नेपाल सरकार
संघीय मामिला तथा स्थानीय विकास मन्त्रालय
स्थानीय पूर्वाधार विकास तथा कृषि सडक विभाग
(डोलिडार)

श्रीमहल, पुल्चोक, ललितपुर

प.श.०६१।६२ मिति २०७२।१२।१८
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श्री जिल्ला विकास समितिको कार्यालय, सबै

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विषय: कार्यान्वयन सम्बन्धमा ।

प्रस्तुत विषयमा यस विभागबाट तयार पारिएको *Quality Control Hand Book : Vol I & Vol II* मंन्त्रालयको मिति २०७२।१२।०२ को (सचीव स्तरिय) निर्णयानुसार स्वीकृत भएको ब्यहोरा अवगत गराउँदै तहांबाट सम्पादन हुने ग्रामीण सडक निर्माण तथा मर्मत सम्भार कार्यहरुको गुणस्तर सुनिश्चितताको लागि उक्त *Hand Book* अनिवार्य रुपमा प्रयोग गर्नु गराउनु हुन जानकारी गराइन्छ ।

रामकृष्ण सापकोटा
महानिर्देशक

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Ministry of Federal Affairs And Local Development
Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)

Quality Control Handbook for Rural Road Construction and Maintenance

(Volume-I)

Quality Control Requirement
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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR) was establish under the Ministry of Federal Affairs and Local Development (MoFALD) with an objective to undertake infrastructure development programs in accordance with decentralization policies for attaining the goals set forth by the Government of Nepal's National Strategy for Rural Infrastructure Development by making the local authorities technically capable and competent and ensuring their accountable participation.

DoLIDAR in co-ordination with the other departments (Department of Roads, Department of Irrigation, Department of Urban Development and Building Construction, Department of Water Supply and Sewerage, Department of Electricity Development) and in accordance with national policies it is carrying out the development works in planning, design, and arrange for construction and maintenance of agricultural and local road,network, irrigation cannels and river protection works. Also it manages, arrange and undertake other infrastructure development works in the field of water supply and sanitation, trail bridges, housing and building, rural energy ect.

To achieve its goal, DoLIDAR is undertaking for the planning, design, construction and maintenance of rural roads as well as other infrastructure developments in all the districts of Nepal through District Technical Offices (DTO). Hence, (DoLIDAR) provides the overall administrative, technical and program support to the District Technical Offices (DTO) in the execution of works. In addition to this DoLIDAR is working with the international development partners as World Bank, Asian Development Bank, DFID, SNV etc in building the rural roads by upgrading the fair weather roads to all weather roads. Emphasis is given on planning, design, construction and maintenance of rural roads based on sound engineering principles, which conform to specifications, present codes of practice and other relevant standards (BS/IS/NS/AASHTO etc).

DoLIDAR with the support of World Bank (WB) has completed a major rural road program under Rural Access Improvement and Decentralization Project (RAIDP) for the improvement and upgrading the rural roads in 30 districts of Nepal. The project was focused on construction of good quality all-weather roads to provide connectivity to habitations with in the walking distance ranging between two hours in tearai and to four hours in mountain and hills . To enhance the quality of works RAIDP supported the DDCs in establishing the Material Testing Laboratory in all 30 participating districts and provided training to DDC/DTO technicians on material testing. A comprehensive document on testing of material "Manual of Quality Control For Local Infrastructure works" has been brought in practice to the facilitate the lab technician in conducting the test for construction material at the field level. In addition to this RAIDP has prepared draft Interim Quality Control Hand Book for quality assurance of construction and maintenance, of the rural roads in Nepal.

DoLIDAR with support of World Bank (WB) has established a new program Strengthening THE National Rural Transport program as the follow on program of the RAIDP for the maintenance and improvement of Rural Roads in 33 districts in Nepal. SNRTP plans to establish three additional material testing laboratories in three additional districts included in SNRTP and finalized the Draft of Interim Quality Control Hand Book for use in construction and maintenance of the rural roadS.

1.2. QUALITY CONTROL

Rural Road Projects are very small in size and constructed in remote area where basic facilities like electricity and drinking water supply and access to heavy plant and equipment are limited. In addition to that the materials which are locally available are low in cost and hence are widely used for the rural road construction. Keeping in view of above constrains and factors such as Quality of materials, and workmanship, reliable quality control system for supervision & monitoring of works are essential for the construction and maintenance of rural roads.

Supervision and Monitoring is an important tool for the quality control where as quality control system deals with establishment of functional material testing laboratory, inspection and testing the construction materials according to the specified standard, checking the work methodology and workmanship including design for the road works. Quality of end product depends upon the quality of materials and construction workmanship. Poor workmanship leads to inferior quality of end product even if the materials used are of good quality. With poor quality material, it is almost impossible to attain desired strength. Therefore, utmost care is needed to ensure that proper material is used in the construction work. Hence, quality control in material selection cannot be over-emphasized. The design strength and function can only be attained if the specification is strictly followed while selecting/approving material and performing the work.

During developing of a suitable Quality Control System the above constrains should be considered for the Construction and Maintenance of road works. The types and frequency of the tests for such projects should be specified carefully so that they are attainable during the prevailing conditions.

1.2.1 QUALITY CONTROL SYSTEM

The Quality Control System comprises the methods, procedures and organization for the Quality Control of the works. The implementation of the Quality Control System is in the following sequence:

(1) Sequence

(a) Complaint testing for materials including laboratory trials,

(b) Complaint testing for methods and equipment prior to the commencement of the work,

(c) Control testing during construction,

(d) Acceptant testing on completed works or parts of the works.

It is the responsibility of the contractor to carry out all necessary tests for materials and works and submit report of such tests to the Engineer for approval in accordance with the Specification. In certain circumstances, tests may be required to be carried out at the place of manufacture as specified in the Contract.

For acceptance of the quality of the works, quality control tests are to be conducted by the Engineer himself or by any other agencies deemed fit by the Engineer. Additional tests may also be required to be conducted where in the opinion of the Engineer when such tests are needed.

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

(2) The supply, testing and monitoring shall be in compliance with a Quality Assurance Plan, as detailed below or as per the provisions made in the contract.

1.2.2 QUALITY ASSURANCE PLAN

The Contractor shall submit to the Engineer for his approval, the Quality Assurance Plan (QAP) which shall be based on the detailed testing Programme for the Works as per specified in the Specifications.

The Quality Assurance Plan shall include the following:

(1) The Quality Control Schedule Comprising of:

(a) The recapitulative test schedule and testing program detailing the list of tests for compliance, laboratory trials, site trials and trials Sections, construction control tests and their frequencies, tests for acceptance of the completed works with their dates.

(b) Recapitulative list of "critical" acceptance testing procedures, for equipment or parts of the works which corresponds to the tasks on the Critical Path according to the construction Programme.

(c) Estimate of the number of tests to be carried out, list and number of appropriate equipment required to conduct them, list of tests to be conducted outside the site laboratory, if any, identification of the outside laboratory where proposed to carry out the test.

(d) List of staff assigned to the laboratory, their position and responsibilities in the quality control procedures, their qualification and experience, general description and detailed organization of the laboratory activities.

(2) The list of sources of materials and/or of manufactured articles, their main characteristics, their identification mode as provided by the supplier when required; the program of supply and procurement of material and/or manufactured articles in accordance with the Program submitted by the Contractor.

(3) The list of tests and quality control procedures to be implemented by the Sub-contractors, if any, pointing out the "critical" acceptance testing procedures relating to the Sub-contracted works, which correspond to the tasks on the Critical Path included in the Sub-contracted works.

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

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

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

The Quality Control on Rural Roads construction and maintenance shall be exercised as follows:

(i) Quality Control Tests on Materials before incorporation in the Works:

All materials before incorporation in the work shall be tested by the Contractor for the tests indicated under 'Tests to be carried out Prior to Construction'. The tests shall be carried out from each source identified by the Contractor. The test samples shall be representative of the material available from the source. Any change/variation in the quality of material with depth of strata shall be reported. Important tests like the Moisture-Density Relationship (Proctor Compaction), Aggregate Impact Value, Plasticity Index, California Bearing Ratio (CBR) and any other tests specified by the Engineer shall invariably be carried out in the presence of a representative of the Engineer, who will not be below the rank of Sub- Engineer. The test results shall form the basis for approval of the source and the material for incorporation in the work and shall be approved by the Engineer. For manufactured items, however, such as concrete pipes, elastomeric bearings etc, a test certificate obtained by the Manufacturer from an approved Test House shall be accepted.

(ii) Quality Control Tests During Construction:

During execution of the work, quality control for ensuring conformance to specifications and workmanship shall be exercised on the basis of the tests indicated under 'Field Quality Control Tests During Construction'. The tests shall be carried out by the Contractor independently or in the presence of Employer's representative, normally a Sub- Engineer, when available at site or where association of the Employer's representative in test is prescribed. The Sub-Engineer shall record the results in his own handwriting. The Contractor shall be fully responsible for all the tests carried out for the work. The Assistant Engineer/Executive Engineer during their site visits shall have a few tests carried out in their presence and sign the Quality Control Register.

(iii) Stage Passing

The field supervisory officers of the level of site engineer and project manager shall exercise quality control checks and certify the work of various stage on the basis of tests and frequencies indicated in "Quality Assurance Plan" (QAP). The officers certifying the work at various stages as prescribed shall be responsible for the quality and quantity of the work certified by him.

(iv) Procedure to form part of Contract.

The prescribed tests, frequencies and the procedure for stage passing by Supervisory Officers shall be mandatory and shall form the part of the Contract.

Random Checks

For purposes of Quality Monitoring, only random checks are envisaged. For soils and other road materials being used at site, a representative sample from the borrow pit in use or stockpiled material can be collected at random. Similarly, while checking placement moisture content during compaction, a random sample can be collected and its moisture content determined using a Rapid Moisture Meter. For in-situ density determination by sand replacement method, the location of the test can be selected at random. A similar approach can be adopted during bituminous and cement concrete construction. However, where a completed section is to be checked, the entire completed section should be divided into 10 sub-sections, of equal length. Two such sub-sections may be selected at random for carrying out the identified tests.

Where random checking has been recommended, the procedure to be adopted for random checking shall be as follows:

(i) The complete section to be checked shall be divided into ten sub sections of equal length viz. 0-100 m, 100-200 m, 200-300 m. Of these, only two sub-sections shall be selected for carrying out tests by draw of lots.

(ii) Longitudinal profile shall be tested by a 3 m straight edge in a stretch of at least 9 m length.

(iii) Transverse profile viz. camber/cross fall/ super elevation shall be tested using camber templates at two or three locations for each 100 m length.

Simple/Hand-Feel Tests

For monitoring the quality of work, generally it may not be possible to carry out the detailed quality control tests and therefore, for the purpose of quality monitoring simple/handfeel tests can be performed. Normally various simple tests have been used by the experienced practicing engineers in the field to make a quick assessment of the quality of the product. However, these procedures have not been standardized and involve human judgment. Therefore, these tests which provide useful guidance for supervisory officers during inspections should by no means be used as a replacement of the specified quality control tests. Some simple hand feel tests which are useful for quality monitoring are given in Appendix I.

The requirement of a quality control organization will vary for different projects depending on size of the project. The minimum suggested organization of quality control laboratory set-up at Field, District and Central level shall be as follows:

Field Laboratory

The Contractor shall be responsible to set up and maintain an adequately equipped Field Laboratory for routine tests for quality control required to be conducted on a day to day basis. The Field Laboratory will have normally those test equipment that do not require electric power supply and are relevant to the project specifications. Field Laboratory will be managed by suitably trained personnel in material testing and quality control works, as specified in the contract document.

District Laboratory

The tests which are required to be done during the project planning stage such as those pertaining to suitability of construction materials, selection of quarries etc. to be carried out before incorporation in the work as part of quality control or the tests which cannot be carried out in the Field Laboratory shall be conducted in the District Laboratory. The District Laboratory will cover the testing requirements for the entire District. Such a Laboratory shall be equipped with facilities for most of the tests, including those required for detail Project Report (DPR) preparation.

Central Laboratory

Tests requiring high level of skills and sophisticated test equipment and those tests which cannot be conducted in district level laboratory will be carried out at the Central Laboratory under the control of the Director General or In-charge Quality Control, of DoLIDAR.

Any special or sophisticated tests, for which the necessary equipment and expertise are not available in the Central Laboratory, shall be outsourced, to National Laboratories approved by Government of Nepal or Higher Technical (academic) Institutes or Research Laboratories.

1.3. COVERAGE OF THE HANDBOOK

The Handbook is divided into two volumes:

Volume I: Quality Control Requirements for Rural Road Construction and Maintenance

Volume II: Material Testing Procedure for Rural Road Construction and Maintenance

Coverage of Hand Book Volume I

The Quality Control Hand Book Volume I covers the quality management system and describes in detail quality control of works by Field Units and supervisory staff for various activities of construction and maintenance of rural roads. The Sections in this Volume correspond to the Sections of the Technical Specifications for Agricultural and Rural Roads of the Ministry of Federal Affairs and Local Development/ Department of Local Infrastructure Development and Agricultural Roads.

Coverage of Hand Book Volume II

The quality Control Hand Book Volume II covers the test procedures to be followed to conduct the various tests of construction materials and required equipments and apparatus for the field, District and central level laboratories. The test procedure are followed as per the methods given in the respective relevant IS standard. The objective and significance of the tests have been provided for each tests. A list of equipments with the minimum facilities required for the establishment of the laboratory is provided in this hand book. In addition of that for the ease to the laboratory technicians and technical staff of District Technical Office worked out Examples of some of the tests which are most essential at the field level are presented in the Annex. A list of documents and standards referred in preparation of the hand book is listed in the reference.

CHAPTER 2

QUALITY CONTROL OF WORKS

SECTION-G
GENERAL

G-6. CONSTRUCTION EQUIPMENT

1. For ensuring quality of work, an appropriate technology must be adopted. In the context of rural roads, an appropriate technology implies an optimum blend of manual methods and mechanical equipment of adequate capacity which may also involve in the use of agricultural implements towed by tractor.

2. Make sure that the equipment provided is appropriate to the work with proven efficiency and is properly operated and maintained.

3. Carry a trial run of the equipment before commencement of the work to establish their capacity.

4. Ensure that no equipment is deployed at or removed from the site of work without prior approval of the employer.

G-9. SETTING OUT

A Methodology

1. Establish working bench marks at every 250 m intervals and also at or near all drainage structures/ cross drainage structures on the road. All the bench marks should be tied with the Reference Bench Mark in the area.

2. Setup centre line of the carriageway and make its reference by marker pegs and chainage boards set near the road land boundary at 100 m intervals for roads in plain and rolling terrains. For roads in hilly areas and on curves in plains, the reference pegs should be at every third chainage (60 m) interval. For sharp curves and hair pin bends the interval should be 20 m and 10 m respectively.

3. For hill roads, the valley side top edge of reference pillar shall be at ground level. The top levels of reference pillars should be tied with the level of Bench Mark adopted in the DPR.

4. For hill roads, back cutting line shall be demarcated on the hill face by digging, taking into account the designed slope of hill cutting. Back pillars showing the requisite information should be located at about 1.5 m away (towards hill side) from the back cutting line. Alternatively, back pillars can also be fixed on any permanent existing structures in difficult terrain. Check distance of back cutting line from reference pegs.

5. The markers/ reference pegs should be maintain after preparing a schedule of reference dimensions until the works reach finished formation level and are accepted by the Engineer.

6. Any errors or discrepancies in dimensions and level which does not comply with design drawing found during verification at site shall be informed to engineer and shall be corrected accordingly.

7. Carefully setout and frequently check the lines and levels of formation, side slopes, drainage works, carriageway and shoulders, care being taken to ensure that correct gradients and cross-sections are obtained as per drawing everywhere.

8. Wherever necessary, especially after completion of sub-grade, sub-base and base re-establish the centre line pegs at sufficiently close intervals to determine the edges of base and surfacing accurately.

9. The sectional dimensions of the foundations for culverts shall be set out at the bottom of foundation trench as per drawing and check with reference to original line of reference and axis.

Note:

- Don't commence work until the initial center line is established by marker pegs and cross sections at specified intervals have been approved by the Engineer.
- Frequently check the working bench marks as work proceeds.

Tools and equipment required

Automatic levels, having a standard deviation of ±2 mm per km, shall be used for all double run leveling work. Setting out of the road alignment and measurement of angles shall be done by using Theodolite, Distomat, Total Station (±1 Sec accuracy) with traversing target having an accuracy of 20 seconds. Measurement of distances shall be done generally by using tape measurements.

G-10 & G-16. PUBLIC UTILITIES AND PUBLICLY & PRIVATELY OWNED SERVICES

A Methodology

1. Public and private utilities like water pipes, sewers, electric lines, telephone cables etc as included in contract document should be identified at site by the contractor for the accuracy of the information prior to the commencement of any works.

2. The contractor shall schedule the work in such a manner as to protect the existing utilities/ facilities until they are relocated abandoned or replaced.

2. Arrange and conduct regular meetings with various agencies owning utilities before the commencement and during the period of the works.

3. Provide temporarily support to the utilities affected by the works. Protect utility services during construction period.

4. Any services affected by the works shall be restored immediately by the Contractor who must also take all measures reasonably required by the varies bodies to protect their services and property during the progress of the works.

5. Assist agencies owning the utilities in carrying out the works with approval of the Engineer.

G-11 PRECAUTIONS FOR SAFEGAURDING THE ENVIRONMENT

1. Stand for and follow all laws, acts, rules and regulations in force governing pollution and environment and wild life protection, applicable in the area.
2. Get the approval from concerned authorities for obtaining materials from quarries.
3. Safely dispose the cut materials and unused materials at designated dumping site.
4. Take care to prevent the pollution of natural water source, pools, tanks and reservoirs.
5. The quarry shall be restored as per the contract document.
6. The contractor must take all reasonable steps to minimize dust nuisance during the construction of works along the haul road and the work site by sprinkling water at a frequency specified by engineer.

G-12 TRAFFIC MANAGEMENT AND SAFETY

1. The contractor shall submit traffic management plan to Engineer for approval for those section of road, where chances of obstruction in traffic movement. The plan should include :

- Provision of traffic safety devices and road sign in construction zones
- Provision of flag person
- First aid tool and emergency response arrangements
- Flow of information to public through public media regarding the disturbance.

METHODOLOGY AND SEQUENCE OF WORK

A. Methodology

Prior to start of the construction activities at site, the Contractor shall submit to the Engineer for approval, the detailed method statement. The method statement shall be submitted in two parts.

General Part

The general part of the method statement shall describe the Contractor's proposals regarding preliminary works, common facilities and other items that require consideration at the early stage of the contract. The general part shall include information on:

a) Sources of materials like coarse aggregates and fine aggregates, quantity and quality of materials available in different sources.

b) Sources of manufactured materials like bitumen, cement, steel reinforcement, pre-stressing strands and bearings etc. He shall also submit samples/test certificates of materials for consideration of the Engineer.

c) Locations of the site facilities such as batching plant, hot mix plant, crushing plant, etc.

d) Details of facilities available for transportation of men/material and equipments.

e) Information on procedure to be adopted by the Contractor for prevention and mitigation of negative environmental impact due to construction activities.

f) Safety and traffic arrangement during construction.

g) Implementation of activities provided in Environment Management Plan.

h) Any other information required by the Engineer.

Special part

Special part of the method statement shall be submitted to the Engineer by the Contractor for each important item of work as directed by the Engineer. The statement shall be submitted at least 4 weeks in advance of the commencement of the activity of item of work unless otherwise stipulated in the contract. The statement shall give information on:

a) Details of the personnel both for execution and quality control of the work;

b) Equipment deployment with details of the number of units, capacity, standby arrangement.

c) Sequence of construction and details of temporary or enabling works like diversion, cofferdam, formwork including specialized formwork for superstructure, details of borrow areas, method of construction of embankment, sub-grade and pavement, pile concreting, proprietary processes and products and equipments to be deployed. Wherever required technical literature, design calculations and drawings shall be included in the method statement.

d) Testing and acceptance procedure including documentation;

The Engineer shall examine and approve the method statement with the required modifications. The modified method statement if required shall be submitted within 14 days of the receipt of the Engineer's approval. The sole responsibility for adequacy and safety of the method adopted by the Contractor shall rest on the Contractor irrespective of any approval given by the Engineer.

CONSTRUCTION SURVEY

1. Before the Commencement of works the Contractor shall carry out the construction survey jointly with the engineer, by obtaining the design survey data for Bench Marks from the Project Manager and confirm the co-ordinates and levels of the stations. The required data can be used from the design drawing developed during preparation of Detail Project report (DRP) and provided during the procurement of contract.

2. Setting out of centre lines and benchmarks shall be carried out by the use of standard instruments such as Total Station, Theodolite, and Automatic Levels in accordance to verify the design drawing at the field. Any discrepancies observed during the survey such as replacement for any missing station from the original station shall be informed to the engineer and shall be amended with the approval from the Engineer.

3. The working bench marks shall be at the rate of four per kilometer and also at or near drainage structures, over-bridges. The levels of working bench marks should be approved by the Engineer.

4. All the centre line of the carriageway shall be accurately established as per the design drawing and referenced accurately at an interval of 100 m in plain and rolling terrain and 60 m in hilly terrain respectively and approved by the Engineer. In all curves the beginning of curve, end of curve and apex points shall also be referenced to the satisfaction of the Engineer and approved.

5. The Contractor shall check, replace and supplement as necessary station points and agree any revised or additional station details with the Engineer and get approval.

6. The existing profile and cross-sections shall be taken jointly by the representative of the Engineer and the Contractor. These shall form the basis for the measurements and payments.

7. The lines and levels of formation, side slope, drainage works, etc. shall be carefully set out and referenced accurately to the satisfaction of the Engineer. Care shall be taken to ensure that correct gradients and cross-sections are obtained everywhere as per the design drawing.

8. Jointly prepare the inventory of road structure required including cross drainages and also the dismantling of the existing structure required.

9. Prepare the list of the trees to be removed or cut, shifting or removal of the public utilities and private property to be dismantled.

10. Prepare the construction drawing as per the collected data recorded during the construction survey which shall be the working drawing for the construction period. The prepared drawing shall follow the same gradient for the longitudinal profile as per the design drawing. Any change in the longitudinal profile shall be agreed by the Engineer and approved by him.

11. In the opinion of the Engineer, design modifications of the center lines and/or grade advisable, the Engineer shall issue detailed instructions to the Contractor and the Contractor shall perform modifications in the field, as required, and modify the levels on the cross-sections accordingly.

12. The Engineer shall review the working drawings submitted by the contractor as per Condition of Contract (COC), revise the drawings, if required, approve and issue to the Contractor for the construction purpose.

13. Calculate the quantity of items as per the joint survey works and if the quantity exceed than the original quantity as mentioned in Bill of Quantities (BOQ), the joint survey report shall be the basis for the variation.

14. The Contractor shall provide the engineer with all necessary assistance for checking the setting out, agreement of levels and any other survey or measurement which the engineer needs to carry out in connection with the contract during the entire period of contract. Such assistance shall include
    - **(a)** provision of suitably qualified surveyors to work under the direction of the engineer as required
    - **(b)** provision of all necessary support for these surveyors including assistant, chainmen, labours, handtools, pegs and materials.
    - **(c)** provision of survey equipment (Precision automatic levels, Total station) as required by the engineer for survey works.

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

16. Examination and/or approval of the construction drawing or any other documents submitted by the Contractor by the engineer shall not relieve the Contractor of his responsibilities or liabilities under the Contract.

SECTION 1
SITE CLEARANCE

1. SITE CLEARANCE & DISMANTLING

1-1 Clearing and Grubbing

1. All the unsuitable materials should be cleared from the roadway by cutting, trimming, removing and disposing of all materials, such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150 mm in thickness and rubbish, etc. This should be carried out well in advance of earthwork operations.
2. During clearing and grubbing of site, if top soil is suitable for re-use shall be transported to suitable site and stacked for re-use.
3. All trees, stumps, etc. that falls within the excavation and embankment lines should be cut minimum of 500 mm below the sub-grade level.
4. The depressions below the ground level arising out of removal of trees, stumps, etc., should be filled in layers with suitable material and compacted to the specified density as per the specification.
5. Measurement of trees having girth more than 300 mm should be done as per sizes given in the Bill of Quantities (BOQ).
6. Any ant-hills both above and below the ground shall be removed by excavating to a suitable depth as directed by the Engineer. Cavities/holes in the ground after removal of ant-hills shall be filled with suitable material and properly compacted to the required density as specified.
7. The material after cutting tree shall be stocked at suitable locations
8. All materials that arises from clearing and grubbing operations shall be disposed off at suitable disposal site as instructed by engineer

1-2 Dismantling Culverts, Bridges Pavements and other Structures

1. Existing structures those falls within the roadway and proposed for removal should be dismantled carefully and the resulting materials so removed as not to cause any damage to the part off structure to be retained and any other adjoining properties and utilities
2. Holes and depressions caused by dismantling operations or caused by rats etc. shall be backfilled with approved material and compacted to the required density.
3. All the unsuitable materials that are obtained after clearance shall be disposed to the designated spoil pit.
4. Unless other wise specified in the design drawing the superstructure portion of the culvert/bridge shall be entirely removed and other parts removed up to at least 600 mm below the sub grade, slope face or original ground level which ever is the lowest or as necessary depending upon the interference they cause to new structure.
5. Where existing culvert/bridge are to be extended or otherwise incorporated in the new works only such part or parts of the existing structure shall be removed as are necessary and directed by the engineer to provide the proper connection with the new works
6. The connecting edge shall be cut chipped and trimmed to the required line and grade without weakening or damaging any part of the structure to be retained.

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7. Pipe in pipe culvert shall be carefully removed in such a manner as to avoid damage to the pipe.

Note:

- Take appropriate measures to protect soil erosion and water pollution.
- Stock the top soil for reuse if found suitable.
- Take care of existing poles, fences, signs, monuments, buildings, pipelines, sewers, trees etc. which do not interfere the work and are to be retained

SECTION 2
EARTH WORK

2. Earthwork and Drain Construction

2-1 ROADWAY AND DRAIN EARTHWORK (Earthwork Cutting)

A. Methodology

1. Setout the line of excavation after clearance of site to its line, level, slope, grade and cross section as per the drawing by providing reference pillars/pegs for back cutting lines 1.5 m away from edge of formation on both hill and valley side.
2. The top soil shall be stripped to specified depths and stockpiled for reuse if suitable,
3. Excavation shall be done manually or mechanically. After excavation, the sides of excavated area should be trimmed such as to minimize erosion and ponding, allowing drainage of water naturally.
4. Cross drainage works like scuppers/pipe culverts/small culverts 1 to 2 m span and side drains, shall be so constructed along the formation cutting work, such that there shall least interference with the existing drainage.
5. The sub-grade prepared after cutting the formation should be checked for field density, if the field density of the material in the top 150 mm portion is less than 95 per cent of maximum Proctor density, then the formation material shall be loosened to a depth of 300 mm and compacted in layers (not exceeding 150 mm compacted layers) to 95 per cent of Modified Proctor Density.
6. Cutting should be carried out from top to bottom in hill areas. Special care should also be taken to side slopes and side drains in cutting.
7. Rock that comes up during road excavation shall be removed upto the formation level. Any unsuitable materials that are encountered at the formation level shall be excavated to the extent of 500 mm below the formation level.
8. Granular sub-base material shall be provided to get the specified profile and levels in rocky formation where surface irregularity occurs.
9. For blasting in rock cutting, guidelines given in sub-section 2-2 shall be followed.
10. While excavating in marshy area backfilling shall be done immediately after excavation of marsh. The excavation shall be carried out from one end and proceed in other end across the entire marsh. Ensure that entire marsh are completely removed for the formation width.
11. For widening of existing pavement, the existing shoulders shall be removed to their full width and upto sub-grade level to enable proper compaction in the widened portions.

B. Quality Control Requirements

1. Horizontal Alignment

The horizontal alignment should be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the roadway as constructed should be correct within a tolerance limit of (±) 25 mm.

2. Finishing

Any point on the slopes shall not vary from the design slopes by more than 150 mm measured at right angles to the slope (300 mm in case of rock excavation).

3. Surface Levels

The tolerance of surface level for sub-grade will be (+) 0 mm and (–) 25 mm.

4. Surface Regularity

The maximum allowable difference between the sub-grade surface and underside of a 3 m straight edge shall be 20 mm for the longitudinal profile and ± 0.50 % for the cross profile.

5. Quality Control Tests

Subgrade material shall be tested as per tests given in Table 2-5.4 (B). If the material in the subgrade has a density of less than 95% of maximum dry density(IS:2720 Part 7), the same shall be loosened to a depth of 300 mm and compacted in layers (not exceeding 150 mm compacted layers) to 95% of maximum dry density.

2-2 BLASTING OPERATION

A Methodology

1. Guidelines on Blasting Operations

Ensure that-

(i) All the statutory laws, regulations, rules, etc. pertaining to the acquisition, transport, storage, handling and use of explosives are followed and information describing pertinent blasting method and procedures is furnished by the Contractor prior to starting the work.

(ii) The magazine for the storage of explosive is built to the designs and specifications of concerned authority as per clause 2-2.1.2 of Technical Specifications for Agriculture and Rural Roads and it shall be located at the approved site.

(iii) No unauthorized person is allow to enter the magazine.

(iv) No match sticks or inflammable material shall be allowed in the magazine store.

(v) All explosives are stored in a secure manner and such storage places shall be clearly marked and provided with no smoking sign.

(vi) The blasting operation shall be carried out with the written approval of engineer in presence of police personal and as per the prior arrangement made with the security authorizes of the area.

(vii) The blasting operations remain in the charge of competent and experienced licenses holder supervisors and workmen who are thoroughly familiar with the details of handling explosives and blasting operations.

(viii) The blasting is carried out during fixed hours of the day, preferably during the mid-day luncheon hour or at the close of the work.

(ix) All public utility companies near by the proximity of the site of work are notified sufficiently in advance of the blasting work.

(x) During the blasting operation red danger flags are displayed and placed at 200 m away from the blasting site in all directions.

(xi) Safety arrangements shall be made sufficiently, including positioning of manpower at proper locations to ensure that all persons including workmen are out side from the flagged area at least 10 minutes before the firing.

(xii) A warning siren shall be blown 10 minutes before the firing.

(xiii) Blasting should be as light as possible, consistent with thorough breakage of material.

(xiv) When blasting is done with powder or dynamite, the procedure outlined in Clause 2-2.4.4 of Technical Specifications for Agriculture and Rural Roads should be followed.

(xv) Not more than 10 charges are prepared and fired at a time.

(xvi) After blasting operations, all loose residual material below sub-grade is compacted and any material removed from below sub-grade is replaced with suitable material.

2. In case of misfire, follow the procedure as per the clause 2-2.5 of Technical Specifications for Agriculture and Rural Roads.

3. Carefully maintain a day-to-day account of the explosives in an approved register. Such account shall be open to inspection at all times.

4. Position sufficient guards at proper locations to avoid entrance of persons in the area of influence during the blasting operations.

B. Quality Control Requirements

1. All the materials, tools and equipment used for blasting operations shall be of approved in advance by the concerned authority.
2. Excavation by blasting shall be to the lines indicated in drawings, with the least disturbance to the adjacent material.
3. The magazine shall have a lightning conductor.
4. The fuse to be used in wet locations shall be fully water-resistant for at least 30 minutes after immersing in water.
5. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as will permit sufficient time to the firer to reach a safe point before explosion takes place.
6. Detonators shall be capable of giving effective blasting of the explosives.
7. The blasting powder, explosives, detonators, fuses, etc. shall be fresh and not damaged due to dampness, moisture or any other reason.
8. The charge holes shall be drilled to required depths and at suitable places as directed in clause 2-2.4.4 of Technical Specification for Agricultural and Rural Roads.

2-3 Pre-splitting Rock Excavation Slopes

A Methodology

1. Prepare a operation plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern and sequence of firing. Controlled blasting shall begin with a short test section of a length approved by the Engineer. The test section shall be separated by presplit blasting. Then the separated portion shall be removed by mass blasting

2. All the overburden soil and weathered rock along the top of the excavation for a distance of about 5 to 15 m beyond the blasting limits shall be removed, before commencement of drilling operation of the pre-splitting holes.

3. Make sure that the slope holes for pre-splitting are drilled along the line of the planned slope within the specified tolerances. The drill holes shall be within the range of 60 mm to 70 mm in diameter. No hole shall deviate from the plane of the planned slope by more than 300 mm nor shall any hole deviate from being parallel to an adjacent hole by more than two-thirds of the planned horizontal spacing between holes. The length of presplit holes shall not exceed 900 mm on centers.

4. The maximum diameter of explosives used in presplit hole shall not be greater than one-half the diameter of the presplit hole. Ammonium nitrate composition blasting agents shall not be permitted in pre-splitting operations.

5. Where stemming is required to achieve satisfactory presplit face, stemming material shall be dry free-running passing 10 mm sieve and 90 percent of which is retained on 2.36 mm sieve. Stemmed presplit holes shall be completely filled to the collar.

B Quality Control Requirements

1. Quality control requirements for rock cutting mentioned in Para 2.2B above shall apply.
2. Drilling operations shall be controlled by the use of proper equipment and technique.
3. Only standard cartridge explosives prepared and packaged by explosive manufacturing firms shall be used in pre split holes.
4. The presplit face shall not deviate by more than 300 mm from the plane passing through adjacent holes.
5. When completed, the average plane of the slope shall conform to the slopes indicated on the drawings and at no point shall the completed slopes vary from the designated slopes by more than 300 mm as measured perpendicular to the plane of the slope.
6. In no case shall any portion of the slope encroach on the side drains.

2-4 EXCAVATION FOR STRUCTURES

A Methodology

1 Set up the line, length and breadth of the structure on the ground with reference pillars 1.5m away from the line of excavation.

2. Excavation shall be carried out to the length and width of the footing and sides shall be left vertical where the nature of slope permits it. When the nature of slope does not permit vertical sides, necessary shorting, shuttering and planking or cut the slope to a safer angle or both with regards to the safety for men at work.
3. The excavation shall be carried out to the line and dimensions as shown on the design drawing or as instructed by the Engineer.
4. The depth to which the excavation is to be carried out shall be as shown on the design drawing. Where the blasting is to be carried, the same should be carried out in accordance to clause 2-2 of this handbook.
5. The bottom of the foundation shall be leveled both longitudinally and transversely. The surface shall be slightly watered and rammed, if the surface is not sufficiently wet before the laying of footing.
6. At any point, the foundation material is found unsuitable, remove all such material and refill with suitable material and compact thoroughly in layers not exceeding 150 mm.
7. Where water is encountered during the excavation due to stream flow, seepage, spring, rain or other means adequate measure shall be taken to protect the excavation from coming water by constructing diversion channels, bunds, cofferdams and remove the water-hall be by pumping.
8. When rock or other harder strata is encountered during excavation, the base shall be cut to a firm and level or stepped surface or as instructed by the Engineer. The base shall be cleaned and kept free from all soft and loose material. The rock seams shall be cleaned and filled with cement mortar or grout to the satisfaction of Engineer.
9. The structural works shall be carried out only after approval of the excavated foundation dimension by the engineer.

B Quality Control Requirement

1. The inner slope of the foundation shall be maintained as per the design drawing.
2. The bottom part of foundation shall be excavated in box cutting and the minimum depth of the outer edge shall be 800 mm from the existing ground level or as shown in the design drawing.
3. 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. No ordinary filling by soil shall be allowed in such cases.

2-5 EMBANKMENT CONSTRUCTION

A Methodology

1 The materials (soil) for embankment are obtained from approved sources. Suitable materials available at nearby road excavation are given the preference or any other excavation sites approved by engineer under the contract.

2 Clearance of embankment site is carried out as per section-, Site Clearance.

3 After clearing the site, setup the boundaries of embankment by fixing batter pegs and marking toe lines on both sides at regular intervals as directed. The embankment shall be built/constructed 300 mm wider on either side of Roadway than the specified formation width so that to get proper compaction of the edges and side slopes after trimming the excess width

4. Remove stagnant/pounding water, if any, from the foundation of the embankment.

5. The top soil of the existing ground is stripped to the specified depth not exceeding 150mm and stored for covering the embankment slope if the available embankment material (soil) is not suitable for plant growth..

6. Foundation for embankment construction after removing the top soil/ unsuitable material, shall be prepared as follows:

   (a) For embankment height less than 1.0 m over natural ground, the ground surface should be loosened up to a minimum depth of 150 mm by ploughing or scarifying and compacted to the specified density as per Table.2-5.3

   (b) For embankment height less than 0.5 m over an existing black-topped or gravel road, the black-topping shall be removed and the pavement/ gravel road should be scarified to a minimum depth of 150 mm. All particles shall be reduced to a maximum size of 75 mm and compacted according to Table.2-5.3.

   (c) If the granular/ black topped surface lies within 0.50 m - 1 m of the new sub-grade level, the same should be scarified to a depth of at least 50 mm for achieving bond between old and new material.

   (d) If the existing surface is of cement concrete type and lies within 1 m of the new sub-grade level, the same shall be removed completely.

   (e) For embankment over ground not capable of supporting equipment, successive loads of embankment materials should be spread in a uniformly distributed layer of adequate thickness to support the equipment and to construct the lower portion of the embankment.

7. The size of the coarse material in the mixture of earth used for embankment construction should ordinarily not exceed 75 mm.

8. The soil should be spread over the entire width of the embankment in layers not exceeding 150 mm compacted thickness. The clods should be broken to less than 75 mm size. Each layer is thoroughly compacted by roller at moisture content within (±) 2 % of the optimum moisture content, to the specified requirements as per Table.2-5.3.and finished parallel to the final cross-section of the embankment. (Compacted layer thickness can be increased upto 200 mm if heavy vibratory rollers are used and satisfy the result to the engineer).

9. Compaction of soil should be done at OMC with a tolerance limit of (±) 2 percent. If the moisture content of soil is outside these limits, it shall be made good by adding water or drying by aeration and exposure to sun till the moisture content is acceptable for compaction.

10. Each layer below 500 mm should be compacted to at least 93 percent of the Modified Proctor Density. The top 500 mm of the embankment constituting the sub grade should be compacted to 95 percent Modified Proctor Density according to Table.2-5.3.

11. Ensure that longitudinal and cross profiles should be in conformity with the approved drawings.

12. Approval of the Engineer should be obtained for each finished layer. Subsequent layers shall be placed only after the finished layer has been tested and accepted by Engineer. (Such an approval would require surface level and compaction control tests).

13. When an existing embankment and/ or sub-grade is to be widened and its slopes are steeper than 1 vertical to 4 horizontal, continuous horizontal benches, each at least 300 mm wide, should be cut into the old slope for ensuring adequate bond with the fresh embankment/ sub-grade material to be added.

14. When the width of the widened portions is insufficient to permit the use of conventional rollers, compaction shall be carried out with the help of small vibratory rollers/ plate compacters/ power rammers or any other equipment approved by the Engineer.

15. The filling around culverts and bridges, for forming approaches up to a distance of twice the height of the road from the back of abutment should be done with granular materials and should not be placed until the concrete or masonry has been in position for 14 days. Approval for the sequence of work and equipment should be obtained from the Engineer before taking up the work.

16. The material used for back filling (filling on the back of structures) should free from organic content and having the plasticity index not more than 20 and liquid limit of more than 40. The material shall be filled in layers not exceeding 150mm compacted thickness and compacted to required density as per Table.2-5.3.

B Quality Control Requirements

1. Materials

(a.) The material used in embankment, sub-grade, shoulders, etc. shall be soil, moorum, gravel, a mixture of these or other material approved by the Engineer. It shall be free from logs, stumps, roots, rubbish, etc.

The following types of material shall be considered unsuitable:

(i) Material from swamps, marshes and bogs

(ii) Peat, log, stump and perishable material; soil classified as OL, OI, OH or Pt as per IS:1498.

(iii) Materials susceptible to spontaneous combustion

(iv) Material having liquid limit exceeding 40 and plasticity index exceeding 20

(v) Material with salts resulting in leaching action e.g. sodic soils (pH > 8.5)

(vi) Expansive clay with free swelling index exceeding 50 per cent

(vii) Materials in a frozen condition

(viii) Fill materials with a soluble sulphate content exceeding 1.9 gm of sulphate, (expressed as SO3) per liter, if deposited within 500 mm or other distance described in the Contract, of concrete, cement bound materials or other cementaneous materials forming part of permanent works

(ix) Material with a total sulphate content (expressed as SO3) exceeding 0.5 per cent by mass, if deposited within 500 mm or other distance described in the Contract, of metallic items forming part of permanent works

(b) The size of coarse material shall not ordinarily exceed 75 mm when placed in embankment and sub-grade.

(c) Only the materials satisfying the density requirements given in Table 2-5.1 should be used for the embankment.

TABLE 2-5.1: MINIMUM DENSITY REQUIREMENT FOR SUITABILITY OF EMBANKMENT/SUB-GRADE MATERIALS

S.No	Type of Work	Max. laboratory dry unit weight
(a)	Embankment -	IS:2720, Part 7
	- height upto 3 m	Not less than 14.4 kN/m^3
	- height more than 3 m not subject to flooding	Not less than 15.2 kN/m^3
(b)	Sub-grade, earthen shoulder, back filling	Not less than 16.5 kN/m^3

2. Horizontal Alignment

The alignment shall be considered with respect to the centre line of the carriageway as shown on the drawings. The edges of the roadway as constructed shall be within the following tolerances indicated in Table 2-5.2:

TABLE 2-5.2: PERMITTED TOLERANCES FOR EDGES OF CARRIAGEWAY AND ROADWAY

Description	Plain and Rolling Terrain	Hilly Terrain
Edges of carriageway	(±) 25mm	(±) 25mm

3. Surface Levels

The permitted tolerance in surface level for sub-grade will be +0 mm and (-) 25 mm.

4. Surface Regularity

The maximum allowable difference between the road surface and underside of a 3 m straight edge shall be 20 mm for the longitudinal profile and ± 0.50% for the cross profile.

5. Degree of Compaction

The embankment shall be compacted to satisfy the density requirements given in Table 2-5.3.

TABLE 2-5.3: COMPACTION REQUIREMENTS FOR EMBANKMENT/SUB-GRADE/EXPANSIVE CLAYS

Type of work	Relative Compaction as percentage of maximum laboratory dry density
Embankment below 500 mm	Not less than 93 percent of Standard Proctor Density (IS: 2720 Part 7)
Sub-grade (Top 500 mm of embankment and shoulders)	Not less than 95 percent of Standard Proctor Density (IS: 2720 Part 7)
Expansive clays i) Sub-grade and 500 mm portion just below ii) Remaining portion of Embankment	Not less than 95 percent of Standard Proctor Density Not less than 90 percent of Standard Proctor Density (IS: 2720 Part 7)

6. Quality Control Tests and their Frequency

6.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction and their frequency shall be as given in Table 2-5.4.

Table 2-5.4: QUALITY CONTROL TESTS AND THEIR FREQUENCY FOR BORROW MATERIAL, EARTHWORK FOR EMBANKMENT AND FOR SUBGRADE

Type of Test	Frequency
A. Earthwork for Embankment	
1. Soil Classification as per IS:1498 i) Sieve Analysis (IS 2720 Part 1) ii) LL, PL and PI (IS 2720 Part 5)	One test from each source
2. Modified Proctor Compaction Test (IS:2720 Part 7). Test results to ascertain Dry Density-Moisture Content Relationship.	-do
3. Free Swell Index Test (IS:2720 Part 40).[a]	-do
4. Deleterious Content[b] (i) Organic matter content by loss-on-Ignition method or as per IS 2720-Part 22.	-do
B. Earthwork for Subgrade (Cutting or Filling)	
(i) Tests at 1 to 4, under A above. (In case the soil for embankment meets the prescribed requirements for the Subgrade, the above four tests need not be repeated.) (ii) CBR Test (IS:2720 Part 16) soaked/unsoaked as specified.	One test for each source or change of material

Notes:

(a) Test for free swell index to be conducted only in case of expansive soils.

(b) Presence of deleterious content can be initially detected through colour, odour and existence of any organic matter. Where such observations justify need for further testing, simple tests at (i) above shall be carried out. Detailed testing as per IS:2720-Part 22 and Part 27 shall be done only after presence of deleterious content is confirmed by simple tests.

6.2 Tests During Construction

The quality control tests to be carried out during construction and their frequency shall be as given in Table 2-5.5.

TABLE 2-5.5: FIELD QUALITY CONTROL TESTS DURING CONSTRUCTION.

S.No	Type of Test	Frequency
1.	Maximum Dry Density/ Optimum Moisture Content:	One test for each 1500 m^3
2.	Insitu Density Measurements (IS:2720 Part 28) (Each layer)	-do- (i) One test in each 1000 m^2
3.	Thickness of subgrade layer.	At random

Note:

- Do not allow borrow pits within a distance equal to the height of the embankment subject to a minimum of 1.5 m from the toe of the road embankment
- The depth of borrow pits should be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 0.30 to 0.50 m.
- For widening of existing embankment start earth work from toe line.

2-5-1.SUBGRADE CONSTRUCTION

The sub-grade is top 300 mm compacted layer in embankment or cutting just beneath the pavement crust. The sub-grade in embankment is compacted to a higher standard than the lower layers of the embankment. In cutting, the cut formation, which serves as the sub-grade, is treated similarly to achieve the specified density to provide a suitable foundation for the pavement.

A Methodology

1. Setting out, dewatering, stripping of top-soil etc. for sub-grade construction shall be the same as for embankment construction described in sub-section 2-5.
2. Ensure that the soil for sub-grade meets the specified requirements in terms of physical properties and the specified CBR value for pavement design.
3. Compact each layer of the material in the sub-grade at OMC (±) 2% to at least 95% of Maximum Dry Density.
4. If the difference between the sub-grade level (top of the sub-grade on which the pavement rests) and ground level is less than 300 mm and the ground does not have the needed 95% relative compaction, loosen the ground upto a level 500 mm below the subgrade level, correct moisture content to OMC (±) 2% and compact in layers to 95% of the maximum dry density.
5. If the sub-grade soil does not possess the requisite engineering properties like highly plastic black cotton soil and other weak soils yielding very low soaked CBR values, the same should be improved in strength (CBR) and workability by replacing suitable material having high CBR value as instructed by the engineer.
6. For a road in cutting, prepare the sub-grade in accordance with subsection 2-1 to receive a sub-base course.

7. Ensure that the sub-grade is compacted and finished to the design strength consistent with other physical requirements.

8. Maintain the surface of sub-grade, at all times during construction, at such a cross fall as will shed water and prevent ponding.

B. Quality Control Requirements

1. Materials

(i) The material used for sub-grades shall be soil, moorum, gravel, a mixture of these or any other approved material. Material considered unsuitable for embankment construction as per subsection 2-5 shall not be used for sub-grade.

(ii) The material for sub-grade shall be non-expansive in nature.

(iii) Where an expansive clay with acceptable "free swelling index" value is used as a fill material in embankment, the sub-grade and top 500 mm portion of the embankment just below the sub-grade shall be non-expansive in nature.

(iv) Any fill material which yields a maximum dry laboratory unit weight of less than 16.5 kN/m3 shall be considered unsuitable for use in sub-grade.

(v) The size of coarse material in the soil shall ordinarily not exceed 75 mm when placed in the sub-grade.

2. Surface Level

The permissible tolerances in surface levels of sub-grade shall be (+)0 mm and (-) 25 mm.

3. Surface Regularity

The maximum allowable difference between the sub-grade and underside of a 3 m straight edge shall not exceed 20 mm for longitudinal profile and ± 0.50% for cross profile.

4. Quality Control Tests

4.1 The Quality Control Tests on Earthwork for Sub-grade (in cutting or filling) and their frequency, prior to construction, shall be as per **Table 2-5.4**.

4.2 The Field Quality Control tests during construction shall be as per Table **Table 2-5.5**

2-9 SURFACE/ SUB-SURFACE DRAINS

SURFACE DRAIN

A. Methodology

1. Ensure that the surface drains/roadside ditches are provided strictly according to the Design Drawing.
2. Excavate to the specified lines, grades, levels and dimensions.
3. Remove all excavated material from the area adjoining the drains. If the excavated material is found suitable, utilize in embankment/sub-grade construction, otherwise dispose of the material away from the road site.
4. Ensure that the excavated bed and sides of the drains are in conformity with the specified dimensions, levels and slopes.
5. Provide proper gradients and fix the invert for quick disposal of water to the outfall.
6. For any stretch of the rural road passing through a built-up area, ensure that any water coming from the adjacent habitations discharges only into the drain and is not allowed to flow over the road surface.
7. Any sharp edges, where cut/fill surfaces meet the ground level, should be rounded off to prevent erosion and promote turffing.
8. Provide safe outlets to natural or artificial water courses.
9. Provide catch water/intercepting drains on hill slopes to intercept water from upper reaches, such drains to be provided over stable slopes only, outside any slide or unstable areas.

B. Quality Control Requirements

1. Materials

(a) For, lined drain with random masonry coursed, M 7.5 grade of cement sand mortar should be used

(b) For unlined drain turf and variety of grass shall be used for erosion control .

(c) The materials used for other types of linings like brick masonry, stone masonry etc. must meet the relevant specifications given in Sections 7 and 8 respectively.

2. Dimensions

The cross-section and side slopes should conform to the specified dimensions.

Note:

- Ensure that the gradients are adequate for free flow of water to the outlet without overflowing or pounding or undue siltation.
- Do not allow the bottom of roadside ditch/drain to be below the bed of the cross-stream at an outlet and do not provide any catch water/ intercepting drain in any slide area/unstable area.
- In high gradient more than 7%, provide step on the surface of the side drain to reduce the velocity of water flow.

SUB-SURFACE DRAINS

A Methodology

1. Mark the area to be excavated as per the drawing by reference pegs 1.50m away from the cut line.
2. Excavate the trench for sub-surface drain as per the specified lines, grade and dimensions on the design drawings. The sides of the trench shall be as vertical as could be.
3. The excavation shall started from outlet end of the drain and proceed towards the upper end.
4. If unsuitable material is found at the trench bed, such material shall be removed and refill the trench by suitable material with required compaction.
5. 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 specified density or to the satisfaction of the Engineer. The pipe shall then be firmly embedded on the bed.
6. Perforated pipes, unless otherwise specified, shall be placed with perforated holes facing upwards wrapped with geo-textile in order to minimize clogging. Pipes shall be joined securely with appropriate couplings, fittings or collars.
7. After completion of the pipe laying, filter material of the required grading as specified shall be placed over the pipe to the required level in layers, each having maximum compacted thickness of 150 mm.
8. Outlets of pipes shall be carefully positioned to avoid any possible blockage. 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 or sealed with dry stone/ stone masonry depending on the condition of the site. Further, the pipe in this section shall not have any perforations.

B. Quality Control Requirements

Tests prior to construction

Table 2-5.6 FIELD QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No	Material/Work	Test/Check	Frequency
1	Filter Material	Gradation	One test per source
2	PVC Pipe (Perforated)	Diameter of pipe; Manufactures defects, Manufacture's Certificate	At factory before delivery &

Tests/Check during Construction

Table 2-5.7 FIELD QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No	Material/Work	Test/Check	Frequency
1	Bedding	Length, Breadth and thickness of bedding material	While laying
2	Laying and Jointing of pipe	Invert level, Longitudinal gradient Jointing of Pipes	While laying, before back filling
3	Backfilling by filter material	Gradation	One set of test for every 50 m^3 and part of it
		Filling of trench on both side of pipe	After laying the pipe

TABLE 2-5.8: Grading requirements of Filter Materials

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 microns	30 - 75	5 - 15	-
300 microns	10 - 30	0 - 7	-
150 microns	0 - 10	-	-
75 microns	0 - 3	0 -3	0 - 3

SECTION 3
GRANULAR SUB-BASES, BASES & SHOULDER

3-1 GRANULAR SUB-BASE

A Methodology

1. Use the materials from approved sources. The material should be natural sand, moorum, gravel, crushed or broken stone, over burnt brick aggregate, or a combination thereof and it shall conform to grading and physical requirements indicated in Table 3.1.1
2. When the sub-base material consists of a combination of materials from different sources, mixing shall be done mechanically at stock piled yard.
3. Before laying the sub-base material remove all vegetation and other extraneous material etc. from the sub-grade already prepared, lightly sprinkle with water, if necessary, and roll with two to three passes of 80-100 kN road roller or any other suitable compactor/vibratory roller. Repair/correct any defect on prepared sub-grade prior to laying the sub-base.
4. The sub-base material should be spread in layers not exceeding 150 mm compacted thickness.
5. If the thickness of the sub-base is more than 150 mm, successive layer shall be laid after obtaining approval of the Engineer for previous layer. Such an approval would require surface level and compaction control tests.
6. Each layer shall be uniformly spread and thoroughly compacted as specified.
7. Compaction should be carried out at OMC, with a tolerance limit of ±2%. If the loose material is dry, as compared to OMC, water should be added by sprinkling and thoroughly mixed for uniform wetting. If water content is higher than the optimum, it should be left exposed to sun and dried till the moisture content is acceptable for compaction. Each layer should be compacted to 95 per cent maximum dry density as per Modified Proctor Test.
8. Rolling shall be carried out longitudinally commencing from outer edge and progressing towards center in straight portion of road. In Curves rolling shall be commence from lower level edge (inner edge) towards upper level edge (outer edge) by moving the roller parallel to the center line.
9. The shoulders should be constructed simultaneously with the sub-base construction.

B Quality Control Requirements

1. **Materials**

(i) **Grading:** The grading for granular sub-base (GSB) should conform to the requirements given in Table 3.1.

TABLE 3-1.1: GRADING FOR GRANULAR SUB-BASE MATERIALS

Sieve Designation	Percentage passing by weight
63 mm	100
40 mm	70 - 100
20 mm	50 - 85
10 mm	40 - 75
4.75 mm	30 - 60
2.36 mm	20 - 45
1.18 mm	15 - 35
0.075 mm (75 micron)	4 - 15
CBR Value minimum	30 %

(ii) Atterberg limits:(IS:2720 Part5) the material passing 425 micron sieve when tested according to IS:2720 Part 5 shall have liquid limit and plasticity index not more than 25 and 6 percent respectively.

(iii) CBR value: The material with a minimum CBR value of 30 % at 95 % MDD will be acceptable for granular sub-base.

(iv) The aggregate Impact Value (IS:5640) shall not exceed 40.

2. Horizontal Alignment

The edges of the sub-base shall be correct within a tolerance limit of (±) 25 mm .

3. Surface Levels

The tolerance in surface level for granular sub-base will be restricted to ± 15 mm. A grid of 10 m by 2.5 m may be formed to check the surface level. The cross profile should conform to the required camber.

The average thickness of any sub-base layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness.

4. Surface Regularity

The maximum permitted difference between the sub-base and 3 m straight edge shall be 15 mm for longitudinal profile and ± 0.50% for cross profile. The cross profile should conform to the required camber.

5. Degree of Compaction

Density shall be 95 per cent of maximum dry density for the material determined as per modified proctor density test (IS:2720part7)

6. Quality Control Tests

6.1 Tests Prior to Construction.

Table 3-1.2 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No	Type of Test	Frequency
1.	Soil Classification i) Sieve Analysis, except for cohesionless soils ii) Liquid and Plastic Limits iii) flakiness Index	One test on the material from each source or on the combined material, as the case may be.
2.	Combined Grading and Plasticity tests on materials from different sources, mixed in the design proportions. This shall be done when materials from more than one source are combined.	One test on the material from each source or on the combined material, as the case may be.
3.	Modified Proctor Compaction Test MDD & OMC (IS:2720 Part 7)	One test on the material from each source or on the combined material, as the case may be.
4.	Aggregate Impact Value Test where soft/marginal aggregates are used (IS:5640)	One test from each source identified by the Contractor.
5.	CBR test on representative sample (IS:2720 Part 16)	One test. (average of a set of three compacted at 95% Proctor dry density. specimens).

6.2 Tests During Construction

The field quality control tests during construction are indicated in Table 3-1.3.

TABLE 3-1.3 : QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No	Type of Test	Frequency
1	Sieve Analysis on the GSB material combined in the design proportions from various sources.	Once per 400 m^3 or part of it and change of source
2	. Liquid and Plastic Limit tests	-do-
3	MDD, OMC	Once per 1000 m^3 or part of it and change of source.
4	Field Density	Once per 1000 m^2 of each layer
5	Thickness of Compacted layer Surface Level Width Smoothness	20 m 20 m 200 m 40 m^2

Notes:

Do not permit organic or other deleterious materials, and do not use materials, which do not conform to the specified requirements.

Do not allow rejected material to remain at site to prevent its reuse. The rejected material shall be marked with lime.

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

A Methodology

1. Prepare the surface on which the WBM course is laid to the lines, grade and cross fall. It should be made free of dust and extraneous material. Large irregularities, where predominant, should be made good by providing profile corrective course.

2. If the WBM is laid over a fine grained soil sub-grade, a layer of 25 mm thick intervening layer of course of screenings (Table 3-2.3 B) shall be spread on the prepared sub-grade before laying of course aggregates.

3. Any existing bituminous surface over which WBM is to be laid shall be completely removed before laying WBM layer.

4. The coarse aggregate should meet the physical and grading requirements laid down in Table 3-2.1 and Table 3-2.2. Coarse aggregate can be crushed or broken stone, crushed slag, over burnt brick aggregate, kankar, laterite meeting the prescribed requirements.

5. The spreading of coarse aggregate shall be done from stockpiles along the side of the roadway or directly from vehicles. The aggregate shall not be dumped in heaps directly on the surface prepared for laying the aggregates nor shall hauling over un-compacted or partially compacted base be permitted.

6. The coarse aggregate shall be spread uniformly on the prepared sub-grade, sub-base or base, as the case may be, to proper profile (by using templates placed across at 6.0 m intervals) in such quantities that would give the required compacted thickness. The thickness of compacted layer should be 75 mm . The appropriate quantity of aggregates is given in Table 3-2.4. The surface should be checked with templates and all high or low spots remedied.

7. Roll the surface with suitable road rollers till aggregates are partially compacted with sufficient

void space left for application of screenings. However, where screenings are not to be applied as in the case of crushed aggregates, compaction shall be continued until the aggregates are thoroughly keyed. If necessary, water shall be sprinkled slightly during rolling.

8. Rolling shall proceed from inner edge to outer edge at the super-elevated portions and from the edges towards the centre in other portions. The edge should be first compacted with roller running forward and backward.

9. Check the rolled surface transversely and longitudinally with templates/ straight edge. Correct the irregularities if any by loosening the surface, adding or removing the needed amount of aggregates and re-rolling until the entire surface conforms to the specified camber/ cross fall and grade.

10. After rolling the course aggregate, apply screenings to completely fill the interstices maintaining a slow and uniform rate, in three or more applications. The screenings should not be damp (moist) at the time of application.

10. Do not apply screenings so fast and thick as to form cakes or ridges on the surface.

11. Continue dry rolling and brooming till no more screenings can be forced into the voids of course aggregates.

12. Sprinkle water on the surface taking care that the underlying layer is not damaged.

13. Sprinkling, sweeping and rolling should continue till aggregates are thoroughly keyed, well bonded and firmly set in its full depth and a grout has been formed of screenings.

14. If it is necessary to add binding material (PI between 4 and 6) after application of screenings. The binding material should be applied in two or more layers at a slow and uniform rate. Generally, the quantity required for 10 m^2 of 75 mm thickness of WBM is 0.06 to 0.09 m^3

15. The process of water sprinkling, sweeping and rolling should continue till the resulting slurry forms a wave ahead of roller.

16. The compacted WBM course should be allowed to completely dry and set before the next pavement course is laid or traffic is allowed.

17. The shoulders should be constructed simultaneously with the WBM construction in accordance with Sub-Section 3-3.

18. The finished surface of WBM should conform to the prescribed tolerances given in **Para B Quality Control Requirement** below. Where the surface irregularity exceeds the tolerances, the WBM layer should be scarified to its full depth over the affected area and corrected by adding or removing and replacing with fresh material.

B Quality Control Requirements

1. Materials

(i) Coarse Aggregate

(a) Physical requirements

Physical requirements of coarse aggregate for water bound macadam for sub-base, base and wearing course should conform to the requirements given in Table 3-2.1. If the water absorption of aggregate is greater than 2 per cent, Soundness test should be carried out.

TABLE 3-2.1: PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WBM

Test	Sub-base	Base	Wearing course
Aggregate Impact value or Los Angeles Abrasion value	Less than 30 Less than 40	Less than 30 Less than 40	Less than 30
Flakiness index	Less than 35	Less than 35	Less than 35
LL	< 20	<20	
PI	<6	NP	NP
Water absorption	< 2%	< 2%	< 2%
Soundness	< 12%	< 12%	< 12%
CBR	>30	>80	

Aggregates like brick bats, kankar, laterite etc. which get softened in presence of water shall be tested for Aggregate Impact Value under wet conditions in accordance with IS:5640.

(b) Grading :

The coarse aggregates should conform to the grading specified in the Contract and meet the requirements given in Table 3-2.2.

(ii) Screenings

The use of screenings shall be omitted in the case of soft aggregates like brick metal, kankar, laterite etc.

(a) Physical Requirements

Screenings should normally consist of same material as the coarse aggregate. However, where economic considerations so warrant, non-plastic material such as moorum or gravel with LL less than 20 and PI less than 6 may be used. Fraction passing 75 micron should not exceed 10 percent.

(b) Grading

The screening shall conform to the grading specified in Table 3-2.3.

TABLE 3-2.2: GRADING REQUIREMENTS OF COARSE AGGREGATE FOR WBM

Grading No.	Size Range	IS Sieve Designation	Per cent by weight passing
I	63 mm to 45 mm	75 mm 63 mm 53 mm 45 mm 22.4 mm	100 90 - 100 25 - 75 0 - 15 0 - 5
II	53 mm to 22.4 mm	63 mm 53 mm 45 mm 22.4 mm 11.2 mm	100 95 - 100 65 - 90 0 - 10 0 - 5

TABLE 3-2.3: GRADING FOR SCREENINGS

Grading Classification	Size of Screenings	IS Sieve Designation	% Passing by weight
A	13.2 mm	13.2 mm 11.2 mm 5.6 mm 180 micron	. 100 95 - 100 15 - 35 0-10
B	. 11.2 mm	11.2 mm 9.5 mm 5.6 mm 180 micron	100 80 - 100 50 - 70 5 - 25

TABLE 3-2.4: APPROXIMATE QUANTITIES OF COARSE AGGREGATE AND SCREENINGS REQUIRED FOR 100/75 mm COMPACTED THICKNESS OF WBM SUB-BASE/BASE/ SURFACING COURSE FOR 10 m^2 AREA

Classification	Course Aggregate			Screenings			
	Size Range in mm	Compacted thickness in mm	Loose Quantity m^3	Stone Screenings		Crushable screenings such as Moorum or gravel	
				Grading classification & Size mm	For WBM Sub-base/ Base course (loose quantity) m^3	Grading Classification	Loose Quantity m^3
Grading I	63 to 45	75	0.91 to 1.07	Type A13.2	0.12 to 0.15	Not uniform	0.22 to 0.24
Grading I	63 to 45	75	0.91 to 1.07	Type B11.2	0.20 to 0.22	-do-	0.22 to 0.24
Grading II	53 to 22.4	75	0.91 to 1.07	Type B11.2	0.18 to 0.21	-do-	0.22 to 0.24

(iii) Binding Material

Application of binding material may not be necessary when the screenings used are of crushable type. Binding material if used as a filler material shall comprise of a suitable material approved by the Engineer having a Plasticity Index (PI) of value 4- 6 in accordance with IS:2720 part 5. The quantity of binding material will depend upon the type of screenings. For estimation of quantities, the following may be adopted: Quantity for 75 mm compacted thickness WBM = 0.06 – 0.09 m^3 / 10 m^2.

2. Horizontal Alignment

The edge of carriageway with WBM surfacing shall be correct within a tolerance limit of (±) 25 mm.

3. Surface Level

The tolerance in surface levels of the WBM would be as under:

(a) Sub-base course (±) 15mm,
(b) Base course (±) 10 mm
(c) Surfacing Course (±) 10 mm

(A grid of 10 m by 2.5 m may be formed to check the surface levels).

The average thickness of any layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness

4. **Surface Regularity**

The maximum allowable difference between the road surface and 3 m straight edge shall be as per Table 3-2.5.

TABLE 3-2.5: MAXIMUM PERMITTED UNDULATIONS MEASURED WITH 3 M STRAIGHT EDGE

Type of Construction	Maximum permissible difference	
	Longitudinal Profile	Cross Profile
WBM	10 mm	±0.5 %

5. **Quality Control Tests**

5.1 **Tests Prior to Construction**

The quality control tests to be carried out prior to construction are indicated in Table 3-2.6.

Table 3-2.6: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Type of Test	Frequency
1. Aggregate Impact Value Test (IS:2386 Part4)	One test from each identified source.
2. LAA	-do-
3. Aggregate Water Absorption (IS:2386 Part3)	-do-
4. Soundness Test of Aggregates (where water absorption, as at 2 above, exceeds 2%) (IS:2386 Part5)	-do-
5. Grading, LL and PI of Crushable Screenings (IS:2720 Part5) (where Screenings are to be used from the same source as the Stone Aggregates, this test is not needed).	-do-
6. LL and PI of the Binding Material, when used	. -do-
7. MDD, OMC, CBR	. -do-

5.2 **Tests During Construction**

The quality control tests to be carried out during construction are indicated in Table 3-2.7.

TABLE 3-2.7 : QUALITY CONTROL TESTS DURING CONSTRUCTION

Type of Test	Frequency
1. Grading of Stone Aggregates and Screenings (IS:2386 Part1)	Once per 400 m^3 or part of it and change of source.
2. Flakiness Index of Stone Aggregates (IS:2386 Part1)	-do-
3. PI of Crushable Screenings/binding material (IS:2386 Part5)	-do-
4. Aggregate impact value (IS:2386 Part4)	-do-
5. MDD; OMC (IS:2720 Part 8) CBR (IS:2720 Part 16)	Once per 1000 m^3 or part of it and change of source.
6. Field Density (IS:2720 Part 28)	Once per 1000 m^2 of each layer
7. Thickness of Compacted layer Surface Level Width Smoothness	20 m 20 m 200 m 40 m^2

3-3. Shoulder Construction

A. Methodology

1. The construction of shoulders (whether hard/gravel or earth with brick or stone block edging) on either side of the road pavement, should be in conformity with the specified lines, grades and cross-sections.

2. The shoulders with specified dimensions should be constructed in layers, each layer matching the thickness of adjoining pavement layer.

3. After a pavement layer and the corresponding layers in hard and earth shoulder portion have been laid and compacted, the construction of next pavement layer and shoulder should be taken up.

4. The adjacent layers having same material should be laid and compacted together. However, where the materials in adjacent layers are different, these should be laid together, but the pavement layer should be compacted first.

5. Where hard/gravel shoulders have to be provided alongside the existing carriageway, the existing shoulders should be excavated in full width and to the required depth to ensure proper compaction.

6. For earth shoulders with brick/stone /concrete edging, the bricks/stone /concrete blocks should be laid on edge, with the length parallel to the transverse direction of the road. These should be laid on a bed of 25 mm sand, set carefully, rolled into position by a light roller/hand compaction and made flush with the finished pavement level.

7. Earth/gravel shoulder should be compacted to at least 95 per cent of maximum dry density.

8. In order to shed off surface water, the required cross-fall should be maintained during all stages of construction. Normally cross-fall on shoulder should be 1 per cent higher than the camber on the main carriageway.

B. Quality Control Requirements

1. Materials

(i) The shoulder material should be selected earth with maximum laboratory dry unit weight not less 16.5 KN/m^3 and LL and PI not to exceed 50 and 25 respectively or granular material quarry waste conforming to the requirements of GSB as per Subsection 3-1.

(ii) For earth shoulders with brick or stone block edging, the bricks should conform to Sub-section 7 and should be of size 225 mm x 110 mm x 75 mm. The stone blocks should conform to Subsection 8.

2. Horizontal Alignment

The edges of the shoulders should be correct within a tolerance limit of (±) 25 mm.

3. Surface Levels

The tolerance in surface levels of the shoulders should be (±) 10 mm. A grid of 10 m x 2.5 m may be formed to check the surface level.

The average thickness of any layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness

4. **Surface Regularity**

The maximum permitted difference between the shoulder and 3 m straight edge will be 10 mm for longitudinal profile and ±0.5% for cross profile.

5. **Quality Control Tests**

The quality control tests and their frequency for earth/hard shoulders should be exercised in accordance with the requirement of the following Sub-section:

Earth Shoulders	-	Sub-section 2-5
Hard Shoulders	-	Sub- section 3-1
Brick Edging	-	Section 7
Stone Edging	-	Section 8

Note:

- Construct shoulders simultaneously with the pavement layers such that each layer of the shoulder matches the thickness of adjoining pavement layer
- Do not compact the shoulder layer before the compaction of the adjoining pavement layer.
- The material for earth shoulders should be good quality, ordinarily not inferior to the subgrade material.

3-4 GRADED CRUSHED STONE MACADAM BASE

A. Methodology

1. Prepare the existing surface on which the crushed stone base is to be laid to the specified lines, grade and cross-section. All ruts, deformations and soft spots should be repaired and the surface compacted to the required density before placing the aggregate base thereon.
2. The aggregate should be uniformly deposited on the prepared surface and spread over the surface covering full width of carriageway to the specified depth.
3. After spreading, the material shall be mixed by grading to full depth.
4. By grading bring the materials from the edge to the centre forming windrows.
5. Spray the windrow with water if required.
6. The windrow is spread back the road depositing all the material to give the correct camber.
7. A second application of water may be required to obtain the correct moisture content for compaction.
8. The layer shall then be compacted with the use of a smooth wheel roller of 80 to 100 kN or vibratory roller to 98 % of maximum dry density.
9. The compacted thickness of any layer laid, processed and compacted at a time should not be more than 150 mm, where a greater thickness is required the graded crushed stone shall be laid in two or more layers.
10. Successive layers shall be laid only after the approval of the previous layer by the engineer. The approval shall be of level and compaction of such layer.
11. The hole made for field density tests shall be covered with M15 concrete with required compaction.

B. Quality Control Requirements

1. Materials

The material shall be crushed stone. The aggregate shall conform to the physical requirements and grading indicated in Tables 3-4.1 and 3-4.2

TABLE 3-4.1: PHYSICAL REQUIREMENTS OF AGGREGATES

Test	Value
1. LAA Maximum(IS:2386 Part4)	35
2. Aggregate Impact Value Maximum (IS:2386 Part4)	25
3. Sodium Sulphate Soundness (SSS) % Maximum (IS:2720 Part27) if water absorption exceed 2%	12
4. Flakiness Index Maximum (IS:2386 Part1)	25
5. Water Absorption*% Maximum (IS:2386 Part3)	2
6. CBR % Minimum (IS:2720 Part 16)	80
7. Crushing Ratio(CR) % Minimum	80
8. Plasticity Index of material passing 425 micron Maximum(IS:2720 Part 5)	NP

TABLE 3-4.2: AGGREGATE GRADING REQUIREMENTS

IS Sieve Designation (mm)	% passing by wt.
40.0	100
31.5	85 - 100
20.0	62 - 92
10.0	40 - 70
4.75	26 - 55
2.36	21 - 53
600 micron	12 - 28
75 micron	2 - 10

2. Horizontal Alignment:

The edges of Crusher Run Material base will be correct within the tolerance of (±) 25 mm.

3. Surface Level

The tolerance in surface levels of crusher run macadam base shall be (±) 10 mm .

The average thickness of any layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 6 mm for longitudinal profile and ± 0.25% for cross profile respectively.

5. Quality Control Tests

Tests Prior to Construction

The quality Control tests for Crusher Run Macadam Base prior to construction shall be as per Table 3-4.3

Table 3-4.3 QUALITY CONTROL TESTS PRIOR TO CONSTRUCYION

Type of Tests	Frenquency
Aggregate Impact Value Test, (IS:2386 Part4) Loss Angles Abrasion value (IS:2386 Part4)	One test on representative sample from each source identified
Flakiness Index Test (IS:2386 Part1)	-do-
Water Absorption Test	-do-
Soundness Test, if the water absorption exceeds 2% (IS:2386 Part5)	-do-
Grading Test (IS:2720 Part4)	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
.Proctor Compaction Test (MDD, OMC)	-do-
CBR	-do-
Crushing Ratio (CR) Test	-do-

Tests during Construction

The quality Control tests for Crushed stone Macadam Base prior to construction shall be as per Table 3-4.4

Table 3-4.4 QUALITY CONTROL TESTS DURING CONSTRUCTION

Type of Tests	Frequency
Aggregate Impact Value Test	Once per 200 m^3 or part of it and change of source
Flakiness Index Test	-do-
Water Absorption Test	-do-
Crushing Ratio (CR) Test	-do-
Grading Test	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
Soundness Test, if the water absorption exceeds 2%	Once per 500 m^3 or part of it and change of source
CBR	As required
Proctor Compaction Test (MDD, OMC)	Once per 1000 m^3 or part of it and change of source
Field Density test	Once per 1000 m^2 or part of it and change of source
Thickness of Compacted layer Surface Level Width Smoothness	20 m 20 m 200 m 40 m^2

Note:

- Ensure that the quantity of water applied is sufficient to prevent segregation of the fine and coarse particles and to achieve the requisite compaction with maximum dry density.
- Use templates at about 6 m apart to check surface to profile.

3-4-1 CRUSHER RUN MATERIAL (IMPROVED SUB-BASE)

A. Methodology

1. Prepare the existing surface on which the improved sub-base is to be laid to the specified lines, grade and cross-section. All ruts, deformations and soft spots should be repaired and the surface compacted to the required density before placing the aggregate base thereon.
2. The aggregate should be uniformly deposited on the prepared surface and spread over the surface covering full width of carriageway to the specified depth.
3. After spreading, the material shall be mixed by grading to full depth.
4. By grading bring the materials from the edge to the centre forming windrows.
5. Spray the windrow with water if required.
6. The windrow is spread back the road depositing all the material to give the correct camber.
7. A second application of water may be required to obtain the correct moisture content for compaction.
8. The layer shall then be compacted with the use of a smooth wheel roller of 80 to 100 kN or vibratory roller. The roller must follow close up behind the grader, but only on the section where grading is completed. The rolling shall be started from the edge to centre at straights and from lower end to higher end on curves. Compaction is done at least 98% of MDD is achieved
9. The compacted thickness of any layer laid, processed and compacted at a time should not be more than 150 mm, where a greater thickness is required the graded crushed stone shall be laid in two or more layers.

B. Quality Control Requirements

1. **Materials**

   The aggregate shall conform to the physical requirements and grading indicated in Tables 3-4-1.1 and 3-4-1.2

TABLE 3-4-1.1: PHYSICAL REQUIREMENTS OF AGGREGATES

Test	Value
1. LAA Maximum	40
2. Aggregate Impact Value Maximum	30
3. Sodium Sulphate Siundness (SSS) % Maximum	12
4. Flakiness Index Maximum	30
5. Water Absorption*% Maximum	2
6. CBR % Minimum	60
7. Crushing Ratio(CR) % Minimum	30
8. Plasticity Index of material passing 425 micron Maximum	NP

**If the water absorption is more than 2 percent, the Soundness test should be carried out as per IS:2386 (Part 5)*

TABLE 3-4.2: AGGREGATE GRADING REQUIREMENTS

IS Sieve Designation (mm)	Percentage passing by weight
50.0	100
40.0	85 - 100
31.5	75 - 95
20.0	60 - 87
10.0	50 - 80
4.75	12 - 32
2.36	7 - 21
600 micron	6 - 17
75 micron	3 - 10

2. **Horizontal Alignment:**
The edges of CRM Sub-base will be correct within the tolerance of (±) 25 mm.

3. **Surface Level**
The tolerance in surface levels of crusher run sub-base shall be (±) 10 mm .

The average thickness of any layer measured at five conjugative points at every 20 m in any section shall not be less than the specified thickness nor more than 120% of the designed thickness. The thickness of pavement layer measured at any point shall have tolerance of + 2.5% and -2% of designed thickness

4. **Surface Regularity**
The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 6 mm for longitudinal profile and ± 0.25% for cross profile respectively.

5. **Quality Control Tests**

5.1 **Tests Prior to Construction**

The quality Control tests for Crusher Run Sub- Base prior to construction shall be as per Table 3-4-1.3

Table 3-4-1.3 QUALITY CONTROL TESTS PRIOR TO CONSTRUCYION

Type of Tests	Frequency
Aggregate Impact Value Test	One to two tests on representative sample from each source identified
LAA	-do-
Flakiness Index Test	-do-
Water Absorption Test	-do-
Soundness Test, if the water absorption exceeds 2%	-do-
Grading Test	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
.Proctor Compaction Test (MDD, OMC)	-do-
CBR	-do-
Crushing Ratio (CR) Test	-do-

5.2 Tests during Construction

The quality Control tests for Crusher Run Sub- Base prior to construction shall be as per Table 3-4.4

Table 3-4-1.4 QUALITY CONTROL TESTS URINGNSTRUCYION

Type of Tests	Frequency
Aggregate Impact Value Test	Once per 200 m^3 or part of it and change of source
Flakiness Index Test	-do-
Water Absorption Test	-do-
Crushing Ratio (CR) Test	-do-
Grading Test	-do-
Atterberg Limits of portion of aggregate passing 425 micron sieve	-do-
Soundness Test, if the water absorption exceeds 2%	Once per 500 m^3 or part of it and change of source
CBR	As required
Proctor Compaction Test (MDD, OMC)	Once per 1000 m^3 or part of it and change of source
Field Density test	Once per 1000 m^2 or part of it and change of source
Thickness of Compacted layer Surface Level Width Smoothness	20 m 20 m 200 m 40 m^2

3-4-2 COBBLE STONE PAVEMENT

Description

Cobble stone pavement consists of cobblestones placed side by side manually on a prepared sub base over sand cushion. It provides a uniform riding surface for vehicular movement and effective also for walkways. This pavement is constructed from chisel dressed or hammer dressed stones to form cubical shaped cobblestones. The standard cubical size of cobble stone are best suited for patterned cobble laying works in urban or suburban areas. Layout shall be either random or in a specific patterns as instructed by engineer.

A Methodology

i) **Preparation of Sub-grade:**

The sub-grade shall be prepared prior to laying sub-base as per Section 2-5.1 of this Hand Book.

ii) **Granular Sub base**

The material to be used for such works shall be, any individual or combination of naturally occurring river gravels, or crushed gravels, or granular materials resulting from the fractured rocks, clayey, silty sand etc, depending upon the approved quality and grading. The material shall be free from organic or undesirable substances.

The sub-base work shall be carried out as per the Section 3-1 of this Hand Book.

iii) **Setting out and Cobble stone paving**

a) Prepare the existing surface of base course on which the cobble stone is to be laid to the specified lines, grade and cross-section. All ruts, deformations and soft spots should be repaired and the surface compacted to the required density before paving the cobble stone.

b) After preparation or correction of sub-base lay the loose sand or similar granular material of thickness 50 mm as the cushion or binding layer and spray uniformly through out the road width with the help of suitable tools.

c) Pave the cobble stone by embedding the stone over sand cushion by hammering with a special hammer gently to form a uniform riding surface. For leveling of the upper surface of the pavement use the cushion sand.

d) The cobble stones are paved in place by providing a staggered joints not exceeding 10 mm and the in the patterns in a row, diagonal or semi-arch as instructed by the engineer.

e) Fill the joints between the cobble stones by sand, silt and clayey sand. The joints shall be filled appropriately to its full depth and watered after filling as instructed by the engineer.

f) After laying of cobble stones and filling the joints for a considerable length compaction shall be done by a steel wheel road roller with out vibration.

B. Quality Control Requirements

1. Physical Requirements

Granular Bedding :

a) The bedding material shall be well graded sand or other granular material passing through 5.6 mm sieve

Edge Stone and Kerb Stone

a) Stone shall be angular or cubical shaped as specified. It shall be hard sound ,free from cracks, iron band ,free from decay weathering and should be from the approved quarry.
b) Specific gravity of stone shall not be less than 2.5
c) Water absorption of the stone shall not be more than 5% when tested in accordance with IS 1124
d) Size of stone Height = 20-25cm; Length and breadth = 12-20 cm

Cobble Stone

a) Stone shall be angular or cubical shaped as specified. It shall be hard sound ,free from cracks, iron band ,free from decay weathering and should be from the approved quarry.
b) Specific gravity of stone shall not be less than 2.5
c) Water absorption of the stone shall not be more than 5% when tested in accordance with IS 1124
d) Size of Cobble stone Height =9-11cm Length = 10-15 cm Breadth = 10-12

Sand and Clay fill material

Sand and clay used as fill material shall comply with the following requirements

a) % passing 2 mm sieve : max 95%
b) % 0.075 sieve min 10% and max 30%
c) Plasticity Index min 5 % max 12 %

2.Quality Control Tests

2.1 Tests prior to construction

The tests / checks to be carried out prior to construction are indicated in Table 3-4-2.1

TABLE 3-4-2.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Stones	a) Shape and Dimension (IS:1597 part 1)	3 samples on receipt at site
		b) Water absorption/Sp .gr (IS:1124)	3 samples on receipt at site
		c) Dressing of Stones via Hearting, Bond, Quoin, Face stones, Headers, etc. (IS:1129)	Once for each stock after selection for individual work
2	Sand (Granular bedding)	a) Gradation (IS:2116)	3 samples for each source of supply,
3	Sand -Clay fill material	a) Gradation	
		b) PI	

2.2. Tests During Construction

The tests to be carried out during construction are indicated in Table 3-4-2.2

TABLE 3-4-2.2: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Stones	a) Shape and Dimension (IS:1597 part 1) b) Water absorption/Sp .gr (IS:1124) c) Dressing of Stones via Hearting, Bond, Quoin, Face stones, Headers, etc. (IS:1129)	Once for each stock after selection for individual work
2	Sand (Granular bedding)	a) Gradation (IS:2116)	
3	Sand -Clay fill material	Gradation PI	
4	Sub grade /sub base	MDD/OMC	Once in 1000 m^3
		Field density	Once in 1000 m^2

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SECTION 4
BITUMIN COURSES

4-1. PREPARATION OF BASE FOR BITUMINOUS COURSE

This Subsection deals with preparing an existing granular (WBM) or black-topped surface to specified lines, grades and cross-sections prior to laying a bituminous course.

A. Methodology

1. Preparing an existing granular surface

(i) All loose and extraneous materials should be removed and surface shall be cleaned where a granular profile corrective course is to be provided prior to laying a bituminous course; the existing granular surface after cleaning should be loosened to a depth of 50-75 mm and slightly watered and the granular course laid with required compaction.

(ii) The surface of all granular layers on which a bituminous course is to be laid should be cleaned of all loose material and dust by air jet or wire brushes or other approved means and should be correct to line, level and camber within the tolerances specified for base course. Prior to laying the bituminous course the existing surface shall be approved by the engineer for line, level and density.

(iii) Where a profile corrective course of bituminous material is to be laid, the granular surface after removal of all loose material and dust should be primed with a suitable bituminous primer as per 'Sub-section' 4-7 and a tack coat as per "sub-section 4-2.

2. Scarifying an existing bituminous surface

(i) Where an existing bituminous layer is required to be removed, it should be done without causing undue disturbance to the underlying layers. Any underlying material which may have been disturbed should be loosened to a depth of 50 – 75 mm and removed from road bed and screened for used in renewal course by adding supplementary fresh base material if necessary and compact to line and level.

(ii) The compacted granular surface, finished to line, level and cross-slope should be primed as per specified procedure after getting approval from the engineer for the existing surface.

3. Preparing an existing bituminous surface

The surface shall be cleaned and any pot holes and cracks should be repaired before laying bituminous treatment as described below:

(a) Pothole and Patch Repairs

(i) The existing bituminous surface should be inspected and all pothole and patch areas should be marked and measured the area to be repaired. The edges of all potholes shall be cut / trimmed with hand tools vertically to form rectangular shape and shall be thoroughly cleaned with wire brush, compressed air or other approved means. All dust, loose and defective materials should be removed from site. Layers below the level of bituminous construction should be replaced using material of equivalent specification to the original construction and degree of compaction. The area of bituminous construction should be primed and/or tacked with an emulsion/ bitumen cut-back meeting specified requirements depending on whether the lower area is granular or bituminous in nature.

(ii) The bituminous patching material should be either a hot mix or a cold mix, adopting the respective specification. The bituminous mixture, prepared in a plant of suitable capacity should be placed in layers of not more than 100 mm (loose) and compacted in layers with roller/plate compactor/hand roller/rammer to the desired compaction standard.

(iii) In the final layer, the mix should be spread slightly above the adjoining surface so that after rolling, the surface shall be flush with the adjoining surface.

(iv) Where required, a Seal Coat should be applied as per the specified procedure. The surface levels should be checked using a 3 m straight edge.

(b) Crack Sealing

(i) The fine cracks (less than 3 mm in width) should be sealed by Fog Spray, which is a very light application of low viscosity Slow Setting Emulsion. Prior to this treatment, it is important that the surface is thoroughly cleaned, preferably with compressed air. The Fog Spray should be applied at a rate of 0.5-1.0 liter/m^2 of the specified emulsion, using an approved hand-held 'sprayer. For sites in sub-zero temperatures, Medium Curing Cutback can be used.

(ii) The wide cracks (more than 3 mm in width) should be filled with crusher dust or approved course sand passing 4.75 mm IS sieve to a level about 5 mm below the road surface level. After sweeping the surface clear of dust, prior to the application of binder or premix. Binder shall be poured into the cracks with minimum spillage. Dust shall be applied to the excess bitumen on the road surface until it is blotted up.

(iii) Isolated areas, with wide cracks, shall be cut and patched as per Section 4-1 patch repair.

4. Profile Corrective Course

(i) Where specified, a profile corrective course should be provided to thickness as per design drawing.

(ii) After preparing the surface as explained above, the profile corrective course with the specified material should be laid and compacted to the requirements of the particular specification.

(iii) Any high spot in the existing black top surface shall be removed to the satisfactory of the engineer.

(iv) A tack coat as per Sub-section 4-2 should be applied over a primed granular surface or an existing bituminous surface prior to laying the bituminous profile corrective course.

(v) The maximum thickness of the profile corrective course will not be more than 40 mm. The profile corrective course shall be constructed as an integral part of overlay course. In other case the profile corrective course shall be constructed as separate layer adopting appropriate construction procedure and equipment approved by the engineer.

(vi) The profile corrective course shall be laid to the tolerance and densities as specified for wearing course.

B. Quality Control Requirements

1. Material

(i) Crusher stone dust for crack filling or course sand should be a material, passing 4.75 mm sieve.

(ii) The bituminous mixture to be used for patching should be either a hot mix or cold mix in accordance with appropriate specifications.

(iii) The binder for prime coat and crack filling should be a Medium Curing (MC) Cutback . Prime coat should be applied as per Sub-section 4-7

(iv) The binder for tack coat and its application should be as per sub-section 4-2.

2. The prepared surface should comply with the permitted tolerances in respect of horizontal alignment, surface levels and surface regularity specified for base course.

(i) Horizontal Alignment Edges of the pavement layer (±) 25 mm

(ii) Surface levels

Granular Surface	(±)10 mm
Bituminous Surface	(±) 10 mm

(iii) Surface Regularity

Granular/Bituminous Surface

Longitudinal Profile	6 mm
Transverse Profile	± 0.25 %

Ks

4-2 TACK COAT

The tack coat is the application of single coat of low viscosity liquid bituminous material to existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix.

A. Methodology

1. Use a suitable grade of bitumen as binder in the form of cutback. Rapid setting bitumen emulsion may be used as binder to areas having sub-zero temperature or for emergency applications.
2. The surface on which tack coat is to be applied should be clean, free from dust, dirt and any extraneous materials and dry.
3. The surface should be prepared as per sub-section 4-1.
4. The binder should be heated to the required temperature according to the grade of bitumen and sprayed uniformly over the surface using suitable bitumen pressure sprayer capable of spraying bitumen at specified rates and temperature so as to provide a uniformly unbroken spread of bitumen. Normal range of spraying temperature should be 50°C-80°C for cutback. The rate of application depends upon the type of surface and is given in Table 4-2.1
5. The surface should be allowed to cure until all the volatiles have evaporated.

B. Quality Control Requirements

1. Materials

(i) Binder for Tack Coat

The binder shall be a penetration bitumen applied hot immediately prior to laying the bituminous mixture or alternatively a rapid curing cutback RC-800 or medium curing cutback MC30, MC70 or MC-800 applied at sufficient time before laying the bituminous mixture to allow the evaporation of cutter (solvent) or a quick breaking emulsion K1-60 applied sufficient before laying the bituminous mixture to allow the emulsion to break and the water to evaporate and run off.

(ii) Rate of application of Binder is provided in Table 4-2.1

TABLE 4-2.1: RATE OF APPLICATION OF BINDER FOR TACK COAT

Type of Surface	Quantity of Cutback per sqm area (Kg)
Normal Bituminous surfaces	0.20 to 0.30
Granular surface treated with primer	0.25 to 0.30
Cement Concrete Pavement	0.30 to 0.35

2. Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 4-2.2. These tests shall be carried out on the bitumen binders brought on the site by the Contractor to be use in the work.

TABLE 4-2.2: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No	Type of Test	Frequency
1	Penetration at 25° C (100g - % s) in 0.1 mm	One test for every 50 Kl or part of it and change of source & certificate from suppliers
2	Softening Point (Ring & Ball), °C	-do-
3	Flash point (Cleveland open cup) °C (min)	-do-
4	Ductility at 25° C	-do-
5	Loss on heating (5 h at 163° C) % (max)	-do-
6	Penetration of residue from loss on heating at 25° C (100 - 5 s) % of initial penetration (min)	-do-
7	Specific Gravity at 25° C	-do-
8	Water, % by weight (max)	-do-
9	Solubility in Trichloroethylene, % by weight (min)	-do-
10	Viscosity Test (IS:217), where bituminous cutback is to be used	-do-

3.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 4-2.1.3.

TABLE 4-2-1.3 : QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No	Type of Test	Frequency
1	Temperature of Binder, when cutback is to be used	Regularly
2	Rate of Spread of Binder	At least two tests per run
3	Percentage of cutter for making cutback	During making cutback

Note:

Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed

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.4-3 Bituminous Macadam

A. Methodology

1. Prepare the base on which bituminous macadam course is to be laid and shape to the specified lines, grade and cross-section as per the design drawing. Get approval from the engineer before laying tack coat.
2. Apply tack coat over the base prepared for laying of the bituminous macadam.
3. Bituminous Macadam should be prepared in a Hot Mix Plant of adequate capacity. Ensure manufacturing and rolling temperatures for Bituminous Macadam as given in Table 4-3.1.

TABLE 4-3.1: MANUFACTURING AND ROLLING TEMPERATURES FOR BITUMINOUS MACADAM

Bitumen Penetration	Bitumen Mixing (°C)	Aggregate Mixing (°C)	Mixed Material (°C)	Laying (°C)	Rolling (°C)
80/100	150-165	125-150	Max. 160	Min. 135	Min. 110

4. Transport the mixed material quickly to site of work and lay by means of an approved self-propelled mechanical paver.
5. Initial rolling is done with 80-100 KN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the centre longitudinally. On super elevated portions, rolling should progress from lower to upper edge parallel to centre line of pavement. Thereafter, do intermediate rolling with pneumatic tyred road rollers. This should be followed by final rolling while the material is still workable.
6. Any high spots or depressions noticed after the roller has passed over the whole area once should be corrected by removing or adding premixed material. Rolling should recommence thereafter. Each pass should have an overlap of at least one-third of the track made in the preceding pass. Rolling should be continued till all roller marks have been eliminated.
7. For single lane roads no longitudinal joint is required, while for double-lane roads longitudinal joints may be required depending on the paver width.
8. For making longitudinal or transverse joint, cut the edges of the bituminous layer laid earlier to their full depth vertically so as to expose fresh surface and apply a thin coat of binder. Lay adjacent new layer and compact flush with the existing layer.
9. Cover the bituminous macadam with the wearing course within a period of 48 hours. If there is any delay in providing wearing course the bituminous macadam surface should be covered with a seal coat before opening to traffic.

B. Quality Control Requirements

1. **Material**

The Bituminous Macadam shall be composed of aggregate meeting the physical requirements indicated in Table 4-3.2 and a paving bitumen of penetration grade complying with IS:73 or as specified in the Contract. The grading and binder requirements shall be in conformity with the requirements indicated in Table 4-3.3.

TABLE 4-3.2: PHYSICAL REQUIREMENTS FOR AGGREGATES FOR BITUMINOUS MACADAM

Test	Specification
Aggregate Impact Value Test	30 % maximum
Los Angeles Abrasion Value	40 % maximum
Flakiness Index Test	35 % maximum
Bituminous Stripping of Aggregate Test	5 % maximum
Water Absorption	2 % maximum
Soundness Test(SSS), if water absorption of aggregate exceeds 2%	12 % maximum

Table 4 -3.3 : Grading Requirement of Aggregates and Bitumen Content

Grading	Grading I	Grading II
Nominal maximum Aggregate size	**40 mm**	**19 mm**
Layer Thickness	**80- 100 mm**	**50 - 75 mm**
Sieve Designation	**Percentage by Weight Passing the Sieve**	
45 mm	100	-
37.5 mm	90 - 100	-
26.5 mm	75 - 100	100
19 mm	-	90 - 100
13.2mm	35 - 61	56 - 88
4.75 mm	13 - 22	16 - 36
2.36 mm	4 - 19	4 - 19
0.300 mm	2 - 10	2 - 10
0.075 mm	0- 8	0 - 8
Bitumen Content % by mass of total Mix	3.3	3.4

Note: The specific gravity of the aggregate is taken as 2.7. In case the specific gravity of aggregate is more than 2.7, bitumen content shall be reduced proportionately.

In the regions where the mean daily air temperature is 30° C or lower and lowest daily mean air temperature is -10° C or lower, the bitumen content shall be increased by 0.50 percent.

2. **Horizontal Alignment**

The edges of the bituminous macadam base should be correct within a tolerance limit of (±) 25 mm .

3. **Surface Level**

The tolerance in surface level of the bituminous macadam would be (±) 10 mm.

4. **Surface Regularity**

The maximum allowable difference between the road surface and a 3 m straight edge would be 6 mm for longitudinal profile and ± 0.25 % for cross profile.

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 4-3.4.

TABLE 4-3.4: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Materials/work	Type of Test	Frequency
Bitumen straight run	AS per Table 4-2.2	
Aggregates	Aggregate Impact Value Test (IS:2386 Part 4)	One test per source identified
	Los Angeles Abrasion Value(IS:2386 Part 4)	-do-
	Flakiness Index Test (IS:2386 Part 1)	-do-
	Water Absorption (IS:2386 Part 3)	-do-
	Soundness Test, if water absorption of aggregate exceeds 2% (IS:2386 Part 5)	-do-
	Stripping Value of aggregate Test (IS:6241)	-do-
	Gradation	-do-

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 4-3.5.

Table 4-3.5: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No	Type of Test	Frequency
1	Grading of Aggregate	Two tests per day
2	Quality of Binder	One set of test for each 50 kl of supply and part of it
3	Density of Compacted Layer	One test per 700 m^2.
4	Aggregate impact value or LAA	Once per 200 m^3 or part of it
5	Flakiness Index	Once per 350 m^3 or part of it
6	Temperature of Binder before mixing	Regularly
7	Temperature of mix during laying and compaction	Regularly
8	Thickness of compacted layer	Regular, at close intervals
9	Rate of spread of mixed material	Regular control through checks on layer thickness

Note:

Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed.

4-4 SURFACE DRESSING

A. Methodology

1. Design the surface dressing following the guidelines given in TRL Overseas Road Note 3 to determine the rate of spread of binder and stone chippings for actual conditions covering traffic categories, type and size of chippings, existing surface and climatic condition. Any deviation between the quantities and spread rates as specified in the contract and those as per actual design will be brought out and got approved from the competent authority before making any change during construction.
2. Prepare the base on which surface dressing is to be laid to the specified lines, grade and cross-section as per Sub-section 4-1. If the base is of granular material, a prime coat should be applied as per Sub-section 4-7.
3. Prepare the cutback bitumen binder comprising of penetration grade 80/100 bitumen and cutter which shall be diesel or kerosene or a mixture of both prepared on Site ranging between 1% to 10% as required and instruction of Engineer.
4. Apply the binder (at specified temperature) as per rate of spread of binder as per the designed rate by an appropriate bitumen distributor fitted with a spray bar. Binder shall be sprayed/distributed uniformly over the prepared base, with self propelled or towed sprayer capable of supplying the binder at specified rate to provide a uniformly unbroken spread of binder.
5. The range of spraying temperature for binders is normally within the range 140°C to 170°C. The minimum temperature of the surface during the spray of binder shall not be less than 15° C.
6. Spray runs will be limited to 300 metres length initially until the Contractor demonstrates his ability to plan and execute longer lengths. Spray widths shall be calculated allowing for 150mm longitudinal overlap with adjoining passes and for the width that the following chipping spreader is able to cover. Longitudinal sprayed butt joints shall not be permitted.
7. Immediately after application of binder, spread clean slightly moist stone aggregate at the rate as designed with the help of a mechanically operated chip spreader, in a single layer.
8. Immediately after spreading of aggregates, roll the surface with the help of pneumatic tire road rollers. Commence rolling from the edges and progress towards the center except in super elevated portions where it shall proceed from the lower edge to the higher edge. Each pass should have an overlap of not less than one-third of the track made in the preceding pass. Spread additional stone chips to make up irregularities, if any. Rolling should continue until all aggregate particles are firmly embedded in the bituminous binder and present a uniform closed surface.
9. Where a second surface dressing is specified, the first surface dressing shall be left open to traffic for a minimum period of 21 days and preferably a longer period before applying the second surface dressing unless special approval is obtained from the Engineer for a shorter period. Surplus chippings shall be removed by firm hand-brooming before applying the second surface dressing. Procedures stated here-in-above will apply. The road may be opened to traffic 24 hours after the work of rolling is complete. In exceptional circumstances, traffic may be allowed immediately after rolling provided the traffic speed is limited to 20 km/hr until the following day.
10. Back rolling of at least 15 pass by pneumatic roller covering whole width of road shall be carried out on the following day of spreading of aggregates. The back rolling shall be continued for three days in case of low traffic volume.

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B. Quality Control Requirements

I. Materials

(a) Stone Chippings

(i) Physical requirements:

Stone chippings should satisfy the requirements given in Table 4-4.1

Table 4-4.1 Physical Requirements of Chippings

Tests Requirement	Specification
LAA Max	35 %
AIV Max	25 %
SSS Max	12 %
CR Min	80 %
FI Max	25 %
Degradability	<5 %

*for crushed stone aggregate only

(ii) Grading:

The stone chippings should conform to the Grading given in Table 4-4.2

TABLE 4-4.2 GRADING REQUIREMENTS FOR CHIPS FOR SURFACE DRESSING (as per TRL- Road Note – 3)

IS Sieve Designation (mm)	Cumulative percent by weight			
	Nominal Size			
	20	14	10	6.3
25.00	100	-	-	-
20.00	85-100	100	-	-
14.00	0-40	85-100	100	-
10.00	0-7	0-40	85-100	100
6.30	-	0-7	0-35	85 - 100
5.00	-	-	0 - 10	0 - 35
3.35	-	-	-	-
2.36	0 - 3	0 - 3	0-3	0 - 10
0.600	0 - 2	0 - 2	0 - 2	0 - 2
0.075	-	-	-	-

(b) Bitumen

Cutback bitumen binder shall comprise penetration grade 80/100 bitumen and cutter which shall be diesel or kerosene or a mixture of both prepared on Site. The type and proportion of cutter if required shall be instructed by the Engineer on Site, in the range 1% to 10% after design of the surface dressing in accordance with the procedures set out in Chapter 5 of TRL-ORN 3. The preparation of cutback bitumen shall be carried out in accordance with TRL Research Report RR104 "Preparation of Cutback Bitumen" (Hitch and Stewart).

(c) Where aggregate fails to pass the stripping test, an approved adhesion agent may be added to the binder, in accordance with the manufacturers instructions.

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2. **Horizontal Alignment**
The edges of the Surface Dressing should be correct within a tolerance limit of (±) 20 mm

3. **Surface Level**
The tolerance in surface level of the surface dressing would be (±) 6 mm.

4. **Surface Regularity**
The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 10 mm for longitudinal profile and (±) 0.25% for cross profile respectively.

5. **Quality Control Tests**

5.1 **Tests Prior to Construction**
The quality control tests to be carried out prior to construction are indicated in Table 4-4.3.

Table 4-4.3 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Materials/work	Type of Test	Frequency
Bitumen straight run	AS per Table 4-2.2	
Aggregates	Aggregate Impact Value Test (IS:2386 Part 4)	One test per source identified
	Los Angeles Abrasion Value	-do-
	Flakiness Index Test (IS:2386 Part 1)	-do-
	Bituminous Stripping of Aggregate Test (IS:6241)	-do-
	Water Absorption (IS:2386 Part 3)	-do-
	Soundness Test, if water absorption of aggregate exceeds 2% (IS:2386 Part 5)	-do-
	Degradability	-do-
	Gradation	One test per source identified

5.2 **Tests During Construction**
The quality control tests to be carried out during construction are indicated in Table 4-4.6.

TABLE 4-4.4 : QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1	Rate of spread of binder	At least two tests per run
2	Rate of Spread of aggregate	At least two tests per run
3	Quality of binder (Straight Run Bitumen)	One set of test for each 50000 ltrs or part of it; certificate from suppliers
4	Flakiness Index Test (IS:2386 Part 1)	One test pr 100 m^3
5	Grading of Aggregate	Once per 50 m^3 or part of it
6	Aggregate impact value , or LAA, CR	Once per 250 m^3 or part of it
7	Temperature of binder during spraying	At close Interval.

Note:
Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed

4-4-1 20 mm THICK PREMIX CARPET

Open graded Premix Surfacing using Bitumen

A. Methodology

1. Prepare the base on which premix carpet is to be laid to the specified lines, grade and cross-section and get approval from engineer before applying prime coat.
2. Apply a prime coat over the prepared base as per 4-7.
3. The tack shall be applied over primed surface as per 4-2 prior to laying of the carpet.
4. Mixing should be thorough to ensure that a homogenous mixture is obtained. The temperature of bitumen at the time of mixing should be in the range of 150^0 C to 163^0 C and that of aggregates 155^0C to 163^0C, provided that the difference between the temperature of aggregate and the binder should not exceed 14^0C. The temperature at the time of discharge of the mixture should be between 130°C and 160°C.
5. Locate hot mix plant near the work site. The mixed material should be transported quickly to the site of work and laid uniformly by suitable means.
6. The premixed material shall be spread on the road surface with rakes.
7. Commence rolling with 80-100 kN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the centre longitudinally. (On super-elevated portions, rolling should progress from lower to upper edge parallel to centre line of pavement). Continue rolling operations till a smooth uniform surface is achieved and all roller marks are eliminated. Each pass should have an overlap of at least one-third of the track made in the preceding pass.
8. Correct any high spots or depressions noticed after the roller has passed over the whole area once by removing or adding premixed material and re-compacting.
9. Provide a seal coat to the surface immediately after laying the carpet as per details in Sub-section 4-5.
10. Ordinarily, the road may be opened to traffic after laying the seal coat with restrictions given in Subsection 4-5.

B. Quality Control Requirements

1. Materials

(a) Aggregates

Aggregates shall conform to the physical requirements indicated in Table 4-4-1.1

TABLE 4-4-1.1 PHYSICAL REQUIREMENTS OF STONE AGGREGATE

Test	Specification
Flakiness index	Max. 35 %
Aggregate Impact Value	Max. 25 %
Loss Angles Abrasion value	Max. 35
Soundness Sodium sulphate, if water absorption is more than 2%	Max. 12 %
Water Absorption	Max. 2 %
Coating and stripping of bitumen aggregate mixture.	Minimum retained coating 95 %

TABLE 4-4-1.2 GRADATION OF STONE AGGREGATE

IS Sieve Designation (mm)	Cumulative percent by weight of total aggregate passing	
	Type A	Type B
13.2	-	100
11.2	100	88 - 100
5.6	52 - 88	31 - 52
2.8	14 - 38	5 - 25
0.090	0 - 5	0 - 5

The type A gradation is used in areas having rainfall more than 150 cm/ year. In other areas type B grading is used.

(b) **Binder**

The binder shall be a penetration grade bitumen of a suitable grade depending on climatic condition of the area or of the type as specified in the Contract.

2. **Horizontal Alignment**

The edges of the carriageway with Premix Carpet should be correct within a tolerance limit of (±) 20 mm in plain and rolling terrain and (±) 30 mm in hilly terrain.

3. **Surface Level**

The tolerance in surface level of the surface dressing would be (±) 6 mm.

4. **Surface Regularity**

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 10 mm for longitudinal profile and ± 0.25% for the cross profile.

5. **Quality Control Tests**

5.1 **Tests Prior to Construction**

The quality control tests to be carried out prior to construction are indicated in Table 4-4-1.3.

Table 4-4-1.3: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Type of Test		Frequency
1	Quality of Binder (Straight-run Bitumen)	As per Table 4-2.2
2	Aggregate Impact Value Test	One test per each source identified
3	Flakiness Index Test	-do-
4	Water Absorption	-do-
5.	Soundness Sodium sulphate Max	-do-
6	Gradation	-do-
7	Bitumen Stripping of Aggregate Test	One set of 3 specimen for each source of supply

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 4-4-1.4.

TABLE 4-4-1.4: QUALITY CONTROL TESTS DURING CONSTRUCTION

Type of Test	Frequency
1. Grading of Aggregates (IS:2386 Part 1)	Once per 100 m^3 or part of it
2. Flakiness of Aggregate	- do -
3. LAA or AIV,	Once per 200 m^3 or part of it or change of source
4. Quality of Binder	One set of test for each 50 kl of supply and part of it
5. Binder Content before seal coat	At least two tests per day
6. Temperature of Binder	Regular close intervals
7. Thickness of layer	Regularly at close intervals

Note:
Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed.

4-5 SEAL COAT

The seal coat shall be any of the two types mentioned below:

Type A : **Liquid seal coat** comprising of an application of layer of bituminous binder followed by a cover of stone chips.

Type B : **Premixed seal coat** comprising of a thin application of fine aggregate premixed with bituminous binder.

A. Methodology

Apply seal coat immediately after laying the bituminous course. The surface should be clean and free of dust and extraneous material before application of the seal coat.

1. Type A Seal coat with bitumen:

(i) Apply heated bitumen with a temperature between 150°C and 163°C uniformly with the help of a bitumen sprayer.

(ii) Immediately thereafter, spread stone chips over the bitumen layer at a uniform rate, preferably, with the help of a mechanical grit spreader so as to cover the surface completely.

iii) Commence rolling with suitable and appropriate rollers (3-wheel or tandem type or pneumatic), rolling should progress from lower to upper edge parallel to centre line of pavement. If required, spread additional chips by hand to make up irregularities. Continue rolling operations until all aggregate particles are firmly embedded and present a uniform closed surface.

iv) The traffic shall be open on following day. In special circumstances, however, the engineer may open the road to traffic immediately after the rolling with a maximum speed limit of 20 Km/hr until the following day.

2. Type B Pre-mixed seal coat

i) Mixing should be thorough to ensure that a homogenous mixture is obtained. The temperature of bitumen at the time of mixing should be in the range of 140^0 C to 160^0 C and that of aggregates 140^0C to 165^0C, provided that the difference between the temperature of aggregate and the binder should not exceed 14^0C. The temperature at the time of discharge of the mixture should be between 140° C and 160° C. The temperature at the time of laying 130° C.

ii) Locate hot mix plant near the work site. The mixed material should be transported quickly to the site of work and laid uniformly by suitable means.

iii) The premixed material shall be spread on the road surface with rakes.

iv) Commence rolling with 80-100 kN rollers (three-wheel or tandem type), beginning from the edge and progressing towards the centre longitudinally. (On super-elevated portions, rolling should progress from lower to upper edge parallel to centre line of pavement). Continue rolling operations till a smooth uniform surface is achieved and all roller marks are eliminated. Each pass should have an overlap of at least one-third of the track made in the preceding pass. The rolling should be completed before the mat pulls to the temperature of 80° C.

v) Traffic may be allowed after completion of rolling operations and the surface is at ambient temperature.

B. Quality Control Requirements

1. Materials

(a) Aggregates

Aggregate shall conform to the physical requirements indicated in Table 4-5.1

TABLE 4-5.1 PHYSICAL REQUIREMENTS OF STONE AGGREGATE

Test	Specification
Flakiness index	Max. 35 %
Aggregate Impact Value	Max. 25 %
Loss Angles Abrasion value	Max. 35 %
Sodium Sulphate Soundness if water absorption is more than 2%	Max.12 %
Water Absorption	Max. 2 %
Coating and stripping of bitumen aggregate mixture.	Minimum retained coating 95 %

Quantities and grading requirements for aggregates are given in Table 4-5.2.

TABLE 4-5.2 : QUANTITY AND GRADATION REQUIREMENT OF AGGREGATE FOR SEAL COAT

Type of seal coat	Quantity of aggregate required per 10 sqm area	Gradation requirement	
		100% passing sieve designation	100% retained sieve designation
Type A	0.09 cum	11.2 mm	2.36 mm
Type B	0.06 cum	2.36 mm	180 microns

(b) Binder

The binder shall be a penetration grade bitumen of a suitable grade depending on climatic condition of the area or of the type as specified in the Contract.. The quantities required for seal coat are given in Table 4-5.3.

TABLE 4-5.3: QUANTITIES OF BINDER REQUIRED FOR SEAL COAT

Type of seal coat	Bitumen in kg per 10 m^2
Type A	9.8
Type B	6.8

2. Quality Control Tests

2.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 4-5.4.

Table 4-5.4 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Materials/work	Type of Test	Frequency
Bitumen straight run	AS per Table 4-2.2	
Aggregates	Aggregate Impact Value (IS:2386 Part 4)	One test per source identified
	Los Angeles Abrasion Value	-do-
	Flakiness Index (IS:2386 Part 1)	-do-
	Bituminous Stripping of Aggregate (IS:6241)	-do-
	Water Absorption (IS:2386 Part 3)	-do-
	Soundness, if water absorption of aggregate exceeds 2% (IS:2386 Part 5)	-do-
	Gradation	One test per source identified

2.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 4-5.5.

TABLE 4-5.5 : QUALITY CONTROL TESTS DURING CONSTRUCTION

	Type of Test	Frequency
1	Rate of spread of binder	At least two tests per run
2	Rate of Spread of aggregate	At least two tests per run
3	Quality of binder (Straight Run Bitumen)	One set of test for each 50 kl or part of it; certificate from suppliers
4	Grading of Aggregate	Once per 100m^3 or part of it
5	Aggregate impact value or LAA,	Once per 200 m^3 or part of it
6	Temperature of binder during spraying	At close Interval.

Note:

Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed

4-7. PRIME COAT

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

A Methodology

Preparation of surface

1. The prime coat should be applied only on the top most granular base layer, over which bituminous treatment is to be applied. The granular base surface should be cleaned by sweeping with mechanical brooms and/or washing or other approved means and all laitance of soil or binder material, loose and foreign material shall be removed.
2. The surface to be sprayed shall be checked for line, camber and level, and the surface corrected if any, made good as necessary and approved by the Engineer before bituminous spray is applied
3. In order to bring the surface to be primed to the condition required, water shall be applied in small increments by a water distributor to damp the surface but in no case the surface shall be made saturated. If water applied is more, the surface shall be allowed to dry until dampness is uniform over entire surface. Any water on the surface after spraying shall be allowed to drain away before the prime coat is applied.
4. Mark the area to be applied of prime coat with a line of string by pegging at an interval of 15 m on straights and 7.5 m on curves

Spraying of Prime coat

5. The primer should be sprayed uniformly over the dry surface of absorbent granular base, using suitable bitumen distributor or sprayer capable of spraying primer at specified rates and temperature so as to provide a uniformly unbroken spread of primer. No hand spraying is permitted except in very small area.
6. The application rate of cutback bitumen and percentage of cut back to be used shall be instructed by the Engineer on Site after field trials. The object of the trials is to achieve the optimum penetration (8 - 10 mm) of prime coat and the minimum rate of spread at which this penetration can be achieved. However, the nominal rate of application of prime coat is 1 l/m^2
7. The temperature for storage and spraying is given in Table 4-7.1

Table 4-7.1 temperature for storage

Type of Prime	Maximum Storage Temperature ° C		Spraying Temperature
	Up to 24 hours	Over 24 hours	
Cutback Bitumen MC-30 MC-70	 65 80	 40 50	50 - 70° C

8. When, in the opinion of the Engineer, blinding to the primed surface is required due to failure of bituminous material to penetrate within the specified time or the road must be used by traffic, blinding aggregate shall be spread evenly over the full width of the primed surface such that no bituminous prime material will be picked up by passing traffic.
9. The surface should be allowed to cure preferably for 24 hours.

B. Quality Control Requirements

1 Material

a) Binder

The prime coat shall consist of medium curing cutback bitumen MC-30, MC-70 or MC-250. Kerosene is used as the cutter.

b) Aggregate for sand blending

The blinding layer, if any, shall be crushed rock or river sand having a grading within the limits of the Table 4-7.2 below. The aggregate shall be clean, hard and free from excessive dust. It shall contain no clay, loam or other deleterious material.

Table 4-7.2: Grading Envelope for Sand for Prime Coat

Sieve size (mm)	Percentage Passing (by mass)
4.75	100
2.36	80 - 100
1.18	60 - 95
0.6	30 - 80
0.3	20 - 55
0.075	10 - 30

2. Quality Control Tests

2.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 4-7.3.

TABLE 4-7.3 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Material	Type of Test	Frequency
Bitumen	Penetration at 25° C (100g - % s) in 0.1 mm	One test for every 50 Kl or part of it and change of source & certificate from supliers
	Softening Point (Ring & Ball), °C	-do-
	Flash point (Cleveland open cup) °C (min)	-do-
	Ductility at 25° C	-do-
	Loss on heating (5 h at 163° C) % (max)	-do-
	Penetration of residue from loss on heating at 25° C (100 - 5 s) % of initial penetration (min)	-do-
	Specific Gravity at 25° C	-do-
	Water, % by weight (max)	-do-
	Solubility in Tricloroethylene, % by weight (min)	-do-
	Viscosity Test (IS:217), where bituminous cutback is to be used	-do-
Sand	Gradation	One test per source

2.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 4-7.4.

TABLE 4-7.4: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No	Type of Test	Frequency
1	Quality of bitumen	One set of test for every 50 Kl or part of it and change of source & certificate from supplier
2	Temperature of Binder,	Close interval
3	. Rate of Spread of Binder (Including Dip Check)	Two tests per run
4	Curing of Primer	Before any subsequent treatment

Note:
Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed

4-8 SAND SEAL

A Methodology

Preparation of surface

1. Before laying seal coat, all loose material and foreign matter shall be removed by thorough brushing with mechanical brooms and/or washing or by use of compressors or by any other acceptable methods. All hardened mud or other foreign matter shall be loosened by scraping before sweeping.

2. Cover all Road furniture including manholes covers etc with adhesive paper or similar materials to prevent from coating of binder while spraying.

3. The surface to be sand seal shall be checked for line, camber and level, and the surface corrected if any, made good as necessary and approved by the Engineer before sand seal is applied.

Application of Sand Seal

4. Immediately after preparation of the surface, spray the binder uniformly at specified rate using suitable bitumen distributor. Spray width shall be calculated allowing for 150 mm longitudinal overlap with adjoining spray passes and for the width that the following chipping spreader is able to cover. Longitudinal sprayed butt joint shall not be permitted. The rate of spray of binder shall be 1.4 Lit/m^2 for MC 3000 cut-back bitumen and 1.6 Lit/m^2 for Emulsion 60% cationic

5. Immediately after the binder has been sprayed, the fine aggregate shall be uniformly spread and rolled. The elapsed time between the spraying of binder and the spreading of fine aggregates shall in no case exceed one minute. Any excess of chipping shall be removed by hand and any insufficiently chipped area shall be chipped over by hand, so that adequate coverage is obtained. The rate of spread of the fine aggregate shall be 13 – 19 kg/ m^2.

6. Rolling shall begin immediately after the chippings have spread and, in no case, later than two minutes after the application of binder. Rolling shall continue until all aggregates are firmly embedded into the binder and until all excess aggregates have been removed or insufficiently chipped areas have been chipped over. Rolling shall be begin from the edge and progressing towards the centre longitudinally. (On super-elevated portions, rolling should progress from lower to upper edge parallel to centre line of pavement). The number of passes shall usually be, at least 6 passes at each point by a pneumatic tyred roller or as directed by the engineer.

B Quality Control Requirements

1. Materials

a) Fine Aggregate

The aggregate shall consists of sand or fine screenings free from organic matter, clay and other deleterious materials. The fines (passing a 0.425 mm sieve) shall be non-plastic. The grading shall be as specified in the Table 4- 8.1.

Table 4-8.1: Grading of Aggregate

Sieve (mm)	Percentage passing by weight
10.00	100
4.75	70-90
2.36	45-70
0.60	15-35
0.15	0-2

b) Binder

The binder shall be a medium-curing cut-back MC-800 or MC-3000 or K1-60 cationic emulsion as specified.

2. Quality Control Tests

2.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 4-8.2.

TABLE 4-8.2 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Material	Type of Test	Frequency
Bitumen	As per Table 4-7.3	One test for every 50 kl or part of it and change of source & certificate from suppliers
Aggregate	Grading	One test for each source
	Plasticity	-do-

2.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 4-8.3.

TABLE 4-8.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No	Type of Test	Frequency
1	Quality of bitumen	One set of test for every 50 kl or part of it and change of source & certificate from supplier
2	Grading	One test per every 50 m^3 or part of it or change of source
3	Plasticity	-do-
4	Temperature of Binder,	At regular interval
5	. Rate of Spread of Binder (Including Dip Check)	Two tests per run
4	Curing of Primer	Before any subsequent treatment

Note:
Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed.

4-9 OTTA SEAL

A Methodology

Preparation of Surface

1. The existing surface where Otta seal is applied may be granular sub-base (gravel) or crusher run gravel (improved sub-base). These are constructed as per Section 3-1 and 3-4-1 for granular sub-base and improved sub-base respectively.
2. Before laying otta seal, all loose material and foreign matter shall be removed by thorough brushing with mechanical brooms and/or washing or by use of compressors or by any other acceptable methods. All hardened mud or other foreign matter shall be loosened by scraping before sweeping.
3. Cover all Road furniture including manholes covers etc with adhesive paper or similar materials to prevent from coating of binder while spraying.
4. The surface to be otta seal shall be checked for line, and level, gradient and super-elevation and the surface corrected if any, made good as necessary and approved by the Engineer before otta seal is applied.

Application of Otta seal First Coat

5. Immediately after preparation of the surface, spray the binder uniformly at specified rate and temperature using suitable bitumen distributor. Spray width shall be calculated allowing for 150 mm longitudinal overlap with adjoining spray passes and for the width that the following chipping spreader is able to cover. Longitudinal sprayed butt joint shall not be permitted. The spraying of binder shall be carried out within 12 hours after preparation of surface. The temperature for storage with spraying temperature of binder and rate of spray of binder is given in Table 4-9.1.and 4-9.2 respectively.
6. Spraying shall be carried out on full width of road if the available equipment permits, if not longitudinal joints can be provided positioned out side the wheel track.
7. Immediately after the binder has been sprayed, the graded aggregate shall be uniformly spread at specified rate by means of mechanical spreader. The elapsed time between the spraying of binder and the spreading of aggregates shall in no case exceed one minute. Any insufficiently chipped area shall be chipped over by hand, so that adequate amount of material is provided. The rate of spray of graded aggregate is given in Table 4-9.3.
8. Immediately after spraying the aggregate rolling shall be carried out uniformly to entire surface with 12 tonne pneumatic tyred roller at a speed of 8 km per hour for minimum of 15 passes over entire surface on the day of spraying aggregate. After the initial rolling of 15 pass over entire area is completed on the day of construction, apply one pass with a 10 – 12 tonnes static tandem roller to improve the embedment of larger aggregate.
9. The following two days after completion of sealing, further rolling of minimum 15 pass shall be carried on the entire surface daily with the pneumatic tyred roller.
10. The road is allowed to open for traffic immediately after initial rolling with the speed restriction of 30 km/hr and shall be continued for 2-3 weeks. The aggregates dislodges due to traffic movement shall be broom back to the wheel track and exposed areas during the first 2-3 weeks. This time can be prolonged to six weeks. After this period the aggregate dislodged shall be

removed from site and collected aggregate can be used after recycling for subsequent sealing operation.

11. The subsequent layer is applied after a elapse of 8-12 weeks of the first seal, during which time road surface should receive as much high traffic as possible.

Application of Second Layer of Otta Seal

If second coat of Otta Seal is required the following steps shall be adopted.

12. Prepare the existing surface by cleaning and removing all the dust and loose material and correct the damaged surface if any.
13. Immediately apply the binder and follow the steps from 5 to 11 described as above.

Application of Sand Cover Seal

14. Before applying the sand cover seal, the surfaced area shall be cleaned and made free of dust and loose stones or other foreign matters by brooming. Immediately after the application of binder at specified rate, sand shall be spread uniformly and sufficiently to cover entire surface at specified rate. The sand can be spread manually by the help of shovels. The temperature for storage with spraying temperature of binder and rate of spray of binder and rate of spraying the sand are given in Table 4-9.1; 4-9.2 and 4-9.3 respectively.
15. After spreading the sand rolling shall be carried out immediately by the 12 tonne pneumatic tyred roller for at least 15 passes on entire area on the day of construction.
16. Traffic shall be allowed immediately after completion of rolling not exceeding the speed 30 km/hr. Dislodged sand due to movement of traffic shall be broomed back into the exposed areas and wheel track during first 2-3 weeks or as directed by the Engineer.

Table4-9.1 Temperature for Storage and Spraying of Binder

Bitumen Product	Storage temp. ^{0}C		Spraying Temp. ^{0}C
	< 24 hours	> 24 hours	
150/200	165	115	165-180
MC 3000	155	100	135-155
MC 800	120	75	110-135

Table 4 –9.2: Bituminous binder spray rate

Type of Otta Seal	Grading	Open	Medium	Dense	
				AADT < 100	AADT > 100
Double	1st layer (*)	1.6	1.7	1.8	1.7
	2nd layer (*)	1.5	1.6	2.0	1.9
Single, with a sand cover seal	Crusher dust or coarse river sand	0.9	0.8		0.7
	1st layer (*)	1.6	1.7	2.0	1.9
Single (*)		1.7	1.8	2.0	—
Maintenance (single)	reseal	1.5	1.6	1.8	1.7

(*) *On a primed base course the spray rate shall be reduced by 0.2 l/m^2 in the first layer.*

Table 4 –9.3 Aggregate application rates

Type of seal	Aggregate spread Rates (m^3/m^2)		
	Open grading	Medium grading	Dense grading
Otta Seals	0.013 – 0.016	0.013 – 0.016	0.016 – 0.020
Sand cover seals	0.010 – 0.012		

B QUALITY CONTROL REQUIREMENTS

1 Materials

a) Aggregates

The following materials are recommended for Otta Seal aggregates.

- Screened natural gravel from weathered granitic rocks;
- Crushed and screened gravel from sandstone and lake deposits;
- Screened river/lake gravel; and sand
- Crushed, screened rock from a variety of rock types such as igneous rocks

All the aggregates must be clean and must be free from heavily plastic fines and other foreign material.

The grading requirements for an Otta Seal shall be any one as in the Table 4 -9.4 below.

Table 4 –9.4: Grading Envelopes

Sieve sizes (mm)	Open Grading (% passing)	Medium Grading (% passing)	Dense Grading (% passing)
16	100	100	100
13.2	52-82	68-94	84-100
9.5	36-58	44-73	70-98
6.7	20-40	29-54	54-80
4.75	10-30	19-42	44-70
2.00	0-8	3-18	20-48
1.18	0-5	1-14	15-38
0.425	0-2	0-6	7-25
0.075	0-1	0-2	3-10

Material for a sand cover seal used in Otta Seals can be crusher dust, river sand or fine pit sand or a combination of these materials. The material shall be free from organic matter and lumps of clay and shall be non-plastic. All material shall pass the 6.7 mm sieve.

The selection of preferred aggregate grading shall be as shown in the table 4 –9.5

Table 4 –9.5: Preferred Aggregate Grading

AADT	Best suited grading
Less than 100	Open
100 – 1000	Medium
More than 1000	Dense

The physical requirements of aggregates for Otta Seal shall be as shown in Table 4 –9.6

Table 4 –9.6: Aggregate Physical Requirements

Test	Specification
Los Angles Abrasion value Or Aggregate Impact value	40 % Maximum 30 % Maximum
Water absorption	2 % Maximum
Flakiness Index	35 % Maximum
Stripping Value	5 % Maximum

b) Binder

The binder shall be 150/200 penetration grade bitumen or MC 3000 cutback bitumen or MC 800 cutback bitumen as specified. MC 3000 cutback bitumen shall be used in warm weather. In cold weather, when night temperatures are likely to fall below 10°C, MC 800 cutback grade bitumen may be used. The blending of cutback bitumen shall be carried out on site to produce required medium curing cutback by mixing kerosene in the proportion as mentioned in the Table 4 -9.7.

Table 4 –9.7: Typical blending proportions to produce medium curing cut- back bitumen.

Required Product	Cutter (kerosene) in percent of total mixture	
	80/100 base bitumen	**150/200 base bitumen**
150/200	3-5% (flux oil is used instead of cutter)	–
MC 3000	8 - 10%	5 - 8%
MC 800	18 - 20 %	15 - 18

c) Selection of Binder

80/100 penetration grade straight run bitumen shall **NEVER** be used in Otta Seals unless softened or cut back to meet the viscosity requirements as given in Table 4 –9.8.

Table 4 –9.8: Selection of Binder:

AADT at the time of construction	Type of bitumen		
	Open grading	**Medium grading**	**Dense grading**
More than 1000	Not applicable	150/200 pen. Grade	MC 3000, MC 800 in cold weather
100 – 1000	150/200 pen. Grade	150/200 pen. Grade in cold weather	MC 3000, MC 800 in cold weather
Less than 100	150/200 pen. Grade	MC 3000	MC 800

2. Horizontal Alignment

The edges of the carriageway with Premix Carpet should be correct within a tolerance limit of (±) 20 mm in plain and rolling terrain and (±) 30 mm in hilly terrain.

3. Surface Level

The tolerance in surface level of the surface dressing would be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 10 mm for longitudinal profile and ± 0.25% for the cross profile.

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 4-9.9

TABLE 4-9.9 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No	Type of Tests	Frequency
1	Quality of Binder (Bitumen)As per Table 4-7.3	One set of test for every 50 KL or part of it and change of source & certificate from suppliers
2	Gradation	One test for each source
3	Plasticity Index	-do -
4	Aggregate Impact Value or LAA	-do -
5	Stripping Value test	One set of three specimens for each source
6	Water absorption	One test for each source

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 4-9.10

TABLE 4-9.10: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No	Type of Test	Frequency
1	Quality of bitumen	One set of test for every 50 KL or part of it and change of source & certificate from supplier
2	Grading	One test per every 50 m^3 or part of it or change of source
3	Plasticity	-do-
4	LAA or AIV	One test per every 500 m^3 or part of it or change of source
5	Flakiness Index	One test per every 250 m^3 or part of it or change of source
6	Stripping value	Subsequently when warranted by change in source
7	Temperature of Binder,	At regular interval
8	.Rate of Spread of Binder (Including Dip Check)	Two tests per run
9	.Rate of Spread of chips	Two tests per run
10	Width	One test each and every spray run
11	Smoothness	All apparently rough area to be checked

Note:
Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed.

4-10 PENETRATION MACADAM, SEMI – GROUT

A Methodology

Preparation of Existing Surface

1. Clean the existing surface by removing all loose materials and potholes if any shall be repaired with suitable patching mixture. Any wave and bumps shall be corrected by scarifying and re-compacting and the surface shall be prepared to the required grade and cross fall as specified. Then the base shall be broomed and cleaned of all loose and foreign materials.
2. Prepare the shallers at the outer edges of road width to support the loose course aggregate and helps to let the roller to roll the edge of loose course aggregate and edge of shallers.

Spreading of Course Aggregates

3. Immediately after preparation of base spread the course aggregate covering full width to such thickness that after compaction the specified thickness, cross slope and grade is achieved. The aggregate is spread by hand or an approved spreading machine. Do not allow to dump mass on the prepared base. The surface of the loose aggregate is carefully shaped and all high and low spots are maintained by removing or adding aggregate.
4. Take precautions to prevent the coarse aggregate from becoming mixed or coated with earth or other deleterious matter both before and after spreading.
5. The coarse aggregate is then be dry rolled with a three wheel roller weighing not less than 8.00 tonnes. Rolling is started longitudinally from the outer sides and proceed towards the centre of the pavement in straight and from lower edge to higher edge on curves overlapping on successive passes by at least one half the width of the rear wheel.
6. Check the cross section of the compacted course aggregate with a help of straight edge and camber plate.

Application of Binder

7. Apply the binder to the rolled course aggregate at specified quantity and temperature with the approved bitumen distributor. The quantity and temperature of binder during application is given in Table 4-10.1 and 4-10.2 respectively.
8. Immediately after the binder has been applied to the coarse aggregate, key aggregate is sprinkled lightly over the surface in sufficient quantity to prevent sticking of the roller wheels. Then it is rolled and simultaneously with the rolling, additional key aggregate are added in small quantities and lightly broomed over the surface while rolling continues until the surface interstices between the coarse aggregate have been filled but without covering the coarse aggregate itself. Roll the surface until the stone is thoroughly imbedded into the binder and anchored in place. Continue rolling until the surface is hard and smooth and shows no perceptible movement under the roller.

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Table 4-10.1: Rate of Application of Binder and Rate of Spread of Aggregate per sq.m

Compacted thickness	Binder	Coarse Aggregate	Key Aggregate
75 mm 50 mm	6.8 liters 5.0 liters	$0.09\ m^3$ $0.06\ m^3$	$0.018\ m^3$ $0.015\ m^3$

Table 4-10.2 Spraying Temperature of Binder

Binder		Spraying Temperature ° C	Maximum Heating ° C
Bitumen	180/200	155-165	170
Bitumen	80/100	160-170	170

Seal Coat

9. Before application of seal coat the surface is cleaned by brooming and removed all loose material and treated with a second coat of binder at the rate of 1.4 ltr per square meter and immediately after application of the binder, cover aggregate will be spread and broomed uniformly over the surface as specified. Then rolling is carried out covering the whole paved area.

B QUALITY CONTROL REQUIREMENTS

I Materials

a) Aggregates

The aggregate is the product of crushed rock or crushed gravel having angular shape with a character that let it compact and interlock under rolling. All the aggregates must be of reasonably uniform quality throughout, clean and free from plastic fines and other foreign material or other deleterious matter. It shall comply with the following requirements given in Table 4-10.3, 4-10.4 and 4-10.5.

Table 4 –10.3: Aggregate Physical Requirements

Test	Specification
Los Angles Abrasion value	40 % (Max)
Aggregate Impact value	30 % (Max)
Water absorption	2 % maximum
Flakiness Index	35% maximum
Stripping Value	5% Maximum

Table 4 –10.4: Grading of Aggregate for Penetration Macadam

Sieve Size (mm)	Percentage passing by weight			
	Coarse aggregate (Course 75 mm thick)	Coarse aggregate (Course 50 mm thick)	Key Aggregate (Type I)	Key Aggregate (Type II)
75.00	100	-	-	-
63.00	90-100	100	-	-
50.00	20-55	90-100	-	-
37.50	0-15	40-75	-	-
25.00	-	15-35	-	-
20.00	0-15	0-15	100	100
12.50		0-5	90-100	90-100
10.00			40-70	40-75
4.76			0-15	5-25
2.36			0-5	0-5

Table 4 –10.5: Composition of Aggregate

Compacted thickness of layer	Nominal single sized aggregate	Percentage
50 mm	40 mm 28 mm 14-20 mm	60% 30% 10%
65 mm – 75 mm	50 mm 40 mm 14-20 mm	60% 30% 10%

b) Binder

The binder shall be 80/100 penetration grade bitumen or MC 3000 cutback bitumen.

2. Horizontal Alignment

The edges of the carriageway with Premix Carpet should be correct within a tolerance limit of (±) 20 mm in plain and rolling terrain and (±) 30 mm in hilly terrain.

3. Surface Level

The tolerance in surface level of the surface dressing would be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the pavement course and a 3 m straight edge shall not exceed 10 mm for longitudinal profile and ± 0.25% for the cross profile.

5. Quality Control Tests

5.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 4-10.6

TABLE 4-10.6 : QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No	Type of Tests	Frequency
1	Quality of Binder (Bitumen)As per Table 4-7.3	One set of test for every 50 KL or part of it and change of source & certificate from suppliers
2	Gradation	One test for each source
3	LAA	-do -
4	Aggregate Impact Value	-do -
5	Stripping Value test	One set of three specimens from each source
6	Water absorption	One test for each source

5.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 4-10.7

TABLE 4-10.7: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No	Type of Test	Frequency
1	Quality of bitumen	One set of test for every 50 KL or part of it and change of source & certificate from supplier
2	Grading	One test per every 50 m^3 or part of it or change of source
3	LAA or AIV	One test per every 500 m^3 or part of it or change of source
4	Sodium Sulphate Soundness (SSS)	do-
5	Stripping value	Subsequently when warranted by change in source
6	Temperature of Binder,	At regular interval
7	.Rate of Spread of Binder (Including Dip Check)	Two tests per run
8	Surface level	Every 20 m or at close interval
9	Width	Every 200 m or at close interval
10	Smoothness	All apparently rough area to be checked
11	Thickness of layer	Every 500 m or at close interval

Note:
Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated speed.

SECTION 7
BRICKWORK FOR STRUCTURES

7: BRICKWORK FOR STRUCTURES

A. Methodology

Before commencement of the work, the contractor shall request for works filling the works request form prepared by the Project office indicating location of work with typical construction drawing and get approval from the engineer.

A1 General Brickwork

1. Excavate the foundation to required depth following the methodology provided in Sub-section 2-4 and according to the design drawing conforming as per the Drawing No DLR/ROAD/T-17 of the Technical Guideline on Planning, Design and Construction of Rural Roads.
2. If the foundation is adequate, check the cross slope and check the foundation level and get approval from engineer before brick work is carried out.
3. If foundation work is complete, construct the retaining structure following the steps given below.
4. Soak all bricks for a minimum period of one hour before use and remove from water sufficiently in advance so that they are skin dry before actual laying.
5. Before laying the bricks in foundation, hack the top surface of the foundation block, clean, wet and spread a layer of mortar of 12 mm (minimum) thickness, to prepare the surface. In case of masonry works resting on rock base, lay a leveling course of 150 mm (average) thickness in concrete of M10 grade, if required.
6. Lay all brickwork in English bond, even and true to line, plumb or specified batter and level. All joints are staggered in successive courses and lay joints accurately. The bricks used on the face must be complete one with uniform size and true rectangular face.
7. Lay all bricks with frogs up, if any on a full bed of mortar. Slightly press the bricks so that the mortar gets into all hollow space of bricks to ensure proper adhesion. Flush all joints and pack with mortar, to fill all hollow spaces.
8. To avoid unequal settlement and improper jointing, construct the brickwork in uniform layers so that no part of brickwork shall rise more than one meter above the general construction level in a day.
9. Remove all loose bricks and mortar while joining partially set or fully set brick masonry with new one by roughening the surface and apply cement slurry on it to achieve proper bond. In case of vertical and inclined joints, achieve proper bond by inter locking the bricks.
10. Finish all joints on exposed faces to give a concave shape, the thickness of joint not exceeding 10 mm.
11. Masonry work in cement mortar is kept constantly moist on all faces for a minimum period of seven days. The top of masonry work is left flooded with water at the close of the day. During hot weather cover all finished or partly completed work by wet hessian jute or make it wet by watering to prevent rapid drying of brickwork. Continue watering and curing at the close of day's work or for other period of end of works. Curing is done at least for 7 days.
12. Erect single scaffolding for plastering, pointing and any finishing in which one end of the putlogs/ pole shall rest in the hole provided in the header course of brick masonry. Provide double scaffolding having two independent supports clear of the work when brick work is exposed and not to be finished.
13. Provide weep holes to masonry structures higher than 2 m to drain water from back filling. Use

100 mm dia pipes and extend to the full width of masonry with 1:20 slope to the draining face. Stagger them suitably and their spacing shall not exceed 2 m in horizontal or 1 m in vertical direction, with the lowest one at about 150 mm above the low water level or bed level whichever is higher.

14. Provide concrete coping of 150 mm thickness over the masonry where specified. While using precast or cast in site concrete coping, provide vertical construction joints at spacing of not more than 1.5 m

Pointing and plastering

1. For a surface which is subsequently plastered or pointed, make out the joints to a depth of 15 mm while mortar is green.
2. Carry out pointing using mortar of proportion shown on drawings but not leaner than 1:3 by volume of cement and sand. Fill and press mortar into the raked out joints before giving the required finish.
3. Execute plastering using mortar of proportion where shown on the drawings but not leaner than 1:4 by volume of cement and sand to the specified thickness which will not be higher than average thickness by 3 mm.
4. Commence curing as soon as the mortar or pointing/plastering has hardened sufficiently. Keep the surface wet for a period of at least 7 days.

B. Quality Control Requirements

1 Materials

(a) Bricks

First class burnt clay bricks conforming to the requirements of NS-1/2035 shall be used for the brick work with the physical requirements as given in Table 7.1

TABLE 7.1: PHYSICAL REQUIREMENTS

Item	Requirements
Burnt Clay bricks	NS-1/2035 or IS:1077
Minimum Compressive Strength	Not less than $8 N/mm^2$ for individual bricks and $10 N/mm^2$ for average 5 specimen.
Water absorption	Upto 20% by weight (IS:3495 Part 2)
Efflorescence	'Moderate' upto 50% of exposed area of brick covered with a thin deposit of salt but unaccompanied by powdering or flaking of Surface (IS:3495 Part 3)
Preferred size	According to the local practice or 230 x 110 x 50 mm

b) Cement

Cement of any of the following types Ordinary Port land cement (OPC), High Strength Portland cement (HSPC), Portland slag cement (PSC) Portland Pazzolana cement (PPC) shall be used meeting the physical requirements as per the IS 4031. The Physical Characteristics requirement of the cement is given in Table 7.2.

Table 7.2: Requirements on Physical Characteristics of Cement

S.No	Physical Characteristics	OPC/PSC	PPC	HSPC	Test Procedure
1	Fineness (m^2/kg)	225	320	225	IS-4031 Part2; PPC- IS 1489 Part 2
2	Initial setting Time (Minutes) minimum	45	30	45	IS-4031 Part5
3	Final setting Time (Minutes) maximum	600	600	600	IS-4031 Part5
4	Soundness (mm)	10	10	10	IS-4031 Part2
5	Compressive Strength: Minimum Average Compressive Strength of 3 mortar cubes (N/mm^2) 3 days 7 days 28 days	 16 22 33	 16 22 33	 27 37 53	IS-4031 Part6

(c) **Sand**

Sand shall consist of hard, durable and clean particles, free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified of natural sand, crushed gravel, suitable combinations there of and shall conform to the requirements as per IS2116 (1980) and given in Table 7.3. the gradation of the sand shall be comply as per the Table 7.4 below.

TABLE 7.3: Requirement of Nature /Crushed Gravel / Crushed Stone sand

S.No	Particulars	Requirements	Test Procedure
1	Deleterious material	Not more than 5% by mass	IS:2386 part 2
	Stone/Marble Dust	Colour of liquid shall be lighter than that indicated by standard solution specified in IS 2386 part 2	IS:2386 part 2

Table 7.4: Grading of Sand for the use of Masonry Mortar

IS Sieve	Percentage Passing by Mass	Test Procedure
4.75 mm	100	IS 2386 Part I
2.36 mm	90 - 100	
1.18 mm	70 - 100	
600 μ	40 - 70	
300 μ	5 - 70	
150 μ	0 - 15	

(d) **Cement Sand Mortar**

Cement Sand Mortar is a homogeneous mixture, produced by intimately mixing cement, water and inert materials, such as sand, to the required consistency for use in building together with masonry units. Cement Sand mortar shall in general conform to IS:2250 and its consistency shall be determined as per the code. The mortar used should have the strength not less than $5N/mm^2$ or $7.5\ N/mm^2$ at 28 days as specified.

2 Workmanship and Tolerances

Permissible values of workmanship and tolerances for bricks and brick masonry are given in Table 7.5

Table 7.5: WORKMANSHIP AND TOLERANCES

Item	Permissible Value
Dimensions of Bricks	±5 per cent in size
Thickness of joints for general brick work Plaster furnish	Not more than 10 mm Surface thickness, not less than specified thickness by more than 3 mm.

3 Quality Control Tests

3.1 Tests prior to construction.

The tests / checks to be carried out prior to construction are indicated in Table 7.6.

TABLE 7.6: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material	Test / Check	Frequency
1	Bricks	a) Colour and Dimensional check b) Water absorption (IS:3495 Part 2) c) Efflorescence (IS:3495 Part 3) samples at random, at source d) Compressive strength (IS:3495 Part 1)	3 samples at random at source 3 samples at source In case of doubt, 3 samples at random at source 5 samples at random at source
2	Cement	a) Setting time of cement (IS:4031 part 5) b) Fineness (IS: 4031 Part 1)	One samples of same type and grade of cement
3	Sand (Natural and crushed stone)	a) Gradation (IS: 2115) b) Deleterious material and organic impurities (IS: 2386 Part 2)	3 samples for each source of supply If in doubt, one test per source
4	Water	Normally potable water is good enough. If impurities are present test as per IS:3025 (parts 17, 24, 32)	Samples taken at each source tested at an approved test house if doubt

3.2. Tests during construction

The tests to be carried out during construction are indicated in Table 7.7

TABLE 7.7: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Bond and Plumbness	English bond, verticality by Plumb bob	For each course
2	Laying in Mortar	Laying in full bed of mortar with proper lapping	- do -
3	Individual Course	Height of course and Joint thickness (IS:2212)	- do -
4	Top of coping (If provided)	Sloping to drain off water	Daily
5	Mortar for Joints	a) Mix proportions (Control on quantity of cement by weight) b) Compressive Strength (IS:2250)	Each batch 6 samples of cubes for each 10 m^3 of work or part of it

SECTION 8
STONE MASONRY FOR STRUCTURES

8 : STONE MASONRY FOR STRUCTURES

A. Methodology

Before commencement of the work, the contractor shall request for works filling the works request form prepared by the Project office indicating location of work with typical construction drawing and get approval from the engineer.

A1 General Stone Masonry Work (Random Rubble masonry)

1. Excavate the foundation to required depth following the methodology provided in Sub-section 2-4 and according to the design drawing conforming as per the Drawing No DLR/ROAD/T-17 of the Technical Guideline on Planning, Design and Construction of Rural Roads.
2. If the foundation is adequate, check the cross slope and check the foundation level.
3. If foundation work is complete, construct the retaining structure following the steps given below and get approval from the engineer before commencement of structural works.
4. Dress the stones of required size (least dimension not less than 150 mm) and quantity, immerse in water for sufficient time before use.
5. Before laying the stone in foundation, hack the top surface of the foundation block, clean, wet and spread a layer of mortar of 12 mm (minimum) thickness, to prepare the surface. In case of rock base , place concrete leveling course (M 10 grade) of average thickness of 150 mm.
6. Lay masonry work to lines, levels and dimensions as shown on the drawings. The stones shall be laid on their natural beds in horizontal courses. Keep height of each course same, fine tooled on all bed, joints and faces, full and true.
7. Lay outer layers of masonry first, fix the location of headers and bond stones and lay them. Lay stones in the hearting on their broadest face to ensure filling the spaces between stones.
8. When there is to be variation in the height of the courses, place larger courses at lower levels with heights of courses decreasing gradually towards the top of the wall.
9. In tapered walls, the beds of the stones and planes of courses shall be kept right angle to the batter. In case of piers with batter on both sides, keep the course horizontal.
10. Lay all stones, full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet, immediately on placement and solidly embedded in mortar before it has set.
11. Placing loosed mortar on the course and pouring water upon it to fill the gaps is not allowed.
12. Clean and wet chips and spalls can be used whenever necessary to avoid thick joints or bed of mortar. Ensured that no hollow space are left any where in masonry. Chips and spalls shall be used in the interstices between the adjacent stones in hearting only and shall not be more than 20% of the quantity of masonry.
13. In case any stone already set in mortar, is disturbed or the joint broken, take it out without disturbing the adjacent stones and joint. Reset the stone in fresh mortar after removing dry mortar and thoroughly cleaning the stones and joints.
14. Provide sufficient transverse bonds by the use of bond stones or set of bond stones extending from the front to the back of the wall from outside to the interior and vice versa, overlapping each other by 150 mm (minimum).
15. Make vertical joints truly vertical and staggered as far as possible. Keep the distance between vertical joints of upper and lower layer, more than half the height of the course.

16. Provide weep holes to masonry structures higher than 2 m of size not less than 80 x 150 mm to drain water from back filling. Use 100 mm dia. HDPE pipes and extend to the full width of masonry with 1:20 slope to the draining face. Stagger them suitably and their spacing shall not exceed 1 m in either direction or as shown in the drawing, with the lowest one at about 150 mm above the low water level or bed level whichever is higher or as directed by engineer.

17. Provide concrete coping of 150 mm thickness over the masonry where specified. While using precast or cast in site concrete coping, provide vertical construction joints at spacing of not more than 1.5 m

18. Commence curing as soon as the mortar or pointing/plastering has hardened sufficiently. Keep the surface wet for a period of at least 7 days.

B. Quality Control Requirements

1. Materials

(a) Stone

Use stone which is hard, sound, free from cracks, decay, weathering, defects like cavities, flaws, sand holes and patches of loose or soft materials. Do not use stones with round surface.

The Specifications and requirements of stones shall satisfy those given in Table 8.1

TABLE 8.1: PHYSICAL REQUIREMENTS OF STONES

Item		Requirements
1	Least Dimension (IS:1597 Part 1) Length of stone Height of stone (IS: 1597 Part 1)	150 mm 3 times its least dimension or width of wall which ever is less 300 mm
2	Water Absorption in stone (IS:1124)	5 % of its weight
3	Specific Gravity (IS: 1124)	2.5

i) Bond Stone

Each bond stone or a set of bond stones shall be provided for every 0-5 m^2 of the wall surface and shall be provided at 1.5 m to 1.8 m apart clear in every course.

ii) Quoin-Stone

Quoin stone shall not be less than 0.03 m^3 in volume.

iii) Hearting-Stone

The hearting or interior filling of wall face consist of rubble stone not less than 150 mm in any direction.

(b) Stone Masonry

The specifications and requirements of Stone Masonry shall satisfy those given in Table 8.2

TABLE 8.2: REQUIREMENTS OF STONE MASONRY

Item		Requirements
1	Dressing of Stone	IS:1129 and IS:1597
2	Minimum height of individual course	160 mm
3	Thickness of joint	10 - 20 mm

3 Quality Control Tests

3.1. Tests prior to construction

The tests / checks to be carried out prior to construction are indicated in Table 8.3

TABLE 8.3: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Stones	a) Shape and Dimension (IS:1597 part 1) b) Water absorption/Sp .gr (IS:1124) c) Dressing of Stones via Hearting, Bond, Quoin, Face stones, Headers, etc. (IS:1129)	3 samples on receipt at site 3 samples on receipt at site Once for each stock after selection for individual work
2	Cement	Setting time of cement (IS:4031 part 5)	1 samples of same type and grade of cement
3	Sand	a) Gradation (IS:2116) b) Deleterious materials and organic impurities (IS:2386 part 2)	3 samples for each source of supply, If in doubt, one test per source
4	Water	If impurities are present test as per IS:3025 (parts 17,24, 32)	If doubt Samples taken at each source tested at an approved test house
5	Mortar for Joints (Mix Design)	a) Mix proportions for different works b) Compressive Strength (IS:2250)	As required 6 samples of cubes for each type of cement and source of sand

3.2. Tests during construction

The tests to be carried out during construction are indicated in Table 8.4

TABLE 8.4: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Bond and Plumbness	For stability and appearance with plumb	For each course
2	Laying in Mortar	Horizontality of courses verticality and staggering of joint	- do -
3	Individual Course	Height of course and Joint thickness and laying (IS 1597 part 1&2, IS:2212)	- do -
4	Top of coping (If provided)	Sloping to drain off water	Daily
5	Mortar for Joints	a) Mix proportions (Control on quantity of cement by weight) b) Compressive Strength (IS:2250)	Each batch 6 samples of cubes for each 10 m^3 of work or part of it

A2 Dry Stone Masonry

Dry stone masonry shall be constructed generally to the requirement of random rubble masonry but with the omission of mortar. All the stones shall be carefully shaped to obtain as close a fit as possible at all bed and joints, any interstices between the stone being filled with selected stone spalls. the stone in course shall be laid perpendicular to the batter face.

8.1 Hands Feel Tests for Stones

The chief requirements of a building stone are strength, density and durability. All stones other than those of sedimentary origin are suitable for stone masonry work. Some of the requirements and simple tests are indicated below:

(i) The stones should be hard, tough, compact grained and of uniform texture and colour.

(ii) They should be free from cracks, decay, weathering defects like cavities, flaws, veins, sand holes and patches of loose/soft material.

(iii) Break a stone with a hammer. The surface of a freshly broken stone should be bright, clean and sharp and should show uniformity of texture without loose grains and be free from any dull chalky or earthy appearance.

(iv) If a drop of dilute hydrochloric acid or sulphuric acid on a piece of stone causes effervescence, the stone contains weathering materials.

(v) A sample of stone when struck with a 1 kg hammer should emit a ringing sound and should not break with one blow. A pen-knife when scratched on surface should not make an impressions on hard stone.

Section 9
FORMWORK AND SURFACE FINISH FOR STRUCTURES

9: FORMWORK AND SURFACE FINISH FOR STRUCTURES

A Methodology

Before commencement of the work the contractor shall request for works filling the works request form prepared by the Project office indication location of work with typical construction drawing and get approval from the engineer.

A1 Construction Operation (Design and Erection)

1. Examine all materials and components used for formwork, for damage or excessive deterioration before use and reuse only if found suitable after repairs.
2. For timber formwork, inspect for physical damages, besides signs of attack by decay, rot or insect attack or development of splits.
3. Use familiar materials like timber, steel, plywood, concrete and masonry for false work. For metal forms, the thickness should be adequate to keep them true to shape. Use counter sunk bolts and permit use of approved internal steel ties or steel or plastic spacers. Bamboos supports shall not be provided.
4. Ensure false work (formwork + temporary support system) is designed to meet the requirements of permanent structure including ease of erection and dismantling and is approved by the Engineer.
5. Provide proper and safe access to all parts of formwork for inspection.
6. Make the formwork robust and use ballies of 100 mm dia of heights not more than 4 m. Provide cross and diagonal bracings of 75 mm dia (ballies) in both directions. For metal forms, the diagonal bracings shall be of the same size of angles used for columns.
7. Check for design deficiencies such as shoring or re-shoring, insufficient allowance for unsymmetrical or eccentric loading due to placement sequence of concrete.
8. Pay attention to detailing which otherwise may cause instability, local failure or progressive collapse. Lay emphasis on attention to details.
9. In case of false work erected on normal ground, ensure distribution of loading to the ground, through timber or base plates to avoid differential settlement.
10. Control the alignment of the distribution members, so that shores of the false work system are centrally placed on the member.
11. Make the forms tight and sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between the supports.

A2 Preparation before Concreting

1. Apply a coat of oil or grease as release agent, inside the surfaces of forms to prevent adhesion of concrete to formwork.
2. Make the formwork leak proof to prevent escape of cement slurry during compaction with vibrators. Clean the forms thoroughly just before concreting.
3. Line formwork with a proven material to provide smooth finish of uniform texture and appearance, without leaving stain on concrete.
4. Take special measure to ensure that the formwork doesn't hinder the shrinkage of concrete due to which cracking occur before the framework is removed.

9-5 Removal of Formwork

1. Plan removal of formwork (de-shuttering and de-centering) in advance. Give due consideration to the local conditions viz. character of structure, weather and other conditions that influence the setting of concrete and materials used in mix.
2. Lower centering gradually and uniformly so as to permit the concrete to take self weight, uniformly and gradually to avoid shock or vibration. At reentrant angles of concrete sections, remove formwork soon after setting of concrete to prevent shrinkage cracking.
3. When internal metal ties are permitted, remove them or their parts without damaging concrete. Fill the holes left out with cement mortar (1:3)
4. The time of removal of formwork when OPC is used without any admixtures is given in Table 9.1 Otherwise it may be taken as 14 days for Superstructure.

TABLE 9.1: TIME FOR REMOVAL OF FORMWORK

Member	No. of days
Walls, piers, abutments, columns and vertical faces of structural members	1 to 2
Soffit of slab (with prop left under)	3
Props (left under slabs)	14
Soffit of girders (with props left under)	7
Props (left under girders)	21

Reuse of Formwork

1. After dismantling examine individual components for damage and remove damaged pieces for rectification.
2. Straighten all bent steel props before reuse, the maximum deviation from straightness being 1/600" of its length. Maximum permissible axle loads on used props shall be suitably reduced depending on their condition.

B. Quality Control Requirements

1 Tolerances in Formwork

(a)	Deviations form the specified dimensions of cross section of columns, beams	+ 12 mm - 6 mm
(b)	Deviations dimensions of footing/open foundation	
(i)	Dimensions in plan	+ 50 mm
(ii)	Eccentricity in plan 0.02 times the width of the footings in the direction of deviation but not more than 50 mm	- 12 mm
(iii)	Thickness	± 0.05 times the specified thickness

2. Quality Control Tests

2.1 Tests prior to construction

The Quality Control tests to be carried out prior to construction are indicated in Table 9.2

TABLE 9.2: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Test	Frequency
1	Thickness of Steel tubes	Before use / Procurement
2	Dia of 'ballies'	- do -
3	Size of panels (steel sheets / timber planks)	- do -
4	Formwork if in reuse (Clause 9-5 of DoLIDAR Specifications)	To be approved by Engineer
5	Design of formwork	To be approved by Engineer

2.2 Tests during construction

The quality control tests to be carried out during construction are indicated in Table 9.3

TABLE 9.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. No.	Test	Frequency
1	Clamps for strength and stability of Form work	Regular
2	Camber and Surface smoothness	At the end of erection work
3	Mortar tightness	Before concreting
4	Supporting system on ground (To prevent settlement and distribution of load)	Check before/during concreting
5	Safe access onto and about the formwork	Regularly during concreting
6	Height of panels for supporting structures and return walls	Check before concreting

Note:

- Do not use form panels of height less than 1.0 m for abutments, piers and return walls.
- Do not keep centering and shuttering on soft or filled up earth.
- Use large size panels to keep the number of joints to a minimum.
- Avoid sharp corners by providing fillets of 25 x 25 mm (minimum) size at all angles of formwork.
- Do not allow stagnation of water near the base plate supporting the staging.
- Use clamps of adequate strength to hold the forms together

SECTION 10
STEEL REINFORCEMENT

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10 STEEL REINFORCEMENT

A. Methodology

A 1 Bending and Placing

1. Use the reinforcement bars to the dimensions and shape given in the Bar Bending Schedule shown on the relevant drawing.
2. Use new steel of the same type and grade for main reinforcement in construction. Use of different type of same grade steel as secondary reinforcement may be allowed exceptionally.
3. Straighten the bars which get bent during transportation or handling. Bend re-bars cold to the specified shape and dimensions using a proper bar bender operated by hand or power to obtain correct radii of bands and shape.
4. Provide a U type hook at the end of each bar unless otherwise specified. The radius of bend must be twice the diameter of the bar and the length of the straight part of the bar beyond the end of curve be at least 4 times the diameter of the bar.
5. Place reinforcement bars accurately in position as shown on drawings. Make the skeleton of reinforcement rigid by tying all bars crossing one another at every intersections using annealed binding wire not less than 1 mm diameter.
4. Position the bars on industrially produced polymer cover blocks or concrete cover blocks of required thickness, to provide cover to reinforcement.
5. Position the vertical projected reinforcement from sub-structure or foundation, by means of timber templates with slots cut in them accurately or with cover blocks tied to the reinforcement.
6. Separate layers of reinforcement by spacer bars at a maximum length of 1m, keeping the minimum dia of spacer bar as next higher size of main reinforcement.
7. At construction joints, bend aside reinforcing bars and bend back to the original position, by ensuring that concrete around the bar is not damaged beyond the bend.

A 2 Splicing, Welding and Substitution of bar sizes

1. Stagger the lapped splices and located at points along the span where stresses are low.
2. Minimum spacing between overlapped bars must be 25 mm or 1.25 times the maximum size of course aggregate whichever is greater.
3. Bars are cleaned of all loose scale, rust, grease etc, before carrying out welding by metal arc welding process.
4. Butt weld all bars except bars of dia less than 20 mm, which are to be lap, welded.
5. Locate welded joints well away from the bends and not less than twice the bar dia from a bend.
6. The bars are laid by staggering the weld joints such that at any section less than 20% of the bars are welded.
7. Substitute bars where necessary with the same type and grade after ensuring the minimum area provided is equivalent to the original at each cross section.

B. Quality Control Requirements

1. Material:-

(i) The Steel reinforcement used and works executed shall conform to the requirements given in Table 10.1

TABLE 10.1: Mechanical Properties of High Strength deformed bar and wires

S.No	Properties	Fe415	Fe415 D	Fe 500	Fe 500 D	Fe 500	Fe 550 D
1	0.2%proof stress/yield stress min N/mm^2	415	415	500	500	550	550
2	Elongation %,minimum gauge length $5.56\sqrt{A}$*	14.5	18	12	16	10	14.5
3	Tensile strength ,minimum	10% more than actual 0.2% proof stress/yield stress but not less than 485.0 N/mm^2	12% more than actual 0.2% proof stress/yield stress but not less than 500.0 N/mm^2	8% more than actual 0.2% proof stress/yield stress but not less than 545.0 N/mm^2	10% more than actual 0.2% proof stress/yield stress but not less than 565.0 N/mm^2	6% more than actual 0.2% proof stress/yield stress but not less than 585.0 N/mm^2	8% more than actual 0.2% proof stress/yield stress but not less than 600.0 N/mm^2

*A – the cross sectional area of the test piece

(ii) The workmanship for welding of steel reinforcements shall conform to the specifications given in Table 10.2

TABLE 10.2: WORKMANSHIP FOR WELDING

Welding of Mild Steel	IS:432
Welding Method	IS:2751 and IS:9417
MS Electrodes for welding	IS: 814
Inspection of Welds	IS: 8222

2. Tolerances

The Reinforcement shall be placed within tolerances given in Table 10.3

TABLE 10.3: TOLERANCES FOR COVER

Member/Cover	Tolerance
Members with effective depth less than 200 mm	± 10 mm
Members with effective depth more than 200 mm	± 15 mm
Cover	+ 10 mm (No minus tolerance permitted for cover)

3. Quality Control Tests

3.1 Tests prior to construction

The Quality Control tests to be carried out prior to construction are indicated in Table 10.4

TABLE 10.4: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Test	Frequency
1	Grade, percentage elongation and ultimate tensile strength (For culverts and small bridges) (IS:432 part 1 and IS:1786)	3 samples from each supplier (certificate from an approved test house)
2	Pitch of the Ribs and Nominal Diameter	Random checking
4	Substitution of bar sizes	Approval before execution of work
5	Detailing of reinforcement cages	Approval before execution of work

3.2 Tests during construction

The Quality Control tests to be carried out during construction are indicated in Table 10.5

TABLE 10.5: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. No.	Test	Frequency
1	Bending and placing of reinforcement (IS:2502)	Daily/Regularly
2	Splicing and welding	As and when such work is taken up
3	Tolerances (Spacing and cover)	Before concreting

Note:

- Protect reinforcement steel from rusting or chloride contamination, by thorough cleaning using suitable method before use.
- Follow the working drawings and bar bending schedules and match detailing and construction.
- Do not weld reinforcement at site welding unless adequate facilities, equipment etc to maintain quality is attainable.

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SECTION 11
PLANE AND REINFORCED CEMENT CONCRETE FOR STRUCTURES

11 PLAIN & REINFORCED CONCRETE FOR STRUCTURES

A. Methodology

11-1 General

1. Plan all activities before mixing and placing of concrete Works. This includes procurement of materials, sample testing of cement, coarse and fine aggregates, water and trial mix (Mix Design) of the ingredients to achieve the desired strength and workability.
2. Estimate the total quantity of concrete required for the day's work besides additional quantity required for sampling (cubes, cylinders, beams) and plan production of concrete. All ingredients of concrete shall be specified by weight batching .

A 2 Production of Concrete

1. Designate concrete in grades viz M10, M15, M20, M25, M30, M40, M45 where the characteristic strength of concrete is defined as the strength of concrete below which not more than 5 percent of the results are expected to fall.
2. Choose Design Mix of concrete grades higher than M 20. For culverts and small bridges involving small quantity of concrete, nominal mix of grades M 20 and M 25 may be used with adequate supervision and quality control measures.
3. The suggested grades of concrete together with cement content, for different exposure conditions indicated in Table 11.1. Letter M in class designations stands for Mix, Letter SM stands for Special Mix.

TABLE 11.1: CEMENT CONTENT AND WATER CEMENT RATIO

Classes of concrete	Minimum Cement Content in Kg/ m^3 of Compacted Concrete		
	Moderate exposure	Intermediate exposure	Severe exposure
M 10/75, M 10/40	125	150	175
M 15/40, M 15/20	150	200	225
M 20/40, M 20/20	250	300	325
M 25/20, M 25/40	300	325	350
M 30/40, M 30/20, M 30/12 M 35/40, M 35/20	325	350	375
M 40/20, M 45/20, M 50/20	375	400	425
SM 30/20, SM 30/40	400	400	425
SM 40/20, SM 45/20	425	425	450

Note: The minimum cement contents shown in the above table are required in order to achieve impermeability and durability. In order to meet the strength requirements in the Specification higher contents may be required.

The categories applicable to the works are based on the factors listed hereunder:

Moderate exposure	:	surface sheltered from severe rain, buried Concrete
Intermediate exposure	:	Surface exposed to severe rain; alternate wetting and drying; traffic; corrosive fumes; heavy condensation.
Severe exposure	:	Surface exposed to water having a pH of 4.5 or less, ground water containing sulphates.

4. For "Smaller Contracts Works", the following compositions shown in Table 11.2 are suggested as a starting basis for the Laboratory trials for one m^3 of concrete.

Table 11.2: Quantity of Materials Required for Different Grade of Concrete

Class of Concrete	Characteristic Strength (N/mm^2)	Cement (Kg)	Total Aggregate (Kg)	Fine Agg./ Total Agg. (%)	Maximum Water (Ltr)	Workability
M 15/40 M15/20	15	250	1900	35 - 45	160	Stiff-Plastic
M20/20	20	300	1875	35 - 45	160 – 170	Stiff
M30/40	30	350	1825	35 - 45	170	Stiff
M30/20	30	350	1825	35 - 45	175	Plastic
M35/20	35	350	1825	35 - 45	175	Plastic

Consistency of mix assessed through the slump test where the slump is measured in mm is designated as below:

S : Stiff consistency, for slump ≤ 40
P : Plastic consistency, for slump › 40 and ≤ 90
VP: Very Plastic consistency, for slump › 90 and ≤ 150
F : Flowing consistency, for slump › 150

5. Use Mechanical mixer (min. one bag capacity) fitted with water measuring device for culverts and small bridges with length less than 60 m and individual span less than 15 m. However for control mix of M 25 for superstructure, use mechanical mixer of minimum 200 liter capacity having integral weight batching facility, automatic water measuring and dispensing device.

6. Avoid hand mixing of concrete for use in structural concrete except for isolated culverts (upto 2 m) in remote areas or for certain other reasons. Add 10% extra cement in such situations.

7. Use Admixtures where necessary or instructed by engineer to meet specific requirements of concrete.

A 3 Transportation, Placing and Compaction of Concrete.

1. After mixing, transport concrete to the formwork as quickly as possible in wheel borrows to site. Transport and place concrete such that no contamination, segregation or loss of its constituent materials or ingress of foreign material or water takes place.

2. During hot or cold weather, concrete shall be transported in deep containers or other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

3. Proceed with concreting continuously, over the areas between construction joints. Deposit concrete in horizontal layers to a compacted depth of not more than 450 mm, when internal vibrators are used and not more than 300 mm in other cases.

4. Choose appropriate methods of placing concrete so as to avoid segregation.

5. Care should be taken to avoid displacement of reinforcement or movement of formwork. As a general guidance, the maximum permissible free fall of concrete may be taken as 1.5 m.

6. Compact concrete using internal (needle/poker) vibrators of suitable size or form vibrators, during placing and worked around the reinforcements, to produce dense, homogeneous and void free mass.

7. Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators should receive special consideration to ensure efficient compaction and to avoid surface blemishes.

8. Compact before the initial setting but not later than 30 minutes of its discharge from the mixer

A 4 Concreting under Water and in Extreme Weather

1. When it is necessary to deposit concrete under water, add 10 percent more cement than required and place the mix dry. Proportion the materials so as to produce a slump between 100-180 mm.

2. Make cofferdams or forms in water, sufficiently tight to prevent loss of mortar through the joints in the walls. Avoid pumping of water, while concrete is being placed or until 24 hours thereafter.

3. Concrete cast under water should not fall freely through the water. Otherwise it may be leached and become segregated. Concrete shall be deposited either by bottom –discharging water tight container or through funnel shaped tremie- pipe which are kept continuously full with concrete in order to reduce to a minimum contact of concrete with water. Special care shall be taken to avoid segregation

4. Where concrete is to be deposited at or near freezing temperatures, heat the mixing water to a temperature below 65 ^{0}C and if necessary heat the aggregates as well, before mixing. In general the temperature of water and aggregate shall not be more than 65^{0}C

5. When concrete is to be deposited in hot weather, ensure that the temperature of green concrete does not exceed 30 ^{0}C before placement. Ensure this by mixing water with ice and keeping the aggregates under shade before use and cool the outside of formwork by water sprinkling.

A 5 Curing Protection and Finishing

1. Commence curing and protection immediately after the compaction of concrete, to prevent premature drying, leaching out by rain etc.

2. After initial set (about two hours) of concreting, cover the work with moist gunny bags, canvas, hessian or similar material.

3. After 24 hours, keep all exposed surfaces of concrete in damp or wet condition by pouring or by wet covering with a layer of sacks, canvas, hessian for a period of not less than fourteen days from the date of placement.

4. Use curing compounds only in special circumstances. Avoid use of curing compound at locations where concrete surfaces are required to be bonded together.

5. Examine concrete immediately on removal of formwork and any defects are be made good. Cut all exposed bars or bolts passing through RCC member and used for shuttering or any other purpose, to a depth of 25 mm below the surface of the concrete and close the holes with cement mortar.

A 6 Construction Joints

1. Do not place fresh concrete against concrete which has hardened in position for more than 30 minutes or initial set unless proper construction joint is formed.

2. Before concreting fix a stopping board at predetermined position, for vertical construction joint, which has adequate lateral rigidity to withstand lateral displacement or bulging during concreting.

3. Continue concreting upto the board. Remove the board before expiry of 24 hours.

4. Before resuming work on a partially hardened surface , remove all laitance by scrubbing the wet surface with wire or bristle brush. Coat the prepared surface, thoroughly wetted, with cement grout. Keep thickness of first layer of fresh concrete upto 150 mm and well ram against old work.

5. Before resuming work on a fully hardened surface, hack the surface without dislodging coarse aggregate, clean loose material, wet it and cover with a layer of cement grout.

6. Ram the first batch of concrete against old work, to avoid formation of any pockets, by paying attention to corners and close spots.

7. Carefully tool all construction and expansion joints in the completed work, free from any mortar and concrete. Leave expansion joint filler exposed for its full length with clean and true edges.

B. Quality Control Requirements

1 Materials

(i) Cement

Use any of the following types of cement given in Table 11.3 for Structural Concrete

TABLE 11.3: TYPES OF CEMENT

Type	IS Code
Ordinary Portland Cement (OPC)	IS:269; IS:8112
High Strength Portland Cement (HSPC)	IS:8112
Portland Pozzolana Cement(PPC)	IS:1489 (Part 1)
Portland Blast Furnace Slag Cement (PSC)	IS:455

Obtain samples of cement once for each source of supply and occasionally when called for determine various properties given in Table 11.4

TABLE 11.4: REQUIREMENTS OF CEMENT

Property	Permissible Value	Tested as per
Fineness	Specific surface not less than 225 m^2/kg	IS: 4031 (Part 1,2 & 15)
Setting Time	Initial set > 30 minutes Final Set < 600 minutes	IS: 4031 (Part 1)
Soundness	Not to exceed 10 mm in Lechatelier mould	IS:4031 (Part 3)
Compressive Strength At 3 days At 7 days At 14 days	OPC/PPC HSPC 16 Mpa 27 Mpa 22 Mpa 37 Mpa 33 Mpa 53 Mpa	(IS:4031:Part 6)

(ii) Coarse aggregates

The gradation of coarse aggregate shall satisfy the requirements given in Table 11.5

TABLE 11.5: GRADATION OF COARSE AGGREGATE

	Percent by weight passing the sieve			
IS Sieve Size	40 mm	20 mm	16 mm	12.5 mm
63 mm	100	-	-	-
40 mm	95-100	100	-	-
20 mm	30-70	95-100	100	-
16 mm	-	-	90 - 100	100
12.5 mm	-	-	-	90-100
10.0 mm	10-35	25-55	30 - 70	40-85
4.75	0-5	0-10	0 - 10	0-10

Table 11.5(a) Other Physical Requirements for Course Aggregate

S.No	Type of Tests	Requirements
1	Flakiness Index (IS: 2386 Part 1)	Maximum 25 for ordinary concrete Maximum 15 for high quality concrete
2	Water absorption (IS:2386 Part 3)	Maximum 2%
3	Los Angeles Abrasion (IS:2386 Part4)	Maximum 45% for ordinary concrete Maximum 35% for high quality concrete
4	Aggregate Crushing Value (IS:2386 Part4)	Maximum 30% for pavement structures Maximum 45% for other structure

(iii) **Fine Aggregates**

The gradation of fine aggregates shall satisfy the requirements given in Table 11.6

TABLE 11.6: GRADATION OF FINE AGGREGATES

IS Sieve Size	Percent by weight passing the sieve			
	Zone I	**Zone II**	**Zone III**	**Zone IV**
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 Micron	15-34	35-59	60-79	80-100
300 Micron	5-20	8-30	12-40	15-50
150 Micron	0-10	0-10	0-10	0-15

(iv) **Water**

Samples of water used in making mortar and concrete are tested once for approval of source of supply and subsequently only in case of doubt.The permissible limits for solids in water shall be as per Table11.7

TABLE 11.7: LIMITS FOR SOLIDS IN WATER

	Maximum permissible limit
Organic	200 mg/litre
Inorganic	3000 mg/litre
Sulphates (as SO4)	400 mg/litre
Chlorides (as Cl)	2000 mg/litre (For Plain Concrete) 500 mg/litre (For Reinforced Concrete
Suspended matter	2000 mg/litre

(v) **Concrete**

The grades of concrete and their equivalent nominal mix are given in Table 11.8 as reference only.

TABLE 11.8: NOMINAL MIXES OF CONCRETE

Grade of Concrete	Nominal Mix by volume
M 10	1:3:6
M 15	1:2.4
M 20	1:1.5:3
M 25	1:1:2

• Add approved quality of plasticizer @ 300 ml per 50 kg of cement to M 25 grade concrete or as per Manufacturers specifications

(vi) Frequency of Sampling

The minimum frequency of sampling of concrete of each grade is given in Table 11.9

TABLE 11.9: FREQUENCY OF SAMPLING

Quantity of concrete in work (m3)	No. of samples
1-5	1
6-15	2
16-30	3
31-50	4
51- and more quantity of work	4 plus one additional for each 50 m^3 or part of it.

4. Quality Control Tests / Checks

4.1 Tests prior to construction

The tests and checks to be carried out prior to construction are indicated in Table 11.10

TABLE 11.10: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

Material / Work	Test / Check	Frequency
Cement	a) Setting Time (IS:4031 Part 5) b) Soundness (IS:4031 Part 3) c) Compressive strength of mortar cube (IS:4031 Part 6)	One test for 200 tonnes of cement (same brand & grade) - do – one set for 200 tonnes of cement (same brand and grade)
Coarse Aggregates	a) Gradation for PCC or RCC works b) Flakiness index (IS:2386 part 1) c) Deleterious constituents (IS:2386 part 2) d) Water absorption / content (IS:2386 part 3) e) Aggregate Crushing value (IS:2386 part 4) f) Soundness (IS:2386 part 5) [if water absorption exceeds 2%] g) LAA (IS 2386 -4)	One set of test for each quarry source -do - If in doubt Once for each source of supply One test per source of supply - do – -do-
Fine Aggregates	a) Gradation (IS:2720 part 4) b) Deleterious Constituents (IS:2386 part 2)	One test for each source of supply If in doubt, one test per source
Water	Normally potable water is good enough for making concrete. Determination of Impurities - Suspended matter IS:3025 (Part 17) - Organic IS:3025 (Part 16) - Inorganic IS:3025 (Part 19) - Sulphates (as SO3) IS:3025 (Part 24) - Chlorides (as Cl)IS:3025(Part 32)	For large works If the quality is in doubt Samples taken from each source and tested at an approved test house
Concrete	Mix Design (for each work)	Well before the commencement of work and approved by Engineer

4.2 Tests / checks during construction

The tests required to be carried out during construction are indicated in Table 11.11

TABLE 11.11: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Fine and coarse aggregate	Gradation (IS2720 Part4) Water Absorption (IS:2386 part3) Flakiness index (IS:2386 part 1) Aggregate Crushing value (IS:2386 part 4) LAA (IS 2386 -4)	Each delivery and every 100 ton or part of it for fine aggregate and 250 ton or part of it for course aggregate
2	Cement	a)Setting Time (IS:4031 Part 5) b)Compressive strength of mortar cube (IS:4031 Part 6)	Each supply and not less than 200 ton or part of it -do-
3	Concrete	a) Workability .– Slump cone test (IS:1199) b) Cube Strength (IS:516)	2 tests/ day As per Table 11.9
4	Construction Joints	Fixing location before concreting and resumption of work	As and when work demands
5	Formwork	For stability, leakage of slurry, bulging etc.	Throughout concreting
6	Concreting	a) Transporting / placing segregation of concrete b) Precautions for hot weather or cold weather concreting c) Compaction with vibrators	Random check in each member Once check before commencement of work Regularly
7	Curing of concrete	Regular (not less than 7 days after casting) inspection	Daily

11-a Plum Concrete

Definition:

The use of aggregate as an inert filler can be extended to the inclusion of stone between 200 to 300 mm size in a normal concrete; thus the apparent yield of concrete for a given amount of cement is increased. The resulting concrete is called "Plum Concrete" or "Cyclopean Concrete".

These large stones are called 'plums" and used in a large concrete mass. The volume of plums should not exceed 30 to 40 % of the total volume of the finished concrete and they have to be well dispersed throughout the mass. This is achieved by placing a layer of normal concrete, then spreading the plums, followed by another layer of concrete and so on. The grade of concrete used for plum concrete shall be minimum of M10.

The plums must have no adhering coating. Otherwise, discontinuities between the plums and the concrete may induce cracking and adversely affect permeability.

The proportion of plums should not exceed 40 per cent of total volume of plum concrete /plum masonry. The stone size to be used for plum shall be between 200 to 300 mm. The stone shall be basalt ,trap or any other approved locally available stone from quarries approved by Engineering.

The stone shall be hard durable and tough free from mud and other deleterious materials. The length of stone shall not exceed 3 time its height. The coarse aggregate shall be 25 mm down. The water cement ratio shall be adjusted at site to maintain the flowability of concrete to fill all the interstices properly. The plums are laid in layers using the cement concrete as mortar.

The plum shall be raised uniformly, and no part, at any time shall be raised more than 450 mm above adjoining work.

Double scaffolding shall be provided for construction and piercing of walls for scaffolding shall not be permitted.

Form work shall be of ply wood or steel.

METHODOLOGY

1 Where the plum concrete is used for retaining structures the preparation of foundation for the wall shall be as per section 8 of this hand book. Similarly the concrete used shall be prepared according to Section 11-1.

2 Form work shall be placed in position and approved before the placing plum concrete. The form work shall be according to Section 9 of this Hand Book.

3 Placing Plum in concrete

   i) Provide at least 10 - 15 cm of concrete on the bed of foundation as leveling course.

   ii) Plums shall be washed and all dripping surface water removed before being embedded in the concrete.

   iii) Lay the plum on the laid concrete approximately covering 30 to 40 % of the volume of concrete used for each layer. No stone shall be closer than 30 cm (or 12 in) to an exposed surface nor nearer than 15 cm (or 6 in) to an adjacent stone.

   iv) Place the concrete to fill the half height of the plum throughout the layer .

v) The concrete shall be deposited as nearly 'as practicable in final position and shall not be piled up in large masses at any point and then pushed, shovelled, or vibrated into space for large distances

vi) Place another layer of plum in scatter position and fill the concrete to the half height of the newly laid plum

vii) Repeat the step (iv) to (vi)

viii) Compaction is carried out in each layer of concrete with the help of vibrator.

ix) The stones shall not be dropped in place, but each stone shall be laid and carefully embedded so as to avoid any injury to the forms or adjacent masonry and in such a manner that no planes of weakness of unnecessary seams occur in the structure.

x) Care must be taken to ensure that no air is trapped underneath the stones.

xi) Concrete shall be systematically deposited in shallow layers and at such rate as to maintain, until the completion of the unit, a plastic surface approximately horizontal throughout.

xii) Each layer shall be thoroughly compacted before placing the succeeding layer.

xiii) Weep holes shall be provided by HDPE pipes buried in plum masonry. The end of the weep holes ,on the filled up side, shall be covered by geo-membrane and filled by gravels of sizes 40 mm.

xiv) All plum concrete/ plum masonry shall be thoroughly wet for at least 7 days and maintained for 28 days.

B. Quality Control Requirements

1 Materials

Cement Sand and Aggregate : As per B -1 of Section 11 of this Hand Book

Stone (Plum): Size	:	200 - 300 mm
Water absorption	:	5% maximum
Specific Gravity	:	2.5 minimum

4. Quality Control Tests / Checks

4.1 Tests prior to construction

The tests and checks to be carried out prior to construction for concrete shall be as per Table 11.10, and for stone shall be as per Table 8.3

4.2 Tests / checks during construction

The tests required to be carried out during construction for concrete shall be as per Table 11.13 and for stone shall be as per Table 8.4

SECTION 15
PIPE CULVERTS

15: PIPE CULVERTS

A. Methodology

Before commencement of the work, the contractor shall request for works filling the works request form prepared by the Project office indicating location of work with typical construction drawing and get approval from the engineer

A1 Excavation of foundation for pipes

1. Lay the pipes in shallow excavation of natural ground or in open trenches cut in existing embankments taken down to required level as shown on drawing.
2. For embankments of height of fill more than 3 m, or three times the external dia of pipe above bed level, construct the embankment to the level above the top of the pipe (equal to external dia of pipe) and width not less than five times the dia of pipe. Lay the pipe in trench after the construction of embankments.
3. While trench cutting is involved, the width of pipe bed is cut minimum of 150mm on either side of pipe not exceeding one-third the diameter of pipe and the cut should be as vertical as possible.
4. If spongy, soft or other unstable material is met with at the location of pipe culvert, remove the material to the required depth, width and length, and back fill with approved granular material properly shaped and compacted to the required level as directed by the engineer.
5. Where rock or boulder strata is met with, take down excavation to at least 200 mm below the bottom level of pipe, remove all loose material and fill the space with sand/ moorum or approved granular material, passing 4.75 mm sieve
6. The minimum bed slope for pipe bed shall be 1:20.

A2 Loading and Unloading of Pipes

1. Make arrangements for lifting, loading and unloading of pipes from factory/yard to site, such that no undue strain or damage occurs due to fall or impact.
2. For manual unloading from trucks, roll down pipes on a pair of skids hooked onto the trucks and control movement with a rope passing round the pipes.

A3 Bedding for Pipe

1. Provide a cradle constructed of plain concrete not leaner than M15 as the bedding for pipes of internal dia 900 mm or more and when height of fill is more than 4 m above the pipe..
2. When height of filling is less than 4 m above the pipe. Make a continuous layer of well compacted sand, moorum or approved granular material, passing 4.75 mm sieve and shaped concentrically, to fit the lower part of the pipe exterior for a minimum 10 per cent of its overall height. The compacted thickness of the granular bedding layer shall not be less than 75 mm.
3. For expansive soils, provide a layer of sand/moorum of non-expansive material of minimum 450 mm thickness under the bedding

A4 Laying of Pipes

1. Preload the areas to induce major portion of settlement before the pipe is installed.
2. Lower the pipes in bed either by tripod pulley arrangement or by manual labour using chain pulley blocks in a manner to place them in proper position without damage.
3. When two or more pipes are laid adjacent to each other, place them separated by a distance equal

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to half the dia of the pipe subject to a minimum space of 500 mm.

4. When pipes are laid in two layers, keep the centers of pipes such that when joined shall form equilateral triangles.

5. Lay the pipes on the prepared foundation, commencing from outlet and proceed towards the inlet.

A 4 Jointing

1. Join the pipes either by collar joint or by flush joint. Place the collar such that its center coincides with the joints and even annular space is left between the collar and the pipe.

2. Choose either internal flush joint or external flush joint. Fill the jointing space with1:2 cement mortar , which remains in position when forced with a trowel or rammer.

3. Fill the recess at the end of the pipe with jute braiding dipped in hot bitumen or suitable approved compound, while jointing pipe lines.

4. Keep the width of collars 150-200 mm and caulking space between 13 mm and 20 mm according to dia of pipes.

5. All the joints are made with care so that their interior surface is smooth and consistent with the interior surface of the pipe. After finishing the joints cover the joint with wet jute to make the joint damp at least for four days.

A5 Back Filling

1. Back fill trenches after the pipes have been laid and after jointing material has hardened. On top of pipe upto 300 mm, thoroughly ram, tamp or vibrate the soil in two layers. Thoroughly consolidate the materials under the 'haunches' of pipes using light mechanical tamping equipment.

2. Carryout filling of the trench simultaneously on both sides of the pipe, such that unequal pressures do not occur.

3. Provide minimum cushion of 600 mm or the diameter of pipe which ever is greater by filling the suitable material on the pipe after its laying. When minimum specified cushion cannot be provided over the pipe, enclose the pipe in M10 concrete of specified thickness not less than 200 mm in thickness.

15-8 Head Walls and Other Ancillary Works

1. Headwalls, wing walls, aprons and other ancillary works are constructed in accordance with the details shown on the drawings or as directed by the Engineer. Masonry works for the walls are constructed conforming to the requirements given in **Sections 7, 8** and **11** as applicable.

2. While constructing the headwall, first construct the wall upto the top level of pipe, place the pipe in position and fill the pipe with suitable material up to the road level compact the material as required and construct the remaining part of wall.

3. The construction of apron and other protection works are carried as per Section 17.

B. Quality Control Requirements

1 Materials

(i) Use NP-3 type reinforced concrete pipes, conforming to NS – 80/2042 or IS:458. The internal diameter shall not be less than 600 mm except in exceptional situations.

(ii) Conform brick masonry work for pipe culverts to section 7.

(iii) Conform stone masonry work for pipe culverts to Section 8.

(iv) Conform concrete work for pipe culverts to Section 11.

(v) Conform reinforcement for concrete work for pipe culverts to Section 10.

2 Back filling

The back fill material shall be clean from boulders, large roots, clay lumps and pass from 75 mm sieve.

3 Tolerances

The following tolerances are permitted for concrete pipes as per IS 458

i.	Overall length	±1 percent of standard length
ii.	Internal dia	±10 mm
iii.	Barrel thickness a) 60-90 mm	+ 5 mm -2.5 mm
	b) Over 90 mm	+7 mm -3.5 mm

4. Quality Control Tests

4.1 Tests prior to construction

The quality control tests to be carried out prior to construction are indicated in Table 15.1.

TABLE 15.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Bricks	As in Section 7	As in Table 7.6
2	Stones	As in Section 8	As in Table 8.3
3	Concrete Pipe	- Dimensions - Manufacturing defects - Tolerances (IS:458) - Three edge bearing test (IS:3597)	At factory before delivery Manufacturer's certificate

4.2 Tests / Checks during construction

The Quality Control Tests / checks to be carried out during construction are indicated in Table 15.2.

TABLE 15.2: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Bedding	- Materials (As per specification) - Length, width and thickness - Pre formation of cradle to lay pipes in bedding - Top and bottom levels	While laying
2	Laying and Jointing of pipe	- Invert level - Longitudinal gradient - Spacing when 2 or more pipes are laid in a row or staggered columns. - Jointing of pipes - damage to pipe during laying	Before back filling Before laying pipe
3	. Backfill	- Filling of trench on both sides (simultaneously) - Tamping around pipe	During filling earth / granular material around pipe after laying
4	Cushion over pipes	Thickness	While filling
5	Brick/Stone Masonry for head walls	Set of tests as per Section 7 and 8	As per Section 7 and 8
6	Side slopes on Head walls	- Slope - Stone pitching	Before construction of guard stones

SECTION 17
PROTECTION WORKS AND DRAINAGE

17: PROTECTION WORKS AND DRAINAGE

Methodology

General

In this section, the construction and quality control aspects of aprons, pitching on slopes, masonry flooring over cement concrete bedding, curtain wall besides chute, roadside and hill drains have been dealt with.

Before commencement of the work, the contractor shall request for works filling the works request form prepared by the Project office indicating location of work with typical construction drawing and get approval from the engineer.

17-1 Apron

This work consists laying of boulders directly or in gabion crates on the bed of rivers for protection against scour.

Methodology

1. Keep the length of apron not less than twice the depth of curtain wall or as shown in drawing.
2. Level the surface on which the apron is to be laid and prepare for the length and width as shown on drawings. In case the surface is below low water level, raise the ground level by dumping earth, moorum, brick bats, stones, etc., so that apron can be laid thereon.
3. For regular and orderly disposition of stone in apron, build template cross walls in dry masonry, of about 1 m thickness and full height specified thickness of apron at 30 m intervals all along the length and width of apron. Hand pack stone within these walls.
4. Use wire crates of galvanized steel wire as specified with mesh not more than 150 mm.
5. Use insitu built wire-crates of size not larger than 3 m x 1 m x 1 m and not 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.
6. Place the crates in position before filling in boulders.

17-2 Pitching on Slopes

1. Use quarry stone of minimum 225 mm thickness or 40 kg as pitching or as specified, and spalls of minimum 25 mm size to fill the voids. Alternatively, PCC blocks of 190 x 190 x 225 mm size (minimum) in M15 Concrete can be used for pitching.
2. Provide one or two layers of graded materials (filter medium) of 150 mm thick or as specified under the pitching to drain off the seepage water and prevent erosion of base material.
3. Trim the sides of banks to the required slope and provide before laying the pitching fill the depressions and thoroughly compact before hand.
4. Start the lowest course of pitching from the toe wall and build courses upwards. Use either dry rubble or brick masonry for toe wall.
5. Use dry masonry, when two or more layers of stones are to be laid to obtain design thickness of pitching and bond the stones well. Template cross walls in dry masonry can be built, as done for aprons.
6. When bricks are to be laid in more than one layer, ensure proper bonding the adjacent layers by means of sufficient number of pin headers extending from one layer to the other.

Toe Protection

The toe wall shall be in dry Random Rubble matting conforming to the Clause 8-3.3 of Technical Specifications for Agriculture and Rural Roads or as per drawings. Toe protection shall be done by constructing a toe wall, retaining/breast wall or close bamboo walling at the junction of embankment slope and general ground level, to protect the embankment from damages.

1. Use dry rubble or brick masonry for toe walls.

17-3 Rubble Stone/Brick flooring

1. Where specified provide rigid flooring under culverts and extend for a minimum distance of 1.5 m on upstream side and 3m on downstream side or as shown in drawings.
2. Excavate trench for laying foundation of bed protection and lay 150 mm thick cement concrete of M10 grade, so as to commence paving work.
3. Where rubble stone is specified as flooring, carryout the work with flat stones 150 mm thick, which are bedded on a 25 mm thick layer of 1:5 cement mortar. Fill the joints with 1:3 cement sand mortar of 20 mm thick.
4. Where bricks are to be used, carryout the work on 150 mm thick brick on edge, with each layer of brick bedded on 25 mm thick 1:5 cement mortar. Fill in the joints with 1:3 cement mortar of thickness 10 mm.
5. Keep the top of flooring 300 mm below the lowest bed level and extend the flooring. Extend the line connecting the end of splayed wing walls on either side of the culvert/bridge.
6. Adopt dry rubble stone/brick flooring at Cross Drain works where the velocity of flow is less than 1.5 m/sec by keeping the top of flooring 300 mm below the low bed level.
7. Lay the rubble stones closely, breaking joints and fill all joints with spalls of proper size and wedged in with rammers to ensure tight packing.
8. When dry brick is to be used, follow the procedure as above on a prepared base and lay in one or more layers. Ensure proper bond.

Curtain wall

Enclose flooring by curtain walls in cement concrete (M10) or stone/brick masonry in cement mortar 1:4 and take to a depth of at least 1.5 m on upstream side and 2 m on downstream side below the floor level.

Chute drain, Roadside drain, Hillside drain, Catch water drain

1. Provide rectangular or trapezoidal chute drains of specified dimensions in sections of road embankment, of height more than 8 m at minimum 10 m intervals. Provide them in embankment slopes in approaches of bridges and on horizontal curves connected at the tow of the embankment with parallel open drains discharging into a nearby stream or Cross Drain work.
2. Locate the open drain at the toe of embankment far away from at imaginary slope of 4 (horizontal) : 1 (vertical).
3. Build catch water /intercepting drains on hill slopes to intercept water flooring from upper reaches and guide such flow into culverts. Adopt trapezoidal shape and line them.
4. Refer to IRC:SP:42 'Guidelines on Road Drainage' for more details and design of section.

Protection of Vented Causeways

Damages to submerged structures occur due to out flanking at one or both banks, heavy erosion on downstream side, collapse of headwalls and washing of paved surface. The design of such structures is inter woven taking protection aspects into consideration.

1. For vented causeways, prepare the stream bed crossing by stabilizing with crushed stone, riprap or rubble after removal of silt and compact the base and core to reduce future settlement.
2. Provide side drains on either side along the side slopes which are rubble pitched. Take the side drains at least 10 m away from the edge of main causeway junction, to meet the stream proper.
3. Provide face walls to protect the edges of the structure and to prevent erosion of core material. Build face walls of the approaches strong enough to avoid damage during floods. Seal the joints in concrete face walls to prevent ingress of water to the core.
4. Make the approaches of causeways in Cement Concrete pavement laid over WBM or in Stone Set pavement, to prevent their damage due to frequent over topping.
5. In case of submersible bridges, provide bed protection for the whole bed-width of water course plus 3 m on both sides.
6. Provide a minimum foundation depth of 1.5 m on upstream side and 2.5 m on downstream side for cut off wall.
7. Provide RCC guard stones at 1.2 m c/c for both vented and non-vented causeways.

B. Quality Control Requirements

1. Stones for Apron

The size and weight of stones for laying boulder on apron shall conform to the requirement given in Table 17.1

TABLE 17.1: STONES FOR APRON

Mean Design Velocity m/sec	Minimum size and weight of stone	
	Diameter (mm)	Weight (kg)
Upto 2.0	220	25
2.5	300	40
3.0	380	76
3.5	510	185
4.0	670	417

2. Stones for pitching on slopes

The size and weight of stones for pitching on slopes shall conform to the requirements given in Table 17.2

TABLE 17.2: STONES FOR PITCHING

Mean Design Velocity m/sec	Minimum size and weight of stone			
	Slope 2:1		Slope 3:1	
	Diameter (mm)	Weight (kg)	Diameter (mm)	Weight (kg)
Upto 2.0	220	25	220	25
2.5	300	40	300	40
3.0	300	40	300	40
3.5	350	59	300	40
4.0	450	126	350	59

Where the required size stone are not available for use in wire crates, Cement Concrete blocks in M15 grade weighing not less than 25 kg and size not less than opening of the crate may be used.

3. Quality Control Tests

3.1 Tests prior to construction

The Quality Control tests to be carried out prior to construction are indicated in Table 17.3

TABLE 17.3: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Test / Check	Frequency
1	Size and weight of stones in apron / slope / flooring etc. (Table 17.1 and 17.2)	At quarry site before procurement
2	Wire crates (Size and mesh size)	Before procurement
3	Cement concrete blocks (Weight and Size)	Before procurement/before delivery

3.2 Tests during construction

The quality control tests to be carried out during construction are indicated in Table 17.4

TABLE 17.4: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. No.	Test / Check	Frequency
1	Laying of Filter granular material	Daily check for workmanship
2	Laying boulders for - Apron - Pitching on Slopes - Toe protection - Wire crates	Daily check for uniformity in workmanship
3	Mortar for Joints a) Mix proportions, (control on quality of cement by weight b) Compressive strength(IS:2250)	Each batch 6 samples of cubes for 10 m^3 of work
4	Laying of brick stones in flooring	Daily check for workmanship
5	Curtain wall	Daily check for workmanship
6	Drain (Chute, Road side, Hill side and Catch water)	Daily check for workmanship

SECTION -19
MISCELLANEOUS

19 : GABION MASONRY FOR STRUCTURES

A. Methodology

Before commencement of the work, the contractor shall request for works filling the works request form prepared by the Project office indicating location of work with typical construction drawing and get approval from the engineer.

A1 General Gabion Masonry Work

1. Excavate the foundation to required depth following the methodology provided in Sub-section 2-4 and according to the design drawing conforming as per the Drawing No DLR/ROAD/T-18 of the Technical Guideline on Planning. Design and Construction of Rural Roads.
2. If the foundation is adequate, check the cross slope and check the foundation level and get approved from the engineer.
3. If foundation work is complete construct the retaining structure following the steps given below.
4. Assemble the gabion boxes as described in Clause 19-3.4 of Part-2 Special Specification of Technical Specification for Agriculture and Rural Roads.
5. After assemble of gabion boxes, fix its shape and size by stretching its all sides and fix the diaphragms as per Table 19-2(a).
6. Place in positioned by lay the gabion boxes as required in header bond by tying to adjacent gabion boxes by looping the wire through each mesh of both adjacent boxes around both salvage with three rounds as described in Clause 19-3.4 of Part-2 Special Specification of Technical Specification for Agriculture and Rural Roads. .
7. Lay the Geo-textile at the back of the gabion boxes to cover the length and height including footing of the wall.
8. Fill the gabion boxes with stones with proper bonding in three equal layers for 1 m deep gabions and in two layers for 0.50 m deep gabions. The filling is carried out by placing individual stones into the gabion by hand in courses in such a manner that the stones are bedded on each other and bonded. All stones are carefully set with a bond stone provided at the rate of at least one to every 0.9 m^2 of exposed face. Bond stones shall measure not less than 150 mm x 150 mm on the exposed face; and not less than 450 mm in length or the full thickness of the wall, whichever is the less.
9. No loose stones is allowed to tipped into the crate and the practice of coursing and bonding the outer layer and filling the interior with unlaid stones shall not be permitted.
10. Horizontal bracing wires made with the same binding wire as used for tying is fixed directly above each layer of the stone in the compartments at 330 mm spacing inwards from edge of box in both direction as specified in the Clause 19-3.5 of Part-2 Special Specification of Technical Specification for Agriculture and Rural Roads.
11. After completing stone filling cover the upper faces (Lid) of gabion boxes and tie by gabion wires by looping the wires on the selvedge wires of adjacent panels as per Clause 19-3.6 of Part-2 Special Specification of Technical Specification for Agriculture and Rural Roads. Measure the dimensions of the filled boxes.

12. Repeat the Steps given in para 4,5,6, 8 and 9 for upper successive layers. Both upper and lower boxes shall have vertical tie wires. Construct the vertical joints in staggered position.
13. Take the level of the top of the wall.
14. Cover the entire wall by the Geo-textile already provided covering the footing left in each layer.
15. The back of the wall is filled with suitable materials. Compact the backfilling in layers not exceeding 150 mm of compacted thickness to achieve 95% MDD from the bottom of the wall to full height.

B. Quality Control Requirements

1. Materials

(i) Stone

Use stone which is hard, sound, free from cracks, decay, weathering, defects like cavities, flaws, sand holes and patches of loose or soft materials. Do not use stones with round surface.

The Specifications and requirements of stones shall satisfy those given in Table 19.1

TABLE 19-1: REQUIREMENTS OF STONES

Item		Requirements
1	Least Dimension (IS: 1597 Part 1)	150 mm
2	Water Absorption in stone (IS: 1124)	5 percent of its weight
3	Specific Gravity (IS: 1124)	2.5

(ii) Gabion

The gabion wire consists of steel wire mesh crate conforming to NS-169-2045 and shall satisfy as per the Clause 19-1.2.2 of of Part-2 Special Specification of Technical Specification for Agriculture and Rural Roads

The number and size of diaphragms to be provided with each crate shall be as in Table 19 –2 (a). All crates shall be supplied with binding and connecting wire of the gauges shown in Table 19 –2 (b) of sufficient quantity to bind all diaphragms and closing edges.

Table 19 –2(a): Standard Size of Wire Mesh Gabions

Dimensions in Meters (Prior to fill)	Number of diaphragms	Dimension of diaphragms in meters	Volume of crate in cubic meters
1 x 1 x 1	-	-	1
1.5 x 1 x 1	1	1 x 1	1.5
2 x 1 x 1	1	1 x 1	2

3 x 1 x 1	2	1 x 1	3
1 x 1 x 0.75	-	-	0.75
2 x 1 x 0.75	1	1 x 0.75	1.5
3 x 1 x 0.75	2	1 x 0.75	2.25
1 x 1 x 0.5	-	-	0.5
2 x 1 x 0.5	1	1 x 0.5	1
3 x 1 x 0.5	2	1 x 0.5	1.5
1 x 1 x 0.3	-	-	0.3
2 x 1 x 0.3	1	1 x 0.3	0.6
3 x 1 x 0.3	2	1 x 0.3	0.9

Table 19 –2 (b): Standard Size of Mesh and Wire in Gabions

Mesh opening mm	Mesh type	Thickness of mesh wire	Thickness of binding and connecting wire	Thickness of selvedge wire
(DxH)		S.W.G.	S.W.G.	S.W.G.
64 x 83	60 x 80*	11, 12	13, 14	8, 9
83 x 114	80 x 100	9, 10, 11	11, 12, 13	6, 7, 8
104 x 128	100 x 120	10, 9	12, 11	7, 6

** To be used in special cases subject to approval by the Engineer where stone of larger size are not available.*

Note: Equivalent diameter in mm as per NS 163-2045

SWG	6	7	8	9	10	11	12	13	14
mm	4.88	4.75	4.06	3.66	3.25	2.95	2.64	2.34	2.03

Note: Test of gabion structures shall be carried out as per the Special Specification Part -2.

Quality Control Tests

2.1. Tests prior to construction

The tests / checks to be carried out prior to construction are indicated in Table 19-3

TABLE 19-3: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Stones	a) Shape and Dimension (IS: 1597 part 1) b) Water absorption (IS: 1124)	3 samples on receipt at site 3 samples on receipt at site Once for each stock after selection for individual work
2	Gabion wire	Diameter, Tensile Strength, Mass, Uniformity and adhesion of Zinc coating	As per Table 19-1c of Special specification Part 2
2	Gabion crates	Size and mesh size	Before Procurement/after fabrication

2.2. Tests / Checks during construction

The tests / checks to be carried out during construction are indicated in Table 19-4

TABLE 19-4: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency/ Stage
1	Assembling of Gabion Crate	Size of Crate, Lacing as per specification,	During laying
2	Filling of crate with stone	For stability and appearance with plumb bob and bracing as per specification	While laying each course
3	Securing Lids of gabion crate	Lacing and binding the of panels, filling of stone	While closing the led after completion of stone filling
4	Gabion wire	Diameter, Tensile Strength, Mass, Uniformity and adhesion of Zinc coating	Each lot of gabion received at site As per Table 19-1c of standard specification Part 2

Note;

It is suggested to construct 2x1x1 gabion wall according to the above methodology at the side of the road surface as a sample wall.

SECTION -20
PERMANENT TRAFFIC SIGNS, NOTICE BOARD, ROAD MARKER STONES AND DELINEATORS

TRAFFIC SIGNS AND MARKINGS

Types of Signs and Road Markings

The three main functions of traffic signs are to regulate, warn and inform. There is a different group of signs for each function, and the signs in each group have a uniform shape to help drivers to recognise them quickly. The three groups are:

Regulatory Signs: These signs give orders. They tell drivers what they must not do (prohibitory), or what they must do (mandatory). Most of them take the form of a circular disc, although two signs, the Stop sign and the Give Way sign, have distinctive individual shapes.

Warning Signs: These warn drivers of some danger or difficulty on the road ahead. Most of them take the form of an equilateral triangle with its apex uppermost.

Information Signs: Most of these signs give drivers information to enable them to find their way to their destination. It is a varied group of signs, but they are all either square or rectangular in shape.

Another important group of signs are **Road Markings**. These can regulate, warn and inform, and some help clarify or emphasis the message given by other signs.

A. Methodology

I Traffic Signs

1. The colour, configuration, size, location and dimensions of different road signs shall be in compliance with the Traffic Signs Manual Volume I & II prepared by Government of Nepal, Ministry of Physical Planning and Works, Department of Roads. The language of inscription and font for informatory signs shall also be in conformity with the same manual.

2. Signs shall be semi-reflective, fixed over mild steel sheeting duly stove enameled in white colour in front and grey colour on the back, red engineering grade tape on borders and required message in non-reflective black sheeting of the Engineering grade tape.

3. Road signs, in particular, the Cautionary/ Warning and Mandatory/ Regulatory signs in the approaches to level crossings or narrow bridges may be reflectroised using luminous paints or other similar reflective material.

4. It is desirable that Cautionary/ Warning and Mandatory signs are fabricated through the process of screen-printing. In other cases, signs may have inscription/message having cut letters of non-reflective black sheeting which shall be bonded well with the base sheeting.

5. Concrete for footings shall be of minimum M15 grade. Reinforcing steel shall conform to the requirements of IS:1786. High strength bolts, nuts and washers shall conform to IS:1367. Plates and support sections shall be either 50 mm internal diameter steel tube or 78 mm x 38 mm C - channel conforming to IS:2062.

6. Sign posts, their foundations and sign mountings should be so constructed as to hold them in a proper position against normal wind loads or displacement by vandalism.

7. Normally signs with an area upto 0.90 sqm can be mounted on a single post and for greater area two or more supports shall be provided.

8. Sign supports may be of mild steel (MS), reinforced concrete (RC) or galvanized iron (GI). The post ends should be firmly fixed to the ground.

9. The signs and supports, except the reflectorised portion and GI posts, shall be thoroughly descaled, cleaned, primed and painted with two coats of epoxy paint. The portion of mild steel post below ground should be painted with three coats of red lead paint.

10. The signs should be fixed to the MS posts by welding and to the RC or GI posts by bolts and washers. After the nuts have been tightened, the tails of the bolts should be furred over with a hammer to prevent removal.

11. The extreme edge of the Road Sign adjacent to the highway should be at a distance of atleast 2.0 m from the edge of the carriageway. In no case any part of the Road Sign shall come in the way of vehicular traffic.

12. The lowest edge of Road Sign shall not be less than 2.0 m above the crown of pavement.

II. Road Markings

1. The road markings should be in conformity with the Traffic Signs Manual Volume I and volume II prepared by Government of Nepal, Ministry of Physical Planning and Works, Department of Roads.

2. Paining may be done by machine or by hand, preferably by machine.

3. The finished road markings should be free from ruggedness on sides and ends and these should be parallel to the general alignment of the carriageway. The upper surface of the lines should be free from streaks.

III Road marker Stones

The work covers the supply, painting, lettering and fixing of road markers. The Road Markers Stones includes

Standard Marker Stones (Kilometer Posts)

5^{Th} kilometer Marker Posts

Node Point Marker stones

The Marker Stones is constructed of reinforced cement concrete of grade M15/20 as per Section 11 and the non-reflectrorised paint is used conforming to NS 112-2042. The details of Marker Stones is as per the drawing DLR/Road/T-27 of Technical Guideline on Planning, Design and Construction of Rural Roads.

The location of the marker stones is as shown on the Drawing. The marker stones are placed at right angles to the centre line of the carriageway. On embankments they are installed on the edge of the roadway at least 0.5 m outside the road shoulder. Where there is no shoulder the marker is located at least 1.5 m outside the road edge, if necessary on specially erected platforms. In cut sections they are fixed clear of the shoulders as well as the side drains.

Marker stones are normally placed on the left hand side of the road as one proceeds from East to West and from South to North. On divided roads with a centre median the marker stones are placed on the left hand side of the road in each direction of travel. In hilly areas, where the road has a valley on one side and a hill slope on other, the marker stones are placed on the valley side of the road.

Marker stones posts are bedded into the ground with concrete foundation of grade M 10/40 as shown in the Drawing. Marker stones are applied with a coat of primer and two coats of enamel paint.

IV Delineators

The work covers supplying and fixing of delineator posts. The design and painting of the posts shall be in accordance with the drawing DLR/Road/T-27 of Technical Guideline on Planning, Design and Construction of Rural Roads.

The delineator posts are constructed of reinforced concrete of grade and M20/20 in accordance with Section 11 or as shown in the Drawing. These are painted by non-reflectorised painting after primer in accordance with NS 112-2042 and NS 190/2045 respectively.

The posts are constructed/manufactured as per the drawing with true shape and size, smooth surface with out honeycombing.

Posts are erected after the completion of pavement surface and located at 600 mm from the edge of the road.

Two coat of synthetic enamel paint is done after cement priming. The paint is applied in 200 mm wide alternate strips of white and black starting from top.

Provide grove for reflectorised painting as shown in the drawing and paint accordingly.

B. Quality Control Requirements

1. Traffic Signs

The materials should conform to the following requirements.

(i) **Concrete:** Concrete for footing shall be of the grade shown on the Contract drawings or of minimum M15 grade conforming to Section 11 of these Hand Book.

(ii) **Reinforcing steel:** Reinforcing steel shall conform to the requirements of IS:1786 unless otherwise shown on the drawing.

(iii) **Bolts, nuts, washers:** High strength bolts shall conform to IS:1367

(iv) **M.S. Sheets, Plates and supports:** Plates and support sections for the sign posts shall conform to IS:2062 or any other relevant IS Specifications.

(v) **Reflectorised paint:** Reflectorised paint shall conform to IS 5 or the manufacturer's specifications in case of proprietary product and as approved by the Engineer.

(vi) **Non reflectorised paint:** Non-reflectorised paint shall conform to NS 408/2045, BS IS:164 and as approved by the Engineer.

(vii) **Engineering grade sheeting:** This sheeting shall be enclosed lens type consisting of microscopic lens elements embedded beneath the surface of a smooth, flexible, transparent, water-proof plastic, resulting in a non-exposed lens optical reflecting system. The retroreflective surface after cleaning with soap and water and in dry condition shall have the minimum coefficient of retro-reflection (determined in accordance with ASTM Standard) as indicated in Table 20.1. When totally wet, the sheeting shall not show less than 90 per cent of the values, of retroreflection indicated in Table 20.1. At the end of 5 years, the sheeting shall retain at least 50 per cent of its original retro-reflectance.

TABLE 20.1: ACCEPTABLE MINIMUM COEFFICIENT OF RETROREFLECTION FOR ENGINEERING GRADE SHEETING (CANDEL AS PER LUX PER SQUARE METRE)

Observation angle in degree	Entrance angle in degree	White	Yellow	Orange	Green	Red	Blue
0.2	-4	70	50	25	9	14.5	4
0.2	+30	30	22	7	5.5	6	1.7
0.5	-4	30	25	13.5	4.5	7.5	2
0.5	+30	15	13	4	2.2	3	0.8

(viii) Signs with a maximum side dimension not exceeding 600 mm shall not be less than 2.0 mm thick. The thickness of the sheet shall be related to the size of the sign board and its support and shall be such that it does not bend or deform under the prevailing wind and other loads.

(ix) In respect of sign sizes not covered by Traffic Signs Manual Volume I and volume II prepared by Government of Nepal, Ministry of Physical Planning and Works, Department of Roads, the structural details (thickness, etc.) shall be as per the approved drawings.

2. **Road Markings**

Ordinary paints shall be used for road markings, conforming to NS 408/2045 or BS 6044 or IS:164. These shall have a wear resistance of at least 4 hours under accelerated laboratory test. Yellow colour conforming to NS 408/2045 or BS 6044 IS:164, white and black colours are the standard colors used for markings.

If specified the paint may be reflectorised paint, in which case paint shall be reflectorised by addition of reflecting beads(Ballotini). Ballotine shall comply with BS 6088.

3. **Marker Stones**

The material shall be tested in accordance with the relevant standard specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Engineer.

The work shall conform to these Specification and shall be to the true lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer.

4. **Delineators**

The material shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria.

The work shall conform to these Specification and shall be to the true lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer.

ANNEX -110

RCC SLAB CULVERTS AND MINOR BRIDGES

RCC SLAB CULVERTS AND MINOR BRIDGES

General

A culvert is a cross drainage structure having a total length of 6 m or less between the inner faces of dirt walls or extreme ventway boundaries measured at right angles. A minor bridge is a bridge having a total length upto 50 m(with span≤ 25 m). A major bridge is a bridge where the overall length of bridge is greater than 50m or span greater than 25.A special bridge is that which require special design consideration, whose construction feature (e.g. concrete girder bridges with greater than 50 m span, arch bridges, suspension bridges, cable-stayed bridges and other non-standard bridges).

In this section different items of RCC solid slabs, box culverts, and composite bridges have been dealt with. The cross sections of foundations, substructures such as abutments, return walls besides design of super structure, drainage spouts, railings, parapets etc. and all other details shall be strictly in accordance with contract documents..

A. Methodology

A1 Foundations

1. Take the minimum depth of foundation upto the stratum having specified bearing capacity shown on drawing but not less than 2 m below the scour level where no bed protection is provided or 1.5 m below the protected bed level.
2. In case of rocky bed, ensure embedment of foundation into the rock below, the minimum depth being 500 mm for hard rocks and 1200 mm for soft erodible rocks.
3. Provide 300 mm thick plain concrete M15 grade footing, unless otherwise specified on the drawings. Provide a minimum offset of 150 mm for the base of substructure.
4. Set out plan dimension of the foundation at the bottom of foundation trench and check with respect to original reference line and axis.
5. Before laying foundation concrete, clean the earth surface of all loose material and sprinkle water to wet. Provide side formwork as per required dimensions and height.
6. Lay foundation concrete continuously to the required thickness upto the level of construction joint proposed.
7. Finish the concrete surface smooth with a trowel and ensure curing as specified in Section 11.
8. Carryout dewatering where necessary for the laying of concrete so as to keep the water level below foundation level with adequate provisions/ precautions.
9. Remove loose sand laid on foundation before commencement of back filling. Refill all spaces excavated and not occupied by permanent work with earth upto surface of surrounding ground. In case of excavation in rock, fill the space with M15 concrete.

A2 Substructures

This item covers piers, abutments, wing walls, return walls, pier and abutment caps and RCC dirt walls.

1. Adopt either Brick Masonry or Coursed Rubble (CR) Stone masonry or Plain or Reinforced Concrete for piers, abutments and wing/return walls as per design. For wing and return walls upto 3m height use Random Rubble (RR) masonry.
2. Before commencing the masonry / concrete work, scrub the foundation with wire brush and remove all loose material and wet the surface.
3. Make provision for weep holes in solid (non spill through) abutments and provide back fill.

4. Provide vertical expansion gaps of 20mm width between abutments and wing walls.
5. Provide coping for wing/return walls in plain concrete.
6. Provide dirt wall as per specification.
7. Provide RCC pier and abutment caps as shown on the drawings. For Slab bridges, cast surface of pier and abutment caps and pedestals horizontal.
8. Provide RCC dirt wall with specifications of formwork, reinforcement and concrete as per Sections 9, 10 and 11 respectively.

A3 Superstructures

(a) Reinforced Concrete Solid Slabs

1. Set out dimension, lines and level and check with respect to permanent reference lines and permanent bench marks.
2. Carry out RCC work conforming to the provision of formworks and steel reinforcement given Sections 10 and 11.
3. Where adjacent span of slab has already been cast in place, expansion joint and filler board abutting the already cast span shall form the shutter for the adjacent span.
4. Cast whole of the slab with reinforcement embedded for road kerb and railings.
5. Use vibrators for compaction of concrete.
6. Provide wearing coat after the deck slab has been cast true to lines and levels.

(b) RCC Box Cell

Choose box culvert when safe bearing capacity of soil is less than 150 kN/m² and when angle of friction is less than 15°.

1. Prepare M10 Grade cement concrete bearing surface as shown in the drawings.
2. Keep the top of the raft in bottom of box cell 300 mm below the lowest bed level.
3. Place the reinforcement cages in the shuttering as per drawings.
4. Construct box section in M 25 concrete or as specified, with a maximum of one construction joint located in the web below the fillet between deck slab and web.
5. Carryout concreting operation continuously upto the construction joint.
6. Ensure proper compaction of concrete using vibrator.
7. Provide pressure relief pipes of 100 mm dia. Mark an area of 500 mm x 500 mm below the pressure relief pipe in the form of inverted filter.
8. Provide cut off walls and protective apron as shown in the drawing.
9. Provide earth cushion and/or pavement on the top slabs (carriageway) after specified period of curing of all the box cells.
10. Provide 200 mm thick plain cement concrete parapet.

(c) Composite type (RCC deck slab on steel girders)

Choose Composite type bridges in hill areas or where problems of centering are foreseen for casting of superstructure

1. Provide simply supported spans for composite type superstructure consisting of longitudinal steel girders with RCC solid slab decking.
2. Provide shear connectors of appropriate size and spacing as shown in drawings between the Steel girder and RCC deck to ensure composite action.
3. Ensure the composite section of steel beams and RCC slab and shear connectors conforming to IRC:22 and IRC:24 and carry out welding works as per Table 10.2.
4. Cast the RCC deck slab with steel reinforcements in place as per Sections 9, 11, and 10.
5. Carryout painting and protective coating on Structural steel components in accordance with IS:1477, with a minimum of three coats of paints or a metal coating followed by two coats of paint.

A4 Appurtenances

(a) Wearing Coat

Both bituminous and concrete pavements used in the adjacent road works, are carried over culverts and minor bridges as wearing surface. However, separate bituminous or cement concrete wearing coats are to be laid on RCC slab bridges, as shown in drawings.

1. Use 20 mm thick premix carpet with seal coat as bituminous wearing coat on culverts having earth cushions and pavement carried over such culverts.
2. On minor bridges and culverts without earth cushion, provide 40 mm thick Bituminous Macadam (BM) covered with 20 mm thick premix carpet and seal coat.
3. Where cement concrete pavement is being built for the road, carry the same over box culverts with earth cushion or slab culverts.
4. Provide 75 mm cement concrete wearing coat of M30 grade for isolated RCC slab bridges or submersible structures where specified.
5. Keep a cross slope of 2.5 percent for deck slab level in longitudinal profile for drainage and ensure curing earlier to prevent formation of shrinkage cracks.

(b) Bearings and Expansion Joints

1. Provide only elastomeric bearings for RCC slab bridges of span length more than 10m conforming to IRC:83 part II.
2. Make provision for robust, durable, watertight and replaceable expansion joints, if needed. Such joints shall be designed site specific or adopted as shown in drawings.
3. Install deck joints in accordance with manufacturer's recommendation.
4. For the specifications of filler joints, buried joints, compression seal joints and slab seal expansion joints refer to sections 13 and 14 Technical Specifications for Agricultural and Rural Roads.

(c) Railings/Parapets

Bridge railings include portion of the structure erected on and above the kerb for the protection of pedestrians and traffic and constructed after the centering for false work released. Adopt either metal or cast-in-situ concrete railings for RCC slab culverts and minor bridges as specified in the drawings.

1. Adopt all pipe sections and steel elements of railings, conforming to IS:1239 after galvanizing.

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2. Adjust railings carefully prior to fixing in place, to ensure proper matching at abutting joints and correct alignment and camber throughout their length.

3. Protect all steel rail elements, pipe terminal sections, posts, nuts and both hardware and other steel fittings against corrosion, by galvanizing or painting.

4. Construct portion of the railing or parapet to be cast in place in accordance with the requirements for structural concrete as per Section 11 and reinforcement as per Section 10.

5. For RCC slab culverts and minor bridges having overall length not exceeding 50 m, provide parapets of 200 mm thickness (minimum) in PCC of M15 or brick or stone masonry as shown in drawings.

6. Use forms of either single width board or line with suitable material duly approved.

7. Construct all mouldings, panel work and bevel strips as per drawings and finish all corners, true, sharp and clean cut.

(d) Approach slabs

1. Approach slabs are not needed on culverts/or minor bridges having overall length not exceeding 30 m bridges and road pavement is continued in the full formation width between wing walls/ Returns.

2. When specified, adopt a minimum length of 3.5 m and minimum thickness of 300 mm for approach slab. Provide a 150 mm thick base in M10 concrete for approach slab.

3. Provide 12 mm dia steel bars at 150 mm c/c in both directions at both top and bottom of approach slab and execute concreting work as per Section 11. Use M20 concrete for approach slab unless otherwise specified

(e) Drainage spouts

1. Fix rigid drainage spouts of 100 mm dia, at a spacing not exceeding 10 m.

2. Use corrosion resistant material for drainage spouts.

3. Ensure suitable camber in the carriageway surface for transverse drainage.

4. Seal the shrinkage cracks around drainage assembly with polysulphide or bituminous sealant, after setting of deck slab concrete.

(f) Filling

Filling around culverts and bridges should be done with non-cohesive soils.

(g) Sectional Details

1. For plain concrete structures, provide a minimum skin reinforcement of 2.5 kg/m^2 on all exposed surfaces in horizontal and vertical directions keeping a spacing not more than 200 mm in each direction.

2. For RCC approach slabs provide a reinforcement of 12 mm dia @ 150 mm c/c at both top and bottom side, in both the directions.

3. For structural steel RCC slab composite superstructures, provide haunches of 150 mm x 150 mm between top of steel girder and soffit of slab. Locate the sides of haunches 45° from the outside edge of the base of the connections.

B. Quality Control Requirements

(1) Materials

Materials	Table/Clause
Bricks	Table 7.4
Stones	Tables 8.1 and 8.2
Cement	Clause 7.1/11.2
Coarse aggregate	Table 11.4
Sand	Table 11.5
Water	Table 11.6
Steel Reinforcement	table 10.1
Structural Steel	Section 12 of Technical Specification for Agriculture and Rural Roads
Tolerance in Formwork	As per B of Section 9
Polysulphide or Bituminous Sealant	Sealant IS:1834

(2) Tolerances

A-110.1: Tolerances for different items in Tables A110.1 to A110.3

(i) Construction of Foundations

(a) No point of the bearing surface on which concrete footing is to be laid shall be higher than the founding level.

(b) Variation in Dimensions : +50 mm
: -10 mm

(c) Misplacement from specified position in plan : 15 mm

(d) Surface irregularities measured with 3 m straight edge : 5 mm

(e) Variation of levels at top : ±25 mm

A-110.2: Tolerances in Sub-structures

(ii) Sub-Structure

(a) Variation in cross sectional dimensions : +10 mm
: -5 mm

(b) Misplacement from specified position in Plan : 10 mm

(c) Variation of levels at the top : ±10 mm

(d) Surface irregularities measured with 3 m straight edge : 5 mm

(e) Bearing areas : 3 mm

(iii) Superstructure

(a) Variations in overall depth or width : ±5 mm

(b) Variations in overall length and length : Shall not exceed between bearings — ± 10 mm or ± 0.1 percent of span length whichever is less.

(c) Surface irregularities when measured with 3 m straight edge or template — : 5 mm

3 Quality control tests

3.1 Tests prior to construction

(a) Material / Work

The tests and checks to be carried out prior to construction are listed in Table A-110.1

TABLE A110.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test	Frequency
1	Cement Fine / Coarse Aggregates , water and Concrete for Structures	Tests as in Table 11.13	As in Table 11.13
2	Steel Reinforcement (For 4 culverts and minor bridges)	Tests as in Table 10.4.	As in Table 10.4
3	Plant and Equipment and other arrangements for concrete production	a) Working condition of concrete mixers including stand by arrangement b) Measuring boxes / scales for cement, fine and coarse aggregates c) Standard measuring cans (1/2, 1, 2, 5 litre capacity) for water d) Needle, plate and screed vibrators e) Arrangements for protection of concrete in hot, cold and rainy weather f) Tools and equipment for finishing and curing. g) Formwork (As per Table 9.2)	Check before commencement of concreting

(b) Manufactured items:

Other checks to be done on 'Manufactured items' prior to construction indicated in Table A-110.2.

TABLE A-110.2: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency
1	Elastomeric bearings . (IRC-83 part II) For Spans > 10m	Approved Test house report obtained by Manufacturer.	To be approved before procurement
2	Expansion Joints (IRC:SP:70)	Performance report (To be furnished by manufacturer)	-do-
3	Shear connectors (For composite bridges)	Dia, length and yield strength	-do-
4	Plasticizer (If used to improve workability of concrete)	As per Manufacturer's test reports	- do -

3.2 Tests / checks during construction.

The Tests / Checks to be carried out during construction are indicated in Table A-110.3

TABLE A-110.3: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No.	Material / Work	Test / Check	Frequency / Stage
1	Concrete for Structures	For constituents As in Table 11.14	As in Table 11.14
2	Concreting - For Foundation - For Substructure	Dewatering, before laying of foundation for each foundation work Form panel size and jointing to prevent bleeding	For each foundation work For each work
3	Cube Strength Results	Analysis of Test results	During construction of substructures / super-structures separately
4	Formwork	Tests as in Table 9.3	As in Table 9.3
5	Reinforcement cage	a) Dia and spacing of Reinforcements in cage as per drawing b) Size and placement of briquettes for supporting the reinforcements i.e. to provide bottom and side covers c) Cleaning rust on reinforcements with wire brushing d) Other checks as per Table 10.5	Before commencement of concreting - do - Before placement and compaction of concrete
6	All concrete works	a) Temperature Control & Control of W/C ratio (As per time & season of work) of mix b) Workability (IS:1199) c) Compaction d) Curing	Regularly Twice in a day. Ensure compaction by needle Vibrator To commence 24 h after casting
7	Expansion Joint assemblies	Installation as per Manufacturer's specification	At each Joint location
8	Sealants	To be installed as per Manufacturer's specification.	After hardening of concrete
9	Kerbs, Drain pipes Railings / Parapets	Separate formwork Spacing Dimension	As and when work is taken up
10	Elastomeric bearings	Correct positioning on pedestals	Before concreting

Annex-120
CEMENT CONCRETE CAUSEWAYS

CEMENT CONCRETE CAUSEWAYS

Annex - 120

Under this section quality aspects of different submersible structures viz., Flush Causeway, and Vented Causeway for rural roads are dealt with:

A. Methodology

A1 Flush Causeway

1. Choose flush causeway (Paved dip) to cross a shallow water course.
2. Keep top level of floor of causeway same as that of bed of water-course.
3. Build cut-off walls in brick masonry or stone masonry or plain cement concrete with suitable formwork as per provisions given in sections 7, 8, 10 and 9 respectively of this Hand Book.
4. Excavate for laying of foundation of upstream and downstream cut-off walls. Keep it sufficiently deep to avoid

   exposure due to scouring. Provide a PCC footing of 150 mm thickness in M15 grade, laid on a layer of 100 mm thick lean concrete (M10) or as per design.
5. Adopt a plain cement concrete slab of minimum thickness 200 mm in a minimum grade of M25 as paved dip. Provide construction joints 4-6 m apart and seal them with poly-sulphide or as per the design.
6. Provide upstream and downstream protection works, apron, pitching as per requirement.
7. Provide guide posts/stones at required spacing.

A2 Vented Pipe Causeways

1. Choose vented pipe causeway to cater to low flows through circular vents which overtop during monsoon. Usually RCC pipes NP3 are used for providing circular vents.
2. Follow the same methodology as detailed in Section 15 of this Hand Book for laying of RCC Pipes.
3. For headwalls or other ancillary works, adopt the requirements given in Section 17.
4. Take foundation and head walls sufficiently deep to avoid exposure to scouring in erosive strata. Batter the downstream side headwall on the outside and round the corners.
5. Adopt rectangular or arch type vents instead of circular pipe as per local practice.
6. Raise end portion of face walls and protect entire top of causeway by well desirable non-erodible wearing coat

A3 Ancillary Items (Wearing coat, Railing, Kerbs, Warning signs, Flood gauges)

1. Provide 75 mm thick Cement Concrete. wearing coat in M25 grade with a cross slope of 2.5 per cent towards downstream side of deck slab in submergible bridge. For vented causeways adopt 200 mm thick RCC Slab or as per design.
2. Discontinue wearing coat at expansion joint locations. Extend joint fillers upto the top of wearing coat.
3. For Cement Concrete wearing coat, provide 8 mm dia bars @ 200 mm c/c reducing to 100 mm c/c in both directions over a strip length of 300 mm near expansion joint or as per design.
4. Use open type or filler joint with appropriate nose protection.

5. Use discontinuous kerbs 300 mm wide at 1.8 m c/c on both sides, the continuous length of each piece being 1.5 m.

7. Locate advance warning/cautionary signs at about 200 m from the beginning of submerged portion of causeways and submersible bridges, to indicate speed limit, depth of submergence etc.

8. Install flood gauges as required or as shown in drawing.

B. Quality Control Requirements

Various components of flush and vented causeways shall conform to relevant provisions provided in this Hand Book as listed below:

1. Material

(i)	Bricks	Section 7
(ii)	Stones	Section 8
(iii)	Cement	Section 11
(iv)	Sand	Section 11
(v)	Coarse Aggregates	Section 11
(vi)	Water for construction	Section 11
(vii)	Steel	Section 10

2. Components/ Works

(i)	Earthwork	Section 2
(ii)	RCC Pipe	Section 15
(iii)	Vented Box	Annex 110
(iv)	Drainage Spout	Annex 110
(v)	Cement concrete Pavement	Annex 130

3 Quality Control Tests

The quality control tests/checks listed here in cover causeways and submersible bridges where in materials such as brick or stone masonry, plain or reinforced concrete are used. The openings in causeways could be of concrete pipes or rectangular / arch semicircular vents in RCC.

3.1 Tests prior to construction

The quality control tests to be carried out prior to construction are indicated in Table A-120.1

TABLE A-120.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S.No.	Material	Test / Check	Frequency
1	Bricks	As in Table 7.6	Table 7.6
2	Stones	As in Table 8	Table 8.6
3	Concrete Materials	As in Table 11.3	Table 11.13
4	Steel reinforcement	As in Table 10.4	Table 10.4
5	Cement pipes (If used)	As in Table 15.1	Table 15.1
6	Plant equipment for production of concrete	As in Table A-110.1	Table A-110.1
7	Pavement Materials	a) Sub-base (Table 3-1.2) b) WBM (Table 3-2.6) c) Cement concrete (Table 11.13)	Table 3-1.2 Table 3-2.6 Table 11.13

2. Tests during construction

The Quality Control Tests /checks to be carried out during construction are indicated in Table A-120.2

TABLE A-120.2: QUALITY CONTROL TESTS DURING CONSTRUCTION

S.No	Material / Work	Test / Check	Frequency
1	All concrete works	a) Workability (IS:1199) b) Cube strength (IS:516) c) Curing	As per Table a-110.3
2	Concrete for foundation substructure, super-structure (For submersible bridges)	a) Dewatering b) Form panels, c) Jointing, d) Cover to reinforcements	As per Table A-110.3
1	Formwork	Design, Erection, Camber, etc.	As per Table 9.3
4	Reinforcement cage	Dia, spacing, cover as per drawings	- do -
5	Kerbs, drain pipes railings / parapets	As indicated in drawings	- do -
6	Bearings & Expansion Joints	Manufacturer's Specification	- do -
7	Jointing of pipes & bedding	As per Table 15.2	During construction
8	Cement Concrete Pavement (Additional tests)	As per Table A-130.3 (Items 5,6,7 and 8)	Table A-130.3 (Items 5,6,7 and 8)
9	Equipment for handling pipes (prior to lowering)	- Adequacy of chain pulley block - Stability of Tripod arrangement etc.	Check by Engineer

Annex 130
PLANE CEMENT CONCRETE PAVEMENT

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PLAIN CEMENT CONCRETE PAVEMENT

Annex-130

A. Methodology

1. Approval of materials, plant, equipment and construction method.

(i) Relevant test data of materials and construction methodology listing all steps, details of personnel and plant, equipment, batching and mixing of materials, handling, curing texturing should be furnished by the Contractor before constructing the concrete pavement.

(ii) Before construction of concrete pavement, ensure that the sources with test results of all materials to be used in the concrete work are approved by the Engineer well in advance, (at least 30 days before their use),

(iii) The mix design based on laboratory trial mixes using approved materials is submitted for approval of the Engineer at least 30 days prior to the paving work.

(iv) The mix design shall be based on the compressive strength of concrete as specified in the contract. The cement content should not be more than 425 kg nor less than 310 kg per cum of concrete unless specified otherwise. All batching of materials shall be by weight. Volume batching may be allowed for small jobs with the approval of the Engineer. Minimum M 25 grade concrete is recommended. Water cement ratio should not be more than 0.5. Admixtures may be used to achieve the desired workability and strength after approval of engineer.

(v) Semi-mechanised and labour oriented construction techniques will be permitted. Plant, equipment and tools required for preparation and laying of concrete shall be as specified in the contract, Specifications.

2 Prepare the Sub-grade to the specified grades and cross-sections and compact to the design strength specified in the Contract. A day before placing the sub-base, clean the surface and apply a light spray of water on the sub-grade and roll with one or two passes of suitable 80-100 kN roller to stabilise any loose material.

3 Lay granular or WBM of the specified type and thickness. Near the bridge or culvert, an additional layer of 200 mm thick non-plastic Granular sub base(GSB) over the sub-grade, should be provided in full panel length and full carriageway width.

4 Provide a separation membrane (125 micron thick plastic sheet/geo-textile) between sub-base/base and concrete slab. It should be laid without creases.

5 Mark location and type of the joints on either side of the surface of the sub-base/base, with red paint.

(i) Contraction joints shall be mechanically sawn joints spaced 2.5 m to 3.75 m. Length of panel in the direction of traffic shall not be less than the width of the pavement. Joints shall be cut when the pavement is neither too soft nor too hard and is able to bear the weight of the machine and crew. Normally it may vary from 8 to 12 hours depending on weather conditions.

(ii) Construction joints shall be butt joints and placed after a day's work is over or when work is suspended for more than 30 minutes.

(iii) Expansion joints shall be provided near bridges and slab culverts and consist of a bitumen impregnated joint/ pre-moulded synthetic joint filler board, about 20 mm thick, and dowel bars.

(iv) Longitudinal joints shall be provided for a two-lane road and shall be saw-cut.

6 All side forms shall be of mild steel channels or fabricated plates with adjustable jacks at the back and of depth equal to the thickness of pavement. Plant, equipment and tools required for preparation and laying of pavement concrete are listed as specified in the contract.

7 Pavement concrete shall be produced near the site, using approved concrete mixers of at least 0.2 cum capacity. Readymade concrete conforming to the specified properties of strength and workability may also be used.

8 Check the slump of concrete. It should be in the range of 30 mm ±10 mm

9 Concrete shall be placed between the side forms and shall be leveled with rakes and shovels. In concrete panels having acute angles, a bar mat of 10 mm dia ribbed steel bars at 150 mm center to center in both directions shall be provided at 50 mm below the top of slab, in the entire panel.

10 Around man-holes or other openings in pavement, place 12 mm thick pre-moulded board as specified or as shown in drawing and bar mats before concreting.

11 Compact concrete by a vibrator.

12 As soon as practicable after compaction of concrete, smoothen the surface with a longitudinal float operated from the work bridge. Just before the concrete becomes non-plastic, it shall be textured with a long handled steel or fiber brush.

13 After completion of texturing , before the concrete has taken its initial set, the edges of the slab shall be carefully finished so as to leave the pavement edges smooth and true to line.

14 After completion of the finalizing operations, the surface of the pavement shall be covered with wet Hessian cloth, or jute mats. They shall be maintained fully wetted and in position for 24 hours.

Upon the removal of the wet covering out the end of 24 hours, the slab shall be thoroughly wetted and then cured by pounding or sprinklers of water.

The slab shall be covered with sufficient sandy soil so as to produce a blanket of earth not less than 40 mm thick after wetting. The earth covering shall be thoroughly wetted while it is being placed in the surface and against the sides of the slab and kept thoroughly saturated with water for 14 days. The sand shall not be removed and shall thereafter remain in place till 28 days from date of casting so that the concrete has attained the required strength.

15 After minimum of 28 days after casting the concrete pavement, joint groove at contraction joint shall be widened to 10 mm width and to a depth 18 to 20 mm and shall be sealed.

B. Quality Control Requirements

1. Material

(i) Cement

Cement shall be capable of achieving the design strength and may be

(a) Ordinary Portland Cement, 33 Grade IS:269

(b) Ordinary Portland Cement, 43 Grade IS:8112

(c) Ordinary Portland Pozzalana cement, IS:1489

(ii) Admixture

Chemical admixture conforming to IS:6925 and IS:9103 may be used to improve workability and strength of concrete.

(iii) Aggregate

(a) Aggregate for pavement concrete shall be as per Table 11.5(a) of section 11 of this Hand Book with a Los Angeles Abrasion test value not more than 35% or Aggregate Crushing Value not exceeding 30%.

(b) Coarse aggregate shall be clean, hard, strong, dense, non porous and durable crushed stone or crushed gravel.

The maximum size of coarse aggregate shall not exceed 20 mm. It shall not have a flakiness index more than 15% and water absorption exceeding 2%.

(c) Fine aggregate shall be clean natural sand or crushed stone sand or a mixture of both complying with Table 11.6.

(iv) Water

Water used for mixing and curing concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter.

(v) Dowel Bars

Plain mild steel bars 25 mm dia conforming to IS:432 (Part 1) having minimum yield strength 240 N/mm2 shall be used as dowel bars. These shall be free from oil, dirt, loose rust, scale, irregularities and burring. Dowel bars shall be positioned at mid depth of the slab within a tolerance of (±) 20 mm.

All bars in a joint shall be within (±) 5 mm in length of bar. Normally 500 mm long and spaced 250 mm c/c or as specified. They shall be parallel to the longitudinal axis of the pavement.

(vi) Premoulded Joint Filler

Bitumen impregnated filler board/premoulded synthetic joint filler board for expansion joints shall be 20mm thick within a tolerance of (+) 1.5 mm and of a firm compressible material in conformity with the requirements of IS:1838.

(vii) Joint Sealing Compound

Joint sealing compound shall be hot poured sealing compound type having flexibility, resistance to age hardening and durability and shall conform to IS:1834.

2. Horizontal Alignment

± 20 mm	Plain and Rolling Terrain
± 30 mm	Hilly Terrain

3. Surface Level

The tolerance in surface level of cement concrete pavement shall be (+) 5 mm or (-) 6 mm which may exceed upto (–) 8 mm at 0-300 mm from the edges.

4. Surface Regularity

The maximum allowable difference between the pavement surface and a 3 m straight edge/profile plate shall not exceed 6 mm for the longitudinal profile/cross profile.

5. Acceptance Criteria for cracked concrete slabs (one panel):

(i) Slabs with cracks penetrating to more than half the depth of slab shall not be accepted.

(ii) For cracks with depth less than half the depth of slab, no single crack shall exceed 750 mm length; cumulative length of such cracks in each slab shall not exceed 1250 mm.

6 Quality Control Tests

Plain concrete pavement

6.1 Tests prior to construction

The Quality Control Tests to be carried out prior to construction are indicated in Table A-130.1

TABLE A-130.1: QUALITY CONTROL TESTS PRIOR TO CONSTRUCTION

S. No.	Type of Test	Frequency
1	Cement	As in Table 11.12
2	Fine Aggregates	As in Table 11.12
3	Coarse Aggregates	As in Table 11.12
4	Water	As in Table 11.12
5	Admixture - Chemical (For workability) (IS:6925 & IS:9103) - Mineral (Flyash) (IS:3812)	 Manufacturer's certificate before procurement - do -
6	Dowel bars (Plain steel) IS:432 (Part I)	Tests on 3 samples to determine yield strength
7	. - Premoulded Joint Filler (IS:1838) or - Joint Sealing Compound(IS:1834)	Manufacturer's Certificate -do-
8	Plant, equipment and tools	As per contract
9	Concrete mix design.	To be approved by Project Manager
10	Granular Sub base/base	Table 3-1.2

6.2 Tests during construction.

The tests required to be carried out during construction are indicated in Table A-130.2

TABLE A.-130.2: QUALITY CONTROL TESTS DURING CONSTRUCTION

S. No.	Tests / Check	Frequency
1	Subgrade and Subbase	As in Tables 2-5.5 and 3-1.3
2	Gradation and moisture content of aggregate for CC pavement	As in Table 11.13
3	Concrete workability	One test per 3 cum of concrete at paving site.
4	Strength of Concrete (IS:516)	Minimum 6 cubes (3 each for 7 day & 28 day strength) as per Table 11.9.
5	Straightness of side forms (steel)(For paralleling and possible settlement and securing position before concreting)	To be checked daily
6	Size, spacing, paralleling of Dowel bars and location of different joints	To be checked prior to casting of concrete at the location.
7	Batching and Mixing of materials	Check for measurements and proper mixing
8	Compaction equipment (Needle, Screed and Plate vibrators)	For continuous working and stand by arrangement
9	Levels and Alignment i) Level tolerance (ii) Surface Regularity (Transverse and Longitudinal including camber/cross slope) (iii) Width of pavement and position of paving edges work Regularly at grid points (iv) Pavement thickness (v) Alignment of joints (vi) Depth of Dowel Bars	To be checked for each day's work Regularly To be checked for each day's work To be checked for each day's work -do- -do-

Annex-140
HILL ROAD CONSTRUCTION

HILL ROAD CONSTRUCTION

Annex-140

Most of the quality aspects related to site clearance, setting out of the works, earthworks, including rock cutting and blasting operations; construction of sub-grade, sub-base, base, bituminous surfacing; construction of drainage and cross-drainage works; protection measures and retaining structures; stone masonry, brick masonry and cement concrete are already covered under the respective sections of this Hand Book. The methodology and quality requirements and quality tests specified therein are relevant to hill road construction as well and may be followed. The Specifications already covered under various sections are not repeated in this Section. This Section therefore, brings out only those of the construction aspects and related quality requirements for hill roads which have not been covered in previous sections.

Hill Road Construction should be taken up after carrying out necessary Geo-technical investigations.

A. Methodology

1. Site Clearances

Carry out the site clearance to the requirements of Section -1.

2. Setting Out

Set out the work carefully with reference to the Reference pillars fixed at the Project preparation stage. For details refer to Sub-section G-9.

(i) Mark the hill side edge of roadway (back-cutting line) on the hill face accounting for the specified slope of hill cutting. Ensure its accuracy by measuring distance from each reference peg so as to match with the drawing.

(ii) Where the road is in filling, ensure that the outside edge of the retaining wall is accurately fixed as measured from the Reference Pillar.

(iii) Ensure that the roadway demarcation lines between consecutive reference pillars follow the curvature shown on the drawings.

(iv) In case any discrepancy in length (measured parallel to road grade), direction and grade is found between two reference pillars beyond the specified tolerances, review and take corrective measures.

(v) Ensure that the level pillars are fixed as per the final longitudinal gradient.

3. Rock Cutting

(i) Carry out rock cutting to the specified lines, grades, side slopes, width and cross-slope conforming to the drawings.

(ii) Ensure that hill cutting is carried out in a manner to minimize the deforestation to the extent possible, following the Environmental Management Plan (EMP). Necessary mitigation measures shall be ensured before start of hill cutting work.

(iii) Take care to restrict the rock cutting to the required width. For steep slopes (say more than 30 degrees depending upon the type of rock) initial 3 m bends may be cut manually for movement of machinery.

The prescribed roadway width for hilly terrain is inclusive of parapet and hillside drains. Extra widening on curves and in snow bound areas should be done as per Drawings.

(iv) Resort to slope benching to improve sight distance.

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(v) Make provision for 2 to 3 passing places per kilometre length.

(vi) Where hairpin bends are to be provided, ensure that the hill slopes are stable and gentle. The hairpin bend will be provided as a circular curve with transitions at either end.

(vii) Follow procedure and safety precautions for rock cutting as per Sub-section 2-2.

(viii) Ensure that excavation work starts along back cutting line. Also ensure that completion plan and verification of curve radii and longitudinal gradients is carried out at site. Defects if any shall be corrected immediately.

4. Preparation of cut formation for Subgrade

Prepare as per the requirements of Sub-section 2-1.

5. Retaining Walls, Breast Walls and Gabion structures

(i) Construct retaining/breast walls, and Gabion structures, conforming to the Drawings.

(ii) The foundation bed should be sloped towards the hillside.

(iii) Resort to stepping up of the foundation bed of retaining walls in stable rocks.

(iv) The masonry for retaining/breast walls should conform to Sub-section 8.

(v) Ensure that the top level of the retaining wall matches the adjoining shoulder edge.

(vi) Ensure that full section is constructed as per the drawings.

(vii) Ensure that approved filter material is provided behind the wall before back filling. Also ensure that back filling is done only after the masonry work is approved by the Engineer.

6. Pavement Construction

Prepare sub-grade to the requirements of Subsection 2-5-1 and construct sub-base, base and bituminous surfacing in accordance with the requirements of the respective subsections.

7. Drainage

Carry out excavation for drains along with hillside cutting conforming to the shape, size and grades as shown on the drawings.

(i) Provide lining as specified.

(ii) Locate catch water drains over stable slopes outside the periphery of the slide area.

8. Cross Drainage Works

(i) Use locally available stone for construction of Scuppers with dry stone masonry. Ensure a minimum cushion of 600 mm over corbelling.

(ii) **Cement Concrete Causeways:** Construct causeways as per drawings and conforming to the requirements of Annex-120

(iii) **Pipe Culverts:** Construct pipe culverts conforming to requirement of Section 15.

9. Protection Works

Ensure that protection works are constructed conforming to the Drawings and Section 17.

10. Safety Measures

(i) Provide traffic signs, guide posts, railings/parapets in accordance with the requirements of Section 20

(ii) Security manpower should be deployed for ensuring that any person including labourers are removed from the flagged area at least 10 minutes before the firing.

B. Quality Control Requirements

1. Materials

(i)	Masonry Work :	Conforming to Section 8
(ii)	Sub-Base, Base, Bituminous Works :	Conforming to Sections 3 and 4
(iii)	Cement Concrete :	Conforming to Section 11
(iv)	Pitching/Apron :	Conforming to Section 17
(v)	Steel :	Conforming to Section 10

2. The tolerances for width of formation, longitudinal grade, grade compensation and superelevation shall be as follows:

a)	Width of formation	(+) 5% (-) 1%
b)	Longitudinal profile	(±) 5% of the specified grade
c)	Grade compensation	(±) 5% of the specified gradient
d)	Super-elevation	(±) 5% of the specified super-elevation

3. The tolerances for layout of hairpin bends shall be as follows:

a)	Length	(+) 0.5%
b)	Direction	(±) 20 minutes
c)	Grade	(±) 0.2%

4. The tolerances in the various courses of pavement should conform to the provisions given in the relevant Sub-sections of this Handbook.

Annex-150
MAINTENANCE

MAINTENANCE OF ROADS & DRAINS

Annex-150

MAINTENANCE OF EARTHEN ROAD

The maintenance of Earthworks in this Sub-section includes restoration of rain cuts, maintenance of earthen shoulders, embankment slopes and drains.

A. Methodology

I. Restoration of Rain Cuts

1. Clear the areas affected by rain cuts of all loose soil and then provide benching. The width of benches should be at least 300 mm and should extend continuously for a sufficient length, the height of benches being in the range of 150-300 mm.

2. Lay fresh material, meeting the requirements of a suitable fill material (as per Section 2-5) in layers not exceeding 250 mm loose thickness and compact at a moisture content equal to optimum ± 2%. Carryout compaction using plate compactors/ rammers or by suitable implements handled manually.

3. Ensure that the finished work conforms to the specified alignment, levels and slopes.

II. Maintenance of Earthen Shoulders

1. For making up of an earthen shoulder where extra soil is required to be added, loosen the existing earthen shoulder to receive fresh soil. Make up the deficiency in layers of loose thickness not exceeding 250 mm. After ensuring the placement moisture in the loose soil layer at optimum ± 2%, compact the layer to obtain 95% of maximum dry density in accordance with IS:2720 (Part 7). For compaction, an 80 to 100 kN smooth wheel roller, plate vibrator, hand-held roller or even a hand rammer can be used, provided the specified dry density is achieved.

2. Where earth is required to be excavated from the shoulder, remove high spots/excess earth either using equipment like grader or by manual means using hand tools. The resulting surface should be uniform and have a field density of at least 95% of maximum dry density as per IS:2720 (Part 7), otherwise excavate/loosen the surface to a depth of 150 mm and compact to 95% of maximum dry density as per IS:2720 (Part 7), making sure that the moisture content prior to compaction is at OMC± 2%. The compacted layer should be finished to the required cross fall.

3. All obstructions like tree branches, heaps of soil, debris etc. must be removed, and disposed of to an off-road dumping place. This task should be performed along with other tasks like patching shoulders, grass cutting, cleaning ditches etc.

4. Carry out weed cutting and bush clearing at least once a year after the rainy season or more often where climatic conditions so warrant. Where long stretches of shoulder vegetation is to be cut and the work cannot be done by hand tools, use an agricultural tractor towed mower/ripper.

III. Maintenance of Slopes and Drains

1. Together with clearing unwanted vegetation on shoulders, clearing of slopes and drains/ditches should also be carried out.

2. Carry out reshaping, re-grading and deepening of ditches/drains preferably by tractor-towed grader, wherever possible, otherwise by manual methods. Alignment should be set by string line and the materials within the string line should be cut and removed. Cross-section, grading and

depth should be checked and corrected. Excess material must be removed from the site and should never be spread over the road.

3. Any objects which can interfere with water flow must be removed.

4. Repair drains erosion by replacing and backfilling the lost soil. In case of recurring problems of erosion, permanent measures like masonry lining should be considered.

5. Check for any settled or damaged precast drain sections or loose stone, which should be removed and underlying soil compacted. After addition of fresh soils, the levels should be corrected then only fresh stones or precast drain should be laid.

6. For vegetation control, tractor-towed mower can be employed where available and as an alternative hand-guided mower can also be used.

7. For erosion control, turfing (grass sodding) is suitable when climate and soil conditions are favorable. Seek advice of local agriculture department on topsoil required, seed type and rate of spread, fertilizer types and rate of spread and most favorable season and weather for seeding. Suitable mulch like jute netting can be provided for preventing the seeds from getting washed away before the seeds sprout.

B. Quality control requirements

1. Materials

All soils and other materials used for maintenance should satisfy all quality requirements for use in shoulders, along slopes and in roadside ditches/drains, as laid down for original construction.

2. Surface Finish

All maintenance works must be carried out to the finished surface standards laid down in original designs.

3. Camber/Cross Fall/Side Slopes

Check that the maintenance work has been carried out to the specified camber/cross-section and side slopes.

MAINTENANCE OF BITUMINOUS SURFACE ROAD

It is considered an essential requirement prior to undertaking any maintenance measures that the road be inspected at least once a year and that the past record of performance, maintenance and traffic data is available with the Maintenance Engineer.

A. Methodology

1. After a field inspection, determine the areas for

   (i) **Surface defects** like fatty surfaces, smooth surfaces, streaking and hungry surfaces.

   (ii) **Cracks**-hair-line cracks, alligator cracks, longitudinal cracks, edge cracks, shrinkage cracks and reflection cracks.

   (iii) **Deformation**- slippage, rutting, corrugation, shoving, shallow depressions, settlements and upheavals; and

   (iv) **Disintegration** – stripping, loss of aggregates, raveling, pot-holes and edge breaking.

2. Surface Defects

2.1 Fatty Surfaces

(i) If the bleeding is fairly uniform and the surface is free from irregularities, application of cover aggregates or sand (sand blotting or sand-blinding) would be successful. The aggregate or sand used shall be of small size, clean and regular, and may be heated, if necessary.

(ii) An open-graded premix surfacing with a low bitumen content can absorb the excess binder.

(iii) A liquid seal coat, with special care taken to select the rate of application of the binder and the quantity and size of cover aggregates, can also be effective.

(v) In case of large areas of fatty surface having irregularities, removal of the affected layer in the area and replacing it with layer having a properly designed mix, may be necessary.

2.2 Streaking

Repair for longitudinal and transverse streaking is to remove the streaked surface and apply a new surface treatment. It is always desirable to prevent longitudinal and transverse streaking than to correct it. Whenever mechanical equipment is used for spraying of bitumen, manufacturer's recommendations of the bitumen distributor should be carefully adhered to.

2.3 Hungry Surface

A slurry seal may be used as a repair measure. It is applied in an average thickness of 2-5 mm. As an emergency repair, a fog seal may be used.

3. Cracks

The treatment for cracks would depend on whether the pavement remains structurally sound or has become distorted or unsound.

In case the pavement remains structurally sound, then the cracks should be filled with a bituminous binder having a low viscosity so that it can be poured and worked into the cracks. Cut back bitumen and emulsions are generally suitable. All loose materials are removed from the cracks with brooms and if necessary, with compressed air jetting. The binder is poured with a pouring can and a hand squeegee is used to assist the penetration of the binder into the cracks. Light sanding of the cracks is then done to prevent traffic picking up the binder.

If the cracks are wide enough a slurry seal, or sand bituminous premix patching can be used to fill the cracks.

If the cracks are fine (crazing) and extend over large areas, a light-cut-back or an emulsified bitumen (fog seal) can be broomed into the cracks and lightly sounded to prevent the picking up of the binder by the traffic.

4 Deformation

4.1 Slippage

Remove the surface layer around the area affected upto the point where good bond between the surfacing and the layer underneath exists and patching the area with premix material after a tack coat.

4.2 Rutting

Fill the depression or groove in the wheel tracks with premix open-graded or dense-graded patching materials and compact to the desired levels. The limits of the depression are first

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determined with a string line and marked on the surface. After applying a suitable tack coat, the premix is spread and compacted.

Situations indicative of shear failure or sub-grade movement generally require excavation. The job should be carefully assessed. The area to be opened up should as far as possible be limited to that which can be completed and made safe in a day's working.

4.3 Corrugations

If the surface is thin, the same is scarified, including some portions of the underlying water-bound macadam base, and the scarified material is recompacted. A new surfacing layer is then laid. Cutting of high spots with a blade with or without heating and addition of leveling course materials can also be resorted to.

Spreading of sand bituminous premix with a drag spreader with its blade adjusted to just clear the high spots can also be an effective way of making up the corrugations. The area is then thoroughly rolled.

4.4 Shoving

Remove the material in the affected area down to a firm base and lay a stable premix patch.

4.5 Shallow depression

Fill up the depression with premix materials, open-graded or dense-graded and compact to the desired profile as the surrounding pavement after applying tack coat.

4.6 Settlement and Upheaval

If settlements and upheavals indicate an inherent weakness in the fill or sub-grade, it may be necessary to excavate the defective fill and upto bottom of sub-grade and do the embankment a fresh under properly controlled conditions. Material having good drainage qualities should be preferred. Under-drains may become necessary in locations where lack of drainage has been identified as the cause of failure. Where the cause of deformation is inadequate pavement thickness, then properly designed pavement shall be provided. Frost-affected regions may need thorough investigations and a complete reconstruction of the pavement.

5. Disintegration

5.1 Stripping

In the case of surface dressing, hot coarse sand heated to at least 150°C and spread over the affected areas, may be used to replace the lost aggregates. After spreading, it should be rolled immediately so that it will be seated into the bitumen. If aggregates are only partially whipped off, a liquid seal may be the solution.

In other cases the existing bituminous mix should be removed and a fresh one laid. As a precautionary measure, a suitable anti-stripping agent should be added to the bitumen, at the time of construction.

5.2 Loss of Aggregate

If the loss of aggregates is due to ageing and hardening of the binder, the condition may be rectified by applying liquid seal, fog seal or slurry seal.

If the loss of aggregates has occurred over large isolated areas, the best thing to do would be to provide another surface dressing layer, after carefully cleaning the surface.

If the loss of aggregates has taken place in small isolated patches, a liquid seal would be sufficient.

5.3 Raveling

Raveled surface is corrected by adding more quantity of binder, the rate of application depending upon the condition of existing surface and degree of hardening occurred to the binder. If the raveling has not developed too far, the condition may be corrected by a simple application of a cut-back bitumen covered with coarse sand, or a slurry seal can be applied. Where the raveling has progressed far, a renewal coat with premix material would be necessary.

5.4 Pot-hole

Fill pot holes with premix open-graded or dense-graded patching or penetration patching

5.5 Edge-breaking (Frayed edges)

The shoulder and the pavement material in the affected area should be fully removed to a regular section with vertical sides. The pavement and the shoulders should be built up simultaneously with thorough compaction. A bituminous surface similar to that in the adjacent reach should be laid. The shoulder should have an adequate slope to drain away the water. A slope one per cent steeper than the camber of the bituminous surface should be found generally necessary for earthen shoulders. In order to prevent the edges from getting broken again, the maintenance operations should include periodic inspection of the shoulder condition and replacement of worn out shoulder material with adequate compaction. In sandy areas where the soil is likely to be eroded by wind and rain, it may be advantageous to have brick paving at least for some width to protect the edges. Surface and subsurface drainage, wherever deficient, should be improved.

II Periodic Surface Renewal

When the condition survey data reveals the need for surface renewal, provide 20 mm thick Premix Carpet as per Sub-section 4-4-1 and seal coat as per Sub-section 4-5. Prior to laying a surface renewal, clean the existing surface of all dust and cake mud by wire brushes and brooms.

MAINTENANCE OF GRAVEL ROAD

It is considered an essential requirement prior to undertaking any maintenance measures that the Gravel road can be inspected at least once a year and that the past record of performance, maintenance and traffic is available with the Maintenance Engineer.

A. Methodology

I. Routine Maintenance Measures

1. Where loss of profile is observed on a gravel road, drag the accumulated material from the roadsides/shoulders to the center, using an approved tractor-towed grader and compact by roller. If a suitable mechanical grader is not available, adopt manual methods. Prior to roller compaction, ensure that the gravel is at optimum moisture content ± 2%

2. Where the surface is corrugated, rectify it by grading with a mechanical grader or by using a tractor-towed drag of approved design. The scrapped material should be spread over the surface and roller compacted. Prior to compaction, ensure that the material is at optimum moisture content ± 2%

3. Repair all local depressions, ruts, potholes and erosion gullies, replacing or adding new surface material of specified properties as per Section 3-1 and then compact the replaced/new surface

material by road roller. Before under taking repairs, the affected area should first be cleaned of all loose material, bringing it to a regular rectangular shape with the help of spades and pick axes and hand ramming the bottom surface. The prepared area should be filled up with gravel of specified properties and roller compacted, ensuring that prior to compaction, the moisture content is at the optimum ± 2%.

II. Periodic Surface Renewal

Prior to re-gravelling, scarify the old surface and provide additional gravel 50 mm to 75 mm in loose thickness meeting specified requirements over the scarified surface. After bringing the moisture content of the additional gravel to optimum ± 2%, compact the loose gravel layer to the maximum dry density as per IS:2720 (Part 7).

B. Quality Control Requirements

1. Materials

Any gravel used for routine maintenance repairs and for periodic re-gravelling should conform to the requirements as per Section 3-1.

2. Surface Finish

The surface finish after the routine maintenance repairs and periodic re-gravelling should conform to the requirements laid down in Section 3-1.

3. Camber/Cross-fall

Check that the final surface conforms to the specified camber/cross fall.

MAINTENANCE OF WBM ROAD

It is considered an essential requirement prior to undertaking any maintenance measures that the WBM road be inspected once a year and that the past record of performance, maintenance and traffic data is available with the Maintenance Engineer.

A. Methodology

I. Routine Maintenance

1. After a field inspection, determine the areas for (a) filling up potholes (b) filling up ruts, (c) rectifying corrugated surface, (d) repairing damaged edges and (e) rectifying ravelled surface.
2. Before filling up a pothole, remove all loose material from the pothole upto the firm base, cut the affected area made into a regular rectangular shape with sides of the hole kept vertical. Fill the prepared pothole space with aggregate of the same size and type as used in the original layer and apply screenings and binding material of the same type (if found suitable) as used in original construction over the aggregate and compact by hand rammer. After watering, compact the layer again by hand rammer first and then by a road roller.
3. Clean the rutted potion of all loose material and sprinkle with water and shape the rutted portion into a rectangular portion with flat bottom. Compact the bottom after sprinkling water. Fill the prepared rut portion with salvaged material, if found suitable and/or fresh suitable aggregates and roll after addition of screenings, binding material and watering following the standard procedure as per Sub-section 3-2. After rolling, provide a 6 mm sand layer over the finished surface and lightly sprinkle with water.
4. Remove any damaged portions at the edges, replace by fresh material and roll.

5. Any corrugated surface formed by excess blindage material should be rectified by removing all excess blindage material by dragging or brooming. Where corrugations develop in WBM course itself, a renewal layer of WBM will be required.

6. Fine hair cracks on the surface are usually indicative of raveling taking place later. This tendency for raveling can be remedied by blending with good binding material and watering the surface. Where raveling has developed prominently, resurfacing should be carried out.

II. Periodic Surface Renewal

Where the condition survey data reveals the need for surface renewal, provide a 75 mm thick layer of WBM grading 3 as per Section 3-2. Prior to laying a surface renewal, clean the existing surface of all dust and coated mud by wire brushes and brooms. After light sprinkling of water, scarify the surface and screen the salvaged materials to be used later, if found suitable. The salvaged material together with fresh additional material should be spread and dry rolled followed by application of screenings and binding material and wet rolling as per Sub-section 3-2.

B. Quality Control Requirements

1. Materials

The quality of stone aggregates, screenings and binding material used for routine maintenance as well as periodic surface renewal should conform to the requirements laid down in Subsection 3-2 for WBM construction.

2. Surface Finish

The surface finish requirements after carrying out various maintenance measures should also conform to the surface finish requirements laid down in Subsection 3-2.

3. Camber/Crossfall

Camber/Crossfall should be checked for ensuring conformance with the specified requirements.

MAINTENANCE OF CULVERTS AND SMALL BRIDGES

General:

Under this Section the maintenance aspects of all the culverts and small bridges are covered.

A. Methodology

1. Inspect approaches of Cross Drainage works for possible erosion and settlement, besides any damage due to movement of cattle between stream and roadway.
2. Examine floor protection to assess extent of cracking/damage to the floor condition and cut off walls, aprons etc.
3. Observe any abnormal change of channel flow and movement of debris, floating material, sand/ silt and boulders.
4. Examine the general condition of foundation, pier, abutment, wing wall, return walls, springing of arches, headwalls, cut off walls for any damages due to scouring / earth pressure.
5. Check for growth of vegetation in all structural components for cracking in concrete, loosening of brick/stone masonry work, opening of joints at crown section, separation of walls, settlement/tilt of foundation etc.

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6. Check for condition of inlets, outlets and catch pits of pipe culverts/boxes from inside and on outer faces for growth of vegetation, erosion and choking of culverts.

7. For concrete members examine for signs of distress such as cracking, spalling/corrosion of embedded steel etc.

8. Examine drainage spouts, guide posts, railings, parapets guard stones, kerbs and wearing coat for durability and for safety of pedestrians and animals.

B. Quality Control Requirements

1. Clear and clean debris of sand and silt from culvert opening and catch water pit including growth of vegetation at inlet and outlet. Remove and dump the same far away from water channel.

2. Undertake repairs for damages caused due to erosion, cracks and spalls and to substructures and protection works.

3. Inspect general condition of foundation and for separation walls and carry out repairs.

C. Materials

1. Carry out repairs on cement based components / parts with cement mortar.

2. Inject epoxy grout for sealing of cracks and filling of voids in concrete, under pressure, following Manufacturer's specification.

3. Carry out repairs on concrete deck slabs with Methyl Methacrylate (MMA) or Trimethyl Propane, Trimethacrylate as per Manufacturer's specification.

4. Carry out repairs to approaches and banks periodically with local soil.

5. Use brick or stone masonry for repair of components made of the same materials.

MAINTENANCE OF CAUSEWAYS

A. Methodology

1. Check for adequacy of waterway and any abnormal change in flow pattern of channel on upstream and downstream side after each flood season, including out flanking.

2. Examine major damages caused by outflanking or cavitations, causing collapse of head walls, damages to paved surface and fill material that holds multiple pipes/openings.

3. Check the condition of vents for accumulation of sand/debris etc. and check for accumulation of debris on the surface of causeway after each submergence and clean it.

4. Check the approaches for erosion/wash out and face walls and head walls for loosening of material.

5. Check the condition of guideposts/guardstones/kerbs including slopes of approaches.

6. Check any damages to down stream protection works like Cement Concrete blocks, stone pitching and wire crates.

7. Check the functioning of flood gauge of causeways before onset of monsoon.

B. Quality Control Requirements

1. Carryout repairs to the submerged portions of the structure with the same parent material.

2. Remove growth of vegetation in different components debris/floating material on both upstream and downstream side of causeway as well as roadway.
3. Carryout repairs to guide posts/guard stones/kerbs, debris arresters and roadway.
4. Undertake minor repairs to flood gauges and other ancillaries.
5. Undertake repairs to the damages caused by out flanking, collapse of head walls and to paved roadway surface.

C. Materials

1. Carry out repairs to concrete components on cement plaster with the same material.
2. Use stones / bricks for replacement of parts or to repair local damages
3. Use local soil if suitable, for repairs to embankments approaches etc.

MAINTENANCE OF ROAD SIGNS

A. Methodology

1. All road signs should be inspected at least four times a year both in day and night.
2. All signs along with the posts shall be maintained in proper position and kept clean and legible at all times.
3. Damaged signs shall be replaced immediately. All road signs along with the posts should be maintained in proper position and kept clean and legible at all times
4. A schedule of painting of the posts and signs periodically shall be maintained. Painting the signs may be undertaken after every two years.
5. Tree branches, plantations, weeds, shrubbery and mud etc. shall not be allowed to obscure the sign.

B. Quality Control Requirements

1. Materials

The material for repair/fabrication of signs shall conform to Section 20.

APPENDIX - 1
SIMPLE/HANDFEEL TESTS

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HAND-FEEL TESTS FOR MATERIALS

1. SOILS

1.1 Dilatancy Test

Remove all particles larger than IS 425 micron sieve size and prepare a pat of moist soil with a volume of about 8000 mm^3. Make the soil soft by adding water if necessary. Place the pat of soil on the open palm of one hand and shake horizontally by striking against the other hand, a number of times. A positive reaction consists of the appearance of water on the surface of the pat rendering the surface glossy, which disappears when the sample is squeezed between the fingers, the pat stiffens and begins to crumble. The rapidity of appearance of water during shaking and its disappearance during squeezing signify the nature of fines in the soil pat. While clean fine sands give the quickest reaction, a plastic clay shows no reaction at all and silts will show a fairly quick reaction by way of a shiny surface.

1.2 Dry Strength Test

Remove all particles larger than IS 425 micron sieve size and mould a pat of soil to the consistency of putty by adding water, if necessary. Dry the pat by air drying or under the sun or in an oven and test its strength by breaking and crumbling between fingers. The strength of dried pat of soil is indicative of its plasticity and the nature, as well as quantity of the colloidal fraction. Dry strength increases with increasing plasticity and is of a very high order in highly swelling type Black Cotton soils. While the highly plastic clay (CH soil) exhibit high dry strength, the silts and silty fine sands have only slight dry strength but can be distinguished by the feel when powdering the dried sample: fine sands feel gritty while silts give a smooth feel.

1.3 Toughness Test

Remove all particles larger than the IS 425 micron sieve size and mould a soil specimen of about 12 mm cube in size, at the consistency of putty. If the soil sample is too dry, adequate amount of water should be added to bring it to the consistency of putty; if too sticky, allow it to lose some moisture by evaporation. Roll out the specimen by hand on a smooth surface or between palms into a thread about 3 mm diameter. The thread should then be folded and re-rolled separately. During such a manipulation, the thread stiffens, loses its plasticity and crumbles at a moisture content corresponding to the Plastic Limit. Lump together the pieces of crumbled thread, apply kneading action until the lump crumbles. Tougher the thread near the Plastic Limit and stiffer the lump when it finally crumbles, higher the plasticity and more potent is the colloidal clay fraction in the soil. Weakness of the thread at Plastic Limit and quick loss of cohesion of the lump below the Plastic Limit signify clay of low plasticity or such materials which occur below the "A"-line in the Plasticity Chart.

1.4 Tests for Presence of Deleterious Material

The presence of organic matter and/or harmful salts also need to be determined in areas infested with salts like sulphates and/or organic matter. The presence of organic matter can generally be detected by its smell and dark colour and in some cases by the presence of fibrous materials. The organic content can be determined by burning a weighed quantity of the soil and noting the loss on ignition. The presence of sulphates can be detected by adding a few crystals of barium chloride to the filtrate of soil suspension in water. If a white precipitate is formed, this gives an indication of the presence of sulphates. From the extent of milkiness of the solution, an approximate evaluation of sulphate content can be made, with experience.

1.5 Estimating Optimum Moisture Content

Take a handful of the wet soil on the palm of hand and attempt to make a ball out of it. The moisture content at which the ball of wet soil can retain its round shape is approximately the optimum moisture content. At moisture contents below the optimum, the ball tends to crumble while at moisture contents wet of optimum, the water will tend to ooze out of the surface.

2. BRICKS

The bricks should be sound, of compact structure (as seen when broken) free from cracks and flaws. They should be regular in shape and of uniform size (dimensional accuracy) with plane faces and sharp edges. The colour should be uniform and of deep red or copper colour. The quality of bricks is generally assessed by compressive strength, efflorescence, dimensional accuracy, water absorption and evenness of baking. Some of the simple tests to fairly assess the quality of bricks are given below:

(i) In efflorescence test, a sample brick is soaked in water for 24 hours and its appearance after removal from water, should be free from white patches, the total area not exceeding 50%. In case the surface area exhibiting, patches exceed 50% of total area both the brick and water samples shall be subjected to further testing for ascertaining suitability.

(ii) In water absorption test, a brick should not absorb more than one-fifth of its dry weight after immersion in water for 24 hours.

(iii) Bricks are considered good when clear ringing sound is heard when two bricks are struck against each other. A sample brick should not break when dropped flat on hard ground from a height of about 1 m.

Correct firing promotes toughness. The bricks should not be under-burnt. A well burnt brick when scratched with a finger nail should leave no impression.

3. STONE MASONRY

3.1 Stones

The principle requirements of a building stone are strength, density and durability. All stones other than those of sedimentary origin are suitable for stone masonry work. Some of the requirements and simple tests are indicated below:

(i) The stones should be hard, tough, compact grained and of uniform texture and colour.

(ii) They should be free from cracks, decay, weathering defects like cavities, flaws, veins, sand holes and patches of loose/soft material.

(iii) Break a stone with a hammer. The surface of a freshly broken stone should be bright, clean and sharp and should show uniformity of texture without loose grains and be free from any dull chalky or earthy appearance.

(iv) If a drop of dilute hydrochloric acid or sulphuric acid on a piece of stone causes effervescence, the stone contains weathering materials.

(v) A sample of stone when struck with a 1 kg hammer should emit a ringing sound and should not break with one blow. A pen-knife when scratched on surface should not make an impressions on hard stone.

3.2 Cement-Mortar

(i) The cement mortar if unused for more than 30 minutes after addition of water shall be rejected and removed from site.

(ii) The mix proportion of cement: sand can be checked as follows:

Take about 200 gm of green cement mortar and add 100 ml of water in a measuring jar and shake the contents well and allow the contents to settle. While the sand gets deposited at the bottom, cement shall settle above. From the volumes of each, the approximate proportion of cement and sand can be determined.

(iii) **Consistency:** Mortar consistency can be checked by the following:

(a) If a small quantity of mortar is dropped from a trowel, the trowel ought to be left perfectly clean.

(b) A little mortar worked gently in the hands should be easily moulded into a ball; on the surface of which water would appear.

(c) When the ball is dropped from a height of half a meter (500 mm) on a hard surface, it must retain its rounded shape.

4. CONCRETE FOR STRUCTURES

4.1 Water

Water should be clean and free from oils, acids, alkalies, vegetable and other organic impurities. Water shall be got tested before the start of works, thereafter each monsoon till completion of works. Some of the simple tests to fairly judge the suitability of water in cement-concrete works are given below:

(i) Presence of acids or alkalies in water can be tested by litmus paper. If blue litmus paper turns red, it indicates acidity; while the red litmus paper turning blue indicates alkalinity. Rapid change in colour of litmus paper indicates significant amounts of acids or alkalies.

(ii) Make two identical pats of 75 mm dia and 12 mm thick of neat cement paste, one with water under test and the other with water of known suitability. Place the pats on a clean nonabsorbent surface and leave for 48 hours, and setting and hardening time observed for both the pats. If the quality of water under test is not upto mark, both setting and hardening time of the pat would be different from the one of known quality.

4.2 Cement

Cement more than three (3) months old shall be got tested to ascertain its quality and satisfy the acceptability requirements as per Table 11.4. The quality of cement can be roughly judged by the following:

(i) Thrust a hand into a cement bag. It must give cool feeling. There should be no lump inside.

(ii) Take a pinch of cement and feel between the fingers. It should give a smooth and not a gritty feeling.

(iii) Take a handful of cement and throw it in a bucket full of water. The particles should float for sometime before they sink.

(iv) Take about 100 gm of cement and mix it with water to make a stiff paste. Make a cake with sharp edges. Put it on a glass plate and slowly take it under water in a bucket, without disturbing the shape of cake. After 24 hours, the cake should retain its original shape and gain some strength.

(v) **Setting time**: Make a stiff paste of neat cement and water, and form it into a pat of about 75 mm dia and 12 to 25 mm thick. The pat should commence to set in 30 to 60 minutes. The commencement of setting can be roughly estimated by pressing the uncut end of a lead pencil into mass. The resistance to piercing increases suddenly when setting commences. In 18 to 24 hours, the pat should have hardened sufficiently so that a scratch can be made with a thumb nail.

(vi) **Soundness**: Boil the set pat (as above) in water for about 5 hours. The pat should remain sound and hard and should not swell, crack or disintegrate, but may show only hair cracks. Reject cement if pat shows radial cracks or curl or crumble.

(vii) **Fineness**: In the sieve test, 100 gm cement is correctly weighed and placed on 90 micron sieve. Air set lumps, if any, are broken down with fingers. The sample is sieved for 15 minutes and the residue left on the sieve is weighed. The amount of residue should not exceed 10% for OPC.

4.3 Sand or Fine Aggregate

The sand should be sharp, clean, chemically inert, coarse and gritty to the touch and free from silt/clay and organic impurities. The general quality of sand can be assessed as below:

(i) **Presence of Silt or Clay**: Rub a sample of sand between damp hands and note the discolouration caused on the palm. If the sand is clear, the palm would be stained slightly. If the hands stay dirty after sand has been thrown away, it indicates too much of silt or clay.

(ii) **Sedimentation:** Place, without drying, a sample of sand in a 200 ml measuring cylinder upto 100 ml mark. Add clean water upto 150 ml mark. Shake the contents vigorously and allow it to settle for 3 hours. The height of the silt visible as a layer above the sand is expressed as a percentage of the sand below.

(iii) **Organic impurities:** Shake the sample with an equal volume of 3% solution of NaOH (Caustic soda) and allow it to settle for 24 hours. Examine the colour of the liquid above the sand. Clear or pale yellow color shows that the sample is tolerably free from organic impurities. Dark yellow or brown tinge shows that the sand should be washed and tested again. If on retesting, dark yellow color persists, the sand should be rejected.

4.4 Coarse Aggregate

Coarse aggregates shall be hard, strong, non-porous, free from friable, elongated and laminated particles. They shall be clean and free from clay, coal, vegetable and other organic material. Two simple tests to check the suitability of stone aggregates are given below:

(i) If the aggregates of a known quantity absorb more than 10 percent of their weight after 24hours immersion in water, they are considered porous and are avoidable.

(ii) If Mica inclusions persist on the surface, the stone aggregates shall be rejected as presence of Mica affects durability of concrete.

However, the detailed tests indicated in Table 11.13 are to be conducted before the use of coarse aggregates in concrete bridge works.

4.5 Cement Concrete

The principal requirements of concrete include workability, strength, durability, impermeability, and volume changes. Some of the simple tests to determine quality of concrete are described below:

(i) **Consistency**: The concrete can be considered to satisfy consistency requirement if an ordinary iron rammer sinks into concrete mixture by its own weight. It shall run-off a showel unless showelled very quickly; and shall spread out and settle to a level surface after wheeling for about 8 m distance in a wheel barrow.

(ii) **Workability**: Take a handful of concrete in left hand and make a round ball with both hands. If a ball can be maintained for a while, it is indicative of a 'workable mix'. Any low or high content of water cannot make a good ball of concrete.

(iii) **Alkali Silica Reaction (ASR)**:

Alkali Silica reactivity is noticed in aggregates crushed with siliceous rock. When aggregates are immersed in water, a slight increase in volume occurs. If alkali content in Portland cement is less than 0.6 percent by weight, no harmful reaction occurs.

Due to ASR, normally damp patches are visible at the junction of cracks, the edges of cracks often appear light in colour, the concrete often has an uncharacteristic pinkish appearance in the affected areas. There will be negligible spalling of concrete but exudation may occur from some of the cracks.

If aggregates are suspect of likely positive ASR on the basis of past performance or any evidence, it is always recommended that the aggregates are tested as per IS:2386 part 7 before they are approved for use in making concrete.

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Government of Nepal

Ministry of Federal Affairs and Local Development

Department of Local Infrastructure Development And Agriculture Roads
(DoLIDAR)

Technical Guidelines

on

Planning, Design and Construction of Rural Roads

April 2015

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A

Planning Rural Roads

1.0 INTRODUCTION

1.1 General

Reducing the pervasive poverty in the country is the overriding goal of contemporary development efforts in Nepal. One of the means to achieve this goal is by improving accessibility of the people through improved transport thereby promoting economic development, fairer and better distribution of development outcomes and better provision of social services. As a result of the country's efforts over the past half a century a large network of strategic roads connecting most part of the country is in the place along with more than two dozens of airfield, thousands of kilometers of improved trials, hundreds of pedestrian bridges and other access infrastructures. Strategic Road Network (SRN), comprises of highways and feeder roads. Therefore, development planning perspective of the SRN is that of providing transport access to the whole area or to a point of particular importance, and that of rural roads, which generally offset out from the SRN, is to address providing transport service to the rural communities at the household level.

In a country with characteristic feature of more than three fourth of the population dwelling in poorly accessed rural areas, development of rural roads is obviously very important. Over the last two decades, therefore, increasing emphasis is being accorded to development of rural roads in the country. The local authorities, the DDCs in particular, are becoming more and more responsible for planning, development and management of rural roads. NGOs, INGOs and donor agencies are increasingly collaborating with DDCs in this endeavor. From the government side DoLIDAR coordinates, facilitates, regulates and monitors the rural roads development activities in the country. DoLIDAR also provides technical assistance to DDCs. It is believed that some 50000 km of rural road tracks have been opened so far with perhaps less than 2,000 km developed up to all weather standards.

1.2 Stakeholders and Responsibilities

In the current context of rural roads development different agencies are likely to be the stakeholders with different kind of responsibilities that they have and roles that they have to play. The chart below indicates these agencies and their likely roles and responsibilities:

Agencies	General roles and responsibilities in rural road development	Planning Specific Responsibilities
Central government agencies such as: • NPC	• Policy formulation and preparing overall country-wide development plan: • Annual Investment Programs:	• Providing overall framework including policies and budgetary ceiling.

Agencies	General roles and responsibilities in rural road development	Planning Specific Responsibilities
• Ministry of Finance, • Ministry of Local Development	• Budget Plan and Allocating Budget for Annual Program; • Monitoring overall progress;	
Donar Agencies and INGOs	• Making financial resources available; • Help in making other supports (hardware as well as software) available;	• Help with technical (and sometimes financial) assitance;
DoLIDAR	• Coordinate and facilitate rural roads sub-sector activities; • Provide technical assistance for managing rural road development • Regulate and monitor the rural road development process; • Monitor/Evaluate the impacts;	• Providing techincal and financial assitance; • Helping in planning exercies; • Regulating and monitoring the planning exercise and its outcomes;
DDCs	• Planning road networks within the district; • Planning and prioritizing individual road links; • Allocating financial resources; • Implementing the road development and maintenance activities;	• Preparing District Transport Master Plan and/or updating the same; • Prioritizing the individuals links and making budgetary allocation; • Project preparation (survey, design) including implementation plan of action;
VDCs and Communities	• Planning and prioritizing individual road links within the VDC area; • Participation in implementing the road development and maintenance activities;	• Participate in DTMP preparation including prioritization of individual links; • Participate in resource allocation for the concerned section of road; • Prepare local plan of

Agencies	General roles and responsibilities in rural road development	Planning Specific Responsibilities
		action for civil works pertaining to construction/ maintenance of local roads;

1.3 Planning Roles

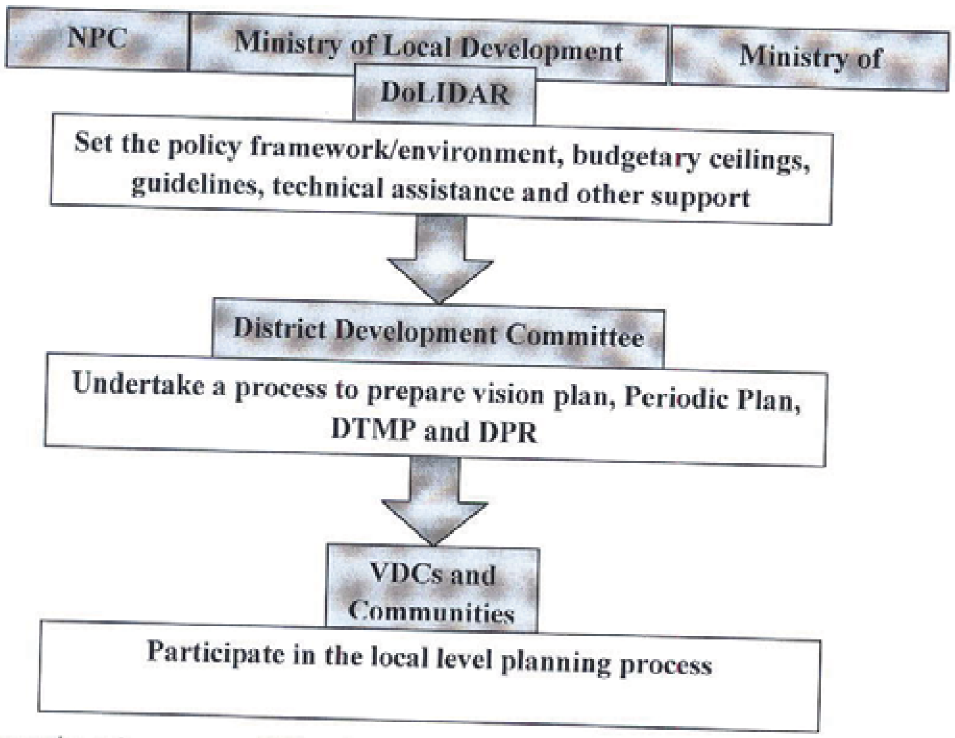
From the above chart it can be seen that in planning rural roads, the main role at the local level is that of DDCs which undertakes the actual planning exercise and that of DoLIDAR which provides technical support through know-how, manuals, guidelines and expertise to the DDCs. DoLIDAR also has a role of facilitating inter-district coordination as well as in processing investment decisions. As being placed within the DDC for providing technical and management support the DTO officials actually undertake the background work of collecting information, analysis and objective assessment for prioritization. The DDC makes the official decisions pertaining to individual road links.

2.0 RURAL TRANSPORT PLANNING AND RURAL ROADS

2.1 General Approach

Planning of rural road is a part of rural transport planning, which, in turn, has its own characteristics. Objective of rural transport planning is to identify and priorities infrastructure and service interventions that help improve physical accessibility of the rural settlements. Therefore, it is focused around providing improved transport at the household level. For this, first of all, it is necessary to know the travel and transport needs of the people. Then, developing infrastructures and services to meet this need becomes the objective of the rural transport project. Identification of rural transport needs is done in different ways such as collecting the demand from the local communities, officials of higher authorities determining the needs and through an objective and participatory assessment at the community level.

Annual Program of the district is formed on the basis of Periodic District Development Plan (which is a five-year program tied up with national Five-Year Development Plan and is based on a 20-years visions/strategic/perspective development plan of the district). Most of the road connected districts also have prepared District Transport Master Plan the indicate Projects/ Programs concerning rural transport, which are ultimately incorporated into Periodic Plan and Annual Program. Individual rural transport sub-projects including those for the rural roads will have to be prepared from within this planning framework.



The DDCs have the prime responsibility for preparing individual rural road projects, whether for new construction, upgrading or maintenance. Choosing one or the other road, for this purpose should be strictly based on DTMP and priorities of other plans of the district. The project should also be part of the Periodic Plan and Annual Program of the district.

Development Process of Rural Roads

In the context of rural road a specific line of development process can be seen. In the Terai and valley plains mostly there are pre-existing fair-weather tracks (FWT) which evolve into fair-weather motorable roads (FWR). In the hills and mountains there are no pre-existing FWT, therefore, FWR have to be developed from the pre-existing trails or travel corridors. Fair-weather roads (FWR) then are gradually improved to all-weather standards as all-weather road (AWR). Further, any AWR may be upgraded to blacktop standards depending upon the efficiency requirements and traffic volume.

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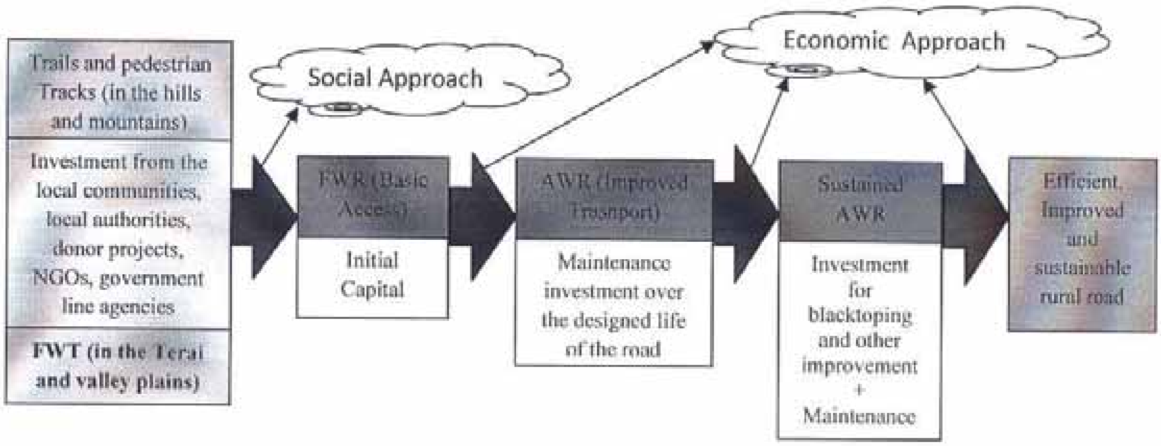
Development of Rural Roads in Nepal



2.2 Rural Roads Planning and Project Preparation

Development planning of rural roads, and project preparation for any individual roads, should be undertaken as process starting from identifying district's priorities within the rural road sub-sector. This can be done from updated DTMP, Vision Plan and Periodic Plan of the district. At the end the result of this process is a comprehensive sectoral investment plan and fully prepared sub-projects ready to go for implementation. The following points indicate this process step by step.

1. **Prepare/Update DTMP:** First of all if there is no updated DTMP the same needs to be prepared or updated.

2. **Prepare Road Sector Program:** a) Identify roads that are maintainable, roads need to be improved/upgraded and roads to be newly constructed (that is opening a fair-weather track). Generally opening of a new motorable track on an existing trail or track; in fact, it is start of building a new road. b) For the purpose of preparing road sector program of the DDC and making budgetary allocation accordingly priority should be given to maintainable roads. Therefore, the district must, first of all, have a **maintenance plan** for all its maintainable roads. Only then district may go for planning of improvement/upgrading of existing tracks to all-weather standard and opening of new motorable track.

3. **Prepare Sub-project Proposal:** Keeping the above in view, once individual roads have been selected to be incorporated in the Annual Roads Programs detailed information on these roads should be compiled for preparing sub-project proposals. For this a walkover survey of the road (and the corridor) needs to be undertaken so that technical, socio-

economic, environmental and social information pertaining to the road and the corridor is collected. At the same time an assessment of the required civil works should also be undertaken so that a tentative cost estimate for the sub-project is made. A format for this work is given in the **Appendix**. Outcome of this process will be at par with feasibility study.

4. **Review/Appraisal of the Proposal:** The sub-project proposal should be reviewed thoroughly by DDCs before approving and/or making decision as to budgetary allocation. If the budgetary allocation is to be made by some agency other than DDC then the agency may appraise the proposed project. Under review and/or appraisal process there may be various issues including information on technical, socio-economic, environmental and social aspects of the proposed road. Result of this process may be approval or acceptance of the project, refinement and approval and rejection.

5. **Detailed project Preparation:** Once the sub-project proposal is accepted and investment decision is made the project needs to be prepared in detail. For this number of activities will have to be undertaken such as – a) detail topographical survey; b) socio-economic assessment including impact baseline; c) social and environmental assessment; d) detail cost estimates and preparation of bid documents as deemed necessary; e) preparation of implementation plan including schedules of activities and procurement plan. As these activities are accomplished the project becomes ready for implementation.

2.3 Socio-economic and Technical Consideration in Rural Roads

There are number of socio-economic issues to be considered while planning and prioritizing rural roads. Many of these issues get already addressed while preparing/updating DTMP. Others will have to be consistently pursued through out the project preparation. The main socio-economic issues pertaining to development of rural roads can be summarized in the following points and criteria.

- A socio-economic justification in the conventional sense is not generally required for upgrading a trail or track to a FWT. Opening up of a FWT is justified by the DTMP and usually from the social grounds of ***providing basic access*** to the isolated settlements.

- Improvement of FWT to AWR generally requires to be justified on socio-economic grounds. For this actually served population/households per kilometer must not be less than the threshold criteria[1].

[1] An analysis shows that the threshold criteria for Terai and valley plains is 32 households served per kilometer and for hills and mountains is 47 households per kilometer.

- For AWRs proposed to be blacktopped (or bituminous seal coated) there must exist minimum of 50 vehicles per day as Annual Average Daily Traffic.

- Sustainability of rural roads may be assured only when local authorities take full responsibility of their development and maintenance.

- Local peoples' effective participation in planning and implementation of civil works is imperative for better managing development of rural roads as well as for acquiring higher extent of desired impacts.

- One of the desirable approaches for rural road development is that most of the financial investment for civil works should remain within the local economy.

- Choice of geometric parameters for the road elements should be appropriate for the road in question and in accordance with the approved standards. (*This is dealt in detail in the later part of this Manual*).

- While designing or choosing type-designs for different components of road it should be kept in mind that simple, low-cost and appropriate solutions that do serve the purpose are opted rather going for sophisticated and high-cost solutions. The designs should also be based on availability of local materials and skills as far as possible.

- Related to various issues above is choice of civil works approach. For managing different kind of civil work construction appropriate approaches as to by involving users groups or small labor contract or local contractor or combination thereof should be chosen.

2.4 Environmental and Social Consideration in Rural Roads

There are number of environmental and social concerns associated with development of rural road whether the case may be that of maintenance, improvement of a FWT to AWT or that of constructing a new FWT. These concerns are to be thoroughly studied during planning to identity safeguard measures. DDC's full commitment to comply with these safeguard measures is often a condition for financial support to implement the project and practically adoption of the same is a condition for financial support to implement the project and practically adoption of the same is a condition for continued support in the sector. Therefore, proper attention is required during all stages of project starting from the planning through to implementation so that there is ensured environmental and social safeguard measures provided. For the reference of details in this aspect recently developed **Environmental and Social Management Framework, RAIP/DoLIDAR** may be used. The following points summarize the issues in this context.

Environmental:

The basic intention of environmental consideration is to develop the best possible rural road in the given environmental settings. Environmental consideration basically addresses two aspects: *risks or threats,* which are the likely damages to the environmental quality, services and natural wealth; and *opportunity or potential* in the given natural setting for road works to harness the same. Environmental considerations should, therefore, focus on avoiding or minimizing damages and, at the same time, promoting sensible use of opportunities to improve the natural environment. The following points summarize the concerns and approaches to deal with them.

- *Help evolve an environmentally better shaped road:* The greatest value of environmental consideration lies in helping evolve and environmentally better shaped road. For this, environmental considerations should begin early in the sub-project-cycle and continue all-through planning, project preparation, survey and design, construction and operation. In the sub-project-cycle, there are a number of decision points where environmentally better choices can be made. Approach must be to help make better decisions and choices, rather than react to decisions/choices already made. For example, deciding environmentally better road route and designing road elements and layout to suit the local environmental setting.

- *Start with broad overview and concentrate on site-specific issues:* In the initial stage of sub-project concept, only broad overviews of environmental aspects is adequate to aware and promote internalization of environmental factors at early stage. As the sub-project take more definite shape and proceeds from route selection to design, environmental consideration concentrates increasingly on site specific issues in progressively more detail.

- *Environmental factors:* Main environmental factors that need to be considered are:
    - Forest and protected areas;
    - Landslides and erosion risks;
    - Flood and drainage problems;
    - Valued environmental features (wet-land, lakes, drinking water source, etc);
    - Significant development potential area;
    - Sites of historic, cultural, religious or archaeological significance; and
    - Population centres.

- *Use of environmentally sound and appropriate approaches, methods, standards and techniques:* Phased-widening of road width, placing road centre-line and designing road attempting to balance cut and fill, bio-engineering for slope stability (combined use of vegetation and simple civil engineering works), use of labor and hand-tools instead of heavy machines, not allowing blasting, use of local resources, and management of water are environmentally better than the conventional approach. There are thus desirable.

- *Improvement or upgrading can be utilized to rectify past mistakes;* The improvement of existing road is unlikely to case or introduce significant additional environmental damages or new adverse environmental consequences. Instead, opportunity may exist to rectify the past mistakes or to make positive environmental contribution by addressing the already created environmental problems or difficulties or damages by the existing road.

- *Monitoring is essential:* environmental monitoring during construction and operation is necessary to ensure that environmental best practices are followed and effective. Although excellent recommendations were made, environmental monitoring is seriously lacking in most of the rural infrastructure sub-projects.

Social:

The social consideration in road development is associated with promoting broader social development benefits including those not addressed by forces of market economy and to discourage any social harms and dis-benefits from the road. The rural road as an infrastructure may have different kind of social impacts on the local communities at different time horizons. At the beginning road building exercise may have to intervene in the prevailing social tranquility and processes such as by acquiring local land, property and by negatively affecting other livelihood resources. Once the road is built and improved transport service becomes available the people will reap off the direct and indirect benefits. This means livelihood patterns of individuals and, thus, social life of the community will change, which, in turn will render long-term social changes. While planning development of road transport, therefore, the immediate and long-term social ramifications should be adequately considered for the purpose of avoiding or lessening undesirable ones and promoting desirable ones. The following points summarize the main issues of social consideration in rural road development.

1. *Identification of relevant social issues* – While planning rural road development, first of all, the likely social issues should be identified. This requires and awareness of social development policies, strategies, plans and priorities of the country including those concerning poverty alleviation, employment, and social security on part of the planner. There are number of sources through which this can be learnt, such as government rules, regulations, guidelines, plan documents, Constitution and Acts, and policy statements. Once the issues are identified they should be dealt one by one in different points of time.

2. *Avoidance of acquisition of private and community property and/or damage of livelihood assets* – An approach not to acquire any private or community property including land and houses should be strictly taken as far as possible. Any damage to the local livelihood resources e.g. community forests, water resources, resting places (Chautaras) and cultural and religions sites that results into or promotes displacement of local people should also be avoided.

3. *Emphasized care on not harming the poor, landless and vulnerable Groups* – Regarding any likely harmful impacts of the road conscious efforts should be made not to harm the interest of the already disadvantaged groups in the community such as the poor, landless and vulnerable groups (women, disabled groups, children and old people .....). There may be issue of acquiring land, damaging a private property e.g. house, destroying sources of livelihood incomes and loss of employment opportunities. Such impacts on poor, landless and vulnerable groups should be avoided as far as possible.

4. *Compensation to the loss of private property* – There should be no involuntary acquisition of any private property in general. Especially in case of unavoidable acquisition of private property from poor, landless and vulnerable groups there must be some kind of direct or indirect compensation built into the project process.

5. *Compensation for the loss of livelihood assets and employment opportunities* – For the unavoidable loss of livelihood assets and employment opportunities there should be compensatory measures within the project. The compensatory measures such as rehabilitating or mitigating the resulting damages should b e part and parcel of the project.

6. *Resettlement Plan* – If displacement of one or more household is unavoidable then a well worked out resettlement plan is indispensable and the same should be built into the project such that the cost is part of the project.

7. *Promotion of social services* – Emphasis should always be placed in enhancing and promoting the social service to the community such as by promoting access to the education and health services. One of the ways of achieving this may be by encouraging road alignment such that accessibility to any intended social service centre is enhanced.

8. *Avoid social exclusion and promote social inclusion* – While planning and implementation of the project there are processes designed for community participation. In undertaking these participatory process there is often a risk of certain section of people such as women, dalits, indigenous people, youngsters, being excluded. Such possibility

should be minimized in designing the participatory process by promoting social inclusion as much possible.

2.5 District Transport Master Plan

District Transport Master Plan is a document prepared and owned by the concerned district. It contains inventory of existing rural transport infrastructures including all the rural roads with respect to settlements/population, comprehensive list of all the rural transport infrastructures to be developed within the district (Perspective Plan) and prioritized list of rural roads to be developed within next five years (Master Plan). For preparing this document, as prescribed by DoLIDAR[2], a set of particular steps as given below, are to be followed.

Steps for preparing/updating DTMP (from DoLIDAR Approach Manaul)
Step 1 : Prepare and finalize Indicative Development Potential Map of the District.
Step 2 : Prepare District Inventory Map of Rural Road Network
Step 3 : Collection of Demands for New Transport Linkages from VDCs
Step 4 : Prepare Draft Perspective Plan of District Rural Road Network
Step 5 : Synchronizing the Draft Perspective Plans of adjoining district
Step 6 : Acceptance of the Perspective Plan of District Rural Road Network
Step 7 : Preparation of Five Year Rural Road Master Plan of District
Step 8 : Updating year-wise list of prioritized road links and approval

Note: Please contact Planning Section, DoLIDAR for any revised and updated guidelines on this.

Once the DTMP is prepared for a district it needs to be periodically updated as the transport situation changes overtime. The District Technical Office (DTO) located within DDC and deputed from DoLIDAR to work for DDC has to undertake all the necessary activities for preparing or updating DTMP. If deemed necessary the DDC may arrange consultant's services for this.

2.6 DTMP Status Update

Due to some reason when it is not possible to undertake a full-fledged process of updating the DTMP then the DDC may have to quickly update the status of the road priorities on an *adhoc* basis. For this an improvised method may be adopted as the following:

[2] APPROACH for the Development of Agricultural and Rural Roads; 1999; HMGN, MoLD, DoLIDAR. This document is referred to as DoLIDAR Approach Manual in short.

- DTO prepares an inventory of all the rural roads with their current status as operation (maintainable AWR), requiring periodic maintenance and/or spot improvement, requiring upgrading or rehabilitation;
- From the updated inventory DTO prepares a proposed priority list;
- DDC organizes it's a meeting to discuss and officially approve the proposed priority;
- It is desirable to include elected/ex-elected members of the DDC, local political leaders, other community leaders and key local people in this meeting as participants/observes;

2.7 Updated Methodology for DTMP

The above stated methodology for preparing or updating DTMP is to be reviewed and further improved to incorporate elements like accessibility indicators and accessibility profiles of the settlements. This is being planed to undertake in near future by DoLIDAR. Once this is done the improved methodology for preparing or updating DTMP should be applied.

B

Alignment and Geometric Standards

1.0 Introduction

Roads are geometrically defined spaces on the earth surface primarily for rolling vehicles including the motorized ones. Different elements of this space such as width, turning radius, gradient and carriageway surface and its camber, therefore, have to have standardized shape and size. Defining of these shapes and sizes is what is determining basic geometric parameters. For protecting the basic geometric parameters a road has to be built as composite of various components such as pavement, drainage structures, retaining and protecting structures. These components also may need to have some kind of standardized shape and size. Therefore, geometric standards for a road are composed of basic geometric parameters together with some aspect of shape, size and type of components taken together. This depends upon the topography and soil condition on which the road is created and type of vehicles that are to ply on it. Geometric parameters for various elements of a particular type of road have to be pre-determined and they have to be adhered to uniformly throughout the length of the road.

Following is the list of elements and components of which standardization of parameters is deemed essential in case of rural roads.

Elements/Components	Depending Factors
1. Alignment Selection	Type of road, topography and other terrain features
2. Design Parameters:	
(a) Design Traffic Volume	Travel and transport needs
(b) Design Speed	Travel and transport needs
(c) Number of lane	Traffic Volume and Characteristics
(d) Passing Zones	Formation width, number of lane
(e) Minimum Stopping Distance	Number of lane, traffic volume, design speed
3. Carriageway Width	Vehicle type and size, traffic volume
4. Formation Width	Required shoulder size, passing zones, traffic volume
5. Right of Way	Protection of the road, future expansion, settlement
6. Longitudinal Gradient	Topography, vehicular traction
7. Cross-Sectional Gradient	Climate condition, surface type
8. Radius of Curvature (Horizontal & Vertical)	Vehicle type and size, topography, design speed

Alignment selection of a road from engineering point of view is simply trying to fit geometric parameters and design features on the ground along the line of the road. This, therefore, depends on various factors such as type of the road, geometric standards, cost of construction and the topography of the terrain.

2.0 ALIGNMENT SELECTION FOR RURAL ROADS

2.1 General

The location or the layout of the centre line of the road on the ground is called the alignment. The horizontal alignment includes the straight path, the horizontal deviations and curves. Changes in gradient and vertical curves are covered under vertical alignment of road. A new road should be aligned very carefully, as improper alignment would mean either capital loss initially in construction as well as recurring loss in cost of maintenance and vehicle operation. Once the road is aligned and constructed, it is not easy to change the alignment due to increase in cost of adjoining land and construction of costly structures by road side.

The alignment of rural road should be decided only after conducting proper surveys and investigations. In general, most new roads will also have to follow the existing foot tracks and other such existing alignments. However, during route location the following points should be considered:

(i) Adoption of appropriate geometric design standards and safety requirements
(ii) Keeping to the high ground so as to avoid low laying areas and minimizing the drainage requirements
(iii) Following the land contours as far as practicable to reduce the extent of cut and fill.
(iv) Conforming to any property boundaries to the extent possible.
(v) Avoiding or minimizing the effect on vegetation
(vi) As far as poss1ble, alignment should not interfere at any stage with services, like power transmission lines, water supply mains etc

Following special considerations are to be given due importance for the alignment in mountainous terrain:

(i) When crossing mountain ranges, the road should preferably cross the ridges at their lowest elevation. In certain cases it may be more expedient to negotiate high mountain ranges through tunnels. This decision should be taken after considering the relative economics or the strategic requirements.
(ii) While fixing the alignment the introduction of hair pin bends should be avoid as possible. In unavoidable cases, the bends should be located on stable and flat hill slopes in due consideration of geometric design. Also, a series of hair-pin bends on the same face of the hill should be avoided
(iii) As far as possible, attempt should be made to avoid unstable hill features, areas having perennial/potential landslide or settlement problems, areas subjected to seepage/flow from spring etc.

The ideal alignment between two points should satisfy requirements as given under:

(i) **Short**: It 1s desirable to have a shot (or shortest) alignment between two terminal stations. A straight alignment would be the shortest, though there may be several practical considerations, which would require deviations from the shortest path.
(ii) **Easy**: The alignment should be such that it is easy to construct and maintain the road with minimum subsequent problems. Also, the alignment should be easy for the operation of vehicles with easy gradients and curves
(iii) **Safe**: The alignment should be safe enough for construction and maintenance from the view point of stability of natural hill slopes, embankment and cut slopes and foundation of embankment. Also, it should be safe for the traffic operation in terms of safe geometric features.

(iv) **Economical**: The road alignment would be considered economical only if the total cost including initial cost, maintenance cost and operation cost is the lowest

(v) **Sound**: The alignment should be on the firm ground and should not be susceptible to large settlement, deformation and landslide, etc,

(vi) **Aesthetic**: While selecting the alignment, the aesthetics of the area should be borne in mind.

(vii) **Environment**: The alignment should be decided giving due weightage to environment protection, particularly in hilly areas. Tree cutting should be avoided as far as possible by suitably locating the road alignment.

Governing Factor for Route Selection

(i) The alignment should be as direct as possible so that there is maximum economy in cost of construction, maintenance and transportation.

(ii) The grades, curvatures and profile should be so designed as to be economical, consistent with the service requirement.

(iii) While improving the existing alignment, the endeavour should be to utilize the existing facility as much as possible in order to minimize the cost and effort of land acquisition and construction

(iv) The alignment should not interfere at any stage with services, like power transmission line, water supply mains, etc.

(v) Embankment and pavement account for major proportion of the road cost therefore, availability of material for embankment and pavement construction should be kept in view while finalizing the alignment. Similarly good sub-grade conditions would mean lower pavement cost and thus the sub-grade conditions also affect the choice of alignment. To the extent poss1ble, areas susceptible to subsidence (due to mining, etc.), marshy and low laying .areas prone to flooding, inundation and erosion should also be avoided.

(vi) While connecting population centre, the alignment should preferably skirt round the population pocket rather than pass through congested area.

Factors controlling Alignment

The various factors controlling the road alignment are listed as

a) Obligatory points
b) Traffic
c) Geometric Design
d) Economics
e) Drainage
f) Other Factors (Hydrological factors, Social obligation and Environmental factors)

Special Consideration for Hill Roads

In hill roads, additional care has to be taken for ecological considerations, such as:

(i) Stability against geological disturbances
(ii) Land degradation and soil erosion
(iii) Destruction and denudation of forest
(iv) Interruption and distrubance to drainage system
(v) Aesthetic consideration
(vi) Siltation of water reservoirs

2.2 Selection of General Route and Surveying

Route selection is a basic step in road building. It must be carried out with great care. A study is necessary before finalizing the alignment. In this study, the factors like population to be served, topography and condition of sub-grade, existing road network, environmental factors, sources of materials etc. should be considered in detail. It is recommended to study at least three alternative routes before deciding to the best among the three.

The survey for the route selection is normally carried out in four stages: Rreconnaissance Survey, Preliminary survey, Determination of final center line and Final location and detailed survey. The final center line is determined from the preliminary records. Four different stages of route location survey and described below.

a) **Reconnaissance Survey**: Reconnaissance survey is carried out to examine the general character of the area for deciding the most feasible route for detailed studies. A field survey party inspects a fairly broad stretch of land along the proposed alternative routes of map studies. Only very simple instruments like Compass, Abney level, tangent clinometer and barometer are used for this survey.

b) **Preliminary Survey**: After the reconnaissance survey, a preliminary survey is carried out in order to study and collect all physical information which are necessary in connection with the proposed road alignment. In this survey, use of survey instrument is necessary. Based on the information and data collected, the calculation and plotting work should be done in the design office.

c) **Determination of Final Centre Line**: Making use of the maps from preliminary survey showing the longitudinal profile, cross-sections and contours, a few alternative alignments for the final centre line of the road are drawn and studied and the best one satisfying the engineering, aesthetic and economic requirements is selected. Horizontal curves are designed and final centre l ine is marked on the map. The vertical curves are designed and the profile is then determined.

d) **Final Location and Detail Survey**: The alignment finalized after the preliminary surveys is to be translated on the ground by estabi1ishing the centre. The line to be estabilished in the field should follow as closely as practicable the line finished after the preliminary survey and conforming to the major and minor control points estabilishled and the geometric design standards. However, modifications in the final location may be made in the field if necessary.

2.2.1 Reconnaissance Survey

The process of reconnaissance survey is as follows:

i. Study of topographical, geological and meteorological maps
ii. Aerial reconnaissance (where necessary and feasible)
iii. Ground reconnaissance
iv. Final reconnaissance of inaccessible and difficult places

The ground reconnaissance is the most important one. It consists of an examination of the ground by carrying out walk over survey. In inaccessible and difficult places, aerial survey is carried out or aerial photo graphs are studied. One of the alternative processes could even be aerial reconnaissance depending upon the size of the project. It is recommended to fix several reference pegs along the route which makes easy for the follow up survey. During reconnaissance survey, a general route for the alignment is selected.

a) *Reconnaissance survey is conducted based on the following broad guidelines.*
Guidelines for Route Selection (General)
- Alignment should be as direct as possible between the obligatory points and control points
- Location results in minimum interference to agriculture and industry
- When the utility services like overhead transmission lines, water supply lines etc interfere with the route, a decision should be made on whether to change the road alignment or to shift the utility services.
- Avoid too many crossing and re-crossing of ridges, streams, canals, etc.

Guidelines for Route Selection (Obligatory and Control Points)

- Obligatory points which are under administrative, strategic or other consideration should be taken into account while making the final decision of the alignment.
- Control points like river crossing, mountain passes, saddles, etc. should be kept in mind while deciding the alignment
- Mountain ranges shall preferably be crossed at the lowest elevation

Guidelines for Route Selection (Grades and Curvature)

- Ruling gradient shall be attained for most of the length of the road.
- Adoption of a uniform design speed and convenient curvature throughout the length shall be considered.
- Avoid hairpin bends wherever possible. Such bend should not be in valleys.
- Hairpin bends, if unavoidable, shall be located on stable and flatter hill slopes.
- Series of hairpin bends on the same face of the hill shall be avoided
- Avoid unnecessary rise/fall at places where elevation needs to be attained from lower to higher point.
- Discourage deep cut and avoid destabilization of the hill slope.

Guidelines for Route Selection (River/Stream Crossings)

- Crossing of major rivers (more than 100 m long) shall be crossed at right angle to the flow.
- Crossing of medium, minor streams shall also be crossed at right angle.
- Try to locate the bridge where:
  - ⇨ the river is straight on upstream and downstream side.
  - ⇨ channel is well defined and narrow
  - ⇨ location is away from the confluence tributaries
  - ⇨ banks are high and rocky/firm and well defined
  - ⇨ above the HFL.

Guidelines for Route Selection (Areas to be avoided)

- Areas having perennial landslides
- Areas subject to:
  - ⇨ seepage/flow from streams
  - ⇨ subterranean channel
  - ⇨ hydel channels
- Locations involving destruction of forest land
- Areas subject to water logging or flooding
- Steep hill slopes
- Areas liable to snow drift or avalanches

Guidelines for Route Selection (Environment Concerns)

- National parks and wild life reserves
- Forests, marginal land, common property
- Precious ecology and high bio-diversity areas
- Drinking water sources, good agricultural areas
- Cultural and archeological sites
- Unique geological and geographical features, features of scientific value
- Natural beauty spots
- High erosion and land instability zones
- Resettlement and relocation of people
- Special ethnic communities

Guidelines for Route Selection (Miscellaneous)

- Location shall be such that the road fully integrates with the surrounding
- Study the environment impact of the road and try to bring down the adverse effects to the minimum
- Choose the location where obtaining of construction materials is easier (e.g. along the river valley).
- Prefer sunlight face rather than the sun shadow face.

b) *Instruments needed*

- Compass
- Abney level/altimeter
- Pedometer
- Aneroid
- Clinometer
- Ghat tracer
- Camera
- Ranging rods
- Tape

c) *Aspects on which data should be collected during ground reconnaissance survey are listed as follows:*

- Collection of data and maps about the topography of the area
- Lengths of the road along various alternatives
- Requirements of cross-drainage structures, number and length
- Geometric features
  - ⇨ Gradients
  - ⇨ Curves and hairpin bends
- Existing means of transportation:
  - ⇨ Mule trails
  - ⇨ Foot trails
  - ⇨ Jeep track
  - ⇨ Earthen cart track
- Terrain and soil conditions:
  - ⇨ Geology of the area
  - ⇨ Nature of the soil
  - ⇨ Drainage condition
  - ⇨ Nature of hill slopes
  - ⇨ Road length passing through
    - (i) Mountainous terrain
    - (ii) Steep terrain
    - (iii) Rocky structures
    - (iv) Areas subjected to snow
    - (v) Areas subjected to flooding
    - (vi) Areas subjected to poor soil and drainage conditions
- Available right-of-way and constraints such as:
  - ⇨ Built up area
  - ⇨ Monuments and structures
- Cliffs and gorges
- Elevation of the road with ascent and descent counts
- Vegetation
- Climate conditions:
  - ⇨ Temperature (maximum and minimum)

- ⇨ Rainfall (average, peak)
- ⇨ Snowfall (average, peak)
- ⇨ Wind direction and speed
- ⇨ Fog conditions
- ⇨ Exposure to sun
- ⇨ Water table and its variations

- Facilities/Resources:
  - ⇨ Landing ground in case of hilly road
  - ⇨ Dropping zones in case of hilly road
  - ⇨ Foodstuff
  - ⇨ Labour, locally available or not
  - ⇨ Construction materials
  - ⇨ Availability of water
  - ⇨ Availability of local contractors
- Value of land:
  - ⇨ Agriculture land
  - ⇨ Irrigated land
  - ⇨ Built up land
  - ⇨ Forest land
- Approximate construction cost of various alternatives
- Period required for construction
- Important villages, towns and marketing centers connected
- Economic factors:
  - ⇨ Population served by the alignment
  - ⇨ Agricultural and economic potential of the area
  - ⇨ Marketing centers
- Other major development projects in the area.
- Crossings with other roads
- Location of existing and proposed utilities along the alignment
- Necessity of bypasses for towns and villages
- Position of monuments, burial grounds, temples, hospitals, schools, etc
- Ecological and environmental information:
  - ⇨ Forest areas, national parks
  - ⇨ Landslide/soil erosion zones
  - ⇨ Water sources
  - ⇨ Natural beauty spot
  - ⇨ Unique geological/geographical features, features of scientific value
  - ⇨ Archaeological and cultural sites
  - ⇨ Special ethnic communities
  - ⇨ Resettlement and rehabilitation needed
- Coordination with other administrative authorities needed
- Reconnaissance report:
  - ⇨ Information collected during the survey

⇨ A plan to the scale of 1:25,000 showing the alternative alignment with a general profile

⇨ Rough cost estimate

2.2.2 Preliminary Survey

It's large scale engineering survey for the physical information of the proposed road.

The main objectives of preliminary survey are:

i) To survey various alternative alignments after reconnaissance and to collect all the necessary physical information and details of topography, drainage and soil.

ii) To compare the different proposals in view of the requirements of a good alignment.

iii) To estimate quantity of earthwork materials and other construction aspects and to works out the cost of alternate proposals.

iv) To finalize the best alignment from all alternatives.

The follows steps are carried out for preliminary survey:

a) *Collection of information*

- Accurate traverse line shall be run along the route selected during reconnaissance survey
- In case of improvement of existing road, survey line shall be run along the existing alignment
- Topographic features and features like houses, temples, monuments, utility lines, etc shall be tied to the traverse line.
- Longitudinal sections and cross sections shall be taken
- Benchmarks shall be established
- High degree of accuracy is required to form the basis for the final centre line of the road.
- Information shall be collected from records or by inspection and measurements on the following:
  - ⇨ Traffic
  - ⇨ Soil
  - ⇨ Construction materials
  - ⇨ Drainage

b) *General Facts*

- In difficult situation, a secondary traverse connecting the primary one at either end may be run
- In hilly areas, a trace cut of 1 m wide may be required
- Selected alternative shall be pegged
- Easier grades at preliminary stage with a margin of 10 to 20 percent are provided.
- Make the grade line on ground look more noticeable from a distance by leaving indicative marks.

c) *Procedures*

- Strip of sufficient width (15 to 30m) to accommodate cut/fill and for possible shift in the centre line at the final design shall be surveyed.
- Traverse survey shall be done by theodolite with angles using double reversed method. If the theodolite is not available, prismatic compass may be used.
- No hard and fast rules shall be applied for the distance measurements between two consecutive transit stations: The accuracy may vary according to the directional changes and terrain conditions.
- Transit stations shall be pegged and numbered following a sequential order, the pegs shall be protected till the final location survey
- Features like buildings, monuments, burning ghats and graveyards, temples, power and telephone lines, pipelines, existing roads and trails shall be located by offset measurements from the traverse line.
- Leveling line along the centre line trace cut (Longitudinal section) shall be taken at 10-25 m interval and at closer intervals in places having abrupt slope changes
- Benchmarks shall be fixed at every 250m intervals or at 500m intervals in special cases. Benchmarks shall also be fixed at bridge sites.
- Check all levels with the levels of established Benchmarks for accuracy
- Single datum preferably geodetic survey datum shall be used to tie up all levels
- Cross sections shall be taken at every 20m interval general and at closer intervals in places having slope changes or different soil type
- Grid survey at 1 or 2 m intervals may be necessary at places of sharp curves of difficult places and at all bridge sties. It helps to determine the contours of such areas.

d) *Map preparation*

- Plans and longitudinal sections shall be prepared to determine the final centre line of the road. The plan should show contours at 1 or 2 m intervals at places like sharp bends, hairpin bends, bridges sites, etc.
- Scales for the drawings are normally 1:2500 (or 1:2000) for horizontal and 1:250 (or 1:200) for vertical in terai and 1:1000 (horizontal) and 1:100 (vertical) in hills
- Scale should be larger in cases where detail study is required.

e) *Instruments needed*

- Compass
- Abney level/altimeter
- Camera
- Theodolite/Total Station
- Leveling staff
- Ranging rods
- Tape
- Level instrument
- Drawing table and instruments

2.2.3 Determination of Final Center Line

Determination of final centre line is done in the design office. The involved operations are as follows:

(a) Studying the outcome of preliminary survey

- Plan
- Longitudinal profile
- Cross sections
- Contours
- Alternative alignments (refer to table B-1)

Table B-1: Model Chart for Ranking of Alternative Alignments
(Final Selection of Best Alternative)

Attributes		Initial Cost	Maintenance Cost	Duration of Construction	Design Life	Hazards and Risks	Socio-economic Benefits	Environmental impact	Strategic or other considerations	Total rating	Rank
Relative importance		10%	10%	10%	10%	20%	15%	15%	10%	100%	
Alignment I	Relative Rating	82	100	100	100	50	70	89	60	79.5	3
	Weighted Rating	8.2	10.0	10.0	10.0	10.0	11.9	13.4	6.0		
Alignment II	Relative Rating	70	90	100	100	44	56	73	100	74.2	2
	Weighted Rating	7.0	9.0	10.0	10.0	8.8	8.4	11.0	10.0		
Alignment III	Relative Rating	100	88	100	100	100	100	100	80	96.8	1
	Weighted Rating	10.0	8.8	10	10.	20.0	15.0	15.0	8.0		

(b) *Select the best alternative which satisfied the following:*

- Technical viability
- Aesthetic requirements
- Most economical
- Least disturbance to the environment
- More earth work which generates more employment to rural poor
- Efficient drainage system
- Requirements of protective works like retaining/breast walls
- Balance the cut and fill or less spoil

2.2.4 Final location survey

The final centre line of the alignment determined in the design office should be cross-checked in the field. The final location survey should the operations mentioned below.

- Traverse survey with theodolite to fix the final centre line of the road.
- Detail leveling with level instrument
- Hydrological and drainage survey
- Soil investigation survey (if necessary only)
- Initial Environmental Examination or Environmental impact Assessment (refer to "Proposed Social and Environmental M&E System" manual).

(a) *Traverse Survey*

- Recheck the Benchmarks established during the preliminary survey (if found wrong re-established them at 250/500 m intervals and near to bridge sites).

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- Fixing of final road alignment (intersection points) as per the determined angles and lengths.
- Setting out of curves
- Pegging of centre line at 20/25 m (Hill/Terai or Plain area) intervals
- Fixing of reference points with large wooden spikes planted in ground at 100m spacing. Reduced levels should be fixed with reference to that of Benchmarks.
- Reference points are marked with information as below:
  - ⇨ Chainage
  - ⇨ Horizontal distance from the centre line of the road
  - ⇨ Reduced level at the top of the reference pillar
  - ⇨ Formation level of the road
- The above information on reference pillars should be recorded and reproduced later on the final alignment plan
- Distance of the reference pillars should be measured along the slope line. Slope angle should be measured with theodolite and the actual horizontal projection should be calculated.
- Distance measurements along the final centre line should be continuous following the horizontal curves as well.
- Fixing of toe line (cut/fill line) at every curve and cross-section
- At road/trail crossings, transit angles of intersection should be fixed.
- Profile along the intersection roads and important trails should be measured up to 150m
- Centre line profile should normally be continued upto 200m beyond the end points of the project's limit.
- Proper protection of reference points should be ensured.

(b) *Detailed leveling with level instrument (Longitudinal section and cross section)*

- Levels along the final centre should be taken:
  - ⇨ at all staked stations
  - ⇨ at all breaks on the ground

- Cross sections should be taken at:
  - ⇨ 20/25 m (Hill/Terai or Plain area) intervals
  - ⇨ at the beginning and the end of transition curves
  - ⇨ at the beginning, mid and end of circular curves

- Cross sections should be referred with the final centre line and be extended normally up to the right of way limits.
- Levels of cross sections should be taken at 1-5 m intervals and at every break in the profile
- The final location survey is considered as complete when,
  - ⇨ all information is available and ready for the designers to plot and complete the final profile including other project drawings,
  - ⇨ field notes are well taken as per the needs of designers

(c) *Hydrological and Drainage Survey*

- Take data information on all gullies, depressions, streams and rivers where cross drainage structures are required. Data and information are:
  - ⇨ Longitudinal details at closer intervals
  - ⇨ Cross sectional details at closer interval
  - ⇨ Discharge, HFL, etc

- Contour (or grid) survey for large structures.
- Sketch of catchment area
- Assessment of length of bridge/culvert/causeway
- Take notes on;
  - ⇨ Sequential number, type and size of the proposed cross drainage structure
  - ⇨ Chainage of the cross-drainage

3.0 PREPARATION AND PRESENTATION OF PROJECT DOCUMENTS

All project data and information collected during the above survey should be complied as a project document. The project document should comprise of:

- ⇨ report
- ⇨ cost-estimate, and
- ⇨ construction drawings

3.1 Report

It contains the following:

(a) background information
(b) road's salient features
(c) road design and specification
(d) drainage facilities including cross-drainage structures
(e) materials, labour and equipment
(f) Social and Environmental Safe guard
(g) rates
(h) construction schedule
(i) miscellaneous

(a) Background Information

- Name of the work and its scope of activities
- Authority and plan provision
- History, geography, climate, etc
- Necessity, or other words, project justification

(b) Road's Salient Features

- Route selection
- Alignment
- Environmental considerations
- Right of way, roadway, carriageway and other cross-sectional elements
- Salient features of road structures
- Present/anticipated traffic

(c) Road design and Specification

- Road design
- Pavement design
- Protection works (other than cross-drainage works)
- Specifications

(d) Drainage facilities including cross-drainage structures

- Discuss investigations carried out
- Give details of the surface/sub-surface drains and drainage measures, attach design calculations/drawings.
- Highlights and propose special measures to check soil erosion and environment
- Discuss the proposals on small cross-drainage structures i.e. culverts/causeways.
- In case of improvement to existing roads, list out the cross-drainage structures proposed to be improved
- State whether any standard designs were followed

(e) Materials, labour and equipment

- Type, quality and specifications of materials required and their availability
- Type, number and skills of labour requried and its availability
- Type, number and specifications of tools/equipment/plants required

(f) Social and environmental Safe guard

i) Social safe guard

- Social screening status of road
- Social management plan
    - VDIEMP
    - VCDP
    - GAP
- Cost for social safe guard

ii) Environmental Safe Guard

- Environmental Screening of the road
- IEE and EMP or only EMP
    - Environmental issued to be addressed
    - Appropriate mitigation measures
    - Different environment management plan
- Cost foe environmental safe guard

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(g) Rates

- Give reference to the schedule of rates of the year adopted
- Highlight the items for which suitable rates are not available in the schedule and for such items give reference to the analysis of rates attached to the estimate

(h) Construction schedule

- Mention the proposed system of work execution to be adopted
- Mention the proposed project period
- Discuss the prevailing and anticipated constraints to project implementation
- Draw up a construction schedule in the form of bar chart along with the responsible parties. This should be done after scheduling the activities according to the Critical Path Analysis.

(i) Miscellaneous

- Indicate the camping, store and office requirements
- Mention identified diversions and borrow pits
- Mention arrangements for water supply and other site amenities
- Identify traffic control devices, if necessary
- Indicate proposed roadside plantations and ways amenities

3.2 Cost-estimate

The project's cost-estimate should provide all financial requirements and it should be realistic too. In the project's cost-estimate, it is ensured that all

- the work items are carefully listed
- the quantities are determined to a reasonable degree of accuracy, and
- the rates provided are workable

The cost-estimate should consist of

- A general abstract of cost, and
- The detailed cost-estimate for each major activity as described below

General abstract of cost provides the total cost of the scheme along with a general break-down given under the following major headings:

- Land acquisition
- Site clearance
- Earthwork
- Sub-bases
- Bases
- Surfacing
- Cross drainage and other structures
- Social and environmental safe guards
- Miscellaneous items

- Provision for tools, equipment and plants
- Provision for contingencies
- Work charges of the establishment
- Quality control, etc

The detailed cost-estimate for each major activity consist of,

- Abstract of cost
- Estimate of quantity
- Analysis of rates for work items not covered by relevant schedule of rates and
- Chart of quarry/material sources

Where the project work is proposed to be executed in stages, the cost-estimate should be prepared for each stage separately. The cost-estimates for respective stages should be presented in a logical sequence

3.3 Construction Drawings

The construction drawings should clearly show and interpret the proposed works in relation to the existing features with other necessary information for accurate translation of the proposed in the field. *All the drawings* should follow a uniform standard with regard to:

- Size
- Scale, and
- Details

(a) *Drawing Size*

Drawings should be of adequate size to accommodate a reasonable length of the road or an independent structure such as a culvert in full details but, at the same time, should not be inconveniently large which may require many folds.

The appropriate size of a drawing sheet is 594 mm x 420 mm corresponding to A2 size which can easily be stitched in a folio. The standard size of the folded compact is 297 mm x 210 mm.

In each sheet of this size, it is possible to accommodate the plan and longitudinal section of one kilometer length of the road with reasonable overlaps at the sides if they are drawn to the horizontal scale of 1:2500

To facilitate the stitching of drawings into a folio, a margin of 40 mm should be kept on the left hand side of the drawing sheets.

(b) *Component of a set of Project Drawings*

In general, the following are the components of set of engineering drawings prepared for a rural road project.

i. Location map-cum-site plan

ii. Land acquisition plans
iii. Plan and longitudinal section
iv. Typical cross-section sheet
v. Detailed cross-sections
vi. Drawings for cross-drainage structures, retaining walls, breast walls and other road side structures.

(i) Location map-cum-site plan

- Key map also called as location map
- Index map also called as site plan

Key map and index map are usually drawn in a single sheet and this sheet forms the first sheet in the folio of project drawings.

Where the length of the road is substantially long, location map and site plan are separated in such manner that locality map is accommodated in one sheet and the site plan on a series of sheets.

The location map or "Key Map" should be draw to a scale of 1:250,000 and should have a bird's eye view of the proposed work with respect to the

- Road network serving the area
- Important town/village centres, and
- Other prominent places

The site plan or "Index Map" should be drawn to a scale of 1:25,000 and should show the project road with chainage and its immediate neighborhood covering the important physical such as hills, rivers, tracks, main trails, air strips, etc.

The sheet which contains the location-cum-site plan should have a legend to explain the abbreviations and symbols used in subsequent drawing sheets. Alternately, the legend could be shown on a separate sheet at the beginning of a folio.

(ii) Land acquisition plans should be prepared on land maps or revenue maps which could be purchased from the District Survey Office. The scale of these plans ranges from 1:2,000 to 1:8,000.

(iii) Plan and longitudinal section of one 500 m length of road could easily be shown in a single drawing sheet with plan at the top and L-section at the bottom.

Common scales normally adopted are

⇨ Horizontal – 1:2500 (or 1:2000) for terai and 1:1000 for hills
⇨ Vertical – 1:250 (or 1:200) for terai and 1:100 for hills

The manner in which the details of the plan and L-section could be presented as illustrated in Typical Design Drawings DLR/Road/T2.

(iv) The elements in a rural road are generally same for most of the length. They are:

- Width of carriageway
- Width of roadway, i.e. formation width
- Width of shoulder
- Width of right of way
- Side slopes
- Pavement cross fall

It is desirable to show the above mentioned elements of a rural road as a typical section instead of repeating the same details on every cross-section. A sample of a typical section is illustrated in Typical Design Drawings.

(v) The cross-sections of the road should be presented serially according to the chainage starting from Ch. 0+000 to up going chainage. Each sheet should accommodate a number of cross-sections which should be easily readable.

(vi) In rural roads, structures generally consist of

- Surface (side)-drainage structures
- Cross- drainages (Hume pipe/ Slab culvert/ Causeways/ Scuppers)
- Sub-surface drainages
- Retaining walls
- Breast walls, and
- Other road side structures

When the designs/drawings prepared for individual projects are of typical or standard nature, making a reference to such drawings is enough rather than enclosing drawings in the project document every time.

The drawings should show clearly the details of foundation, proposed materials, etc. and should be prepared on a scale which is large enough to accommodate all details comprehensively.

Bill of Quantities, Schedule of Labour and Materials and Work Plan

3.3.1 Bill of Quantities

Bill of quantities of a project should cover all the required work items listed in the cost estimate. All the details of labour and materials should be given as a break-down under respective work item. In general, quantities of the work items and their units should be given in the approved format.

3.3.2 Schedule of Labour and Materials

Schedule of labour and materials are essential, in advance, for construction planning and management purposes.

3.3.3 Work Plan

Detailed work plan should be drawn up for any project before the actual work starts. In the case of contractor, it is provided by the contractor before the agreement for work is signed. In case of user's group, it is prepared jointly by the office and users' group prior to the signing of work agreement.

4.0 RURAL ROADS GEOMETRIC PARAMETERS

In case of Nepal roads in different type of terrain the geometric parameters depend on the vehicles to ply on these roads, their characteristics such as the size, speed, safety and required comfort and the prevailing geological condition. The relevant vehicle types in rural countryside are motorized light vehicles (e.g. car, motorcycle, jeep, pick-up, tractor, mini bus and truck), non-motorized vehicles (e.g. Rickshaw, bicycle, animal drawn carts, and hand cart) and pedestrian. Topographical feature of the terrain where rural roads are (or are to be) located is either fairly plain (in Terai and valley plains) or rolling hills (as in large parts of mid hills) or mountainous (mostly in the northern mountains) or comprising combination of these. For the purpose of designing rural roads these features of Nepalese terrain can be put two categories: a) Terai and Valley Plain, where the surface is fairly plain and b) Hills and Mountains, where there are frequent undulations and road requires ascending/descending.

In choosing geometric standards for rural roads in Nepal it is often seen that there is varying practice from project to project and from road to road. Even within one road uniformity is not maintained. For the purpose of promoting and facilitating safe, efficient and better travel and transport on the roads standardized geometric parameters and designs features should be used as far as possible. Considering this aspect the DoLIDAR has specified the following design parameters of rural transport linkage.

Table B-1: Design Parameters of Rural transport Linkage

S.N	Design Parameters	District Road (Core Network)		Village Road (VR)		Comments
		Hill	Terai	Hill	Terai	
1	Design capacity- in both directions(Vpd /P.C.U per day)	200 (400)	400 (800)	100 (200)	200 (400)	
2	Design speed (km per hour)	Ruling-25 Min -20	Ruling-50 Min -40	15	30	
3	Road way width (m)	7.00 5.25 4.50	7.50 6.75 6.00	4.00	4.50	• Given road way width are excluding drain; parapet and top width of retaining wall • If an available existing road way width is more than defined and carriageway has paved surface , distance between side drain and pavement edge can be maintained partially as hard shoulder and earthen shoulder
4	Carriageway width (m)	5.50 3.75 3.00	5.50 3.75 3.00	3.00	3.00	The carriageway width of District Road (core network) is 3.75 m but it can be reduced to 3 m where traffic intensity is less than 100 motorised vehicles per day and where the traffic is not likely to increase due to situation like dead end, low habitation and difficult terrain. • Desirable road surface for District Road (Core Network) is gravel or paved, whereas, for Village road is unpaved or gravel. • If a village Road carries traffic volume more than 100 motorised vehicles per day, the carriageway width will be 3.75 m and other parameters upgrade accordingly. • District road (core network) with volume of traffic > 400 ADT,single lane width may not be adequate for operation, therefore,should go for higher lane width of 5.5 m
5	Shoulder width, either side (m)	0.75 0.75 0.75	1.00 1.50 1.50	0.50	0.75	
6	Total right of Way (RoW) (m)	20.00	20.00	15.00	15.00	• In case of DRCN 10 m RoW on either side from road centre line • In case of VR 7.5 m RoW on either side from road centre line • If in any case existing RoW is more than defined value, existing available value shall be adopted as a right of way

S.N	Design Parameters	District Road (Core Network)		Village Road (VR)		Comments
		Hill	Terai	Hill	Terai	
7	Setback distance from Road land boundary / RoW to Building line on either side (m)	6.00	6.00	3.00	3.00	
8	Minimum safe stopping sight (m)	20.00	45.00	15.00	30.00	Since, opposing vehicle occupies the same lane in single lane road; it should be designed for intermediate site distance. However, it might be difficult to design the horizontal alignment with intermediate sight distance for hill terrain.
9	Lateral Clearance between roadside object and the edge of the shoulder (m)	Normally -1. Min – 0.5	Normally -1.5 Min – 1	Normally -1 Min – 0.5	Normally -1.5 Min – 1	5 m vertical clearance should be ensured at all underpasses, and similarly at overhanging cliffs. The vertical clearance should be measured in reference to the highest point of carriageway However, in case of overhead wires, poles etc. shall be at least 7.0 m above the road surface
10	Minimum radius in horizontal curve (m)	Ruling min - 20 Min -12.5	Ruling min -90 Min-60	10	30	At sharp horizontal curve, it is necessary to widen the carriageway to provide safe passage of vehicles – refer 10.4 of text part of standard
11	Hairpin Bends					
	Minimum spacing between Hairpin Bends (m)	100		100		100 m spacing is desirable but it may be less as per site condition
	Minimum radius of curve (m)	12.5		10		
	Minimum Road way width at apex (m)	5.5 for 4.5 roadway width 6.25 for 5.25 roadway width		5 for 4 roadway width		
	Maximum gradient (%)	4		4		
	Minimum gradient (%)	0.5 (max 1)		0.5 (max 1)		Desirable minimum gradient for this purpose is 0.5%, if the side drains are lined and 1% if unlined
	Maximum super elevation (%)	10.		10		
	Minimum transition curve length (m)	15		15		
12	Ruling gradient (%)	7	5	7	5	If non-motorised vehicles are in significant number in traffic stream then due consideration need to be given to the pulling power of animal drawn vehicles and ruling gradient need to be limited up to 3%

S.N	Design Parameters		District Road (Core Network)		Village Road (VR)		Comments
			Hill	Terai	Hill	Terai	
13	Limiting gradient (%)		10	6	10	6	
14	Exceptional gradient (%)		12	7	12	7	
15	Limitation of maximum gradient length (m) above average gradient of 7%		300		300		
16	Maximum recovery gradient (%) to be applied after gradient in excess of 7% for a minimum recovery length of 150 m		4		4		
17	Maximum gradient at bridge approach (%)		6	5	6	5	In terai, If non-motorised vehicle like bullock cart, Tricycle are in traffic stream then maximum gradient limit to 3%
18	Minimum gradient on hill roads (for better drainage) (%)		0.5 (max1)		0.5 (max1)		Desirable minimum gradient for this purpose is 0.5%, if the side drains are lined and 1% if unlined
19	Co-ordination of horizontal and vertical alignment		•Sharp horizontal curve should be avoided at or near the apex of the summit vertical curve or the lowest point of the valley curve. • Horizontal and vertical alignment should coincide with each other as far as possible and their length should be more or less equal. If this is difficult for any reason, the horizontal curve should be somewhat longer than the vertical curve. • The degree of curvature should be in proper balance with the gradients. Excessive curvature in a road with flat grades, do not constitute balanced design and should be avoided				
20	Cross slope in carriageway camber (%)	Earthen(existing)	5	5	5	5	• Shoulder having the same surface as the carriageway should have the same cross slope • Unpaved shoulder on paved carriageway should be at least 0.5% steeper than the cross fall of carriageway. However, 1% more slope than the carriageway is desirab
		Gravel	4	4	4	4	
		Bituminous Seal Coat	3	3	-	-	
21	Passing Zone, Dimensions (width x length) (m x m)		The width of carriage way should be 5.5 m and length is about 12 m along outside edge and 30 m along inside i.e towards the carriageway side and each end it should be tapered gradually towards the carriageway.				
	Lay-bys, Dimension (width x Length) (m x m)		Minimum bus lay-bys width shall be additional 3 (I,e total min carriageway width is 6 m) and the length is about 12 m along outside edge and 30 m along inside i.e towards the carriageway side and at each end it should be tapered gradually towards the carriageway				
22	passing zone strips at interval of (m) (maximum)		300	500	300	500	• Lay-bys are provided as an where needed. • The location of passing place depends on the sight distance – should provide at or near blind and sharp summit curve; the likelihood of vehicles meeting between passing places; and the potential difficulty of reversing

S.N	Design Parameters	District Road (Core Network)		Village Road (VR)		Comments
		Hill	Terai	Hill	Terai	
23	Carriageway width at culvert/bridge (m) (Single lane)	4.25	4.25	4.25	4.25	• Measured from inside to inside of parapet walls or kerbs • Additional width for footpath can be considered as per site requirement, volume of pedestrian flow.
	Carriageway width at culvert/bridge (m) (Intermediate lane)	6	6	-	-	
24	Level of embankment above HFL (m)	1 (0.5 min)	1 (0.5 min)	0.5	0.5	1 m is desirable but minimum is 0.5 m
25	Traffic sign and road safety	• Different regulatory and warning signs for narrow road width; sharp and blind curve; stop sign at the junction should be provided in rural roads, which are in maintainable state. For detail dimension follow traffic manual published by DoR, August 1997. • All-weather road should have kilometre post. The shape and size of kilometre post can be used as given in DoR standard design, published in January 1978. • Delineator post or other low cost delineating device such as earth filled bitumen drum etc. or low cost safety barrier such as gabion barrier should be provided along the sharp curve and blind curve, which has big (> 3 m) drop on valley side. • In case of intersection with other road, since the higher category of road will normally have wider right of way provision, the intersection is to be flared along the higher category of road and rural road should generally meet the other road at right angle junction, whereas, it should have clear line of sight, minimum 45 m along the rural road and 100 m along the higher category road and should discourage settlement development within this area of intersection.				

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5.0 GREEN ROAD APPROACH

Several rural roads in Nepal are constructed using Green Road Approach in a following manner.

Green Road Approach:

This is an experience based approach of constructing new low-cost earth roads and it comprises of various successful environment-friendly techniques. If favors a participatory method of civil works construction based on locally available materials and skills. Therefore, this approach is also referred to as low-cost, environment-friendly and self-help approach (LES Approach) to road construction. This approach is found particularly useful for opening a fair weather track in a hill/mountainous terrain of Nepal. The following are the main technical elements of "Green Roads Approach".

- *Phased construction of the formation width:* The full width of the road formation is not to be built right away, instead a smaller track, say earthwork for half the formation width, is done in the first phase. Then, the remaining half is done in the second phase. Finally, the retaining and other structures are put into place at the third phase.

- *Cut and fill balance:* The general engineering principle of maintaining cut volume and fill volume in the same spot is followed rather firmly.

- *No side drains:* No side drain structure is provided for getting rid of surface run-off. Instead an outward slope (camber) of 5% is in sections where longitudinal gradient is less than 5%.

- *Extensive use of bio-engineering:* Various bio-engineering techniques for protection of road as well as that of the local environment are to be used extensively. For example, avoiding removal of trees, plantation of upward and downward slopes and combining vegetation with retaining structures will make the road harmonized with the local environment.

- *Use of hand-tools rather than heavy machinery:* Simple, low-cost and local-material based designs of different road components is preferred over sophisticated, costlier and import of materials. For this priority for making use of hand-tools rather than heavy machinery (e.g. Bull Dozer and explosives) is given

- *Local participation and promotion of local skills:* Local participation in selecting the alignment on the ground as well as in undertaking civil works construction is must. For this a conscious approach to promote local skills is maintained throughout.

It is strongly recommended that this approach is generally applied, in a flexible manner, while opening a FWT. That is the various elements therein are to be particularly used as per the demand of the site conditions, but not as a standard everywhere and all the time.

SPEED BREAKER

A speed breaker is a hump surface across the roadway having a rounded shape with width greater than the wheel base of most of the vehicles using the road. When there is decreased variation in sensory stimuli and at locations where speed controls are desired, a speed breaker acts as a strong stimuli to arouse reaction in the brain. Since the driver reaction times are faster in response to audible and tactile stimuli than to visual stimuli, a driver subconsciously reduces his speed. An ideally designed hump should satisfy the following requirements:

(i) There should be no damage to vehicles nor excessive discomfort to the drivers and passengers when passing at the preferred crossing speed.
(ii) The hump should not give rise to excessive noise or cause harmful vibrations to the adjoining buildings or affect the other residents of the area.
(iii) Above the design speed, a driver should suffer increasing level of discomfort (but without losing directional control and without any vehicle damage) depending on the extent through which des1gn speed is exceeded.

Use of speed breakers is justified primarily under the following three circumstances:

(I) T-intersections of minor roads with rural trunk highways, characterized by relatively low traffic volumes on the minor road but very high average operating speed and poor sight distances. Such locations have a high record of fatal accidents and as such a speed breaker on the minor road is recommended;
(2) Intersections of minor roads with major roads, and mid-block section in urban areas where it is desirable to bring down the speeds; and
(3) Selected local streets in residential areas, school, college or university campuses, hospitals, etc. Also an area where traffic is observed to travel faster than the regulated or safe speed in the area.

Other places where these may be used include:

(1) Any situation where there is a consistent record of accidents primarily attributed to the speed of vehicles e.g. when hazardous sections follow a long tangent approach;
(2) Approaches to temporary diversions;
(3) Approaches to weak or narrow bridges and culverts requiring. Speed restriction for safety;
(4) On the minor arms of uncontrolled junctions and at railway level crossings;
(5) Sharp curves with poor sight distances; and
(6) Places of ribbon development, where road passes through built-up areas and vehicles travelling at high speeds are a source of imminent danger to pedestrians.

DESIGN OF SPEED BREAKERS

Speed breakers are formed basically by providing a rounded (of 17 metre radius) hump of 3.7 metre width and 0.10 metre height for the preferred advisory crossing speed of 25 km/h for general traffic. Trucks and buses having larger wheel bases may feel greater inconvenience on passage at such humps. To facilitate appreciable and comfortable passage for larger and heavier vehicles (where their proportion is quite high) humps may be modified with 1.5 meter long ramps (1 : 20) at each edge. This design will also enable these vehicles to pass the hump at about 25 km/h, in certain locations speed breakers may have to be repeated over a section to keep speeds low throughout. More humps may be constructed at regular intervals depending on desired speed and acceleration/deceleration characteristics of vehicles. The distance between one hump to another can vary from 100 to 120 meters centre to centre shown in DRL/Road/T-30.

PLACEMENT OF SPEED BREAKERS

The pattern of placement of speed breakers depends upon the location and the type of treatment used. Some of the suggested locations have already been indicated in above paragraphs. At 'T' intersections speed breakers should be installed on minor roads or perpendicular arms about 10 meters away from the inner edges of major roads. Proper sign boards and markings are required to be provided at such locations. On sharp curves, available sight distances guide the placement and number of speed breakers. For other situations the Engineer-incharge should use his ingenuity and judgment.

To check the tendencies of drivers to avoid speed breakers and using shoulders, it is recommended that the speed breakers should be extended through the entire width of shoulder supported on a proper base.

For undivided carriageways speed breakers should invariably be extended over the entire carriageway width including shoulders.

On bridges speed breakers should not be provided. However, where frequent accidents have been reported or the bridges are on curves or they are narrow, either approach must have two speed breakers each.

Upgrading of Geometric Parameters of Existing Rural Roads

There is a misconception that Rural Roads being the lowest category of roads need no elaborate design and engineering. It was on this presumption that several thousand kilometers of such roads were constructed in the past. As a result, rural roads had poor geometrics, inadequate compaction of embankment an inadequate drainage. Consequently, these did not last long. Rural Roads do require proper design, and the same attention is needed as for any other class of highway. Given the fact that rural roads serve an 'access' function rather than a 'mobility' function the scope for engineering intervention to ensure a cost-effective solution is all the greater.

Most of rural roads in Nepal are constructed without considering the sound road geometrics. These roads are constructed using the machine following the counter with high gradient and randomly fixed horizontal curves. As these roads are constructed without planning and engineering survey with design, it is ought most difficult to upgrade horizontal and vertical alignment according to the design standard established for rural roads by DoLIDAR.

The following steps are suggested to improve the geometrics of road for these non-engineering roads.

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Typical Design Drawings

1.0 INTRODUCTION

It was the situation while designing various structures incurred for the development of rural roads in the districts that the DDCs and Projects adopted different design standards for the same type of structures. These standards were found varying to a great extent. Some of them were under design and some were over design. In order to bring about uniformity in standards in all the districts and projects and to avoid unnecessary lengthy design computation it was thought to scrutinize all the standard designs which are in practice in Nepal and put them in a book form. The result of this exercise is presented here and it is tilted as Typical Design Drawings of Rural Roads. Most of the design standards presented here are based on design standards of DoR, IRC, TRL, etc. or are adopted from design drawings of the built structures which are performing satisfactorily in Nepal. Since this is a first effort, the designs prescribed in this manual might need modifications at some instances. It would be highly appreciated if the users suggest modifications wherever required. Since these are the standard designs, they should be used by considering the local conditions properly. It is to be noted that many standard designs presented here are applicable to all types of roads and might be costly for the low cost rural roads. Hence, these designs, which are expensive should be adopted only when low cost designs are not suitable for the given site conditions.

2.0 CONTENTS

The Typical Design Drawings presented in these guidelines are given in the following table.

Drawing No.	Title
	General Notes and Legends
	Abbreviations
DLR/ROAD/T-1	Typical Road Sections
DLR/ROAD/T-2	Plan and Profile of Road (Sample)
DLR/ROAD/T-3	Pipe Culvert at Terai
DLR/ROAD/T-4	Pipe Culvert at Hill
DLR/ROAD/T-5	Pipe Culvert for Irrigation Purpose
DLR/ROAD/T-6	Dry Stone Causeway at Hill
DLR/ROAD/T-7	Concrete Causeway at Hill
DLR/ROAD/T-8	Dry stone Causeway at Terai
DLR/ROAD/T-9	Concrete Causeway at Terai
DLR/ROAD/T-10	Vented Causeway
DLR/ROAD/T-11	Concrete Slab Details of Causeway
DLR/ROAD/T-12	Abutment and Wing Wall Details of Slab Culvert
DLR/ROAD/T-13	Deck Slab Details of Slab Culvert
DLR/ROAD/T-14	Typical Side Drains
DLR/ROAD/T-15	Sub Surface Drains
DLR/ROAD/T-16	Dry Random Rubble Masonry Wall
DLR/ROAD/T-17	Mortared Random Rubble Masonry wall
DLR/ROAD/T-18	Gabion Wall
DLR/ROAD/T-19	Composite Wall
DLR/ROAD/T-20	Proper Construction Method of Dry RRM Wall

DLR/ROAD/T-21	Revetment Structures
DLR/ROAD/T-22	Bioengineering Slope Protection Measures (I)
DLR/ROAD/T-23	Bioengineering Slope Protection measures (II)
DLR/ROAD/T-24	Typical Scour Checks
DLR/ROAD/T-25	Typical Surfacing Methods
DLR/ROAD/T-26	Standard Details of Hairpin Bend
DLR/ROAD/T-27	Delineator and Kilometer Posts
DLR/ROAD/T-28	Speed Breaker

3.0 Explanatory Notes on Typical Design Drawings

3.1 Typical Road Sections, Plan and Profile of Road

3.1.1 Typical Road Sections (DLR/ROAD/T-1)

These drawings show the standard formation widths and carriageway widths of District Core Road Network and Village Roads in terai and hill. The widths shown in the drawings are adopted from the Nepal Rural Road Standard (NRRS). The NRRS specifies roadway width of 6 m to 7.5 m in terai and 4.5 m to 7 m in hill for District Road core network and 3 to 4.5 m in terai and 3 to 4 m in hill for village roads excluding for drainage and parapet depending upon the volume of traffic and due to dead end, low habitation and difficult terrain. It is to be noted that side drains are not required at major road sections in terai. Similarly, width of side drain also varies in hill according to their types. Hence, if the NRRS is strictly followed, there is always the probability of variation of road width within short stretches. The roadway widths specified in the drawing will avoid such confusions. These widths also conform to the "Design Standards for Low Cost Feeder Road" prepared by DoR and therefore, the project (rural) roads can be upgraded to feeder roads standards without changing the geometry of the road.

3.1.2 Plan and Longitudinal Profile of Road (DLR/Road/T-2)

This is a sample drawing for plan and longitudinal profile of the road. The intention of this drawing is to guide the engineers/overseers on type of details they need to incorporate in the drawings such as:

- Ground level, existing road level and proposed road level. For existing hill roads, ground level may not be shown in the drawing.
- Horizontal and vertical curve details
- Location of existing and proposed structures
- Details of bench mark and traverse points
- Location and type of side drains
- Location of houses, electric poles, trees, irrigation canals, land slide areas etc
- Horizontal and Vertical scales. For hill roads the recommended scales are 1:100 (vertical) and 1:1000 (horizontal) and for terai roads the scales may be 1:200 or 250 (vertical) and 1:2000 or 2500 (horizontal)

3.2 Pipe Culverts

For small drainage crossings pipe culverts are often found in practice to be the most economical and easily constructed. Reinforced concrete pipes with a minimum diameter of 600 mm are appropriate for cross drainage. For irrigation purpose the minimum diameter might be less. These culverts can be easily enlarged subsequently to take more discharge by the addition of one or more pipes. It is more economical to provide less number to vents of large diameter pipe culverts then more vents of small diameter for a particular discharge.

Pipe culverts should be laid on firm bedding. In general, granular bedding will be adequate for a cushion height up to 4 m. for cushion height of more than 4 m and at those locations where the soil strata is poor, concrete bedding should be provided.

It is very important that the pipe culverts for cross drainage should be located at the natural water course as far as possible.

Considering the topography and function, three types of pipe culverts are presented in the drawings.

3.2.1 Pipe Culvert at Terai (DLR/ROAD/T-3)

This is the typical drawing of pipe culvert in terai (plain area). This drawing will be useful for the engineers to fix:

- Class and minimum diameter of pipe
- Cushion height above the pipe
- Length, height and foundation depth of head walls
- Type of materials for head walls
- Type of bedding materials for pipes

3.2.2 Pipe Culvert at Hill (DLR/ROAD/T-4)

This drawing will be useful to design pipe culvert in hill. Following details are included in this drawing.

- Class and minimum diameter of pipe
- Dimension of catch pit for different dia pipes
- Cushion height above the pipe
- Length, height and foundation depth of head walls
- Type of materials for head walls
- Type of bedding materials for pipes

3.2.3 Pipe Culvert for Irrigation Purpose (DLR/ROAD/T-5)

The function of irrigation crossing and drainage crossing is quite different. The discharge at the irrigation canals, especially at the project roads, is usually small as they are meant to irrigate small areas. Similarly, the discharge is almost constant throughout the year. Hence, simple and low cost structure will be adequate in majority cases. This drawing is prepared considering the above aspects.

3.3 Causeways

Causeways are used where construction of culverts or bridges cannot be justified. These causeways are intended to be covered by deep water for short period only and to remain trafficable for extended periods. The main advantage of a causeway is that it is cheap and offers little resistance to water flow and flood borne materials.

Four types of causeways are presented in the drawings. The engineers/overseers should be very careful while selecting them for any particular location.

3.3.1 Dry Stone Causeway at Hill (DLR/ROAD/T-6)

This type of causeway will be very suitable for the project roads due to its low cost and simplicity in construction. It is suitable at those locations where the discharge and velocity of he rivulets is low. Compaction by heavy roller before and after the execution of stone pitching is most essential to avoid further settlements. It is to be noted that this causeway needs repair/ maintenance during/after every rainy season. Several such causeways were built by Syangja and Palpa Districts during RIP and are functioning satisfactorily.

3.3.2 Concrete Causeway at Hill (DLR/ROAD/T-7)

This causeway shall be provided at those locations where the discharge and velocity of the rivulet is high. This is an expensive structure and requires proper supervision and quality control. Construction of this structure type should be carried out only when dry pitching causeway or pipe culvert cannot solve the site problem.

3.3.3 Dry Stone Causeway at Terai(DLR/ROAD/T-8)

This type of causeway will be suitable for the project roads due to its low cost. Similarly, its construction is also simple. This structure is suitable at those locations where the velocity of the stream is low. Care should be taken while fixing the height of head walls above the ground. The height of head wall should be fixed in such a way that the interruption to traffic is within the permissible limit (due to low height) and it should also be ensured that the upstream area did not become flooded for a long period (due to excessive height). To avoid flooding for a long period at upstream due to obstruction of waterway (by the causeway), pipes could be provided at the ends of causeway. Compaction by heavy roller before and after laying sand, stone pitching and gravelling is most essential to avoid further settlements. It is to be noted that this causeway needs repair/maintenance during/after every rainy season.

3.3.4 Concrete Causeway at Terai (DLR/ROAD/T-9)

This type of causeway will be more suitable at Siwalik, where the velocity of stream is high and the dry stone pitching causeway cannot function for a long period. This is an expensive structure and requires proper quality control during construction. The top level of this causeway should not be (very) higher than the surrounding area; preferably flushed with the ground level.

3.4 Vented Causeway (DLR/ROAD/T-10)

Vented causeway have the double function of passing normal discharge through the vents below the roadway and the flood discharge both through the vents and over the road-way itself. Some of the aspects which the Engineers should consider during implementation are:

- The vents should be sufficient to pass the normal water flow without overtopping. This should be checked for the annual flood to ensure that the interruption to traffic is within the permissible limit.
- The vents should be distributed throughout the causeway. All entry faces should be bell mouthed to reduce hydraulic losses and thereby the afflux. The vents shall be of circular pipes of and their diameter shall be fixed depending upon the discharge.
- The final road level (grade line on the causeway) should be kept as low as possible as well as satisfying the interruption criteria. It should be clearly understood that the flood level will increase (because of afflux) on the upstream side after the construction of the structure depending upon the extent of obstruction. Therefore, it is very important to ensure that the surrounding area did not become inundated during flood.
- The roadway shall have one way cross fall towards the downstream side. This will have the advantage of reduced afflux and avoid the chance of standing wave (consequent turbulence and serious erosion) being formed.
- Suitable cut-off walls should be provided at downstream side.

3.5 Concrete Slab Details of Causeways (DLR/ROAD/T-11)

This drawing shows the details of concrete slab for causeways and vented causeway. These details include:

- Dimension of individual panel
- Grade of Concrete
- Temperature reinforcement details and clear cover to them
- Dowel bars details
- Type of bedding materials below the concrete slab etc

3.6 Slab Culvert

According to Nepal Road Standard crossing structure of less than 6m span length is defined as a slab culvert. This type of structure is more suitable where the channel is deep and well defined. The span of slab culver should be fixed after thorough investigation of the site as well as inquiring local people. Generally, the topography and discharge are the main factors for fixing the span length of slab culver in hill whereas in terai the discharge is the main governing factor. This structure is more expensive than pipe culverts and hence should be constructed only when pipe culverts will not be sufficient to accommodate the discharge. Scouring around the abutments is one of the main factors for its damage. Hence, the foundation depth of abutment should be fixed by considering scour depth. To protect the structure from scouring, check walls may be required especially in the hills.

3.6.1 Abutment and Wing Wall Details of Slab Culvert (DLR/ROAD/T-12)

Dimension of abutment and wing walls are shown in this drawing. These dimensions are based on slab culvert drawing prepared by IRC with modifications. The layout of the abutment and wing walls including their foundation depth shall be fixed as per site condition or as directed by the Engineer. The materials for the abutment and wing walls shall be either random rubble masonry or brick masonry in 1:3 cement sand mortar.

3.6.2 Deck Slab Details of Slab Culvert (DLR/ROAD/T-13)

This drawing contains dimension and reinforcement details of 2m, 4m and 6m deck slab and abutment cap. The deck slabs are designed for single lane IRC Class A loading and are applicable to square crossings. Due to its high cost, slab culvert of less than 4 m span should be avoided as far as possible. For crossing requiring slab culvert of less than 4m, the Engineers should give preference to multiple cell pipe culverts with larger diameter pipes to save the cost.

Following details are included in this drawing.

- Span length, effective span length, overall length and overall depth of slab.
- Dimension details of abutment cap
- Grade of concrete and reinforcement
- Schedule of reinforcement for deck slab and abutment cap

3.7 Typical Side Drains (DLR/ROAD/T-14)

The main function of side drains along the road is to facilitate the flow of water as well as to prevent moisture from infiltrating the road sub-structure. In majority cases earthen, dry stone pitching and cement mortared drains are in use in Nepal and hence their typical design drawings are presented here. It is to be noted that the cost of lined drain is much higher than the earthen drain. Although, codes specify to adopt lined drain for longitudinal slope of road with more than 3-5%, it is recommended to line the drain of the project roads not according to longitudinal slope but only in extreme cases, where the lined drain is unavoidable. Brief description of the different types of side drains included in this drawing is presented below. The dimensions of the drains are given for guidance. The engineers/overseas may modify them according to the site conditions.

1. **Earthen Drain**

<u>**Type A**</u>

This is a trapezoidal drain with an overall depth of 400mm. its base width is 300mm. This type of drain shall be adopted for normal discharge.

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Type B

This is a saucer type drain and shall be adopted when the discharge is low. This drain type is easy to clean and is suitable for roads having ridge alignment.

Type C

This rectangular drain is designed for normal discharge in rocky area.

Type D

This V-shaped drain is suitable for low discharge in rocky area.

It is to be noted that the drain may not be provided where the valley side of the road is also rocky and the chances of slope erosion due to surface water is minimal. At such instances it is preferable to provide cross slope towards valley side.

2. **Dry RRM Drain**

Type E

This is similar to Type B drain except that stone soling is provided to prevent the surface erosion due to water and shall be adopted where the longitudinal slope is high.

Type F

This kerb and channel type drain shall be adopted where the discharge will be low. Cross drains will be required at frequent interval if this drain type is adopted.

It is to be noted that stones dry RRM become easily displaced due to vehicles. Hence, care should be taken so that the displaced stones are regularly put into its original position during the routine maintenance of the road.

3. RRM in CSM Drain

Type G

This is semi trapezoidal drain. Its overall width is 1000mm and its depth is 400mm. The major disadvantage of this drain type is that it becomes easily damaged by vehicles where the road is narrow.

Type H

This is same as G type drain except that it is covered by RCC slab. This drain type is suitable at/near the settlement and landslide areas.

Type I

This drain type is more suitable at those locations where the road width is comparatively large as well as near the cross drainage where the discharge becomes high due to accumulation of water from larger area. It may also be constructed at the base of fill.

Type J

This is the same as type F except that it is constructed in cement sand mortar. The thickness of the lining shall be varied from 200mm to 300mm according to the site condition. This type of drain will be more appropriate at those locations where the discharge is low and chances of damage due to moving vehicles are high. The engineers/overseers are advised to adopt this type of lined drain more often as the chances of its damage due to vehicles is relatively lower than type G.

Type K

This is a channel type drain and will be suitable at wide road sections. It is also suitable at the settlement areas where the road width is sufficient for its construction. The main advantage of this drain type is that it is easy to clean and chances of damage by vehicle are less.
The ratio of cement to sand for all types of RRM in CSM drains shall be adopted of 1:4 or as directed by the Engineer.

Type L

This section is used as the tick drain and suitable at settlement area as well other areas where the road section is narrow and the slant slope can be used by vehicle. The slant slope is constructed of M15/20 concrete of thickness 100 mm and the inner wall is of stone masonry in M 5 mortar.

3.8 Sub-surface Drains (DLR/ROAD/T-15)

This type of sub-surface drain will be very useful to stabilize the slope in wet areas. It is also useful where there is a chance of surface movement at hill slope due to saturation of top soil. Separate type of sub-surface drains will be required at those locations where the surface and ground water movement is intensive. Similarly this drain type is not suitable at big landslide areas.

3.9 Retaining Walls

Retaining walls are a common feature of road construction in mountainous regions and can account for 20% of total construction costs. For low cost roads, wall constructed to masonry or gabion are far the most common, since the bulk of materials can usually be obtained locally, leaving only cement or gabion wire to be brought from other sources. They are constructed for the following situations:

- To support a road either wholly or partly on fill when the ground profile is too sleep (usually greater than 30 degrees) to allow an embankment slope.
- To support the toe of a slope that has failed or is likely to fail
- To support cut slope that would require a low, uneconomic angle of cut
- When there are constraints on the permissible plan extent of earthworks, or on hairpin stacks, and in densely populated areas.
- As revetments to prevent erosion on steeply sloping cut faces as part of a slope stabilisation schemes

Problems of access in steep terrain can make it impracticable to carry out sufficient foundation investigation during the pre-implementation stages of a project. This may prevent the compilation of definitive designs or even delay decisions on appropriate wall types. Therefore it is often better not to design walls in great detail in advance of construction, but instead to provide standard designs and to make adequate provision in construction contracts for detailing designs at that stage.

Four types of retaining walls are presented in the drawings. These drawings are adopted from "Mountainous Road Engineering with specific reference to Nepal Himalaya; Road Note No. 16 prepared by Transport Research Laboratory (TRL), UK with the modification of base slope. The base slope of the all types of wall in TRL design is horizontal whereas in the proposed design drawings it is in 5:1 towards the mountain side. The main reason for modifying the slope is to increase the stability of walls.

3.9.1 Dry Random Rubble Masonry Wall (DLR/ROAD/T-16)

A wall height not exceeding 2m height on the hill side and 3 to 5 m on the valley side could, if the geotechnical conditions are favorable, be executed in dry masonry. If applied in the proper situation this is the most economic earth retaining structure. Dry masonry walls are around half cost of gabion walls. These walls should be used whenever stones are available and the foundation conditions are uniform and geo-technically favorable.

Apart from the height factor, the application of dry masonry walls is limited to the requirement of a foundation having uniform geological conditions or a mountain side slope whose geological composition is not provoking a very high earth pressure (higher shearing coefficient of earth materials). For walls along the valley side with water-drainage outlets, it is likely that due to geology, water flow and consequent risk of erosion, the conditions of foundation can weaken leading to instability. Dry masonry wall are not recommended at such places.

3.9.2 Mortared Random Rubble Masonry Wall (DLR/ROAD/T-17)

Mortared masonry walls are the most durable of the low cost wall options. They are especially suited to steep rocky ground where foundations are shallow and where the contractor's working area is restricted.

The base width of these walls is usually between 0.5 to 0.75 times the wall heights. If the height of wall varies along its length, (that is, if the base steps down and up to accommodate changes in founding level), the location of vertical joints should reflect the position of foundation steps, and frequency should be adjusted to minimise differential wall movement.

Masonry walls are not tolerant to differential settlement. Their lack of structural flexibility and general impermeability, even with freely-draining back fill and weep holes, make these walls inappropriate on wet colluvial slopes and where ground movements are expected, although cracking in a mortared masonry wall can be tolerated provided it is not accompanied by major deformation. There are many instances where severe cracking and sometimes completer failure have resulted from wall construction across adjoining soil and rock foundation materials. Weep holes should always be covered by filter fabric to prevent piping.

The skills required to construct mortared masonry walls are widely available in Nepal. They are easier to build than dry masonry because any lack of fit between the stones is taken up by the mortar. Rounded masonry stones should represent a maximum of a third of the total stone content. The minimum dimension of tabular stone should be at least 50% of maximum. It is important to ensure that the wall interior is not filled with dry stone rubble as a cost-cutting exercise.

3.9.2A Mortared Brick Masonry Wall (DLR/ROAD/T-17)

Brick masonry work is mostly used in the terai region where sound and good quality of stone is not available as well as the stone is not available in the vicinity of the road corridor. The structural function of the brick masonry wall is almost similar to that of stone masonry wall.

On account of their regular size and shape, the bricks can be arranged in a variety of patterns giving rise to different types of bonds. Bonding is essential to eliminate vertical joints in the body as well as in the face of the wall. The wall having defective arrangement of bricks reduces the strength and stability of the structures. A wall having continuous vertical joint does not act as a homogenous mass to distribute the superimposed loads. On the other hand, it may be assumed to be consisting of small columns and when the particular column of this wall comes under the load it fails, on account of its inability to distribute the load to the wall on either side of it. Hence it is preferred to construct the brick masonry wall in English bond.

3.9.3 Gabion Wall (DLR/ROAD/T-18)

Gabion walls are usually preferred under conditions of poor foundation, wet soils, high ground water and slope movement due to creep, land sliding and seismicity. However, the density of gabion work is approximately 70% of mortared masonry and hence a gabion wall has to be larger in volume for the same retained height. This increase in size could be a factor in the choice of wall type in situations where cross sectional space in limited. Gabion walls have the following characters:

- They can accommodate the settlement without rupture
- They allow free drainage though the wall

- They can be constricted in short sections (2-3 m at a time) which minimises the temporary loss of slope support during excavation
- The shape of gabion structure can easily be varied to accommodate changes in ground conditions across the site.
- A gabion structure is less easy than a masonry structure to fit into an irregular foundation because of the standard size and rectangular shape of the boxes.

Construction of Gabions

Gabion structures offer remarkable qualities in terms of strength, flexibility and free drainage. However, they must be built to a high standard if these attributes are to be attained. The following guidelines are recommended.

- Ensure drainage is provided from the lowest point of foundations
- Use high grade wire with a thick galvansising
- Mesh should be either a proprietary welded mess of a triple-twisted hexagonal mesh of 100 mm width and 120 mm length
- Panel frames should be made using 8 swg mesh wire, and mesh should be made using 10 swg wire
- Wire all gabion boxes together using additional wire of 10 swg
- During construction, add four or five cross-trusses (of 10 swg wire) per square meter in each horizontal direction
- Ensure that the minimum dimension of all stones is larger than the wire mesh size
- Stones should be tabular, of even size and angularity
- Wire the lids down with additional wire of 10 swg
- Filter fabric should be provided at the back face to prevent piping.

The top of a gabion wall can be finished with a course of masonry if a seal is required between the road surface and the wall, in order to form an effective road drainage channel. The masonry will also help to prevent the damage to wires by people, animals, water, etc.

The preferred maximum height of gabion retaining wall is 10m, although walls of up to 14m have been constructed on occasions with minor deformations. Under high lateral and vertical loads there is a potential for stone crushing, in the toe of the structure. If the stones in the toe of the wall crush under the load of those above, the effect on the wall is to settle at the toe, causing the top to tilt outwards and increase the load.

3.9.4 Composite Wall (DLR/ROAD/T-19)

Composite walls are similar to mortared walls except that they have panels of dry masonry about 0.6-1 m square forming a grid on the face with 0.5 m division strip. These walls are stronger than dry masonry walls and, at the same time, maintain the advantage of relatively free drainage. They are used frequently in many mountainous regions are slope support and revetment structures in cuttings though weak rocks, but are difficult to specify and construct as road retaining walls in complex and undulating side-long ground. These walls are more expensive than dry masonry walls and cheaper than mortared walls.

3.9.5 Proper Construction Method of Dry RRM Wall (DLR/ROAD/T-20)

The intention of this drawing is to guide the users on proper construction method of dry RRM wall. In this drawing details are shown.

a) Requirement of stone type
b) Examples showing wrong and right way of stone laying
c) Direction of base slope
d) Benching of ground behind the walls
e) Type of backfilling materials, etc.

3.9.6 Revetment Structures (DLR/ROAD/T-21)

The revetments are very useful to protect the side slopes from surface erosion. It should be borne in mind that these are not retaining structures and cannot protect roads from landslides. There are three types of revetment in the drawings; (a) Dry Random Rubble Type (b) RRM in 1:4 CSM and (c) Composite Type. Besides the above, typical drawing of Composite Masonry Rock Face Protection Wall is also provided for protection of side slope composed of weathered/fractured rocks.

3.10 Bio-Engineering Slope Protection Measures

Where a slope is subject to erosion or very shallow slope failure, bio-engineering methods of slope protection are appropriate. Bio-engineering is the use of living plants either alone or in conjunction with engineering structures and non living plant material to reduce erosion shallow seated instability on slopes. In bio-engineering applications there is an element of slope stabilization as well as slope protection. There is a wide range in bio-engineering techniques which cannot be discussed here in detail. Some examples of bio-engineering techniques for slope protection are presented below.

3.10.1 Bio-engineering slope protection Measures (I) (DLR/ROAD/T-22)

These drawings are adopted from "Mountainous Road Engineering with specific reference to Nepal Himalaya: Road Note No. 16 prepared by Transport Research Laboratory (TRL), UK".

3.10.2 Bio-engineering Slope Protection Measures (II) (DLR/ROAD/T-23)

These drawings of bio-engineering slope protection and retaining walls are adopted from "Design and Appraisal of Rural Transport Infrastructure". The users are advised to modify/change the type of retaining and other structures to suit the site condition.

3.11 Typical Scour Check (DLR/ROAD/T-24)

As already explained, lining of side drain according to the longitudinal gradient of is costly for rural roads. But if the drains are not lined at steep gradient it will start to scour the drain and subsequently shall damage the road. This type of problem can be solved by providing drops and scour check at regular interval. In this drawing example of providing drops and scour check is provided. This typical drawing is extracted from "Design and Appraisal of Rural Transport Infrastructure"

3.12 Typical surfacing Materials (RAIDP/TYP-25)

Some of the low cost surfacing methods for rural roads are presented in this drawing. These typical drawing is extracted from "Design and Appraisal of Rural Transport Infrastructure".

3.13 Standard Details of Hairpin Bend (DLR/ROAD/T-26)

Hairpin bends are very common in hill roads of Nepal. Hairpin bends should be designed very carefully so that the vehicles could move on this stretch without much difficulty. But unfortunately, most of the hairpin bends in the rural roads are constructed without proper design. The main design defect in the existing hairpin bends is insufficient radius of horizontal curves, steep gradients and lack of proper drainage causing disturbance to smooth vehicles movement along this stretch and frequent damage to the roads due to surface water. The drawing of hairpin bend provided in the guidelines is adopted from District Road Support Project (DRSP). The users are advised to follow the basic design elements such as minimum horizontal radius, road way width near/at the main curve, provision of drainage for safe disposal of surface water etc. provided in the drawing.

3.14 Delineator and Kilometer Posts (DLR/ROAD/T-27)

The Drawings of delineator post, kilometer post and 5th kilometer post are adopted for typical drawing of Department of Roads (DoR). The users are advised to adopt same size and materials for these posts so that uniformity could be achieved in all the project districts.

3.15 Speed Breaker (Humps) (DLR/ROAD/T-29)

The details of speed breaker is provided in the drawing including the design of humps and the spacing of humps at the curve are shown with the dimension in the drawing.

Government of Nepal
Ministry of Local Development
Department of Local Infrastructure Development and Agricultural Roads
(DoLIDAR)

TYPICAL DESIGN DRAWINGS OF RURAL ROADS

April 2015

CONTENTS

General Notes and Legends

General Notes

1. All dimensions are in millimeters unless otherwise mentioned.
2. Reinforcement shall be HYSD bars (Grade Designation S415) confirming to IS 1786 or equivalent to be approved by the Engineer.
3. The drawing showing Plan and Profile of road (Drg. No. RAIDP/TYP-2) is shown as an example to guide the users on type of details to be incorporated in the design drawings.

Legends

= CONCRETE

= SAND FILLING

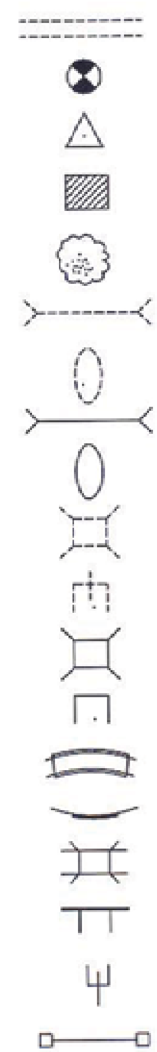
= COMPACTED GRAVEL / GRANULAR MATERIAL

= DRY RRM

= RRM IN CSM

= BMY in CSM

= GABION WALL



= EXISTING ROAD

= BENCH MARK

= TRAVERSE POINT

= HOUSE

= TREES

= EXISTING PIPE CULVERT IN PLAN

= EXISTING PIPE CULVERT IN PROFILE

= PROPOSED PIPE CULVERT IN PLAN

= PROPOSED PIPE CULVERT IN PROFILE

= EXISTING SLAB CULVERT IN PLAN

= EXISTING SLAB CULVERT IN PROFILE

= PROPOSED SLAB CULVERT IN PLAN

= PROPOSED SLAB CULVERT IN PROFILE

= PROPOSED CAUSEWAY IN PLAN

= PROPOSED CAUSEWAY IN PROFILE

= PROPOSED BRIDGE IN PLAN

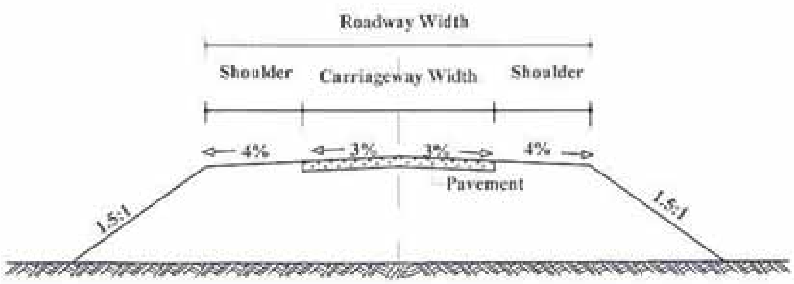
= PROPOSED BRIDGE IN PROFILE

= ELECTRIC POLE

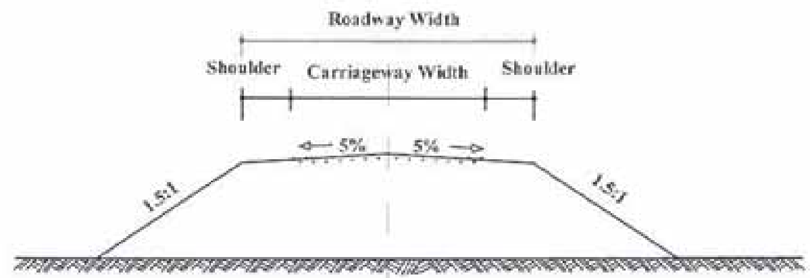
= SYPHON / AQUEDUCT

ABBREVIATIONS

BC	Beginning of circular curve	Hwh	Height of wing wall at high end
Bcm	Base width of composite wall	Hwl	Height of wing wall at low end
Bd	Base width of dry random rubble maonry wall	Hms	Height of random rubble masonry wall in cement sand mortar
Bg	Base width of gabion wall	IP	Intersection point
BHC	Bebinning of horizontal curve	Iel	Invert elevation
BM	Bench mark	Lc	Length of causeway
Bms	Base width of random rubble masonry wall in cement sand mortar	Le	Effective length of deck slab (of slab culvert)
BMY	Brick masonry in cement sand mortar	Lh	Length of horizontal curve
BVC	Bebinning of virtile curve	Lhw	Length of head wall
CSM	cement sand mortar	Lo	Overall length of deck slab (of slab culvert)
CH	Chainage	LP	Lengthbof protection at down stream of slab culvert
D	Diameter of pipe	LVC	Length og verticle curve
Dab	Foundation depth of Abutment height of the slab culvert	Lw1	Length of guide wall at upstream
Dgw	Foundation depth of guide wall	Lw2	Length of guide wall at upstream
Dhw	Foundation depth of head wall	Lw3	Length of guide wall at downstream
Dwl	Foundation depth of head wall at low end	Lw4	Length of guide wall at downstream
E	Apex	MHC	Middle of horizontal curve
EHC	End of horizontal curve	Od	Overall depth of deck slab (of slab culvert)
EL	Elevation	PC	Pipe culvert
EVC	End of verticle curve	PCC	Plain cement concrete
Gw	Guide wall	Rb	Radius of circular pier section at bottom
Hab	Abutment height of the slab culvert	RRM	Randon rubble masonry
Hc	Cushion height above the pipe	SC	Slab culvert
Hcm	Height of composite wall	T	Tangent length
Hd	Height of dry random rubble masonry wall	t	thickness of pipe
Hg	Height of gabion wall	VIP	Verticle intersection point
Hgw	Height of guide wall	Wpf	Foundation width of pier
Hhw	Height of head wall	Wp	Width of protection at downstream

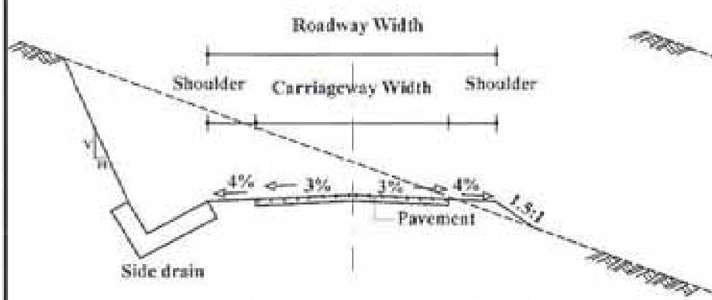


District Road Core Network Single Lane

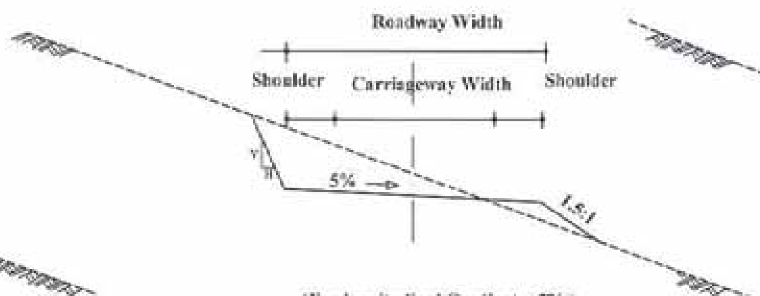


Village Road Single Lane

TYPICAL ROAD SECTIONS AT TERAI

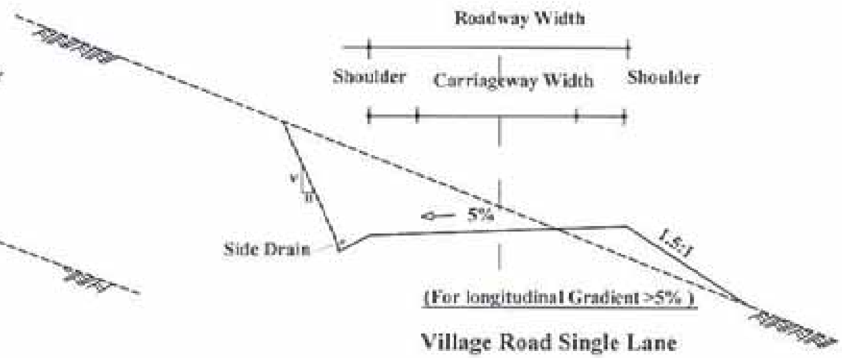


District Road Core Network Single Lane



(For longitudinal Gradient < 5%)

Village Road Single Lane



(For longitudinal Gradient >5%)

Village Road Single Lane

TYPICAL ROAD SECTIONS AT HILL

Cut Slope for Different Soil Types

S.NO.	Soil Type	H	V
1.	Ordinary Soil	1	1.5-2.0
2.	Hard Soil	1	2.0-3.0
3.	Ordinary/Medium Rock	1	4.0- 6.0
4.	Hard Rock	1	> 6.0

Table -1 As per Nepal Rural Road standard

		Carriageway Width (m)	Shoulder width (m)	Roadway width (m)
District Road (core network)	Hill	5.5 (if traffic > 400 vpd)	0.75	7
		3.75 (if traffic > 100 vpd)	0.75	5.25
		3 (if traffic < 100 vpd	0.75	4.5
	Terai	5.5 (if traffic > 400 vpd)	1	7.5
		3.75 (if traffic > 100 vpd)	1.5	6.75
		3 (if traffic < 100 vpd)	1.5	6
Village Road	Hill	3	0.5	4
	Terai	3	0.75	4.5

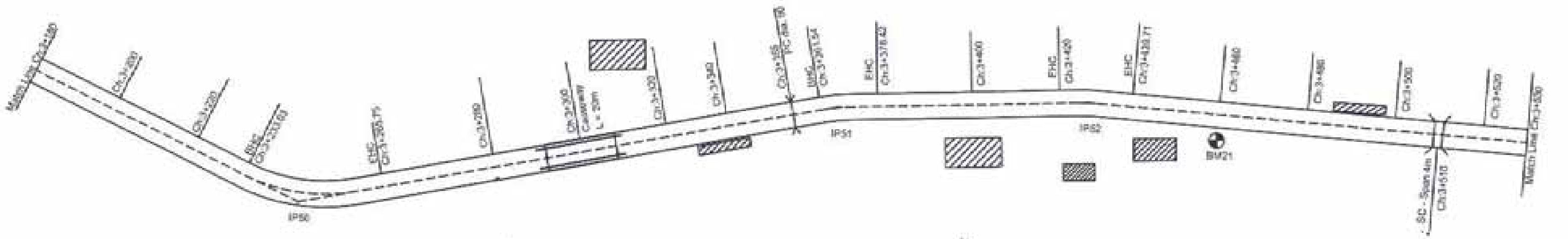
Note:

1. In general, 1 m is desirable embanlment height but minimum height is 0.50 m above existing ground level.
2. The cut slope specified in the table is for design and estimation of new roads. It shall be suitably adjusted to the site condition during excavation as directed by the Engineer.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Typical Road Sections	Scale 1000 0 1000 2000	Drawing No. DLR/ROAD/T-1

3/4/2

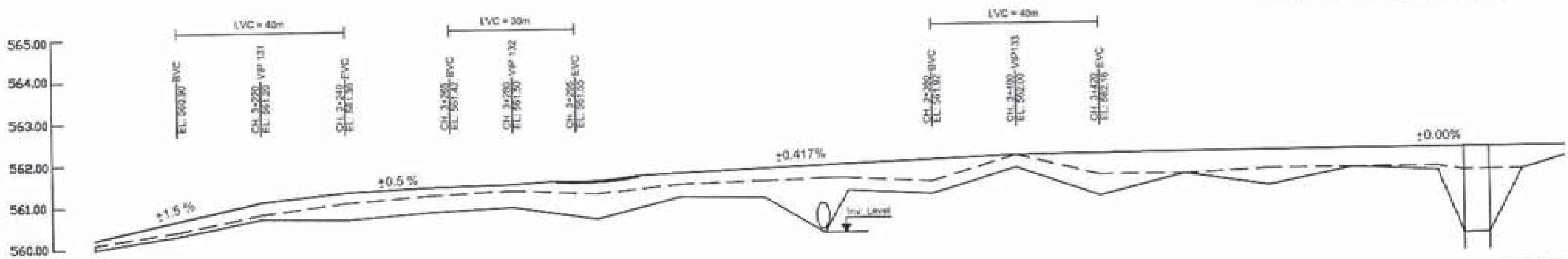
8



I.P.	Distance (m)	Def.Ang.	Radius	Curve Data (m) T	E	Lw	Chainage IP	BHC	MHC	EHC
50	120	17°30'10"	50	16.97	2.80	32.72	3+250	3233.03	3219.39	3265.75
51		09°40'20"	100	8.45	0.36	16.88	3+370	3361.54	3369.98	3378.42
52	60	11°10'40"	100	9.79	0.48	19.50	3+430	3420.21	3429.96	3439.71

Notes:

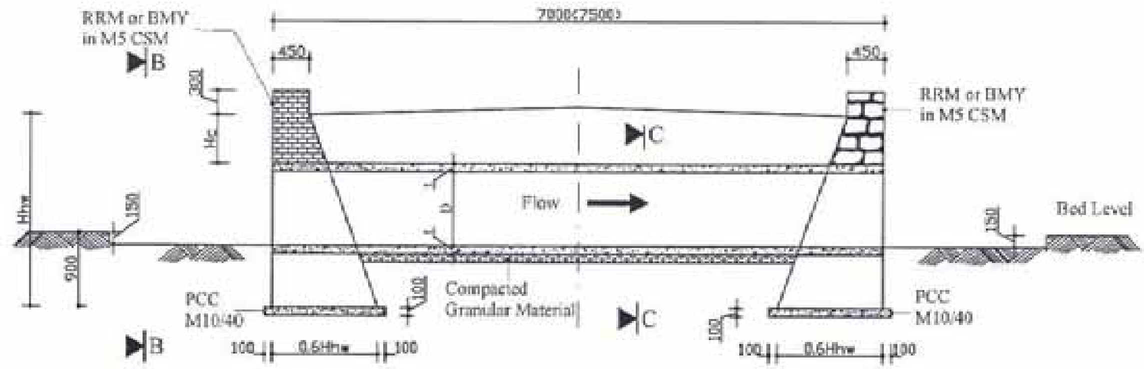
1. All the important features such as houses, schools, electric poles, etc. which lies within the right of way shall be shown in plan.



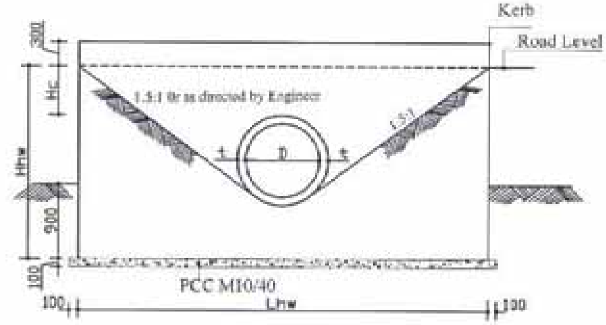
Side Drain — Left: Type A; Right: Type F, Type B

Chainage	Soil Type	Design Level	Existing Road Level	Ground Level
3+180	Hard Soil	560.60	560.10	560.00
3+200	Hard Soil	560.90	560.40	560.30
3+220	Ordinary Soil	561.10	560.80	560.70
3+240	Ordinary Soil	561.30	561.05	560.65
3+260	Ordinary Soil	561.40	561.20	560.80
3+280	Ordinary Soil	561.45	561.30	560.90
3+300	Ordinary Soil	561.58	561.20	560.60
3+320	Hard Soil	561.67	561.40	561.10
3+340	Hard Soil	561.75	561.45	561.05
3+355	Hard Soil	576.417	561.50	560.20
3+360	Hard Soil	561.84	561.50	561.20
3+380	Ordinary Rock	561.92	561.40	561.10
3+400	Ordinary Rock	562.02	562.00	561.70
3+420	Hard Soil	562.16	561.50	561.00
3+440	Hard Soil	562.33	561.50	561.50
3+460	Hard Soil	562.40	561.60	561.20
3+480	Hard Soil	562.50	561.60	561.60
3+500	Hard Rock	562.50	561.60	561.50
3+556	Hard Rock		561.50	560.00
3+562	Hard Rock		561.50	560.00
3+520	Hard Soil	562.50	561.50	561.50
3+530	Hard Soil	562.50	561.80	561.80

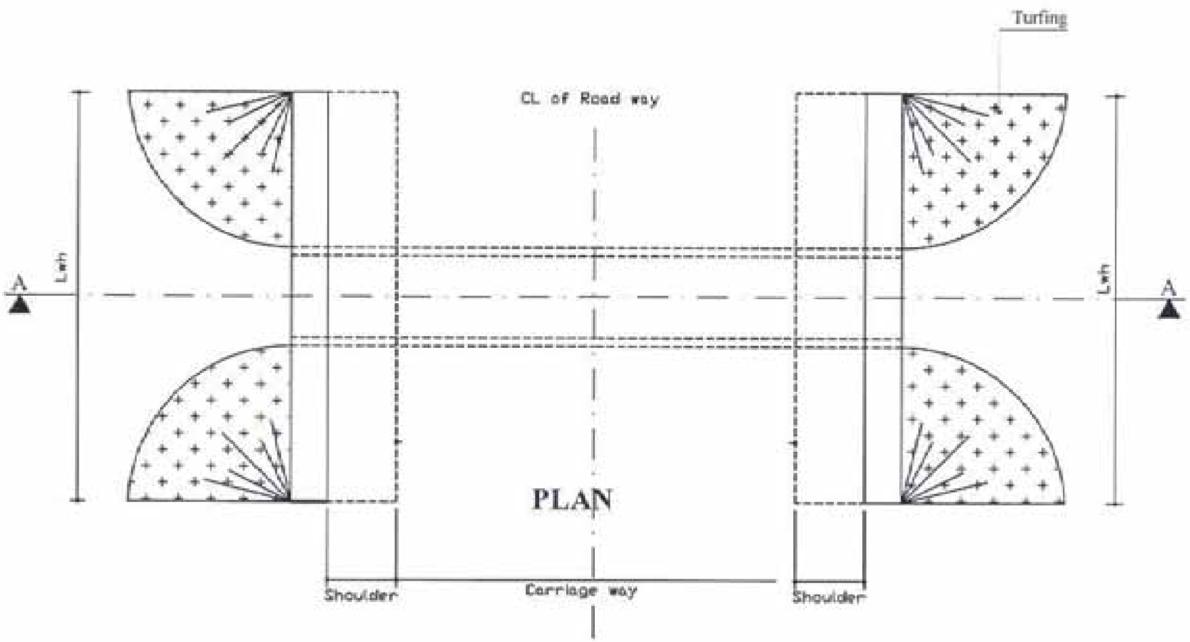
His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Plan/Profile (Sample)	Scale: Horizontal 0 1000 2000; Vertical 0 100 200	Drawing No. DLR/ROAD/T-2



SECTION AA



SECTION BB



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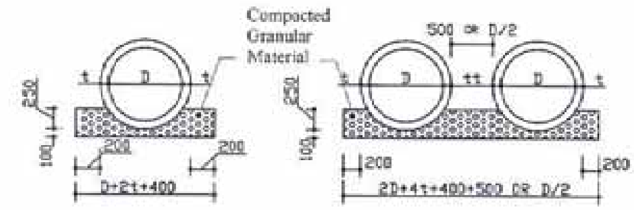


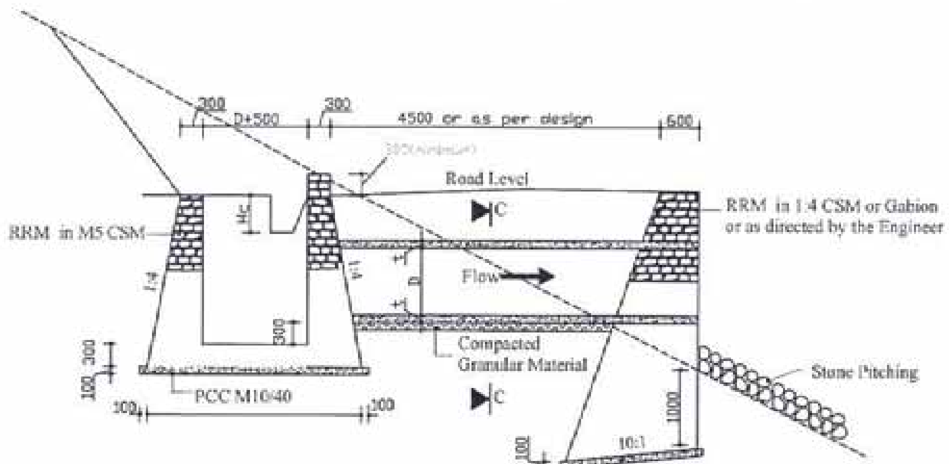
SECTION - CC

SECTION - CC FOR DOUBLE CELLS

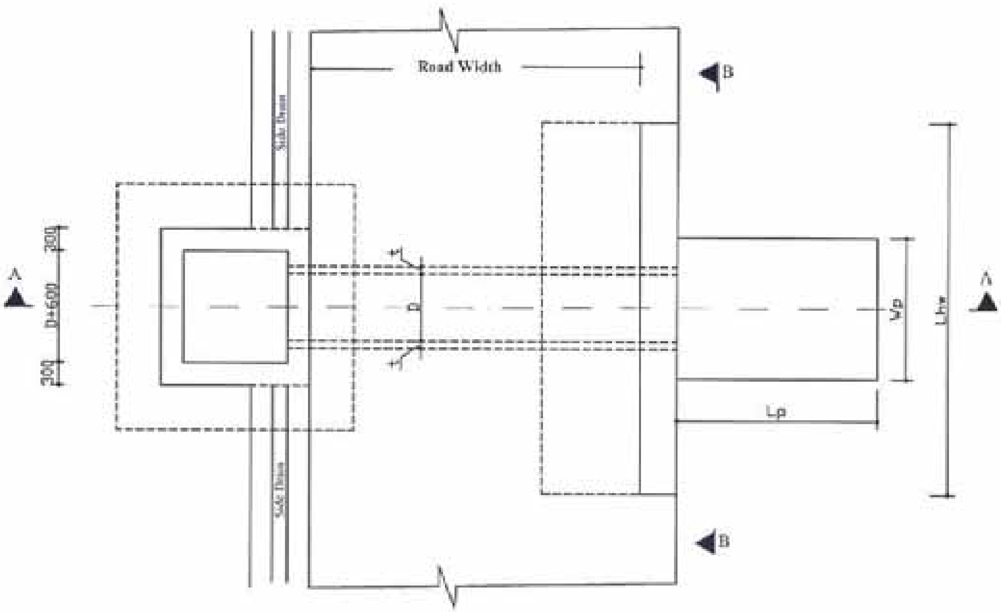
Notes

1. Pipe shall be ISI NP3
2. Minimum diameter of pipe shall be 600
3. Minimum cushion above the pipe shall be HC= 600
4. Longitudinal slope of pipe shall be minimum of 1 in 1000.
5. Beding for pipes shall be of compacted granular materials for Hc < 4m . For Hc > 4m, condrete bedding shall be provided.
6. Pitching at inlet and outlet shall be provided as directed by the Engineer
7. If the Dia of pipe is less than 1200, speing of pipe shall be 500 or D/2 which ever is greater.
8. If the multipe line of pipe greater than 1.2 m Dia. the clear spacing shall be 1.5 D or 1.2 m which ever is less to permit adequate compaction.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Pipe Culvert at Terai	Scale 1000 0 1000 2000	Drawing No. DLR/ROAD/T-3



SECTION AA



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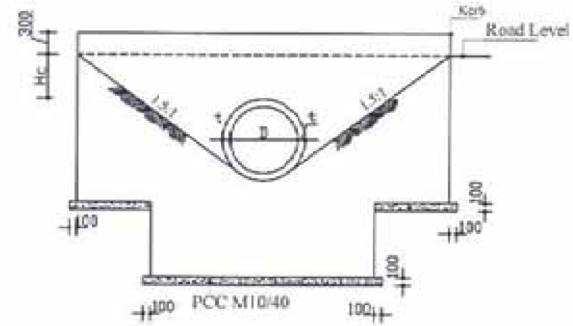
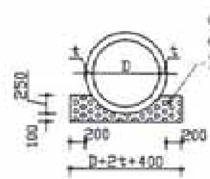
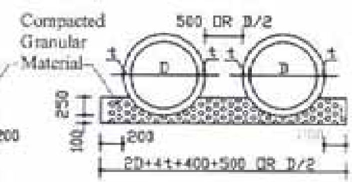


SECTION BB



SECTION CC



SECTION CC
for Double Shells

Notes

1. Pipe shall be ISI NP3
2. Minimum diameter of pipe shall be 600
3. Minimum cushion above the pipe shall be HC = 600
4. Longitudinal slope of pipe shall be minimum of 1 in 20
5. Beding for pipes shall be of compacted granular materials for Hc < 4m . For Hc > 4m, concrete bedding shall be provided.
6. The bed protection type at outlet is shown as an example. It can be of RRM in CSM or gabion or as directed by the Engineer. If the surface at outlet is sound (rocky) the bed protection may be omitted.
7. Type and length of head wall shall be fixed as per the site condition.
8. The dimension of head wall shall conform to the retaining wall drawings; Drawing Nos. DLD/ROAD/T-16 or 17 or 18 or 19 or as directed by the Engineer.
9. If the Dia of pipe is less than 1200, speing of pipe shall be 500 or D/2 which ever is greater.
10. If the multipe line of pipe greater than 1.2 m Dia. the clear spacing shall be 1.5 D or 1.2 m which ever is less to permit adequate compaction.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Pipe Culvert at Hill	Scale	Drawing No. DLR/ROAD/T-4

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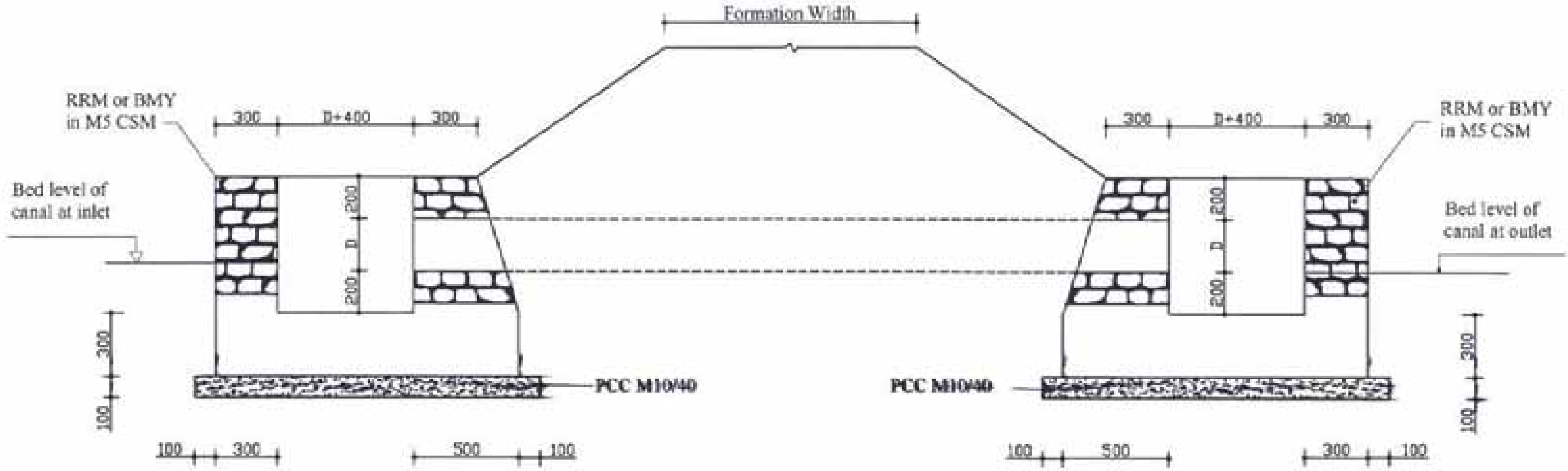
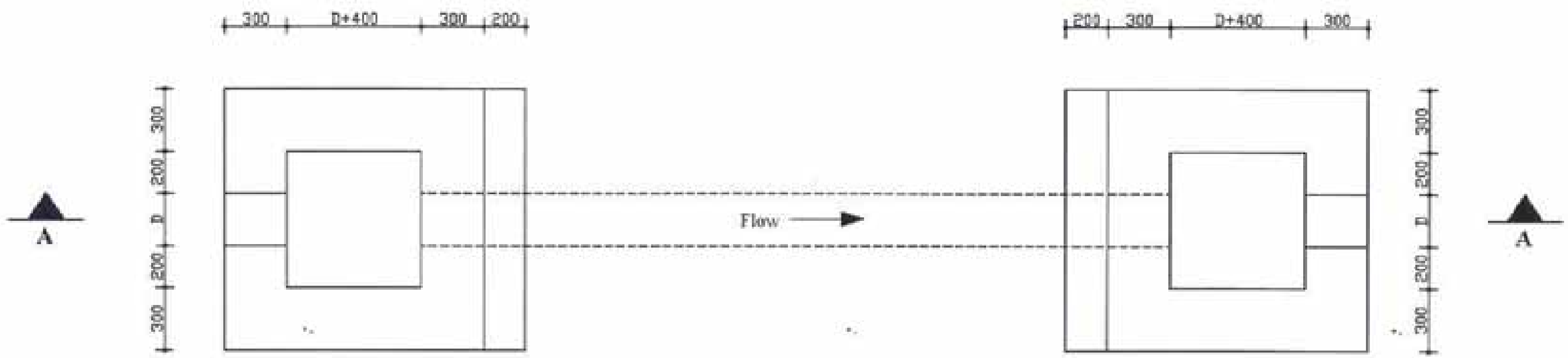


SECTION AA

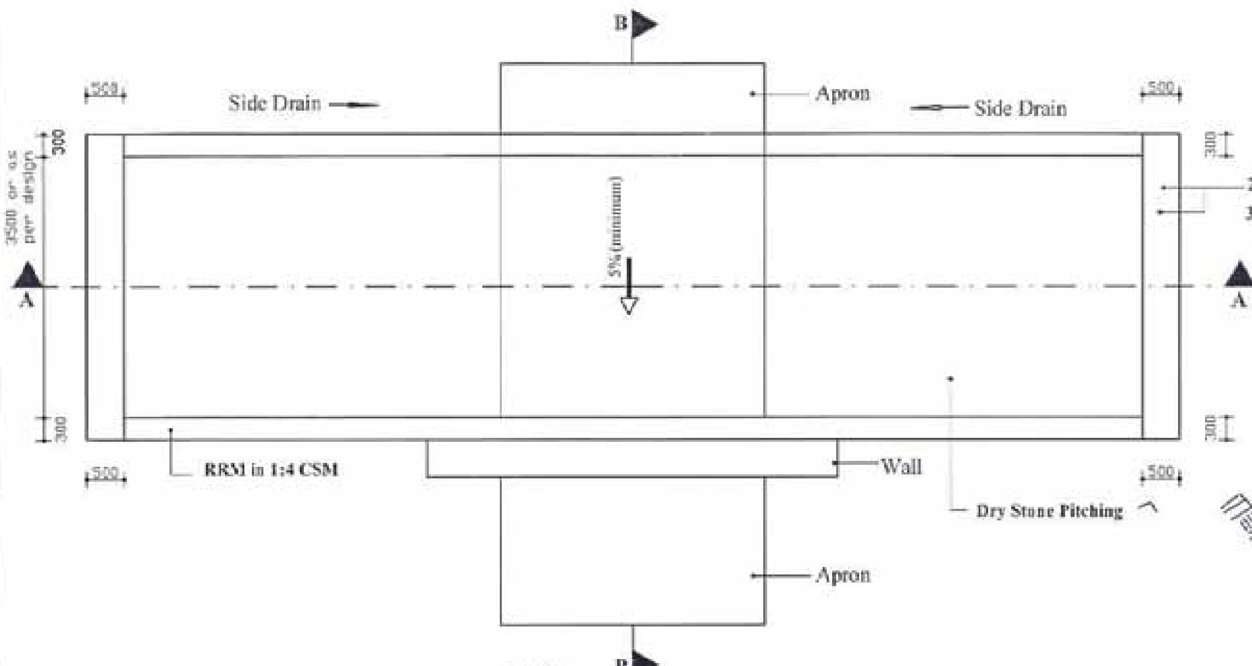


PLAN

Notes

1. The type and diameter of pipe shall be fixed as directed by the Engineer
2. Longitudinal solpe of pipe shall be minimum of 1 in 1000.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Pipe Culvert for Irreigation Purpose	Scale 1000 500 0 1000 2000	Drawing No. DLR/ROAD/T-5



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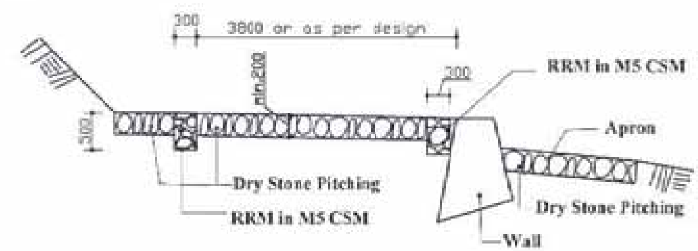
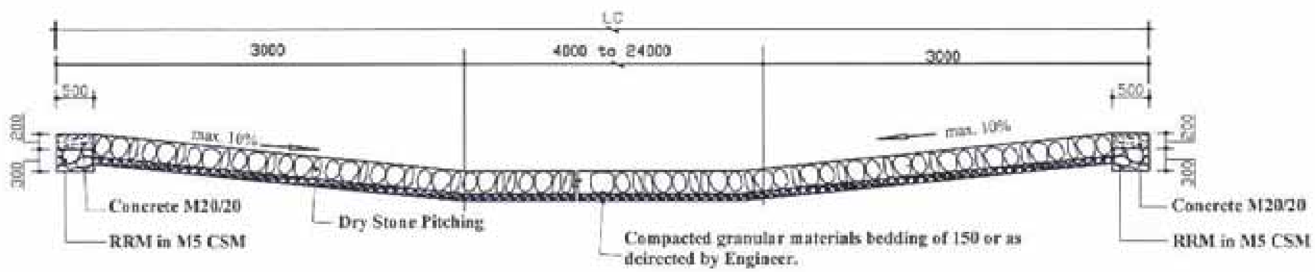


SECTION BB

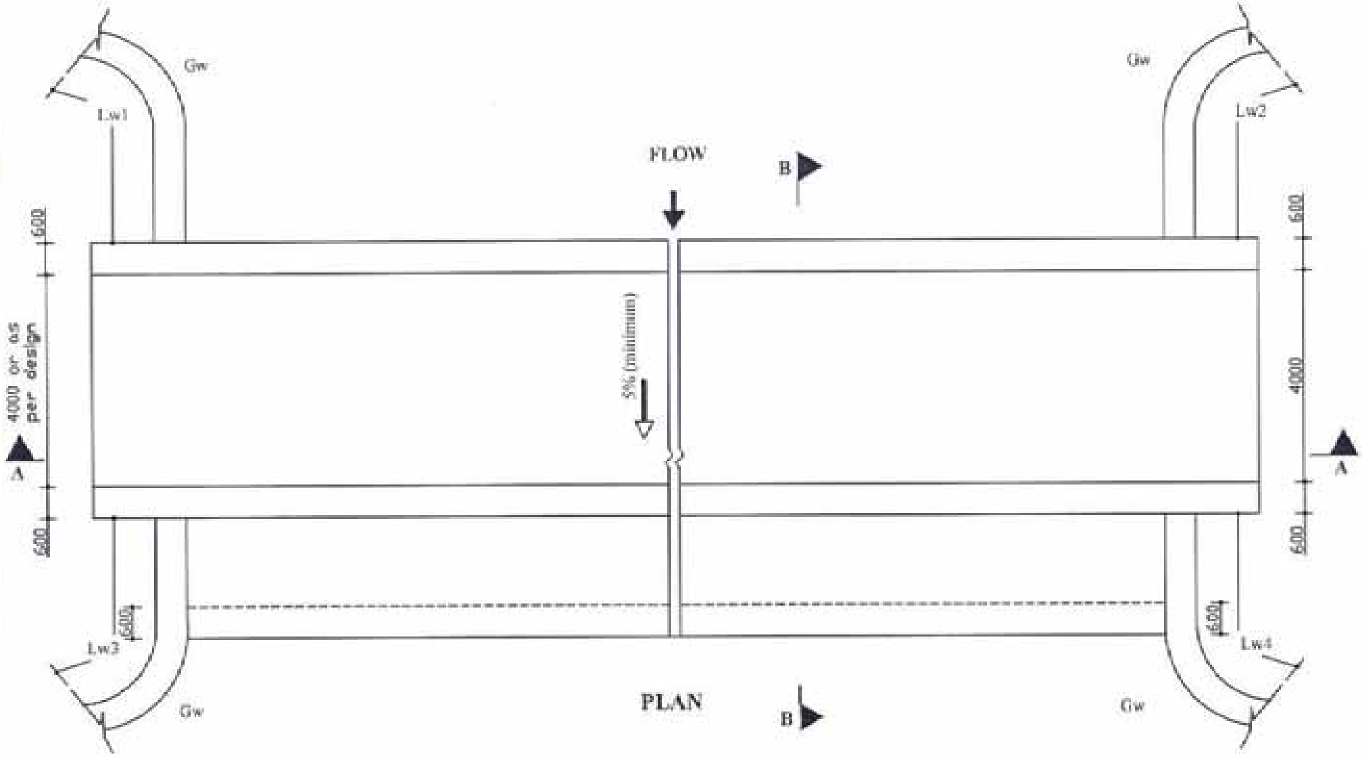


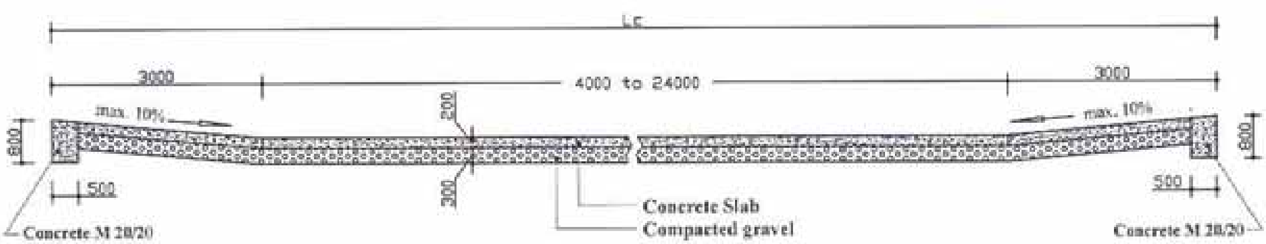
SECTION AA

Notes:

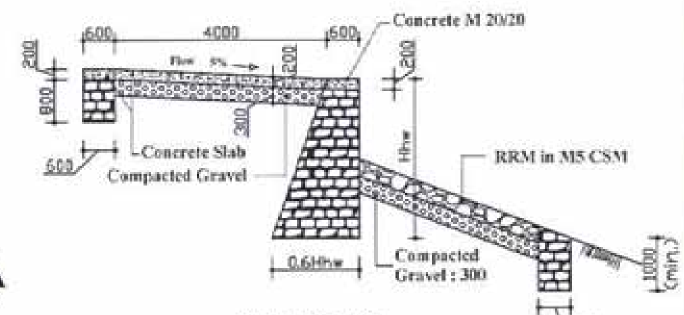
1. Longitudinal Dimension grade of cause way to suit road alignment.
2. The protection wall may be of dry RRM or RRM in CSM or gabion.
3. Minimun thickness of stone soling shall be 200
4. Type and length of wall shall be fixed as per site condition and dimension shall be confirmed as of retaining wall.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Dry Stone Causeway at Hill	Scale 1000 0 1000 2000	Drawing No. DLR/ROAD/T-6





SECTION AA

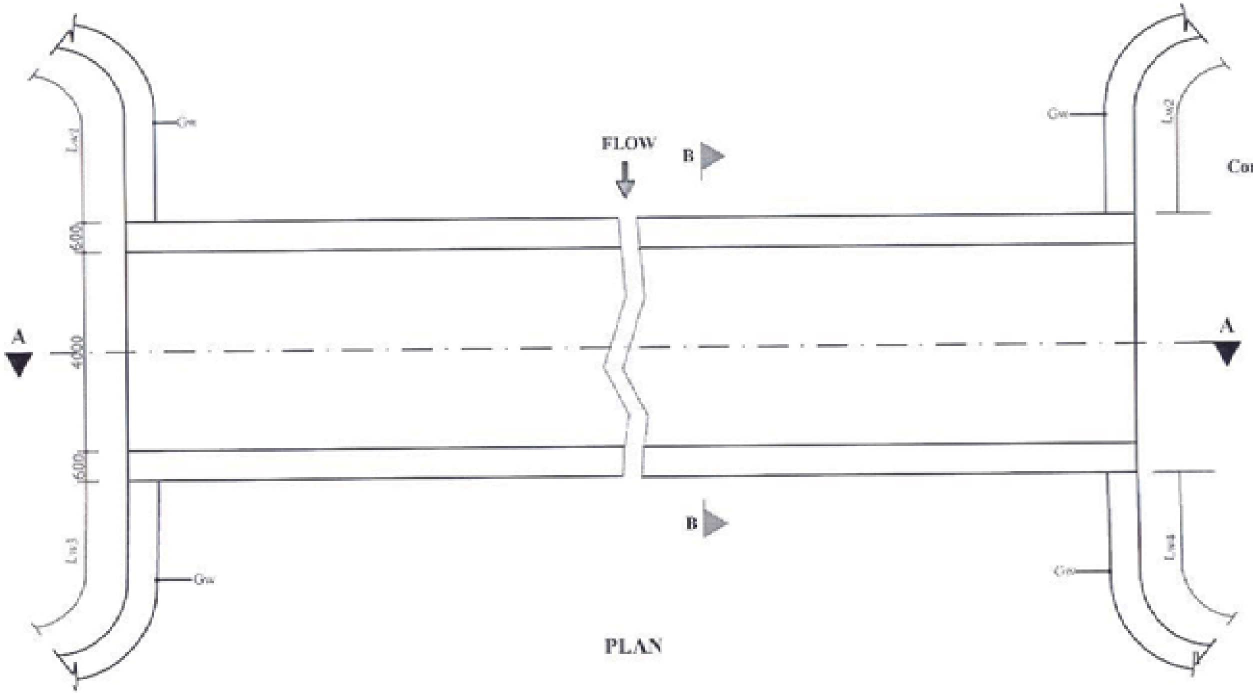


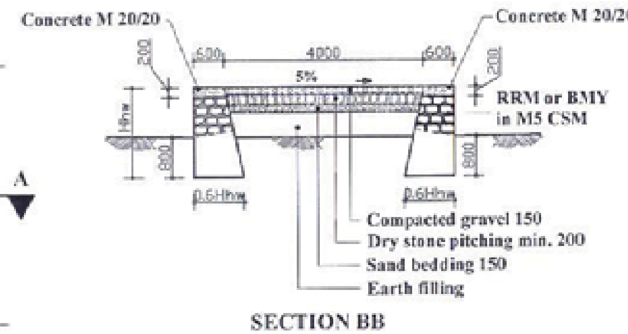
SECTION BB

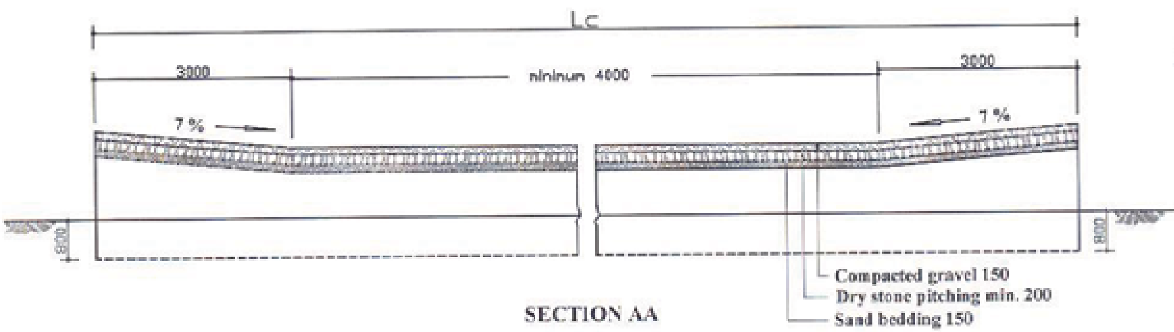
Notes:

1. Longitudinal and cross sectional dimension and grade of cause way to suit the road alignment
2. The configuration, length, height and foundation depth of guide walls shall be as directed by the Engineer.
3. Structural details of concrete slab shall be as per Drg. No. DLR/ROAD/T-11.
4. The bed protection type at outlet is shown as an example. It shall be modified according to site condition.
6. The guide walls (partly or wholly) may be omitted as directed by the Engineer.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Concrete Causeway at Hill	Scale 1000 0 1000 2000	Drawing No. DLR/ROAD/T-7



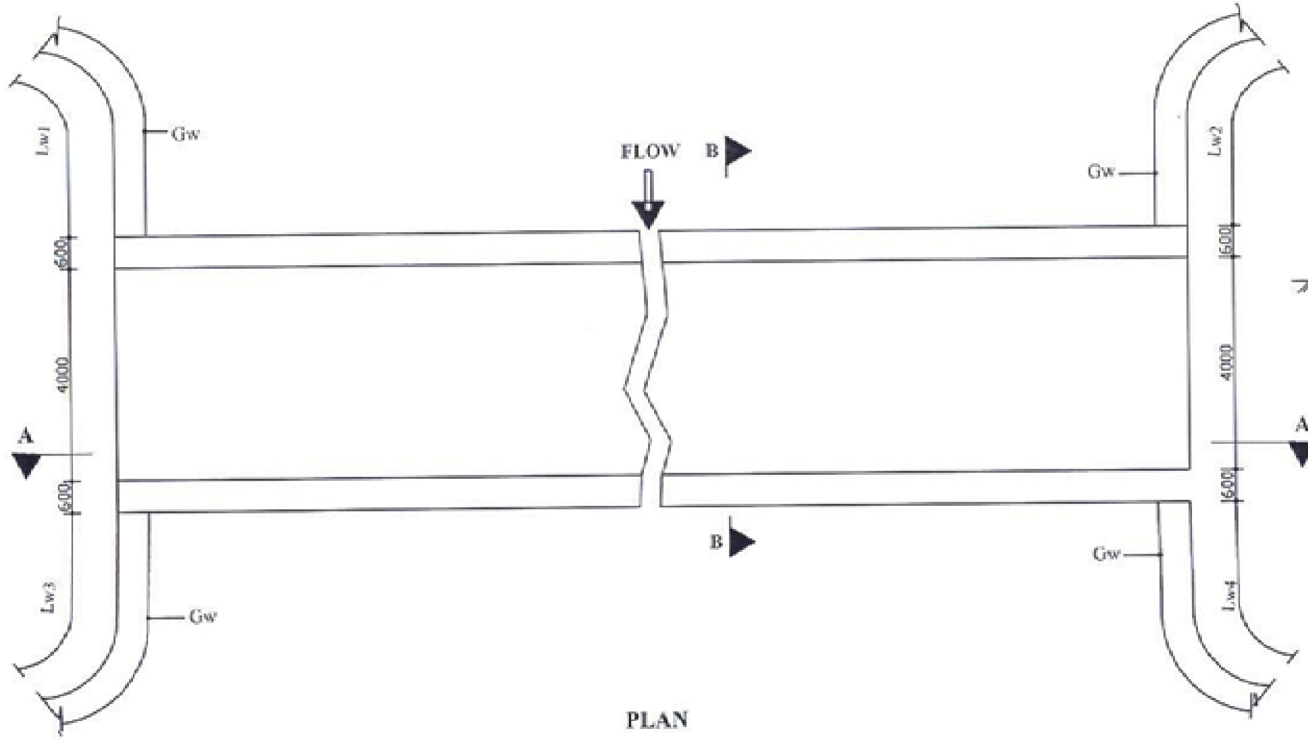




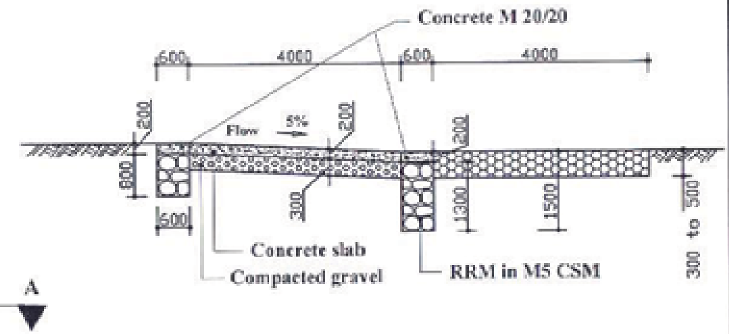
Notes :

1. Longitudinal and cross sectional dimension and grade of cause way to suit the road alignment
2. The configuration, length, height and foundation depth of guide walls shall be as directed by the Engineer.
3. The height of the head wall shall be fixed in such a way that duration of obstruction to traffic is within the permissible limit and shall be as directed by the Engineer.
4. Pipes may be provided at the end of causeway to drain the water at upstream as directed by the Engineer.
5. The guide walls (partly or wholly) may be omitted as directed by the Engineer.

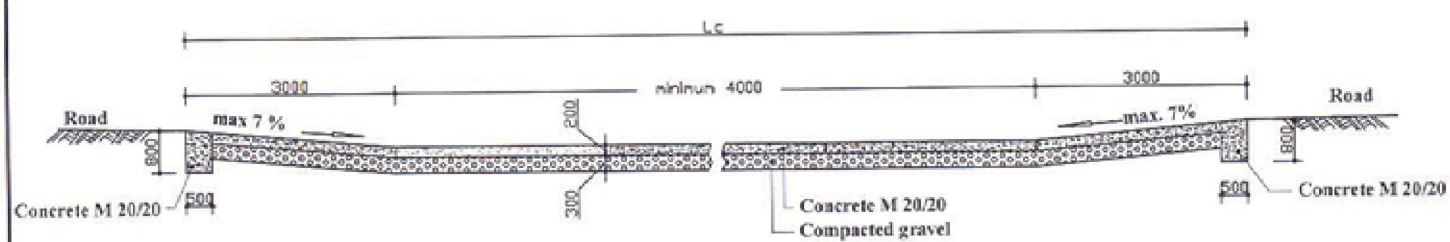
His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Dry Stone Causeway at Terai	Scale 1000 0 1000 2000	Drawing No. DLR/ROAD/T-8



PLAN



SECTION BB

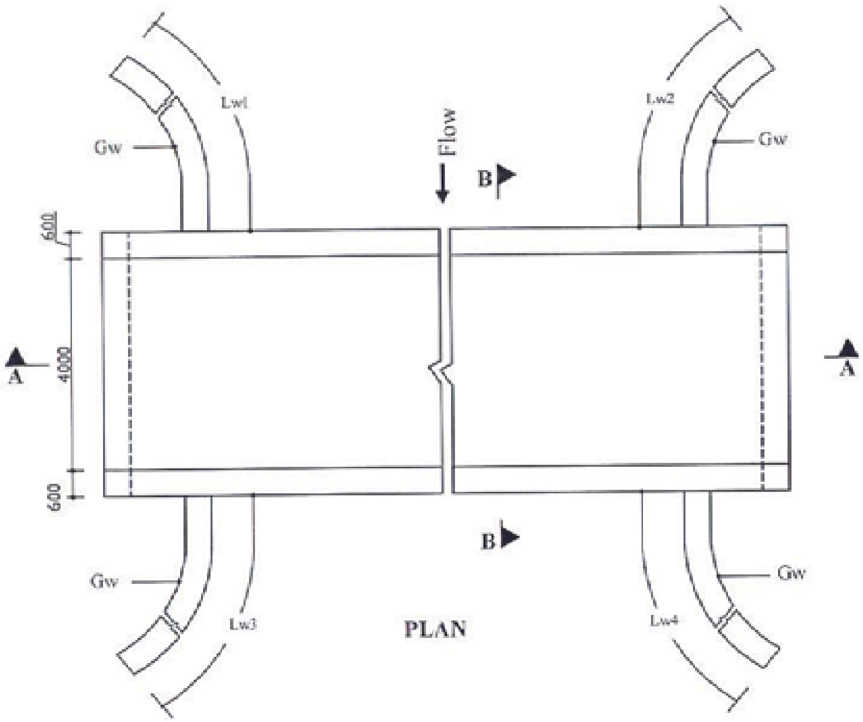


SECTION AA SECTION AA

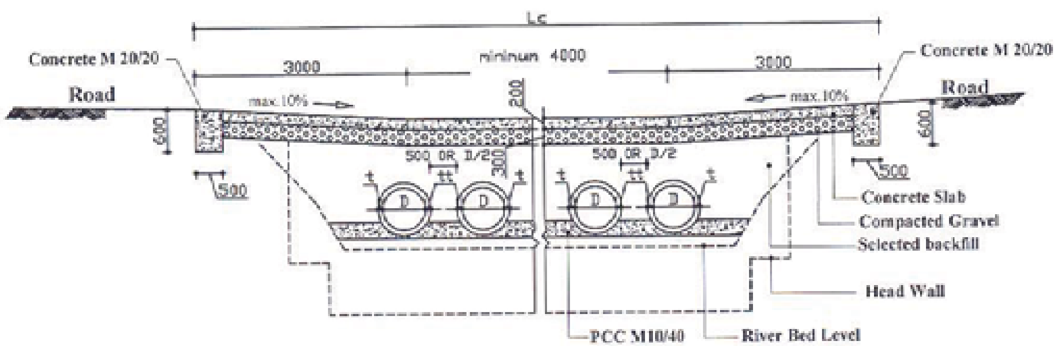
Notes:

1. Longitudinal and cross sectional dimension and grade of cause way to suit the road alignment
2. The configuration, length, height and foundation depth of guide walls shall be as directed by the Engineer.
3. Structural details of concrete slab shall be as per Drg. No. DLR/ROAD/T-11
4. The bed protection type at outlet is shown as an example. It shall be modified according to site condition.
5. The guide walls (partly or wholly) may be omitted depending upon the site condition.

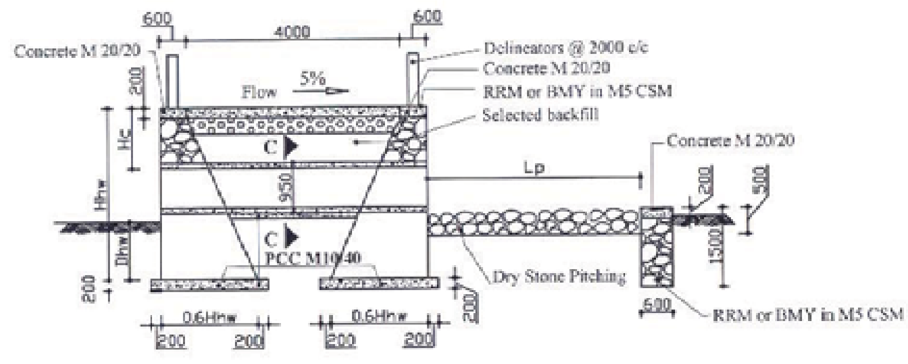
His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Concrete Causeway at Terai	Scale 1000 0 1000 2000	Drawing No. DLR/ROAD/T-9



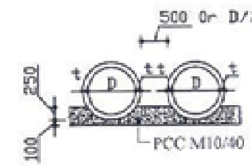
PLAN



SECTION AA



SECTION BB

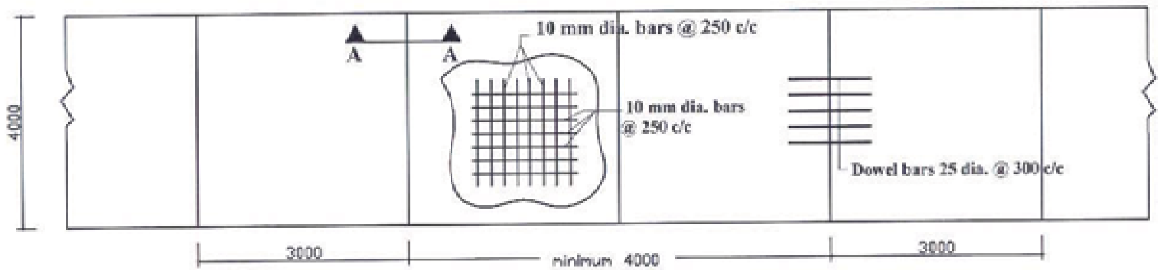


SECTION CC

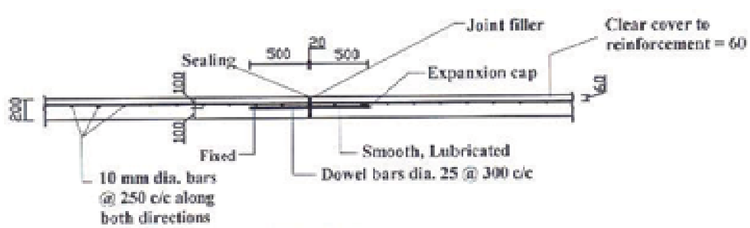
Notes:

1. Longitudinal and cross sectional dimension and grade of cause way to suit the road alignment
2. It is very important that the high flood level at causeway is lower than the surrounding ground level and it should be ensured that area near the causeway did not become flooded due to obstruction of causeway.
3. The configuration, length, height and foundation depth of guide walls shall be as directed by the Engineer.
4. Structural details of concrete slab shall be as per Drg. No. DLR/ROAD/T-11
5. The bed protection type at outlet is shown as an example. It shall be modified according to site condition.
6. The height of selected backfill shall be fixed according to the top level of causeway.
7. if the diad meter of multiple pipe cul;verts up to 1.2 m the clear spacing should not be less than 500 mm
8. If the multiple line of p[ipe gratyer than 1.2 m Dia, the clear spacing should not be closer than 1.5 D or 1.2 m which ever is less to permit adequate compaction.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Vented Causeway	Scale 1000 0 1000 2000	Drawing No. DLR/ROAD/T-10



PLAN

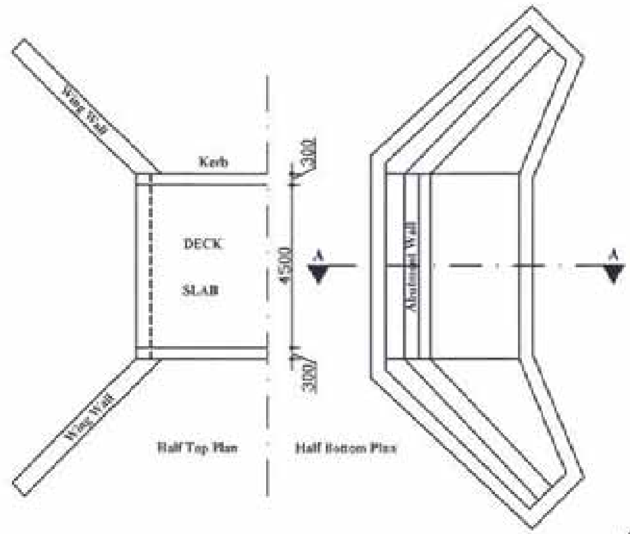


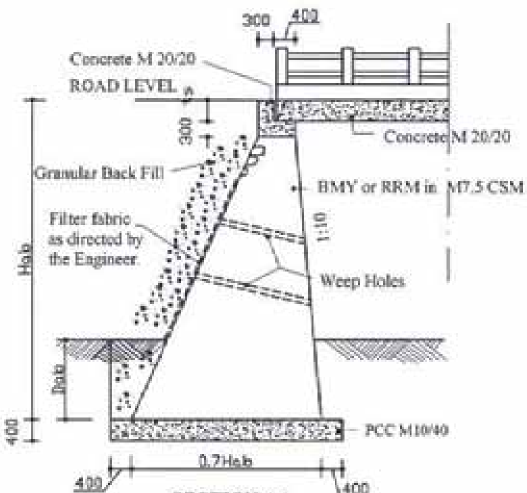
SECTION AA

Notes

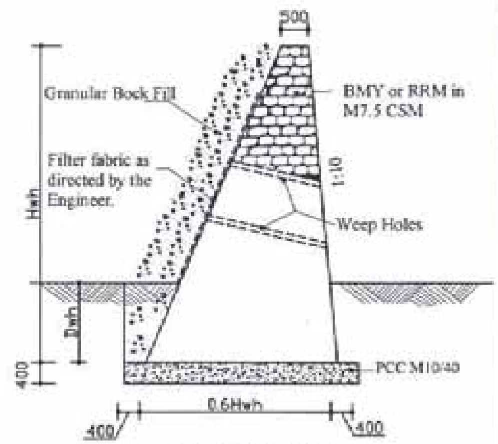
1. Concrete grade for slab shall be M 20/20
2. The concrete slab shall be laid over compacted gravel .

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Concrete Slab Details of Causeway	Scale Plan 1000 0 1000 2000 Section 500 0 500 1000	Drawing No. DLR/ROAD/T-11



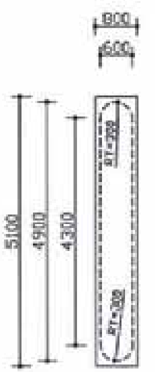


SECTION AA

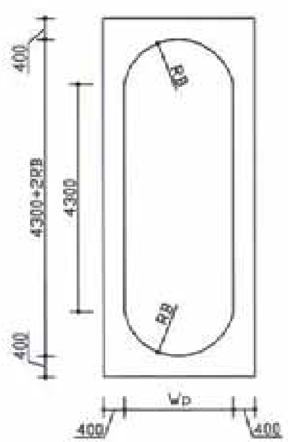


High End of Wing Wall

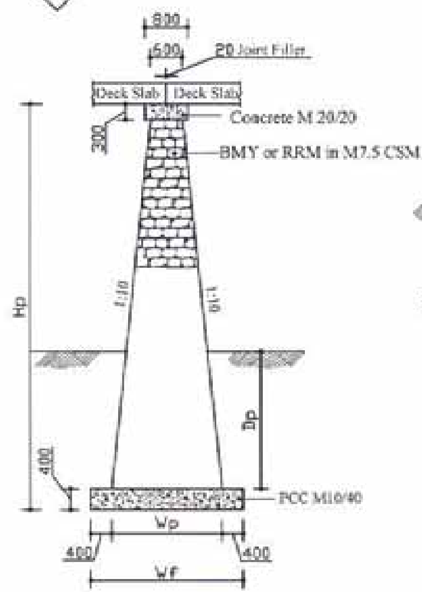
Abutment



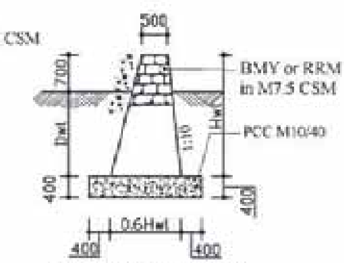
Top Plan



Foundation Plan



SECTION



Low End Of Wing Wall

Wp=600+0.20(Hp-700)

RB=Wp/2

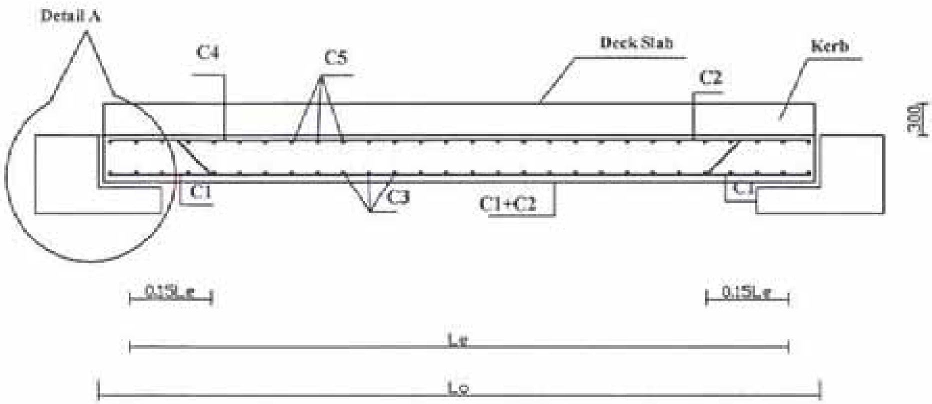
Pier

Notes

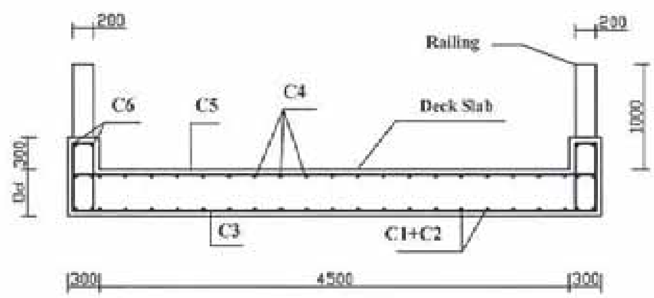
1. Layout of abutment, pier and wing wall shall be as directed by the engineer.
2. The culvert is designed for single lane IRC Class A loading.
3. The minimum clear cover to the reinforcemnet shall be 40mm
4. Suitable cut off wall shall be provided at upstream and downstream as per the site condition.
5. Clear virtical joints shall be provided between abutments and wing walls.
6. This drawing is to be read in conjunction with Drg. No. DLR/ROAD/T-13
7. Slab culvert of less than 4m span shall be avoided as far as possible.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Abutment and Wing Wall Details of Slab Culvert	Scale 1000 0 1000 2000	Drawing No. DLR/ROAD/T-12

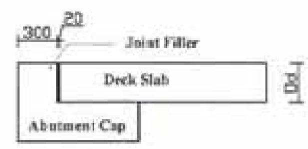
Detail A



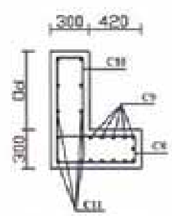
LONGITUDINAL SECTION



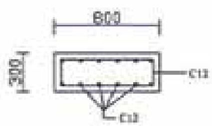
CROSS SECTION AT CENTRE



Detail A



Abutment cap



Pier cap

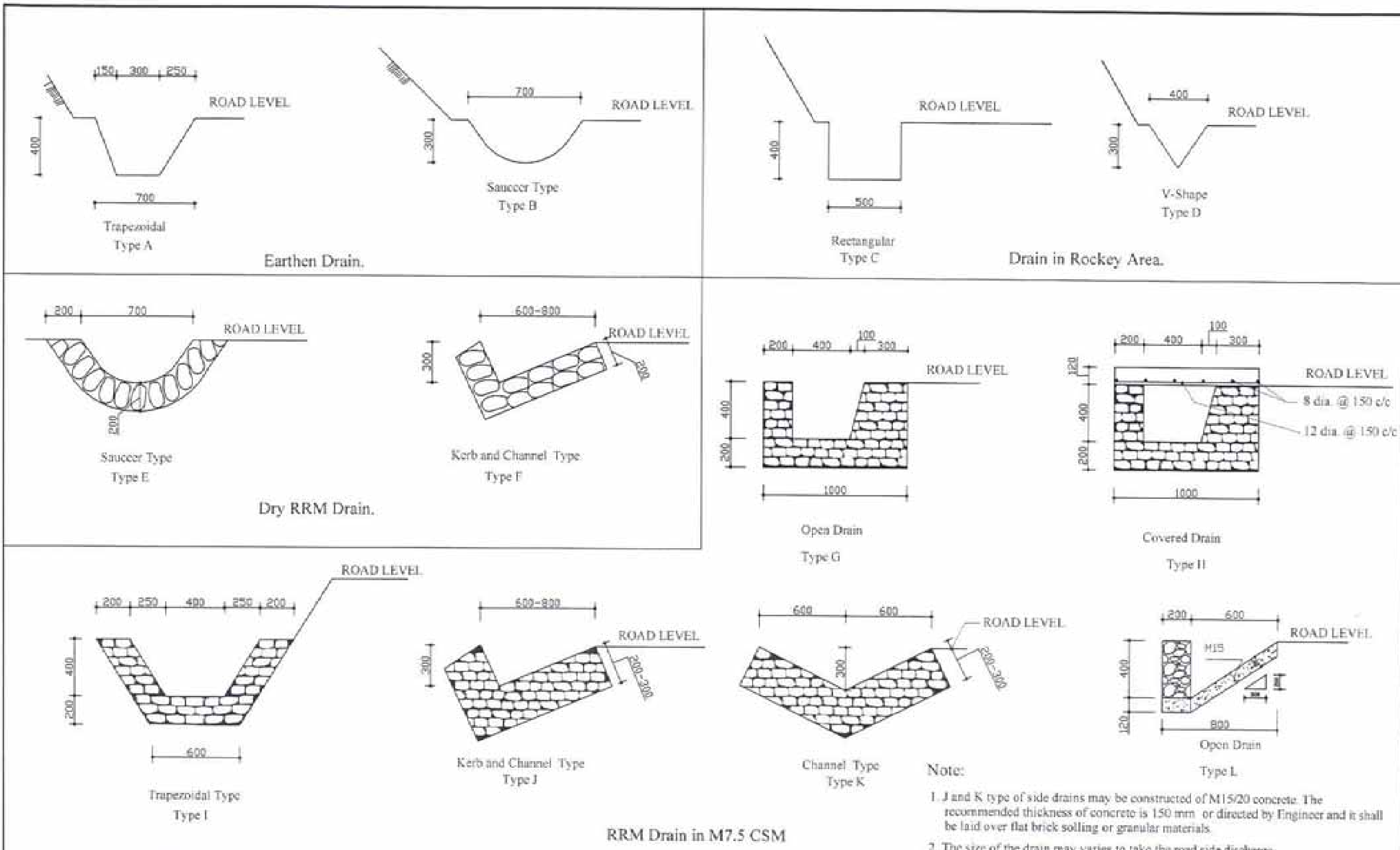
Schedule of Reinforcement

Span Length (m)	Effective Span (mm Le)	Overall Lenght (mm Lo)	Overall Depth (mm)	Bar Mark	Shape and Size of Bars (Not To Scale)	Dia. (mm)	Total Length (mm)	Spacing (mm)	Nos.	Weight Kg /m	Weight Kg.
2.0	2220	2800	270	C1	2720	16	2720	320	17	1.58	73.06
				C2	296 164 1754 164 296	16	2870	320	17	1.58	77.2
				C3	5020	10	5020	250	12	0.62	37.35
				C4	177 2710 177	10	3064	250	21	0.62	37.99
				C5	5020	10	5020	250	12	0.62	37.35
				C6	2720	10	2720	-	2x2	0.62	6.75
				C7	230 500	10	1660	300	2x10	0.62	21.61
										Total	312.05
4.0	4360	4500	350	C1	4720	16	4720	240	22	1.58	164.06
				C2	580 350 3052 350 580	16	4912	240	22	1.58	170.74
				C3	5020	10	5020	200	25	0.62	77.81
				C4	275 4710 275	10	5260	200	26	0.62	84.79
				C5	5020	10	5020	200	25	0.62	77.81
				C6	5020	10	5020	—	2x2	0.62	12.45
				C7	230 580	10	1820	300	2x17	0.62	38.36
										Total	626.02
6.0	6400	6800	450	C1	6720	20	6720	280	19	2.48	316.64
				C2	770 495 4480 495 770	20	7010	280	19	2.48	330.31
				C3	5020	10	5020	200	35	0.62	108.93
				C4	375 6710 375	10	7460	200	26	0.62	120.26
				C5	5020	10	5020	200	35	0.62	108.93
				C6	5020	10	5020		2x2	0.62	12.45
				C7	230 680	10	2020	300	2x23	0.62	57.61
										Total	1055.1[illegible]
				C8	620 300	12	1840	100	2x51	0.89	170.67
				C9	4988 188	12	10592	100	2x5	0.89	94.25
				C10	200 varies	12		100	2x51	34	—
				C11	5020	10	5020	100		0.89	—
				C12	700 240	12	2040	100	51	0.89	92.60
				C13	4988 188	12	10592	100	8	0.89	75.42

Notes:

1. Concrete grade of deck slab,kerb,pier cap and abutment cap shall be M20/20
2. The culvert is designed for single lane IRC Class A loading.
3. The minimum clear cover to reinforcements shall be 40 mm.
4. The drawing is applicable for square crossing only.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Deck Slab Details of Slab Culvert	Scale For Section 500 0 500 1000 For Detail 500 0 500	Drawing No. DLR/ROAD/T-13

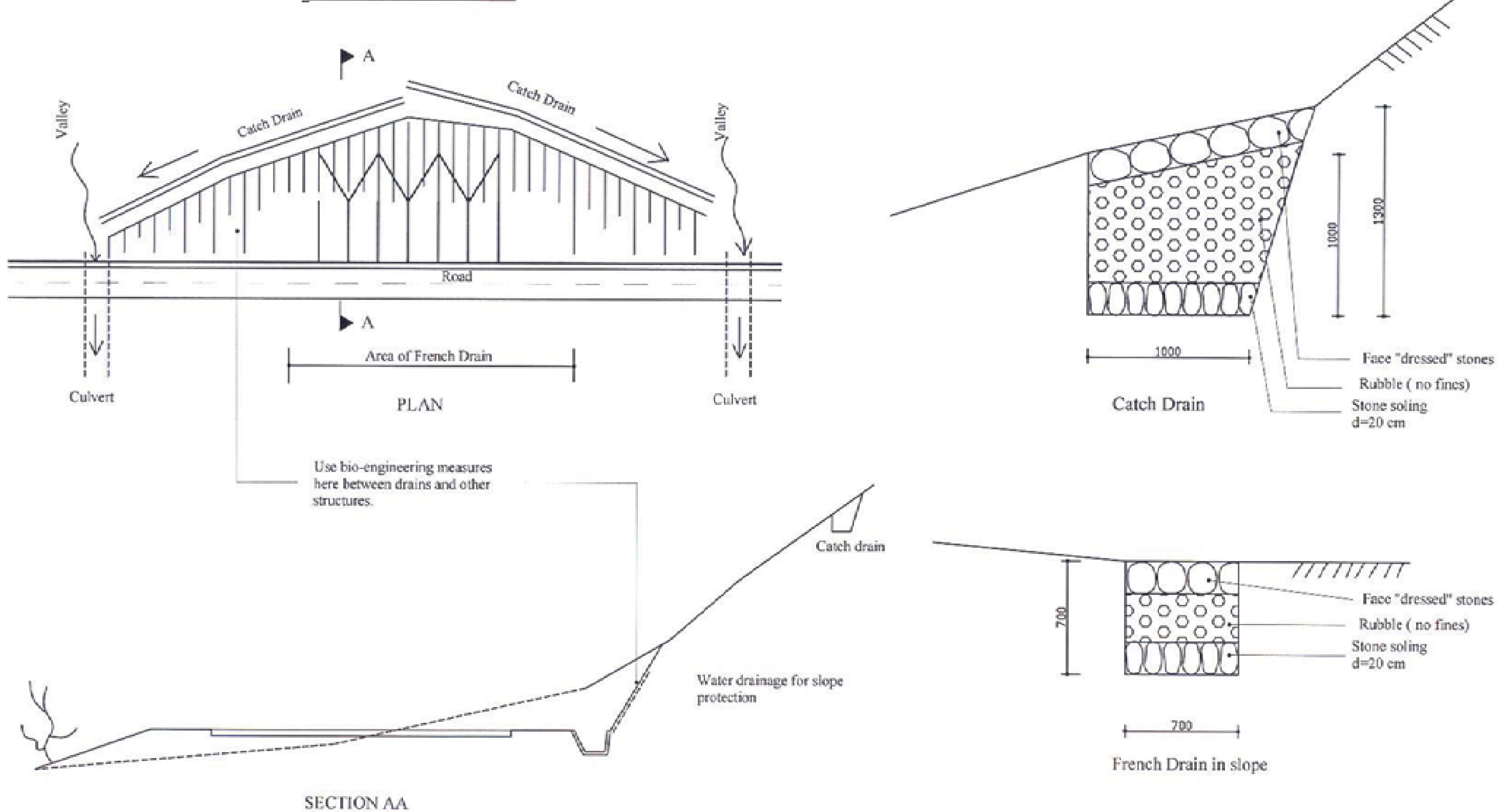


Note:

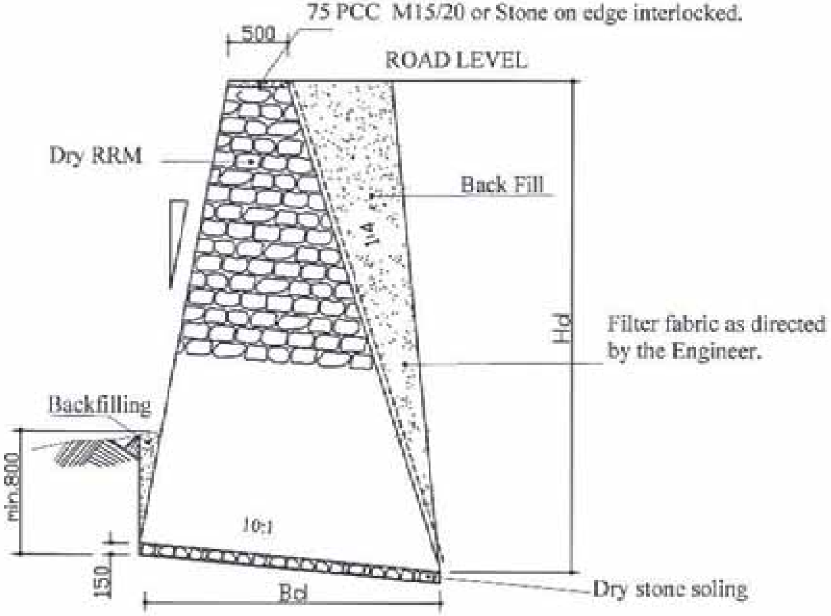
1. J and K type of side drains may be constructed of M15/20 concrete. The recommended thickness of concrete is 150 mm or directed by Engineer and it shall be laid over flat brick solling or granular materials.
2. The size of the drain may varies to take the road side discharge.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Typical Side Drains	Scale 500 0 500	Drawing No. DLR/ROAD/T-14

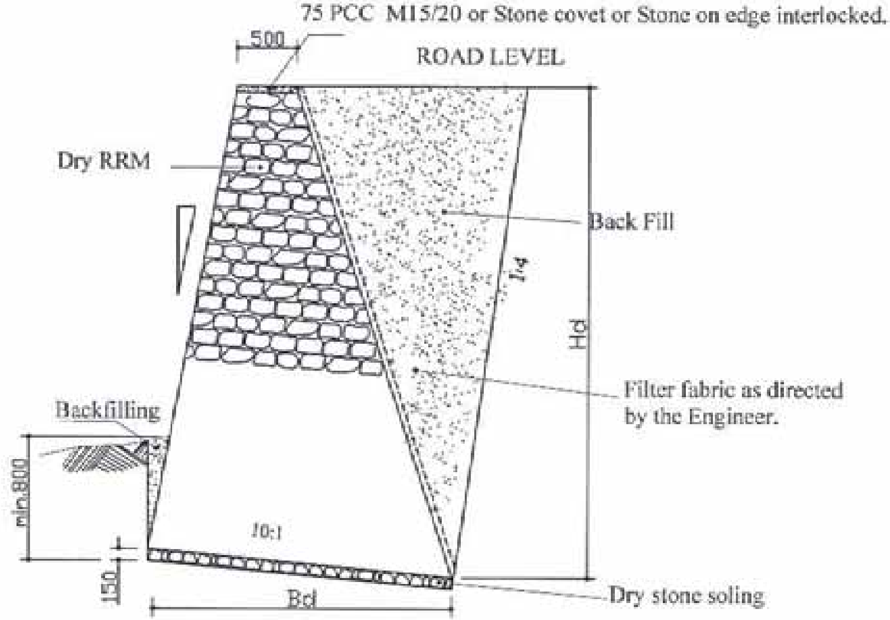
Drainage System - Standards



His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Sub Surface Drains	Scale 100 0 500 1000	Drawing No. DLR/ROAD/T-15



Profile 1



Profile 2

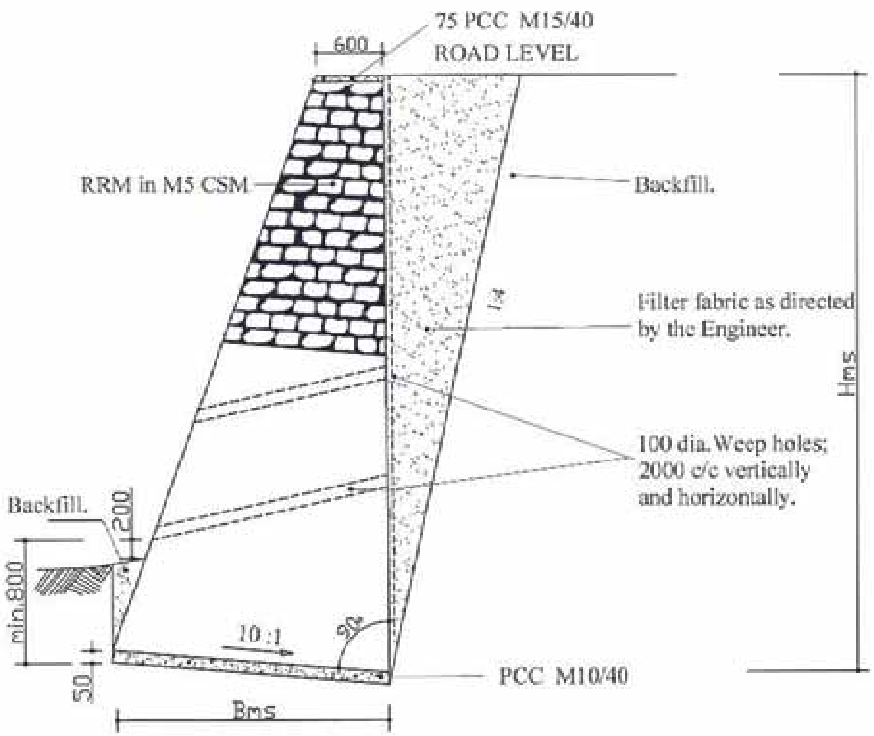
Base Width and Typical Ground Pressure					
	Wall Height (Hd) m	1	2	3	4
Prifile 1	Base Width (Bd) m	0.9	1.3	1.7	2.1
	Ground Pressure : kN/m2	20	35	55	75
Prifile 2	Base Width (Bd) m	1.0	1.5	2.0	2.5
	Ground Pressure : kN/m2	25	45	65	85

Note:

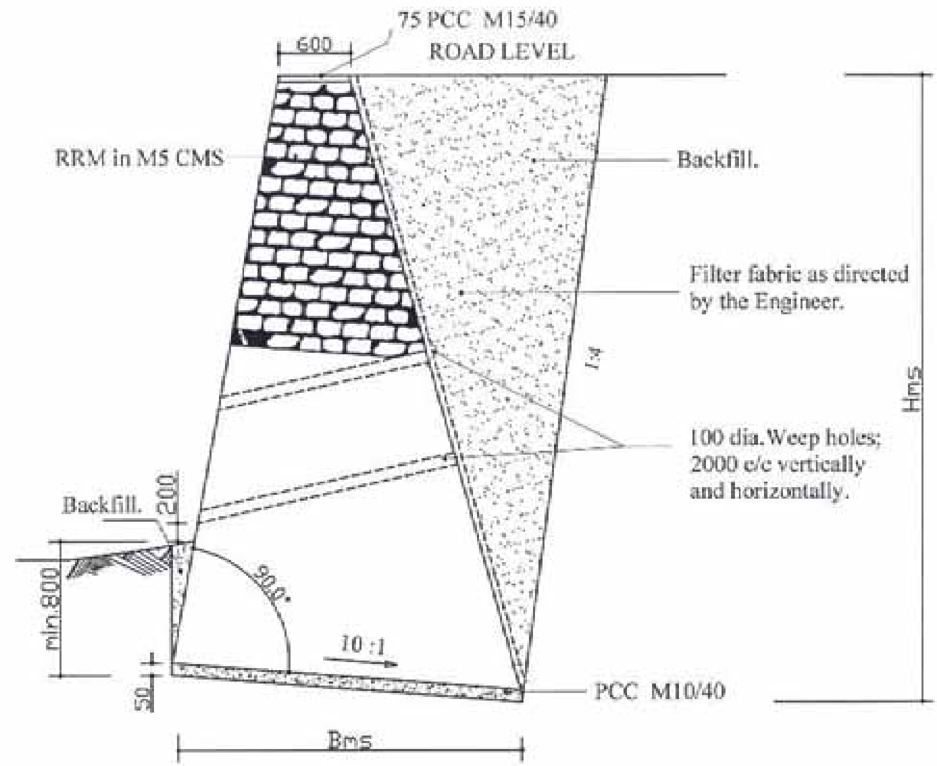
1. Backfill materials behind the walls shall be as directed by the Engineer.

2. Considering vibration from heavy vehicles dry stone wall should not be constructed within in 1 m of the road edge.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Dry Random Rubble Masonry Wall	Scale 500 0 500 1000 2000	Drawing No. DLR/ROAD/T-16



Profile1



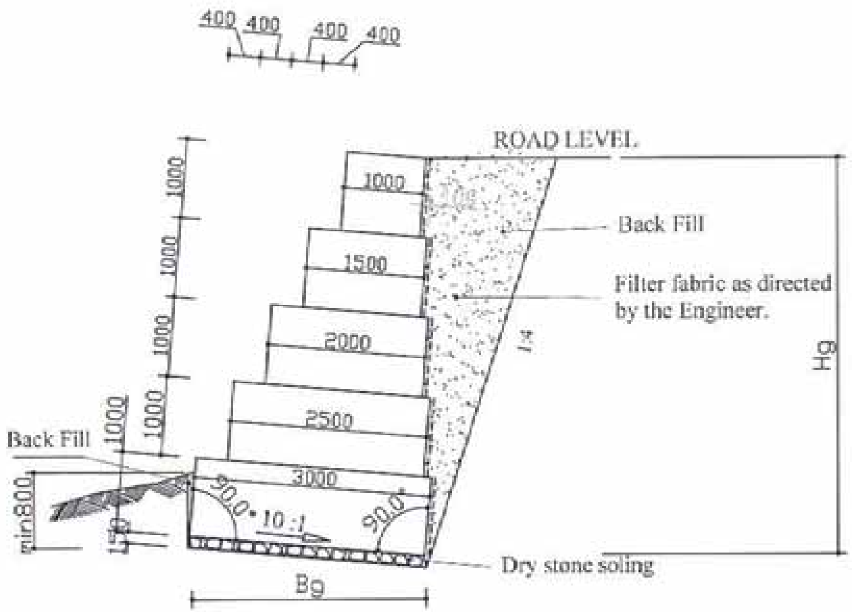
Profile 2

Base Width and Typical Ground Pressure									
Wall Height (Hm) m		2	3	4	6	8	10	12	15
Prifile 1	Base Width (Bm) m	1.4	1.8	2.2	3.0	3.6	4.6	5.4	6.6
	Ground Pressure : kN/m2	40	60	80	120	160	200	250	310
Prifile 2	Base Width (Bm) m	1.5	2.0	2.5	3.5	4.5	5.5	—	—
	Ground Pressure : kN/m2	80	130	170	250	330	410	—	—

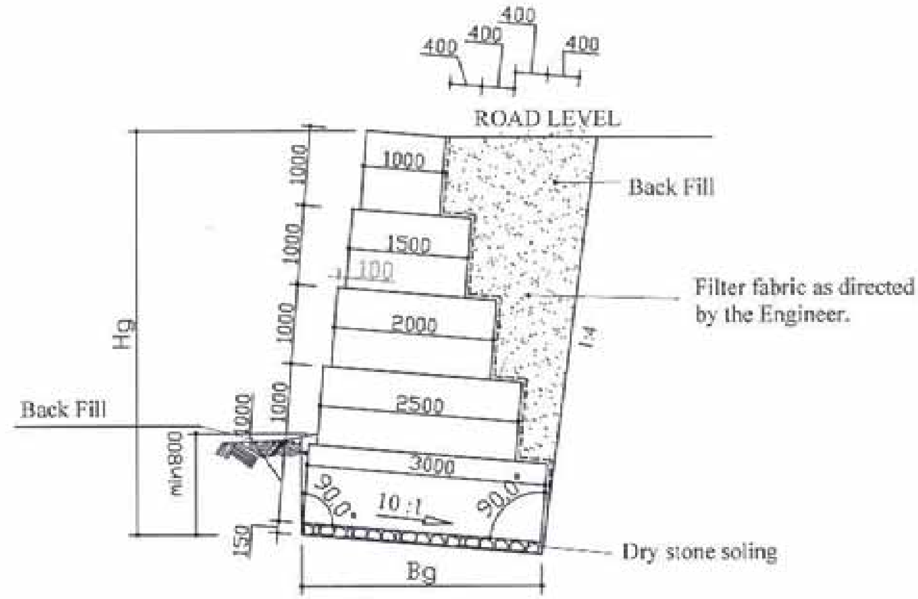
Note:

1. Backfill materials behind the walls shall be as directed by the Engineer.
2. Same dimensions may be used for brick masonry.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Mortared Random Rubble Masonry Wall	Scale 500 0 500 1000 2000	Drawing No. DLR/ROAD/T-17



Profile 1



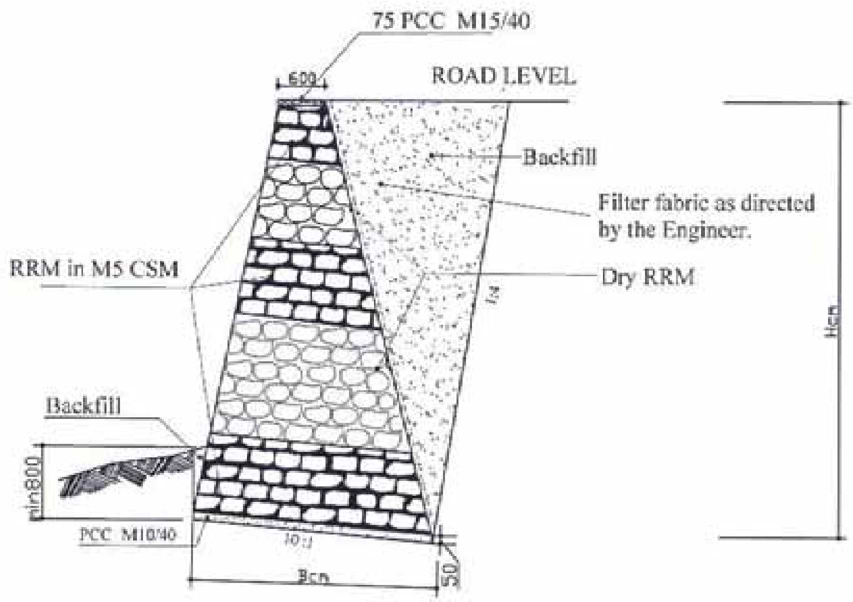
Profile 2

Base Width and Typical Ground Pressure							
Wall Height (Hg)		3	4	6	8	10	12
Prifile 1	Base Width (Bg) m	2.0	2.5	3.5	4.5	5.5	6.5
	Ground Pressure : kN/m2	70	90	120	150	190	230
Prifile 2	Base Width (Bg) m	2.0	2.5	3.5	4.5	5.5	6.5
	Ground Pressure :kN/m2	110	150	220	290	360	420

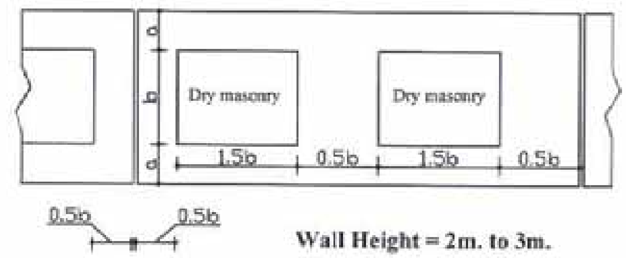
Note:

1. Backfill materials behind the walls shall be as directed by the Engineer.
2. The joints between gabion boxes should be spanned by frequent streture boxes as for bounded brick work, orientd both along the wall and from front to back.
3. Provide drainage of the rear face of wall minimum 300 mm. Drainage channel shoul be packed with 100 -200 mm boulder and provide slope and out let at approximately every 5 m distance.

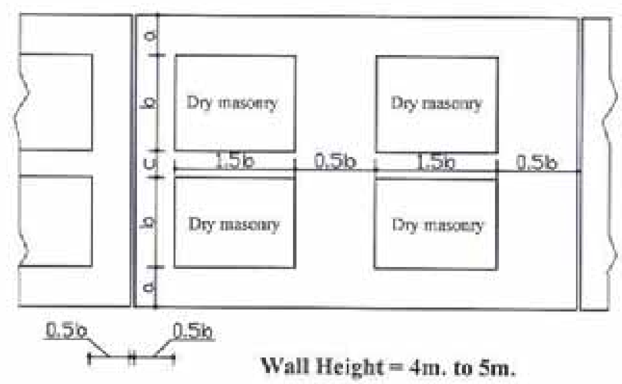
His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Gabion Wall	Scale 500 0 500 1000 2000	Drawing No. DLR/ROAD/T-18



Typical Section



Wall Height = 2m. to 3m.



Wall Height = 4m. to 5m.

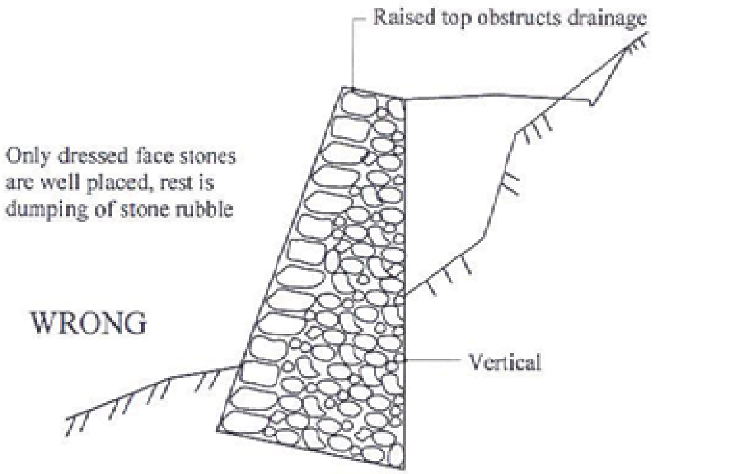
Panel Layout Dimension					
Hc	2	3	4	5	6
a	0.6	0.75	0.6	0.6	0.75
b	0.8	1.5	1.15	1.4	1.75
c	-	-	0.5	1.0	1.0

Note:

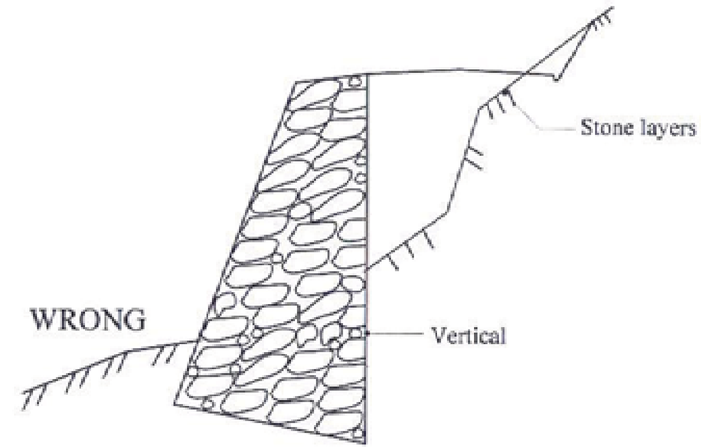
1. Backfill materials behind the walls shall be as directed by the Engineer.
2. The base width (Bc) of Composite wall shall be same as of RRM in CSM

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Composite Wall	Scale 500 0 500 1000 2000	Drawing No. DLR/ROAD/T-19

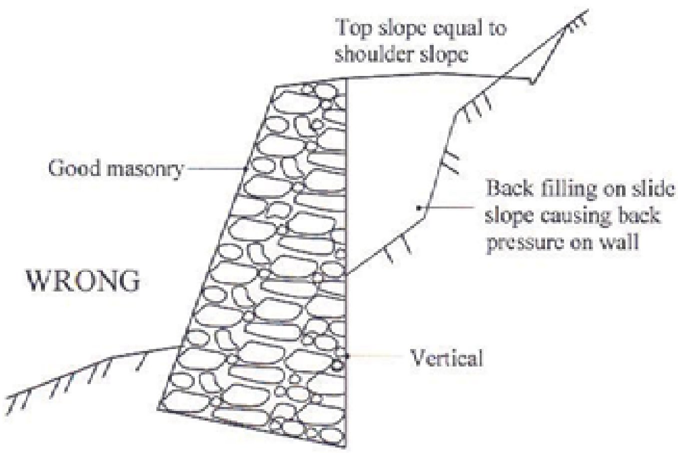
6



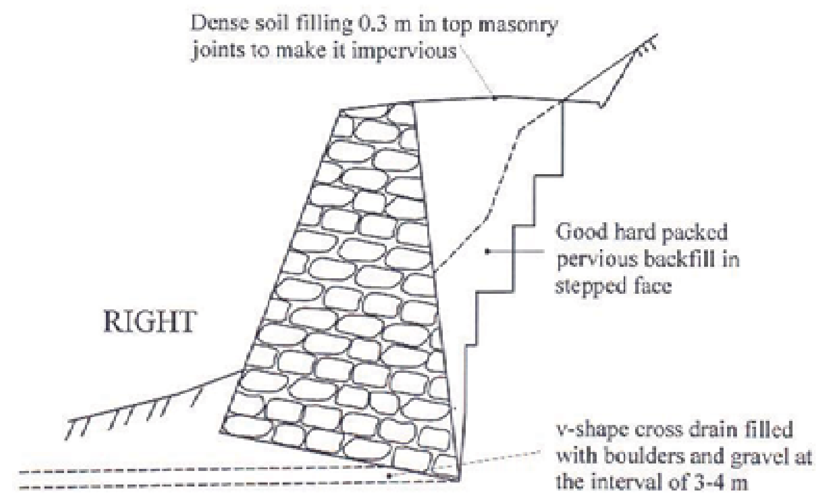
(a) Retaining wall of very poor strength



(b) Retaining wall of poor strength

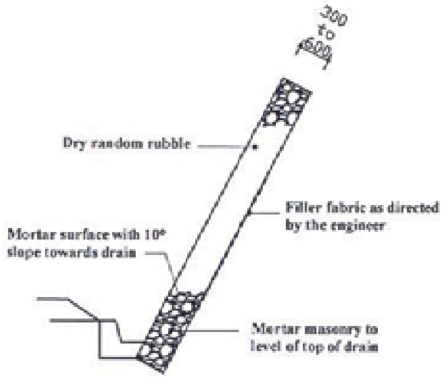


(c) Good retaining wall but unstable filling

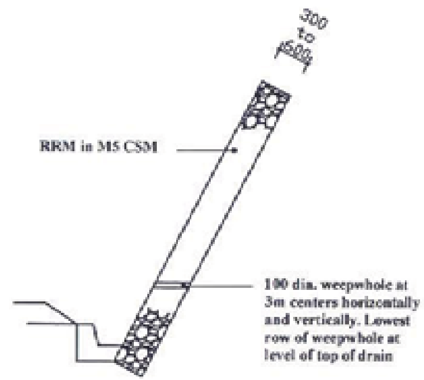


(d) Best retaining wall with good filling

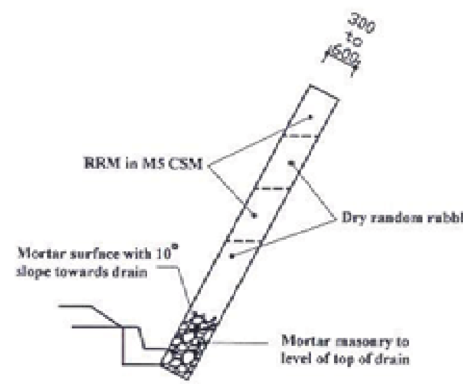
His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Proper Construction Methods of Dry RRM Wall	Scale Not to the Scale	Drawing No. DLR/ROAD/T-20



Dry Random Rubble Type

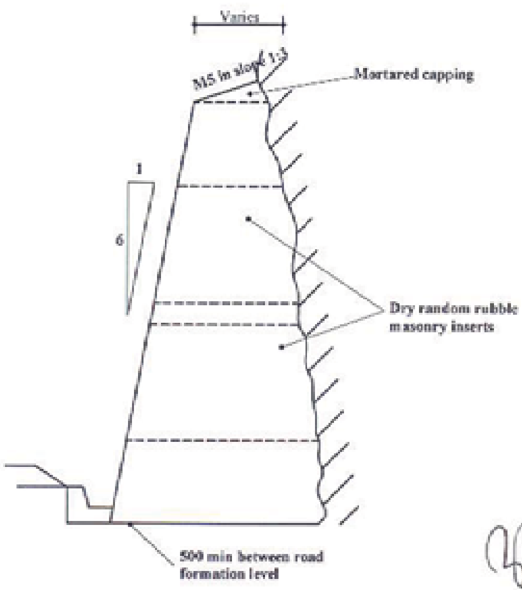


RRM in M5 CSM

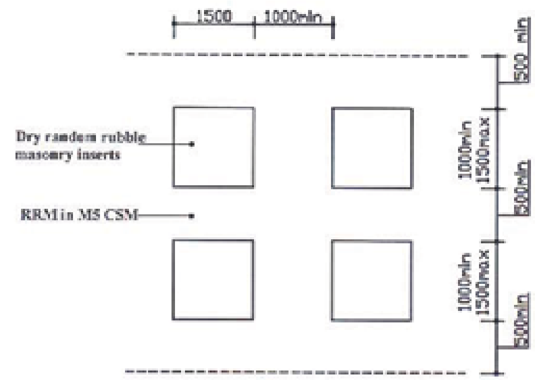


Composite Type

Type of Revetment



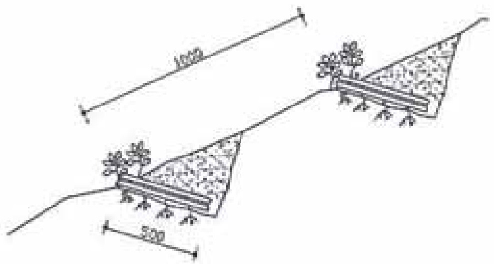
(Wall dimensoions designed to suit conditions)



Composite Masonry Rock Face Protection Wall

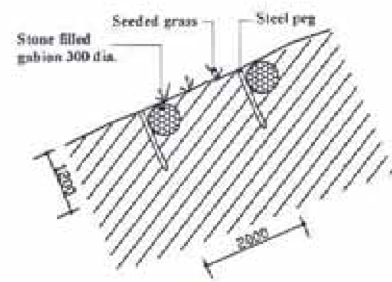
His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Revetment Structures	Scale 0 1000 2000 3000 4000	Drawing No. DLR/ROAD/T-21

Countered or Angled Reinforcement



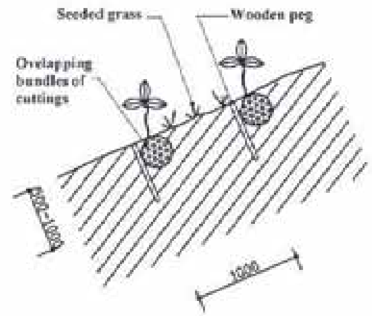
Brush layering

2 rows of live cutting at 20 cutting per metre in each row



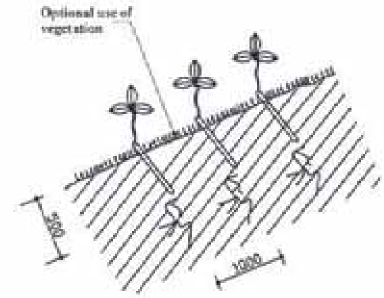
Wire Bolsters

(Gabion sausage)



Fascines

(4 cutting per fascine)

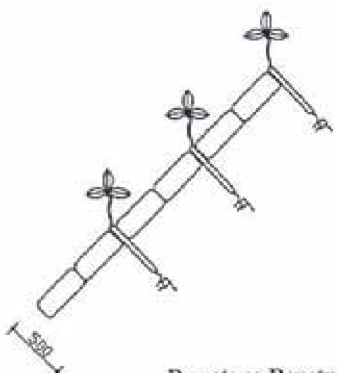


Live cutting

(50 mm spacing in row, Rows cab be double with offset spacing)

Maximum slope $\leq 50^{\circ}$ in all cases

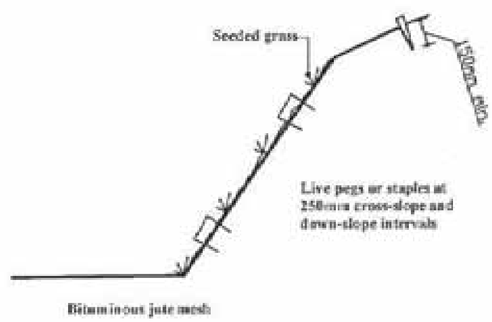
Surface Coverings



Dry stone Revetment with Live Hardwood or Grass Cultings

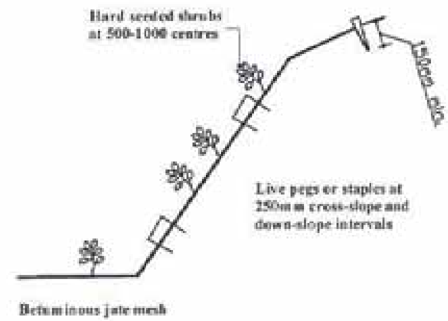
(Random pattern:16 cuttings/m2 apporox if hardwood, 50 cuttings/m2 approx if grass)

(suitable for slope $\leq 40^{\circ}$)



Jute Netting

(Suitable for steeper slope $\geq 50^{\circ}$)

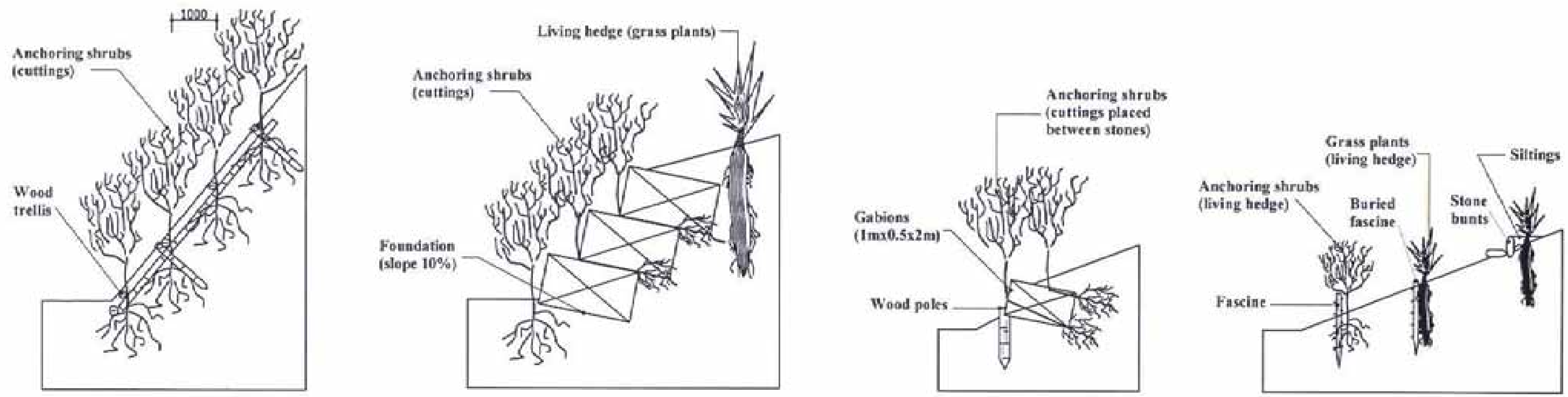


Gabion Netting

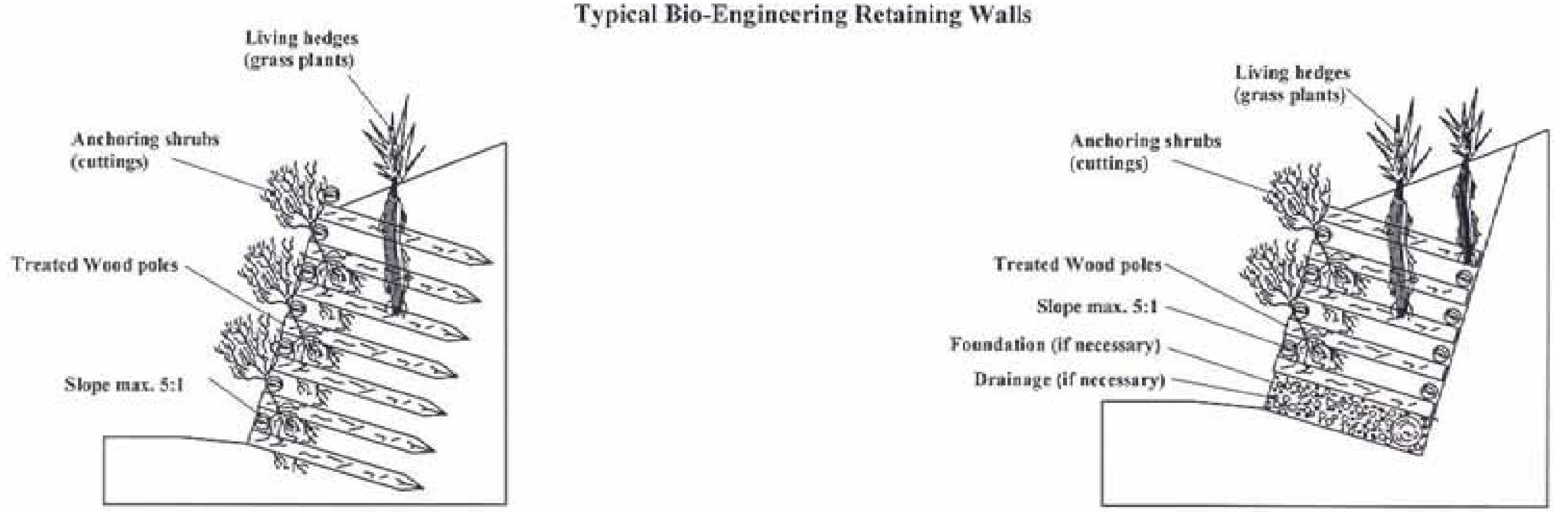
(Suitable for loose rocky slope $\geq 50^{\circ}$)

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Bio-Engineering Slope Protection Measures I	Scale Not to the Scale	Drawing No. DLR/ROAD/T-22

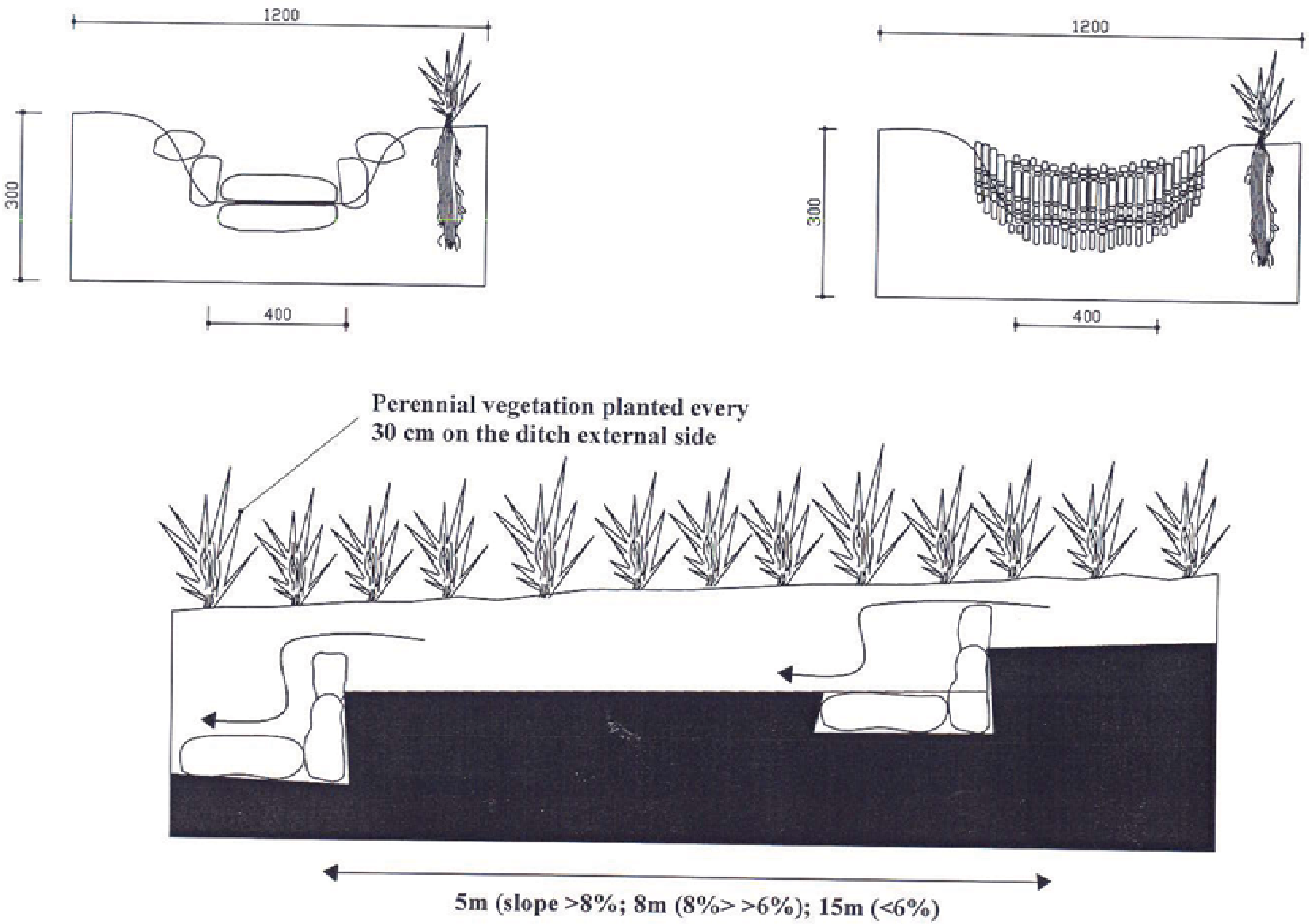
Bio-Engineering Slope Protection Examples



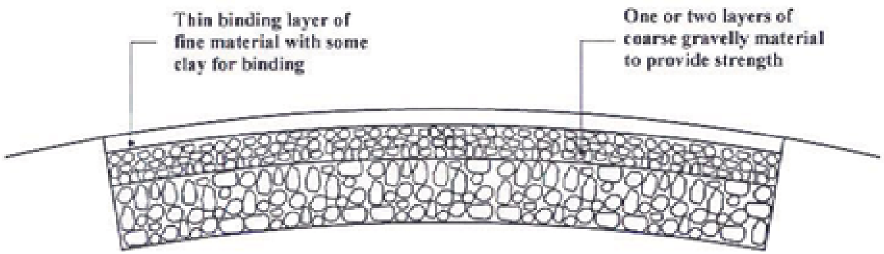
Typical Bio-Engineering Retaining Walls



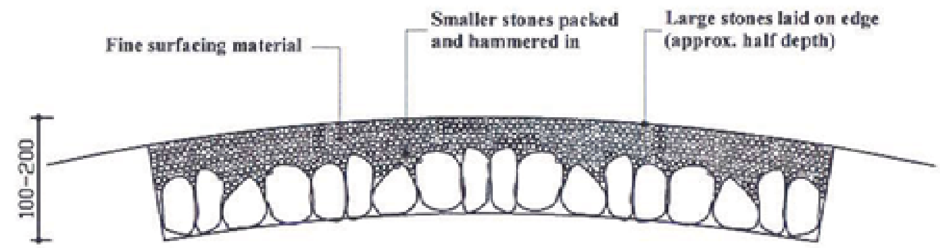
His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Bio-Engineering Slope Protection Measures II	Scale Not to the Scale	Drawing No. DLR/ROAD/T-23



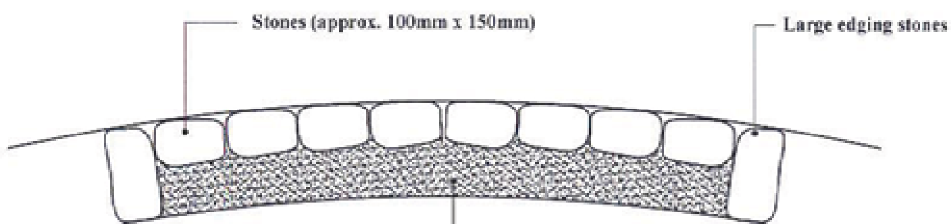
His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Typical Scour Checks	Scale Not to the Scale	Drawing No. DLR/ROAD/T-24



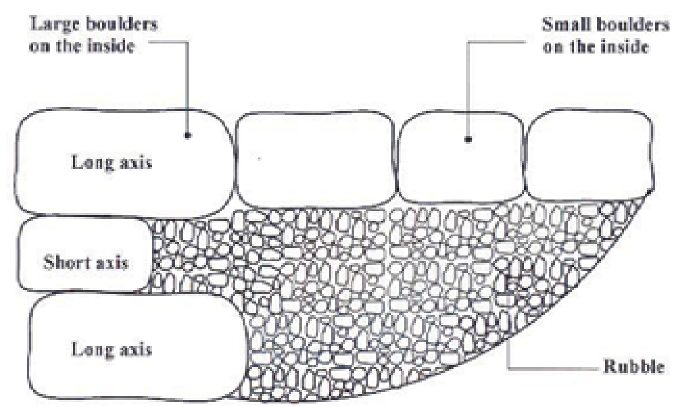
(a) Typical Construction



(b) Telford Construction

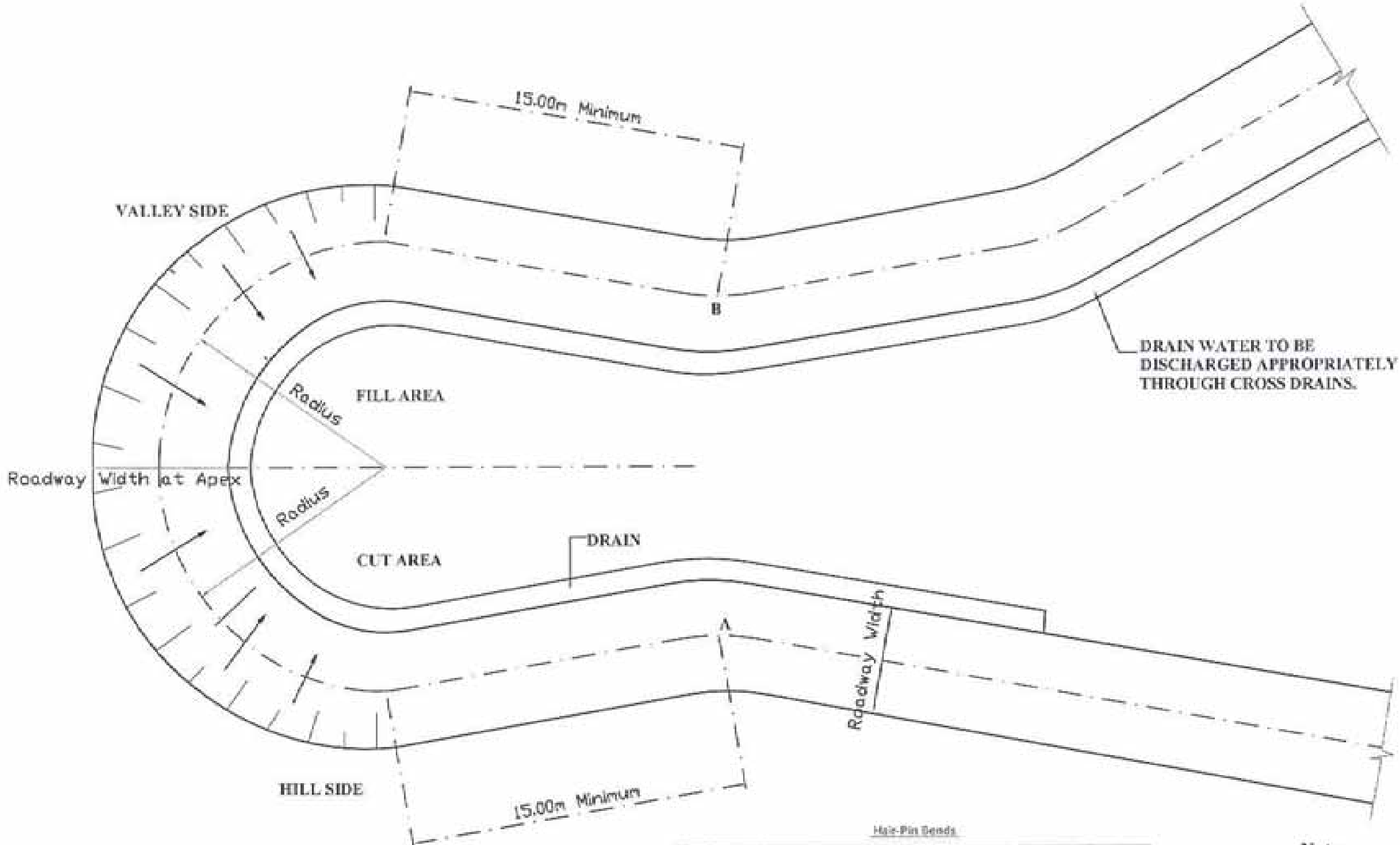


(c) Stone Pitching



(d) Boulder Pavement

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Typical Surfacing Methods	Scale Not to the Scale	Drawing No. DLR/ROAD/T-25



Hair-Pin Bends

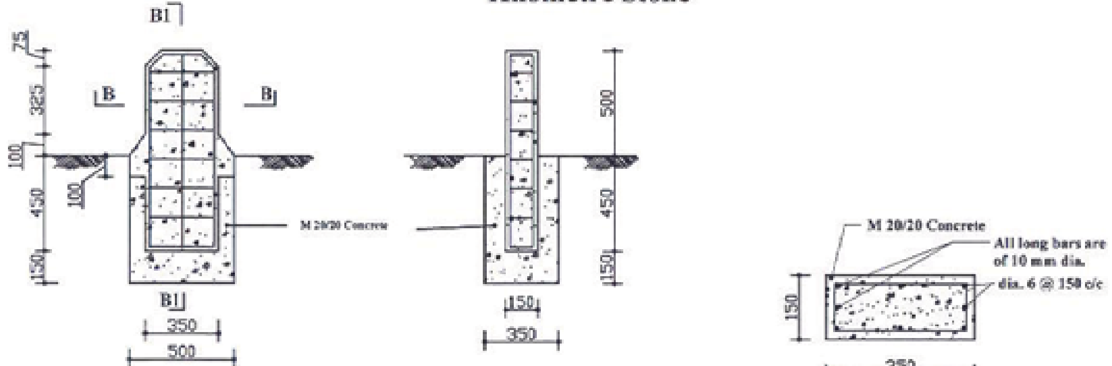
Design Parameter	District Road (Core Network)		Village Road (VR)	
	Hill	Terai	Hill	Terai
Minimum Spacing bretween Hair-pin Bends (m)	100.00	-	100.00	-
Minimum Radius of Curve	12.50	-	10.00	-
Maximum Gradient (%)	4.00		4.00	
Minimum Gradient (%)	0.5 (Max. 1)		0.5 (Max.	
Maximum Super Elevation	10.00		10.00	

Note:

1. Desirable spacing between two hair-pin bend is 100 m but it may be less as per te site condition.
2. The maximum longitudinal gradient at hairpin bend (from A to B) shall be 4 % as far as possible or as directed by Enginner

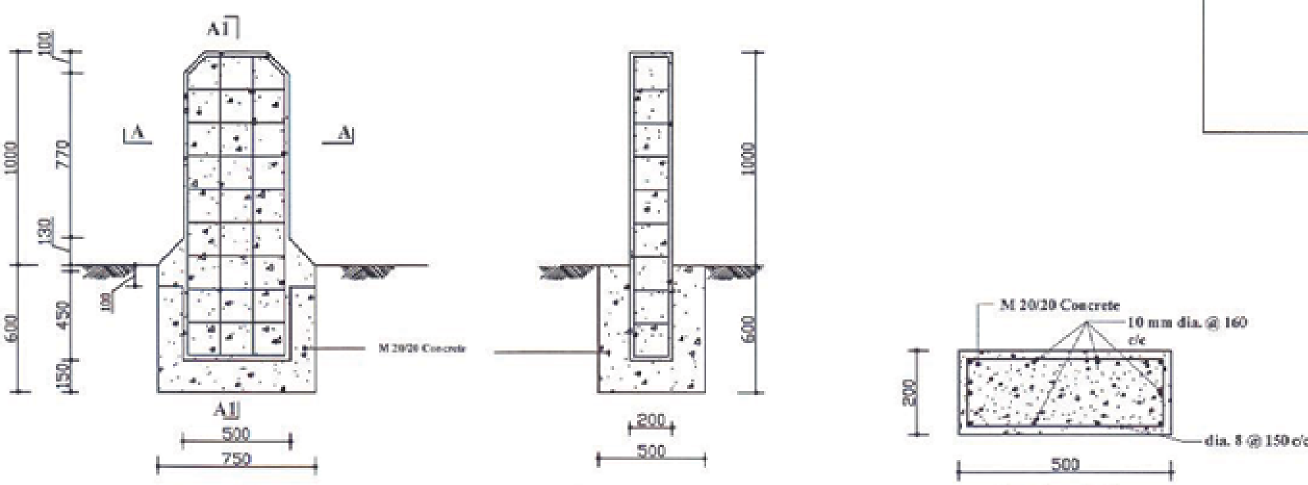
His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Standard Details for Hair Pin Bend	Scale Horizontal 0 1000 2000 Vertical 0 100 200	Drawing No. DLR/ROAD/T-26

Kilometre Stone



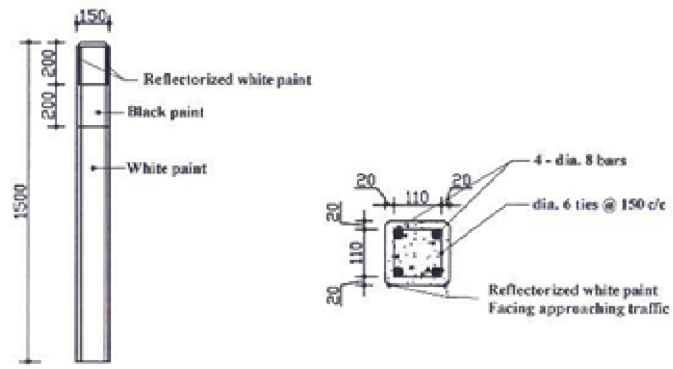
Sectional Elevation | Section B1-B1 | Section B-B

5th. Kilometre Stone



Sectional Elevation | Section A1-A1 | Section A-A

Delineator Post



Delineator Detail

Note:

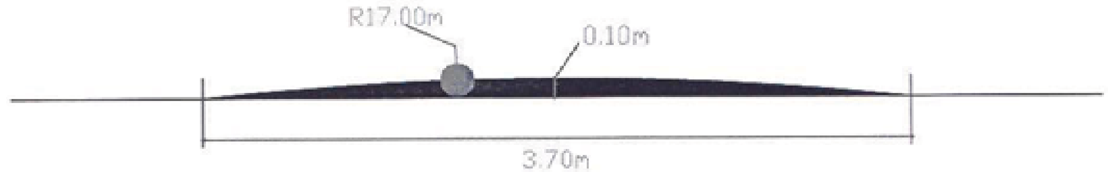
1. Concrete shall be class 250/20.
   No Post shall be installed and paint unless the concrete is 20 days old.
2. The Reinforcement shall be tor steel confirming to IS 456(1978)

Notes:

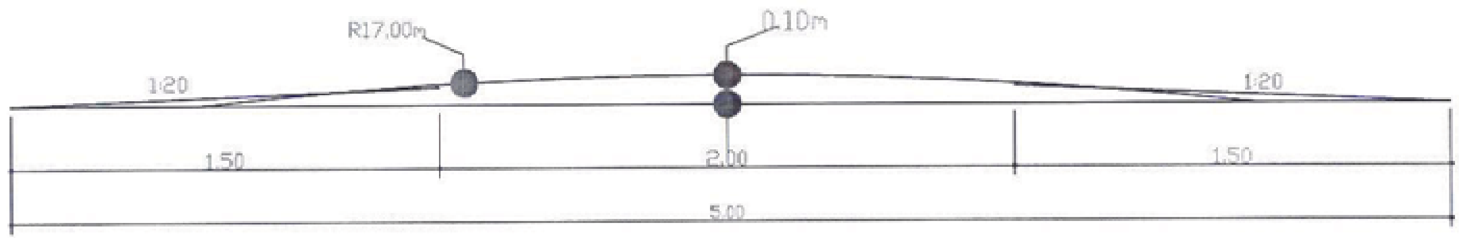
1. K.M. Post will have the name and distance in kilometres of intermediate station only. The name being on top and the distance at the bottom.
2. Alternate K.M. Post will be in Nepali and English languages.
3. The 5th. K.M. Post will have the name and distance in K.M. of terminal station on one face and the starting station at other face.
4. The 5th. K.M. Post will have description both in Nepali and English languages, Nepali language being on top.
5. The top trapezoidal portion of a 5th.K.M. Post will show the R.L. in metre on both faces.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of Rural Roads	Delineator and Kilometer Post	Scale 100 0 500 100 0 200	Drawing No. DLR/ROAD/T-27

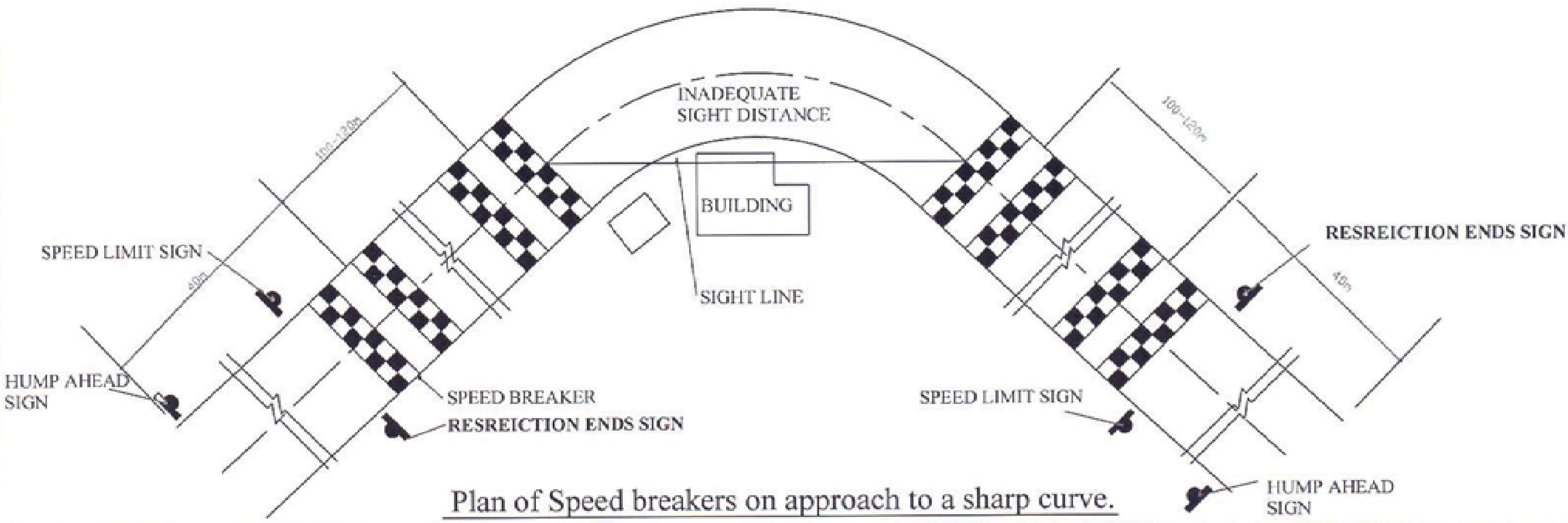
6



Longitudinal Section



Recommended specification for HUMP type of speed breaker for heavy truck and bus at preferred crossing sprrd 25 km/h



Plan of Speed breakers on approach to a sharp curve.

His Majesty's Government of Nepal Ministry of Local Development Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR)	Typical Design Drawings of HUmps	Hump type of Speed breaker	Scale 1000 0 1000 2000	Drawing No. DLR/ROAD/T-28

D Quality Control for Road Works

1.0 INTRODUCTION

This part of the manual deals with issues for assuring the quality of the civil works. Quality of civil works depends not only on good design but also on ***arrangement of the civil works***, adequacy and effectiveness of ***construction supervision*** including quality of materials. These issues need to be addressed early from designing rural roads and preparing the project Implementation Plan. Project Implementation Plan includes, Plan for Work Schedules, procurement of Works, Goods and Services; monitoring and evaluation system.

2.0 CONTROL OF ALIGNMENT AND SURFACE REGULARITY

2.1 Description

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

2.2 Horizontal Alignments

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

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

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

2.3 Vertical Alignment (Longitudinal Profile)

The level 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 directed by the Engineer, beyond 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.

2.4 Surface Regularity of Sub-grade and pavement Courses

The surface regularity of compacted sub-base, base course and wearing surfaces in the longitudinal and transverse direction shall be within the tolerances indicated in Table D-1.

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

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

Table D-1: Permitted Tolerances of urface Regularity for Pavement Courses

S.No	Type of Construction	Longitudinal Profile with 3 m Straight Edge					Cross Profile
		Maximum Permissible Undulation mm	Maximum number of undulations which exceed () mm Permitted in any 300 m length (no)				Maximum permissible variation from specified profile under Camber Template (mm)
			(18)	*(12)*	*(10)*	*(6)*	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	Earthen sub-grade	24	30	-	-	-	15
2	Granular/lime/cement/ stabilized Sub-base	15	-	30	-	-	12
3	Water Bound Macadam with oversize material (40-90 mm size)	15	-	30	-	-	12
4	Water Bound Macadam with nominal size material (20-50 mm and 40-63 mm size), Bituminous penetration Macadam or built spray grout	12	-	-	30	-	8
5	Surface Dressing* (Two coat) over WBM (20-50 mm or 40-63 mm size material) Bituminous penetration Macadam or built spray grout	12	-	-	20	-	8

6	Open graded pri-mix carpet, mix sealing surfacing	10	-	-	-	30	6
7	Bituminous Macadam	10	-	-	-	20**	6
8	Semi-dense carpet	10	-	-	-	20**	6
9	Asphalt Concrete	8	-	-	-	10**	4

Note:

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

** These are the machine laid surfaces. If laid manually, tolerance up to 50% above these value in the 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 column 3 and 8 on the table.

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

3.0 QUALITY CONTROL TESTS DURING CONSTRUCTION

Quality control tests of the materials shall strictly conform to the Technical Specification of DoLIDAR>

Appendix

Appendix – 1: Format for Rural Road Sub-project Proposal

District		**Date:**	
Project Introduction:		**District Priority:** (As per DTMP or other Plan Document/other Policy Decisions)	
Project Description:	*starting point……………………. End point………………..*	**Total length**	
Major settlements within the actual Zone of Influence: (settlements on route, within certain walking distance; also include partially served settlements as well)			
Significant River Crossings: (include major river crossings requiring medium or large span bridge as a separate sub-project)			

Brief history: When the road (or the track) was opened?; How was the traffic volume when the road was first built?;Any traffic variation there after/; Main civil works done in the past?)	
Existing Condition; (Physical condition of the road?; What kind of geometric/Engineering standards the road has?; How is the traffic now?; What needs to be done to develop the track into all weather road, operable condition year around?)	

Socio-economic/ demographic/Environmental Information:		
Influence Area: (Mention settlement and/or VDC wise population/number of households, average walking time from those settlements to the road for all the fully and partially served (influenced) settlements)		
Production and Social Service Condition: (as per the settlements within the influence area)		
Land acquisition and Environmental Concerns: (Specify if any private land acquisition encountered; Specify major environmental concerns e.g passing through conservation area, forests, active land slide etc.)		

Cost Estimate (Civil works only)		**Prevailing Rates in the area**	**Amount (NRs.)**	**Proposed mode of civil works implementation** (mention most likely mode such as through User Group (RBGs), s mall Local Contractors, Group Contract etc)
Earthwork; (A tentative estimate of volumes of earthwork, Distinguished as ordinary soil, soft rock, hard rock etc)				
Stone Soling: (Estimate the magnitude of stonr soling)				
Gravelling: (tentative estimate of required magnitude; Make distinction between broken gravel and river bed material with specification)				
Retaining Structures: (Estimate the magnitude of retaining structures making clear distinction between gabion, drywall, stone masonry RCC or any other type)				
Side Drain: estimate magnitude of side drains with respect to different type of side drain				

Cross Drains; (Estimate number of cross drains such as dry stone causeway(Drift), Masonry Causeway, Vented causeway, Pipe Culvert, hume pipes, slab Culvert or any other appropriate type)				
Roadside vegetation: (Estimate tentative magnitude with some specification of proposed types)				
Other Works : i)				
ii)				
iii)				
iv)				

Proposal Preparation

District Engineer/
DTO Chief...

Approved :..............................

President, DDC

Local Development officer...

Attachments:

1. **Maps of the area showing the road/trail or track as applicable showing the proposed road alignment with its influence area marked.**
2. **Any other relevant documents, if any**

5

Appendix-II selected References

1. Technical Guidelines for Agriculture ana Rural Roads: DoLIDAR, MoLD, HMGN; March 1998

2. Construction Guidelines for Low Cost Feeder Roads; department of Roads. Ministry of works and transport, HMGN, December 1995

3. Technical Specification for labour-based Construction Work of Agriculture and Rural Roads: DoLIDAR, MoLD, HMGN; January 2000

4. Approach for the Development of Agriculture and Rural Roads DoLIDAR, MoLD, HMGN; July 1999

5. Design and Appraisal of rural Transport Infrastructure, World Bank Technical Paper No: 496; Jerry lebo and Dieter Schelling; The World bank, Washington; April 2001

6. Investment in Rural roads: Socio-economic Analysis model foe Nepal (Final Draft for discussion); Project Preparation Team, RAIDP/DoLIDAR; July 2004

7. Rural Road manual; Indian Road Congress Special Publication 20; New Delhi, 2002

8. Principles of low Cost Road Engineering in Mountainous Region with specific reference to Nepal Himalaya; Road Note No:16 prepared by Transport Research laboratory, (TRL), Crowthorne, UK

9. Public Works Directives, HMGN, January 2002

10. IRC 99 Tentative Guidelines on the Provision of Speed Breaker for Control of Vehicular Speed on Minor Roads, Indian Road Congress Publication