for traffic as per clause G -12 except the works such as initial treatment to shoulders and construction of diversions; furnishing all materials to be incorporated in the work including all royalties, fees, rents (where necessary), all leads and lifts; carrying out the work in a part of the roadway width, leaving the rest of the width for the passage of traffic whenever directed; and all labour and incidentals required to complete the work as per the Specifications.

3 -2 **WATER BOUND MACADAM SUB-BASE/BASE COURSE/WEARING COURSE**

3-2.1 Description

Water bound macadam shall consist of clean, crushed aggregates mechanically interlocked by rolling and at the same time, bonded together with screenings, binding materials (where necessary) and water. It shall be laid on any or combination of the prepared sub-grade, sub-base, base or existing pavement and finished in accordance with the requirements of the Specifications and in conformity with the lines, grades, and cross-sections shown on the drawings or otherwise directed by the Engineer.

3-2.2 Materials

3-2.2.1 *Coarse Aggregates (General Requirements)*

Coarse aggregates shall be crushed stone or broken stone or natural gravel or over burnt brick aggregate. The aggregates shall conform to the physical requirements specified in **Table 3 -2(a)**. Type and the range of size of aggregate shall be specified in the contract.

Table 3 -2(a) : Physical Requirements of Coarse Aggregates for Water Bound Macadam

S. No.
Type of Construction
Test
Requirements

2
Sub-base

Base
Los Angeles Abrasion Value
or
Aggregate Impact Value

Los Angeles Abrasion Value
or
Aggregate Impact Value

Flakiness Index
50% maximum

40% maximum

50% maximum

40% maximum

15% maximum

3-2.2.2 Details of Aggregate Materials

Crushed or broken stone : When crushed or broken stone is specified as the coarse aggregate, it shall be hard, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter.

Over burnt brick aggregate : Brick aggregate shall be made out of over burnt bricks or brick bats and be free from dust and other undesirable matter.

3-2.2.3 Grading Requirements of Coarse Aggregates

The coarse aggregates shall conform to one of the grading specified in **Table 3 -2(b)**, provided that the use of Grading I shall be restricted to sub-base course only.

Table 3 -2(b) : Grading Requirements of Coarse Aggregates

Grading No.
Size Range
Sieve Designation
Percentage by Weight Passing the Sieve

I
90 mm to 40 mm
100 mm

80 mm
63 mm
40 mm
20 mm
100
65-85
25-60
0-15
0-5

II
63 mm to 40 mm
80 mm
63 mm
50 mm
40 mm
20 mm
100
90-100
35-70
0-15
0-5

III
50 mm to 20 mm
63 mm
50 mm
40 mm
20 mm
10 mm
100
95-100
35-70
0-10
0-5

3-2.2.4 Screenings

Screenings to fill voids in the course aggregate shall generally consist of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic materials such as moorum or gravel (other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6, respectively, and fraction passing 75 micron sieve does not exceed 10%.

As far as possible, screenings shall conform to the grading specified in **Table 3 -2(c)**. Screenings of Type A in **Table 3 -2(c)** shall be used with coarse aggregates of Grading I in **Table 3 -2(b)**. Screenings of Type A or B in **Table 3 -2(c)** shall be used with coarse aggregates of Grading II in **Table 3 -2(b)**. Similarly, Type B shall be used with coarse aggregates of Grading III. The use of screenings may be omitted in the case of soft aggregates such as over burnt brick bats, quartzite and laterite.

Table 3 -2(c) : Grading for Screenings

Grading Classification

Size of Screenings

Sieve Designation

Percentage by Weight Passing the Sieve

A

12.5 mm

12.5 mm

10 mm

4.75 mm

150 micron

100

90-100

10-30

0-8

B

10 mm

10 mm

4.75 mm

150 micron

100

85-100

10-30

3-2.2.5 Binding

Materials

Binding material to be used for the construction of water bound macadam shall comprise of a suitable material approved by the Engineer having plasticity index of less than 6.

Application of binding material may not be necessary when the screenings are of crushable type such as moorum, quartzite, laterite or gravel.

If the water bound macadam is to be laid directly over the sub-grade, without any intervening pavement course, a 25 mm course of screenings (Grading B) shall be spread on the prepared sub-grade before the application of coarse aggregates.

3-2.3

Construction Operations

3-2.3.1 *Preparation of Base*

The sub-grade or sub-base which receives the water bound macadam course shall be prepared to the specified grade, camber and made free of dust and other undesirable materials. Any ruts and soft yielding places shall be corrected in an approved manner and rolled to make the surface firm.

When water bound macadam is to be laid over an existing black topped surface, 50 mm x 50 mm furrows shall be cut at an angle of 45° to the centre line of the road at 1 m intervals in the existing

3-2.3.3*Spreading Coarse Aggregates*

The coarse aggregates shall be spread uniformly upon the prepared base in such quantities that the thickness of the compacted layer is

100 mm for Grading I and

75-100 mm for Grading II and III, unless otherwise specified.

In no case shall the aggregates be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over un-compacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with templates. All high or low spots shall be rectified by removing or adding aggregates as necessary. No segregation of large or fine particles shall be allowed. The coarse aggregates spread shall be of uniform gradation with no pockets of fine materials. Normally, the coarse aggregates shall not be spread more than 3 days before the subsequent construction operations.3-2.3.4

Rolling Immediately following the spreading of the coarse aggregates, rolling shall be started with three wheeled power rollers of 6 to 10 ton or tandem or vibratory rollers of approved type. The concrete roller of 1.5 ton shall be used if the above ones are not available. The weight of the roller shall depend upon the type of aggregates. On super-elevated portions, the rolling shall be carried out from the inner edge to the outer. On places other than the super-elevated portions, the rolling shall start from the edges and progress gradually towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of the road, in successive passes by uniformly lapping the preceding tracks by at least half the width. Rolling shall be discontinued when the aggregates are partially compacted with sufficient void spaces left. This makes the application of screenings possible. However, where screenings are not required as in the case of crushed aggregates, compaction shall be continued until the aggregates are thoroughly interlocked. During rolling, slight sprinkling of water may be done, if necessary. Rolling shall not be done when the sub-grade is soft or yielding or when it causes a wave-like motion in the sub-grade or sub-base course. The rolled surface shall be checked transversely and longitudinally with templates. If any irregularities are found, these shall be corrected by loosening the surface; adding or removing necessary quantity of aggregates; and re-rolling until the entire surface conforms to the desired camber and grade. In no case shall the use of screenings be permitted to make up depressions.3-2.3.5*Application of Screenings* After the coarse aggregate has been rolled as per clause 3-2.3.4, screenings shall gradually be applied in sufficient quantities in order to fill the interstices of the surface. The screenings shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that the vibration of the roller helps the screenings to be settled in voids. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by spreading motion of hand shovels or by mechanical spreaders or directly from trucks. However, the trucks operating for spreading of screenings shall not disturb the coarse aggregates. The screenings shall be applied at a slow and uniform rate (in three or more applications) in order to ensure the effective filling of all voids. Dry rolling and sweeping (by hand brooms) shall also be applied in order to facilitate the proper application of screenings. If the application of screenings is fast and thick, then it forms into cakes or ridges on the surface and, thus, prevents filling of voids or the direct bearing of the roller on the coarse aggregates. Therefore, such operations shall be discouraged by the Engineer. These operations shall be continued until no more screenings can be forced into the voids of the coarse aggregates. The spreading, rolling and sweeping of screenings shall be carried out only in such lengths of the road which could be completed within one day's operation.3-2.3.6

Sprinkling and Grouting After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand-brooms shall be used to sweep wet screenings into voids and to spread them evenly. The sprinkling, sweeping and rolling operations shall be continued with additional screenings applied as necessary until the coarse aggregate has been thoroughly keyed, well bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to ensure that the base or sub-grade does not get damaged due to the addition of excessive quantities of water during such operations.3-2.3.7 *Application of Binding Material* After the application of screenings in accordance with clauses 3-2.3.5 and 3-2.3.6, the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application of binding materials, the surface shall be copiously sprinkled with

water; the resulting slurry shall be swept with hand-brooms to fill the voids properly; and the surface shall be rolled while applying the water to the wheels of the rollers (This operation removes the binding material which is stuck to the roller drums). These operations shall continue until the resulting slurry, after filling of voids, forms a wave ahead of the wheels of the moving roller. 3-2.3.8 *Setting and Drying* After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning, hungry spots shall be filled with screenings of binding material; lightly sprinkled with water, if necessary; and rolled as directed by the Engineer. No traffic shall be allowed on the road until the macadam is completely set. 3-2.4 *Finishing of Surface and Quality Control Works* The finishing work of surfaces shall conform with the requirements of clause 5 -1. Effective quality control of materials and works shall be exercised by the Engineer as per clause 5 -2. 3-2.5 *Arrangements for Traffic* During the period of construction, the flow of traffic shall be maintained in accordance with clause G -12. 3-2.6 *Measurements for Payment* Water bound macadam shall be measured as finished work in cubic metres. 3-2.7 *Rate* The contract unit rate for water bound macadam which is laid as sub-base/base/wearing course shall be paid in full for carrying out the required operations including full compensation for all components listed in clause 3-1.7. 3 -3 **SHOULDER CONSTRUCTION** 3-3.1

Description This work shall include the construction of shoulders on either side of the pavement in accordance with the requirements of the Specifications; in conformity with the lines, grades and cross-sections shown on the drawings; or as directed by the Engineer. 3-3.2 *Materials* Shoulders may be of selected earth or granular material conforming to the requirements of clauses 2 -5 or 3 -1, respectively. The actual material to be used shall be specified. 3-3.3 *Construction Operations* Except in the case of bituminous constructions, shoulders shall be constructed in advance of the laying of pavement courses. The compacted thickness of each layer of shoulder shall correspond to the compacted layer of the pavement course to be laid adjacent to it. After compaction, the inside edges of shoulders shall be trimmed vertical and all spilled material shall be removed before proceeding with the construction of the pavement layer. In the case of bituminous courses, shouldering operations shall start only after the pavement course has been laid and compacted. Regardless of the method of laying, all shoulder construction material shall be placed directly on the shoulder. Any spilled material dragged on to the pavement surface shall be immediately removed without damage to the pavement. During all the stages of shoulder construction, the required cross-fall shall be maintained to drained off the surface water. 3-3.4 *Measurements for Payment* Shoulder construction shall be measured as finished work in position in cubic metres. 3-3.5 *Rate* The contract unit rate for shoulder construction shall be paid in full for carrying out the required operations including full compensation for all components listed in clause 3-1.7.

4

Bituminous Courses

4 -1 PREPARATION OF BASE FOR BITUMINOUS COURSES

4-1.1 Description

Preparation of base for bituminous courses shall include the preparation of existing water bound macadam (WBM) or black-topped surface to specified lines, grades and cross-sections in advance of laying a bituminous course. The work shall be performed on such widths and lengths as may be directed by the Engineer. Such work may consist of scarifying and relaying the water bound macadam course, filling of pot-holes and/or application of a levelling course as necessary.

4-1.2 Materials

4-1.2.1 *For Scarifying and Relaying the Water Bound Macadam Base Course*

The materials used shall be coarse aggregates which are salvaged from scarification of the existing base course to be renewed and be supplemented by fresh aggregates and screenings corresponding to clause 3 -2.

4-1.2.2 *For Patching Pot-holes*

The materials used for patching pot-holes shall be coarse aggregates, screenings, stone chips, bitumen or combination thereof as specified, conforming to the quality requirements of these materials given elsewhere in these Specifications.

4-1.2.3 *For Levelling Course*

The levelling course shall consist of pre-mixed bituminous material which conforms to clause 4 -3 except binder content which in this case shall be 2.5% by weight of the total mix. The aggregates may conform to either Grading I or II given in **Table 4 -3(b)**.

If the average thickness of surface irregularity is less than 30 mm, no such levelling course shall be required.

4-1.3 Construction Operations

4-1.3.1 *Scarifying and Renewing Base Course*

The surface shall be scarified by means of pick-axes or other means approved by the Engineer. The aggregate base shall be loosened to a depth of 50-75 mm after removing any existing black-topped surface. The resulting materials shall be removed from the road bed and screened for use in the renewal course. High spots on the exposed surface shall be corrected so that the surface broadly conforms to the specified grade and camber. The salvaged coarse aggregates mixed with requisite quantities of fresh aggregates shall be spread on the prepared bed and compacted as water bound macadam to a thickness of 75 mm or more as directed, in accordance with clause 3 -2.

4-1.3.2 *Patching of Pot-holes*

Pot-holes shall be cut to a regular shape with vertical sides after removing the water, if any. All loose and fragmented materials shall be removed from the prepared bed.

The pot-holes shall then be filled with coarse aggregates and screenings which conform to clause 3 -2. After filling, the layer shall be compacted with heavy hand rammers or approved mechanical tampers.

4-1.3.3 Laying of Levelling Course

After filling the pot-holes as per clause 4-1.3.2, the base on which the levelling course is to be laid shall be thoroughly swept and brushed to remove the dust and extraneous material. After the application of tack coat as per clause 4 -2, the levelling course shall then be laid and compacted to the desired levels, grade and camber given in the drawings and as per the requirements of the respective Specifications. The top levels of the course shall be determined from the final road level after accounting for the thickness of the bituminous wearing course which will be laid over it subsequently.

4-1.4 Arrangement for Traffic

During the above operations, flow of traffic shall be maintained as per clause G -12.

4-1.5 Measurements for Payment

4-1.5.1 Filling of Pot-holes

The work of filling pot-holes shall be considered incidental to the construction of bituminous courses for which the base is prepared.

4-1.5.2 Scarifying and Relaying

Scarifying and relaying the aggregate base course shall be measured in square metres. Fresh coarse aggregates and screening materials used in the work shall be measured in stacks in accordance with clause 4 -6.

4-1.5.3 Levelling Course

Levelling course shall be measured as volume compacted in position in cubic metres. The volume shall be worked out through measurement of layer thickness as per clause G-13.3.

4-1.6 Rates

4-1.6.1 Scarifying and Relaying

The contract unit rate for scarifying and relaying the aggregate base course shall be paid in full for carrying out the required operations including full compensation for the components listed in clause 3-1.7 except that the fresh coarse aggregates and screenings to be incorporated in the work shall be paid separately in accordance with clause 4 -6.

4-1.6.2 Levelling Course

The contract unit rate for levelling course shall be paid in full for carrying out the required operations including full compensation for:
making arrangements for traffic as per clause G -12 except for initial treatment to shoulders and construction of diversions;
providing all materials to be incorporated in the work including any royalties, fees, rents and taxes as applicable and all leads unless the contract specifically excludes any item of

material required for the work or provides for separate payment in accordance with clause 4 -6;

preparation of base including filling of pot-holes; all clearing operations; and application of tack coat;

all labour, precautionary measures and other incidentals required to complete the work as per the Specifications; and

carrying out the work in part widths of roadway, where directed.

4 -2 TACK COAT

4-2.1 Description

Tack coat is a bitumen painting applied as an intermediate bonding coat to another bituminous course to be laid on the existing road surface. It shall be applied in single coat of low viscosity liquid bituminous material.

4-2.2 Materials

The only material in this item of work is a binder. Binder used for tack coat shall be bitumen of a suitable grade as directed by the Engineer. It should conform to IS : 73, 217 or 454, as applicable, or to any other approved cutback (*Cut back bitumen is prepared by adding a quantity of kerosene or diesel oil to the bitumen. Often, it may be 5% to 10% by volume of the bitumen*) until similar Nepal's Standards are in place.

4-2.3 Construction Operations

4-2.3.1 *Preparation of Base*

The surface on which the tack coat is to be applied shall be thoroughly swept and brushed to remove the dust or any other extraneous material before the application of the binder.

4-2.3.2 *Application of Binder*

Binder shall be heated to the temperature appropriate to the grade of bitumen used and approved by the Engineer and sprayed on the base at the rate specified below. The rate of spraying in terms of straight-run bitumen shall be

5 kg per 10 square metre area for an existing bitumen treated surface.

10 kg per 10 square metre area for an untreated water bound macadam surface.

The binder shall be applied uniformly with the aid of sprayers. The tack coat shall be applied just ahead of the oncoming bituminous construction.

4-2.4 Quality Control Works

Control on the quality of materials and works shall be exercised by the Engineer in accordance with clause 5-2.4.

4-2.5 Arrangements for Traffic

While the above operations continue, the flow of traffic shall be regulated as per clause G - 12.

4-2.6 Measurements for Payment

Tack coat shall be measured in terms of surface area of application in square metres depending upon the specified rate of spraying.

4-2.7 Rate

The contract unit rate for tack coat shall be paid in full for carrying out the required operations including full compensation for:
making arrangements for traffic as per clause G -12 except for initial treatment to shoulders and construction of diversions;
providing all materials to be incorporated in the work including all royalties, fees, rents and taxes where necessary and all leads;
all labour, precautionary measures and other incidentals required to complete the work as per the Specifications; and
carrying out the work in part widths of roadway, where directed.

4 -3 BITUMINOUS MACADAM BASE/BINDER COURSE

4-3.1 Description

Bituminous macadam base/binder course shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings or as directed by the Engineer. This work shall include the construction of 50 mm/75 mm thickness of compacted crushed aggregates pre-mixed with a bituminous binder which is to be laid as a single layer immediately after mixing on a base prepared previously.

4-3.2 Materials

4-3.2.1 *Binder*

The binder shall be straight run bitumen of a suitable grade as directed by the Engineer complying with IS : 73.

4-3.2.2 *Aggregates*

The aggregates shall consist of crushed stone, crushed gravel (shingle) or other stones. They shall be clean, strong, durable, of fairly cubical shape and free of disintegrated pieces, organic and other deleterious matter and adherent coatings. The aggregates shall preferably be hydrophobic and of low porosity.

The aggregates shall satisfy the physical requirements set forth in **Table 4 -3(a)**.

Table 4 -3(a) : Physical Requirements of Aggregates for Bituminous Macadam

S. No.	Test	Test Method	Requirements
--------	------	-------------	--------------

1
Los Angeles Abrasion Value*
IS : 2386
(Part IV)
35% Maximum

2
Aggregate Impact Value*
IS : 2386
(Part IV)
30% Maximum

3
Flakiness Index
IS : 2386
(Part I)
35% Maximum

4
Stripping Value
IS : 6241

25% Maximum

5
Water Absorption
IS : 2386
(Part III)
2% Maximum

* Aggregates may satisfy requirements of either of the two tests.

The aggregates for bituminous macadam for different thickness shall conform to Grading I or II shown in **Table 4 -3(b)** and **Table 4 -3(c)**. The actual grading to be used shall be specified in the contract.

Table 4 -3(b) : Aggregates Grading for 75 mm Compacted Thickness of Bituminous Macadam

Sieve Designation
Percentage by Weight Passing the Sieve

Grading I
Grading II

63 mm
100
-

50 mm
90-100
-

40 mm
35-65
100

25 mm
20-40
70-100

20 mm
-
50-80

12.5 mm
5-20
-

4.75 mm
-
10-30

2.36 mm
-
5-20

75 micron
0-5
0-4

Table 4 -3(c) : Aggregates Grading for 50 mm Compacted Thickness of Bituminous Macadam

Sieve Designation
Percentage by Weight Passing the Sieve

Grading I
Grading II

50 mm
100
-

40 mm
90-100
-

25 mm
50-80
100

20 mm
-

70-100

12.5 mm

10-30

-

10 mm

-

35-60

4.75 mm

-

15-35

2.36 mm

-

5-20

75 micron

0-5

0-4

4-3.2.3 Proportioning of Materials

The binder content for pre-mixing shall be 3.5% and 4% by weight of the total mix for aggregate Grading I and II, respectively, except otherwise directed by the Engineer. The quantities of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

4-3.2.4 Variation in Proportioning of Materials

It shall be ensured that the materials are mixed in their respective proportions thereby producing a uniform mix. However, a variation in binder content of $\pm 0.3\%$ by weight of total mix could be permitted for individual specimen taken for quality control tests in accordance with clause 5 -2.

4-3.3 Construction Operations

4-3.3.1 Weather and Seasonal Limitations

Bituminous macadam shall not be laid during rainy weather or when the base course is damp or wet.

4-3.3.2 Preparation of Base

The base on which bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross-sections in accordance with clause 4 -1 as directed by the Engineer. The receiving surface shall be thoroughly swept and brushed to remove all dust and undesirable materials.

4-3.3.3 Tack Coat

A tack coat as per clause 4 -2 shall be applied over the base except when the laying of bituminous macadam is being preceded by a bituminous levelling course.

4-3.3.4 Preparation and Transport of Mix

Hot mix plant of adequate capacity shall be used for preparing the mix. Alternatively, the preparation of mix could be performed manually as follows:

Bitumen shall be heated in empty oil drum or big metal pots;

Simultaneously, the aggregates shall be spread on sheets made out of salvaged empty bitumen drums and shall be heated by making a fire underneath;

Finally, mixing the heated bitumen with hot aggregates on a separate big metal tray.

The temperature of binder at the time of mixing shall be in the range of 150° to 165°C and that of aggregates shall be in the range of 125° to 150°C, provided that the difference in temperature between the binder and aggregate at no time exceeds 25°C.

Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregates are coated uniformly. The mixture shall be transported from the mixing plant or the mixing place at site to the point of use in suitable vehicles or carriers. The vehicles or carriers employed for transport shall be cleaned and covered while in transit if so directed by the Engineer.

4-3.3.5 Spreading

The mix shall be spread immediately after mixing by means of manual laying where no mechanical means are available. It shall be carried out as per the screeds previously fixed at intervals. After spreading, the mix shall be tamped and finished according to the lines, grade and cross-sections shown on the drawings or as directed by the Engineer. At the time of laying, the temperature of the mix shall be maintained in the range of 110° to 135°C.

The longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centre line of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface shall be painted with hot bitumen before placing fresh material for the next stretch.

4-3.3.6 Rolling

After the spreading of mix, rolling shall be done by 8/10 ton power rollers or other approved plant. Rolling should start as soon as possible after the material has been spread. Rolling shall be done with care by avoiding any undue roughening of pavement surface.

Rolling of the longitudinal joint shall be done immediately after the paving operation. Then, rolling shall commence at edges and progress towards the centre longitudinally. In the case of super-elevated portions, rolling shall commence at the lower edge and progress towards the upper edge moving parallel to the centre line of the pavement.

The initial or breakdown rolling shall be done as soon as it is possible to roll the mixture without cracking the surface. The second or intermediate rolling shall follow the breakdown rolling as closely as possible and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while the material is still workable enough for the removal of roller's track marks.

When the roller has passed over the entire area once, any high spots or depressions which become apparent shall be corrected by removing or adding fresh material. The rolling shall then be continued till the entire surface has been rolled to requisite compaction. At this point, there is no crushing of aggregates and all the roller's track marks have been eliminated. Each pass of the roller shall uniformly lap over not less than one third of the track made by the preceding pass. The roller wheels shall be kept damp, if necessary, to avoid the bituminous material from sticking to the wheels and being picked up. In no case shall fuel or lubricating oil be used for this purpose.

Rolling operation shall be completed in every respect before the temperature of the mix falls below 80°C.

Rollers shall not stand on newly laid material when there is a risk of any deformation. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose the fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

4-3.4 Finishing of Surface and Quality Control Works

The finishing of surface shall conform to the requirements of clause 5 -1. Control on the quality of materials and works shall be exercised by the Engineer in accordance with clause 5 -2.

The bituminous macadam shall be provided final surfacing without any delay. If there is to be any delay, the course shall be covered by a seal coat to the requirements of clause 4 -5 before allowing any traffic over it.

4-3.5 Arrangements of Traffic

The flow of traffic during construction shall be maintained as per clause G -12.

4-3.6 Measurements for Payment

Bituminous macadam shall be measured as finished work in cubic metres.

4-3.7 Rate

The contract unit rate for bituminous macadam shall be paid in full for carrying out the required operations including full compensation for:
making arrangements for traffic as per clause G -12 except for initial treatment to shoulders and construction of diversions;
preparation of base except laying of levelling course but including filling of pot-holes;
providing all materials to be incorporated in the work including all royalties, fees, rents and taxes where necessary and all leads;
all labour, precautionary measures and other incidental required to complete the work as per the Specifications; and
carrying out the work in part widths, where directed.

4 -4 SURFACE DRESSING

4-4.1 Description

This work shall consist of the application of one or two coats of surface dressing. Surface dressing with single coat is generally referred as Single Bitumen Surface Treatment or as SBST. Similarly, Double Bitumen Surface Treatment (DBST) means surface dressing with two coats.

The base for surface dressing shall be a water bound macadam or other similarly prepared surface. The first layer of bituminous liquid (after heating up to an appropriate temperature) shall be sprayed on the prepared base. Before the binder is set, the specified quantities of stone chippings shall be spread to form the wearing surface and then rolled to the requirements of these Specifications. If required, the second layer shall also be placed in a similar manner.

4-4.2 Materials

4-4.2.1 *Binder*

The binder shall be straight run bitumen of a suitable grade as directed by the Engineer and conforming to IS : 73.

4-4.2.2 *Stone Chippings*

The stone chippings shall consist of fairly cubical fragments of clean, hard, tough and durable stones of uniform quality. These shall be obtained by crushing stone, river gravel (shingle) or other approved materials. Rounded gravel shall be used only when specifically permitted by the Engineer. The chippings shall be free of elongated or flaky pieces, soft or disintegrated stone, salt, alkali, organic matter, dust and adherent coatings. They shall conform to the quality requirements of **Table 4 -3(a)**, except that the Flakiness Index shall be limited to a maximum of 30.

The size of stone chippings shall be in accordance with **Table 4 -4(a)**.

Table 4 -4(a) : Size Requirements of Stone Chippings for Surface Dressing

S. No.

Type of Construction

Nominal Size of

Stone Chippings

Specifications

1

2

Single coat surface dressing or the first coat of two coat surface dressing

Second coat of two coat surface dressing

12 mm

10 mm

100% passing through 20 mm sieve and retained on 10 mm sieve.

100% passing through 12.5 mm sieve and retained on 6.3 mm sieve.

4-4.2.3 *Quantities of Materials*

The quantities of materials used in bituminous surface dressing shall be as specified in **Table 4 -4(b)**.

Table 4 -4(b) : Quantities of Materials required for 10 m² of Road Surface for Surface Dressing

S. No.	Type of Construction	Binder	Stone Chippings
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1			
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2			
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	Single coat surface dressing or the first coat of two coat surface dressing		
--	---	--	--

	Second coat of two coat surface dressing or renewal coat		
--	--	--	--

	18 kg		
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	11 kg		
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	0.15 m ³		
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	0.10 m ³		
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4-4.3 Construction Operations

4-4.3.1 *Weather and Seasonal Limitations*

The surface dressing work shall be carried out only when the atmospheric temperature in shade is above 16°C. No bituminous material shall normally be applied when the surface of cover material is damp, when the weather is foggy or rainy, or during dust storms.

4-4.3.2 *Preparation of Base*

The base on which surface dressing is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross-sections in accordance with clause 4 -1 as directed by the Engineer. Where the existing surface is bulged, it should be rectified.

The surface shall be thoroughly swept and brushed to remove dust and any other undesirable matter before the spraying of binder. The cleaning shall be done first with hard wire-brushes then with softer brushes and finally by blowing with sacks or gunny bags when necessary.

4-4.3.3 Application of Binder

Binder shall be heated to a temperature range of 163°-177°C and sprayed on dry surface in a uniform manner with the help of sprayers. Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage or any other reason shall be suitably corrected before the stone chippings are spread.

4-4.3.4 Application of Stone Chippings

Immediately after the application of binder, stone chippings in a dry and clean state shall be spread uniformly on the surface manually so as to cover the surface completely. If necessary, the surface shall be swept in order to ensure a uniform spread of chippings.

4-4.3.5 Rolling

Immediately after the application of cover material, the entire surface shall be rolled with a 8-10 ton smooth wheeled roller. Rolling shall commence at the edges and progress towards the centre except in super-elevated portions where it shall proceed from the inner edge to the outer. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress, additional chippings shall be spread by hand in whatever quantities necessary to patch up the irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

4-4.3.6 Application of Second Coat of Surface Dressing

Where surface dressing in two coats is specified, the second coat shall be applied immediately after the laying of first coat. The construction operations for the second coat shall be the same as described in clauses 4-4.3.3, 4-4.3.4 and 4-4.3.5.

4-4.4 Opening to Traffic

Traffic shall not be allowed to run on any newly dressed surfaces until the following day. In special circumstances, however, the Engineer may open the road to traffic immediately after rolling, but in such cases, its speed shall be limited to 16 kmph till the following day.

4-4.5 Finishing of Surface and Quality Control Works

The surface finish of construction shall conform to the requirements of clause 5 -1 of the Specifications. Control on the quality of materials and work shall be exercised by the Engineer in accordance with clause 5 -2 of the Specifications.

4-4.6 Measurements for Payment

Each coat of surface dressing shall be measured as finished work in square metres.

4-4.7 Rates

The contract unit rate for each coat of surface dressing shall be paid in full for carrying out the required operations including full compensation for all components listed in clause 4-3.8.

4 -5 SEAL COAT

4-5.1 Description

The work of seal coat shall consist of application of a coating of sealing material over a bituminous surface laid to specified levels, grade and camber. It shall be of two types as specified below:

- i. Type A - liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chippings.
- ii. Type B - pre-mixed seal coat comprising of a thin application of fine aggregate pre-mixed with bituminous binder.

4-5.2 Materials

The materials for seal coat shall be binder, stone chippings and fine aggregates.

4-5.2.1 *Binder*

The binder shall be bitumen of a suitable grade as directed by the Engineer and conforming to the requirements of IS : 73, 217 or 454 as applicable or any other approved cutback.

The quantity of binder to be utilised, in terms of straight run bitumen shall be
9.8 kg per 10 square metre area for Type A, and
6.8 kg per 10 square metre area for Type B.

4-5.2.2 *Stone Chippings for Type A Seal Coat*

The stone chippings shall
consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout;
be free of elongated or flaky pieces, soft or disintegrated stone, or organic matter; and
be of 6 mm size defined as 100% passing through 10 mm sieve and retained on 2.36 mm sieve.

The quantity used for spreading shall be 0.09 cubic metre per 10 square metre area. The chippings shall satisfy the quality requirements spelled out in **Table 4 -3(a)** except the upper limit for Flakiness Index which in this case shall be 30.

4-5.2.3 *Fine Aggregates for Type B Seal Coat*

The fine aggregates shall be sand or fine grit.
The fine aggregate of sand or grit shall
consist of clean, hard, durable, un-coated dry particles;
be free from dust, soft or flaky material, organic matter and other deleterious substances;
and

pass 1.7 mm sieve and be retained on 180 micron sieve.

The quantity used for premixing shall be 0.06 cubic metre per 10 square metre area.

4-5.3 Construction Operations

4-5.3.1 *Preparation of Base*

The seal coat shall be applied immediately after the laying of bituminous course which is required to be sealed. Before the application of seal coat material, the surface shall be cleaned and made free of any dust or other extraneous matter.

4-5.3.2 *Construction of Type A Seal Coat*

The binder shall be heated in boilers of suitable design or alternately in an open mouthed empty oil drums to the temperature (preferably, 163°-177°C) appropriate to the grade of bitumen approved by the Engineer.

The seal coat shall be applied in accordance with the construction operations described in clauses 4-4.3.3, 4-4.3.4 and 4-4.3.5.

4-5.3.3 *Construction of Type B Seal Coat*

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder. In rural road construction, the hand mixing tray made out of metal sheets could be used in place of mixer plants. In this case, an adequate number of labourers equipped with shovels, rubber boots, gloves, safety hats, etc. shall be required in order to achieve the requisite quality of mixing.

The binder shall be heated in boilers of suitable design to the temperature appropriate to the grade of bitumen approved by the Engineer. Also, the aggregates shall be dry and suitably heated to a temperature directed by the Engineer before the same are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued till the aggregates are thoroughly coated with the binder.

The mix shall be transported immediately from the mixing plant/site to the place of use and spread uniformly on the bituminous surface to be sealed.

As soon as sufficient length has been covered with the pre-mixed material, the surface shall be rolled with 6-9 ton smooth wheeled power rollers. Rolling shall be continued till the pre-mixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

4-5.4 Opening to Traffic

In the case of Type B seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. However, as regard to Type A seal coat, clause 4-4.4 shall apply.

4-5.5 Finishing of Surface and Quality Control Works

The surface finish of construction shall conform to the requirements of clause 5 -1. Control on the quality of materials and works shall be exercised by the Engineer as per clause 5 -2.

4-5.6 Arrangements for Traffic

During the period of construction, flow of traffic shall be maintained as per clause G -12.

4-5.7 Measurements for Payment

Seal coat, Type A or B shall be measured as finished work in square metres.

4-5.8 Rate

The contract unit rate for seal coat, Type A or B shall be paid in full for carrying out the required operations including full compensation for all components listed in clause 4-3.8.

4 -6 SUPPLY OF MINERAL AGGREGATES FOR PAVEMENT COURSES

4-6.1 General

These Specifications shall apply to works where it is intended only to collect, transport and stack the mineral aggregates and mineral filler for use in pavement courses. The actual work of laying the courses shall, however, be governed by the relevant sections of the Specifications. The size and quantities of the aggregates to be supplied shall be selected by the Engineer in such a manner that the intended supply should satisfy the grading requirements of relevant courses set forth in these Specifications.

All the materials shall be procured from the approved sources and shall conform to the physical requirements of individual items specified in the respective sections of these Specifications.

4-6.2 Sizes of Mineral Aggregates

The mineral aggregates shall be designated by their standard sizes in the contract and shall conform to the requirements set forth in **Table 4 -6(a)**.

Table 4 -6(a) : Size Requirements for Mineral Aggregates

S. No.

Standard Size of Aggregate

Designation of Sieve through which the Aggregate shall pass Entirely

Designation of Sieve on which the Aggregate shall be retained Entirely

Coarse Aggregates

- 1
- 2
- 3
- 4
- 5
- 90 mm

75 mm
63 mm
40 mm
25 mm
100 mm
100 mm
80 mm
50 mm
40 mm
80 mm
63 mm
50 mm
25 mm
20 mm

S. No.
Standard Size of Aggregate
Designation of Sieve through which the Aggregate shall pass Entirely
Designation of Sieve on which the Aggregate shall be retained Entirely

Coarse Aggregates

6
7
8
9
20 mm
12 mm
10 mm
6 mm
25 mm
20 mm
12.5 mm
10 mm
12.5 mm
10 mm
6.3 mm
2.36 mm

Fine Aggregates

10
11
12
2 mm
500 micron
75 micron

4.75 mm
2.36 mm
150 micron
75 micron
150 micron
-

4-6.3 Stacking

Only the aggregates satisfying the requirements of Specifications shall be transported to the road side and stacked. Each size of aggregate shall be stacked separately. Similarly, materials obtained from different sources shall be stacked separately.

The aggregates shall be stacked outside the roadway on a levelled ground or platform prepared in advance for the purpose by the Contractor at his own cost. It shall be done in such a manner that it facilitates for correct and easy measurement. Materials shall not be stacked in locations liable to inundation or floods.

The dimensions of the stacks and their locations shall be as approved by the Engineer. Where the material is improperly stacked, the Engineer shall have the right to order complete re-stacking of the materials at the cost of the Contractor.

Mineral filler shall be supplied in dry state in bags or other suitable containers approved by the Engineer and shall be protected from weather, dampness, etc. so as to prevent any deterioration in quality.

4-6.4 Quality Control of Materials

The Engineer shall exercise control over the quality of materials so as to ascertain their conformity with the requirements of Specifications. For this, he/she shall carry out necessary tests for the specified properties. Testing shall be carried out to the following frequencies and the Engineer shall have the right to modify these according to the needs.

Coarse and fine aggregates : one test for each specified property per 50 m³ of material.
Mineral filler : one test for each specified property for every 5 ton subject to a minimum of one test for each consignment.

Materials not conforming to the requirements of Specifications shall not be brought to the work site.

4-6.5 Measurements for Payment

Coarse and fine aggregates supplied at site of works shall be measured in cubic metres. The actual volume of the aggregates to be paid shall be computed after deducting the following percentages from the volume obtained from stack measurements.

Table 4 -6(b) : Percentage Reduction in Volume obtained from Stack Measurements

S. No.
Standard Size of Aggregates
Percentage Reduction in Volume obtained from Stack Measurements

1
2
3
4
75 mm and 63 mm
40 mm and 25 mm
20 mm, 12 mm, 10 mm and 6 mm
Fine aggregates
12.5%
10%
5%
nil

Unless otherwise directed, measurements shall not be taken until sufficient materials for use on the road have been collected and stacked. Immediately after measurement, the stacks shall be marked by whitewash or other means as directed by the Engineer.

Mineral filler as delivered at site of works shall be measured in tonnes.

4-6.6 Rates

The contract unit rates for different sizes of coarse aggregate, fine aggregate and mineral filler shall be paid in full for collecting, transporting and stacking or storing at site of works including full compensation for:

all royalties, fees, rents and taxes where necessary;

all leads; and

all labour, precautionary measures and other incidentals required to complete the work as per the Specifications.

5

Quality Control for Road Works

5 -1 CONTROL OF ALIGNMENT AND SURFACE REGULARITY

5-1.1 Description

All works performed shall conform to the lines, grades, cross-sections and dimensions shown on the drawings or as directed by the Engineer subject to the permitted tolerances described hereinafter.

5-1.2 Horizontal Alignments

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the construction drawings.

The edges of the carriageway as constructed shall be conformed within a tolerance of ± 25 mm.

The corresponding tolerance for edges of roadway and lower layers of pavement shall be ± 40 mm.

5-1.3 Longitudinal Profile

The levels of the sub-grade and different pavement courses as constructed shall not vary from those calculated with reference to the longitudinal profile and cross-sections of the road shown on the drawings or as directed by the Engineer, beyond the tolerances mentioned below:

Sub-grade	± 25 mm
Sub-base	± 20 mm
Base course	± 15 mm
Wearing course	± 10 mm

However, the negative tolerance for wearing course shall not be permitted in conjunction with the positive tolerance for base course if the thickness of the wearing course is reduced by more than 6 mm.

5-1.4 Surface Regularity of Sub-Grade and Pavement Courses

The surface regularity of completed sub-bases, base courses and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in **Table 5 -1**.

The longitudinal profile shall be checked with a 3 m long straight edge along the centre line of the road.

The transverse profile shall be checked with a set of three camber boards kept at interval of 10 m.

Table 5 -1 : Permitted Tolerances of Surface Regularity for Pavement Courses

S.

No.

Type of Construction

Longitudinal Profile

with 3 metre Straight Edge

Cross Profile

Maximum Permissible Undulation

Maximum Number of Undulations which exceed () mm Permitted in any 300 m Length

Maximum Permissible Variation from specified Profile under Camber Template

mm

no.

mm

(6)

Earthen sub-grade

Granular/lime/cement/

stabilised sub-base

Water Bound Macadam with oversize metal (40-90 mm size)

Water Bound Macadam with normal size metal (20-50 mm and 40-63 mm size), Bituminous Penetration Macadam or built-up spray grout

Surface dressing* (two coat) over WBM (20-50 mm or 40-63 mm size metal), Bituminous Penetration
Macadam or built-up spray grout

Open graded premix carpet, mix-seal surfacing

Bituminous macadam

20**

Semi-dense carpet

20**

Asphaltic Concrete

10**

Note : * For surface dressing in all other cases, the standards of surface smoothness will be the same as those for the surface receiving the surface dressing.

****** These are for machine laid surfaces. If laid manually, tolerance up to 50% above these values in this column may be permitted on the approval of the Engineer. However, this relaxation does not apply to the values of maximum undulation for longitudinal and cross profiles mentioned in columns 3 and 8 on the table.

- Requirements of surface smoothness in respect of both the longitudinal and cross profiles should be simultaneously satisfied.

5-1.5 Rectification

Where the surface irregularities of sub-grade and the various pavement courses fall outside the specified tolerances, the Contractor (Users' Group, in case of sub-grade) shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer.

(i) Sub-grade : Where the surface is high, it shall be trimmed and sufficiently compacted. Where the surface is low, the deficiency shall be corrected by adding fresh material. When adding, the degree of compaction and the type of material to be used shall conform to the requirements of clause **2 -5**.

(ii) Granular sub-base : It is same as in the case of sub-grade, except the fact that the degree of compaction and the type of material to be used shall conform to the conditions of clause 3 -1.

(iii) Water Bound Macadam base : Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and re-compacted as per clause 3 - 2. The area treated at a place shall not be less than 5 m long and 2 m wide.

(iv) Bituminous constructions : Such constructions, other than for the wearing course, all depressions shall be rectified by adding fresh material and re-compacted as per the Specifications. If the surface is high then the full depth of the layer shall be removed; replaced with fresh material; and re-compacted as per the Specifications.

In bituminous construction for wearing course, the full depth of layer shall be removed; replaced with fresh material; and re-compacted irrespective of the surface being high or low.

In all cases of removal and replacement of bituminous layer, the area treated shall not be less than 5 m long and 2 m wide.

5 -2 QUALITY CONTROL TESTS DURING CONSTRUCTION

5-2.1 General

The materials supplied and the works carried out by the Contractor/Users' Group shall conform to the Specifications prescribed in the preceding clauses.

To ensure the requisite quality of construction, all materials and works shall be subjected to the following quality control tests which shall be carried out by the Engineer or any designated person/institution. The given testing frequencies are the absolute minimum. However, the Engineer shall have the full authority to carry out tests as frequently as he/she may deem necessary to satisfy him/herself on the quality of materials and works.

Test procedures for the various quality control tests are indicated in the respective sections of the Specifications or for certain tests within this section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practices or as directed by the Engineer.

5-2.2 Tests on Earthwork for Embankment Construction

5-2.2.1 *Quality Control of Borrow Material*

(i) Sand Content Test shall be carried out as per IS : 2720 (Part IV) or other equivalent International Standards, at a frequency of 1-2 tests per 8000 m³ of soil.

(ii) Plasticity Test shall be carried out as per IS : 2720 (Part V) or other equivalent International Standards, at a frequency of 1-2 tests per 8000 m³ of soil. Each soil type shall be tested.

(iii) Density Test shall be carried out as per IS : 2720 (Part VII) or other equivalent International Standards, at a frequency of 1-2 tests per 8000 m³ of soil. Each soil type shall be tested.

(iv) Deleterious (Undesirable Material) Content Test shall be carried out as per IS : 2720 (Part XXVII) or other equivalent International Standards, as and when required by the Engineer.

(v) Moisture Content Test shall be carried out as per IS : 2720 (Part II) or other equivalent International Standards, at a frequency of one test for every 250 m³ of soil.

(vi) CBR Test on materials (soaked/unsoaked samples) which are to be incorporated in the sub-grade shall be carried out as per IS : 2720 (Part XVI) or other equivalent International Standards, as and when required by the Engineer.

5-2.2.2 *Quality Control of Compaction*

Quality control shall be exercised by taking at least one set of measurements of density for each 1000 m² of compacted area, or closer as required to yield the minimum number of test results for evaluating the day's work on statistical basis. The density shall be determined in accordance with IS : 2720 (Part XXVIII) or other equivalent International Standards. Test locations shall be chosen only through random sampling techniques. Quality control shall not be based on the result of any one test but shall be based on the mean value of 5-10 tests. The number of tests in one set of measurements could be limited to 5, if the Engineer feels that sufficient control over borrow material and the method of compaction is being exercised to his/her satisfaction. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurements shall be increased to 10. The acceptance of work shall be subjected to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08 g/cm³.

However, for earthwork in shoulders and in top 0.5 m portion of the embankment (sub-grade), at least one set of density measurements shall be taken for every 500 m² of the compacted area. In such cases, the number of tests in each set of measurements shall be at least 10.

5-2.3 Tests on Sub-Bases and Bases (excluding bituminous macadam)

The tests and their frequencies for different types of bases and sub-bases shall be as given in **Table 5 -2(a)**. The evaluation of density results on quality control of compaction shall be in accordance with clause 5-2.2.2.

Table 5 -2(a) : Control Tests and their Frequency for Sub-bases and Bases (excluding bituminous macadam)

S.

No.

Types of Construction

Test

Frequency

1

Granular

(i) Gradation

1 test per 200 m³

sub-base

(ii) Atterberg limits

1 test per 200 m³

(iii) Moisture content prior to compaction

1 test per 250 m²

(iv) Density of compacted layer

1 test per 500 m²

(v) Deleterious materials
As required.

2

Water Bound

(i) Aggregate Impact Value
1 test per 200 m³ of aggregate

Macadam

(ii) Grading
1 test per 100 m³ of aggregate

(iii) Flakiness Index
1 test per 200 m³ of aggregate

(iv) Atterberg limits of binding material
1 test per 25 m³ of binding material

5-2.4 Tests on Bituminous Constructions

The tests and their frequencies for tack coat, seal coat, single bitumen surface treatment (SBST), double bitumen surface treatment (DBST) and bituminous macadam shall be as given in **Table 5 -2(b)**.

Table 5 -2(b) : Control Tests and their Frequencies for Bituminous Constructions

S. No.	Type of Construction	Test	Frequency
--------	----------------------	------	-----------

1

Tack Coat

(i) Quality of binder
As required.

(ii) Binder temperature for application
At regular close intervals.

(iii) Rate of spread of binder
Two tests per day.

2

Seal Coat; Single Bitumen

(i) Quality of binder
As required.

Surface Treatment (SBST)

(ii) Aggregate Impact Value

One test per 50 m³ of aggregate

and Double Bitumen

(iii) Flakiness Index

One test per 50 m³ of aggregate

Surface Treatment (DBST)

(iv) Stripping Value of Aggregates

Initially, one set of 3 representative specimens for each source of supply.

Subsequently, when warranted by changes in the quality of aggregates.

(v) Water absorption of aggregates

- do -

(vi) Grading of aggregates

One test per 25 m³ of aggregate

(vii) Temperature of binder at application

At regular close intervals.

(viii) Rate of spread of materials

One test per 500 m³ of aggregate

3

Bituminous Macadam

(i) Quality of binder

As required.

(ii) Aggregate Impact Value

One test per 50-100 m³ of aggregate

(iii) Flakiness Index

- do -

(iv) Stripping Value and water absorption of aggregates

Initially, one set of 3 representative specimens for each source of supply. Subsequently, when warranted by changes in the quality of aggregates.

(v) Grading of aggregates

Two tests per day per plant both on individual constituents and mixed aggregates from the dryer.

(vi) Binding content (vide ASTM : D-2172)

Periodic subject to minimum of two tests per day per plant.

(vii) Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling

At regular close intervals.

(viii) Rate of spread of mixed material

Regular control through checks on layer thickness.

6

Materials for Structures

6 -1 GENERAL

All materials to be used in the work shall be in conformity with the requirements laid down in this section. Any special material which is not covered in this section shall either be in accordance with the defined Specifications given in the contract or be approved by the Engineer.

6 -2 BRICKS

Minimum compressive strength of burnt clay bricks shall not be less than 8.4 N/mm² for any individual brick and 10.5 N/mm² for an average of 5 specimens. The size of bricks shall be according to the local practice with a tolerance of $\pm 10\%$.

6 -3 CAST IRON

Cast iron manufactured in India shall conform to IS : 210. Other qualities of cast iron shall conform to the standardisation equivalent to IS : 210 until Nepal's Standards are in place.

6 -4 CEMENT

Cement to be used shall conform to the requirements of
IS : 269 for ordinary and rapid hardening Portland cement
IS : 455 for Portland blast furnace slag cement
IS : 3466 for masonry cement (for use in mortars for masonry only)
until similar Nepal's Standards are in place.

6 -5 COARSE AGGREGATE

Coarse aggregate shall conform to the requirements of IS : 383 until similar Nepal's Standards are in place.

6 -6 REINFORCED CONCRETE PIPE

Reinforced cement concrete pipes for road structures shall be of NP3 type conforming to the requirements of IS : 458 until similar Nepal's Standards are in place.

6 -7 SAND

Sand to be used shall conform to the requirements of
IS : 2116 for masonry work
IS : 383 for cement concrete work
until similar Nepal's Standards are in place.

6 -8 STEEL

6-8.1 High Tensile Steel for Pre-stressing

Steel for pre-stressing shall conform to the requirements of IS : 1785 (Part I) until similar Nepal's Standards are in place.

6-8.2 Mild Steel Reinforcement

Mild steel reinforcement shall conform to the requirements of
IS : 432 for Mild Steel Grade I or medium tensile steel bars
IS : 1139 for high yield strength deformed (hot rolled) bars
IS : 1786 for high yield strength deformed (cold twisted) bars
until similar Nepal's Standards are in place.

6-8.3 Rivet Steel

All rivets and rivet bars shall conform to IS : 1148 or IS : 1149, as applicable.

6-8.4 Structural Steel

All structural steel shall conform to the requirements of
IS : 226 for mild steel
IS : 961 for high tensile steel
IS : 2062 for fusion welding quality steel
until similar Nepal's Standards are in place.

6 -9 WATER

Water shall be clean and free from injurious amount of deleterious materials. Normally, potable water may be considered satisfactory for mixing and curing concrete and masonry work. As a guide, the following concentrations represent the maximum permissible values of deleterious materials.

Not more than 2 ml of 0.1normal NaOH shall be required to neutralise 200 ml of the sample.

Not more than 10 ml of 0.1 normal HCl shall be required to neutralise 200 ml of the sample.

Percentage of solids shall not exceed the following:

Organic	0.02%
Inorganic	0.03%
Sulphates	0.05%
Alkali-chlorides	0.10%

6 -10 TIMBER

The timber used for structural purposes shall conform to IS : 883 until similar Nepal's Standards are in place.

6 -11 GABION WIRE

Gabion wire used for structural purposes shall confirm to NS 163-2045 or equivalent.

6 -12 STORAGE OF MATERIALS

6-12.1 General

All materials shall be stored to prevent their deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work.

Any material which has deteriorated or has been damaged or is otherwise considered defective by the Engineer shall not be used in the works.

6-12.2 Bricks

Bricks when unloading shall not be dumped at site. shall be stacked orderly in regular tiers.

Supply of bricks to construction works shall be so arranged that the stock at site is always enough for two days' work. Bricks selected for use in different situations shall be stacked separately.

6-12.3 Cement

Cement shall be stored above the ground level in perfectly dry and water tight sheds and shall be stacked not more than 8 bags in a column. Wherever bulk storage containers are used, their capacity should be sufficient to cater to the requirements at site. These containers should be cleaned at least once every 3 to 4 months. Cement more than 3 to 4 months old shall invariably be tested to ascertain that it satisfies the acceptability requirements.

6-12.4 Aggregates

The aggregates shall be stored in such a way as to prevent admixture of foreign materials. Different sizes of fine or coarse aggregates shall be stored in separate stock piles sufficiently away from each other in order to prevent any intermixing.

6-12.5 Mild Steel

Mild steel rods or coils shall be stored in such a way as to avoid distortion and to prevent deterioration by corrosion. When directed, the steel reinforcement bars shall be given a cement wash before stacking in order to prevent forming of scale and rust.

6-12.6 High Tensile Steel for Pre-stressing

All high tensile steel for pre-stressing work shall be stored about 30 cm above the ground in a suitably covered and closed space to protect it from dampness. It shall also be invariably wrapped in gunny clothes, tar papers or any other suitable material. If it is to be stored for a short period (say 2 to 3 months) in an open area at the site, it must be properly covered. Effective protection of the pre-stressing steel against corrosion shall be ensured. The Engineer could, however, conduct necessary tests in order to confirm the physical characteristics prior to its usage.

7 Brick Workfor Structures

7 -1 MORTARS While preparing mortar, cement, sand and water shall be mixed in proportion as specified in the drawings or as directed by the Engineer. The ingredients of the mix shall be proportioned as follows: Cement by weight taking its unit weight as 1440 kg per cubic metre; Sand by volume after making due allowances for bulking; and Water in required quantity to make the mix workable. The mixing shall be done intimately in a mechanical mixer unless hand-mixing is specifically permitted by the Engineer. If hand-mixing is done, the operation shall be carried out on a clean watertight platform and while mixing cement and sand be first mixed dry in the required proportion to obtain a uniform colour and the mortar shall be mixed for at least two minutes after the addition of water. If the cement mortar has stiffened because of evaporation of water then it shall be re-tempered by adding water as frequently as needed to restore the requisite consistency. However, such re-tempering shall be permitted only for a period of thirty minutes counting from the time of addition of water during the initial mixing. Required tests to determine compressive strength of the mortar, consistency of the mortar and its water retentiveness shall be carried out in accordance with IS : 2250 until similar Nepal's Standards are in place. The frequency of testing shall be one cube for every 2 cubic metre of mortar prepared subject to a minimum of 3 cubes for a day's work.

7 -2 SOAKING OF BRICKS Bricks shall be soaked in water for a minimum of one hour before their use. Soaked bricks shall be taken out from the soaking tank sufficiently in advance so that the skin of bricks would be dry at the time of laying. Such soaked bricks shall be stacked on a clean place where they will not be spoiled by dirt, earth, etc.

7 -3 LAYING OF BRICKS All bricks shall be laid in an appropriate bond and such work shall be even and true to line, plumb and level. All joints shall be kept accurately. The bricks used on the face shall be of complete ones with 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 could get into 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. When laying bricks in foundation, a layer of not less than 12 mm of mortar shall be spread over the base on which the brick work will be laid even. Immediately after the placing of mortar, the first layer of bricks shall be laid. The brick work shall be built in uniform layers. All corners and other advanced work shall be raked back. Brick work shall be done true to plumb or in specified batter. To avoid unequal settlement and improper jointing during construction, no part of the brick work shall rise more than one metre above the general construction level planned for the day's work. Toothing may be done where future extension is contemplated but shall be used as an alternative to raking back.

7 -4 JOINTS The thickness of joints shall not exceed 10 mm.

7 -5 JOINTING WITH EXISTING STRUCTURES When fresh masonry is to be placed against the existing surface of structures, the surfaces shall be cleaned of all loose materials; roughened; and wetted as directed by the Engineer in order to ensure an effective bond with the new work.

7 -6 CURING Green work shall be protected from rain by suitable covering. Masonry work in cement or composite 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 at the close of each day's work. During hot weather, all finished or partly completed work shall be covered or/and wetted in order to prevent any rapid drying of brick work.

7 -7 SCAFFOLDING The scaffolding shall be sound and strong enough to stand for all loads which might come on it. The holes which are created in masonry to 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. Such holes shall be filled and made good as quickly as possible.

7 -8 CONDITION OF EQUIPMENT All equipment used for mixing mortar and for transporting of mortar and bricks shall be cleaned and kept free from set mortar, dirt or injurious foreign substances.

7 -9 FINISHING OF SURFACES

7-9.1 General The surfaces can be finished by 'Jointing' or by 'Pointing' or by 'Plastering', as specified in the drawings. For a surface which is subsequently to be plastered or pointed, the joints shall be squarely raked out to a depth of 15 mm when the mortar remains green.

The raked joints shall be well brushed to remove dust and loose particles. The surface shall be thoroughly washed with water; cleaned and wetted prior to any of the above operations. The mortar for finishing work shall be prepared as per clause 7 -1.7-9.2 JointingIn jointing, the face joints of the mortar shall be worked out when mortar is still green. This allows the finished surface to be flushed with the face of the brick work. The faces of brick work shall be cleaned by removing any splashes of mortar set during the course of raising the brick work.7-9.3 PointingFirst of all, the mortar shall be filled and pressed into the raked out joints. The pointing shall then be finished to a proper type given on the drawings. If the type of pointing is not specified in the drawings, it should be ruled pointing.For ruled pointing, the mortar shall be filled in to the joints; pressed; and finished off level with the edges of the bricks. When the mortar remains as green, it shall then be ruled along the centre with a half round tool of such width as may be specified by the Engineer. The superfluous mortar shall then be cut off from the edges of the lines. Finally, the surface of masonry shall also be cleaned of all mortar.7-9.4 PlasteringPlastering work shall start from the top and proceed downwards. All putlog holes shall be properly filled well in advance of the plastering as soon as the scaffolding is being removed. Wooden screeds having the size of 75 mm wide and the thickness of plaster shall be fixed vertically 2.5 m to 4 m 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. The layer shall be pressed hard enough to make the raked joints filled properly with mortar. 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 for a length of 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 permitted in this regard.When recommencing plastering beyond the work suspended earlier, the edges of the old plaster shall be scraped, cleaned and wetted before the plaster is applied to the adjacent areas.No portion of the surface shall be left out initially 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 Engineer.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 by more than 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 shapes and re-done as directed by the Engineer.7-9.5

Curing of FinishesCuring shall be started as soon as the mortar used for finishing has hardened sufficiently. The plaster shall not be damaged when curing by water.The plastering shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages.7-9.6 Scaffolding for FinishesThe scaffolding for the work shall be provided as stages or platforms erected independently to the structure.7 -10

WEEP HOLESIn case of abutments, wing walls and retaining walls, weep holes as shown on the drawings or directed by the Engineer shall be provided in the masonry to drain out the seepage from back filling. Weep holes are provided to release the pore water pressures, built up in back filled earth, which may cause damages to the structure. Weep holes shall generally be of rectangular shape having dimensions of 8 cm wide x 15 cm high or of circular shape having a diameter of 15 cm. They shall extend through the full width of the masonry with a slope of 1:20 (0.05) towards the draining face.The spacing of weep holes shall be generally 1 m in either direction as shown on the drawings with the lowest one at about 15 cm above the low water level or ground level whichever is higher. For special cases, the spacing of weep holes shall be determined by the Engineer at site.7 -11

ARCHITECTURAL COPING FOR WING/RETURN/PARAPET WALLSThis work shall consist of providing an architectural coping along the top of wing/return/parapet walls. The material used in coping work shall be cement mortar of 1:4 cement-sand ratio prepared as per clause 7 -1.The cement mortar shall be laid evenly to an average thickness of 15 mm to the full width of the wall top and in continuation to this, a band of 15 mm thick and 15 cm deep shall be projected out of the mortar along the top outer face of the walls.7 -12

MEASUREMENTS FOR PAYMENT All brick works shall be measured in cubic metres. In arches, the length of arch shall be measured as the mean length between the extrados and intrados. The work of plastering and pointing shall be measured in square metres of the surface treated. Architectural coping shall be measured in linear metres. **7 -13**

RATE 7-13.1 Brickwork The contract unit rate for brick work shall be paid in full for all necessary operations including full compensation for all labour, materials, scaffolding and other incidentals required to complete the work as per the Specifications. The rate shall also include full compensation for using specially moulded bricks on the face of walls with batter and provision of weep holes. 7-13.2 Plastering The contract unit rate for plastering shall be paid in full for all necessary operations including full compensation for all labour, materials, scaffolding and other incidentals required to complete the work as per the Specifications. 7-13.3 Pointing The contract unit rate for pointing shall be paid in full for all necessary operations such as erecting and removal of scaffolding, raking out joints, cleaning, wetting, filling with mortar, trowelling, pointing, curing, etc. including full compensation for all labour, materials and other incidentals required to complete the work as per the Specifications. 7-13.4 Architectural Coping The contract unit rate for architectural coping shall be paid in full for all necessary operations including full compensation for all labour, materials and other incidentals required to complete the work as per the Specifications.

8

Stone Masonry for Structures

8 -1 MATERIALS

Stone shall be of the type specified. It shall be hard, sound, free from cracks, free from decay and weathering and shall be freshly quarried from an approved quarry. Stones with round surface shall not be used.

The stones when immersed in water for 24 hours shall not absorb water by more than 5% of their dry weight when tested in accordance with IS : 1124.

The length of stone shall not exceed 3 times of its height. The breadth of stone at base shall be neither greater than three fourths of the thickness of wall nor less than 15 cm.

Other materials used in stone masonry shall conform to the requirements given in **Section 6** of the Specifications.

Mortar used in stone masonry shall conform to the requirements specified in clause 7 -1.

8 -2 TYPE OF MASONRY

The type of masonry used for structures shall be random masonry (coursed or uncoursed) or coursed rubble masonry (First or Second sort). The actual type of masonry used for different parts of structures shall be specified in the drawings. If specified in the drawings, ashlar masonry shall be used for facing work.

8 -3 CONSTRUCTION OPERATION

8-3.1 General Requirements

The dressing of stone shall be as specified for individual type of masonry work. It shall also conform to the general requirements for dressing of stone covered in IS : 1129 until similar Nepal's Standards are in place. Other specific requirements are covered separately with respect to various types of rubble stone work.

Stone shall be sufficiently wetted before laying in order to prevent any absorption of water from the mortar. The bed for each layer of stones shall be cleaned, wetted and covered with a layer of fresh mortar. All stones shall be laid full in mortar both in bed and in vertical joints and settled carefully in place with a wooden mallet immediately after placing so that they are solidly bedded before the mortar is set. Clean chips and spalls shall be wedged into the mortar joints and beds wherever necessary, to avoid thick beds or joints of mortar. Whenever foundation masonry is laid directly on the rock, the face stones of the first course shall be dressed to fit into the rocks snugly when pressed down in the mortar bedding over the rock. No dry or hollow space shall be left anywhere in the masonry. Each stone shall have all the embedded faces completely covered with mortar.

Courses of the masonry shall ordinarily be pre-determined. They shall generally be of the same height. Where there are variations in the height of courses, larger courses shall be placed at the lower levels with height of courses decreasing gradually towards the top.

Vertical joints shall be staggered as far as possible.

All necessary chases for joggles, dowels and cramps shall be formed in the stones beforehand. Sufficient transverse bond shall be provided by the use of bond stones extending from the front to the back of the masonry. In case of thick walls, bond stones shall overlap in their arrangement. Bell shaped bond stones or headers shall not be used.

At all angular junctions, stones at each alternate course shall be well bonded into the respective course of the adjacent wall. As far as possible, all connected masonry in the structure shall be carried out at one uniform level throughout. When breaks are unavoidable, the masonry shall be raked in sufficient long steps to facilitate proper jointing of new work with the old. The stepping of raking shall not be more than 45° with the horizontal. Wing walls, abutments and piers, etc. shall be carried out true to the plumb or to the specified batter.

Face work and hearting shall be brought up evenly. The top of each course, however, shall not be levelled up by use of flat chips.

8-3.2 Random Masonry (Coursed and Un-coursed)

8-3.2.1 *Dressing*

Stone shall be hammer dressed on the face, sides and beds in order to bring it in contact with adjacent stones. The bushing on the face shall not be more than 4 cm on exposed face.

8-3.2.2 *Insertion of Chips*

Chips and spalls of stone may be used wherever necessary to avoid thick mortar beds and joints. It shall be ensured that no hollow space is left anywhere in the masonry. The chips shall not be used below hearting stones as an attempt to bring them up to the level of face stones. Use of chips shall be limited to the filling of interstices between the adjacent stones during the process of hearting. However, they shall not exceed 20% of the quantity of stone masonry.

8-3.2.3 *Hearting Stones*

The hearting or interior filling of wall face shall consist of rubble stones not less than 15 cm in any direction. They shall be carefully laid; hammered down with wooden mallet into position; and solidly bedded in mortar. The hearting stones should be laid such that the stones are nearly level with facing and backing stones.

8-3.2.4 *Bond Stones*

Through bond stones shall be provided in masonry up to 60 cm thickness. In case of masonry having thickness of above 60 cm, a set of two or more bond stones which overlap by at least 15 cm shall be provided along a line from face to back. In case of highly absorbent types of stones (porous limestone and sandstone), the bond stone shall extend only about two-third into the wall, as through stones may give rise to penetration of dampness. Therefore, a set of two or more bond stones which overlap by at least 15 cm shall be provided for all thickness of such masonry. One bond stone or a set of bond stones shall be provided for every 0.50 square metres of the masonry surface.

8-3.2.5 *Quoin Stone*

Quoin stone is a specially selected stone which shall be neatly dressed to form an internal angle in masonry work. Its size shall not be smaller than 0.03 cubic metre in volume.

8-3.2.6 *Plum Stone*

The plum stones are selected long stones which shall be embedded vertically in the interior of masonry in order to form a bond between successive courses. It shall be provided at interval of about 90 cm.

8-3.2.7 *Laying*

The masonry shall be laid with or without courses as specified. The quoins shall be laid as header and stretcher, alternately. Every stone shall be fitted to the adjacent stone in order to form neat and close joint. Face stone shall extend and bond well in the back. This shall be arranged to break joints, as much as possible, and to avoid long vertical lines of joints.

8-3.2.8 *Joints*

The face joints shall not be more than 20 mm thick, but shall be sufficiently thick to prevent stone-to-stone contact and shall be completely filled with mortar.

8-3.3 Dry Rubble Masonry for Retaining Walls

This work shall conform to clause 8-3.2 of Random Masonry (Un-coursed) except that

- i. the masonry shall be dry without mortar;
- ii. the spaces between large stones shall be filled with spalls as tightly as possible;
- iii. the foundations shall be excavated at right angle to the face batter (not horizontally). Similarly, beds of the stones shall also be laid at right angle to the face batter.

8-3.4 Square Rubble-Coursed Rubble Masonry (First sort)

8-3.4.1 *Dressing*

Face stones shall be hammer dressed on all beds and joints in order to give them rectangular shape as much as possible. The face stone shall be square on all joints and beds. The bed joints shall be chisel drafted for at least 8 cm back from the face and for at least 4 cm for the side joints. No portion of the dressed surface shall show a gap of more than 6 mm depth from the straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the bed and side joints. The requirements regarding bushing shall be the same as for random rubble masonry.

8-3.4.2 *Hearting Stone*

The hearting or interior filling of the wall shall consist of flat bedded stone carefully laid on their proper beds in mortar. The use of chips shall be limited to the filling of interstices between the adjacent stones during the process of hearting. However, they shall not exceed 10% of the quantity of masonry. While using chips, it shall be ensured that no hollow spaces are left anywhere in the masonry.

8-3.4.3 *Bond Stones*

The requirements regarding through or bond stones shall be the same as for random rubble masonry but, these shall be provided at a clear distance of 1.5-1.8 m apart in every course.

8-3.4.4 *Quoin Stone*

The quoins which are of the same height as the course shall be formed as header having a length of not less than 45 cm. They shall be laid length-wise alternately along each face, square in their beds, which shall be fairly dressed to a depth of at least 10 cm.

8-3.4.5 *Face Stones*

Face stone shall tail into the work for not less than their heights. Furthermore, at least one-third of the face stones shall tail into the work for a length not less than twice their height. These shall be laid headers and stretchers, alternately.

8-3.4.6 *Laying*

The stones shall be laid on horizontal courses and all vertical joints shall be truly vertical. The quoin stones shall be laid stretchers and headers, alternately. These shall be laid square on their beds which shall be rough chisel dressed to a depth of at least 10 cm.

8-3.4.7 *Joints*

The face joints shall not be more than 10 mm thick but shall be sufficiently thick to prevent stone to stone contact. Such joints shall be completely filled with mortar.

8-3.5 Square Rubble-Coursed Rubble Masonry (Second sort)

8-3.5.1 *General*

All the requirements are the same as of Coursed Rubble Masonry (First sort) except that no portion of dressed surface joints shall show a gap of more than 10 mm depth from a straight edge placed on it. Use of chips in the process of hearting shall not exceed 15% of the quantity of stone masonry.

8-3.5.2 *Joints*

The face joints shall not be more than 20 mm thick but shall be sufficiently thick to prevent stone to stone contact. Such joints shall be completely filled with mortar.

8-3.6 Ashlar Masonry (Plain Ashlar)

8-3.6.1 *Dressing*

Every stone shall be cut to the required size and shape, and chisel dressed on all beds and joints in order to be free from bushing. Dressed surface shall not show a gap of more than 3 mm depth from straight edge placed on it. The exposed faces and joints shall be fine tooled so that a straight edge can be laid along the face of the stone in contact with every point. All visible angles and edges shall be true and square and free from chippings. The corner stones (quoins) shall be dressed square and the corner shall be straight and vertical.

8-3.6.2 *Bond Stones*

Through bond stones shall be provided in masonry up to 60 cm thick. In case of masonry above 60 cm in thickness, a set of two or more stones which overlap by at least 15 cm shall be provided in a line from face to back. In case of highly absorbent type of stones (porous lime stone and sandstone), the bond stone shall extend about two third into the wall, as through stones may give rise to penetration of dampness. Hence, for all thickness of such walls, a set of two or more bond stones which overlap by at least 15 cm shall be provided. Each bond stone or a set of bond stones shall be provided at a clear distance of 1.5-1.8 m apart in every course.

8-3.6.3 *Laying*

The face stones shall be laid header and stretcher, alternately. The headers are so arranged to be positioned approximately at the middle of stretcher above and below. Stones shall be laid in regular courses of not less than 30 cm in height. All courses shall be of the same height, unless otherwise specified. No stone shall be less in breadth than its height or less in length than twice its height, unless otherwise specified.

8-3.6.4 *Joints*

All joints shall be full of mortar. The thickness of any joint shall not be less than 3 mm. Face joints shall be uniform throughout and should have a uniform groove of 20 mm depth which is made with the help of a stone plate during the progress of work.

8-3.7 Pointing

Pointing shall be carried out in cement mortar not leaner than 1:3 (cement : sand) and shall conform to clause 7-9.3. The thickness of joints shall not exceed what is prescribed for each type of masonry.

8-3.8 Curing

Curing shall conform to clauses 7 -6 and 7-9.5.

8-3.9 Scaffolding

For scaffolding, clause 7 -7 shall apply.

8-3.10 Weep Holes

For weep holes in stone masonry, the Specifications given in clause 7 -10 shall apply except for the following:

- iv. The height of the weep holes shall be the same as the height of the course in which they are formed.
- v. The sides and bottom of the weep holes in the interior shall be made up with stones having fairly plain surface. The channel should then be formed by keeping stones having not less than 15 cm thickness as a slab over the side stones. These slab stones shall have a bearing of not less than 15 cm on each side.

8-3.11 Jointing with Existing Structures

For jointing with existing structures, the Specifications given under clause 7 -5 shall apply.

8-3.12 Architectural Coping for Wing/Return/Parapet Walls

Architectural coping for wing/return/parapet walls shall conform to clause 7 -11.

8 -4 MEASUREMENTS FOR PAYMENT

- Stone masonry shall be measured in cubic metres.
- In arches, the length of arch shall be measured as the mean length between the extrados and intrados.
- The work of pointing shall be measured in square metres of the surface treated.
- Architectural coping shall be measured in linear metres.

8 -5 RATES

The contract unit rate for stone masonry work shall include the cost of all labour, materials, scaffolding and other incidentals required to complete the work as per the Specifications. The rate shall also include full compensation for using specially dressed stones on the face of walls with batter and provision of weep holes.

The contract unit rate for pointing shall be paid in full for all necessary operations such as erecting and removal of scaffolding, raking out joints, cleaning, wetting, filling with mortar, trowelling, pointing, curing, etc. including full compensation for all labour, materials and other incidentals required to complete the work as per the Specifications.

The contract unit rate for architectural coping shall be paid in full for all necessary operations including full compensation for all labour, materials and other incidentals required to complete the work as per the Specifications.

9 Formwork and Surface Finish for Structures

9 -1 GENERAL Formwork shall include all temporary or permanent forms required for forming the concrete together with all temporary construction required for their support.

9 -2 CONSTRUCTION OPERATION Forms for concrete shall be constructed of metal or timber, suitably lined and be of substantial and rigid construction true to shape and dimensions shown on the drawings. Where metal forms are used, all bolts and rivets shall be of countersunk and well ground to provide a smooth and plane surface. Where timber is used, it shall be well seasoned and be free from loose knots, projecting nails, splits or other defects that may mar the cement surface of concrete. For exposed concrete faces, timber for shuttering shall be wrought on all faces in contact with concrete. Forms shall be mortar-tight and shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports. They shall be strong enough to withstand all pressures, ramming and vibration without any occurrence of deflection during and after the placement of concrete. Wherever required, screw jacks or hard wood wedges shall be provided to check any incumbent settlement in the formwork. Suitable camber shall be provided in horizontal members of structure, specially in long spans to counteract the effects of any deflection. The formworks shall be fixed in a manner to ensure the formation of such camber. Forms shall be so constructed as to be removable in sections in the desired sequence without damaging the surface of concrete or disturbing other sections of the formwork. Unless otherwise specified or directed, chamfers or fillets having the size of 25 mm x 25 mm shall be provided at all angles of the formwork in order to avoid sharp corners.

9 -3 FORMED SURFACES AND FINISH The formwork shall be lined with a material approved by the Engineer in order to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete. The lining material shall be joined and fixed to the formwork in such a manner that no blemishes will be left with the concrete. It shall be of the same type and obtained from only one source throughout the construction of any structure. The Contractor shall make good any imperfections in the resulting finish as required by the Engineer. Internal ties and embedded metal parts will be allowed only with the specific approval of the Engineer.

9 -4 PREPARATION OF FORMWORK BEFORE CONCRETING The inside surfaces of forms shall, except in the case of permanent formwork or where otherwise agreed by the Engineer, be coated with an approved material to prevent adhesion of concrete to the formwork. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come in to contact with any reinforcement or pre-stressing tendon or anchorage. Different release agents shall not be used in formwork for concrete which will be visible in the finished work. Special measures shall be taken to ensure that the formwork does not hinder the shrinkage of concrete, because without this, cracking could occur before the formwork is removed. Wherever applicable, arrangements must be made to ensure that the formwork does not restrain the shortening and hogging of the beams or slabs during tensioning of the tendons. The formwork should take due account of the calculated amount of positive or negative camber in order to ensure the correct final shape of the structures, having regard to the deformation of false work, scaffolding or propping and instantaneous or deferred deformation due to various causes affecting pre-stress structures. Where there are re-entrant angles in the concrete sections, the formwork should be removed as soon as possible after the concrete has set in order to avoid cracking due to shrinkage of concrete. Formwork shall be tight enough to prevent any appreciable loss of cement during vibrations. Suitable tolerances should be provided in the formwork. Immediately before concreting, all forms shall be thoroughly cleaned. Contractor shall give due notice to the Engineer before placing any concrete in the forms to enable him to inspect and accept the false work and forms as to their strength, alignment and general fitness. But such inspections shall not relieve the Contractor of his/her responsibility for safety of men, machinery, materials and for results obtained.

9 -5 REMOVAL OF FORMWORK The Engineer shall be informed in advance by the Contractor of his/her intention to remove any formwork. While fixing the time for removal of formwork, due consideration shall be given to the local conditions, character of the structure, weather and other conditions that influence the setting of concrete and of the

materials used in the mix. The period shall be suitably increased in case of temperatures lower than 23°C and for any other conditions tending to delay the setting of concrete. Where field operations are controlled by strength tests of concrete, the removal of load-supporting or soffit forms may commence when concrete has attained strength equal to at least twice the stress to which the concrete will be subjected at the time of removing props including the effect of any further addition of loads. When field operations are not controlled by strength tests of concrete, the vertical forms of beams, columns and walls may be removed after 2 days. The props of beams may be removed after 21 days. If rapid hardening cement is used, the periods specified above may be reduced to 3/7th. All formworks shall be removed without causing any damage to the concrete. Centering shall be gradually and uniformly lowered in such a manner so as to avoid any shocks or vibrations. Supports shall be removed in such a manner that the concrete is allowed to take stresses due to its own weight uniformly and gradually. Where internal metal ties are permitted, they or their removable parts shall be extracted without causing any damage to the concrete and the remaining holes shall be filled with mortar. All permanently embedded metal parts should have a cover of not less than 25 mm to the finished concrete surface. Where it is intended to re-use the formwork, it shall be cleaned and made good to the satisfaction of the Engineer.

9 -6 MEASUREMENTS FOR PAYMENT Where it is stipulated in the contract that the formwork shall be paid for separately, measurement for formwork shall be taken in square metres of the area of concrete surface which is in contact with formwork. Where it is not specifically stated in the description of the item that formwork shall be paid separately, the rate of the reinforced cement concrete or pre-stressed cement concrete items shall be deemed to include the cost of all formwork.

9 -7 RATE The contract unit rate for formwork where it is provided as separate item, shall include the cost of all labour, materials, precautionary measures and other incidentals required for the construction and removal of forms as described above and also for framing required to support the members until the concrete is sufficiently cured, set and hardened.

10 Steel Reinforcement for Structures

10 -1 DESCRIPTION This work shall include furnishing and placing of reinforcement according to the shape and dimensions given in the drawings and as specified in these Specifications.**10 -2 GENERAL** Steel shall be clean and free from loose rust and loose mill scale at the time of fixing in position and subsequent concreting.**10 -3 BENDING OF REINFORCEMENT**

The reinforcement bars shall conform to the dimensions and shapes given in the Bar Bending Schedule shown on relevant drawings. Bars must not be heated and shall be bent to the specified shape and dimensions or as directed by the Engineer using a skilled bar bender who does these works manually or by power-driven tools. Bars shall not be bent or straightened in a manner that will damage the material. Bars which are bent during transportation or handling shall be straightened before being used on work. They shall not be heated to facilitate bending. Unless otherwise specified, a U type hook at the end of each bar shall invariably be provided. The radius of the bend shall not be less than twice the diameter of the round bar. The length of the straight part of the bar beyond the end of the curve shall be at least four times the diameter of the round bar. In the case of deformed bars, the diameter shall be taken as the diameter of a circle having an equivalent effective area. The hooks shall be suitably encased to prevent any splitting of the concrete.**10 -4 PLACING OF REINFORCEMENT**

All reinforcement bars shall be accurately placed in exact position shown on the drawings. They shall be securely held in position during the placing of concrete by binding them by annealed binding wire of not less than 1 mm in diameter and by supporting them by stay blocks, metal chairs, spacers, metal hangers, supporting wires or/and other approved devices which are placed at sufficiently close intervals. Bars will neither be allowed to sag between supports nor displaced during concreting or any other operations. All devices used for positioning shall be of non-corrosive material. Wooden and metal supports will not be extended to the surface of concrete except where shown on the drawings. If placing of additional bars on the layers of freshly laid concrete is required as an attempt to adjust the bar spacing then such placing shall not be allowed at any instances. Layers of bars shall not be separated by stone pieces, bricks or wooden blocks, instead, these shall be separated by spacer bars, pre-cast mortar blocks or other approved devices. Reinforcement after being placed in position shall be maintained in a clean condition until it is completely embedded in concrete. Special care shall be exercised to prevent any displacement of reinforcement at the time of concreting. A cover of concrete shall be provided as indicated on the drawings in order to protect reinforcement from corrosion. All bars which are protruding from concrete and are to be joined to the other bars shall be protected by a thick coat of neat cement grout if these are likely to be exposed to open air for sometime. In case of columns and walls, vertical bars shall be kept in true vertical position by sliding them through the slots which are cut accurately on horizontally kept timber templates as per the exact bar positions. Such templates shall be removed after the concreting has progressed up to a level just below them. Bars crossing each other shall be secured by binding wire (annealed) of not less than 1 mm in diameter in such a manner that they do not slip over each other at the time of fixing and concreting. As far as possible, bars of full length shall be used. Where this is not possible, overlapping of bars shall be done as directed by the Engineer. When practicable, overlapping bars shall not touch each other but be kept apart by 25 mm or $1\frac{1}{4}$ times the maximum size of coarse aggregate, whichever is greater by allowing concrete between them. Where not feasible, overlapping bars shall be bound with annealed steel wire of not less than 1 mm in diameter and twisted tightly. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum.**10 -5 COUPLING OF BARS**

Whenever indicated on the drawings or required by the Engineer, bars shall be joined by couplings having a cross-section which is sufficient for the transmission of requisite stresses transferred from the bars. The ends of the bars that are joined by coupling shall be upset for a sufficient length so that the cross-section at the base of threads is not less than the normal cross-section of the bar. The threads shall be standard Whitworth threads. Steel for coupling shall conform to IS : 226 until similar Nepal's Standards are in place.**10 -6**

WELDING OF BARS When permitted or specified on the drawings, joints of reinforcement bars shall be butt-welded in order to transmit the full strength exerted on the bars. Welded joints shall preferably be located at points where steel will not be subjected to more than 75% of the maximum permissible stresses. The welds shall be so staggered that, at any one section, not more than 20% of the rods are welded. Only electric arc welding using a process which excludes air from the molten metal and conforms to any or all other special provisions for the work will be accepted. Suitable means shall be provided for holding the bars securely in position during welding. It must be ensured that no voids are left in welding. When welding is done in several stages, previously welded surface shall be properly cleaned prior to each stage. Ends of the bars shall be cleaned of all loose scale, rust, grease, paint and other undesirable matter prior to welding. Only competent welders shall be employed for this work. The Mild Steel electrodes used for welding shall conform to IS : 814 until similar Nepal's Standards are in place. The welded pieces of reinforcement shall be tested. Specimens for the tests shall be taken from the actual site and their number and frequency of tests shall be as directed by the Engineer.

10 -7 MEASUREMENTS FOR PAYMENT Reinforcement shall be measured in length, separately for different diameters, as actually used in the work excluding overlaps. From the measured length, the weight of reinforcement shall be calculated in tons on the basis of the type of steel. Lengths shall include hooks at ends but exclude the wastage, overlaps, couplings, welded joints, spacer bars and annealed steel wire for binding. Cost of these items shall be deemed to be included in the rates for reinforcement.

10 -8 RATE The contract unit rate for reinforcement shall include the cost of all steel, its bending, placing, binding and fixing in position as shown on the drawings and as directed by the Engineer. It shall also include the cost of all devices for keeping reinforcement in approved position; jointing as per approved method; and all wastage, overlaps and spacer bars.

11

Plain and Reinforced
Cement Concrete
for Structures

11 -1 GENERAL

These Specifications cover all the requirements of cement concrete for use in various components of rural road structures.

For all the items of concrete in any structural portion of a cross drainage structure or its components, “controlled” concrete shall be used unless otherwise specified on the drawings or directed by the Engineer. For other concreting work that generally comes across in rural road structures, “ordinary” concrete mix may be used provided that such works are clearly specified in the drawings.

11 -2 GRADES OF CONCRETE

11-2.1 Controlled Concrete

For controlled concrete, design of the mix shall be ascertained after the preliminary tests. During the production of controlled concrete, all necessary precautions shall be taken to ensure that the required cube strength is attained and maintained in the work. The controlled concrete shall be in eight grades designated as M 10, M 15, M 20, M 25, M 30, M 35, M 40 and M 45 with the suffix “Controlled” added to it.

11-2.2 Ordinary Concrete

In case of ordinary concrete, the mix is not required to be designed by preliminary tests. The proportions of cement, fine aggregates and coarse aggregates are specified by volume. The ordinary concrete shall be in four grades designated as M 10, M 15, M 20 and M 25. It can also be specified by volume as given in **Table 11 -6(a)**.

In the designation of a concrete mix, letter ‘M’ refers to the mix and the number refers to the specified 28 days’ cube compressive strength of that mix on 150 mm cubes, expressed in N/mm².

11 -3 STRENGTH REQUIREMENT OF CONCRETE

Where ordinary Portland cement conforming to IS : 269 or Portland blast furnace cement conforming to IS : 455 is used, the compressive strength requirements for various grades of concrete “controlled” as well as “ordinary” shall be as given in **Table 11 -3**. Where rapid hardening Portland cement is used, the 28 days’ compressive strength requirements specified in **Table 11 -3** shall be met at 7 days.

For “controlled” concrete, the mix shall be so designed to attain in preliminary tests a strength of at least 33% higher than that required on work tests. Preliminary tests need not be made in the case of “ordinary” concrete.

Table 11 -3 : Compressive Strength of Concrete in Work Tests

Grade of Concrete

Compressive Strength in N/mm² on 150 mm cubes to be achieved in Work Tests after mixing is conducted in accordance with IS : 516

**minimum at 7 days
minimum at 28 days**

M 10
7.0
10.0

M 15
10.0
15.0

M 20
13.5
20.0

M 25
17.0
25.0

M 30
20.0
30.0

M 35
23.5
35.0

M 40
27.0
40.0

M 45
30.0
45.0

Note : In all cases, the 28 days' compressive strength specified in this Table shall be the only criterion for acceptance or rejection of the concrete.

Where the strength of a concrete mix, as indicated by tests, lies in between the strength for any two grades specified in **Table 11 -3**, such concrete shall be classified for all purposes as a concrete belonging to the lower of the two grades.

11 -4 ADMIXTURES

No materials other than the essential ingredients, i.e., cement, aggregates and water, shall generally be used in the production of concrete or mortar. But the Engineer may permit the use of approved admixtures for imparting special characteristics to the concrete on the basis

of satisfactory evidence that its use does not in any way adversely affect the properties of concrete, particularly its strength, volume changes, durability and has no deleterious effect on the reinforcements.

11 -5 SIZE OF COARSE AGGREGATES

The maximum nominal size of coarse aggregates differs according to the type or item of work as given in **Table 11 -5**.

Table 11 -5 : Maximum Nominal Size of Coarse Aggregates

Item of Construction	Maximum Nominal Size of Coarse Aggregate
-----------------------------	---

- | | |
|--|-------|
| (i) RCC well curb, RCC well steining and RCC piles | 40 mm |
| (ii) PCC well steining | 63 mm |
| (iii) Well cap or pile cap, solid type piers, abutments and wing walls and their pier caps | 40 mm |
| (iv) RCC work in cross girders, deck slabs, wearing courses, kerbs, lamp posts, ballast walls, approach slabs, hollow type piers, abutments, wings walls and their pier caps | 20 mm |
| (v) RCC bearings | 20 mm |
| (vi) For any other item not covered by items (i) to (v).
As specified on the drawings or as directed by the Engineer in case it is not specified on drawing. | |

For heavily reinforced concrete members as in the case of ribs of main beams, maximum nominal size of aggregate shall usually be restricted to 5 mm less than the minimum lateral clearance between the main bars or 5 mm less than the minimum cover to the reinforcement, whichever is smaller.

11 -6 PROPORTIONING CONCRETE

11-6.1 Controlled Concrete

Concrete mix for the controlled concrete shall be designed on the basis of preliminary tests. The proportions for ingredients chosen shall be such that concrete has adequate workability for conditions prevailing on the work in question; and can be properly compacted with the means available.

Except where it can be shown to the satisfaction of the Engineer that supply of properly graded aggregate of uniform quality can be maintained till the completion of work, grading of aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions as required. Different sizes, however, shall be stocked in separate stock piles. Required quantity of materials shall be stock-piled several hours,

preferably a day, before use. Grading of coarse and fine aggregates shall be checked as frequently as possible to ensure that the suppliers are maintaining the uniform grading as approved for samples used in the preliminary tests. The frequency of such checks for a given job shall be determined by the Engineer.

In proportioning concrete, the quantities of both cement and aggregate shall be determined by weight. Where the weight of cement is determined by accepting the manufacturer's weight per bag, a reasonable number of bags shall be weighed separately to check the net weight. Where cement is weighed from bulk stocks at site and not by bags, it shall be weighed separately from the aggregates. Water shall either be measured by volume in calibrated tanks or by weight. All measuring equipment shall be maintained in the clean and serviceable condition. Their accuracy shall be periodically checked.

It is most important to keep the specified water-cement ratio constant and at its correct value. For this, moisture content in both coarse and fine aggregates shall be checked as frequently as possible. The frequency of such checks for a given job shall be determined by the Engineer according to the prevailing weather condition. The amount of mixing water shall then be adjusted to compensate for variations in the moisture content. For the determination of moisture content in the aggregates, IS : 2386 (Part III) shall be referred. Suitable adjustments shall also be made in the weight of aggregates to allow for its variations resulted due to the variations in moisture content.

The minimum quantity of cement to be used in controlled concrete shall not be less than 210 kg per cubic metre in plain concrete and not less than 300 kg per cubic metre in reinforced concrete. Similarly, the minimum quantity of cement for pre-stressed concrete shall not be less than 360 kg per cubic metre of concrete nor shall it be more than 540 kg per cubic metre of concrete.

11-6.2 Ordinary Concrete

The ordinary concrete mix shall generally be specified by volume. For cement which normally comes in bags and is used by weight, the volumes shall be worked out taking 50 kg of cement as 0.035 cubic metre in volume. Shaking, ramming or hammering shall not be done when measuring aggregate by volume. Proportioning of sand shall be as per its dry volume and in case it is damp, allowance for bulking shall be made as per IS : 2386 (Part III).

Ingredients required for ordinary concrete containing one 50 kg bag of cement for different proportions of mix shall be as given in **Table 11 -6(a)**.

Table 11 -6(a) : Ingredients Required for Different Grades of Ordinary Concrete

Grade of Concrete

Mix by Volume

Total quantity of dry aggregates by volume per 50 kg of cement to be taken as the sum of the individual volumes of fine and coarse aggregates (maximum)

Proportion of fine aggregate to coarse aggregate

Quantity of water per 50 kg of cement (maximum)

- 1
- 2
- 3
- 4
- 5

M 10
1:3:6
300 litres
Generally 1:2 for fine aggregate to coarse aggregate
34 litres

M 15
1:2:4
220 litres
by volume but subject to a
32 litres

M 20
1:1½:3
160 litres
upper limit of 1:1½ and a
30 litres

M 25
1:1:2
100 litres
lower limit of 1:3*
27 litres

* The proportions of the aggregates shall be adjusted from the upper limit to lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregates becomes larger.

Example : For an average grading of fine aggregate, the proportions shall be 1:1½, 1:2 and 1:3 for maximum size of aggregates 10 mm, 20 mm and 40 mm, respectively.

Note : A mix leaner than M 10 (1:3:6) may be used for non-structural parts of the bridge, if specified on the drawing or provided in the contract. In such case, grading of aggregates shall be as specified in the contract or on the drawing. Other requirements for mixing, placing and curing shall be the same as specified in this section.

11-6.3 Quantity of Water

The quantity of water shall be just sufficient to produce a dense concrete of required workability for the job. An accurate and strict control shall be kept on the quantity of mixing water.

In case of reinforced concrete work, workability shall be such that the concrete surrounds and properly grips all reinforcements. The degree of consistency which shall depend upon the nature of work and methods of vibration of concrete shall be determined by regular slump tests. The following slump values shall be adopted for different types of work.

Table 11 -6(b) : Slump Values for Different Types of Work

Type of Work
Slump Value

**where vibrators
are used**

**where vibrators
are not used**

Mass concrete in RCC foundations, footings and retaining walls
10 mm to 25 mm
80 mm

Beams, slabs and columns simply reinforced
25 mm to 40 mm
100 mm to 120 mm

Thin RCC section or section with congested steel
40 mm to 50 mm
125 mm to 150 mm

11 -7 MIXING CONCRETE

Where available on easy access, concrete for all works shall be mixed in a mechanical mixer. The mixer and its accessories shall be kept in good working condition and be maintained throughout the construction. Mixing shall be continued till materials are uniformly distributed; an uniform colour of the entire mass is obtained; and each individual particle of the coarse aggregate shows complete coating of mortar containing its proportionate amount of cement. In no case shall the mixing be done for less than 2 minutes after all ingredients have been put into the mixer.

When hand mixing is permitted by the Engineer for majority of the jobs in labour based rural roads, it shall be done on a smooth watertight platform large enough to allow efficient turning over of the ingredients of concrete before and after the addition of water. Mixing platform shall be so arranged that no foreign material shall get mixed with concrete nor does the mixing water flow out. Cement in required number of bags shall be placed in a uniform layer on top of the measured quantity of fine aggregates which shall have been spread in a layer of uniform thickness on the mixing platform. Dry sand and cement shall then be mixed thoroughly by turning over to get a mixture of uniform colour. Enough water shall then be added gradually through a rose and the mass turned over till a mortar of required consistency is obtained. Measured quantity of coarse aggregate shall then be placed on the mixing platform. Then it shall be wetted and the mortar shall be added. Finally, the entire mass shall be turned and re-turned until all particles of the coarse aggregate are fully covered with mortar and the mixture obtained is of uniform colour and required consistency. In hand mixing, quantity of cement shall be increased by 10% above that specified in clause 11-6.2.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before loading a new batch. Unless otherwise agreed by the Engineer, the first batch of concrete from the mixer shall contain only two thirds of the normal quantity of coarse aggregate. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

11 -8 TRANSPORTING, PLACING AND COMPACTING OF CONCRETE

The method of transporting and placing of concrete shall be approved by the Engineer. Concrete shall be so transported and placed that no contamination, segregation or loss of its constituent materials takes place.

All formwork and reinforcement contained in the concrete shall be cleaned and made free from standing water, dust, snow or ice immediately before the placing of concrete.

No concrete shall be placed in any part of the structure without the approval of the Engineer. If concreting is not started within 24 hours of the approval, it shall have to be obtained again. Concreting shall then proceed continuously over the area between construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a proper construction joint is formed.

Concrete when deposited shall have a temperature not less than 4.5°C and not more than 38°C. It shall be compacted in its final position within 30 minutes of its discharge from the mixer unless the concreting work is carried out with properly designed agitators, operating continuously. When using agitators, the delay time shall be maximum of 2 hours, counting from the addition of cement to the mix. However, the delay time shall be within 30 minutes of its discharge from the agitator.

Except where otherwise agreed by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 0.45 m when internal vibrators are used and not exceeding 0.30 m in all other cases.

Unless otherwise agreed by the Engineer, concrete shall not be dropped into place from a height exceeding 2 m. When trunks or chutes are used, they shall be kept clean and used in such a way as to avoid segregation.

When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without the use of an excessive quantity of water and without any segregation of its gradients. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with water before and after each working period. The water used for this purpose shall be discharged outside the formwork.

When concreting has to be resumed on a surface which has hardened, it shall be roughened, swept clean, thoroughly wetted and covered with a 13 mm thick layer of mortar composed of cement and sand in the same ratio as in the concrete mix itself. The 13 mm thick layer of mortar shall be freshly mixed and placed immediately before placing of new concrete.

Where concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes. During this operation, care must be taken to avoid dislodgement of any particles of coarse aggregate. The surface shall then be thoroughly wetted and all free water shall be removed. Then, the surface shall be coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 150 mm in thickness. It shall be well rammed against old work giving particular attention to corners and close spots.

All concrete shall be compacted to produce a dense homogeneous mass with the assistance of vibrators or mild steel bars. Sufficient vibrators in serviceable condition shall be kept at site so that spare equipment is always available in case of breakdowns.

Internal vibrators shall be of not less than 10,000 rpm whereas external or form vibrators shall be of not less than 3,000 rpm. Vibrations shall not be applied through reinforcement. As far as possible, contact with reinforcement and all inserts shall be avoided where vibrators of the immersion type are used.

11 -9 CONCRETING UNDER WATER

When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of the mix to be used shall have to be approved by the Engineer before the work starts. Such concrete shall not be considered as "Controlled Concrete".

Concrete shall not be placed in water having a temperature of below 4.5°C. The temperature of the concrete, when deposited, shall not be less than 16°C and not be more than 38°C.

Concrete shall contain 10% more cement than that required for the same mix placed in the dry place. The material shall be so proportioned as to produce a concrete having a slump of not less 100 mm and not more than 180 mm. The slump shall be tested as per IS : 516.

Coffer dams or forms shall be sufficiently tight to ensure still water conditions, if practicable, and in any case to reduce the velocity of water to less than 3 m per minute through the space into which concrete is to be deposited. Coffer dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the joints in the walls. Pumping shall not be done during concreting and 24 hours thereafter.

Concrete shall be deposited continuously until it has been brought to the required height. While depositing, the top surface shall always be kept as evenly level as possible and formation of seams shall be avoided. For depositing concrete in structural components of rural road structures, the "Drop Bottom Bucket Method" which is the simplest method of depositing concrete underwater should be adopted.

Drop Bottom Bucket Method : The top of the bucket shall be closed. The bottom doors shall move freely downward and outward when tripped. The bucket shall be filled completely and lowered slowly to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited. When concrete is discharged, the bucket shall be withdrawn slowly until it reaches well above the concrete.

The other method called "Tremie" which is considered to be more sophisticated for labour-based rural road construction is not discussed in these Specifications.

To minimise the formation of laitance, great care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

11 -10 CURING OF CONCRETE

11-10.1 Protection and Water Curing

Immediately after compaction, concrete shall be protected against harmful effects of weather, running water, shocks, vibrations, traffic, rapid temperature changes, frost and drying out process. It shall be covered with wet sacking, hessian or other similar absorbent material approved by the Engineer soon after the initial set and shall be kept continuously wet for a period of not less than 14 days from the date of placement. Masonry work over the

foundation concrete may be started after 48 hours of its laying but curing of concrete shall be continued for a minimum period of 14 days.

11-10.2 Steam Curing

For concreting in rural road structures, this particular method of curing is not recommended.

11 -11 WORKING IN EXTREME WEATHER CONDITIONS

Where concrete is to be deposited at or near freezing temperatures, necessary precaution shall be taken to ensure that the temperature of the concrete shall not be less than 4.5°C. Not only that, this temperature should be maintained until it is thoroughly hardened. If necessary, the ingredients shall be heated before mixing and the concrete shall be carefully protected after placing. In general, heating of water alone to about 60°C may be sufficient for this purpose. Salt or other chemicals should not be used as a prevention from freezing. Calcium chloride up to 1½% by weight of cement can be used to accelerate the rate of hardening. Use of calcium chloride in excess of this percentage is considered to be harmful. No frozen material or materials containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to freezing weather shall have entrained air and the water content of the mix shall not exceed 30 litres per 50 kg of cement.

When depositing concrete in very hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 38°C while placing. This shall be achieved by stacking aggregate under the shade and keeping them moist; using cold water; reducing the time between mixing and placing to the minimum; cooling formwork by sprinkling water; starting curing before the concrete dries out; and organising concreting as far as possible during mornings and evenings.

11 -12 FINISHING

Immediately after the removal of forms, all exposed bars or bolts which either pass through the reinforced cement concrete member or use for the shuttering or any other purpose shall be cut inside the RCC member to a depth of at least 25 mm below the surface of the concrete. The resulting holes shall be closed by cement mortar. All fins caused by form joints, cavities produced by the removal of form ties, all other holes and depressions, honey-comb spots, broken edges or corners and other defects shall be thoroughly cleaned; saturated with water; and carefully pointed and rendered true with mortar of cement and fine aggregates mixed in the proportions used in the grade of concrete that is being finished. Considerable pressure shall be applied in filling and pointing to ensure proper filling in all voids. Surfaces which have been pointed shall be kept moist for a period of 24 hours.

All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

If, in the opinion of the Engineer, the rock pockets/honey-combs are existing in the concrete to an extent which may affect the strength of the structure materially as well as endanger the life of the steel reinforcement then, he may declare the concrete defective and instruct for the removal and replacement of the portions of the structure affected.

11 -13 CONSTRUCTION JOINTS

Concreting shall be carried out continuously up to the construction joints. The position and details of the construction joints shall be as shown on approved drawings or as directed by the Engineer. Such joints shall, however, be kept to the minimum.

For a vertical construction joint, a stopping board shall be fixed previously at the pre-determined position and shall be properly stayed for sufficient lateral rigidity to prevent its displacement or bulging when concrete is compacted against it. Concreting shall be continued right up to the board. The board shall not be removed before the end of the specified period for removal of vertical forms.

Before resuming work at any construction joint, all laitance shall be removed thoroughly if the concrete has not yet fully hardened. While removing the laitance, care should be taken to avoid any dislodgement of coarse aggregates. In case where the concrete has fully hardened, the surface shall be thoroughly hacked, swept clean, wetted and covered with a layer of neat cement grout. The neat cement grout shall be followed by a 13 mm thick layer of mortar mixed in the same proportion as in concrete. The first batch of concrete shall be rammed against the old work to avoid formation of any stone pockets. Particular attention shall be paid to corners and close spots.

In pre-stressed concrete structures, construction joints shall be avoided as far as possible specially in the area of tensile stresses. Where necessary, concreting shall be carried out continuously up to such joints which shall preferably be transverse to the line of main compression. In all cases, the position and detailed arrangement of all construction joints shall be predetermined. For such works, the approval shall be taken in advance from the Engineer.

11 -14 TESTS AND STANDARDS OF ACCEPTANCE

11-14.1 Preliminary Tests for Controlled Concrete

For controlled concrete, the preliminary tests (refer to clause 11-2.1) shall be conducted as three sets of separate tests. In each set, tests shall be conducted on six specimens. On any particular day, not more than one set of six specimens shall be made. Out of the six specimens in each set, three shall be tested at seven days and the remaining three at 28 days. The preliminary tests at 7 days are intended only to indicate the strength likely to be attained at 28 days.

11-14.2 Work Strength Tests for Controlled and Ordinary Concrete

Work strength tests shall be made in accordance with IS : 516. Each test shall be conducted on ten specimens, five of which shall be tested at 7 days and the remaining five at 28 days. The samples of concrete shall be taken on each day of concreting and cubes shall be made at the rate of one set (10 specimens) for every 5 cubic metres of concrete or a part thereof. However, if concreting done in a day is less than 15 cubic metres, the number of cubes could be reduced to a minimum of 6 with the special permission of the Engineer. If so, three shall be tested at 7 days and the remaining three at 28 days.

Similar work tests shall be carried out whenever the quality and grading of materials is changed, irrespective of the quantity of concrete poured. The number of specimens may be

suitably increased as deemed necessary by the Engineer when the procedure of tests given above reveals a poor quality of concrete or in other special cases.

All work shall be carried out under the supervision of a qualified and a competent Engineer/Overseer who will supervise proportioning, placing and compacting of concrete at all stages.

All necessary labour, materials, equipment (other than testing), etc., for sampling, preparing test cubes, curing, etc., shall be arranged by the Contractor. However, if any additional support is required, it shall be provided by the Engineer. Testing of the materials and concrete shall be arranged by the Engineer in an approved laboratory at the cost of the Contractor.

11-14.3 Standards of Acceptance

The average strength of the group of cubes cast in each day shall not be less than the specified compressive cube strength of works. However, 20% of the cubes cast in each day may have values less than the specified strength, provided that the lowest value is not below 85% of the specified strength.

11 -15 USE OF PLUMS IN ORDINARY CONCRETE

Stone plums shall not be used unless specified on the drawings. When used, the size of stone plums may be from 150 to 300 mm. The maximum dimension of these stones or plums shall not exceed $1/3^{\text{rd}}$ of the least dimension of the members.

All plums shall be hard, durable, clean and free from soft materials or loose pieces or deleterious substance and shall not have sharp corners.

During concreting, the first layer of concrete of the specified mix shall be laid to a thickness of at least 2.5 times the thickness of the maximum size of plums to be used. The plums shall then be laid while the top portion of this concrete is still within the initial setting time. But, the concrete should then be sufficiently stiff enough to prevent complete submergence of the plums. These plums shall remain half embedded in the concrete and the other half exposed so as to form a key with the next layer of concrete. No plums shall be used for concrete which is laid under water.

While placing the plums, care shall be taken to ensure that the clear distance between any two plums is not less than either the width or thickness of either of the plums. The distance from plums to the outer surface or to any steel reinforcement shall be equal to the greatest width of the plum.

If plums of stratified stone are used, they shall be laid on their natural bed. Stones with concave faces shall be laid with the concave face upwards. The thickness of the next and successive layers of concrete shall be at least twice that of the largest plums. The total volume of plums shall not exceed 15% of the volume of the finished concrete.

11 -16 MEASUREMENTS FOR PAYMENT

The cement concrete shall be measured in cubic metres. In reinforced concrete, the volume occupied by reinforcement shall not be deducted. The slab shall be measured as running continuously through and the beam as the portion below the slab.

11 -17 RATE

The contract unit rate for concrete shall include the cost of all labour, materials required for mixing, placing in position, vibrating and compacting, finishing as per the directions of the Engineer, curing and all other incidental expenses including precautionary measures for producing concrete of specified strength to complete the structure or its components as shown on the drawings and according to these Specifications. The rate shall also include the cost of making, fixing and removing of all centres and forms required for the work unless otherwise specified in the contract.

12

Structural Steel Work for Structures

12 -1 DESCRIPTION

This work shall include furnishing, fabricating, transporting, erecting and painting of structural steel, rivet steel, cast steel, forged steel, cast iron and other incidental metal construction of the kind, size and quantity in conformity with the drawings or as desired by the Engineer.

12 -2 GENERAL

General requirements relating to the supply of material shall conform to the specification of IS : 387, for the purpose of which the supplier shall be the Contractor and the purchaser shall be the Engineer.

Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have smooth, uniform finish and shall be straightened in the mill before shipment. It shall also be free from loose mill scale, rust, pits or other defects which affect its strength and durability.

The acceptance of any material on inspection at the mill, i.e., rolling mills, foundry or fabricating plant where material for the work is manufactured shall not be a bar to its subsequent rejection, if found defective.

Unless otherwise specified, high tensile steel rivet conforming to IS : 1149 shall be used for members of high tensile steel conforming to IS : 961 and shall not be used for mild steel members. The use of cast steel shall be limited to bearings and other similar parts. Generally, all steel pins (including knuckle pins) and rollers shall be of forged steel. Cast iron shall not be used in any portion of the bridge structure except where it is subjected to direct compression.

12 -3 MATERIALS

All materials shall conform to **Section 6** of these Specifications. Special requirements which are not addressed in **Section 6** are given below.

Mild steel for bolts and nuts shall conform to IS : 226 but shall have a minimum tensile strength of 440 N/mm² and a minimum percentage elongation of 14. High tensile steel for bolts and nuts shall conform to IS : 961 but with a minimum tensile strength of 580 N/mm². High strength friction grip bolts shall be permitted for use only on satisfactory evidence of performance to the requirements (not covered by these Specifications) specified by the Engineer or included in the special provisions.

For cast steel, the yield stress shall be determined and shall not be less than 50% of the minimum tensile strength.

Plain washers shall be of steel. Tapered or other specially shaped washers shall be of steel or of malleable cast iron.

Parallel barrel drifts shall have a tensile strength not less than 550 N/mm² with elongation of not less than 20% measured on a gauge length of $4\sqrt{S_0}$ (S_0 = cross sectional area).

Copper alloys, mechanite or special steels used for bearings or similar other parts shall conform to the requirements specified by the Engineer or included in the special provisions.

Mild steel electrodes shall conform to IS : 814 and those of high tensile steel shall conform to IS : 1442.

All paints and enamels used shall conform to the requirements specified on the drawings or to the other special provisions laid down by the Engineer. Unless otherwise specified, paints shall conform to the relevant IS Specifications until similar Nepal's Standards are in place.

12 -4 FABRICATION

12-4.1 General

All works shall be in accordance with the drawings and as specified in these Specifications. Care shall be taken to fit all parts of an assembly accurately together. Unless otherwise specified under the contract, corresponding parts need not be interchangeable but the parts shall be match marked as required under clause 12-4.7.

Templates, jigs and other appliances used for ensuring the accuracy of the work shall be of mild steel. Where specially required, these shall be bushed with hard steel. All measurements shall be made by means of steel tape or other device which is properly calibrated. Where bridge materials have been used as templates for drilling, these shall be inspected and passed by the Engineer before they are used in the finished structure.

All structural steel members and parts shall have straight edges and blunt surfaces. If necessary, they shall be straightened or flattened by pressure unless they are required to be of curvilinear forms. They shall also be free from twist. When straightening or flattening of such members, pressure shall be applied without damaging the materials. Adjacent surfaces or edges shall be in close contact or at uniform distance throughout.

12-4.2 Preparation of Edges and Ends

Where required, all structural steel parts shall be sheared, cropped, sawn or flame cut and ground accurately to the required dimensions and shapes.

In the case of high tensile steel, at least 6 mm of the materials from the flame cut edge shall be removed by machining.

Longitudinal edges of all plates and cover plates in plate girders and built-up members shall be machined except in the following cases:

Rolled edges of single universal plates or flats may not be machined;

Covers to single flange plates may be left un-machined;

Machine flame cutting instead of machining is acceptable for edges of single plates in compression and for edges of single plates having thickness of 25 mm or less in tension; Edges of single shaped plates over 25 mm thick which are not possible to be machined by ordinary method may be machine flame cut with the end surface ground.

Edges of universal plates or flats of the same nominal width used in tiers may be left un-machined, if so authorised by the Engineer.

All edges of splice and gusset plates having a thickness of at least 12 mm shall be machined. Those which are of less than 12 mm thick may be sheared and ground.

The ends of plates and sections forming the main components of plate girders or built-up members shall be machined, machine flame cut, sawn or hand flame cut and ground.

In joints and splices of compression members, in girder flanges and in tension members where so specified on the drawings, the abutting surfaces shall be faced and brought to an even bearing. A tolerance of 0.5 mm may be permitted locally. Where close fitting is not specified, any clearances shall not exceed 3 mm.

Where ends of stiffeners are required to be fitted, they shall be machined, machine flame cut, sawn, sheared and ground, or hand flame cut and ground.

The ends of lacing bar shall be rounded unless otherwise specified. Other edges and ends of mild steel parts may be sheared and any burrs at edges shall be removed.

12-4.3 Preparation of Holes

12-4.3.1 *Drilling and Sub-punching*

All holes for rivets shall be drilled or drilled small and reamed. However, if preferred, the holes may be sub-punched to a diameter of 6 mm less than the finished size and then reamed to the proper size.

When several plates or sections form a compound member, they shall, where practicable, be firmly connected together by clamps or tack bolts. For this, the holes shall be drilled through the group in one operation. Alternately and in the case of repetition work, the plates and sections may be drilled separately from jigs and templates. The jigs and templates shall be checked at least once after 25 operations. All burrs shall be removed.

In the case of repetition of spans, the erection of every span shall not be insisted upon, except where close tolerance or turned bolts are used, provided that methods are adopted to ensure strict interchangeability. In such cases, one span in 10 or any number less than 10 of each type shall be erected from pieces selected at random by the Engineer. If there is any difficulty in fitting of the pieces together then all similar spans shall be erected completely. In the event of the spans being proved completely interchangeable, all corresponding parts shall carry the same marks so that sorting of the materials at the site will be easier.

0

1 12-4.3.2 *Block Drilling*

2

3 Where the number of plates to be riveted exceeds three or the total thickness of the plates is 90 mm or more, the rivet holes, unless they have been drilled through steel bushed jigs, shall be drilled out in such a manner that 3 mm gap is all around each hole after assembling. In such cases, the work shall be thoroughly bolted together.

4

5 12-4.3.3 *Sizes of Holes*

6

7 The sizes of holes in mm are given in **Table 12 -4**.

8

9

10 **Table 12 -4 : Diameter of Holes for Rivets**

11

Nominal Diameter of Rivets

Diameter of Holes

mm

mm

12
14
16
18
20
22
24
27
30
33
13.5
15.5
17.5
19.5
21.5
23.5
25.5
29.0
32.0
35.0

12

13

14

15 **12-4.3.4** *Close Tolerance Bolts and Barrel Bolts*

16

17 The diameter of the holes shall be equal to the nominal diameter of the bolt shank minus 0.15 mm to 0.0 mm.

18

19 **12-4.3.5** *Removal of Burrs*

20

21 The work shall be taken apart after drilling and all burrs left by drilling and the sharp edges of all rivet holes are completely removed.

22

23 **12-4.4** Rivet and Riveting

24

25 The diameter of rivets shown on drawings shall be the size before heating. Each rivet shall be of sufficient length to form a head of the standard dimensions as given in IS Handbook on Steel Sections, Part I. It shall be free from burrs on the under side of the head.

26

27 When countersunk heads are required, the heads shall fill the countersunk. The included angle of the head shall be as follows:

for plates over 14 mm thickness - 90°

for plates up to and including 14 mm thickness - 120°.

The tolerance on the diameter of rivet shall be in accordance with IS : 1148 and IS : 1149 until similar Nepal's Standards are in place. Unless otherwise specified, the tolerance shall be minus tolerance.

Rivets shall be heated uniformly to a light cherry red and shall be red hot from head to the point when inserted. They shall be upset in its entire length so as to fill the hole as completely as possible when hot. Rivets after being heated and before being inserted in the hole shall be made free from scale by striking the hot rivet on a hard surface.

Wherever possible, the rivets shall be machine driven, preferably by direct acting riveters. The driving pressure shall be maintained on the rivets for a short time after the up-setting is completed.

Where flush surface is required, any projecting metal shall be chipped or ground off.

Before commencing riveting, all work shall be properly bolted up so that the various sections and plates are in close contact throughout. Drifts shall be used only for drawing the work into position and shall not be used to such an extent as to distort the holes. Drifts of a larger size than the nominal diameter of the hole shall not be used.

When struck sharply on the head with a 100 g rivet testing hammer, driven rivets shall be free from movement and vibrations.

All loose or burnt rivets and rivets with cracked or badly formed defective heads or with heads which are unduly eccentric with the shanks shall be removed and replaced. In removing rivets, the head shall first be sheared off. The rivet shall, then, be punched out without damaging the adjacent metal. If necessary, they shall be drilled out. Recupping and caulking shall not be permitted.

12-4.5. Bolts, Nuts and Washers

12-4.5.1 *Black Bolts (black all over)*

Black bolts are forged bolts in which the shanks, heads and nuts do not receive any further treatment except cutting of screw threads. They shall be true to shape and size and shall have the standard dimensions as shown on the drawings.

28

29 12-4.5.2 *Close Tolerance Bolts*

30

31 Close tolerance bolts shall be faced under the head and turned on the shank.

32

33 12-4.5.3 *Turned Barrel Bolts*

34

35 The diameter of the screwed portion of turned barrel bolts shall be 1.5 mm smaller than the diameter of the barrel unless otherwise specified by the Engineer. The diameter of the bolts as given on the drawings shall be the nominal diameter of the barrel. The length of the barrel shall be such that it bears fully on all the parts connected. The threaded portion of each bolt shall project through the nut by at least one thread. Faces of heads and nuts bearing on steel work shall be machined.

36

37 12-4.5.4 *Washers*

38

39 In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a steel washer under the nut. The washer shall be of sufficient thickness to avoid any threaded portion of the bolt being within the thickness of the parts bolted together and to prevent the nut when screwed up from bearing on the bolt.

40

41 For close tolerance or turned barrel bolts, steel washers whose faces give a true bearing shall be provided under the nut. The washer shall have a hole having a diameter not less than 1.5 mm larger than the barrel and a thickness of not less than 6 mm so that the nut, when screwed up, will not bear on the shoulder of the bolt.

42

43 Taper washers with a correct angle of taper shall be provided under all heads and nuts bearing on bevelled surfaces.

44

45 Spring washers may be used under nuts to prevent slackening of the nuts when excessive vibrations occur.

46

47 Where the heads or nuts bear on timber, square washers having a length of each side not less than three times the diameter of the bolts or round washers having a diameter of $3\frac{1}{2}$ times the diameter of bolts and with a thickness not less than one quarter of diameter shall be provided.

48

49 12-4.5.5 *Studs*

50

51 Ordinary studs may be used for holding parts together, the holes in one of the parts being tapped to take the thread of the stud. Countersunk studs may be used for making connections where the surfaces are required to be clear of all obstructions such as protruding heads of bolts or rivets. Studs may also be welded on the steel work in the positions required.

52

53 12-4.5.6 *Service Bolts*

54

Service bolts shall have the same clearance as black bolts. Where it is required, there should be no movement prior to final riveting and sufficient drift or close tolerance bolts shall be used to locate the work.

12-4.5.7 *Drifts*

Barrel shall be drawn or machined to the required diameter for a length of not less than one diameter over the combined thickness of the metal through which the drifts have to pass.

The diameter of the parallel barrel shall be equal to the nominal diameter of the hole subject to a tolerance of + 0 mm and - 0.125 mm. Both ends of the drift shall be turned down for a length which is equal to $1\frac{1}{2}$ times the diameter of the parallel portion of the bar. It shall be tapered to a diameter at the end which is equal to one-half the diameter of parallel portion.

12-4.6 Pins and Pin Holes

12-4.6.1 *Pins*

The pins shall be parallel throughout and shall have a smooth surface which is free from flaws. They shall be of sufficient length to ensure that all parts connected thereby shall have a full bearing on them. Where the ends are threaded, they shall be turned to a smaller diameter at the ends for the thread and shall be provided with a pilot nut, where necessary, to protect the thread when being drawn to place.

Pins which are having a length or a diameter of more than 175 mm shall be forged and annealed.

12-4.6.2 *Pin Holes*

Pin holes shall be bored true to gauge, smooth, straight at right angles to the axis of the member and parallel with each other, unless otherwise specified. The tolerance in the length of tension members (from outside to outside of pin holes) and of compression

members (from inside to inside of pin holes) shall be one millimetre. In built-up members, the boring shall be done after the members have been riveted or welded.

The specified diameter of the pin hole shall be its minimum diameter. The resulting clearance between the pin and the hole shall not be less than 0.5 mm and not more than 1.0 mm.

12-4.7 Shop Erection and Match Marking

Before being despatched, the steel work shall be temporarily erected in the fabrication shop for inspection by the Engineer either wholly or in such portion, in order to satisfy him/herself regarding the alignment and fitting of all connections. For this purpose, sufficient number of parallel drifts and service bolts shall be employed. All parts shall fit accurately and be in accordance with the drawings and Specifications.

After the work has been passed by the Engineer and before it is dismantled, each part shall be carefully marked with distinguishing marks and stamped with durable markings in order to facilitate easy re-erection. Drawings showing these markings shall be supplied to the Engineer.

Where close tolerance or turned barrel bolts are used for those cases where interchangeability is not insisted upon, each span shall be erected and members of each span shall be marked distinctly.

12-4.8 Welding

All welding shall be done with the prior approval of the Engineer and the workmanship shall conform to the Specifications of IS : 823 until similar Nepal's Standard are in place.

When material thickness is 20 mm or more, special precautions like pre-heating shall be undertaken as laid down in IS : 823.

Welding shall be permitted to be performed, for the project either in the shop or in the field, only by skilled welders whose work satisfies to the Engineer.

12-4.9 Tolerances

Tolerances in the dimensions of components of structural steel work shall be specified on the drawings and shall be subjected to the approval of the Engineer.

Unless otherwise specified, the following tolerances shall be maintained.

The tolerance on all depths of girders shall be
 $\pm 0.002 \times \text{depth}$: for depths up to 1500 mm and
 $\pm 0.0015 \times \text{depth}$: for depth above 1500mm.

The tolerance on lengths of individual components and the total length or span of the assembled components shall be
 $\pm 3.0 \text{ mm}$: for lengths less than 12 m and
 $\pm 0.00025 \times \text{length}$: for lengths greater than 12 m.

The spacing of the stiffeners of the plate girders shall be accurately maintained with a tolerance of $\pm 4 \text{ mm}$.

The tolerance in distances between the consecutive gusset plates shall be ± 2.0 mm.

12 -5 ERECTION

12-5.1 General

The provisions of this item shall apply to the erection of steel bridge structures composed of steel which span between supports.

If the sub-structure and the super-structure are built under separate contracts, the sub-structure will be constructed at first instance by the designated Contractor to the correct lines, dimensions and elevations shown on the drawings or directed by the Engineer. All requisite lines and elevations required for setting of steel members shall be in accordance with the construction drawings. Then, the other Contractor shall erect the structural steel; remove the temporary construction and do all the work required to complete the construction of super-structure in accordance with the drawings and Specifications and to the satisfaction of the Engineer.

12-5.2 Organisation and Equipment

The Contractor shall submit an erection plan which is prepared by the fabricator. This plan shall show the method and procedure of erection that are in compatible with the details of fabrication.

Unless otherwise specified in the contract, the Contractor shall supply and erect all necessary false work and staging and shall supply all labour, tools, erection plant and other materials necessary to complete the work in all respects.

The Contractor shall supply all rivets, bolts, nuts, washers, etc. required to complete erection at site with an allowance for wastage, etc. of 12.5% of the net number of field rivets, bolts, washers, etc. or a minimum of five number of each item.

Service bolts and nuts, ordinary platters, washers and drifts for use in the erection of work shall be supplied at the rate of 60% (45% bolts and 15% drifts) of the number of field rivets per span in each size (This includes wastage). A reduction in the quantities of service bolts, etc. may, however, be specified by the Engineer if more than one span of each type is ordered.

Before starting work, the Contractor shall obtain the necessary approval of the Engineer with respect to the method of erection and the number and character of tools and plants to be used.

The approval of the Engineer shall not relieve the Contractor of his/her responsibility for the safety of the method or equipment or from carrying out the work fully in accordance with the drawings and Specifications.

When progressing the work, the Contractor shall have a competent engineer or an overseer as in charge of the work who shall be adequately experienced in steel erection and acceptable to the Engineer.

12-5.3 Handling and Storing Materials

Materials to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members shall be supported on skids placed near enough together to prevent any deflection. The Contractor shall be held responsible for loss or damage to any material which has been paid already but still remained in his/her custody.

12-5.4 False Work

The false work shall be properly designed; substantially built; and maintained for all anticipated loads. The Contractor, if required, shall submit plans for approval to the Engineer. Approval of the plans, however, shall not relieve the Contractor from his/her responsibility.

12-5.5 Straightening Bent Material

The straightening of plates, angels and other shapes shall be done by methods which are not likely to produce any fracture or damage. The metal shall not be heated unless permitted by the Engineer. However, heating shall not be done to a temperature higher than that producing a dark cherry red colour. Further, it must be cooled as slowly as possible. Following the straightening of a bend or buckle, the surface shall be carefully investigated for evidence of fracture. Sharp kinks and bends may be the cause for rejection of material.

12-5.6 Assembling Steel

The parts shall be accurately assembled with reference to the match marks and as per the drawings. The materials shall be carefully handled so that no parts will be bent, broken or otherwise damaged.

Hammering which will damage or distort the members shall be avoided. Bearing surface or surfaces to be in permanent contact shall be cleaned before the members are assembled. The truss spans shall be erected on blocks which are placed in such a way that the proper camber is ensured. The blocking shall be left in place until the tension chord splices are fully riveted and all other truss connections are pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung.

Any connections to be riveted or bolted shall be secured in close contact with service bolts or with a sufficient number of permanent bolts before the rivets are driven or before the connections are finally bolted. Joints shall normally be made by filling not less than 50% of holes with service bolts and barrel drifts in the ratio of 4:1. The service bolts are to be fully tightened up as soon as the joint is assembled. Connections to be made by close tolerance or barrel bolts shall be completed as soon as practicable after assembling. Any connection to be in-situ welded shall be securely held in position by approved methods to ensure accurate alignment, camber and elevation before welding is commenced.

The field riveting, welding, bolting and pin connection shall conform to the requirements of clause 12 -4 as appropriate.

The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered as a legitimate part of erection. However, any error in the shop fabrication or any deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the Engineer and

his/her approval of the method of correction shall have to be obtained. The correction shall be made in the presence of the Engineer.

12-5.7 Field Inspection

All materials, equipment and work of erection shall be subjected to the inspection of the Engineer. Any work which is found defective shall be liable to be rejected. No material or work shall be painted until it has been inspected and approved.

12 -6 PAINTING

12-6.1 General

Unless otherwise specified, all metal work shall be given approved shop coats as well as field coats of painting. The item of work shall include
the preparation of metal surfaces;
the application of protective covering;
drying of the paint coatings; and
the supply of all tools, scaffolding, labour and materials necessary.

General steel work shall be protected against corrosion by a minimum of three coats of paint or a metal coating followed by two coats of paint.

Unless otherwise specified, all painting and protective coating works shall generally be done in accordance with IS : 1477 (Part I) until similar Nepal's Standards are in place.

12-6.2 Surface Preparation

Steel surface to be painted either at the fabricating shop or at the site of work shall be prepared in a thorough manner with a view to ensure complete removal of mill scale by one of the following processes as agreed by the fabricator and the Engineer:
grit and sand blasting
pickling which should be restricted to single plates, bars and sections
flame cleaning
scraping and wire brushing.

Primary coat shall be applied as soon as practicable after cleaning. In case of flame cleaning, primary coat shall be applied while the metal is still warm. All slag from welds shall be removed before painting. Care shall be taken to brush the surface clean prior to painting. Surfaces shall be maintained dry and free from dirt and oil. Outdoor work in frosty and humid weather shall be avoided. 12-6.3 Coatings Prime coat to be used shall conform to the specification of primers approved by the Engineer. Metal coatings shall be regarded as prime coatings. All coats shall be compatible with each other. When metal coatings are used, the undercoat shall be compatible with the metal concerned. The undercoat and the finishing coat shall preferably be from the same manufacturer. Successive coats of paint shall be of different shades or colours and each shall be allowed to dry thoroughly before the following coat is applied. Particular care shall be taken with the priming and painting of edges, corners, welds and rivets. 12-6.4 Painting in the Shop All fabricated steel shall be painted with at least one priming coat in the shop unless the exposed surfaces are

subsequently to be cleaned at site or are metal coated. If required, all contact surfaces which could not be painted at site shall be painted and brought together at shop while the paint is still wet. Surfaces which are not in contact but are inaccessible after assembling at the shop shall receive the fully specified protective treatment before assembling. Where surfaces are to be welded, the steel shall not be painted or metal coated within a suitable distance from any edge to be welded if the specified paint or metal coating would be harmful to welders or is expected to impair the quality of site welds. Exposed machined surfaces shall be adequately protected.

12-6.5 Painting at Site Surfaces which will be inaccessible after assembling at site shall receive the full specified protective treatment before assembling. Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet. Damaged or deteriorated painted surfaces shall first be made good with the same type of coat as the shop coat. Where steel has received a metal coat in the shop, this coating shall be continued at site (after welding or assembling) in order to have a continuous paint cover over any welds, bolts and site rivets. Specified protective treatment shall be completed after erection.

12 -7 MEASUREMENTS FOR PAYMENT The measurements of this item shall be in tonnes based on the net weight of metal in the fabricated structure. The net weight shall be computed on the basis of nominal weight of materials. The weight of rolled or cast steel and cast iron shall be determined from the dimensions shown on the drawings on the following basis: rolled or cast steel : $7.84 \times 10^{-3} \text{ kg/cm}^3$ cast iron : $7.21 \times 10^{-3} \text{ kg/cm}^3$. Weight of structural sections shall be their nominal weight. The weight of castings shall be computed from the dimensions shown on the drawings with an addition of 5% for fillets and over-run. The weight of weld fillets shall not be included in the measurement. Similarly, the weight of protective coatings of the structure shall also not be included in the measurement. The weight of rivet heads shall be computed by taking the weight of 100 snap heads as given in

Table 12 -7. Table 12 -7 : Weight of Rivet Heads

Diameter of Rivet as Manufactured Weight of 100 Snap

Heads mm	kg
12	1.4
14	1.6
16	1.8
18	2.2
20	2.4
22	2.6
24	2.7
27	3.0
30	3.3
33	3.6
36	3.9
40	4.3
45	4.8
50	5.4
56	6.1
63	7.0
70	8.0
76	9.0
80	10.0
100	15.0
120	20.5
150	27.2
200	36.0

When especially agreed upon, allowance for snap heads may be taken as a flat percentage of the total weight. This percentage may be taken as 3% or modified by mutual agreement. The Contractor shall supply detailed calculation sheets for the weight of the metal in the fabricated structure. No additions shall be made for the weight of protective coatings or weld fillets. Where computed weight forms the basis for payment, the weight shall be calculated for exact cut sizes of members used in the structure. In such case, the deductions shall be made for all cuts except for rivet holes and additions shall be made for the rivet heads as mentioned above. When especially agreed upon, the basis for payment may be the complete weight of the bridge which shall be included in the special provision of the contract.

12 -8 RATE The contract unit rate for the completed structural steel work shall include the cost of all labour, materials required for fabrication, connections, oiling, painting, temporary erection, inspection, tests and complete final erection as shown on the drawings and as specified in these Specifications.

13

Bearings

13 -1 DESCRIPTION

This work shall consist of furnishing and fixing in position of bearings in accordance with the details shown on the drawings to the requirements of these Specifications.

13 -2 GENERAL

Bearing plates, bars, rockers, assemblies and other expansion or fixed devices shall be constructed in accordance with the details shown on the drawings.

When bearing assemblies or plates as of the drawings are to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed for slightly above grade and shall be finished by grinding.

It shall be ensured that the bearings are set truly level and in exact position as indicated on the drawings in order to have full and even bearing on the seats. Thin mortar pads (not exceeding 12 mm) may be made to meet with this requirement.

It shall be ensured that the bottoms of girders to be received on the bearings are plane at the location of these bearings. Care shall be taken so that the bearings are not displaced while placing the girders.

Wherever rockers and rollers are provided for expansion or contraction of superstructure spans which are longer than 30 m, they shall be adjusted at the time of placement in such a manner that the line of bearing is as central as possible on the bearing plates at normal design temperature. It should further be ensured that the line of bearing is still on the bearing plate even after the subsequent bridge movement computed at the design stage.

When elastomeric bearing pads, elastic bearing pads or pre-formed fabric pads are shown on the drawings, the concrete surfaces on which pads are to be placed shall be wood float finished to a level plane which shall not vary by more than 1.5 mm from a straight edge placed in any direction across the area.

13 -3 RCC BEARINGS

Material for RCC bearings, namely, cement, sand, aggregates and mild steel reinforcement shall conform to **Section 6** of these Specifications.

The bearings shall be of the strength specified on the drawings and shall comply with the Specifications for plain or reinforced cement concrete for structures given in **Section 11**. Mild steel reinforcement shall conform to **Section 10**.

13 -4 STEEL BEARINGS

13-4.1 Materials

The material for steel bearings shall conform to the requirements of **Section 6**.

Cast steel components thicker than 200 mm shall be subjected to radiographic, ultrasonic or any other accepted method of testing which is used to check the quality of casting.

The grease for bearings shall conform to the requirements of IS : 1002 until similar Nepal's Standards are in place.

13-4.2 Construction Operations

All works shall strictly conform to the drawings and shall be in accordance with the provisions of this section. Care shall be taken to ensure that all parts of an assembly fit accurately together. The workmanship shall satisfy all relevant provisions laid down in **Section 12**.

Knuckle pins, rolling surfaces of the rollers and bearing surface of the bearing plate shall be machined and all bolt holes shall be drilled. The whole bearings shall be fitted and finished as required for good quality machined work to the satisfaction of the Engineer. However, in case of bearings which are to be grouted or bedded on a suitable yielding material, such steel surface which is to be in permanent contact with the grout or the yielding material may be left un-machined.

13.4.3 Tolerances

Tolerances for its individual components or of the assembled bearings shall be according to the drawings or subjected to the approval of the Engineer. Unless otherwise specified, the following tolerances shall be maintained.

13-4.3.1 *Diameter of Rollers, Knuckle Pins and Bores*

Tolerances on diameter of rollers and all convex surfaces shall conform to K7 of IS : 919 until similar Nepal's Standards are in place.

Tolerances on diameter of all concave surfaces shall conform to D8 of IS : 919 until similar Nepal's Standards are in place.

13-4.3.2 *Height of Bearings*

Tolerance on the height of any component cast shall not exceed + 0.5 mm. No minus tolerance will be allowed. The edges of all ribs shall be parallel throughout their length.

13-4.3.3 *Base Plate*

Tolerance on length and width of the base plate shall not exceed ± 5 mm. All rolling, rocking and sliding surfaces shall be machined to a smooth finish having a maximum mean deviation of 20 micron, as per IS : 3073 until similar Nepal's Standards are in place.

13 -5 ELASTOMERIC BEARINGS

13-5.1 General

The term 'bearing' in this case refers to an elastomeric bearing.

The elastomeric bearing shall consist of one or more internal layers of elastomer bonded to internal steel laminates by the process of vulcanisation. The bearing shall cater for translation and/or rotation of the superstructure by elastic deformation.

For the construction of rural and agricultural road bridges, the use of elastomeric bearings is considered to be minimum. When required, they shall generally be ordered directly from the manufacturers as per the requirements. Therefore, the details of elastomeric bearings are not fully covered in this section.

13-5.2 Materials

13-5.2.1 *Elastomer*

The elastomer to be used for bearings shall be made from natural or synthetic rubber and satisfy the physical properties given in **Table 13 -5**. The test specimens required for the tests shall be selected from the centre layer of the bearings.

Table 13 -5 : Physical Properties of Elastomeric Bearings

S. No.	Item	ASTM Designation	Requirement
I	Durometer Hardness	D-2240	55 to 70 (± 5 points from the nominated value)
II	Ultimate Tensile Strain (%)	D-412	450 for 55 grade 400 for 60 grade 300 for 70 grade
III	Tensile Strength (N/mm ²)	D-412	17.5 minimum 13.5 minimum for natural rubber of hardness greater than 65
IV	Adhesion to Metal (N/mm)	D-29 (Method B)	9
V	Tear Resistance (N/mm)	D-624 (DIEC)	40
VI	Compression set 22 hrs at 70°C (%)	D-395 (Method B)	25 maximum
VII	Ozone Resistance		20% strain 100 hrs at 380°C $\pm 1^\circ\text{C}$

(1 part per million in air by volume)
D-1149
no cracks

VIII
Accelerated ageing 70 hrs, 100°C
Hardness increase
Tensile strength reduction
Elongation at break reduction
D-573

< 10
< 15% of original
< 25% of original

IX
Low Temperature Stiffness
Young's Modulus at 40°C (N/mm²)
D-797
70 maximum

13-5.2.2 *Adhesive*

Adhesives used in bearing location or attachment to bridge decks shall be subjected to the approval by the Engineer. It shall be of high viscosity resins which are cold setting and free of solvent. Adhesives shall not be used to bond layers of cured elastomer.

13-5.2.3 *Reinforcement*

Mild steel used for plate reinforcement shall comply with the requirements of IS : 226.

13-5.2.4 *Certification*

The Contractor/Supplier shall furnish to the Engineer a certification by the manufacturer which states that the elastomer and fabric (if used) in the elastomeric bearing conforms to all the above requirements. The certification shall be supported by a certified copy of the results of tests performed by the manufacturer upon samples of elastomer and fabric to be used in the bearings.

13-5.3 General Requirements

The thickness of a single layer bearing shall not exceed 20% of the least plan dimension. The total thickness of a laminated bearing shall not exceed 40% of the least plan dimension.

The thickness of any internal layer of elastomer shall not be less than 6 mm nor greater than 12 mm. The thickness of outer plates shall be not less than 3 mm and that of inner plate not less than 1.5 mm. Metal plates in which dowels are located shall be, in general, not less than 6 mm thick. The edges of all plates shall be lightly rounded to approximately 5 mm radii. The metal plates referred above should not be composed of thinner plates joined together.

Laminated bearings shall have side cover of elastomer of minimum thickness of 6 mm to protect the ends of the steel plates and to give a reduced surface strain to that occurring at the edge of the bonded plates. However, the side cover of elastomer shall not be

considered in evaluation of deformations. The cover of elastomer at the top and bottom surfaces shall neither be less than 3 mm nor more than half the thickness of internal layer. The outer cover at top and bottom surfaces, having thickness less than half that of a single internal layer and not exceeding 3 mm, may be considered as a simple protection and need not, therefore, be considered in calculating deflections. Where the above elastomer covers are provided as shown in the following figure, there is no objection in keeping the thickness of the top most and bottom most plates same as that of inner plates.

Figure 13 -5

Bearings shall be set back from the edge of a bearing surface by a distance not less than the thickness of the layer of elastomer which is in contact with the bearing surface. This allows the elastomer to spread under load.

Bearings may be located in position by means of dowels or studs or other devices. Alternately, the bearings may be bonded to the structure with approved adhesives which shall generally be of high viscosity resin.

For spans on an inclined grade and without hinge bearings, sole plates shall be provided and be levelled so that the masonry surfaces and the bearing shall be kept horizontal.

To facilitate maintenance, the ends of trusses and plate girders shall preferably be supported on plates and pedestals so that there is at least 15 cm clearance between the bottom chord or flange and the sub-structure. The plan dimensions of the bearings to be finally adopted shall preferably be selected from series R20 of IS : 1076 until similar Nepal's Standards are in place.

Only one bearing shall be permitted to be placed under a girder. Further, bearings of different sizes must not be placed next to each other to support a span.

The bearings shall be fully moulded when metal laminations are used. These laminated elastomeric bearings shall consist of one or more elastomer slabs bonded to metal plates so as to form a sandwich arrangement. Such fully moulded bearings shall be manufactured to the required size.

The bond between elastomers and metal or fabric shall be such that, when a sample is tested for separation, failure shall occur within the elastomers but not between the elastomer and the metal.

13-5.4 Tolerances

The following tolerances are acceptable for the respective cases:

Length : 0 mm
Width : +5 mm
Thickness for single layer pad : ± 0.5 mm
Total thickness 'h' of finished bearings
10 < h $\leq$ 30 mm : ± 0.5 mm
30 < h $\leq$ 50 mm : ± 0.8 mm
50 < h $\leq$ 80 mm : ± 0.9 mm
80 < h $\leq$ 120 mm : ± 1.1 mm.

For a finished bearing, the parallelism of the individual elastomer laminations shall not exceed the tolerances specified at (iii) above when measured at the extremities of the laminations.

13-5.5 Protection against Corrosion

Proper arrangement shall be made to avoid corrosion of metal plates or deterioration of adhesive by encasing the bearings totally in elastomer or by some other methods approved by the Engineer.

13 -6 PAPER BEARINGS FOR SLABS

Paper bearings shall be reinforced bitumen laminated kraft paper conforming to the requirements of IS : 1398 until similar Nepal's Standards are in place.

While concreting the slab, care shall be taken to prevent the bearing material from being displaced.

13 -7 INSPECTION AND TESTING

Where any patents are used, the manufacturer's certificate with test proofs shall be submitted along with the design and be approved by the Engineer before their use on work.

13 -8 MEASUREMENTS FOR PAYMENT

Bearings shall be measured in numbers. Expansion and fixed bearings shall be counted separately and with respect to their capacities and particular Specifications.

Paper bearing shall be measured in square metres.

13 -9 RATE

The contract unit rate for each type of bearing shall include the cost of supplying and fixing the bearings in position as specified in the drawings or as directed by the Engineer.

The contract unit rate shall also include the cost of samples and their testing when desired by the Engineer.

In case of steel bearings, the contract unit rate shall include the cost of all nuts, bolts, supplying and filling the grease boxes with the specified grease, cost of all tests prescribed in the Specifications and shown on the drawings.

When the office supplies the bearings, the contract unit rate for fixing them shall include the cost of anchor bolts, their fixing, transport of bearings from the place of supply to the site, handling and placing them in position, and supplying and filling the grease in grease boxes as per directions of the Engineer.

In case of elastomeric bearings, the contract unit rate shall also include the cost of adhesives for fixing them.

14 Expansion Joints

14 -1 GENERAL Expansion joints shall be constructed according to the details shown on the drawings. The position of all bolts cast into concrete and holes drilled in plates shall be accurately determined from templates. Vehicular traffic shall not be allowed on the expansion joint after its construction for such period as may be determined by the Engineer. **14 -2**

FABRICATION
14-2.1 Open Joints Open joints shall be constructed at the locations shown on the drawings using a wood strip, metal plate or other suitable material which is subsequently removed. When removing the material, care shall be exercised to avoid chipping or breaking the corners of the concrete. The edge of the concrete at the joints shall be edge finished. Reinforcement shall not extend across an open joint.
14-2.2 Filled Joints The filler material shall conform to clause 14-2.4. When performing the filler shown in the drawings, the filler shall be placed in correct position before concrete is placed against the filler. The filler material shall form part of the joint. While concreting the slab, care shall be taken to prevent the filler material being displaced. After the work is completed, the exposed face of the joint shall be cleaned of all loose material sticking to it.
14-2.3 Steel Work Steel plates, angles or other structural shapes provided in the expansion joints shall conform to the provisions made in Section 12; be accurately shaped to the section of concrete deck; and be hot-dip galvanised after fabrication. Positive methods shall be employed in placing the assemblies to keep them in correct positions during the placing of concrete. Care shall be taken to avoid impairment of the clearance in any manner.
14-2.4

Filler Material at Expansion Joints The material used for filling the expansion joints shall be bitumen impregnated felt, elastomer or any other suitable material as specified on the drawings. Impregnated felt shall conform to the requirements of IS : 1838 until similar Nepal's Standards are in place. It shall be approved by the Engineer prior to its application. The joint filler shall consist of large pieces. Assembly of small pieces to make up the required size shall be avoided.
14 -3 MEASUREMENTS FOR PAYMENT The expansion joints shall be measured in linear metres.
14 -4 RATE The contract unit rate for the expansion joints shall include the cost of all labour, materials and other incidentals which are required to fix the joints completely in all respects as per the drawings and the Specifications.

15Pipe Culverts

15 -1 GENERAL This work shall consist of furnishing and installing reinforced cement concrete pipes having the type, diameter and length required at locations shown on the drawings or as directed by the Engineer. All such works shall be in accordance with the requirements of these Specifications.

15 -2 MATERIALS All materials used in the construction of pipe culverts shall conform to the requirements of **Section 6**. Each consignment of cement concrete pipes shall be inspected, tested (if necessary) and approved by the Engineer either at the place of manufacture or at the site before their use in the works.

15 -3 EXCAVATION FOR PIPE The foundation bed for pipe culverts shall be excavated true to the lines and grades shown on the drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embankments according to the levels shown on the drawings. In case of high embankments where the height of the fill is more than three times the external diameter of the pipe, the embankment shall first be built to a height which is equal to the external diameter of the pipe and to a width which is not less than five times the external diameter in each side of the pipe. Then, a trench shall be excavated and the pipe shall be laid. Where trenching is involved, its width on either side of the pipe shall not be less than 150 mm nor more than one-third the diameter of the pipe. The sides of the trench shall be as vertical as they could be. During excavation, if the material encountered is soft, spongy or other unstable soil and unless other special construction methods are employed under special provisions, such unsuitable material shall be removed to such depth, width and length as directed by the Engineer. The excavation shall then be backfilled with approved granular material which shall be properly shaped and thoroughly compacted up to the specified level. Where bed-rock or boulder strata are encountered, excavation shall be continued at least 200 mm below the bottom level of the pipe with prior permission of the Engineer. All rock and boulders in this area shall be removed and the space in between shall be filled with approved earth which is free from stone and fragmented materials. Then, the fill shall be shaped to the requirements and be thoroughly compacted to provide adequate support for the pipe. Trenches shall be kept free from water until the pipes are installed and subsequently, the joints have hardened.

15 -4 BEDDING FOR PIPE The bedding surface shall provide a firm foundation of uniform density throughout the length of the culvert. The bedding surface shall conform to the specified levels and grade and shall be of one of the following two types as specified on the drawings.

15-4.1 First Class Bedding Under first class bedding, the pipe shall be evenly bedded on a continuous layer of well compacted approved granular material which is shaped concentrically to fit the lower part of the pipe exterior for at least 10% of its overall height or otherwise shown on the drawings. The bedding material shall be well graded sand or another granular material passing 4.75 mm sieve. The thickness of the bedding layer shall be as shown on the drawings and in no case shall it be less than 75 mm.

15-4.2 Concrete Cradle Bedding When indicated on the drawings or directed by the Engineer, the pipe shall be bedded in a cradle which is constructed of concrete having a mix not leaner than M 15 and conforming to **Section 11**. The shape and dimensions of the cradle shall be as indicated on the drawings. The pipes shall be laid on concrete bedding before the setting of concrete.

15 -5 LAYING OF PIPE No pipe shall be placed in position until the foundations have been approved by the Engineer. Where two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm. The laying of pipes on the prepared foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades.

The pipes shall be fitted and matched so that when laid in work, they form a culvert with a smooth and uniform invert. Any pipe found defective or damaged during laying shall be removed at the cost of the Contractor/Users' Group.

15 -6 JOINTING The pipes shall be jointed either by collar joint or by flush joint.

15-6.1 Collar Joint In a collar joint, the collars shall be of RCC having 150 to 200 mm width and the same strength as of the pipes to be jointed. Caulking space shall be between 13 and 20 mm according to the diameter of the

pipes. 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 so placed that its centre coincides with the joint and an even annular space is left between the collar and the pipe.15-

6.2 Flush Joint Flush joint may be internal flush joint or external flush joint. In either case, the ends of the pipes shall be specially shaped to form a self centering joint with a jointing space of 13 mm wide. The jointing space shall be filled with mortar of cement and sand having a ratio of 1:2 which is mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids as well as to remove excess mortar.15-

6.3 Jointing Pipes under Light Hydraulic Pressures When jointing pipe lines which are under light hydraulic pressures, the recess at the end of the pipe shall be filled with jute braiding dipped in hot bitumen or other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The ring shall be thoroughly compressed by jacking or by any other suitable means.15-6.4

Joints (General) All joints shall be made with care so that their interior surface is smooth and consistent with the interior surface of the pipes. After finishing, the joint shall be kept covered and damp for at least four days.15 -7 **BACKFILLING** Trenches shall be backfilled immediately after the pipes have been laid and the jointing material has been hardened. The backfill soil shall be clean and free from boulders, large roots, excessive amounts of sods or other organic matter, and lumps and shall be approved by the Engineer. Backfilling up to 0.3 m above the top of the pipe shall be carefully done. The soil shall be thoroughly rammed, tamped or vibrated in layers of not more than 150 mm thickness. Particular care shall be given in instances where the materials are to be compacted under the haunches of the pipes. Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur on the pipe surface. In case of high embankments, after filling the trench up to the top of the pipe in the above said manner, a loose fill of a depth equal to external diameter of the pipe shall be placed over the pipe before further layers are added and compacted.15 -8

HEAD WALLS AND OTHER ANCILLARY WORKS Headwalls, wing walls, aprons and other ancillary works shall be constructed in accordance with the details shown on the drawings or as directed by the Engineer. Masonry for the walls shall conform to the requirements given in Sections 7, 8 and 11 as applicable. The work on aprons shall conform to the requirements given in Section 17 of the Specifications.15 -9 **OPENING TO**

TRAFFIC No traffic shall be permitted to cross the pipe line unless the earth filling above the pipe is at least 0.6 m.15 -10 **MEASUREMENTS FOR PAYMENT** RCC pipe culverts shall be measured along their centre line between the inlet and outlet ends in linear metres. Selected granular material and cement concrete for pipe bedding shall be measured as laid in cubic metres. Ancillary works like headwalls, etc. shall be measured as described in the respective Sections of the Specifications.15 -11 **RATE** The contract unit rate for the pipe shall include the cost of pipe including loading, unloading, hauling, handling, storing, laying in position and jointing of the pipe completely. Ancillary works such as excavation including backfilling, concrete and masonry shall be paid for separately as provided under the respective clauses.

16

Boring at Site

16 -1 DESCRIPTION

The investigation shall consist of a boring programme and detailed sampling. In-situ density tests, bearing capacity tests, in-situ vane shear tests and more advanced means of logging of bore holes by radio-active methods shall be done for detailed investigation as specified in the contract or in special provisions.

All in-site tests shall be supplemented by laboratory investigations. Field tests shall be carried out as per IS : 1888, IS : 2131, IS : 2720 and IS : 4434 until similar Nepal's Standards are in place.

16 -2 GENERAL

The location of the boring hole shall be either given or determined by the Engineer. The soundings by dynamic method shall be carried out in bore holes using a standard sampler as specified in IS : 2131 until similar Nepal's Standard are in place.

16 -3 BORINGS

Boring shall be done by any of the following methods depending upon the soil type and type of samples required for investigation:

- Auger boring
- Shell and auger boring
- Percussion boring
- Wash boring
- Rotary boring.

16 -4 METHODS OF SAMPLING

There are two types of samples, viz.,
Disturbed sample
Undisturbed sample.

The usual methods for sampling are given below:

Table 16 -4 : Methods of Sampling

Nature of Ground
Type of Sample
Method of Sampling

Soil
Disturbed

Undisturbed
Hand samples
Auger samples (in clays)
Shell samples (in sand)

Hand samples
Tube samples

Rock
Disturbed

Undisturbed
Wash samples from percussion or rotary drilling

Cores

16 -5 PROCEDURE FOR TAKING SAMPLES

16-5.1 Disturbed Soil Samples

Disturbed samples of soils shall be obtained in the course of excavation and boring. For procuring samples from the ground which is below the ground water level, special type of samplers shall be used. The size of sample generally required shall be as given below:

Table 16 -5 : Size of Soil Sample Required

S. No.

Purpose of Sample

Soil Type

Weight of Sample Required

(kg)

i

Soil identification

Natural moisture content tests

Mechanical analysis

Index properties

Chemical tests

Cohesive soils

Sands and gravels

1

3

ii

Compaction tests

Cohesive soils and sand

12.5

iii

Comprehensive examination of construction materials including soil stabilisation

Cohesive soils and sands

Gravelly soils

25 to 50

50 to 100

While taking out disturbed soil samples, Standard Penetration Tests may also be conducted to find out the bearing capacity of the sub-soils at specified levels/depths.

16-5.2 Undisturbed Soil Samples

Samples shall be obtained in such a manner that their moisture content and structure do not get altered. These may be ensured by careful protection and packing as well as by the use of a correctly designed sampler.

In soft clay, the sampling procedure may have to be supplemented by in-situ vane shear tests as per IS : 4434.

For compression test samples, a core having a diameter of 40 mm and a length about 150 to 200 mm may be sufficient. But for other laboratory tests, a core of 75 mm diameter and 300 mm long shall be taken unless otherwise specified by the Engineer. The upper few millimetres of both types of sample shall be rejected as the soil at the bottom of the bore hole usually gets disturbed by the boring tools.

16-5.3 Disturbed Rock Samples

The sludge from percussion borings or from rotary borings which have failed to yield a core shall be collected for a disturbed sample. It may be recovered by settlement in a trough through the circulation of water.

16-5.4 Undisturbed Rock Samples

Block samples taken from rock formation shall be dressed to a size of about 90 x 75 x 50 mm.

For core samples : Cores of rock shall be taken by means of rotary drills fitted with a coring bit having a core retainer, if warranted.

16 -6 RECORDS OF BORINGS AND TRIAL PITS

For all borings and trial pits, necessary information as detailed below shall be given. A site plan showing the locations of bore holes shall also be attached.

Agency;

Location, with reference map;

Pit number;

Reduced level (R.L.) of ground surface or other reference point;

Dates, started and completed;

Name of the supervisor;

Scales of plans and sections;

Dimensions, methods of advancing exploration such as by hand tools, blasting, boring, etc.;

General description of strata met with and the RLs at which they are met;

Position and attitude of contacts, faults, strong joint, slicken sides, etc.;

Inflow of water, methods of controlling the water, required capacity of pumps for dewatering;

The level at which the sub-soil water is met with;

Dip and strike of bedding and of cleavage; and

Any other information and remarks.

16 -7 PROTECTION, HANDLING AND LABELLING OF SAMPLES

Care shall be taken in handling and labelling of samples so that they are received in a fit state for examination and testing and can be correctly identified as coming from a specified trial pit or boring.

16 -8 MEASUREMENTS FOR PAYMENT

The work of boring and trial pits shall be considered as incidental to the foundation works and nothing extra shall be paid unless otherwise specified in the contract. If it is to be paid separately, the boring shall be measured in running metres and the trial pits in cubic metres.

16 -9 RATE

The contract unit rate shall include the cost of all labour, materials, precautionary measures and tools, plant and all equipment required for doing boring or making pits as per these Specifications, taking out and packing the samples, and sending and getting them tested in approved laboratories.

17

Protection Work

17 -1 APRON

17-1.1 Description

This work shall consist of laying boulders directly or in gabion crates on the bed of rivers for protection against scour.

17-1.2 General

The stones used in apron shall be sound, hard, durable and fairly regular in shape. Stones subject to marked deterioration by water or weather shall not be used.

The thickness and shape of apron shall be as indicated in the drawings.

The surface on which the apron is to be laid shall be levelled and prepared for the length and width as shown on the drawings.

17-1.3 Laying Boulder Apron

The size of stone shall be as large as possible. In no case, shall any fragment weigh less than 40 kg. The specific gravity of stones shall be as high as possible and it shall not be less than 2.50.

To ensure regular and orderly disposition of the full intended quantity of stone in the apron, template cross walls in dry masonry shall be built about a metre thick and to the full height of the specified thickness of the apron at intervals of 30 m all along the length and width of the apron. Within these walls, the stone shall then be hand-packed.

17-1.4 Laying GI Wire Crates (Gabion) and Mattresses in the Apron

The crates shall be made from 5 mm galvanised iron wire. The mesh of the crate shall not be more than 150 mm.

Wire crates for shallow or accessible situations shall be 3 m x 1 m x 0.5 m in size. Where there is a chance of overturning, the crate shall be divided into 1.5 m compartments by cross netting.

For deep or inaccessible situations, wire crates can be made smaller subject to the approval of the Engineer.

Wire crates built in-situ shall not be larger than 3 m x 1 m x 1 m nor smaller than 2 m x 1 m x 0.3 m. Sides of large crates shall be securely stayed at intervals of not more than 1.5 m to prevent bulging.

The netting shall be made by fixing a row of spikes on a beam at a spacing equal to the mesh. The beam must be a little longer than the width of netting required. The wire is to be cut to lengths about three times the length of the net required. Each piece is bent at the middle and circled around one of the spikes. Then, the weaving shall commence from one corner.

A double twist shall be given at each intersection. This twisting shall be carefully done by means of a strong iron bar. In twisting, 5 half turns shall be given to the bar at each splice.

The bottom and two ends of the crate or mattress shall be made at one time. The other two sides shall be made separately and shall be secured to the bottom and to the ends by twisting adjacent wires together. The top of the crate shall be made separately. It shall be fixed in the same manner as the sides after the crate or mattress has been filled with stones.

Wherever possible, crates shall be placed in position before filling with boulders. The crates shall be filled carefully by hand-packing of the boulders as tightly as possible. Mere throwing of stones or boulders shall not be permitted.

17 -2 PITCHING ON SLOPES

17-2.1 Description

The work “pitching” shall consist of covering the slopes of guide banks, river training works and road embankments with stones, boulders or bricks over a layer of granular material called ‘filter’.

17-2.2 General

The pitching shall be provided as indicated on the drawings.

Stones subjected to marked deterioration by water or weather shall not be accepted. The stones shall be sound, hard, durable and fairly regular in shape. The largest possible stones shall be supplied. In no case, shall any fragment of stone weigh less than 40 kg unless otherwise permitted by the Engineer. The sizes of spalls shall be minimum of 25 mm and shall be suitable to fill the voids in the pitching.

To drain out seepage water and to prevent erosion of the base material, one or more layers of graded materials, commonly known as a filter medium, shall be provided underneath the pitching. The material for the filter shall consist of sound gravel, stone or brick ballast and coarse sand. For a single-layer filter, the compacted thickness shall not be less than 150 mm. For a multi-layer filter, the compacted thickness of each layer shall not be less than 115 mm.

The gradation of the filter material shall satisfy the following requirements:

Requirements for filter material

- A.** (i) $\frac{D_{15} \text{ of Filter}}{D_{15} \text{ of Base Material}} = 5 \text{ to } 40,$

Note 1 : Filter may not be required if embankment consists of CH or Ch soils having a liquid limit of greater than 30 and a resistance to surface erosion.

Note 2 : In this case, if a layer of material is used as bedding for pitching then it shall be well graded and its D_{85} size shall be at least twice the size of maximum void in pitching.

Note 3 : D_{15} means the size of the sieve that allows 15% by weight of the filter material to pass through it.

- (ii) $\frac{D_{15} \text{ of Filter}}{D_{85} \text{ of Base Material}} = 5 \text{ or less.}$

The grain-size curve of the filter should be roughly parallel to that of the base material.

B. If more than one filter layer is required, the same requirement as given above shall be followed. The finer filter shall be considered as the base material for selection of gradation of the coarser filter.

C. The filter material shall be suitably compacted to a firm condition.

17-2.3 Construction Operations

Before laying the pitching, the sides of banks shall be trimmed to the required slope and profiles. Prior to trimming, the line shall be demarcated by pegs fixed at intervals of 3 m in order to ensure regular straight work and an uniform slope throughout. Depressions shall be filled and thoroughly compacted.

The granular filter material shall be laid over the prepared base and suitably compacted to a thickness of 150 mm or as specified in the drawings.

The lowest course of pitching shall be started from the toe wall. Then, the pitching operation shall progress in similar courses upward. The toe wall shall be in dry rubble masonry (uncoursed) conforming to clause 8-3.3 in case of rubble pitching. It shall be in brick work in cement mortar 1:4 (cement : sand) in case of brick pitching.

The stone pitching shall commence in a trench below the toe of the slope. Stones shall be placed by hand to the required length, thickness and depth as per the drawings. 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 largest stones shall be placed in the bottom courses and shall be used as headers for subsequent courses.

When full depth of pitching can be formed with a single stone, the stones shall be laid breaking joints and all interstices between adjacent stones 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, dry masonry shall be used and stones shall be well bonded.

Where bricks are to be used, the same shall be laid on the prepared base in one or more layers as specified. When more than one layer is to be adopted, adjacent layers shall be properly bonded by means of a sufficient number of pin headers extending from one layer to the other. The bond used in laying shall be as directed by the Engineer.

17 -3 RUBBLE STONE/BRICK FLOORING OVER CEMENT CONCRETE BEDDING

17-3.1 Description

This work shall consist of constructing rubble stone/brick flooring in cement mortar laid over a cement concrete bedding.

17-3.2 Construction Operations

The base for the cement concrete bedding shall be prepared to the specified levels and slope and compacted suitably to have an even bedding surface.

Cement concrete of the specified mix shall then be laid to the required thickness in accordance with the provisions given in **Section 11** except that the surface of the concrete

shall not be given a smooth finish. The paving work shall start only after the concrete has been in position for at least 48 hours.

Where rubble stone is specified, the thickness of paving shall be made up with one stone only. The stones shall be bedded on a layer of cement mortar prepared in accordance with clause 7 -1. Spalls shall be used to fill the voids. The joints shall then be filled with cement mortar and finished neatly. The stone shall break joints and the joint shall not exceed 20 mm in thickness.

Where bricks are to be used, the flooring shall be built up in one or more layers as specified. Each layer of brick shall be bedded on cement mortar and the joints shall be filled with cement mortar. The bond used for laying shall be as directed by the Engineer. The thickness of the joints shall not exceed 10 mm.

17 -4 DRY RUBBLE/BRICK FLOORING

This work shall consist of constructing dry rubble stone/brick flooring at cross drainage works.

The base for flooring shall be prepared to the specified levels and slope and compacted suitably with hand rammers or by other means to give an even bedding.

Where rubble stone is specified, the thickness of flooring shall be made with one stone only. The stones shall be laid closely breaking joints and all joints shall be filled with spalls of the proper size and wedged in with rammers to ensure tight packing.

Where brick is the material to be used, the same shall be laid closely on the prepared base in one or more layers as specified. The bond used shall be as directed by the Engineer.

17 -5 MEASUREMENTS FOR PAYMENT

The protection works shall be measured as described below:

If directed by the Engineer, the materials may have to be stacked at site for measurement before laying. No extra payment shall be made to the Contractor for such stacking.

The boulders and wire crates (gabion) in apron shall be measured in cubic metres.

The filter and stone pitching shall be measured separately in cubic metres, unless otherwise specified.

Rubble stone flooring and cement concrete bedding shall be measured in cubic metres for each class of material.

Brick flooring shall be measured in square metres for one or two layers as specified.

Preparation of base for laying the flooring shall be deemed incidental to the work.

For laying apron, excavation up to an average depth of 15 cm shall be deemed to be included in the main item and shall not be measured separately, unless otherwise specified. Excavation for more than 15 cm depth shall be measured in cubic metres as given in clause 2 -4.

17 -6 RATE

The contract unit rate for one cubic metre of finished work of apron shall include the cost of all labour, materials required to complete the work as per the Specifications. Excavation up to an average depth of 15 cm shall also be deemed to be included in this rate as dressing of the bed. Excavation beyond this depth shall be paid separately, unless otherwise specified.

The contract unit rate for one cubic metre of filter or stone pitching on slopes shall include the cost of preparing the base; placing materials to the profile; laying and compacting the filter; and stone pitching of dry rubble/brick revetment for embankment slopes to the specified thickness, lines, curves, slopes and levels including the cost of all labour, materials required to complete the work as per the Specifications.

The contract unit rate for rubble stone/brick flooring shall include the cost of all labour and materials required to complete the work as per the Specifications and drawings.

18

Bio-engineering Work

Extracted from the **Bio-engineering Information** of
the Department of Roads, Ministry of Works and
Transport

18 -1 PROVISION OF SEED

18-1.1 General

18-1.1.1 The Contractor/Users' Group shall provide or collect seeds of the required species in accordance with the requirements described hereafter, of the species and quantities required, as and when required. He shall supply all necessary expertise, resources and facilities to ensure that these requirements are met in full. It is essential that the seed is of a high quality as it forms the basis to the success of any bio-engineering programme.

18-1.1.2 The Engineer will give indications as to the expected amounts of seeds required and the time of availability. But it is the Contractor/Users' Group responsibility to ensure that adequate quantities of seeds are obtained in a timely fashion.

18-1.1.3 The weights to be specified are for sun-dried seeds separated completely from fruiting bodies and other unwanted parts, and ready for storage and subsequent sowing. There is usually a large discrepancy between this weight and that of the freshly collected, untreated fruits.

18-1.1.4 Should the Contractor/Users' Group be unable to supply the specified seeds, the advice of the Engineer should be sought. It may be possible to substitute other species. Some commercial seed sources in Nepal and India are known to supply old or badly treated seeds. For this reason, seed should not be obtained commercially without the Engineer's written authority.

18-1.2 Grass Seed Collection

18-1.2.1 The species of grass seeds to be collected will be determined by the Engineer. The Contractor/User's Group will be responsible for determining seed sources, though these may be specified by the Engineer's instructions. Seeds should normally be collected in or very close to VDC of use or the project area.

18-1.2.2 If the Engineer does not specify the species, then the current approved list of bio-engineering plants, as determined by the Geo-Environmental Unit of the Department of Roads (DoR) or the Designs and Technology Promotion Section (DTPS) of the Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR) should be referred to.

18-1.2.3 Seeds must be collected from as many individual plants as possible. With grasses, it is difficult to determine the best genetic material from the appearance of form; but it is generally sound practice to select from the largest and most vigorous plants.

18-1.2.4 The Contractor/User's Group may under no circumstances damage or remove the roots of grass plants while collecting seeds. The Contractor/User's Group is responsible for safety measures and for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the collection of seeds.

18-1.2.5 Seeds may only be collected when fully ripe. Seeds collected early are not viable when planted and will cause a failure of the planting programme. The Contractor/User's Group will be held liable if the germination rate of seeds is seriously lower than the normally expected percentage (As defined in publications issued by the Geo-Environmental Unit or the DTPS of DoLIDAR).

18-1.2.6 Immediately after collection, seeds must be separated from flower heads by the method normally used by farmers for other grasses. Once separated, the seeds must be sun-dried before storage.

18-1.2.7 Seeds must be stored in a cool, dry, ventilated building with adequate precautions taken against pests. Containers should be raised above the floor. They should not be kept in the same building as cement, or any chemicals, fuels or lubricants. Grass is best stored in bags made of hessian (jute) sheet. Seeds should be carefully inspected on a weekly basis to ensure that there is no deterioration or mould formation, or pest attack. Seeds can only be stored successfully if they have been properly dried in the sun beforehand.

18-1.3 Tree and Shrub Seed Collection

18-1.3.1 The species of tree and shrub seeds to be collected will be determined by the Engineer. The Contractor/User's Group will be responsible for determining seed sources, though these may be specified by the Engineer's instructions. Seeds should normally be collected in or very close to the working area.

18-1.3.2 If the Engineer does not specify the species, then the current approved list of bio-engineering plants, as determined by the Geo-Environmental Unit of the DoR or the DTSPS of DoLIDAR should be referred to.

18-1.3.3 Seeds must be collected from as many healthy individual plants as possible. In any event, they must be collected from at least ten individual plants. The plants from which the seeds are collected must show vigorous growth and good form. Mis-shaven and stunted plants should not be considered.

18-1.3.4 The Contractor/User's Group must under no circumstances damage plants while collecting seeds. The Contractor/User's Group is responsible for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the collection of seeds.

18-1.3.5 The collection of seeds from trees can be a dangerous business, placing the collectors at considerable personal risk. Specialist equipment and training is available in Nepal for this purpose. It is the Contractor's/User's Group's responsibility to ensure safe working conditions for his/her employees.

18-1.3.6 Seeds may only be collected when fully ripe. Seeds collected early are not viable when planted and will cause a failure of the planting programme. The Contractor/User's Group will be held liable if the germination rate of seeds is seriously lower than the normally expected percentage.

18-1.3.7 Immediately after collection, seeds must be separated from fruit by the method normally used by farmers and foresters for this purpose; this depends on the individual species but may be a time-consuming process for certain fruits. Once separated, the seeds must be sun-dried before storage.

18-1.3.8 Seeds must be stored in a cool, dry, ventilated building with adequate precautions taken against pests. Containers should be raised above the floor. They should not be kept in the same building as cement, or any chemicals, fuels or lubricants. If kept in sealed containers, seeds should be carefully inspected on a weekly basis to ensure that

there is no deterioration or mould formation. Seeds can only be stored successfully if they have been properly dried in the sun beforehand.

18 -2 PROVISION OF PLANT CUTTINGS

18-2.1 General

18-2.1.1 The species of plants to be collected for vegetative propagation will be determined by the Engineer. The Contractor/Users' Group will be responsible for determining plant material sources, though these may be specified by the Engineer's instructions. Plants should normally be collected in or very close to the working area.

18-2.1.2 If the Engineer does not specify the species, then the current approved list of bio-engineering plants, as determined by the Geo-Environmental Unit of the DoR or the DTPS of DoLIDAR should be referred to.

18-2.2 Provision of Grass Cuttings

18-2.2.1 Cuttings of various types must be taken from grass species which are known to propagate easily by vegetative means.

18-2.2.2 Cuttings must be made from as many healthy individual plants as possible. The plants from which cuttings are taken must show vigorous growth and good form. Grass clumps showing stunted growth should not be considered as sources.

18-2.2.3 Apart from the clumps which are dug up to make cuttings, the Contractor/Users' Group must under no circumstances damage other plants. The Contractor/Users' Group is responsible for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the making of hardwood cuttings.

18-2.2.4 The type of cuttings to be made depends on the species and should be as shown in the **Table 18 -2** below. If the species used is not listed here, then the latest technical information provided by the Geo-Environmental Unit or the DTPS of DoLIDAR should be consulted. If the species is still not covered, then stem and root slip cuttings should be used.

Table 18 -2 : Details of Plant Cuttings

Local Name
Botanical Name
Best Propagation
Details

Amliso
Thysanolaena maxima
Rhizome cuttings
Stem: 100-150 mm; rhizome: 50-80 mm

Babiyo
Eulaliopsis binata
Slip cuttings
Stem: 100-150 mm; root: 30-60 mm

Dhonde

Neyraudia reynaudiana

Stem/slip cuttings

Stem cuttings: 2 nodes plus 50 mm each side; Slips: stem: 100-150 mm; root: 30-60 mm

Kans

Saccharum spontaneum

Slip cuttings

Stem: 100-150 mm; root: 30-60 mm

Khar

Cymbopogon microtheca

Slip cuttings

Stem: 100-150 mm; root: 30-60 mm

Khus

Vetiver zizanioides

Slip cuttings

Stem: 100-150 mm; root: 30-60 mm

Napier

Pennisetum purpureum

Stem cuttings

Two nodes plus 50 mm each side

Local Name

Botanical Name

Best Propagation

Details

Narkat

Arundo donax

Stem/slip cuttings

Stem cuttings: 2 nodes plus 50 mm each side; Slips: stem: 100-150 mm; root: 30-60 mm

Padang bans

Himalayacalamus hookerianus

Large slip cuttings

Stem: 750-1200 mm; root: 100-200 mm

Phurke

Arundinella nepalensis

Slip cuttings

Stem: 100-150 mm; root: 30-60 mm

Sito

Neyraudia arundinacea

Slip cuttings

Stem: 100-150 mm; root: 30-60 mm

Tite nigalo

Drepanostachyum intermedium

Large slip cuttings

Stem: 750-1200 mm; root: 100-200 mm

18-2.2.5 Where roots are required for the cuttings, grass clumps should carefully dug up. They must not be pulled hard, as this can damage the material. They must be separated carefully by hand, using a sharp khukuri or razor blade when necessary. There must be no tearing of the plant fabric.

18-2.2.6 Stem cuttings must be made using sharp secateurs. The top cut should be made at right angles to the stem and the bottom cut should be made at 45° to the stem: this is to show the orientation of planting.

18-2.2.7 Once cuttings have been made, they must be wrapped in wet hessian (jute) immediately. At all times, cuttings are to be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as digging out of the ground, splitting out, trimming and planting. Under any circumstances, all cuttings must be planted the same day that they are made.

18-2.3 Provision of Hardwood Cuttings

18-2.3.1 Hardwood cuttings must be taken from shrubs and trees of species which are known to propagate easily by vegetative means.

18-2.3.2 Cuttings must be made from as many healthy individual plants as possible. The plants from which the cuttings are taken must show vigorous growth and good form. Mis-shaven and stunted plant should not be considered as sources.

18-2.3.3 Apart from the branches from which cuttings are taken, the Contractor/Users' Group must under no circumstances damage plants while taking cuttings. The Contractor/Users' Group is responsible for taking safety precautions and for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the making of hardwood cuttings.

18-2.3.4 Hardwood cuttings must be made from stems which are between 6 and 18 months old. Materials outside this range are not normally vigorous or strong enough to survive as cuttings. The Contractor/Users' Group may be held liable if the success rate of cuttings is seriously lower than the normally expected percentage.

18-2.3.5 Hardwood cuttings must be made using sharp secateurs or a sharp saw. The top cut should be made at right angles to the stem and the bottom cut should be made at 45° to the stem: this is to show the orientation of planting. Under no circumstances must there be any damage to the bark of the cutting.

18-2.3.6 Hardwood cuttings are normally 300 to 500 mm in length and 20 to 40 mm in diameter. This size should not be exceeded for the majority of species unless specified by the Engineer.

18-2.3.7 A number of species can be propagated using large truncheon cuttings. In this category fall chuletro (*Brassaiopsis hainla*), dabdabe (*Garuga pinnata*), kavro (*Ficus lacor*), phaledo (*Erythrina* species) and *Gliricidia sepium*. Hardwood cuttings for these species should be in the range of 1500 to 2500 mm in length and 30 to 80 mm in diameter unless otherwise specified.

18-2.3.8 Once cuttings have been made, they must be wrapped in wet hessian jute immediately. At all times, cuttings are to be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as taking from the parent plant,

trimming and planting. Under any circumstances, all cuttings must be planted the same day that they are made.

18-3 NURSERY CONSTRUCTION

18-3.1 General

18-3.1.1 The Contractor/Users' Group shall provide nurseries to contribute stocks of grasses, shrubs and trees for planting operations as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required by the Engineer. The Contractor/Users' Group shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

18-3.1.2 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/Users' Group should seek the advice of specialist agencies and should refer to the large number of reference books available on the subject.

18-3.1.3 The purpose of a nursery is to supply good quality, healthy plants of the correct type and species, at the precise time they are required, and at a reasonable cost.

18-3.2 Nursery Establishment

18-3.2.1 The Contractor/Users' Group shall provide nursery facilities adequate to supply all of the stock required for planting operations. Alternatively, he/she may procure planting stock from elsewhere at the time of site planting, providing it is of a standard acceptable to the Engineer and as described hereunder.

18-3.2.2 In selecting a site for a nursery, the Contractor/Users' Group must fulfil the following requirements.

Nurseries must be as close as possible to all sites to be planted. They must be at the same altitude as, and in an identical climatic area to, the sites to be planted.

Wherever possible, nurseries must be established on land owned by the DDCs if it is available and bio-physically suitable. If it is not, other land of His Majesty's Government should be used if it is available.

Nurseries should have a reliable and adequate supply of water which remains constant throughout the later part of the dry season.

Nurseries should have all weather vehicular access.

Nurseries should have a perimeter of stock proof fencing, effective against all domestic animals.

Nurseries should have a weather and pest-proof office cum seed store and proper storage facilities for seed. Seed must be kept cool, dry and in sealed containers, as specified in clauses 18-1.2 and 18-1.3.

All nurseries should be provided with two compost pits. These will be used on an alternative basis to ensure a continual supply of compost.

Where a nursery is established on a slope exceeding 2°, the ground must be levelled by terracing before beds are constructed.

A constant staff of qualified and experienced people must be provided.

There must be adequate space in each nursery location for all operations to be performed in the cycle of work. In particular, all plants need to be spaced out periodically as they grow and there must be adequate bed area to accommodate them.

18-3.3 Construction of Nursery Beds

18-3.3.1 Nursery beds must be made in a different way according to their purpose. The Contractor/Users' Group must ensure that there are adequate beds available for all the operations to be undertaken in the nursery.

18-3.3.2 There must be paths around all beds to ensure the best possible access for operations such as weeding and watering.

18-3.3.3 **Table 18 -3** below summarises the construction details of the four main bed types, which are described in full in clauses 18-3.3.4 to 18-3.3.7.

Table 18 -3 : Construction Details of Nursery Beds

Bed Type

Beds for grass seeds, grass slips and tree stool cuttings
Seed beds for tree seedlings
Stand out beds for polypots seedling
Beds for the propagation of bamboo culm cuttings

Bed Size

1 m wide x 0.25 m high
1 m wide x 0.17 m high
1 m wide x 0.15 m high
1 m wide x 0.3 m high

Details of Construction

50 mm of washed gravel placed above the ground; then 50 mm of 1:1 mix of sieved soil and compost; and topped with 150 mm of 3:1 mix of sieved forest topsoil and washed sand.
50 mm washed gravel placed above the ground; then 50 mm of 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 sterilised sand.
50 mm layer of gravel placed above compacted ground. A flat stone or brick surround.
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 100 mm high is formed around the edge.

18-3.3.4 Soil beds should be constructed to hold grass seeds, grasses being propagated by vegetative means and tree stool cuttings. These can be of any practical length but must be flat and of one metre in width. They should rise to a height of 250 mm above the surrounding ground. They are made up as follows: 50 mm of washed gravel is placed above the ground; then 50 mm of 1:1 mix of sieved soil and compost; and the bed is topped with 150 mm of 3:1 mix of sieved fertile, loamy forest topsoil and washed sand. All sieving should be done with a mesh size of 2 mm or smaller. One square metre of such a bed will contain 100 grass slips spaced at 100 mm centres within rows at 100 mm centres and will produce at least 300 slips for planting out, depending on the particular species, and the soil and climate of the nursery.

18-3.3.5 Seed beds must be very carefully for germinating small seeds of shrubs and trees. These can be of any practical length but must be flat and of one metre in width. They should rise to a height of 250 mm above the surrounding ground. They are made up as follows: 50 mm of washed gravel is placed above the ground and then 50 mm of unsieved forest soil: 50 mm of 1:3 mix of sieved forest soil and washed sand: and the bed is topped with 20 mm of washed, sieved and sterilised sand. All sieving should be done with a mesh size of 1 mm or smaller.

18-3.3.6 Standout beds should be constructed to hold seedlings in polythene pots. These can be of any practical length but must be flat and of one metre width. Bed floors should be above surrounding ground level and they should have a 50 mm layer of gravel placed above compacted ground. They should have a surround, preferably made from flat stones or bricks. One square metre of standout bed will contain an average of 115 filled pots of the size specified (100 x 180 mm) when spaced out.

18-3.3.7 Beds for the propagation of bamboo culm cuttings should be made specially. These can be of any practical length but must be flat and of one metre width. They should rise to a height of 300 mm above the surrounding ground. They are made up as follows: the ground below the bed is 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 sieved soil above this. All soil sieving should be done with a mesh size of 2 mm or smaller. Finally, a bund 100 mm high is formed around the edge.

18-3.3.8 Shaded must be constructed over the beds and kept in position over delicate seedlings during hours of intense sunlight, according to need. Shades should be 750 to 1000 mm above the soil or the top of filled pots 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 coir (coconut fibre) string are particularly suitable in most cases; but over tree and shrub seed beds, thatched shades with a polythene lining must be used.

18 -4 NURSERY OPERATION AND MANAGEMENT

18-4.1 General

18-4.1.1 The Contractor/Users' Group must operate the nursery according to a high standard. The nursery is to be staffed well tended at all times. It must be maintained in a clean, tidy and efficient manner at all times. Plants must always be healthy and vigorous.

18-4.1.2 Due to the nature of bio-engineering works, nurseries will normally be operated and managed by small local contractors or users' groups with a range of agricultural skills. Nurseries may also be operated and managed by direct employees of the DDCs of concerned.

18-4.1.3 Plants must be kept properly weeded at all times.

18-4.1.4 Watering, as required for good plant growth, must be carried out regularly in the cool of the evening between sunset and dusk. The Contractor/Users' Group must ensure that the soil in all beds is kept moist but not saturated at all times. Beds must be kept moist even when empty, so that the soil is kept in good condition.

18-4.1.5 The timing of many nursery operations is of the utmost importance. Activities such as seed sowing and the taking of cuttings must 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, must also be carried out in a timely manner. The Contractor/Users' Group is responsible to keep works to the strict schedule required and under no circumstances to permit delays.

18-4.2 Nursery Production of Grass

18-4.2.1 Grass will be propagated in nurseries either by seeding in carefully prepared beds or by vegetative propagation.

18-4.2.2 Where grass seeding is required in the nursery, finely sieved fertile soil mixed with clean sand to a texture of sandy loam must be placed in beds before the seeds are sown. Seeds will be covered with a sheet of hessian jute until they have germinated, when it will be carefully removed. Watering of fresh seedlings will be by a fine spray and not by the use of a watering can.

18-4.2.3 Grasses to be propagated by vegetative methods will be of the species instructed. The Contractor/Users' Group should obtain adequate quantities of the plant material required, but under no circumstances is he/she to cause serious depletion of grass stocks in any steep or erosion-prone area.

18-4.2.4 Vegetative propagation will normally be by rhizome cuttings. With this method, the grass is treated in exactly the same way as a bamboo being propagated by the traditional Nepalese farmer's technique. A clump is carefully dug up and brought to the nursery, being kept cool and damp at all times. Stems are cut above the first or second node above the ground: this usually gives a length of 100 to 200 mm. The clump is separated carefully, with the minimum of damage to the rhizomes and fine roots. Slips should be separated out which keep a length of stem and about 50 mm of the rhizome. Each slip should have some buds on the rhizome, but in some grasses these can be difficult to see. The slips should be planted with the soil surface at the same level as it was originally, in rows at 200 mm centres; slips should be at 200 mm centres within the rows. A sheet of hessian jute should be placed over the tops of the cuttings. When the new shoots are about 50 mm long, it can be removed.

18-4.2.5 Every two to three months, all grasses should 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.

18-4.3. Nursery Production of Tress and Shrubs in Polypots

18-4.3.1 Tress and shrubs will 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 must be placed in well shaded beds for seeding. Watering of fresh seedlings will be by a fine spray, and not by the rose of a watering can.

18-4.3.2 All plants must be grown on in pots of dimensions 100 x 180 mm (4 x 7 inches) or greater when laid flat. The pots should be of black, 200 gauge polythene. They must have adequate drainage holes at the bottom and be filled with fertile forest topsoil mixed with clean sand to a texture of sandy loam.

18-4.3.3 Roots protruding from the bottom of pots must be pruned with a razor blade on a regular basis which will not exceed weekly and may need to be more frequent. Protruding roots should never be allowed to become more than 25 mm in length.

18-4.3.4 When polypot seedlings begin to compete with each other for light, they should be re-spaced as required. This would typically mean doubling the bed space occupied by the plants.

18-4.3.5 To be acceptable for planting on site, trees and shrubs must be healthy, vigorous and showing no signs of damage, wilt, irregular growth, fungal or pest attack, or nutrient disorders. They must be at least 300 mm in height above soil surface level and of good form. The roots must be in good condition and there should be no signs of disturbance to the soil in the polythene pot, even after transport to site.

18-4.4. Nursery Production of Hardwood Plants by Vegetative Methods

18-4.4.1 Trees and shrubs which can be propagated by vegetative method may be specified by the Engineer. The Contractor/Users' Group should produce these by the appropriate method, as required.

18-4.4.2 All cutting and stools must be made as specified in the clause 18-2.3 and planted in fertile soil beds of the typed specified in clause 18-3.3.

18-4.4.3 Cuttings must be planted 300 mm apart in holes slightly larger than their diameter. They must be placed at such a depth that only one bud remains above the soil surface (i.e. about 30 mm of the cutting).

18-4.4.4 When plants compete with each other for light, they should be cut back as necessary.

18-4.4.5 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 disorder. They must be at least 500 mm in height above soil surface level and of good form.

18-4.5 Extraction of Plants from the Nursery

18-4.5.1 The Contractor/Users' Group is responsible for extracting plants from nursery beds and preparing them ready for transport. They should be extracted from the beds only on the morning that they are required for planting on site.

18-4.5.2 Plants must be hardened off, starting at least two weeks before they are to be taken out of the nursery. This process requires a gradual reduction in the amount of watering and shading. The aim is to prepare them for transfer to a much more hostile location.

18-4.5.3 The night before the plants are to be lifted, they should be thoroughly watered. This is to make the soil softer and ease the business of extracting the roots.

18-4.5.4 Plants growing in soil beds should be carefully lifted from the soil. There must be no pulling of stems or roots, but they must be dug out and extracted with no strain on any part of the plant.

18-4.5.5 Plants from soil beds must be wrapped in wet hessian jute. Hardwood plants should have a ball of soil around the roots. Grass clumps have most of the soil shaken or washed off.

18-4.5.6 Polypot seedlings should be lifted and stacked neatly in metal or wooden trays. They must always be lifted by the pot and never by the stem or leaves.

18-4.5.7 All plants are to be kept moist, in a cool, shady place, until they are loaded for transport to site. In the vehicle, they must not be stacked high. For transport on rough roads, they must be packed in carefully so that they do not fall over or roll around. The vehicle must be shaded.

18-4.6 Compost and Mulch Production

18-4.6.1 The Contractor/Users' Group is to produce compost and mulch for nursery or site operations. It is to 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 is normally produced to enhance site planting works, particularly the direct seeding of grass.

18-4.6.2 Compost and mulch should be made from annual and perennial weeds of poor rooting characteristics, such as ban mara (*Eupatorium adenopherum*) and tite pate (*Artemesia vulgans*). The greenery should be collected when there is most material available but before it forms seeds. This is most often in Shrawan and Bhadra.

18-4.6.3 Collected material should 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.

18-4.6.4 Both compost and mulch should be kept moist but not waterlogged and in an aerated condition. They should be completely turned once a month on a regular schedule. Compost can have cow manure mixed in to assist the process of decomposition.

18-4.6.5 Neither compost nor mulch should be applied until they are fully rotted. By this time they should be black and the parts of individual plants should be indistinguishable. Early application can lead to a nutrient loss in the soil if microbes extract nitrogen to decompose the added organic material.

18 -5 FINAL SLOPE PREPARATION FOR BIO-ENGINEERING

18-5.1 General

18-5.1.1 The Contractor/Users' Group shall prepare slopes for planting operations as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor/Users' Group shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

18-5.1.2 In the course of all slope preparation works, it is essential that no damage is done to existing vegetation unless the Engineer's instruction specifically requires certain plants to be removed.

18-5.1.3 The timing of many bio-engineering operations is of the utmost importance. Activities such as planting and seed sowing must be carried out within the critical few weeks when they will yield the desired results. All other operations must be carried out in a timely manner to permit this to happen. The Contractor/Users' Group is responsible to keep works to the strict schedule required and under no circumstances to permit delays.

18-5.2 Cut Slope Preparation for Grass Planting

18-5.2.1 The objective of final cut slope preparation is to produce a surface adequately prepared for grass planting. Grass lines are used to provide a strong surface cover but need a well prepared surface in which to be planted; if grass is to be an effective form of slope protection, it must be allowed to establish properly on a slope which does not subject it to undue stress from erosion and mass movement in its initial stages.

18-5.2.2 The Contractor/Users' Group must ensure that the slope under instruction is trimmed to a straight angle, according to the Engineer's specification. Cut slopes to be planted with grass will normally be instructed a 3 vertical:2 horizontal, but this may be varied at the Engineer's discretion. In any event, a straight profile must be obtained. Concavities must be filled with well compacted material or, in some cases, with dry stone dentition. Convexities must be removed and it is essential that the general profile does not have a shape giving over-steep segments.

18-5.2.3 All loose material must be removed from the slope and tipped elsewhere in an approved location.

18-5.3 Final Preparation of Fill Slopes for Bio-Engineering

18-5.3.1 The objective of the final preparation of fill slopes is to produce a surface adequately prepared for shrub or tree planting or grass sowing, or a combination of these. Vegetation is used to provide a strong surface cover but needs a well prepared surface in which to be planted: if it is to be an effective form of slope protection, it must be allowed to establish properly on a slope which does not subject it to undue stress in its initial stages.

18-5.3.2 The Contractor/Users' Group must ensure that the slope under instruction is trimmed to a straight angle, according to the specification. In any event, a straight profile must be obtained. All masses of loose debris, especially where it has previously been tipped at the head of the slope, must be removed. Concavities must be filled with well compacted material or, in some cases, with dry stone dentition. Convexities must also be removed and it is essential that the general profile does not have a shape giving over-steep segments.

18 -6 SITE PLANTING AND SOWING

18-6.1 General

18-6.1.1 The Contractor/Users' Group shall plant or sow grasses, shrubs and trees as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor/Users' Group shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

18-6.1.2 Due to the nature of bio-engineering works, they will normally be undertaken by small local contractors or users' groups with a range of agricultural skills. Any bio-engineering site activity may also be managed by direct employees of the DDCs concerned.

18-6.1.3 It is the Contractor's/Users' Group'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.

18-6.1.4 All seeds and other planting stock must be of species indigenous to Nepal unless otherwise specified. All species must be covered in the current approved lists of species produced from time to time by the Geo-Environmental Unit of the DoR or the DTPS of DoLIDAR. They must be appropriate for the precise site conditions in which they are to be planted and the Contractor/Users' Group must ensure that they apply to the specific altitude and other environmental characteristics of the site in question.

18-6.1.5 The timing of many bio-engineering operations is of the utmost importance. Activities such as planting and seed sowing must be carried out within the critical few weeks when they will yield the desired results. All other operations must be carried out in a timely manner to permit this to happen. The Contractor/Users' Group is responsible to keep works to the strict schedule required and under no circumstances to permit delays.

18-6.2 Sowing of Grasses on Site

18-6.2.1 The sowing of grasses is intended to create a strengthened slope surface which is resistant to erosion. The Contractor/Users' Group is required to carry out the sowing of grass seeds according to the Engineer's specific instructions.

18-6.2.2 It is assumed that the site will already have been prepared for seed sowing, under a separate instruction; but it is nevertheless the responsibility of the Contractor/Users' Group to ensure that the condition of the site is good enough for the successful establishment of grasses.

18-6.2.3 The Contractor/Users' Group is required to supervise all field operations very closely. The sowing of grass seeds is a delicate business and should be approached in the same way as for agricultural crops. The Contractor/Users' Group should employ experienced agricultural labourers for this work.

18-6.2.4 Seeds will have been collected and stored under a separate instruction well before the time of sowing. However, it is the Contractor's/Users' Group's responsibility to check that it has been carefully stored and remains fully viable.

18-6.2.5 Immediately before sowing, the ground surface should be lightly scarified to ease early root penetration. Seeds should then be laid thinly over the surface. Under no circumstances should they be broadcast, 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/Users' Group is responsible for ensuring that the correct quantities of seeds are used, while giving a good, even cover.

18-6.2.6 A cover of 25 grams of grass seed per square meter of surface should be achieved unless otherwise specified.

18-6.2.7 After sowing, a mulch of prepared and dried cut herbs should 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. Herbs suitable for this and locally available in large quantities are:

tite pate (*Artemisia vulgans*);

tapre (*Cassia* species);

ban mara (*Eupatorium adenophorum*).

However, freshly cut herbs should not be used because of the danger of resprouting and weeding.

18-6.2.8 If specified, the mulch should be secured with jute netting of mesh size 300 x 500 mm and the netting fixed in place using suitable live pegs or hardwood cuttings (e.g. simali, *Vitex negundo*) at one metre centres.

18-6.3 Direct Seed Sowing of Shrubs and Trees on Site

18-6.3.1 The direct sowing of shrubs and trees is intended to create a strengthened slope surface which is resistant to erosion, and anchorage of unstable surface layers. The technique is particularly effective where very stony materials preclude the use of other planting techniques or where the site will be badly effected by disturbance during the planting of polypot seedlings, or where the site is still unstable and does not warrant the costs involved in planting but would benefit from relatively cheap seeding. The Contractor/Users' Group is required to carry out the sowing of shrub and tree seeds according to the Engineer's specific instructions.

18-6.3.2 It is assumed that the site will already have been prepared for seed sowing, under a separate instruction; but it is nevertheless the responsibility of the Contractor/Users' Group to ensure that the condition of the site is good enough for the successful establishment of shrubs and trees.

18-6.3.3 The Contractor/Users' Group is required to supervise all field operations very closely. The sowing of any seeds is a delicate business and should be approached in the same way as for agricultural crops. The Contractor/Users' Group should employ experienced agricultural labourers for this work.

18-6.3.4 Seed will have been collected and stored under a separate instruction well before the time of sowing. However, it is the Contractor/Users' Group's responsibility to check that it has been carefully stored and remains fully viable.

18-6.3.5 Sowing should start at the top of the slope and the labourers should work downwards. Care must be taken not to disturb areas already seeded.

18-6.3.6 To sow the seeds, a small hole should be made in the slope. The tool used to do this depends on the size of the seed. For some seeds, a piece of gabion wire is adequate; for others, a piece of mild steel with a flattened end is required. The hole should 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 should be placed over them. This covering should never exceed 10 mm and should preferably be about 5 mm; it should never be less than this. Seeds should be placed at 50 to 100 mm centres, as ground conditions dictate.

18-6.3.7 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 is 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 depend on the type of seed involved but are generally half that of the quantities used in the nursery. With utis (*Alnus nepalensis*) seed it should be at a rate of 1 gram of seed per square metre.

18-6.4 Site Planting of Grass Slips and Cuttings

18-6.4.1 The planting of grass slips and cutting is intended to create a strengthened slope surface which is resistant to erosion. The Contractor/Users' Group is required to carry out the planting of grass seedlings or rooted cuttings, according to the Engineer's specific instructions. The configuration of planting will be determined according to individual site conditions. It will be either random, contoured or downslope.

18-6.4.2 It is assumed that the site will already have been prepared for planting, under a separate instruction; but it is nevertheless the responsibility of the Contractor/Users' Group to ensure that the condition of the site is good enough for the successful establishment of grasses, and accords with the specifications given in clauses 18-5.1, 18-5.2 or 18-5.3.

18-6.4.3 Using appropriate tools (such as tape measures and spirit levels), planting lines must be marked out with string as required. Unless specified differently, the row spacing to be marked out is as shown in the **Table 18 -6 (a)**.

18-6.4.4 The Contractor/Users' Group is required to supervise all field operations very closely. The planting of grass slips is a delicate business and should be approached in the same way as the transplanting of millet seedlings. The Contractor/Users' Group should employ experienced agricultural labourers for this work.

Table 18 -6 (a) : Spacing of Plant Lines

Planting Configuration Slope Steepness Row Spacing

Random lines
slope less than 30 degrees
slope 30 to 45 degrees
slope more than 45 degrees
1000 mm centres
500 mm centres
250 mm centres

Contour lines
slope less than 30 degrees
slope 30 to 45 degrees
slope more than 45 degrees
1000 mm centres
500 mm centres
250 mm centres

Diagonal lines
all slopes
500 mm centres

Down slope lines
all slopes
500 mm centres

18-6.4.5 The plants supplied to the Contractor/Users' Group should be prepared for planting by the Contractor/Users' Group as given below. The Contractor/Users' Group is to transport them from the nursery wrapped in hessian jute. At all times, plants are to 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 must be planted the same day that they are lifted from the nursery.

18-6.4.6 Grass slips or cuttings should be carefully separated from the clumps to give the maximum viable planting material. Any roots in excess of 25 mm should be cut off using a sharp khukuri or razor blade. Shoots and stems should be lopped off 100 mm above ground level.

18-6.4.7 Planting should be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed. Using a small bar (usually made of mild steel and with a flattened end), a hole should be made that is just big enough for the roots. The slip or cutting is inserted; care must be taken that the roots are not tangled or bent back to the surface. Soil is then replaced around the roots and firmed with the fingers. The spacing of plants within rows should be 100 mm unless otherwise specified.

18-6.4.8 If the soil is dry and there is no rain within 16 to 24 hours of planting, the site should be watered carefully with a fine spray. The Contractor/Users' Group will be required to water for the first two weeks after planting in the event of inadequate rainfall.

18-6.4.9 In certain circumstances it may not be possible to provide grass plants from a nursery. In this case the Engineer will specify the species and expected source of grass plants. It is important to minimise disruption to neighbouring land, in the event that species are collected from areas surrounding the road. It is the Contractor's/Users' Group'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.

18-6.5 Site Planting of Shrubs and Trees Raised in Polythene Pots

18-6.5.1 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/Users' Group is required to carry out the planting of seedlings to the Engineer's specific instructions.

18-6.5.2 It is assumed that the site will already have been prepared for planting, under a separate instruction; but it is nevertheless the responsibility of the Contractor/Users' Group to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

18-6.5.3 The spacing of plants will be determined according to individual site conditions. However, it will normally be at one meter centres unless otherwise specified.

18-6.5.4 The Contractor/Users' Group is required to supervise all field operations very closely. 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/Users' Group should employ experienced agricultural or forestry labourers for this work.

18-6.5.5 The plants supplied to the Contractor/Users' Group will normally be from a nursery as arranged by separate instructions, and will be ready for planting. They should be at least 300 mm in height above the soil surface and hardened off in the normal way. The Contractor/Users' Group is to 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 should not be removed until the moment of planting. Plants are to 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/Users' Group is 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.

18-6.5.6 Planting should be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed.

18-6.5.7 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 should be made at the time of planting. Some compost if available should be mixed with the soil from the slit prior to back filling 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 should then be mulched using any appropriate, locally available material, such as manure, compost, dead leaves or cut herbage. The use of freshly cut ban mara (*Eupatorium adenophorum*) and tite pate (*Artemisia vulgaris*) should be avoided, since it can resprout from the buds after being cut.

18-6.5.8 The Engineer 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 will be of 300 mm diameter and 300 mm depth. In addition, well-rotted compost will be mixed with the soil back fill in a ratio of at least one part compost to ten parts soil.

18-6.6 Site Planting of Hardwood Cuttings

18-6.6.1 Certain trees and shrubs can be planted on site by means of hardwood cuttings. Where these are specified, the Contractor/Users' Group is required to carry out the planting of cuttings as required in the Engineer's instructions.

18-6.6.2 It is assumed that the site will already have been prepared for planting, under a separate instruction; but it is nevertheless the responsibility of the Contractor/Users' Group to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

18-6.6.3 The spacing of hardwood cuttings will be determined according to individual site conditions. However, it will normally be at 500 mm centres unless otherwise specified.

18-6.6.4 The Contractor/Users' Group is required to supervise all field operations very closely. The planting of tree and shrub cuttings is a delicate business and should be approached in the same way as the planting of horticultural cuttings (e.g. those of tea). The Contractor/Users' Group should employ experienced agricultural or forestry labourers for this work.

18-6.6.5 The cuttings supplied to the Contractor/Users' Group will normally be from a nursery as arranged by separate instructions, and will be ready for planting. They should be at least 300 mm in length. The Contractor/Users' Group is to collect the Cuttings from the nursery and transport them from the nursery wrapped in hessian jute. At all times, cuttings are to be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied must be planted the same day that they are lifted from the nursery.

18-6.6.6 Planting should be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed. Using a small bar (usually made of mild steel and with a flattened end), a hole should be made that is just big enough for the cutting. The cutting is inserted and the soil is replaced around it and firmed with the fingers. The cutting should be inserted to a depth such that two-thirds to three-quarters of it is buried.

18-6.6.7 If the soil is dry and there is no rain within 16 to 24 hours of planting, the site should be watered carefully with a fine spray. The Contractor/Users' Group will be required to water for the first two weeks after planting in the event of inadequate rainfall.

18-6.6.8 In certain circumstances it may not be possible to provide cuttings from a nursery. In this case the Engineer will specify the species and expected sources. The Contractor/Users' Group should then obtain the cuttings required in the manner described in clause 18-2.3.

18-6.6.9 The Engineer may specify bigger cuttings for specific areas, using large truncheon cuttings. In this category fall chuletro (*Brassaiopsis hainla*), dabdabe (*Garuga pinnata*), kavro (*Ficus lacor*), phaledo (*Erythrina* species) and *Gliricidia sepium*. Cuttings of these species should be planted at 1000 mm centres. A large crowbar should be used to make the planting hole, but otherwise the technique is as described above for smaller cuttings. Under no circumstances should these cuttings be hammered into the ground.

18-6.7 Brush Layering, Palisades and Fascines

18-6.7.1 Under certain conditions, the Contractor/Users' Group will be required to construct vegetation structures using hardwood cuttings. Where these are specified, the

Contractor/Users' Group is required to carry out the necessary preparation and planting works as required in the Engineer's instructions.

18-6.7.2 It is assumed that the site will already have been prepared for planting, under a separate instruction; but it is nevertheless the responsibility of the Contractor/Users' Group to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

18-6.7.3 The cuttings supplied to the Contractor/Users' Group may be from a nursery as arranged by separate instructions, and will be ready for planting. They should be at least 400 mm long for brush layering, 600 mm long for palisades and 1000 mm in length for fascines. The Contractor/Users' Group is to collect the cuttings from the nursery and transport them from the nursery wrapped in hessian jute. At all times, cuttings are to be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied must be planted the same day that they are lifted from the nursery.

18-6.7.4 If the instruction to the Contractor/Users' Group includes the provision of cuttings, then the Engineer will specify the species and expected sources, and the Contractor/Users' Group must then obtain the cuttings required. This will be done in the manner described in clause 18-2.3 except that the size of cuttings will be of a minimum length of 400 mm for brush layering, 600 mm for palisades and 1000 mm for fascines, and minimum diameters of 30 mm for brush layering, 40 mm for palisades and 50 mm for fascines.

18-6.7.5 Cuttings of the following species, if specified, should be a minimum of 2000 mm in length; chuletro (*Brassaiopsis hainla*), dabdabe (*Garuga pinnata*), kavro (*Ficus lacor*), phaledo (*Erythrina* species) and *Gliricidia sepium*.

18-6.7.6 The Contractor/Users' Group is required to supervise all field operations very closely. The planting of tree and shrub cuttings is a delicate business and should be approached in the same way as the planting of horticultural cuttings (e.g. those of tea). The Contractor/Users' Group should employ experienced agricultural or forestry labourers for this work.

18-6.7.7 Planting should always be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed.

18-6.7.8 Brush layering should 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 should be marked out. From 1 metre below the top of the slope, a precise contour line should be marked out every 1 metre down the slope.

Starting at the top, trenches approximately 400 mm in depth should be excavated along the lines.

Cuttings should then be placed into each trench at 50 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 to three-quarters of their length is buried.

The trench should then be partially back filled and another line of cuttings placed along the trench at 50 mm centres and 100 mm behind the first line, and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line. The trench is then completely back filled and gently compacted. Any loose or excess material is cleared down the slope before the next line is planted.

In some cases it will be specified that cuttings should be placed in a criss-cross fashion. Where this is to be done, one layer of cuttings is laid in the trench at 30 degree to one side of the line of maximum fall of slope. A second layer of cuttings is laid on top of this at 30 degree to the other side of the line of maximum fall of slope. Back filling and compaction are then completed.

18-6.7.9 Palisades should 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 should be marked out. From 1 metre below the top of the slope, a precise contour line should 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 flattened end), a hole should be made that is just big enough for the first cutting. The cutting is inserted and the soil is replaced around it and firmed with the fingers. The cutting must be the correct way up and angled so that it is vertical. The cutting should be inserted to a depth such that two-thirds to three-quarters of it is buried.

This process should 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 must 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 is then completely back filled into any remaining gaps and gently compacted. Any loose or excess material is cleared down the slope before the next line is planted.

18-6.7.10 Fascines are bundles of hardwood cuttings laid horizontally in trenches, and parallel to the line of the trench. The bundles are thereby completely buried. Fascines should 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 should be marked out. From 1 metre below the top of the slope, a precise contour line should be marked out every 1 metre down the slope.

Starting at top, trenches approximately 200 mm in depth should be excavated along the lines.

Cuttings should then be laid along each trench, so that they lie horizontally along the trench. There must be a minimum of four cuttings together. They must be overlapped so that no two ends coincide. The cuttings must then be tied using jute or coir (coconut fibre) 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 should then be back filled and gently compacted. The top of the fascine should be 50 to 100 mm below the surface. Any loose or excess material is cleared down the slope before the next line is planted.

18-6.7.11 The Engineer may specify that orientations other than along the contour of the slope are used. In this event, the Contractor/Users' Group must alter the laying out of lines accordingly and meet the precise angle required.

18-6.7.12 If the soil is dry and there is no rain within 16 to 24 hours of planting, the site should be watered carefully with a fine spray. The Contractor/Users' Group will be required to water for the first two weeks after planting in the event of inadequate rainfall.

18-6.8 Use of Fertiliser

18-6.8.1 Under certain circumstances, the use of chemical fertilisers may be specified in place of farmyard manure or mulching. Unless otherwise specified, the rates given below should be used.

18-6.8.2 Levels of fertiliser application vary according to soil type and nutritional content. However, if nutritional data are not available, the following figures can be used as a rough guide:

Nitrogen: 10 g/m²;
Phosphorus: 5 g/m²;
Potassium: 4 g/m².

Table 18 -6 (b) below lists the chemical composition and percentage of the major plant nutrient elements in the chemical fertilisers commonly available in Nepal.

Table 18 -6 (b) : Chemical Composition of Chemical Fertilisers Commonly Available in Nepal

Commercial Name
Chemical Formula
Percentage

N
P
K

Sulphate of Ammonia
(NH₄)₂SO₄
21
0
0

Urea
CO(NH₄)₂
46
0
0

Triple Superphosphate

CaHPO_4

0

21

0

Muriate of Potash

KCl

0

0

49

Complexol

Unknown

20

9

0

Diammonium Phosphate

$(\text{NH}_4)_2\text{HPO}_4$

18

20

0

18-7 JUTE NETTING WORKS

18-7.1 General

18-7.1.1 The Contractor/Users' Group shall provide and install jute netting as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor/Users' Group shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

18-7.1.2 The Engineer 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 should be applied before the plants are introduced. When planting, the labourers must 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.

18-7.2 Supply of Jute Netting

18-7.2.1 The Contractor/Users' Group will manufacture or obtain a supply of jute netting to the Engineer's specification.

18-7.2.2 The detail specifications for standard jute netting are 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 fibre 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 1.5 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: 0.8 to 1.2 kg per square metre.

18-7.2.3 The detailed specifications for wide mesh jute netting are as follows. "Wide mesh" jute netting is used for holding mulch 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 10.0 metres;
maximum 1.5 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 500 mm rectangular mesh.
- vii) Weight: 0.2 kg per square metre.

18-7.3 Placement of Netting

18-7.3.1 The Engineer will normally instruct the placement of standard jute netting on slopes in excess of 40 degrees. It is therefore a difficult task to place the netting in an effective manner which fulfils the Engineer's purpose. Carelessly placed netting is often useless and can actually be detrimental to the slope surface.

18-7.3.2 It is assumed that the site will already have been prepared for the application of jute netting, under a separate instruction; but it is nevertheless the responsibility of the Contractor/Users' Group 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 must be removed. Concavities must be filled with well compacted material or, in some cases, with dry stone dentition. Convexities must also be removed and it is essential that the general profile does not have a shape giving over-steep segments.

18-7.3.3 Starting at one end of the site to be treated, a roll of netting should be pegged 300 mm above the slope to be covered.

18-7.3.4 The netting should be rolled slowly down the slope. Hardwood cuttings, ideally of simali (*Vitex negundo*) or pegs (usually made from split bamboo culms) should be hammered through the netting at centres of 500 to 1000 mm; they should protrude about 80 mm. Labourers must stand on these cuttings or pegs and not hang on to the netting.

18-7.3.5 This process should be repeated until the entire slope surface is covered. The strips are then laced together with lengths of the same jute yarn, to form a continuous net. The lacing must form joins every 250 mm or less.

18-7.3.6 The tension of the netting must 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 is 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.

18-7.3.7 The netting should then be pegged at 1000 mm centres with staples of 10 mm reinforcing bar at least 100 mm wide and 300 mm long, firmly hammered into the slope face. Additional staples should be used to hold netting closely against the face of concave slope segments.

18-7.3.8 Finally, the bottom of the netting is trimmed to give a tidy finish.

18-7.3.9 In the case of wide mesh jute netting, it will only be specified for use on slopes which have already been treated with grass seed and mulch. These will usually be less than 45° and are therefore easier to work on. However, the process of placing the netting is similar to that for standard netting.

18-7.3.10 Wide mesh netting should be pegged securely at the top and rolled slowly down the slope. Hardwood cuttings, ideally of simali (*Vitex negundo*) or pegs (usually made from split bamboo culms) should be hammered through the netting at centres of 1000 mm; they should protrude about 80 mm. Labourers must stand on these cuttings or pegs and not hang on to the netting. This process should be repeated until the entire slope surface is covered. The strips are then laced together with lengths of the same jute yarn, to form a continuous net. The lacing must form joins every 500 mm or less.

18-7.3.11 The tension of the netting must now be reduced so that it hugs the slope surface precisely and hold the mulch firmly against the surface throughout the area covered. The netting should then be pegged at 1000 mm centres with staples of 10 mm reinforcing bar at least 100 mm wide and 300 mm long, firmly hammered into the slope face. Additional staples should be used to hold netting closely against the face of concave slope segments. Finally, the bottom of the netting is trimmed to give a tidy finish.

18-8 GABION WIRE BOLSTERS

18-8.1 General

18-8.1.1 The Contractor/Users' Group shall provide and install wire bolsters as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor/Users' Group shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

18-8.2 Fabrication of Bolster Panels

18-8.2.1 Bolster panels will be either 5 x 1 metres or 5 x 2 metres in size, according to the type of bolsters to be used. They will be woven with an hexagonal mesh in the same way as normal gabion panels. For the panel frame, 10 swg galvanised wire should be used; for the mesh, 12 swg is adequate. Wire should preferably have a high grade zinc coating. Failing this, a medium grade zinc coating is acceptable.

18-8.2.2 Weaving should start from one of the long sides. A total of 83 coils of wire should be spaced evenly along the 5 metre length. This gives a mesh width of about 60 mm. Each weave should have three twists, as for normal hexagonal mesh. If done reasonably tightly, this gives a length of about 80 mm to each mesh link. In any event, the mesh length should not exceed 90 mm. The mesh should be turned on to the larger frame wire at least one and a half turns and made fully secure.

18-8.3 Placement of Contour Bolsters

18-8.3.1 A contour bolster treatment gives a series of stone-filled wire tubes of 300 mm diameter, laid in trenches cut across the slope. The tops of all the tubes should be flush with the surface of the slope in which they are placed. The purpose is to check scour of the slope surface by preventing the development of rills and gullies.

18-8.3.2 The site to be treated should be given final preparation immediately before bolster installation. All small protrusions and depressions must be obliterated by cutting, or by infilling and compaction.

18-8.3.3 Starting at the base of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out. From 2 metres above the base of the slope, a precise contour line should be marked out every 2 metres up the slope.

18-8.3.4 Starting at the bottom, trenches with circular base should be dug along the lines, adequate to take the final 300 mm diameter tubes.

18-8.3.5 Bolster panels should 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 should be securely joined to the next panel, to form a continuous bolster tube.

18-8.3.6 The panels should be packed with stones, closed over and the edges wired together. All stones must be bigger than the mesh size. The same care should be taken as when filling a conventional gabion basket, and stones must be carefully placed to give good structural integrity.

18-8.3.7 The ends of the bolsters should be closed over and wired together. The trenches around all the bolsters should then be filled and compacted with material left from the excavations.

18-8.3.8 Once all of the lines are in place, all surplus debris should be cleaned off the slope. Mild steel bars of at least 10 mm diameter should then be driven into the slope through the lower sides of the contour bolsters. These should be at least every 2 metres along the lines. Bars should be 2 metres in length on slopes composed of soft materials, but at the Engineer's discretion, on slopes comprising hard rocky materials, bars of 1 metre length will be adequate. All bars must be driven home until the tops protrude no more than 25 mm above the slope surface.

18-8.4 Placement of Herringbone Bolsters

18-8.4.1 A herringbone bolster network is in essence a system of wire tubes of between 300 mm to 1200 mm in diameter depending on the amount of water flowing through the site, laid in trenches cut into the slope. A main bolster runs straight down the slope (the spine) with others running into it at an angle of 30 to 50 degrees to the fall of the slope (the herringbones or branches) depending on slope angle and terrain morphology. The tops of all the tubes should be flush with the surface of the slope in which they are placed or inlaid to allow boulder pitching to be laid over the top. The purpose is both 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 should be at 2 to 5 metre centres if measured straight down the slope.

18-8.4.2 The site to be treated should be given final preparation immediately before bolster installation. All small protrusions and depressions must be obliterated by cutting, or by infilling and compaction.

18-8.4.3 Starting at the base of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out: every 7.1 metres across the slope, a line should 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 should be marked at 45 degrees to the main line (these will form the herringbones).

18-8.4.4 Starting at the bottom, trenches with circular base should be dug along the lines, adequate to take the final 300 mm diameter tubes, or 600 mm diameter tubes if larger (5 x 2 metre) panels are specified.

18-8.4.5 If it is specified that an impermeable lining should be used, then 20 gauge black polythene sheeting must be laid along the bottoms of the trenches and the bolsters constructed on top of this.

18-8.4.6 Bolster panels should 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 should be securely joined to the panels of the main bolster.

18-8.4.7 The panels should 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 should be randomly packed so as to allow free drainage, and all stones must be bigger than the mesh size. The same care should be taken as when filling a conventional gabion basket, and stones must be carefully placed to give good structural integrity.

18-8.4.8 The upper ends of the herringbones should be closed over and wired together; they should touch the ends of the next herringbones but should not be secured to each other. The trenches around all the bolsters should then be filled and compacted with material left from the excavations.

18-8.4.9 Once all of the lines are in place, all surplus debris should be cleaned off the slope. Mild steel bars of at least 10 mm diameter should then be driven into the slope through the sides of the main spine bolsters and the lower sides of the herringbone bolsters. These should be at least every 2 metres along the lines. Bars should be 2 metres in length on slopes composed of soft materials, but at the Engineer's discretion, on slopes comprising hard rocky materials, bars of 1 metre length will be adequate. All bars must be driven home until the tops protrude no more than 25 mm above the slope surface.

18 -9 SITE PROTECTION

18-9.1 General

18-9.1.1 The Contractor/Users' Group is to protect a planted site for the period specified. Protection is to include the prevention of damage to all manner of site works and plants by local people and domestic or wild animals. It also includes an active role in tending the plants and improving their growth, as specified below.

18-9.1.2 Because of the long time required for plants to become robust, the period of maintenance by the Contractor/Users' Group will normally be for twelve months. However, in the case of small contracts, a period of only six months may be specified.

18-9.2 Provision and Role of Site Watchmen

18-9.2.1 The Contractor/Users' Group is required to provide an adequate number of site watchmen to fulfil the specified requirements. The term "watchmen" can be assumed to cover women as well.

18-9.2.2 Watchmen must be mature and reliable characters who need little supervision for the adequate fulfilment of their duties. They must be active and physically fit. Old people who are losing their strength should not be employed. They must be experienced agricultural workers familiar with caring for plants. They must be prepared to remain on site through all hours of daylight and through all adverse weather conditions. They must eat their meals on site and at no time leave the site untended for any reason whatsoever.

18-9.2.3 The role of the watchman is primarily to tend the plants. He must take the initiative in weeding, mulching, replanting failed plants, pruning and protecting plants against all pests. This is an active role requiring individuals with considerable energy and initiative. The watchman must work constantly to maintain and improve the site and its bio-engineering plants.

18-9.2.4 The watchman is also required to protect plants on the site from damage by local people, domestic and wild animals. In doing this he should use a friendly approach to the people as far as possible. The Contractor/Users' Group must educate the watchman fully in the reasons for his/her job, so that he/she can explain to others the importance of safeguarding the plants on the site. He/she should be an effective communicator with others since he/she also fulfils an inevitable function as the ambassador between the DDCs and local road neighbours.

18-9.3 Fabrication of Bamboo Tree Guards

18-9.3.1 The Contractor/Users' Group shall provide bamboo tree guards as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor/Users' Group shall supply all necessary supervision, resources and facilities to ensure that these requirements are met.

18-9.3.2 The bamboo strips used to make bamboo tree guards are to be made from mal bans (*Bambusa nutans subsp cupulata*) whilst the uprights are to be made from tharu or dhanu bas (*Bambusa nutans subsp nutans* or *Bambusa balcooa*). 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 and from the elements for the first 18 months after planting the seedling.

18-9.3.3 The guard is 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 should 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 should be a minimum of 3 years old.

18-9.3.4 Bamboo strips, a minimum of 5 mm thick and 50 mm wide are cut from poles that are at least 2 years old. The bamboo used must be split so that the outer wall remains intact. Only lengths with the outer wall intact are to be used. The split bamboo should be the length of the whole bamboo pole that it is cut from, or as long as possible. The split bamboo must 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 must be woven back into the basket and tied with binding wire to keep it in place. End pieces must not be left sticking out and unbound, because they quickly get broken and the basket starts to unravel from this point. The split bamboo should be woven round the poles so that when they are tightly pressed down there are no gaps in the guard.

18-9.4 Placement of Bamboo Tree Guards

18-9.4.1 Tree guards are to be installed on site at the time of planting, no later than the second week of July, and must be placed carefully around the planted seedlings.

18-9.4.2 The tree guards should be placed over the seedling immediately after planting. The upright posts must be firmly driven at least 200 mm into the ground so that the guard is able to resist bashing and rubbing from cows, buffalo, goats and people. The woven slats should be pushed down firmly from the bottom upwards so that they touch one another and are free from large gaps.

18-9.4.3 Tree guards alone are not adequate protection for small plants. The Contractor/Users' Group must provide a site watchman in addition, for the time specified, to maintain the tree guards and ensure that local people respect them, and generally fulfil all the requirements of clause 18-9.2.

18 -10 SITE AFTERCARE AND MAINTENANCE

18-10.1 The Contractor/Users' Group shall maintain planted bio-engineering sites as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor/Users' Group shall supply all necessary expertise and resources to ensure that these requirements are met.

18-10.2 The Contractor/Users' Group 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 must not be pulled out by the roots since this disturbs the ground surface.

18-10.3 Weeding should be carried out throughout the growing season. It must 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.

18-10.4 The Contractor/Users' Group 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 18-4.6, or the aerial parts of weeds cut on the site or brought from elsewhere for the purpose. The desired plants should be kept mulched at all times but especial care must be taken in the spring, when the soil moisture deficit is at its greatest.

18-10.5 The Contractor/Users' Group 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 will normally be carried out during the monsoon in the year following the first planting works. Vegetation structures will be enriched by the planting of additional cuttings or seedlings, as instructed by the Engineer. Failed seeding areas will be re-seeded at the appropriate time of year.

18-10.6 In replanting and enrichment works, the Engineer may specify the use of different species. This will be done where failures of poor performance of plants may be attributed to poor stock or an incorrect initial choice of species.

18-10.7 All bio-engineering sites must be maintained so that there are at least the following two storeys of vegetation. In certain locations, however, there may be a number of additional vegetation storeys.

i) A dense ground cover of healthy grass plants, in the configuration specified at the time of planting.

ii) An open canopy of shrubs or trees with a deeper rooting network.

18-10.8 In general it is necessary to keep the upper canopy thinned in order to maintain lower ground cover. Most grasses require high light intensities and become degraded if subjected to excessive shade from the over storey. It is therefore the Contractor's/Users' Group's responsibility to thin the canopy as necessary to permit adequate levels of light to penetrate for the optimum growth of the grass under storey.

18-10.9 All thinning and pruning operations are to be undertaken in accordance with the guidelines issued by the Geo-Environmental Unit of the DoR or the DTPS of DoLIDAR. Since these are skilled silvicultural operations, the Contractor/Users' Group must take appropriate professional advice and employ suitably skilled personnel.

18-10.10 All products from thinning and pruning operations are to be disposed of in accordance with the regulations of His Majesty's Government. The Contractor/Users' Group should follow the instructions of the Engineer in this regard.

18-10.11 Other maintenance operations are to be undertaken by the Contractor/Users' Group according to the instructions of the Engineer.

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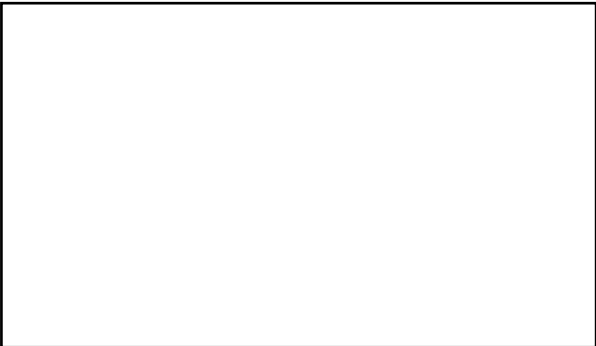
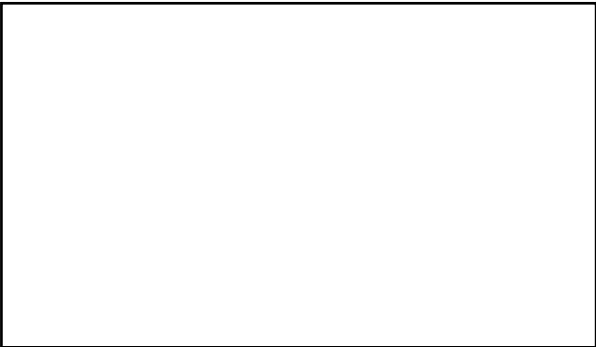
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Technical Specifications

for labour-based construction work of agricultural and rural roads



DoLIDAR/DOC/03

These technical specifications are for the work carried out in agricultural and rural roads in Nepal and shall apply as required under the contracts with Contractors or as per the agreements with Users' Groups or Local Labour Groups. In all cases, the work shall be executed as per the Specifications or otherwise as directed by the Engineer and shall confirm to the location, lines, dimensions, grades and cross-sections shown on the drawings or as indicated by the Engineer.

This document covers EIGHTEEN different areas for which separate Sections are prepared as follows. The general aspects such as definitions, scope of work, construction equipment, engineering drawings, site information, setting out, public utilities, precautions for safeguarding the environment, general rules for the measurement of work, etc. are covered in the 'General' Section, given at the beginning.

Section 1	:	Site Clearance
Section 2	:	Earthwork and Drain
Construction		
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Section 5	:	Quality Control for Road Works
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The quality of work and material shall comply with the minimum requirement or higher than what is requisite in the respective Sections of these Specifications. Where the Specifications and the drawings described a portion of the work only in general terms or in other words do not cover the details, it shall be understood that only the best general practice is to be followed and the materials and workmanship of the best quality are to be employed within the limitations prevailed at site. In such cases, the work shall fully comply with the instructions received from the Engineer at site.