PRADHAN MANTRI GRAM SADAK YOJNA

HAND BOOK FOR PMGSY ENGINEERS

M.P. Rural Roads Development Authority

Hand Book

For PMGSY Engineers

M.P. RURAL ROAD DEVELOPMENT AUTHORITY

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Madhya Pradesh

FOREWORD

Pradhan Mantri Gram Sadak Yojna was launched on 25th Dec. 2000 for providing all weather connectivity to rural, habitations. At that stage, Ministry of Road Transport & Highways specification for Roads and Bridges and SOR Issued by Engineer-in-Chief MPPWD which was based on the these specifications was adopted for construction of Rural Roads under the scheme.

Subsequently Rural Roads Manual (IRC:SP:20-2002) was published by Indian Road Congress containing both guidelines as well as specifications for designing the Rural Roads followed by a book of "Specifications for Rural Roads" (Aug. 2004) published by IRC for Ministry of Rural Development in the context of Pradhan Mantri Gram Sadak Yojna. National Rural Road Development Agency also developed a quality control Hand Book for use in PMGSY works.Several technical circulars were issued by NRRDA and MPRRDA from time to time for the guidance of field engineers. Because of the sheel volume of these circulars. There is a need to arrange them systematically in the form of one comprehensive booklet together with the specifications of Rural Roads in a clear and concise manner.

There is no denial to the fact that engineers at junior level have very vital role to play in the construction of roads right from survey & investigation to construction and quality control. This book is primarily drafted for use as a ready reference by this group of engineers. Engineers at higher levels may also find it useful for reference during their inspections. This book is useful not only to the engineers of PIUs and consultants but also for the contractors and their engineers.

This document is the result of tireless efforts of the engineers of MPRRDA. I, therefore, wish to place on record my appreciation for the hard work done by the officers in bringing out this document.

(Shailendra Singh)
Chief Executive Officer
M.P. Rural Road Development Authority

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CHAPTER - 1

INTRODUCTION

1. It is an established fact that providing good all weather connectivity to any habitation leads a path for all round development of residents of the area. In the recent past, the engineers involved in road making were on the receiving end of public critisism in some part of state. The art of road making, designing, drainage provisions etc. are essentials for any highway engineer and he should be conversant with these. There are lot of changes in techniques and procedures of road making in recent times and engineers are required to be reminded about their role and responsibilities. This hand book is prepared for all engineers involved with execution of their ready reference. This will be more useful to those engineers who are involved in making rural roads.

2. The role of engineers is to ensure proper quality control of roads with desired and adequate design, according to the specifications and providing proper comfort to the users. The quality control in road construction requires proper control on workmanship and materials. The two important means of specifying a finished product are (i) by process. and (ii) by end result. To achieve the required standards in the construction of rural roads, quality control tests are to be carried out and acceptance criteria are to be matched with the IRC SP 20 i.e. Rural Roads Manual. The Manual draws upon several IRC standards, codes of practice and guidelines on various components of roads planning, design, construction and maintenance.

3. For day-to-day reference of the Engineers (departmental, consultant's or contractor's engineer) in the field and the Contractors engaged in construction of rural roads under the PMGSY, a Handbook on Quality Control has been prepared based on the four basic sources namely.

(i) Rural Roads Manual : IRC : SP : 20 - 2002

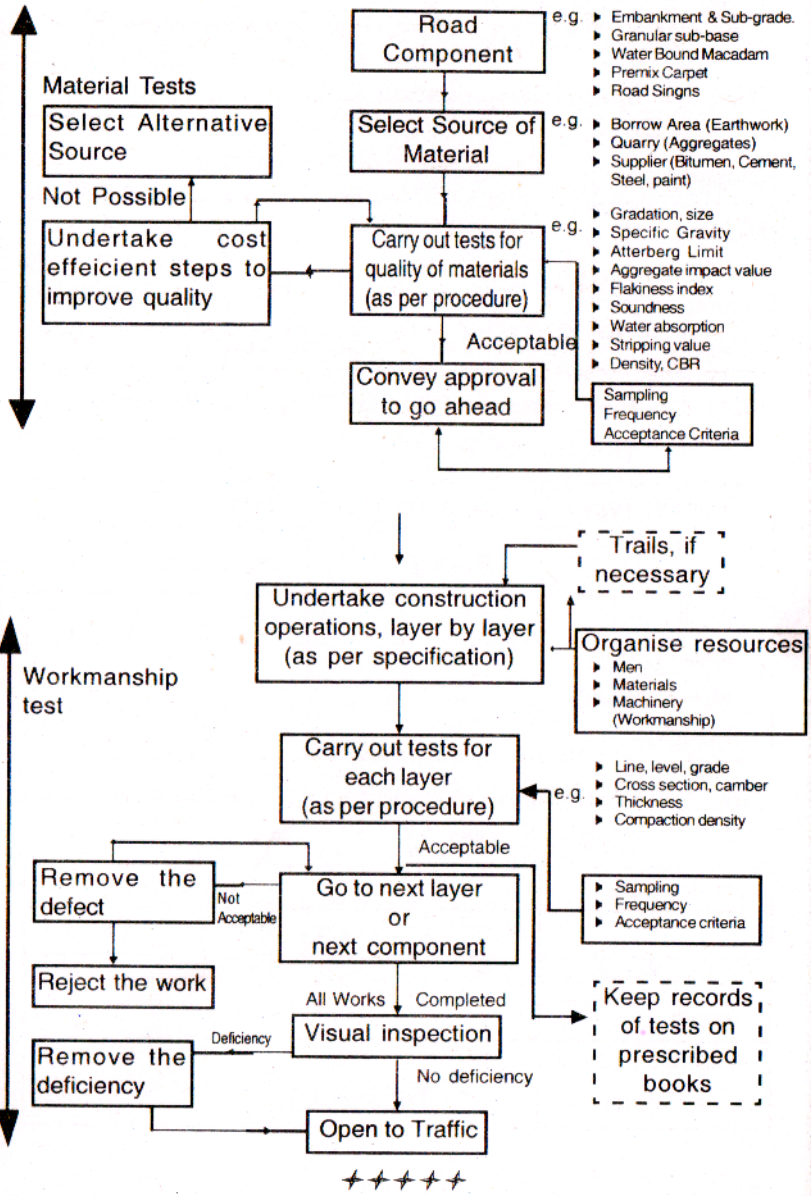
(ii) Specifications for Road and Bridge Works : (Fourth Revision) Ministry of Road Transport and Highways - 2001.

(iii) Hand Book of Quality Control for Construction of Roads and Runways : IRC : SP : 11 - 1988.

(iv) Specification For Rural Roads published by IRC for MORD (2004)

4. A typical flow chart for ensuring quality in road construction covering various phases and components of road works is given as an illustrations in Figure 1.1.

Figure 1.1 : Typical Flow Chart For Quality in Road Works.



CHAPTER - 2

GEOMETRIC DESIGN STANDARDS

Table 2.1. Terrain Classification. [Table 2.1 of SP 20]

Terrain Classification	Cross slope of the country	
Plain	0 - 10 Percent	1 in 10 or more
Rolling	10 - 25 Percent	1 in 10 to 1 in 4
Mountainous	25 - 60 Percent	1 in 4 to 1 in 1.67
Steep	Greater than 60 percent	Less than 1 in 1.67

Table 2.2. Recommended Design Speed For Rural Roads.
[Table 2.2 of SP 20]

Terrain Type	Design Speed (Km/h)	
	Ruling	Minimum
Plain	50	40
Rolling	40	35
Mountainous	25	20
Steep	25	20

Table 2.3. Recommended Road Land Width For Rural Roads.
[Table 2.3 of SP 20]

Terrain Type	Open Area		Built up Area	
	Normal	Range	Normal	Range
Plain & Rolling Terrain	15	15 - 25	15	15 - 20
Mountainous and Steep Terrain	12	12 (Exceptional)	12	9 (Exceptional)

Table 2.4. Recommeded Standards For Building And Control Lines For Rural Roads. [Table 2.4 of SP 20]

Plain & Rolling Terrain		Mountainous and Steep Terrain	
Open Area	Built Up Area	Open Area	Built up Area
Overall Width between Building Lines	Overall width between control lines	Distance between building line and road boundry (Set Back)	Distance between building line and road boundry (Set Back)
25/30*	35	3 - 5	3 - 5

Note : * If the land width is equal to width between the building lines,the building lines should be set - back in 2.5m from the road boundry.

Table 2.5. Recommended Roadway Width [Table 2.5 of SP 20]

	Roadway Width(m)
Plain Rolling	7.5
Mountainous and Steep	6.0

Note :
1. If the traffic intensity is less than 100 motor vehicles per day, and where the traffic is not likely to increase due to situation like dead end, low habitation and difficult terrain conditions, the road way width may be reduced to 6.0m in plain & rolling terrain.
2. The road way width given in above table for mountainous and steep terrain is inclusive of parapet.
3. The roadway width for rural roads is on the basis of a single lane carriage way of 3.75m.
4. On horizontal curves the roadway width should be increased corresponding to the extra width of carriageway for curvature.

Table 2.6. Recommended Carriageway Width [Table 2.6 of SP 20]

Road Classification	Carriageway Width (m)
Rural Road (ODR & VR)	3.75

Note : For rural roads, the carriage way width may be restricted to 3.0m, where the 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 conditions.

Table 2.7. Side Slopes For Rural Roads [Table 2.7 of SP 20]

Condition	Slope (H:V)
Embankment in silty/ Sand/ Gravelly soil	2 : 1
Embankment in clay or clayey silt or inundated condition.	2.5 : 1 to 3 : 1
Cutting in silty/ Sandy/ Gravelly soil.	1 : 1 to ½ : 1
Cutting in disintegrated rock or conglomerate	½ : 1 to ¼ : 1
Cutting in soft rock like shale	¼ : 1 to 1/8 : 1
Cutting in medium rock like sandstone, phylite	1/12 : 1 to 1/16 :1
Cutting in hard rock like quartzite, granite	Near Vertical

Table 2.8. Recommended Roadway Width At Bridge
[Table 2.9 of SP 20]

Road classification	Clear Roadway Width (M)
Rural Road (ODR & VR)	5.5

Note :
1. The road way width specified in above table is exclusive of parapet.
2. If the traffic is less than 100 motorised vehicles per day and it is not likely to grow due to situation, like dead end, low habitations and difficult terrain conditions, road way width at bridge may be reduced to 4.25m.

Table 2.9. Recommended Roadway Width At Causeway & Submersible Bridge [Table 2.10 of SP 20]

Road Classification	Overall Roadway Width (M)	
	Plain & Rolling steep Terrain	Mountainous and
Rural Roads	7.5	6.0

Table 2.10. Recommended Camber For Different Surface Types [Table 2.11 of SP 20]

Surface Type	Camber (Percent)	
	Low Rainfall (Annual Rainfall < 1000mm)	High Rainfall (Annual Rainfall > 1000mm)
Earth Road	4.0	5.0
WBM & Gravel Road	3.5	4.0
Thin Bituminous Pavement	3.0	3.5
Rigid pavement	2.0	2.5

At super-elevated road sections, the shoulder should normally have the slope of same magnitude and direction as the pavement slope subject to the minimum cross-fall allowable for shoulder. The camber for earth shoulder should be at least 0.5 per cent more than that for the pavement subject to the minimum of 4 percent. However, 1 percent more slope than the camber for pavement is desirable.

Table 2.11. Recommended Maximum Superelevation For Rural Road.

Terrain Type	Super Elevation (Percent)
Plain & Rolling Terrain	7%
Hilly but not snow bound	10%

Table 2.12. Radii Beyond Which Superelevation Not Required.

[Table 2.14 of SP 20]

Design Speed (km/h)	Radius (M)			
	4 Percent Camber	3 Percent Camber	2.5 Percent Camber	2.0 Percent Camber
20	50	60	70	90
25	70	90	110	140
30	100	130	160	200
35	140	180	220	270
40	180	240	280	350
50	280	370	450	550

Table 2.13. Minimum Radii Of Horizontal Curve. (in meters)

[Table 2.15 of SP 20]

Terrain Type	Plain	Rolling	Mountainous (Areas not effected by snow)	Steep (Areas not effected by snow)
Ruling minimum	90	60	20	20
Absolute minimum	60	45	14	14

Table 2.14. Widening Of Pavement At Curve.

[Table 2.17 of SP 20]

Radius of Curve (m)	Up to 20m	21 - 60m	Above 60m
Extra widening for 3.75 m wide single lane carriageway	0.90	0.60	Nil.

Note : Widening of curve shall be made at inner edge of the curve.

Table 2.15. Recommended Gradient For Different Terrain Condition. [Table 2.19 of SP 20]

Terrain	Ruling Gradient	Limited Gradient	Exceptional Gradient
Plain & Rolling	3.3 percent (1 in 30)	5 percent (1 in 20)	6 percent (1 in 16.7)
Mountainous terrain and steep terrain having elevation more than 3000m above the mean sea level.	5 percent (1 in 20)	6 percent (1 in 16.7)	7 percent (1 in 14.3)
Steep terrain having elevation more than 3000m above the mean sea level.	6 percent (1 in 16.7)	7 percent (1 in 14.3)	8 percent (1 in 12.5)

Note : Exceptional gradients may be adopted in very difficult situation and for short length not exceeding 100 m stretch and should be separated by at least & between two successive stretches.

Table 2.16. Recommended Minimum Vertical Clearance At Underpass.

Description	Vertical Clearance (m)
Vertical Clearance at under pass	4.5
Vertical Clearance at Railway Traction : (a) Electric Traction (b) Non Electric Traction.	 5.87m Minimum. 4.875m Minimum.
Vertical Clearance for Power / Telecommunication Lines: (a) Lines carrying low voltage up to 110V. (b) Electric Power Lines up to 650V. (c) Electric Power Lines > 650 V.	 5.5m Minimum. 6.0m Minimum. 6.5m Minimum.

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CHAPTER - 3

PREPARATORY WORKS

3.1 This includes :

1. Transit Walk
2. Co-ordination meeting of Contractors, Consultants and PIU Engineers
3. Prepration and approval of construction programme
4. Establishment of contractor's laboratory. (not later than 30 days.)
5. Calibration of Lab Equipments.
6. Site Clearance.
7. Setting out of Works.
8. Pre commencement levels and calculations of R.L.
9. Preparation of Working Drawings.
10. Estimation of quantity of construction material required for each layer i.e.embankment, sub-grade, GSB, WBM layers, surfacing and CD works etc.
11. Identification and approval of quarries.
12. Testing of quarry materials.
13. Testing of Borrow Material.
14. Assessment of requirement of machineries during construction of each layer.

Table : 3.1 Tentative list of key equipments for Rural Roads .

Name of the Equipment	Quantity
Hydraulic Excavators	2
Dozer	1
Motor grader	1
Earth Compactor	1
Drum type hot mix plant with appropriate Capacity	1
Paver Finisher (3.5 to 5m wide)	1
Diesel Road Roller	5
Smooth Wheeled Tendum Roller	1
Vibratroy Rollers	2
Broomer	1
Truck	20
Tractor	3

Name of the Equipment	Quantity
Truck/tractor driven Water tanker with sprinkler	4
Tipper 10 tons and above Capacity	5
Bitumen pressure distributor	1

Note : The number of equipments may vary depending on type, time limit of completion and size of contract package.

Laboratory & Equipments :

The list of required equipments for quality control tests at district level laboratory as well as field laboratory of the contractor is given in appendix 10.2. of Rural Road Manual 2002 (SP 20-2002) for one contract package.

3.2 The Number of Technical personnel, Qualifications and Experience will be as follows:

Table 3.2 Tentative field staff required for one contract package.

Position	Minimum qualification	Number		Minimum Experience (in years)
		For work costing upto Rs. 5 Crores	For work costing more than Rs. 5 crores.	
Project Engineer	B.E. Civil	1	1	3
Asstt. Project Engineer	B.E. Civil		1	3
Material Engineer	B.E.	1	1	3
Lab technician	Dip. in lab technician or equivalent	1	2	3
Field Engineer	Diploma in Civil Engineering	1 per two crores work	1 per two crores work	2

Table 3.3 Field staff for Contractor's Laboratory

Technical Personnel	Number	Minimum Experience in lab work (in years)
Lab Technician	1	5
Lab Assistant	2	2

Note : The number of engineers and lab personnel may vary depending on type and size of contract package as well as time of completion

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CHAPTER - 4

PREPARATION OF DETAILED PROJECT REPORT

For every road there should be a detailed project report. This report should contain following details:-

1. Detail of Transit walk
2. Selection of alignment
3. Selection of quarries of raw material
4. Availability of land along the alignment
5. Locations of cross drainage works
6. Location of important monuments, trees, electric or telephone poles, other places of importance.
7. A land plan.
8. L section.
9. Cross sections.
10. Road classification.
11. Terrain classification.
12. Geometric design.
13. Traffic survey data and projection for design period.
14. Climatic and environmental data.
15. High flood level data.
16. Design speed.
17. Soil investigation data(gradation test, LL and PI, OMC & MDD, CBR, free swelling index and other parameters).
18. Metal and other material investigations.
19. Pavement design.
20. Hydraulic data for cross drainage works.
21. Requirement and Design of rigid pavement.
22. Road side drain, catch water drain and sub surface drain.
23. Drawing and design of CD works.
24. Location of permanent and temporary bench marks.

The engineers of PIU should walk on proposed alignment along with consultancy engineers, patwari, Sarpanch and Senior people of village. The data of this transit walk may be carefully noted down by PIU engineer and consultancy. During this details of HFL, Location of CD, Location of quarries, alternative alignment, availability of Government land, preliminary soil details etc. should be collected. The consultant will then conduct survey after fixing bench marks. PIU engineers will check the survey work for its accuracy. On the basis of this, Preliminary project report (PPR) will be prepared. The engineer of PIU, preferably AM or GM will scrutinise the PPR on site along with data collected in transit walk. GM will submit his observation to consultancy for incorporation in draft DPR. The draft DPR will have all the details shown on previous page. This details will also be scrutinised again in GM office and rectification if any will be suggested to the consultancy who will encorporate them in final DPR. This DPR after scrutiny at PIU will be submitted to STA along with form A, B, C for their scrutiny. The observation of STA may be complied quickly and clearance of STA may be obtained. Form C details should be filled with utmost caution as it is replica of your DPR and form C is scrutinise in detail at every level. The line plan of road and location of CD with its type should also accompany. The sub grade CBR and design CBR may be filled correctly along with details of traffic. Type of road, length and cost should also be checked properly. The name of road should be in the pattern A to B or NH/SH/MDR to B where B is target village name.

Computation of Design Traffic

For upgradation of Exsiting road :-

(i) Traffic census should be conducted over a period of atleast 07 days, both during the peak harvesting season and also during the lean season for various vechicle types, both motorised as well as non-motorised; the number of laden, unladen and overloaded commercial vehicles also to be recorded during the traffic counts. Generally, there are two or more harvesting seasons with intervening lean seasons. Traffic census will be carried out during the lean season. The average duration of each harvesting season and likely change in the peak traffic during which the census has been taken shall be ascertained from local enquiries and suitably considered in estimation of traffic. In case any information regarding change in peak traffic during other harvesting seasons could not be ascertained through local enquiries, the traffic could be assumed to be the same as the traffic data collected during the harvesting seasons.

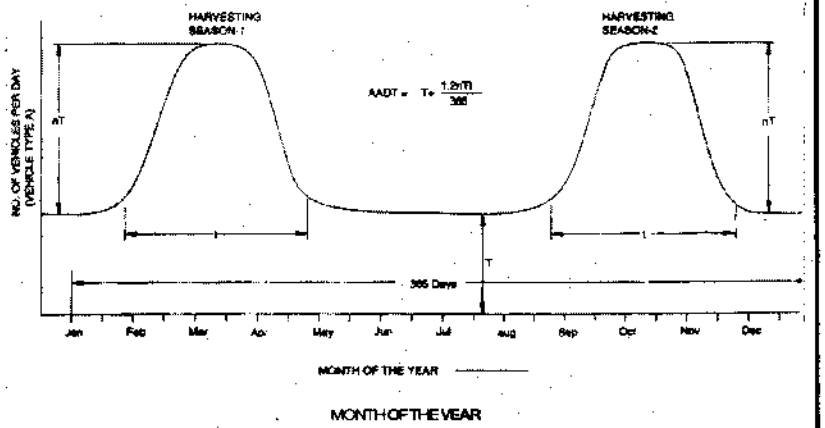

Fig. 1. Seasonal Variations in **Rural** Traffic

(ii) Average daily traffic (ADT) for 24 hours should be computed for each vehicle type, botth during the peak harvesting season and also during the lean season. Knowing the duration of harvesting season, (see Fig. 1, showing seasonal fluctuations in ADT) the total traffic during the year can be computed and consequently the Average Annual Daily Traffic (AADT) can be computed for each vehicle type.

Although the number and duration of harvesting seasons can vary from one region to the other, typically two harvesting seasons during the course of a year are shown in Fig. 1. If it is the average number of commercial vehicles of a given category, moving per day during the lean season, the enhanced traffic during the peak season can be denoted by nT, over above the lean season traffic T, the value of n varying widely from one region to the other. Typically, it takes about 40% of the duration of a harvesting season (t) to build up the traffic from lean-season level T to the peak. The peak traffic may continue for about 20% of the duration of harvesting period before coming down to the lean-season traffic level over a period of time, again about 405 of the total duration of the harvesting season. With these assumptions, the total number of repeatition (N) of a given vehicle type during the course of a year is given by :

$$N = T \times 365 + 2nT\ [0.6t]$$

Average Annual Daily Traffic (AADT)

$$= T + \frac{1.2.Tt}{365}$$

(iii) It should generally be possible to capture the peak traffic from the actual traffic count taken during the harvesting seasons. Thus, if the duration of harvesting season, the peak traffic and the duration of peak traffic are known, the average additional traffic during harvesting season can be estimated on the basis of information collected during the traffic survey. Local enquiries are often useful in estimating average additional traffic during harvesting season.

New road: In case of a new road, an approximate estimate should be made for traffic that would ply on the road considering the number of villages and their population along the road alignment and other socio-economic parameters. Traffic counts can be carried out on an existing road in the vicinity with similar conditions and knowing the population served as well as agricultural/industrial produce to be transported, the expected traffic on the new proposed road can be estimated.

Likely traffic on the proposed road can also be estimated on the basis of O-D survey along the nearby existing roads which presently serve the villages similar to the villages proposed to be connected.

Due consideration should be given to the 'Diverted' and 'Generated' traffic, anticipated as a consequence of the development of the proposed road, land use of area served, the probable growth of traffic and the design life.

Determination of ESAL applications :

For purpose of Pavement Design, only commercial vehicles with a gross laden weight of 3 tonnes or more along Rural vehicles with single axle loads different from 80 kN, can be converted into standard axles using the Axle Equivalency Factor.

Axle Equivalency Factor = $(W/Ws)^4$
Where W= Single axle load (in kN) of the rural vehicle in question
Ws = Standard Axle Load of 80 kN
The Equivalency Factor for converting to the Standard Axle Load 80 kN are given be
The equivalency Factors for converting to the Standard Axle Load of 80 kN are given below .

Equivalency Factors for Different Axle Loads

Axle Load		Equivalency Factor
Tonnes	kN	
3.0	29.4	0.02
4.0	39.2	0.06
5.0	49.1	0.14
6.0	58.8	0.29
7.0	68.7	0.54
8.0	78.5	0.92
9.0	88.3	1.48
10.0	98.1	2.25
11.0	107.9	3.30
12.0	117.7	4.70
13.0	127.5	6.40
14.0	137.3	8.66
15.0	147.1	11.42

The design traffic is considered in terms of cumulative number of Standard Axles to be carried during the design life of the road.
For single-lane and intermediate-lane roads, the design shall be based on the total number of commercial vehicles per day in both directions. For double-lane roads, the design should be based on 75% of the total number of vehicles in both directions.

Traffic Categories : For pavement design, the traffic has been categorised into seven categories as under:

Traffic Category	Cumulative ESAL Application
T_1	10,000-30,000
T_2	30,000-60,000
T_3	60,000-100,000
T_4	100,000-200,000
T_5	200,000-300,000
T_6	300,000-600,000
T_7	600,000-1,000,000

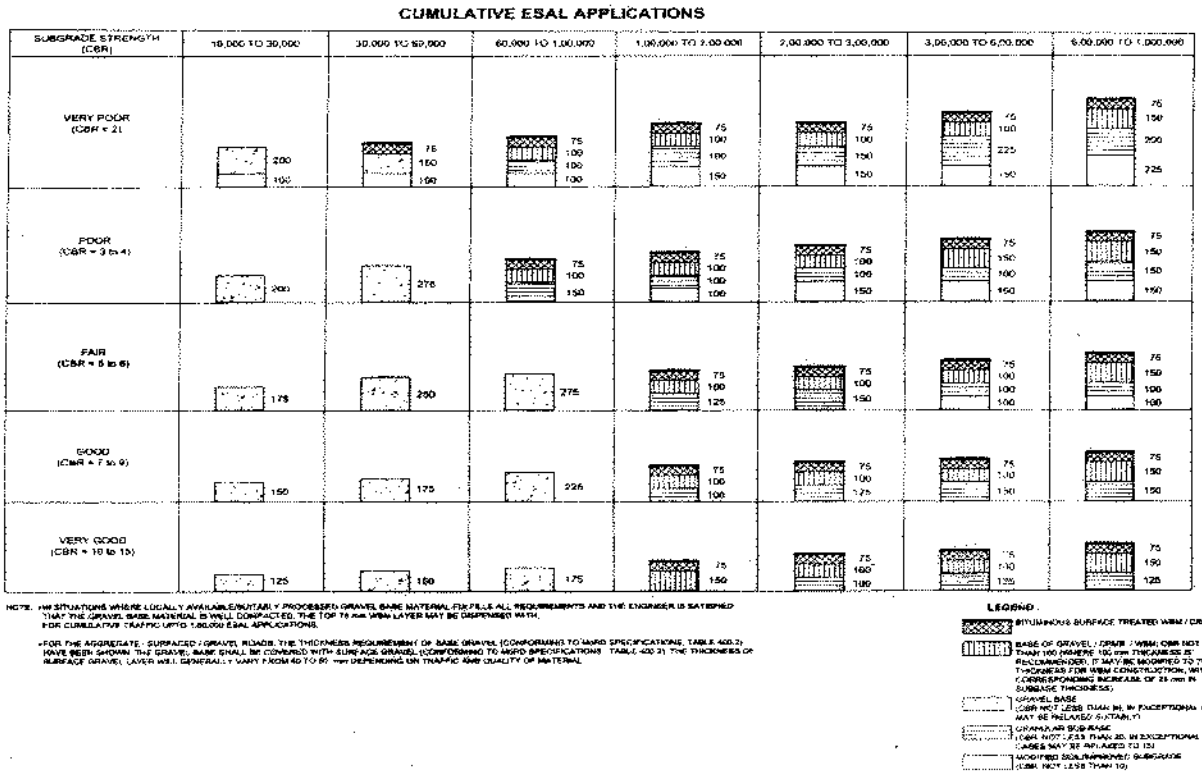

Fig. 4. Pavement Design Catalogues

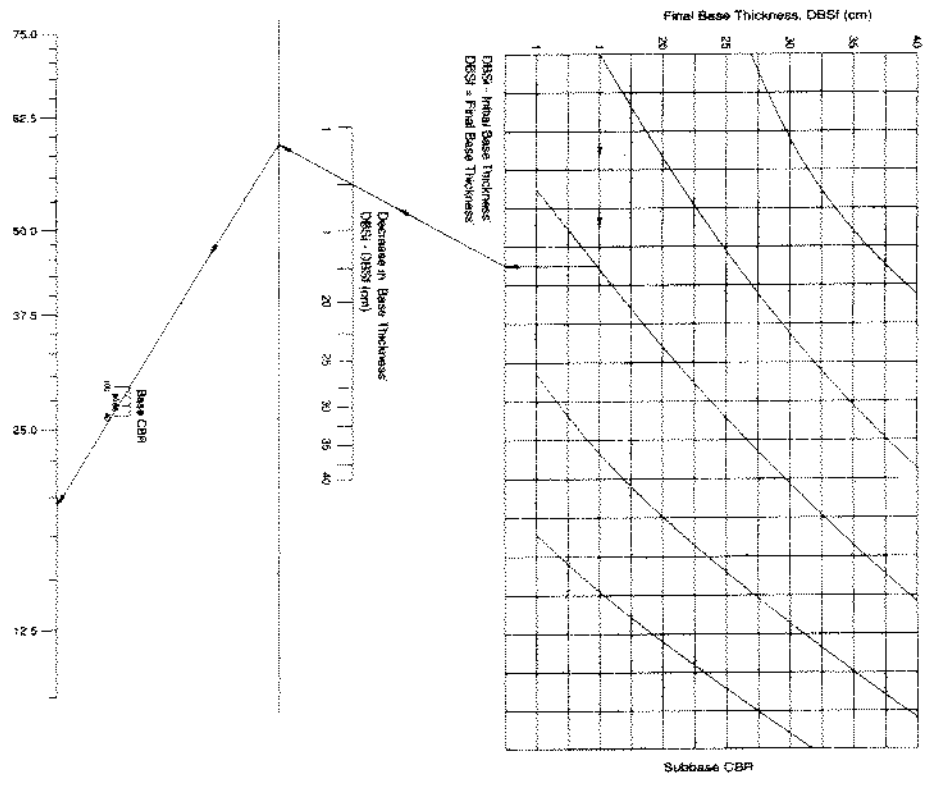

Fig. 5. Chart to Convert a Portion of the Gravel/Soil-Aggregate Base Layer Thickness to an Equivalent Thickness of Subbase (Ref. 2)

SUBGRADE STRENGTH EVALUATION

4.1 Subgrade :

4.1.1 Definition : As per MORD Specifications for Rural roads (Ref 14), subgrade can be defined as a compacted layer, generally of naturally occuring local soil, assumed to be 300 mm in thickness, just beneath the pavement crust, providing a suitable foundation for the pavement. The subgrade in embankment is compacted in two layers, usually to a higher standard than the lower part of the embankment. In cuttings, the cut formation, which serves as the subgrade, is treated similarly to provide a suitable foundation for the pavement. Where the naturally occuring local subgrade soils have poor engineering properties and low strength in terms of CBR, for example in Black Cotton soil areas, improved subgrades are provided by way of lime/cement treatment or by mechanical stabilization and other similar techniques.

4.1.2 The subgrade, whether in cutting or in embankment, should be well compacted to utilize its full strength and to economize the overall pavement thickness. the current MORD Specifications for Rural Roads requires that the subgrade should be compacted to 100% Maximum Dry Density achieved by the Standard Proctor Test (IS2720-Part 7). The material used for subgrade construction should have a dry unit weight of not less than 16.5 kN/m^3.

4.1.3. Soil Surveys: It is necessary that a soil survey along and around the road alignment is carried out following the laid down-procedures and that the results of all field and laboratory investigations are made available to the designer. During the soil surveys, the depth and fluctuations of GWT must be recorded.

All the representative samples of subgrade soils must be subjected to the simple classification test (wet sieve analysis,

liquid and plastic limits) and the soil group shown against each representative sample, ensuring that at least 3 samples are taken per kilometer length even if the same soil type continues.

For each of the soil groups thus identified, atleast one CBR test should be conducted with the soil compacted to the Standard Proctor density and at a moisture content corresponding to the wettest state considered appropriate to the site conditions.

4.2 Subgrade Strength

4.2.1. Design for new roads

4.2.1.1. Subgrade CBR value : for the pavement design of new roads, the subgrade strength needs to be evaluated in terms of CBR value.

The CBR of the subgrade can be estimated by any of the following methods:-

(i) Based on soil classification tests and using Table 1 (Ref 4) which gives typical presumptive design CBR values for soil samples compacted to Proctor density at optimum moisture content and soaked under water for 4 days.

(ii) Using a Nomograph (Appendix C) (Ref 6) based on wet sieve analysis data, for estimating 4-day soaked CBR values on samples compacted to Poctor density.

(iii) Using two sets of equations, based on classification and test data, one for plastic soils and the other for non-plastic soils (Appendix D), for estimating soaked CBR values on samples compacted to Poctor density (Ref 18).

(iv) By conducting actual CBR tests in the laboratory.

The CBR tests should be conducted on representative samples of subgrade soil compacted by static compactor to 100% Standard Proctor dry density.

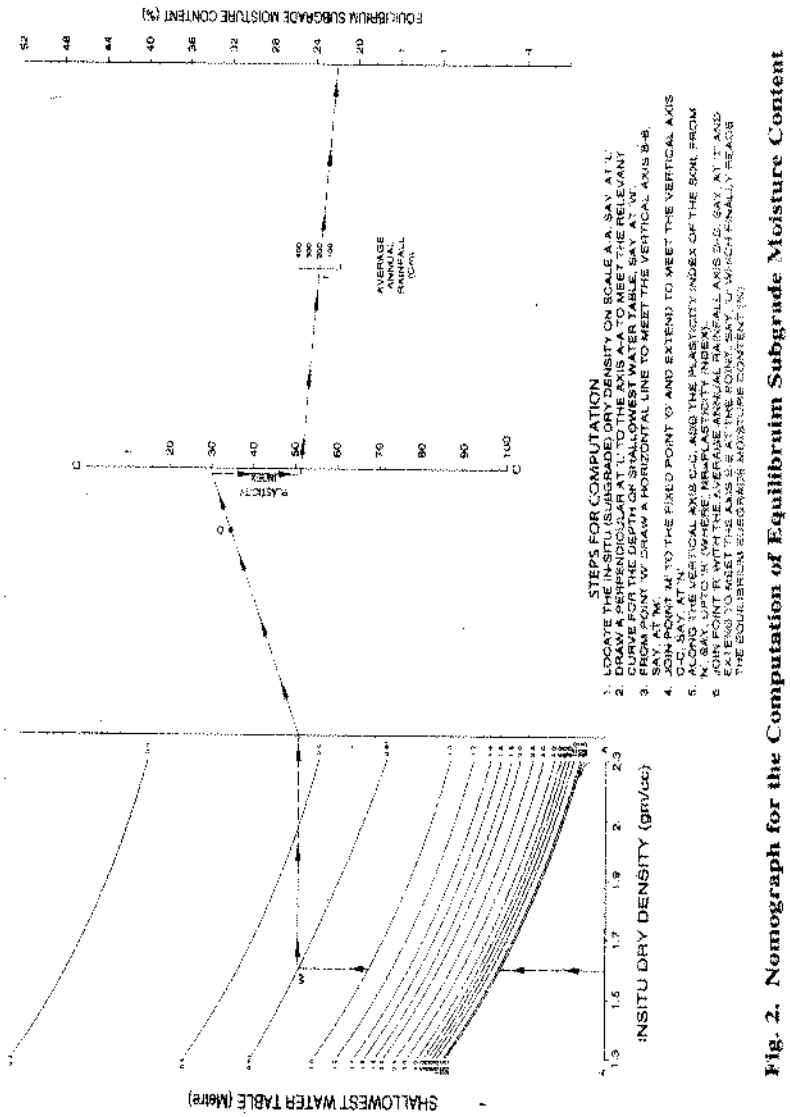

Fig. 2. Nomograph for the Computation of Equilibrium Subgrade Moisture Content

Table 4.1: TYPICAL PRESUMPTIVE DESIGN CBR VALUES

Description of Subgrade Soil	IS Soil Classification	Typical soaked CBR value (%)
Highly Plastic Clays and Silts	CH, MH	*2-3
Silty Clays and Sandy Clays	ML, MI CL,CI	4-5
Clayey Sands and Silty Sands	SC, SM	6-10

* Expansive clays like BC Soil may have a soaked CBR of less than 2%

. A simple Free Swelling Index test (IS 2720-Part 40) should be done on expansive clays.

4.3 Subgrade Strength Classes

In order to use the Design Catalogue (Para 8), the subgrade strength is divided into the following classes:
Table 4.2

Quality of Subgrade	Class	Range CBR(%)
Very poor	S_1	2
Poor	S_2	3-4
Fair	S_3	5-6
Good	S_4	7-9
Very Good	S_5	10-15

* Where the CBR of subgrade soil is less than 2, the economic feasibility of replacing 300 mm subgrade with suitable soil needs to be explored and, if found feasible, the pavement should then be designed based on the CBR value of the improved subgrade. Alternatively, a capping layer of thickness not less than 100mm of modified soil (with CBR not less than 10) should be provided.

4.4 PAVEMENT COMPOSITION AND MAXIMISING USE OF LOCALLY AVAILABLE MATERIALS

4.4.1 Pavement Composition

Sub-base course: For granular sub-base, the materials generally used are natural sand, moorum, gravel, crushed stone, crushed slag, brick metal, kankar or combination thereof depending upon the grading required as per Clause 401 of the MORD Specifications for Rural Roads (Ref 14). For Silty clays and clayey soils including Black-Cotton soils, a lime treated subbase

may be provided as per Clause 403 of the MORD Specifications for Rural Road (Ref 14), taking care that the lime shall have purity of not less than 70% by weight of quicklime (CaO) when tested in accordance with IS 1514. Where the lime of different calcium oxide content is to be used, its quantity should be suitably adjusted so that equivalent calcium oxide content is incorporated in the work. For soils which do not respond to lime treatment and where comparatively higher and faster developement of strength and durability characterisitics are needed, especially for waterlogged and high rainfall areas, cement treated subbase course can be provided, as per Clause 404 of the MORD Specifications for Rural Roads (Ref 14). The cement content for a cement treated subbase should be determined by mix design, yielding a 7-day unconfined compressive strength of not less than 1.7 MPa. For practical considerations, the thickness of subbase, where provided, shall not be less than 100 mm.

4.4.2. Base course: For rural roads designed for cumulative ESAL repetitions more than 1,00,000, unbound granular bases which comprise conventional Water Bound Macadam (WBM), Wet Mix Macadam (WMM) or Crusher Run Macadam Base (CRMB) are adopted as per Clauses 405, 406, and 411 of the MORD Specifications for Rural Roads (Ref 14). Where hard stone metal is not available within economical leads, a cement stabilized base can be provided as per Clause 404 of the MORD Specifications for Rural Roads (Ref 14).

For rural roads designed for cumulative ESAL repetitions less than 100,000, a Gravel base is recommended, except for a very poor subgrade strength (CBR=2) under the Traffic Categories of 30,000 to 60,000 to 100,000 ESAL applications and for poor subgrade strength (CBR=3 to 4) under the

Traffic Category of 60,000 to 100,000 ESAL applications as shown in Fig. 4. The various grading, plasticity and other requirments for a Gravel base are detailed in Clause 402 of the MORD Specifications for Rural Roads (Ref 14).

Surfacing: For rural roads designed for cumulative ESAL repetitions, over 100,000, a bituminous surface treatment of 2-coat surface dressing or 20 mm premix carpet is recommended, as per MORD Specifications for Rural Roads (Ref 14). However, for rural roads designed for ESAL applications less than 100,000 a non-bituminous gravel surfacing is recommended as per Clause 402 of the MORD Specifications, except for the very poor subgrade strength (CBR=2) under traffic categories T_2 and T_1 and for the poor subgrade strength (CBR=3 to 4) under Traffic Category T_3 only, where a bituminous surface treatment has been recommended, as shown in Fig. 4.

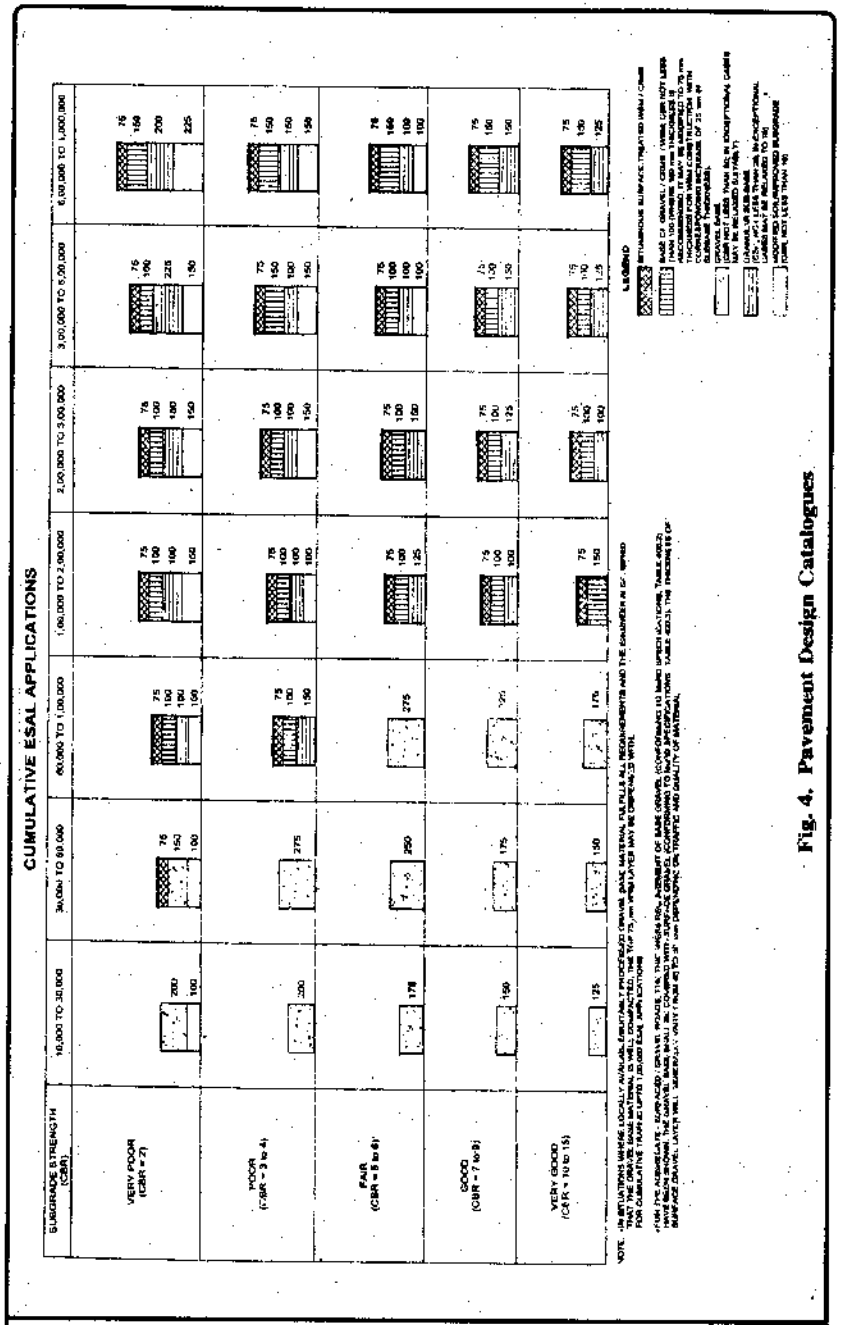

Fig. 4. Pavement Design Catalogues

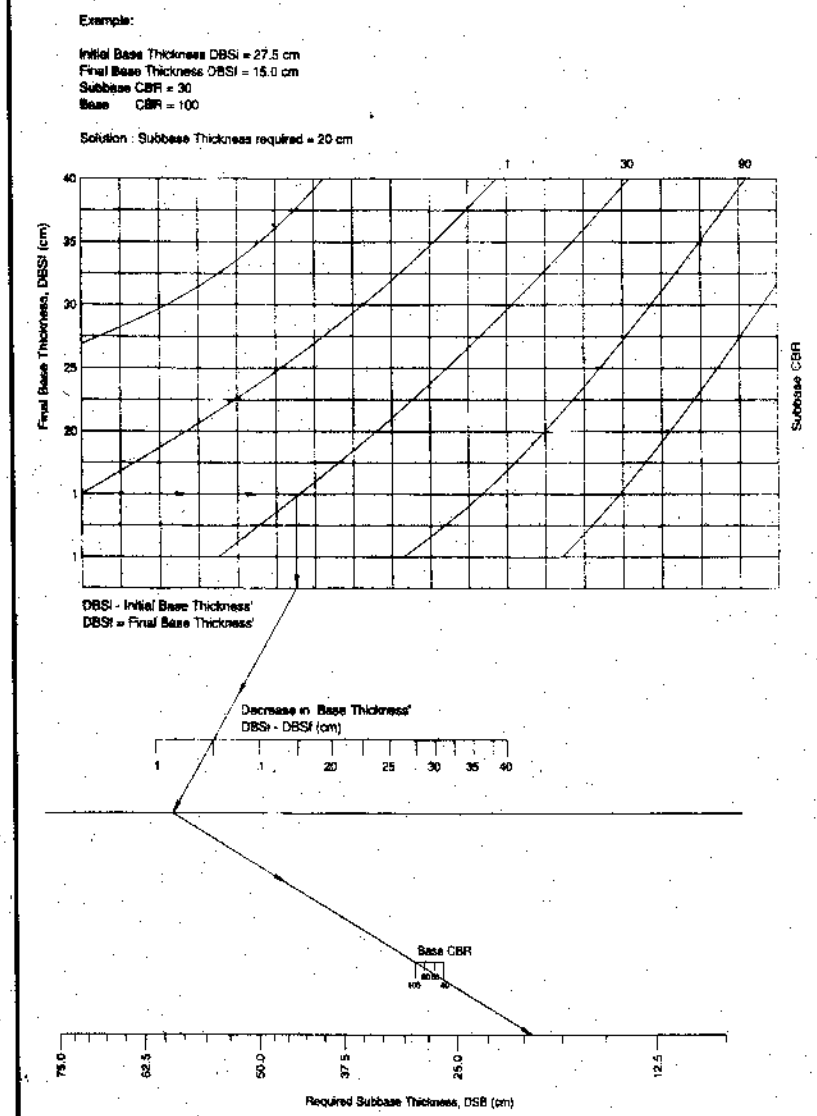

Fig. 5. Chart to Convert a Portion of the Gravel/Soil-Aggregate Base Layer Thickness to an Equivalent Thickness of Subbase (Ref. 2)

However, thick bituminous layers may not be warranted and could be substituted by granular construction.

(ix) In areas susceptible to frost action, all black-topped flexible pavements in the Design Catalogue (Fig. 4), need to be provided with a minimum pavement thickness of 4500 mm (300 mm sub-base + 150 mm base), even when the CBR value of the subgrade warrants a smaller thickness.

(x) The Gravel base thickness requirments for Gravel Roads as given in the Design Catalogue (Fig. 4)need to be increased in areas susceptible to frost action (Ref 2) , as under :

Table 4.3

Cumulative ESAL Applications

Subgrade Class	T_1 (10,000-30,000)	T_2 (30,000-60000)	T_3 (60,000-1,00,000)
S_1 (CBR=2)	250 mm	Flexible Pavement	Flexible Pavement
S_2(CBR=3 to 4)	225 mm	-do-	-do-
S_3(CBR=5 to 6)	200mm	325 mm	425 mm
S_4(CBR=7 to 9)	175 mm	300 mm	400 mm
S_5(CBR=10 to 15)	150 mm	275 mm	375 mm

A Pavement design problem illustrating the use of recommended pavement design catalogue is given in Appendix-F.

4.5 DRAINAGE AND SHOULDERS

4.5.1 Drainage design

It must be recognized that a scientifically worked out drainage design is a vital part of the design of pavement system as a whole. The pavement design recommended in this Mannual is based on the assumption that :

(i) proper cross-slopes are provided over the carriageway and

roadside shoulders to shed off the rainwater quickly.
(ii) top of the subgrade/improved subgrade is raised sufficiently, preferably not less than 300 mm above the GL and not less than 600 mm above the highest GWT.
(iii) adequately designed roadside ditches/drains are provided.
(iv) all cross-drainage structures are provided as per requirments.

Besides the drainage requirments as above, it is also necessary to provide drainage of pavement layers especially where the subgrade is of relatively low permeability e.g. a clay subgrade. While no separate drainage layer is considered necessary for rural roads, it is necessary that atleast half the sub-base layer thickness, subject to a minimum of 100 mm should be extended across the shoulders. In the sub-base material, the percent passing 75 micron sieve must not exceed 5%. Typical cross-section showing drainage layers is shown in Fig. 6.

4.5.2 Shoulders

For the successful performance of a rural road pavement, it is necessary that adequate lateral support be provided by roadside shoulders. These all are more important when the pavement materials is selected using the same principles as for gravel roads or a subbase to carry construction traffic. The shoulder material should normally be of subbase quality compacted to a thickness of 100 mm. Where the anticipated animal-drawn carts, gravelled .

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CHAPTER - 5

SITE CLEARANCE AND SETTING OUT OF WORK

Setting-out

1. Establish working bench marks at the rate of four per km. and one at or near the each cross drainage on the road in question with the help of reference Bench Mark in the area.
2. Mark centerline of road and fix the pegs at a distance of 6m either side of centerline at 50 meter interval at on plain terrain & 20 meter interval on ghats & turnings. Also fix the peg at toe line of the road at the same interval.
3. Provide reference pillars on both sides of the road at 100 meter apart or as required. The location of center line may be marked with paint. This pillars can be RCC, pre cast concrete, cut stone or any other suitable material.
4. Mark the levels of different layers i.e. embankment subgrade,GSB, G-I, G-II & G-III etc. on reference pillars.
5. The lines and levels of formation, side slopes, drainage works, carriageway and shoulders should be carefully set out and frequently checked, care should be taken to ensure that correct gradients and cross sections are obtained everywhere.
6. The setting out item includes setting out of cross drainage structures also. The center line, formation level, foundation level, cross pillars (Bhurji) and pegs etc. may be suitably provided.

Site clearance

1. The road land should be cleared of all materials unsuitable for the work by cutting, removing and disposing of all materials, such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150 mm in thickness, rubbish, etc. This should be in advance of earthwork operations.
2. All trees, stumps, etc. falling within the excavation and embankment lines should be cut to such depth below ground level that in no case they fall within 500 mm from top of the subgrade. Beyond these limits, they need to be cut down to 1 m below ground level.
3. Excavation below ground level arising out of removal of trees, stumps, etc. be filled in layers with suitable materials and compacted thoroughly.
4. The waste material obtained from site clearance operation must be disposed-off properly as directed by Engineer in charge and should never be left at site of work.

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CHAPTER - 6

EXCAVATION

Methodology :

1. The limits of excavation should be set out true to lines, curves, slopes,grades and sections as shown in the drawings. The work of excavation should be carried out in conformity with the drawings.
2. Undertake stripping of top soil before excavation if so required under the contract and stack it suitably for reuse.
3. Keep the excavation dry.
4. After excavation, the sides of excavated area should be trimmed and the area contoured to minimise erosion and ponding, allowing natural drainage to take place.
5. In case in-situ soil is to be used for subgrade, loosen the soil and compact to a thickness of 300 mm with a suitable roller to 100 percent Standard Proctor compaction density in layers of 150 mm thick.

Quality Control Requirements

Table 6.1 : Horizontal Alignment

[As per clause 1802.2 of Rural Road Specification]

	Permitted Tolerance	
	In Plain & Rolling Terrains	In Hilly Terrains
Edges of carriageway	± 20 mm	± 30 mm
Edges of Roadway and lower Lyers of pavement	± 30 mm	± 50 mm

1. Surface Levels and surface regularity may conform to provisions of chapter 18.

2. **Density of Compaction :**

(i) The density of compaction should be minimum 97 percent of Standard Proctor compaction density, i.e. Maximum Dry Density MDD. Where in-situ soil is used, density of compaction should be 100 percent of Standard Proctor Compaction density.

(ii) Acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus.

$$(1.65 - \frac{1.65}{\sqrt{\text{No. of sample}}}) \times \text{standard deviation}$$

3. The quality control test would basically consist of testing the density of compaction. The frequency of test will be 1 test per 2000 m^2 area comprising 6 measurements.

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CHAPTER - 7

EMBANKMENT / SUBGRADE

7.1 Methodology :

1. Where necessary, the original ground should be levelled and rolled to facilitate placement of first layer of embankment. The soil for processing should be brought to proper moisture content, so that the needed degree of compaction can be achieved with least effort. Needed amount of water should be uniformly spreaded or sprinkled in the entire soil mass.

Depending upon the weather conditions and time gap between sprinkling of water and commencement of rolling, an alowance of 3 to 4 percent for evaporation should be made in the quantity of water to be added during summer when temperature is greater than 35°C. In winter their allowance may be reduced to 1 percent.

2. The soil should be spread in layers to achieve not exeeding 150 mm corn pacted thickness. Each layer should be thoroughly compacted to the specified requirements and finished parallel to the final cross section of the embankment (layer thickness can be increased to 22.5 cm. if heavy vibratory rollers are used.)

3. The loose thickness may be decided judiciously by the engineer-in-charge by making test strips of various thickness and arriving at the proper loose thickness of the soil being used.

4. Embankment is compacted to achieve a field density not less than 97 percent of standard proctor compaction density (The compaction is restricted to 90% of standard proctor density in case of expansive soil). It is necessary to further ensure that the top 300 mm of embankment i.e. sub grade is constructed by soil having CBR value not less than 7% in case were local soil CBR is less than 4 or as provided in DPR. The subgrade is compacted to 100 percent standard proctor compaction. The

2. **Density of Compaction :**

(i) The density of compaction should be minimum 97 percent of Standard Proctor compaction density, i.e. Maximum Dry Density MDD. Where in-situ soil is used, density of compaction should be 100 percent of Standard Proctor Compaction density.

(ii) Acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus.

$$(1.65 - \frac{1.65}{\sqrt{\text{No. of sample}}}) \times \text{standard deviation}$$

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CHAPTER - 7

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4. Embankment is compacted to achieve a field density not less than 97 percent of standard proctor compaction density (The compaction is restricted to 90% of standard proctor density in case of expansive soil). It is necessary to further ensure that the top 300 mm of embankment i.e. sub grade is constructed by soil having CBR value not less than 7% in case were local soil CBR is less than 4 or as provided in DPR. The subgrade is compacted to 100 percent standard proctor compaction. The

engineer-in-charge should also varify other soil property also and in case of variation from DPR, approval of variations may beobtained from competent authority.

5. The profile of embankment and sub grade should be made with the help of motor-grader and it may be checked with working drawings.

7.2 Quality Control Requirements :

1. Materials

(i) The material used in embankment, subgrade, shoulders, etc. shall be soil, moorum, gravel, a mixture of these or other materials approved by the Engineer. It shall be free of logs, stumps, roots, rubbish etc. **The following types of material shall be considered unsuitable.**

a) Material from swamps, marshes and bogs.
b) Peat, log, stump and perishable material.
c) Materials susceptible to spontaneous combustion.
d) Materials in a frozen condition.
e) Clay having liquid limit exceeding 70 and plasticity index exceeding 45.
f) Material with salts resulting in leaching action.
g) Expansive clay with free swelling index exceeding 50 percent. Where in expansive clay with a acceptable free swelling 'index' value is used as a fill material in embankment, the subgrade and top 500 mm. portion of the embankment just below the subgrade shall be non expansive in nature (clause 303.3.2 of Specification For Rural Roads)

h) Material with a soluble Sulphate content exceeding 1.9 gm per litre.
(ii) The size of coarse material shall not ordinarily exceed 75 mm when placed in embankment and 50 mm when placed in subgrade.
(iii) The materials should satisfy the density requirements given in Table 7.1 [Table 300.1 & 300.2 of Rural Road Specification]

Table 7.1 : [Table 4.3 of SP 20]

Type of Work	Max. Laboratory dry unit weight (As per standared proctor test)
a) Embankment	
(i) height up to 3 m	Not less than 1.44 gm/cc
(ii) height more than 3 m	Not less than 1.52 gm/cc
(iii) Sub-grade and earthen shoulders/verges/backfill	Not less than 1.65 gm/cc

2. Horizontal Alignment [As per chapter 6]
3. Surface Levels [As per Chapter 17]
4. Surface Regularity [As per Chapter 17]
5. Density of Compaction

The density of compaction should satisfy the requirements given in Table 7.2

Table 7.2 : Compaction Requirements for Embankment
[Table 300.1 & 300.2 Specification For Rural Roads.]

	Type of Work / Material	Relative Compaction
1.	Subgrade and earth shoulders	Not less than 100% Standard Proctor Density
2.	Embankment	Not less than 97% Standard Proctor Density

The acceptance criteria shall be same as in Excavation chapter.

7.3 Quality control test and their frequency

7.3.1.Tests prior to construction

The quality control tests to be carried out prior to construction and their frequency shall be as given in Table 7.3

Table 7.3 : QUALITY CONTROL TESTS AND THEIR FREQUENCY FOR BORROW MATERIAL EARTHWORK FOR EMBANKMENT AND FOR SUBGRADE

TYPE OF TEST	FREQUENCY
A. Earthwork for Embankment 1Soil Classification as per IS: 1498 i) Sieve Analysis (Wet Sieve Analysis except for cohesionless soils) ii) LL, PL and PI	One test from each source for one km or part thereof
2. Standard 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 27) where suspected on past experience. This can be easily confirmed by a quick test using barium chloride.	-do-

B. Earthwork for Subgrade (Cutting or Filling) i) Test at 1 to 4, under A above. (In case the soil for embankment meets the prescribed requirments for the Subgrade, the above four tests need not be repeated.)	One test for each km length or part thereof from each source.
ii) CBR test (IS:2720 part 1C) soaked/unsoaked as specified	One test for each km: this will comprise testing of 3 specimen and the CBR value will be reported as average of the three test values.

Notes

(a) Test for 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 furthur testing, simple tests at (i) and (ii) 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.

(c) For hill roads, the frequency of tests may be increased depending upon the variability of the strata met.

7.3.2 Tests During Construction

The quality control tests to be carried out during construction and their frequency shall be as given in Table 7.4

Table 7.4 Field Quality Control Tests During Construction

S.No.	Type of test	Frequency
1.	Placement Moisture (IS: 2720 Part 2) Any of the rapid test methods for determination of moisture content can be used.	At least 3 tests daily (well spread over the day's work)
2.	In-situ Density Measurements (IS:2720 Part 28) (Each layer)	-do- i) Average of 3 tests results shall not be less than specified degree of compaction. ii) Individual test values of the degree of compaction obtained shall not be less than 1% of the specified value of degree of compaction. (for example, for specified 100% Proctor density, the individual test value shall not be less than 99% of Proctor density and the average of the three (or more) tests carried out in a day shall not be less than 100% Proctor density).
3.	Thickness of subgrade layer.	At random

These frequencies are minimum and engineer may conduct more tests to satisfy himself.

Table 7.5 Construction Operation

[As per clause 1800.2 of Rural Road Specification]

[i]	Moisture content prior to compaction.	1 in 250 cum for each layer, subject to a max of 4tests per day
(ii)	Thickness of layer	Regularly
(iii)	Density of compaction	1 set of tests per 2000 sqm comprising 6 measurements
(iv)	CBR of subgrade	As required.

The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks

CHAPTER - 8

GRANNULAR SUB-BASE

8.1 Methodology :

1. Obtain materials from approved sources. The material should be natural sand, moorum, gravel, crushed stone, crushed slag, granulated slag, crushed concrete, brick metal and kankar etc.

2. Immediately prior to the laying of sub-base, subgrade shall be prepared with the help of a motor grader of adequate capacity. The granular material for sub-base shall preferably be natural. Mixing of ingredients to make granular sub-base may be undertaken under strict quality control. Manual methods shall be permitted only where the width of laying is not adequate for mechanical operations or in small sized jobs. Moisture content of loose material shall be checked in accordance with IS : 2720 (Part 2). After water has been added + 1percent to - 2 percent of OMC as per IS : 2720 (Part 8) - 1993), the material shall be processed by mechanical or other approved means like disc harrows, rotavators, until the layer is uniformly wet. Immediately thereafter, rolling shall start.

3. The sub-base material should be spread in layers not exceeding 100 mm compacted thickness. (If suitable vibratory rollers are available, the thickness of layer can be upto a maximum of 200 mm). Each layer should be thoroughly compacted with rolling commencing from edge to centre for portions having crossfall on both sides (for portions having unidirectional superelevation, rolling should commence at the lower edge and proceeding towards the upper edge). Each

pass should overlap by one-third of the track made in the preceding pass. Speed of roller should be less than 5 kmph. The rolling should continue until density achieved is at least 100 percent of the maximum dry density determined as per IS : 2720 (Pt. 7). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material.

Note : *Where the subgrade is clayey and impermeable, with CBR less than 4 and annual rainfall more than 1000 mm, it is desirable to provide a drainage layer of dust-free coarse to medium sand of 100 mm thickness over the Subgrade in full formation width. Permeability value of sand ranges from 10^{-2} to 10^{-4} cm per second. Permeability can be determined with the help of permeameters immediately following the spreading of sand, and its watering followed by rolling at optimum moisture content.*

8.2 Quality Control Requirements

1. Materials

(i) Grading

The grading for coarse graded granular sub-base (GSB) materials should conform to the requirements given in Table 8.1

Table 8.1 : Grading for Granular Sub-base Materials

[As per table 400-1 of Rural Road Specification]

IS sieve	Percent by Weight passing the sieve		
Designation	Grading I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm	-	100	-
26.5 mm	55 - 75	50 - 80	100
4.75 mm	10 - 30	15 - 35	25 - 45
0.075 mm (75 micron)	< 10	< 10	< 10

Note : 1. The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS : 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 percent respectively.

2. On clayey subgrades, the percent passing through Sieve 0.075 mm shall not exceed 5.

(ii) **Atterberg limits :** The material passing 425 micron (0.425 mm) sieve for all the three gradings 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 soaked CBR value of 20 will be acceptable for granular sub-base.In case the sub-base material of the requisite soaked CBR value is not available within economical leads, the sub-base material meeting any of the prescribed grading and other requirements with a soaked CBR value of not less than 15 can be permitted with the approval of the competent authority

(iv) **For** drainage layer, grading should conform to the requirements given in Table 8.2

Table 8.2 : Grading of coarse to medium sand for Drainage Layer [As per Table 8.3 of IRC sp - 20]

IS sieve Designation	Percent by weight passing
11.2 mm	100
5.6 mm	80 - 100
2.36 mm	70 - 90
180 micron	< 5

(v) **The** Horizontal Alignment, Surface Levels, Surface Regularity and Acceptance criterion shall be as per chapter 6 and chapter 20 of this hand book

(vi) **Density of Compaction :**
Minimum value of field density shall be 100 percent of Maximum dry density determined as IS : 2720 (Pt. 7)

(vii) **The** quality control tests and their frequency for granular subbase construction would be as per Table 8.5

Table 8.3: Grading Requirements for GSB for base course Roads. (As per table 400.2 of Rural Road specification)

Sieve Size	Percentby mass passing IS Sieve Grading Designation		
	A	B	C
53 mm	100		
37.5 mm	97 -100	100	
26.5 mm		97-100	100
19 mm	67 - 81		97 -100
9.5 mm		56 -70	67 -79
4.75 mm	33 - 47	39 -53	47 -59
425 µm	10 -19	12 -21	12 -21
75 µm	4.0 - 8.0	4.0 -8.0	4.0 -8.0

Table 8.4 : Grading Requirements for Surface Course. (As per Table 400.3 of Rural Road Specification)

IS Sieve	Percent by Mass passing Designated Sieve
26.5 mm	100
19 mm	97-100
4.75 mm	41-71
425 µm	12-28
75 µm	9-16
Plasticity Index	4-10

6. Quality Control Tests

6.1 Tests Prior to Construction

(i) The quality control tests to be carried out prior to construction are indicated in Table 8.5

(ii) For existing approved sources, the test frequency shall be as indicated in Table 8.5

(iii) For new sources, test frequencies shall be increased to atleast three tests for each source (average of three tests).

(iv) The samples shall be taken at representative locations and at mean depth of proposed excavation.

Table 8.5 :Quality Control Tests Prior to Construction

	Type Of Test	Frequency
1.	Soil Classification as per IS 1498. i) Wet Sieve Analysis except for cohesionless soils ii) Liquid & Plastic limits	Average of three tests from each source.
2.	Combined Grading and Plasticity tests on materials from different sources mixed as per design	One test on the combined material for 500 m length of road or
3.	Proctor Compaction test (IS:2720 Part 7)	One test on the material from each source or on the combined material as the cast may be.
4.	Wet Aggregate Impact Value Test (IS:5640) where soft marginal aggregates are used e.g. Laterite, Kankar, Brick Ballast etc.	One test from each source identified by the Contractor.

	Type of test	Frequency
5.	CBR test (IS: 2720 Part 16) on representative sample compacted at 100% Procto dry density.	One test per km length (average of a set of three specimens).

Note : Where materials from more than one source are to be combined in the desired proportions, the tests at Sl. Nos. 2,3 and 5 should be performed on the combined material.

6.2 Test During Construction

The field quality control tests during construction are indicated in Table 8.6

Table 8.6 : Quality Control Tests During Construction

	Type of test	Frequency
1.	Wet Sieve Analysis (IS:2720 Part 4) on the GSB material combined in the design proportions from various sources.	Atleast one test to be carried out daily.
2.	Liquid and Plastic Limit tests (IS:2720 Part 5).	-do-
3.	Placement Moisture Content (Any of the rapid methods for determination of moisture) content can be used (IS:2720 Part 2).	Atleast 3 tests to be carried out daily, well spread over the day's work.
4.	Insite Density measurments (IS:2720 Part 28).	-do-
5.	Thickness of compacted layer	At Random.

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CHAPTER - 9

WATER BOUND MACADAM BASE

Methodology :

1. WBM base course shall be constructed in conformity with line, grades and cross section shown in the drawings of tender document. The existing surface of subgrade or sub base to recieve WBM course shall be prepared to the specified grade and camber and cleared of all dust. Any ruts or soft yielding places that have appeared due to improper drainage of surface under traffic or season shall be corrected and rolled.
2. Spread the coarse aggregate uniformly on the prepared base to proper profile by using templates placed for specified compacted thickness. The thickness of one compacted layer should be 100 mm for grading I and 75 mm for grading II & III (for quantity of aggregates see table 9.1 a part from aggregates from quarries, crusher broken ballast can also be used). (In no case metal shall be dumped in heaps directly on the area where neither these are to laid nor shall hauling area a partly compacted base be permitted).

   The coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.The agregate shall be hand packed properly to ensure interlocking. Immediately after spreading agregates rolling is started with 3 wheeled power roller of 8 - 10 tonne capacity of tandom or vibratory roller of 80 to 100 Km static weight. On superelevated portions the rolling shall be proceed from inner to the outer edge. On normal straight portions rolling shall begin from the edge gradually progressing towards centre. First the edge shall be compacted with roller running forward and backward.

   The roller shall then move inward parallel to centre line of the road, in successive passes uniformly overlapping preceding tracks by at least one half of the width. Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings.
3. After coarse aggregates have been rolled, the screening shall be applied gradually over the surface to fill the interstices. Dry rolling shall be done while the screening are being spread so that tarring effect of roller causes them to settle into voids of the aggregates. The screening shall not be dumped in piles but applied uniformly in successive their layers either by spreading motion of hand shovels or mechnical spreaders. The screenings shall be applied at slow rate in three or more application as necessary. Rolling and brooming shall ac company this. After application of screenings, the surface shall be sprinkled with water, swept and rolled. The sprinkling, sweeping and rolling operation shall be continued and additional screenings should be applied where necessary until the coarse agrregates are well bounded and firmly set.
4. After application of screenings, binding material (PI 4 - 6) shall be applied at uniform rate in two more successive thin layers. After each application the surface shall be sprinkled with water and resulting slurry swept-in with brooms so as to fill voids properly. After final application the surface allowed to cure over night.Next morning hungry spots shall be filled with screenings or binding materials as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set.The compacted water bound macadam course should be allowed to completely dry and set before the next pavement course is laid over it.

Table 9.1 : Physical requirements of coarse aggregates for water bound macadam for sub-base / base / surfacing courses. [As per Table 400.7 of Rural Road Specification]

Test	Sub-Base	Base	Surfacing
Aggregate Impact Test (IS : 2386 Part or IS : 5640)	Less than 50	Less than 40	Less than 30
Flakiness Index Test (IS : 2386 Part I)	Less than 30	Less than 25	Less than 20
Soundness Test (IS : 2386 Part I) Loss with Sodium Sulphate Loss with Magnesium Sulphate	Less thatn 12% Less than 18%	Less than 12% Less than 18%	Less than 12% Less than 18%

(i) Grading :

The coarse aggregates should conform to the grading number specified in the contract and meet the requirements given in Table 9.2

Table 9.2 : Grading requirements of Coarse Aggregates for WBM [As per table 400.8 of Rural Road Specification].

Grading No.	Size Range	IS Sieve Designation	Percent by weight passing
1.	90 mm to 45 mm	125 mm 90 mm 63 mm 45 mm 22.4 mm	100 90 - 100 25 - 60 0 - 15 0 - 5
2.	63 mm to 45 mm	90 mm 63 mm 53 mm 45 mm 22.4 mm	100 90 - 100 25 - 75 0 - 15 0 - 5
3.	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

(ii) Screenings :

Screenings should consist of same material as the coarse aggregate. Also 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.

1. Grading :

The screenings should conform to the grading specified in table 9.3

Table 9.3 : Grading for Screenings

[As per table 400.9 or Rural Road Specification]

Grading Classification	Size of Screening	IS Sieve Designation	Percent by weight passing the IS Sieve
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 5.6 mm 180 micron	100 90 - 100 15 - 35

Approximate quantities -

Coarse Aggregates and Screenings required for 100 / 75 mm compacted thickness of Water Bound Macadam (WBM) Sub-base / Base / Surfacing Course for 10m² area

[As per Table 400.10 of Rural Road Specification]

Classification	Size Range m²	Compacted thickness mm	Loose Qty. m³	Screening: Stone Screenings — Grading Classification & Nominal size	Screening: Stone Screenings — For WBM Sub-base/ Base Course (Loose Qty.)m³	Screening: Crushable type as Moorum — Properties	Screening: Crushable type as Moorum — Loose Quantity m³
Grading 1	90 to 45 mm	100 mm	1.21 to 1.43 m³	type A 13.2 mm	0.27 to 0.30 m³	LL<20;PI<6 percent passing 0.075 mm < 10	0.30 to 0.32 m³
Grading 2	63 to 45mm	75 mm	0.91 to 1.07m³	type A 13.2 mm	0.12 to 0.15m³	- do -	0.22 to 0.24m³
Grading 2	63 to 45mm	75 mm	0.91 to 1.07m³	type B 11.2 mm	0.20 to 0.22 m3	- do -	0.22 to 0.24 m3
Grading 3	53 to 22.4mm	75 mm	0.91 to 1.07 m³	type B 11.2 mm	0.18 to 0.21 m³	- do -	0.22 to 0.24 m³

9 Quality Control Tests

9.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 9.4

Table 9.4: Quality Control Tests Prior to Construction

S.No.	Type of test	Frequency
1.	Aggregate Impact Value Test (IS: 2386 Part 4).	One test from each identified source.
2.	Aggregate Water absorption Test (IS: 2386 Part 3).	-do-
3.	Soundness Test of Aggregates (Where water absorption as at 2 above, exceed 2%) (IS:2386 Part 5).	-do-
4.	Grading LL and PI of Crushable Screenings (IS:2720 Part 5) (Where Screenings are to be used from the same source as the Stone Aggregates, this test is not needed).	-do-
5.	LL and PI of the binding Material, when used .	-do-

9.2 Test During Construction

The quality control tests to be carried out during construction are indicated in Table 9.5

Table 9.5 Quality Control Tests During Construction

S.No.	Type of test	Frequency
1.	Grading of Stone Aggregates and Screenings (IS:2386 Part 1).	Atleast 2 tests to be carried out for a day's work.
2.	Flakiness Index of Stone Aggregates (IS: 2386 Pat 1).	-do-
3.	PL of Crushable Screenings / binding material (IS:2720 Part 5)	Atleast 2 tests to be carried out for a day's work.
4.	Aggregate Impact value (IS:2386 Part 4).	At random (one test per km).
5.	Thickness of Compacted layer.	At random.

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CHAPTER 10

Wet Mix Macadam Base

A. Methodolgy

1. The surface to receive Wet Mix Macadam (WMM) shall be prepared as per sub-section 405.

2. WMM shall be prepared in an approved mixing plant with mixing arrangements like the pugmill or pan type mixer of concrete batching plant. For small quantities of WMM, the Engineer may permit the use of concrete mixers.

3. Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part 7) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size.

4. Lateral confinement for WMM should be provided by laying material in adjoining shoulders along with the wet mix layer, refer Sub-section 407.

5. Immediately upon mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-base, in required quantites. In no case should the material be dumped in heaps, directly on the area where it is to be laid. The mix may be spread either by a paver-finisher or motor grader.

6. Thickness of a single compacted WMM layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted thickness up to 200 mm may be adopted.

7. The surface of aggregate shall be carefully checked with templets and all high or low spots should be remedied by removing/adding aggregates as required. The thickness of layer shall be tested with depth blocks.

8. No segregation of large and fine aggregates shall be allowed.

9. After the mix is laid to proper thickness, grade and cross fall/camber, the same shall be uniformly compacted with a suitable roller. Rolling shall be continued till the density achieved is at least 100% of the maximum dry density as per IS:2720 (Part 7).

10. If the surface irregularity of WMM course exceeds the permissible tolerances, the full thickness of layer shall be scarified over the affacted area., reshaped by adding premixed material or removed and replaced with fresh premixed material as applicable and re-compacted. The area treated in this manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with improperly graded and properly graded materials or fines.

11. After final compaction of WMM, the road shall be allowed to dry for at least 24 hours.

12. Preferably no vehicular traffic should be allowed on the finished WMM surface till it has dried and the wearing course has been laid.

B.Quality Control requirements

1. Materials

(i) Physical Requirments

Coarse aggregate shall be crushed stone. If crushed gravel is used, not less than 90% by weight of gravel/single pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregate shall confirm to the requirement of Table 10.1

Table 10.1: Physical Requirments of Coarse Aggregate for Wet Mix Macadam

FOR BASE COURSE

S.No.	Test	Test Method	Requirements
1.	Aggregate Impact Value	IS:2386 (Part 4) or IS:5640	40% (Max.)
2.	Flakiness Index	IS:2386 (Part 1)	25% (Max.)

NOTE:-If water absorption value of coarse aggregate is greater than 2% soundness test shall be carried out.

(ii) Grading Requirements

The aggregate shall confirm to the grading requirements indicated in Table 10.2

Table 10.2: Grading Requirments of Aggregate for Wet Mix Macadam

FOR BASE COURSE.

IS Sieve Designation	Maximum percent weight passing the sieve
53.00 mm	100
45.00 mm	95-100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30
600 micron	8-22
75 micron	0-8

Note:- Material finer than 425 micron shall have Plasticity Index (PI) not exceeding 6

(iii) Optimum Moisture Content :

Optimum Moisture Content shall be determined in accordance with IS: 2720 (Part 7)

2. Horizontal Alignment

The edges of WMM base will be correct within a tolerance limit of (±) 30 mm in plain and rolling terrain and (±) 50 mm in hilly terrain .

3. Surface Level

The tolerance in surface levels of the WMM would be (±)10 mm:(A grid of 10m by 2.5 m may be formed to check the surface levels).

4. Surface Regularity

The maximum permissible undulation measured with a 3 m straight edge, in the longitudinal profile shall be 10 mm and for cross profile the irregularity shall not exceed 8 mm.

10 Quality Control Tests

10.1 Tests Prior to Construction

The quality control tests to be carried out prior to constuction are indicated in Table 10.3.

Table 10.3: Quality Control Tests Prior to Construction

S.No.	Type of test	Frequency
1.	Aggregate Impact Value Test (IS: 2386 Part 4)	One to two tests on representative sample from each source identified by the Contractor, depending on availability.
2.	Flakiness Index Test (IS:2386 Part 1)	-do-
3.	Water Absorption Test (IS:2386 Part 3).	-do-

	Type of test	Frequency
4.	Soundness Test, if the water absorption exceeds 2%	One to two tests on representative sample from each source identified by the Contractor, depending on availability.
5.	Grading Test (IS:2386 Part 1)	-do-
6.	Atterberg Limits of portion of aggregate passing 425 micron sieve (IS:2720 Part 5)	-do-
7.	Proctor Compaction Test (IS: 2720 {Part 7) (after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size) alongwith Dry Density-Moisture Content Relation ship.	-do-

10.2 Test During Construction

The quality control tests to be carried out during construction are indicated in Table 10.4.

Table 10.4: Quality Control Tests During Construction

S.No.	Type of test	Frequency
1.	Grading Test (IS:2386 Part 1)	Atleast one test per dey
2.	Aggregate impact value (IS: 2386 Part 4)	At random one test per Km
3.	Placement Moisture Content (IS: 2720 Part 2)	Atleast three days per day.
4.	Density of Compacted Layer (IS::2720 Part 28.)	-do-

5. Thickness of Compacted Layer	At random.

10.3 Quality Control Checks

Quality Control Checks by AE/EE as per table 10.5

Table 10.5 Quality Control Checks by AE/EE

S. No.	Stage	Tests	Frequency	Designation of inspecting Officer
1.	Top of the finished WMM layer	i) Density of the compacted layer (IS:2720 Part 28)	a)One test for every 500 m length or part there of for each layer	AE
			b) One test for every 1000m length or part there of for each layer	EE
		ii) Surface Regularity and Transverse Profile	Random Checking	EE

11. Inverted choke :

If water bound macadam is to be laid directly over the subgrade, without any other intervening pavement course, a 25 mm course of screenings (Grading B) or coarse sand shall be spread on the prepared subgrade before application of the aggregates is taken up. In case of a fine sand or silty or clayey subgrade, it is advisable to lay 100 mm insulating layer of screening or coarse sand on top of fine grained soil, the grandation of which will depend upon whether it is intended to act as a drainage layer as well. As a prefered alternative to inverted choke, appropriate geosynthetics performing functions of seperation and drainage may be used over the prepared subgrade as directed by the Engineer. Section 700 shall be applicable for use of geosynthetics.

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CHAPTER 11

PRIME COAT

Methodology :

1. Prior to applying the primer, the surface shall be carefully swept or brushed, clear of dust and loose particles. The existing surface shall be made slightly damp in case of using emulsion.
2. The bituminous primer should normally be emulsion (slow setting.) It should be bituminous emulsion of SS1 type as described in MORD specifications. Spraying of primer shall be done only with bitumen pressure sprayer. **Use of hand sprayer strictly probhited.**
3. Normal temperature range of spraying emulsion should be 20°C to 60°C. The rate of application depends upon type of surface to be primed and is given in Table 10.1. A very thin layer of clear sand may be applied to the surface of primer to prexent the primer picking under wheels of paver or thicks delivering material for construction of bitumenious layer.
4. Primed surface shall be allowed to cure for atleast 24 hrs.

Table 11.1 : Rate of application of bituminous emulsion for prime coat

[As per table 500.1 of Rural Road Specification]

Porosity	Type of Surface	Viscosity at 60°C		Rate of Application per 10 sqm
		Kinematic Viscosity of Primer at 60°C (Centistokes)	Saybolt furol Viscosity at 60° C (Seconds)	
Low	Water Bound Macadam / WMM	30 - 60	14 - 28	7 - 10 kg.
Medium	Stabilized base	70 - 140	33 - 66	9 - 12 kg.
High	Gravel Base	250 - 500	117 - 234	12 - 15 kg.

11. Quality Control Requirements.

(i) The viscosity requirements for bitumen emulsion will depend upon the type of surface as already given in Table 11.1

(ii) A priming grade bitumen emulsion (slow setting) conforming to IS:8887 should be used.

Quality Control Tests :

11.1 Tests Prior to Construction

Table 11.2 : Quality Control Tests Prior to Construction

S. No.	Type of test	Frequency
1.	Viscosity (Using Sabolt Furol Viscometer) (IS:8887)	One test for each lot
2.	Residue on 600 mocron sieve (IS:8887)	-do-
3.	Storage Stability Test (IS:8887)	-do-
4.	Flash Point Test where bituminous cut back is to be used (IS:217)	-do-
5.	Viscosity Test (IS:217), where bituminous cutback is to be used	-do-

11.2 Test During Construction

The quality control tests to be carried out during construction are indicated in Table 11.3

Table 11.3: Quality Control Tests During Construction

	Type of test	Frequency
1.	Temperature of Binder, when cutback is to be used	Regularly
2.	Base of Spread of Binder	At least two tests per day
3.	Cutting of Primer	Before any subsequent treatment

Quality Control Requirements :

1. The viscosity requirements for bitumen emulsion will depend upon the type of surface as already given in Table 11.1
2. Quality control tests : The Quality Control tests and their frequencies would be as per Table 11.2, 11.3
3. The primer supplied by reputed companies like Indian oil corporation, Hindustan Petroleum, Bharat Petroleum etc. may only be used.

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CHAPTER 12

TACK COAT

Methodology :

1. The bituminous binder should be bituminous emulsion (medium setting). The use of cutback (RC- 70 or MC- 70) should not be used. The type of emulsion will be bitumen emulsion of RS1 type as described in MORD specifications.
2. The surface to be tack coated must be clean, free of loose material and dust.
3. The binder should be sprayed uniformaly over the surface using suitable bitumen pressure distributor, spraying bitumen at specified rates and temparture so as to provide a uniformaly unbroken spread of bitumen. Normal range of spraying temperature should be 20°C - 60°C in case of emulsion and 50°C - 80°C in case of cutback. The rate of application depends upon the type of surface and is given in Table 12.1

Table 12.1 : Rate of Application of Tack Coat

[as per table 500-2 of Rural Road Specification]

S. No.	Type of Surface	Quality of Bituminous Emulsion in kg per square metre area
1	Normal Bituminous surface	0.20 to 0.25
2	Dry and hungry bituminous surface	0.25 to 0.30
3	Granular surfaces treated with primer	0.25 to 0.30
4	Cement Concrete Pavement	0.30 to 0.35

4. Tack Coat shall be left to cure untill volatiles have evaporated before any subsequent construction is started.

Quality Control Requirements

1. The quality control tests and their frequencies would be as per Table 12.2
2. The emulsion supplied by reputed companies like Indian oil corporation, Hindustan Petroleum, Bharat Petroleum etc. may only be used.

Table 12.2 : Quality Control & Tests and their frequecny

[As per table 1800.3 of MORD Specifications]

S. No.	Tests	Frequency
1	Quality of Binder	1 Test per lot or 10 tonnes
2	Temperature of Binder	Regular Close intervels
3	Rate of Spread of Binder	2 Test per 1000 sqm. not less than 2 test per day

CHAPTER 13

SURFACE DRESSING

Methodology :

1. **Bituminous** binder should be heated to a temperature specified in Table 13.1 and sprayed uniformly at the rates specified in Table13.2

Table 13.1 : Range of spraying temperature for different binders

Binder	Whirling Jets	Slot Jets
♦ Penetration grade bitumen (S - 90)	170°C - 190°C	165°C - 175°C
♦ Modified bitumen	180°C - 200°C	175°C - 185°C
♦ Emulsion (RS)	25°C - 50°C	25°C - 50°C

Table 13.2 : Nominal Rate of spread for binder and chippings.

[As per table 500.11 of Rural Road Specification]

Nominal (Cum / m2)	Binder (Penetration Chipping Size) (mm)	Bitumen Emulsion Grade bitumen kg / m2	Chips kg / m2
13.2	1.0	1.5	0.010
9.5	0.9	1.4	0.008
6.3	0.75	1.1	0.004

Table 13.3 : Physical requirements of stone chipping for surface dressing

[As per table 500.3 of MORD Specification]

♦ Aggregate Impact Value	30 percent maximum
♦ Flakiness Index	25 percent maximum
♦ Stripping Value	Minimum retained coating 95%
♦ Soundness	
- Loss with Sodium Sulphate - 5 cycles	12 percent maximum
- Loss with Magnesium Sulphate - 5 cycles	18 percent maximum
♦ Water absorption	2 percent maximum

(a) Grading : The stone chippings should conform to the Grading given in Table 12.4

Table 13.4 : Grading requirements for chips for surface dressing

[As per table 500.9 of Rural Road Specification]

IS Sieve Designation	Cumulative percent by weight of total aggregate passing for the following nominal sizes (mm)		
mm	13.2	9.5	6.3
19.0	100	-	-
13.2	85 - 100	100	-
9.5	0 - 40	85 - 100	100
6.3	0 - 7	0 - 35	85 - 100
4.75	-	0 - 10	-
3.35	-	-	0 - 35
2.36	0 - 2	0 - 2	0 - 10
0.60	-	-	0 - 2
0.075	0 - 1.5	0 - 1.5	1 - 1.5
Minimum 65% by weight of agrregate	Passing 13.2 mm retained 9.5 mm	Passing 9.5 mm retained 6.3 mm	Passing 6.3 mm retained 3.35 mm

Table 13.5 : Size requirements of stone chips for surface dressing.

[As per table 500.10 of MORD Specification]

Type of Construction	Nominal Size of Stone Chips	Specifiation
Single coat surface dressing or the first coat of two - coat surface dressing	13.2 m	100 percent passing IS sieve 22.4 mm size and reteined on IS sieve 11.2 mm size
Second coat of two- coat surface dressing (also used as a renewal coat)	9.5 mm	100 percent passing IS sieve 11.2 mm and retained on IS sieve 5.6 mm size

(b) **Bitumen** :

The binder should be liquid bituminous material which may be

- Paving grade bitumen (IS 73 - 1992)
- Modified bitumen (IRC 53- 1999)
- Rapid setting bitumen emulsion (IS 8887 - 1995)
- Surface Level [As per Chapter 18]
- Surface Regularity [As per Chapter 18]

c) Quality control Requirements

1. Materials

Aggregates should satisfy requirements given in Table 13.4

Bitumen shall be of paving grade S:35 to S-90

2. Horizontal Alignments

The edges of the Modified Penetration Macadam layer should be correct with in a tolerance limit of (±) 30 mm in plain and rolling terrains and (±) 50 mm in hilly terrain.

3. Surface Levels

The tolerance in surface level of the Modified Penetration Macadam should be (±) 6 mm.

4. Surface Regularity

The maximum allowable difference between the road surface and a 3 m straight edge would be 12 mm for longitudinal profile and 8 mm for cross profile

13. Quality Control Tests

The quality control tests and their frequencies would be as per Table 13.6 and 13.7

13.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table 13.6

Table 13.6 Quality Control Tests Prior to construction

S.NO.	Type of test	Frequency
1.	Quality of binder (straight Bitumen) (IS: 73)	
	a) Penetration test	One test per lot
	b) R&B Softening Point test	-do-
	c) Ductility Test	-do-
2.	Aggregate of Binder (Modified Bitumen) (IS:15462)	
	a) Penetration test	One test per lot
	b) R&B Softening Point test	-do-
	c) Elastic Recovery Test (d) Seperation Test	-do-
3.	Aggregate Impact Value Test (IS: 2386 Part 4)	One test on representative sample per km length from each source identified by the Contractor
.4.	Flakiness Index Test (IS:2386Part 1)	-do-
5.	Bitumen Stripping of Aggregate Test (IS:6241)	-do-
6.	Water Absorption (IS:2386 Part 3)	-do-
7.	Soundness Test, if water absorption of aggregate exceeds 2% (IS:2386 Part 5)	-do-

13.2 Tests During Construction

The quality control tests to be carried out during constructioon are indicated in Table 13.7

Table 13.7: Quality Control Tests During Construction

S. No.	Type of test	Frequency
1.	Rate of spread of binder	At least one test daily
2.	Rate of spread of aggregates	-do-
3.	Aggregates Grading (IS:2386 Part 1)	-do-
4.	Temprature of binder during spraying	-do-
5.	Thickness of compacted layer	-do-

CHAPTER 14

PREMIX CARPET AND SEAL COAT

Methodology :

1. The base on which premix carpet (20 mm thick) is to be laid should be prepared and shaped to specified lines, grades and cross-sections.
2. A prime coat should be followed by tack coat should be applied over the base prepared for laying of the carpet.
3. The temperature of bitumen at the time of mixing should be in the range of 150°C to 163°C and that of aggregates 155°C to 163°C. Mixing should be thorough to ensure that a homogeneous mixture is obtained and all particles of aggregates are coated uniformly. The temperature at the time of discharge of the mixture should be between 130°C and 160°C.
4. The mixed material should be transported quickly to site of work and laid uniformly by suitable means.

Materials :

The materials should be proportioned as per quantities given in Table 14.1

Table 14.1 : Rate of application of materials for premix carpet
[As per table 500.13 of Rural Road Specification]

Aggregates of Carpet	Quantity per 10m²
a] Stone chippings - 13.2 mm size passing 22.4 mm sieve and retained on 11.2 mm sieve	0.18 m³
b] Stone chippings - 11.2 mm size passing 13.2 mm sieve and retainedon 5.6 mm sieve	0.09 m³
Binder for premixing (quantities in term of straight run bitumen)	
a] For 0.18 m³ of 13.2 mm size stoen chippings at 52 kg per m³	9.5 kg
b] For 0.09 m³ of 11.2 mm size stone chippings at 56 kg per m³	5.1 kg

Rolling :

The rolling should commence with 80 - 100 KN rollers (three wheels of tandem type), beginning from the edge and progressing towards the centre longitudinally. (On super elevated portions, rolling should progress from lower to upper edge paralle to centre line of pavement). 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 continue until entire surface has been rolled to required compaction. The entire operation of rolling shall be completed before the temprature of mix falls below 100°C.

Seal Coat : A seal coat should be applied to the surface immediately after laying the carpet at rates given in Table 14.2. The Trafic should not be allowed on the road till seal coat is properly laid and compacted.

Table 14.2 : Rate of application of materials for Seal Coat :

1	**Type A : Liquid Seal Coat**	Quantity per 10 m^2
a]	Stone chipping 6.7 mm size 100% passing through 11.2 mm sieve and retained on 2.36 mm sieve	0.09 m^3
b]	Bitumen	9.80 kg.
2	**Type B : Premix Seal Coat**	Quantity per 10 m^2
a]	The aggregate shall pass 100% through 2.36 mm sieve and retained on 180 micron sieve	0.06 m^3
b]	Bitumen	6.8 kg
3	**Type C : Premix Seal Coat**	Quantity per 10 m^2
a]	Stone chipping 6.7 mm size 100% passing through 9.5 mm sieve and retained on 2.36 mm sieve	0.09 m^3
b]	Bitumen	4.5% of weight of total mixture

The mix for the seal coat should be transported quickly to the site of work and spread uniformly on the premix carpet to be sealed. Rolling operations should be undertaken and continued till all voids are sealed and a smooth uniform surface is achieved.The rolling shall start from outer edge and countinued up to center so that camber is not disturbed. In case of type A seal coat, the road may be opened to traffic after 24 hours of the work of laying seal coat is completed. In case of seal coat type B or type C the traffic can be allowed after final rolling is complete and temperature of the surface has cooled down to the surrounding temperature.

Quality Control Requirements :

1. **Materials :**

(a) Stone Chippings

(i) Physical requirements : Stone chippings should satisfy the requirements given in Table 14.3

Table 14.3 : Physical requirements of stone chippings premix carpet

[As per table 500.3 of Rural Road Specification]

♦ Aggregate impact value	30 percent maximum
♦ Flakiness Index	25 percent maximum
♦ Stripping Value	Minimum retained coating 95%
♦ Soundness	
♦ - Loss with Sodium Sulphate - 5 cycles	12 percent maximum
♦ - Loss with Magnesium Sulphate -5 cycles	18 percent maximum
♦ Water absorption	1 percent maximum

(ii) **Grading :**

The two types of aggregates are mixed to gether : 13.2 mm (passing 22.4 mm and retained on 11.2 mm) and 11.2 mm (passing 13.2 mm and retained on 5.6 mm) in a 2 : 1 proportion.

(b) Bitumen :

The binder should be paving grade bitumen (IS 73 - 1992) S- 65 or S - 90 as per the contract or as decided by the Engineer.

-Surface Level [As per Chapter 18]
-Surface Regularity [As per Chapter 18]

14. Quality Control Tests :

14.1 Test Prior to Construction

The quality control tests and their frequencies would be as per Table 14.4 :

Table 14.4 :Quality Control Tests Prior to construction

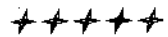
S. No.	Type of test	Frequency
1.	Quality of Binder (Straight-run Bitumen)	
	a) Penetration Test (IS:73)	One set of test per lot
	b) R&B Softening Point test (IS:73)	-do-
	c) Ductility Test (IS:73)	-do-
2.	Quality of Binder (Bitumen Emulsion)	
	a) Viscocity (IS:8887)	-do-
	b) Residue on 600 micron sieve(IS:8887)	-do-
	c) Storage Stability Test (IS:8887)	-do-
3.	Quality of Binder (Modified Bitumen) (IS:15462)	
	a) Penetration Test	One set of test per lot
	b) Softening Point Test	-do-
	c) Elastic Recovery Test	-do-
	d) Separation Test	-do-
4.	Aggregate Impact Value Test	One test per km length on representative sample from each source identified by the Contractor
5.	Flakiness Index Test (IS:2386 Part 1)	-do-
6.	Bitumen Striping of Aggregate test (IS:6241)	-do-
7.	Water Absorption (IS: 2386 Part 3)	-do-

14.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 14.5

Table 14.5. Quality Control Tests During Construction

S. No.	Type of Test	Frequency
1.	Grading of Aggregates (IS:2386 Part 1)	At least two tests per day
2.	Binder content before seal coat	-do-
3.	Temperature of Binder	Regularly close intervals
4.	Thickness of layer	Regularly at close intervals
5.	Aggregates impact value (IS:2386 Part 4)	At random one test per km



CHAPTER 15

MIX SEAL SURFACING

Methodology :

1. The temperature of bitumen at the time of mixing should be in the range of 150°C to 163°C and that of aggregates 155°C to 163°C.

i] **Stone Chipping :**

The rate of application of stone-chips and bitumen should be as given in Table 15.1. The grading of aggregates should be type A as given in Table 15.1.

Table 15.1 : Rate of Application of material for Mix Seal Surfacing

[As per clause 509.2.5 of Rural Road Specification.

Type	Aggregate Quantity per 10 sqm.	Bitumen per 10 sqm.
Type A	0.27 cum	22 kg
Type B	0.27 cum	19 kg

Quality Control Requirements :

Materials

(a) Stone Chippings

(i) Physical requirements : Stone chippings should satisfy the requirements given in Table 14.2

Table 15.2 : Physical requirements of stone chipping for Mix Seal Surfacing

[As per table 500-3 of Rural Road Specification]

◆ Aggregate Impact Value	30 percent maximum
◆ Flakiness Index	25 percent maximum
◆ Stripping Value	Minimum retained coating 95%
◆ Soundnes	
- Loss with Sodium sulphate - 5 cycles	12 percent maximum
- Loss with Magnesium Sulphate - 5 cycles	18 percent maximum
◆ Water absorption	1 percent maximum

(ii) **Grading :**

The stone chipping should confirm as given in Table 15.3

Table 15.3 : Aggregate gradation

[As per table 500.15 of Rural Road Specification]

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

(b) Bitumen :

The binder should be paving grade bitumen (IS 73 - 1992) S- 65 or S - 90 as per the contract or as decided by the Engineer. (Appendix 1 for guidelines on selection of binder).

- Surface Level [As per Chapter 18

- Surface Regularity [As per Chapter 18]

15. Quality Control Test :

The quality control test and their frequencies would be as per same as Table 14.4 and 14.5 of Premix Carpet.

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CHAPTER 16

MODIFIED PENETRATION MACADAM

Methodology :

1. The base on which modified penetration macadam course is to be done should be prepared and shaped to the specified lines, grade and cross-section.
2. A prime coat should be applied over the base preparatory to laying of the modified penetration macadam.
3. The coarse aggregates 40 mm size should be spread uniformly at the rate of 0.9 cum for 75 mm thickness (0.6 cum for 500 mm thickness) per 10 m^2 area. All high spots and depressions should be remedied by removing or adding aggregates.
4. Rolling should commence with 80-100 KN rollers (three wheels or tandem type), begining 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).
5. Any irregularities, noticed after the roller has passed over the whole area once, should be corrected by loosening the surface and removing or adding the coarse aggregates followed by rolling. Rolling should continue till the entire surface has been rolled to desired compaction such that there is no crushing of aggregates and all roller marks have been eliminated.
6. The bitumen should be heated to a temperature of 177°C to 191°C and sprayed uniformly on aggregate layer at the rate of 20 kg per 10m^2 for 75 mm thick layer. (17.5 kg per 10 m^2 for 50 mm thick layer)
7. Immediately after application of bitumen. 12mm size key aggregates should be spread at a uniform rate of 0.18 cum for 75 mm thickness (0.12 cum for 50 mm thickness) per 10m^2 so as to cover the surface completely followed by rolling. Rolling should continue until the key aggregates are firmly embedded in position.

8. A wearing coarse should be applied immediately after laying the modified penetration macadam. If there is publisity of any delay in laying of wearing course, a seal coat should be applied immediately as per rates given in Table 15.2

Table 16.1 : Rate of application of aggregates for 10 sqm. area

[As per table 500.7 of Rural Road Specification]

Description	Thickness of Modified Penetration Macadam Layer			
	75 mm		50 mm	
	On Bituminous Surface (cum)	On WBM Surface (cum)	On Bituminous Surface (cum)	On WBM Surface (cum)
(a) 40 mm size hand broken metal	0.9	0.9	0.6	0.6
(b) 12 mm size stone chips	0.18	0.18	0.18	0.18

Table 16.2 : Rate of application of bitumen for 10 sqm. area

[As per table 500.8 of Rural Road Specification]

Description	Thickness of Modified Penetration Macadam Layer			
	75 mm		50 mm	
	On Bituminous Surface (Kg)	On WBM Surface (Kg)	On Bituminous Surface (Kg)	On WBM Surface (Kg)
(a) Bitumen of Grouting	20	20	17.5	17.5
(b) Tack Coat	As per Clause 503 of Rural Road Specification			

Quality Control Requirements :

Materials :

(a) Coarse Aggregates and Key Aggregates

(i) Physical requirements : Aggregates should satisfy the requirements given in Table 16.3

Table 16.3 : Physical requirements of aggregates for bituminous macadam

[As per table 500.3 of Rural Road Specification]

♦ Aggregate Impact Value	30 percent maximum
♦ Flakiness Index	25 percent maximum
♦ Stripping Value	Minimum retained coating 95%
♦ Soundness	
- Loss with Sodium Sulphate - 5 cycles	12 percent maximum
- Loss with Magnesium Sulphate - 5 cycles	18 percent maximum
♦ Water absorption	2 percent maximum

(ii) Grading :

The coarse aggregates should be 40 mm size. Hand broken metal is acceptable. Key aggregates should be 12 mm size.

(b) Bitumen :

The binder should be paving grade bitumen S- 35 or S- 65 as per the contract or as decided by the Engineer. (Appendix 1 for guidelines on selection of binder).

- Surface Level [As per Chapter 18]
- Surface Regularity [As per Chapter 18]

16. Quality Control Test

16.1 Tests Prior to Construction

The quality control tests to be carried out prior to construction are indicated in Table16.4

Table 16.4 : Quality Control Tests Prior to Construction

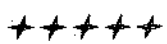
S. NO.	Type of test	Frequency
1.	Quality of Binder (Straight-run Bitumen)(IS:73)	One set of tests per lot (Average of three test)
	a) Penetration Test	
	b) R&B Softening Point test	-do-
	c) Ductility Test	-do-
2.	Quality of Binder (Bitumen Emulsion)	
	a) Viscocity (IS:8887)	-do-
	b) Residue on 600 micron sieve(IS:8887)	-do-
	c) Storage Stability Test (IS:8887)	-do-
3.	Quality of Binder (Modified Bitumen) (IS:15462)	
	a) Penetration Test	-do-
	b) R&B Softening Point Test	-do-
	c) Elastic Recovery Test	-do-
	d) Separation Test	-do-
4.	Aggregate Impact Value Test	One test per km length on representative sample from each source identified by the Contractor
5.	Flakiness Index Test (IS:2386 Part 1)	-do-
6.	Bitumen Stripping of Aggregate test (IS:6241)	-do-
7.	Water Absorption (IS: 2386 Part 3)	-do-

16.2 Tests During Construction

The quality control tests to be carried out during construction are indicated in Table 16.5

Table 16.5 : Quality Control Tests During Construction

S.No.	Type of test	Frequency
1.	Rate of spread of binder	At least two tests per day
2.	Rate of spread of aggregate(Anex.IV)	At least two tests per day
3.	Grading of Aggregates (IS:2386 Part 1)	At least one test per day
4.	Temperature of Binder during spraying (Annex-I)	Regularly at close intervals
5.	Storage stability Test for Bitumen Emulsion	One test per day
6.	Aggregates impact value (IS:2386 Part 4)	At random one test per km.



CHAPTER 17

CEMENT CONCRETE PAVEMENTS

Methodology :

1. Sub-grade is prepared as per procedure mentioned in chapter-7.
2. Granular sub-base is prepared as per processure mentioned in chapter-8.
3. Base course is prepared as per procedure mentioned in chapter-9
4. Form work for cement concrete slab shall be over the base course it shall be set to true level and securely fixed in position to prevent any subsequent disturbance during compaction.
5. Mixing of concrete shall be done in a power driven mixer of approve type that will ensure a uniform distribution of materials. The mixer with hopper attachment should only be used.
6. Concrete shall be placed on the prepared base between formwork in such a manner as to avoid segregation and uneven compation. Concrete shall be deposited within 20 minutes and compacted within 60 minutes in summer and 75 minutes in winter. Concreting shall not be done when the atmospheric temperature is below 5°C and above 40°C.
7. Concrete shall be compacted fully using vibrating screed and internal vibrator. Water in fresh concrete should not be in excess of the stipulated quantity, otherwise concrete is like to crack within very short period after drying. After compacting and finishing with screed a float and then a broomer is used to finally finish the top surface with required texture to avoid skidding. Any depressions or high spot showing deviation from the true surface shall be immediately rectified. High spots shall be cut down and refinished.

8. Contraction and expansion joints shall be provided as per the Guidelines mentioned in IRC : 15 or IRC : 58. All materials required for the joints, viz, tie bars at longitudinal joints, dowel bars at expansion joints, expansion joint filler boards and joint sealing compounds shall be checked for specifications requirements as per IS : 1834 and IRC :
9. Curing shall commence soon after the finished pavement surface can taken the wet burlap, cotton or jute mats normally apply for initial curing, without leaving any marks thereon (ISR : 11). The mates shall extend beyond the pavement edges at least by 0.5 m and be constantly wetted. Initial curing shall be for 24 hours or till the concrete is hard enough to permit labour operations without damages. Upto 24 hours no water other than mixing water, should be added to the surface of concrete except just wet burlaps. Final curing, after removal of the mats,etc. shall be carried out by wet ponding earth, ponding of water or other means specified. Where water is scarce or pavement is on a steep gradient, impervious membrance curing shall be adopted.

Materials :

Cement:

Any of the following types of cement capable of achieving the design strength may be used with prior approval of the Engineer.

i. Ordinary Portland Cement, 33 Grade, IS: 269
ii. Ordinary Portland Cement, 43 Grade, IS: 8112
iii. Ordinary Portland Pozzolana Cement, IS: 1489
iv. Portland Blast Furnace Slag Cement IS: 455
v. Ordinary Portland Cemet (OPC), 53 grade (IS: 12269) is to be used only when a part of cement is replaced by flyash.

Coarse Aggregates:

Flakiness index not more than 35%. The maximum size of coarse aggregate shall not exceed 25mm for pavement concrete. Water absorption of aggregate should be less than 3%.

Fine Aggregates :

The fine aggregate shall not contain deleterious substances more than the following limits :

Clay Lumps	4 %
Coal and lignite	1 %
Material passing IS Sieve	4 % in natural sand
No. 75 micron	15 % in crushed sand
Fineness Modulus	2 to 3.5

Table 17.1 : Course Aggregate gradation for Concrete

[As per table 1500.1 or Rural Road Specification]

Sieve Designation	Percentage Passing the Sieve by Weight
26.5 mm	100
19.0 mm	80 - 100
9.5 mm	55 - 80
4.75 mm	35 - 60
600 micron	10 - 35
75 micron	0

Dowel bars :

Plain steel bars as per IS : 432 (Part 1) having minimum yield strength 240 N/mm^2 shall be used as dowel bars.

Joint filler:

Bitumen impregnated fuller board or synthetic joint filler board may be used for expansion joint as per drawing and material should

comply the requirement of IS: 1838. The board should extend little more beyond edge of pavement and side form. The holes shall be accurately bored or punched out to have sliding fit on the dowel bars.

Joint Sealing Compound

This shall be hot poured sealing compound of reputed make having desired flexibility, resistance to age, hardening and durability conforming to IS:1834.

Concrete strength :

The concrete mix shall be of minimum M 30 grade and its design shall be based on the flexural strength of concrete. The target average strength for the mix design shall be obtained from the following relationship :

$S = S1 + Za*ó$

where

S = target average flexural strength, at 28 days, in MPa

S1 = characterstic flexural strength, at 28 days, in MPa

Za = normal variate, for rural roads the the tolerance level of 1 in 20 is recommended for which Za = 1.65

σ = Standard Deviation in MPa

Mix Design

For concrete having strength more than M20 should be properly design with all the material like cement, fine and coarse aggregate to be actually used in the work. The Engineer-in-charge will ensure that the sample of material with which mix design is done, is available at site and no deviation is made. In case of deviation the process of mix design shall be done again. The mix design is based on IRC 44 and IS: SP 23 and will be based on flexural strength of concrete. The range of cement content can be 310 Kg. to 425 Kg. per cum of concrete.

DRY LEAN CEMENT CONCRETE SUB-BASE *

1. Scope

1.1. The work shall consist of construction of dry lean concrete subbase for cement concrete pavement in accordance with the requirements of these Specifications and in confirmity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer . The work shall include furnishing of all plant and equipment, materials and labour and performing all operations, in connection with the work, as approved by the Engineer.

1.2. The design parameters of dry lean concrete sub-base, viz., width, thickness, grade of concrete, details of joints, if any, etc. shall be as stipulated in the Concrete drawings.

2 Materials

2.1. Source of Materials : the Contractor shall indicate to the Engineer the source of all materials with relevant test data to be used in the lean concrete work sufficiently in advance and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work. If the contractor later proposes to obtain the materials from a different source, he shall notify the engineer for his approval at least 45 days before such materials are to be used.

2.2 Cement : Any of the following types of cement may be used with prior approval of the Engineer:

(i) Ordinary Portland Cement	IS :	269
(ii) Portland slag Cement	IS :	455
(iii) Portland Pozzolana Cement	IS:	1489

If the subgrade is found to consist of soluble sulphates in a concentration more than 0.5 per cent, cement use shall be sulphate resistant and shall conform to IS:6909.

***NOTE - DLC work should not be done without prior permission of Head Office.**

Cement to be used may preferably be obtained in bulk from. It shall be stored in accordance with stipulations contained in Clause 1014 shall be subjected to acceptance test prior to its immediate use.

2.3 Aggregates

2.3.1 Aggregates for lean concrete shall be natural material complying with IS:383. the aggregates shall not be alkali reactive. The limits of deleterious materials shall not exceed the requirements set out in IS:383. In case the Engineer considers that the aggregates are not free from dirt, the same may be washed and drained for at least 72 hours before batching, as directed by the Engineer.

2.3.2. Coarse aggregate: Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, soft, flaky, elongated very angular or splintery pieces. The maximum size of the coarse aggregate shall be 25 mm, The coarse aggregate shall comply with clause 602.2.4.2.

2.3.3. Fine aggregate : The fine aggregate shall consist of clean, natural sand or crushed stone sand or a combination of the two and shall conform to IS:383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica, organic and other foreign matter. The fine aggregates shall comply with clause 602.2.4.3.

2.3.4 The coarse and fine aggregates may be obtained in either of the following manner :

(i) In separate nominal sizes of coarse and fine aggregates and mixed together intimately before use.

(ii) Separately as 25 mm nominal single size, 12.5 mm nominal size graded aggregates and fine aggregate of crushed stone dust or sand or a combination of these two.

The material after blending shall conform to the grading as indicated in Table17.2

TABLE 17.2. AGGREGATE GRADATION FOR DRY LEAN CONCRETE

[As per table 600.1 of MOSRTH]

Sieve Designation	Percent passing the sieve by weight
26.50 mm	100
19.00 mm	80-100
9.50 mm	55-75
4.75 mm	35-60
600.00 micron	10-35
75.00 micron	0-8

2.4 Water : Water used for mixing and curing of concrete shall be clean and free from injurious amounts of oil, salt, acid, vegetable matter or other substance harmful to the finished concrete. It shall meet the requirements stipulated in IS:456.

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CHAPTER 18

CONTROL OF ALIGNMENT, LEVEL AND SURFACE REGULARITIES

1. SURFACE LEVEL :

Table 18.1 : Tolerances in surface levels

[As per table 1800.1 of Rural Road Specification]

1	Subgrade	+ 20 mm	- 25 mm
2	Sub-base		
	(a)Flexible pavement	+ 10 mm	- 20 mm
	(b)Concrete pavement	+ 6 mm	- 10 mm
	[Dry lean concrete or rolled Concrete]		
3	Base-course for flexible pvement		
	(a)Bituminous course	+ 6 mm	- 6 mm
	(b)Other than bituminous		
	i]Machine laid	+ 10 mm	- 10 mm
	ii]Manually laid	+ 15 mm	- 15 mm
4	Wearing course for flexible pavement		
	(a)Machine laid	+ 6 mm	- 6 mm
	(b)Manually laid	+ 10 mm	- 10 mm
5	Cement concrete pavement	+ 5 mm	- 6 mm*

** This may not exceed 18 mm at 0 - 300 mm from the edges.*

Table 18.2 : [As per clause 1802.4 of Rural Road Specification]

Type of Construction	Maximum Permissible Undulation Measured with 3 m Straight Edge	
	Longitudinal Profile	Cross Profile
Subgrade	20 mm	15 mm
Granular Sub - base	12 mm	10 mm
Stablized Soil Layer	12 mm	10 mm
W.B.M. Grade I	15 mm	12 mm
W.B.M. Grade II & III	12 mm	8 mm
Wet Mix Macadam Base	10 mm	8 mm
Surface Dressing	10 mm	12 mm
Built - up Spray Grout	12 mm	8mm
20 mm Bituminous Premix Carpet	8 mm	8 mm
Bituminous macadam	12 mm	8 mm
Mix Seal Surfacing	8 mm	8 mm
Cement Concrete	6 mm	6 mm

Table 18.3 : Maximum Permitted Numbers of Surface Irregularities [As per Table 10.14 of IRC SP -20]

Irregularity	Number of Irregularity of Size			
	4 mm		7 mm	
Length for Measurement (m)	300	75	300	75
Number of Irregularities	50	25	6	3

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CHAPTER 19

CULVERTS AND SMALL BRIDGES

19.1.General :

In order to adopt uniform standards and to assist the field engineers in providing cross drainage works, type designs and estimates of culverts of probable spans and heights for rural roads are given. These designs are based on relevant IRC codes and guidelines. This Chapter generally deals with culverts, small bridges and minor bridges for rural roads, having height from foundation to road top up to 8 m and spans up to 10 m. Information and details of causeways and submersible bridges are also given. The required formation width for rural roads [Other District Raod (ODR) and Village Road (VR)] is 7.5m. In case of roads of short length connecting only one village and hill roads, the formation width can be reduced to 6m.

19.2.Geometrics of Culverts & Small Bridge :

The overall width of culvert should be equal to the formation width of the road. In rural Roads, the roadway width is 7.5 m in plain and rolling terrain. However from cost and low traffic point of view 6.3 m formation (roadway width) can be adopted for such roads, which connect only a small habitation and where length of the road is small. After careful consideration of various issues and with due consideration of traffic and cost, overall width of culverts and small bridges are given in Table : 18.1

Table 19.1 : Geometrics Standards : (Table 7.1 of IRC SP 20)

Type of Cross Drainage Works	For 7.5 m Roadway Width		For 6.0 m Roadway Width	
	Overall width, m	Carriageway, m	Overall, m	Carriageway, m
Culverts	7.5	6.6	6.0	5.5
Small and Minor Bridges	6.4	5.5	6.0	5.5
Submersible Bridges	7.5	6.6	6.0	5.5

19.3.Minimum span and clearance :

From the consideration of maintenace of culverts, it is preferable that the clear waterway of slab culvert is minimum 1.5 m and diameter of pipe in case of pipe culvert is 1000 mm (900 mm internal dia). Culverts of small span or diameter get choked due to silt. It is not possible to enter the pipe and carry out inspection and repairs in span or diameter less than the ones given above as the requirements. Irrigation pipes do not come under the purview of pipe culverts. Minimum height of soffit of slab should be 1.5 m above lowest bed level from the consideration of inspection and maintenance. Table 19.3 indicates clearance required for different spans.

Table 19.2 : Spans & Clearance : (Table 7.2 of IRC SP 20)

Span in m.	Vertical Clearance in mm.
1.0 and 1.5	150
2.0 and 2.5	300
3.0 and 4.0	450
5.0 and 6.0	600

(IRC : SP : 13 provides more detailed hydraulic calculations)

19.4.Kerb and parapet wall :

Parapet walls of culverts generally consist of either Random Rubble (RR) or Coarse Rubble (CR) stone masonry in cement mortar 1 : 5 or RCC railings of 0.8 m high above kerb. It is observed that these railings get damaged due to impact of vehicles and repair takes time. Where overall roadway is 7.5 m or 6.4 m, the combined width of kerb and parapet is 450 mm as per standards. However, for 6 m wide culverts or bridges, 250 mm wide RCC kerb, 300 mm above road level should be provided. If considered necessary either pipe raling or guard stones of 200 x 200 mm section projecting 300 mm above

kerb and spaced at 1200 mm c/c may be fixed. In case of small bridges with 7.5 m and 6.4 m overall width, parapet may be of Plain Cement Concrete (PCC) railing or brick masonry or of guard stones. At the end of parapets and returns, 400 x 400 x 600 mm RCC blocks are provided at four corners at the end of returns. Numbering of culverts and direction of flow can be marked on these pillars.

19.5.Types of Culvert :

Following types of culverts are generally provided :

a. RCC Pipe Culvert
b. RCC Slab on Masonry or Plain Concrete Abutment
c. RCC Box Type Culvert
d. Arch Culvert
e. Cut Stone Slab Culvert
f. Stone masonry Scupper
g. Vented Causeway
h. Submersible Bridge.

19.6 Height of Culvert :

The minimum height of the formation level of the road from the bed level is required to be as per Table in case of pipe culvert.

Table 19.3 : Minimum Height of Formation :
(Table 7.3 of IRC SP 20)

Diameter (NP Pipes), mm	Height of Formation, m
For 1000 (900 mm internal dia)	1.75
For 1200	2.15

19.7. Siting of Culverts on Gradient :

The cross drainage works should generally be sited on the straight alignment of a road. If a nalla crosses the road other than at right angle, either a skew culvert should be provided or, if economical, the nalla should be suitably trained. If the road at the culvert is in gradient, the same gradient of road may be provided for deck slab of the culvert. If the culvert is situated at

change of gradient (hump), the profile of vertical curve should be given in the wearing coat on the culvert. In such cases, the levels of the two abutment caps on either side may not be the same. However, the bearing surface of an RCC or Stone slab culvert on the abutment should be horizontal.

19.8 : Pipe Culvert :

Diameter of Pipe : The cost of slab culvert is less if the foun dation is within 2 m from the bed level, otherwise, pipe culvert is chosen. Although use of 450 mm, 600 mm diameter pipes in CD works was more popular in low to moderate rainfall regions, from inspection and maintenance point of view, a minimum of 900 mm (internal) diameter is recommended. However, taking into consideration the smaller length of barrel and low embankment heights, pipes of lesser dia, viz, 600 mm or 750 mm may also be used in exceptional situations. RCC pipes of 300 and 450 mm dia, used for purposes, such as, irrigation/agriculture are to be considered as mere buried conduits and not as culverts. The pipes for culverts of rural roads shall be of NP3 type, which conform to IS : 458 - 1989 and can be chosen as per Table.18.7.

Table 19.4 : Diameter of Pipe : (Table 7.4 of IRC SP 20)

Catchment Area (Hectares)	Diameter of Pipe (mm)
Up to 10	1000 single row
10 to 20	1200 single row
20 to 50	1000 or 1200 (2 to 3 rows)
50 to 60	1000 or 1200 (4 rows)

19.4: Design Requirements of Pipes :

The pipes shall be conform to IS : 458 - 1989 (Specification for concrete pipes) and shall be laid as per relevant IS : 783-1985 (laying of concrete pipes). The structural design of pipe culvert requires calculations of probable maximum load on the pipe, inherent strength of pipe and selection of bedding for the pipe. The load factor of pipe depends on different conditions of bedding as well as laying of pipes.

19.10 : Headwall :

In order to reduce the quantum of masonry wall and the cost, the headwalls are raised up to top of the pipe and 0.5 m parapet wall is provided above it.The length of headwall is equal to four times the diameter of pipe for retaining the slope of earthen bank within 1 (Vertical) to 1.5 (horizontal). By restricting the height, the length and section of headwall is considerably reduced. Longer headwalls are provided for wider streams as per site requirements. Pipes are generally 2.5 m or 3 m long. It shall be ensured that the invert of the pipe is placed 150 mm below the average bed level. Suitably designed RCC face wall (150 mm thick) can also be used for a single row pipe culvert.

19.11 : Excavation for Pipe :

The foundation bed of pipe culverts shall be excavated true to the lines and grades shown on the drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embank ment, taken down to levels as shown on the drawings.

In case of embankments of heights of fill more than 3 m above the bed level or three times the external diameter of the pipe, the embankment shall first be constructed to the level above the top of the pipe equal to the external diameter of the pipe and the width on either sides of the pipe shall not be less than five times the diameter of the pipe. After the construction of embankment, a trench shall be excavated and the pipe shall be laid. The width of trench in the embankment on either sides of the pipe shall be one-fourth of the diameter of the pipe subject to minimum of 50 mm and shall not be more than one third diameter of the pipe.The sides of the trench shall be as nearly vertical as possible.Where rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe.

19.12 : Bedding of Pipe

i. Type A (Concrete Cradle) bedding :

Type A bedding shall be provided for the size of pipes of 900 mm internal diameter or more and height of fill more than 4 metres above the pipe. The pipe shall be bedded in a cradle constructed of concrete having a mix not leaner than M 15 or as specified on the drawings, conforming to Section 800.

ii. Type B (First Class) Bedding :

Type B bedding shall be adopted for a height of fill less than 4 m above the pipe.Under type B bedding, the pipe shall be evenly bedded on a continuous layer of well compacted sand, moorum or approved granular material, shaped concen trically to fit the lower part of the pipe exterior for minimum 10 percent of its overall height. The bedding material shall be well graded sand or other granular material passing 5.6 mm sieve suitably compacted/rammed. The fill material shall be free from clay lumps. The compacted thickness of the bedding layer shall not be less than 75 mm or as specified on the drawings. Backfilling upto 300 mm above the top of the pipe shall be carefully done and the soil thoroughly rammed, tamped or vibrated in layers not exceeding 150 mm, particular care being taken to thoroughly consolidate the materials under the haunches of the pipe using light mechanical tamping equipment.Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur. The earthwork between the pipes shall be compacted thoroughly by hand compacting tools. Normally, granular material shall be used for the purpose. Care shall be exercised during compaction to prevent damage to pipes. In case of expansive soils, like, black cotton soil, which have very low bearing capacity, a layer of sand/moorum or non-expansive material shall be provided under the bedding. The thickness of the sand layer bedding shall be as specified on the drawings or as directed by the Engineer subject to the minimum thickness of 450 mm.

19.13 : Laying of Pipe :

Where two or more pipes are to be laid adjacent of each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm. The pipes shall generally be laid as per IS : 783.The longitudinal slope of the pipe shall not be flatter than bed slope subject to minimum of 1 in 1000 in plains.

19.14 : Jointing of Pipe :

The pipes shall be joined either by collar joint or the flush joint. The collar shall be of RCC 150 mm to 200 mm wide having strength as that of pipes. Caulking space shall be betwen 13 to 20 mm according to the diameter of the pipe. The collar shall be properly placed over the joint of the pipe to cover the joint evenly. Caulking material shall be a wet mix of cement and sand in the ratio of 1 : 2 rammed with caulking irons. In case of flush joint the ends of pipes are specially shaped to or a self-centering joint with jointing space 13 mm wide. The jointing space shall be filled with cement mortar (cement : Sand 1 : 2) mixed sufficently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed.

19.15 : Backfilling :

Trenches shall be backfilled immediately after the pipe have been laid and the jointing material has hardened. The backfill soil shall be clean, free from boulders, large roots, clay lumps retained on 75 mm sieve, stones retained on 26.5 mm sieve and excessive amounts of sods or other vegetable matter.

19.16 : Headwalls And Other Ancillary Work :

Headwalls wings walls, aprons and other connected works shall be constructed in accordance with the details shown on the drawings or as directed by the Engineer.

Brick masonry work in the pipe culvert shall conform to Section 600 of Specifications for Rural Roads.

Stone masonry work in the pipe culvert shall conform to Section 700 of Specifications for Rural Roads.

Concrete work in the pipe culvert shall conform to Section 800 of Specifications for Rural Roads.

Steel reinforcement work in the pipe culvert shall conform to Section 1000 of Specifications for Rural Roads.

19.17 : Materials :

Materials for the construction of various components of culverts and minor bridges shall conform to relevant provisions of these Specifications for Rural Roads as listed below :

i.	Bricks	Clause 602.4
ii.	Stones	Clause 702.4
iii.	Cement	Clause 602.2/702.2/802.2
iv.	Coarse aggregates	Clause 802.3
v.	Sand	Clause 602.5/802.
vi.	Water	Clause 802.5
vii.	Steel reinforcement	Clause 1002
viii.	Structural Steel	Clause 505 of IRC : 24

19.18. RCC Slab Culvert : (Table 7.5 IRC SP 20)

Catchment area and span requirement : RCC slab culvert is one of the common types of culvert. For catchment area more than 60 hectares, RCC slab culvert offer an economical and convenient proposal. The approximate relationship between the catchment area and the span is given in Table.

Table 19.5 : Clear Span of Culverts

Catchment Area in Hectares	Clear Span of Culvert, m
Up to 15	1.5
16 to 25	2.0
26 to 50	3.0
51 to 75	4.0
76 to 100	5.0
101 to 125	6.0
126 to 200 (Deep Channels)	6.0

19.19 : Minimum depth from lowest bed level :

Minimum depth from lowest bed level to soffit is 1.5 m. Normally a small bridge will not be required for catchment area less then 125 hectares. Most of the culverts on roads can be adjusted according to catchment area indicated in Table 18.18

19.20 : Detailing :

M25 concrete and High Strength Deformed bars are specified for usage in deck slab. A nominal 1 : 1.5 : 3 concrete mix with 43 grade cement and a water cement ratio restricted to 0.45 can produce this strength. In case of simply supported slabs, it is a common practice to crank alternative bars at $1/7^{th}$ clear span. Similar practice can be adopted for solid slab culvert of 4.0 m span and above. But in case of 3.0 m span and below, only one bar in every four bars is to be bent. Alternatively, cranking may be avoided. The plates showing the type designs indicate the exact number of bars to be cranked.

19.21 : RCC Box type Culvert

Section of box culvert : Box section of size less than 2 x 2 m is not practicable to implement. Box type culverts are suitable for a situation where the catchment area is more than 30 hectares. An isolated box culvert is economical in such cases where either the depth of foundation is more than 4 metres below bed level or where the total embankment is very high, as in

is very high, as in the case of approaches of a long bridge. Normal sections of box culverts adopted for different catchment areas are given in Table 7.6 Box culverts of smaller sections or arch culverts are cost effective at most of the locations particularly in strata with low bearing capacity and where founding strata is deep seated.

Table 19.6 Sections of Box Culverts (Table 7.6 IRC SP 20)

Catchment Area, Hectares	Sectin of Box Culverts
30 to 40	2.0m x 2.0m
41 to 60	2.5m x 2.5m
61 to 81	3 m x 3 m
upto 200	3m x 3m (2 boxes)

19.22 : Return wall or wing wall :

Splayed wing walls are generally found to be better than straight returns. However, straight returns are easy for construction and standardisation, The layout and construction of wing splayed wall is also difficult. It is, therefore, proposed to provide straight returns increased suitably. Type section for RCC pier and abutment caps besides dirt walls are given in Plate 7.25 of SP 20. The length of return walls beyond the faces of abutments should be as given in Table 19.22

Table 19.7 Length of Return : (Table 7.8 IRC SP 20)

Height of Formation at Abutment Above bed Level, m	Length of Return, m
2.5	3.75
2.5 to 3	3.75 to 4.5
3.5	5.25
4	6

19.23 : Section of abutment, pier and return

a] Section of abutments and returns : following sections are given in the following plates of IRC SP 20.

Height 2 m to .5 m	Masonry Section	Plate 7.2
Height 4.5 m to 8.0 m	Masonry Section	Plate 7.3
Abutment for height upto 8 m	PCC M15	Plate 7.4
Return for height upto 8 m	PC M15	Plate 7.5

The abutment cap and cap on return wall and dirt wall for culverts will be of plain concrete of M20 grade with surface reinforcement. Where bearings are provided the cap will be reinforced. For dirt walls of span more than 6m the dirt wall shall be reinforced. Stepped piers and abutments are chosen for ease of shuttering since tapered sections are likely to pose construction problems in rural areas.

b] Piers :

The sections of PCC pier and the method of designing a pier are given in the Plates 7.04 and 7.06 of SP 20. The sections of PCC return walls and wing walls are given in Plate 7.5. Where bearing capacity of soil is low, the lateral dimensions of the footing could be

c] Miscellaneous :

Stopper, protection around abutment and treatment for the submersible bridge is given in the Plate 7.20 of SP 20

19.24 : Approach Slab :

Abutment is designed for surcharge of equivalent height 1.2 m and return walls for an equivalent height of 0.6 m. Therefore, there is no need to provide approach slab. However, it may be desirable to provide a pavement for entire formation width for length of 3.6 m behind abutment, between returns.

19.25 : Approach Slab :

Abutement is designed for surcharge of equivalent height 1.2 m and return walls for an equivalent height of 0.6 m. Therefore, there is no need to provide approach slab. however, it may be desirable to provide a pavement for entire formation width for length of 3.6 m behind abutment, between returns.

19.26 : Weep hole and water spout :

Weep holes are provided to prevent building up of hydrostatic pressure behind abutments and wing walls.

i. There may not be any need for weep holes and waterspouts in small span culverts. However, local practices prevails on size and spacing of weep holes, which may be followed.

ii. If the height of abutment and return over bed level is more than 2m, weep holes should be provided 150 mm above low water level (LWL) or ground level (GL) whichever is higher. In case of stone masonry, weep holes of 150 mm dia or 80 x 150 mm size in 1 : 20 slope should be provided at required intervals (Refer : IRC : 40)

iii. For 5 m and 6 m span one waterspout of 100 mm dia should be provided in the centre of slab on either side of the deck.

19.27 : Grade of Concrete :

In the past, M10 and M15 grades of cement concrete were extensively used in CD works. As per IRC : 21, the minimum grade of structural concrete is M20 (design mix). Where the quantum of concrete work is small as in CD works of rural roads, it is suggested to use nominal mix based on volumentric proportion of cement, sand and aggregate with a low water cement ratio up to 0.45. The minimum quantity of cement shall be 310 kg/m^3. Superplasticizers could be used to improve workability.

19.28 : Test and Standards of Acceptance :

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

Tolerances in Concrete Elements :

a. Variation in cross-sectional dimensions mm : + 10 mm. - 5
b. Misplacement from specified position in plan : 10 mm
c. Variation of levels at the top : ± 10 mm
d. Variation of reduced levels of bearing areas : ± 5 mm
e. Variations from plumb over full height : ± 10 mm
f. Surface irregularities measured with 3 m straight edge : 5 mm
g. bearing areas : 3 mm

+++++

CHAPTER 20

CONCRETE FOR STRUCTURE

1. Methodology :

(i) Formwork and reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing of concrete.

(ii) For all works, concrete shall be mixed in mechanical mixer com plying with IS : 1791 and IS : 12119 fitted with water measuring device. Mixing shall be continued till materials are uniformly distributed and uniform colour and consistency of entire mass is obtained. Further each individual particle of coarse aggregate shall show complete coating of mortar containing its proportionate amount of cement, if there is segregation after unloading from the mixer, the concrete shall remixed for not less than 2 minutes.

(iii) After mixing concrete shall be transported to formwork as quickly as possible concrete shall be so transported and placed that no contamination segeregation or loss of its constituent materials and workability is also maintained, the concrete (ensure that) shall not be dropped from more than 1.5 m height.

(iv) The concrete shall be compacted before the intial setting of the concrete but not later than 30 minutes of its discharge from the mixer.

(v) Concrete shall be layed 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 case.

(vi) Concrete shall be throughly compacted by vibrations using internal (needle) vibrators of suitable size or form vibrators during placing and worked arround the reinforcement, embeded fixture and into corners of the form work to produce dense homogenious void free mass having face with required surface finish.

(vii) After one or two hours of concreting, the concrete shall be protected from thick drying by covering with moist gunny bags, canvas, Hessian or similar material. After 24 hours, all exposed surfaces of concrete shall be kept continiously in a damp or wet condition by ponding or by coverting with a layer of soaks, canvas, Hessian or similar materials and shall be kept constantly wet for a period of not less than fourteen days, from the date of placing of concrete.

2. Material :

(I) Cement :

Cement to be used in the works shall be any of the following types with the prior approval of the Engineer :

S.No.	Type	Conforming to
1	Ordinary Portland Cement 33 Grade	IS : 269
2	Ordinary Portland Cement 43 Grade	IS : 8112

(ii) Coarse Aggregates :

Coarse aggregates (4.75 to 40 mm size) shall be clean, free from adherent coating, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel, natural gravel or a suitable combination thereof or other inert material. They shall not consist pieces of disintegrated stones, soft, flaky, elongated particles, salt, alkali, vegetable matter or other deleterious materials such as coal, lignite, mica, pytire, shale, clay, organic impurities in such quantities as to reduce the strength and durability of the concrete, or attack the steel reinforcement. Coarse aggregate having positive alkali-silica reaction shall not be used.

Before the commencement of the work, at least three samples in accordance with the procedure laid down in IS : 2430 shall be taken for each quarry source to ascertain the quality, suitablility and fitness of the available material for use in the works.

Table : 20.1 (Table 800. 1 of Specification for Rural Roads)

IS Sieve Size	Percent by Weight Passing the Sieve for Nominal Size of		
	40 mm	20 mm	12.5 mm
63 mm	100	-	-
40 mm	95-100	100	-
20 mm	30-70	95-100	100
12.5 mm	-	-	90-100
10 mm	10-35	25-55	40-85
4.75 mm	0-5	0-10	0-10

(iii) Sand / Fine Aggregates :

Sand / Fine aggregates of sizes 0.15 to 4.75 mm shall consist of natural sand or hard pieces of crushed stone or crushed gravel or combination thereof. They shall be clean and shall not contain lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of concrete or to attack the embedded steel. Fine aggregates having positive alkali-silica reaction shall not be used. The fineness modulus of fine aggregate shall be between 2 to 3.5

Table : 20.2 (Table 800. 2 of Specification for Rural Roads)

IS Sieve Size	Percent by Weight Passing the Sieve		
	Zone I	Zone II	Zone III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

(iv) Water :

Water to be used for mixing and curing shall be clean and free from injurious amount of oils, acids, salts, sugar, organic materials or other substances that may harmful to concrete or steel. Potable water (with pH value between 6 and 8) is generally considered satisfactory for mixing and curing of concrete. The pH value of water proposed to be used shall not be less than 6. Water used for curing shall not produce any objectionable stain or unsightly deposit on concrete surface. Mixing and curing with sea water shall not be permitted.

3. Grades of Concrete :

The concrete shall be in grades designated as per Table 19.3, where the characterstic strength is defined as the strength of concrete below which not more than 5 percent of the results are expected to fall.

Table : 20.3 (Table 800.4 of Specification for Rural Roads)

Grade Designation	Specified characteristic compressive Strength of 150 mm cubes at 28 days in MPa
M 10*	10
M 15	15
M 20	20
M 25	25
M 30	30

Note : In designation of concrete M refers to the mix and number to the specified characteristic compressive strength of 150 mm cubes at 28 days expresed in MPa.

* Lean concrete levelling course/foundation concrete for masonry work.

Table : 20.4 (Table 800.5 (A) of Specification for Rural Roads)

Minimum Cement Content And Maximum Water Cement Ratio

Structural Member	Minimum Cement		Maximum Water	
	Content (kg/cu.m)	Condit--ions Exposure	Cement ratio	Condit ions Expos.
	Normal	Severe	Normal	Severe
a. Plain Cement Concrete member (PCC members)	250	310	0.50	0.45
b. Reinforced Cement Concrete member (PCC members)	310	400	0.45	0.40

Table 20.5 : (Table 800.5 (B) of Specification for Rural Roads)

Mnimum Strength of Concrete Structural Member	Conditions of Exposure	
	Normal	Severe
a. Plain Cement Concrete member (PCC members)	M 15	M 20
b. Reinforced Cement Concrete members (RCC members)	M 20	M 25

4. Finishing :

Immediately on removal of forms, the concrete shall be examined by the Engineer before any defects are made good.

All exposed bars or bolts passing through the reinforced cement concrete merneber and used for shuttering or any other purpose shall be cut inside the reinforced cement concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes be closed by cement mortar.

All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

The portion of concrete, which is porous or honey combed or its placing has been interrupted without providing proper construction joint or construction tolerances have not been met or reinforcement has been displaced to an extent detrimental to structural safety shall be rejected, removed and replaced as per the directions of the Engineer.

5. Sampling and Testing :

i. Concrete for making three test cubes shall be taken from a batch of concrete at point of discharge from the mixer in accordance with the procedures laid down in IS : 1199.

ii. A random sampling procedure to ensure that each of the concrete batches forming under the acceptance inspection has equal chance of being chosen for taking cube shall be adopted. The sampling shall be spread over the entire period of concreting covering all mixing units.

iii. 150 mm cubes shall be made, cured and tested at 28 days age for compressive strength conforming to IS : 516. The 28 days test strength result for each cube shall form an item of the sample representing a lot.

6. Test Specimen and Sample Strength :

Three test specimen shall be made from each sample for test ing at 28 days. Additional set of specimen shall be made to determine the strength of concrete at 7 days or for removal of formwork or any other purpose if directed by the Engineer.

7. Frequency :

The minimum frequency of sampling of concrete of each grade shall be as given in Table 9.1

Table 20.6 (Table 800.10 of Specification for Rural Roads)

Quantity of Concrete in Work (in cu.m)	No. of Samples
1-5	1
6-15	2
16-30	3
31-50	4

At least one sample shall be taken for each shift of work.

8. Acceptance Criteria :

All materials shall comply with the requirements of quality and fitness for the works as specified in Clause 802.Acceptance decision shall be taken lot by lot and samples of different lots shall not be clubbed for the purpose of acceptance. Test strength result of each cube shall form an item of the sample representing a lot.

Useful Data

1. Areas & Weights of Steel

a) Mild Steel Round Bars

Dia in mm	Area Sq. CM.	Weight Kg/M	Perimeter Cms
6	0.283	0.222	1.887
8	0.503	0.395	2.514
10	0.785	0.617	3.143
12	1.131	0.888	3.771
16	2.011	1.578	5.028
18	2.545	2.000	5.657
20	3.142	2.466	6.286
22	3.801	2.984	6.914
25	4.909	3.853	7.857
28	6.157	4.830	8.800
32	8.042	6.313	10.057
40	12.566	9.684	12.577

b) Weight of Materials for construction

S.No.	Material	Unit Metric	Weights
1	Cement	Cum	1440
2	Steel		
	a) Mild Steel	Cu. Cm.	0.0078
	b) Cast Steel	Cu. Cm.	0.0078
	c) H.T. Steel	Cu. Cm.	0.0078
3	Stainless Steel	Cu. Cm.	0.0078
4	Lead	Cu. Cm.	0.0113
5	Plain Cement Concrete of R.C.C.	Cu. Cm.	2306 to 2400
6.	Stones		
	a) Lime	Cum	2650
	b) Sand	Cum	2800
7	Stone Masonry Rubble	Cum	2100
8	Bricks	Cum	1600
9	Bricks Masonry	Cum	1920
10	Timber	Cum	650 to 720

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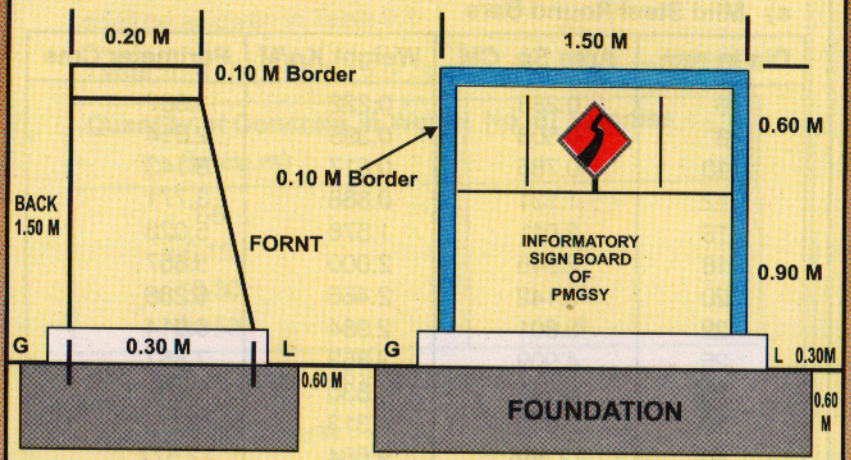
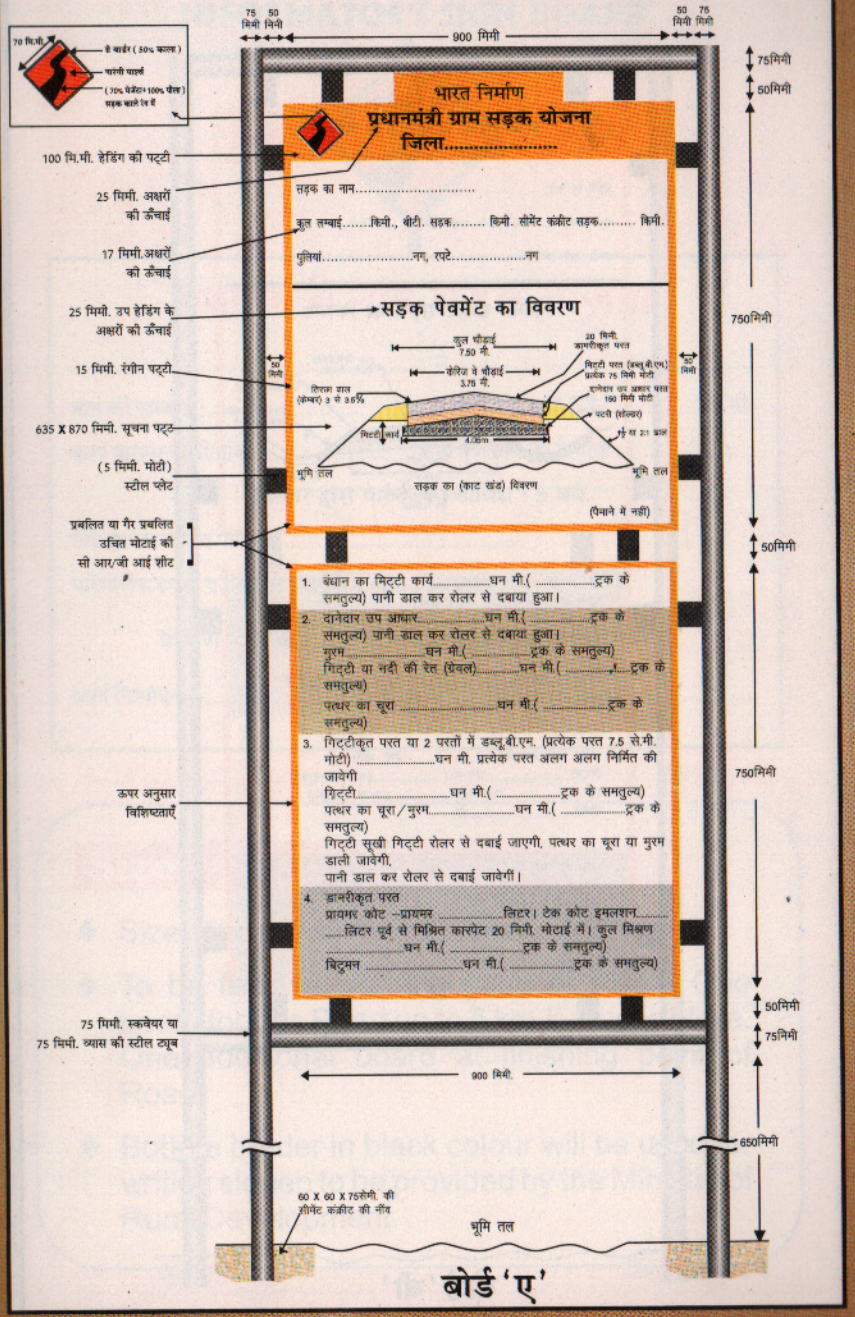
TYPICAL DRAWING OF PMGSY INFORMATORY SIGN BOARD IN CEMENT CONCRETE



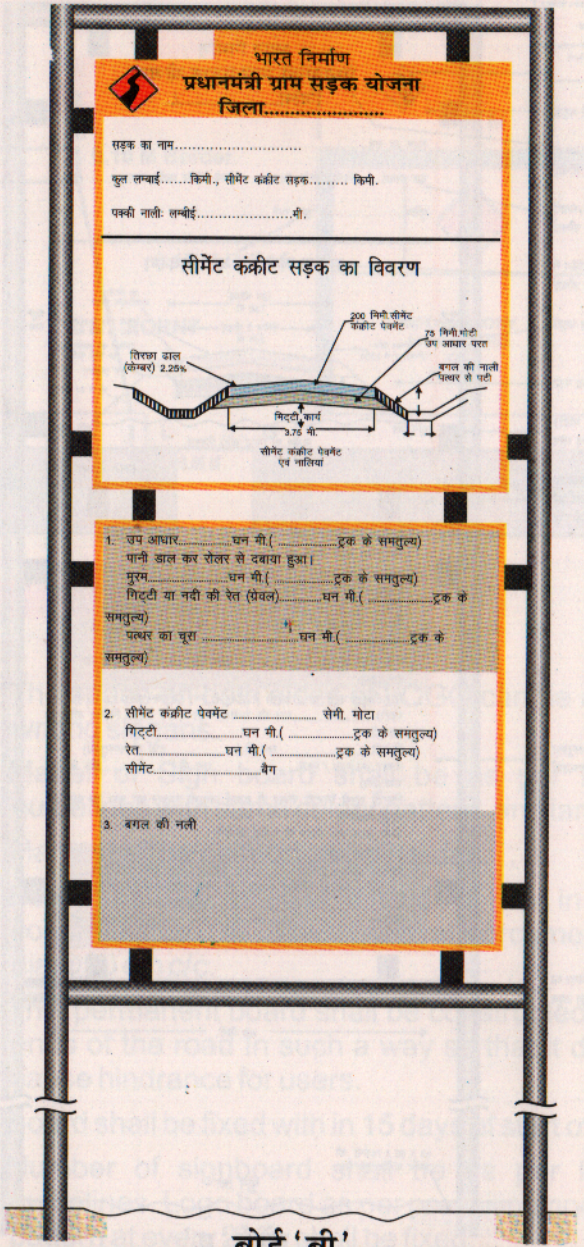
Note :

1. The space on both sides of LOGO can be used for writing slogans.
2. Matter of Sign board shall be as per PMGSY guidelines with same colour pattern and language.
3. Mater shall be painted on both sides.
4. Board shall be casted on left side of road in cement concrete 1:3:6 (M 10) with skin reinforcement 8 mm dia@30 cm c/c.
5. This permanent board shall be constructed at both ends of the road In such a way so that it does not cause hindrance for users.
6. Board shall be fixed with in 15 days of start of work.
7. Number of signboard shall be as per PMGSY guidelines. Logo board as per prevailing norms and pattern at every 2 Km shall be fixed.

नागरिक सूचना बोर्ड डामरीकृत रोड



नागरिक सूचना बोर्ड कंक्रीट रोड



बोर्ड 'बी'

INFORMATORY SIGN BOARD

प्रधानमंत्री ग्राम सड़क योजना

..... से .....

मार्ग की लम्बाई : .....कि.मी.

कार्य प्रारम्भ की दिनांक : ..... कार्य पूर्ण होने की दिनांक :.....

ठेकेदार द्वारा गारंटी की अविध : 5 वर्ष

ठेकेदार का नाम व पता : .....

परियोजना इकाई का नाम व पता : .....

ग्रामीण विकास मंत्रालय, भारत सरकार द्वारा पोषित योजना

कार्य निष्पादन : .....

Size

- Size of board will be 1500 mm x 900 mm.
- To be fixed at starting point of Road. One board for one Road up to 5 km.If road is More. One additional board at finishing point of Road.
- Bottom border in black colour will be used for writing slogen to be provided by the Ministry of Rural Development.

CHAPTER 21

ROAD SIGNS AND MARKINGS

Quality Control Requirements :

1. The materials should conform to the requirements laid down in the Codes of Practice IRC : 67 for road signs and IRC : 35 for road markings.
2. 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.

ROAD FURNITURE
LOGO OF PRADHAN MANTRI GRAM SADAK YOJANA

Colour Specification

Orange: Magenta 60 %, Yellow 100 %,steel

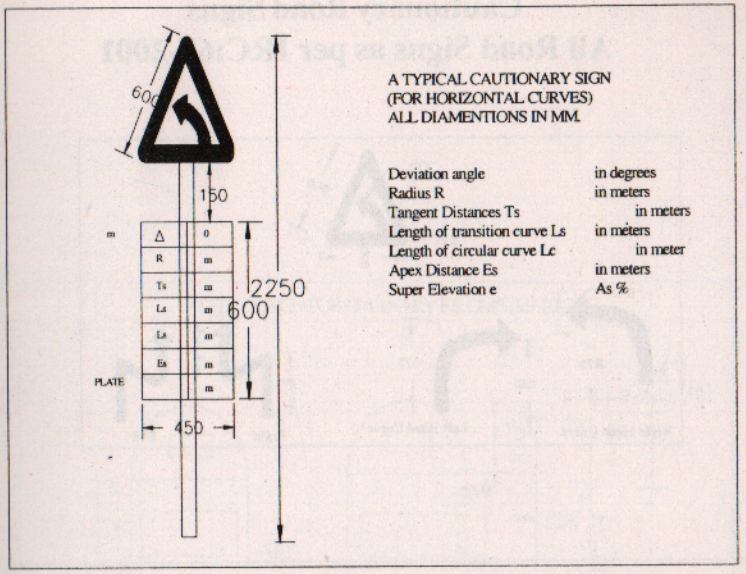
Grey : Black 40 % Luminous paints are to be used

Bar, Road and lettering : Black 100 % size

Diamond 600 mm x 600 mm. Plate 900 mm x 250mm

If road length is < 2 Km one at finishing point of the road

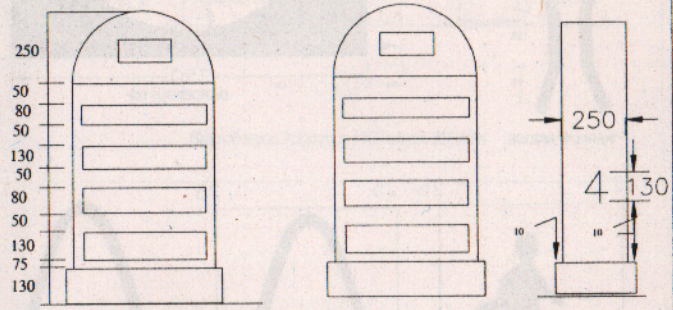
If road length is >2 Km one at every 2 Km including the board at finishing point of the road.



A TYPICAL CAUTIONARY SIGN
(FOR HORIZONTAL CURVES)
ALL DIAMENTIONS IN MM.

Deviation angle	in degrees
Radius R	in meters
Tangent Distances Ts	in meters
Length of transition curve Ls	in meters
Length of circular curve Lc	in meter
Apex Distance Es	in meters
Super Elevation e	As %

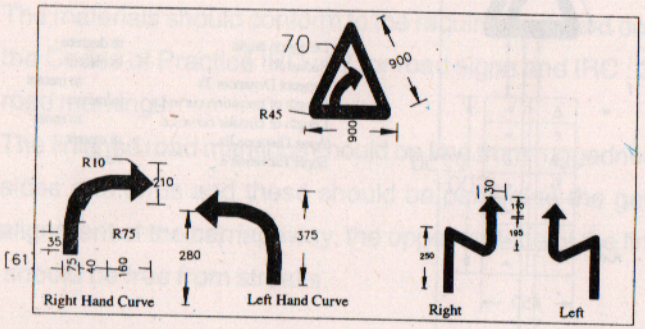
TYPE DESIGN FOR 5th Km STONE

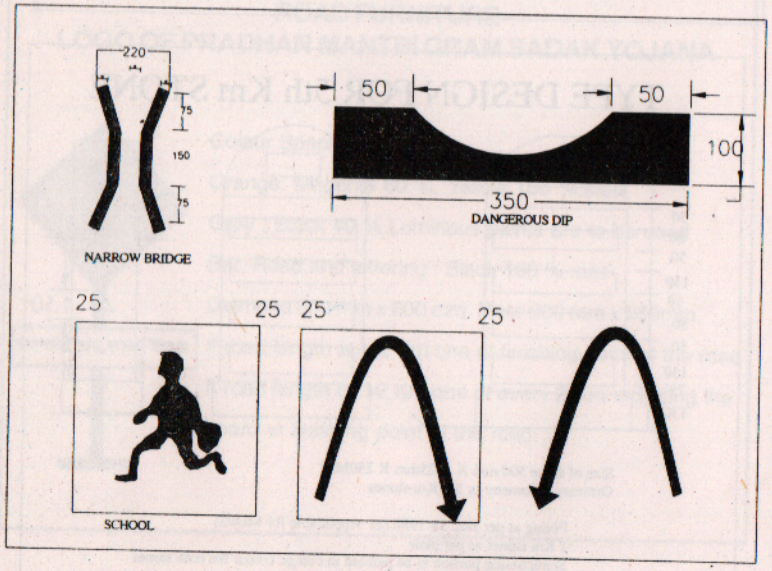


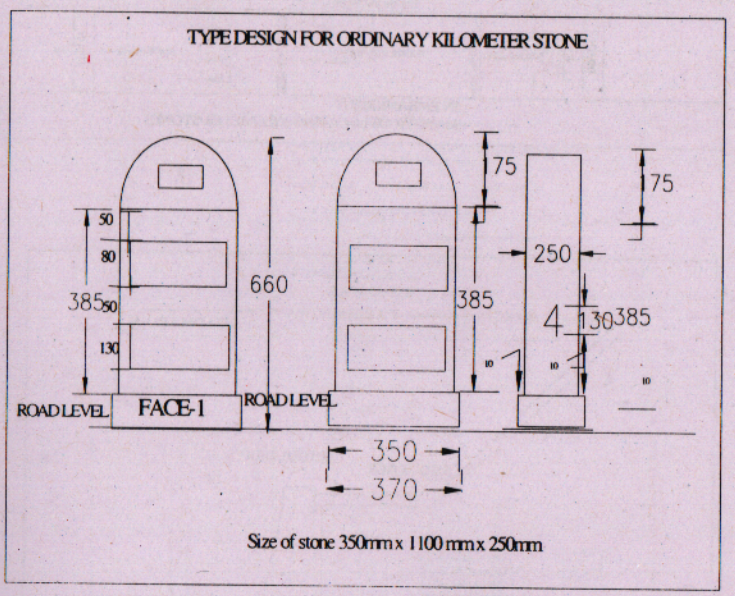
Size of stone 500 mm X 1525mm X 250MM
Ordinary Kilometer or 5th Km stones

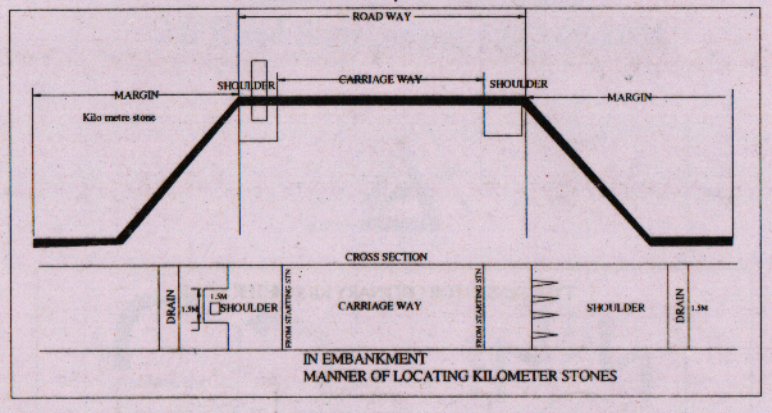
Fixing as per IRC 18-1980 (as Applicable for MDRs)
1 Km stones as per plate
Semicircular portion to be painted in orange colour for both stones

Cautionary Road Signs
All Road Signs as per IRC:67-2001

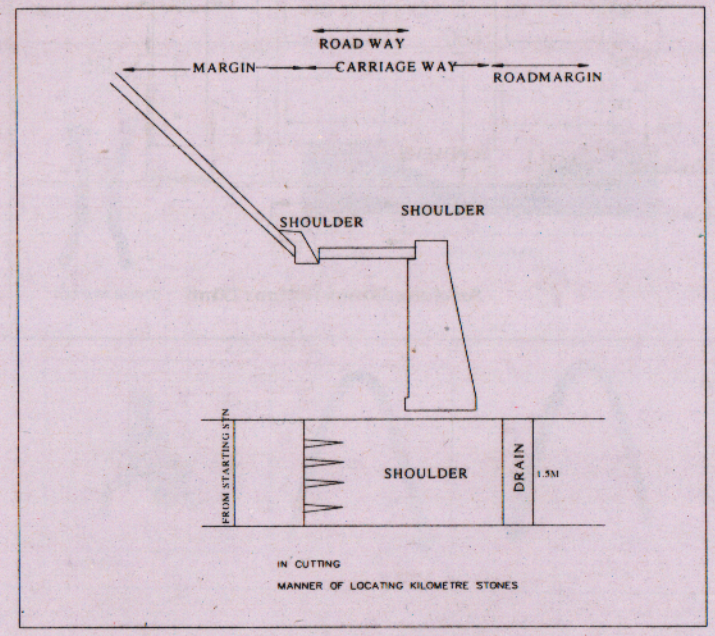




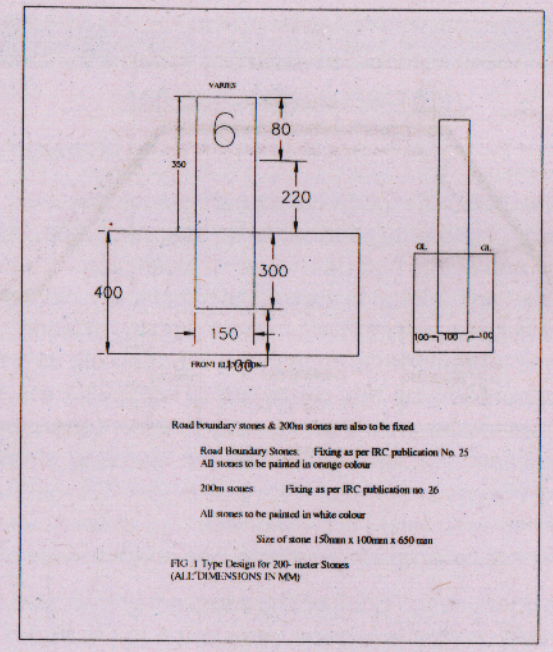




IN EMBANKMENT
MANNER OF LOCATING KILOMETER STONES



IN CUTTING
MANNER OF LOCATING KILOMETRE STONES



Road boundary stones & 200m stones are also to be fixed

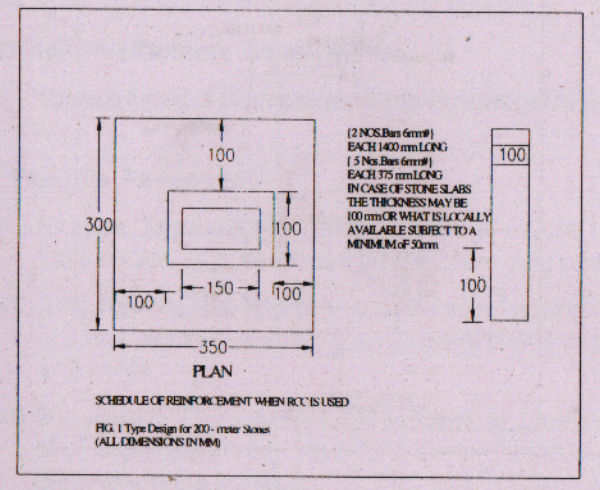
Road Boundary Stones. Fixing as per IRC publication No. 25
All stones to be painted in orenge colour

200m stones Fixing as per IRC publication no. 26

All stones to be painted in white colour

Size of stone 150mm x 100mm x 650 mm

FIG. 1 Type Design for 200- meter Stones
(ALL DIMENSIONS IN MM)

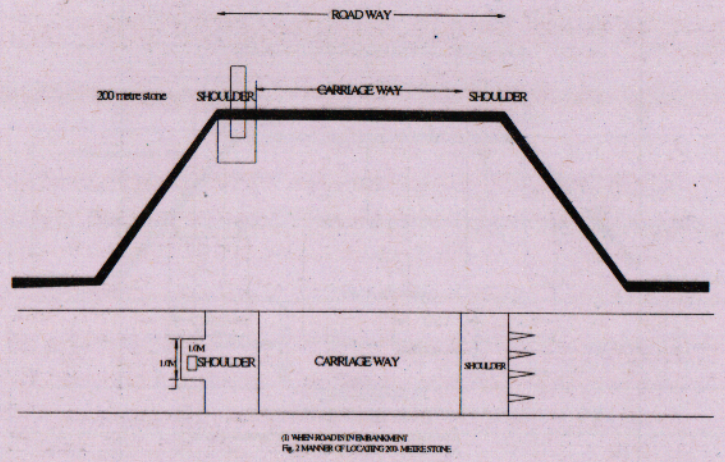


PLAN

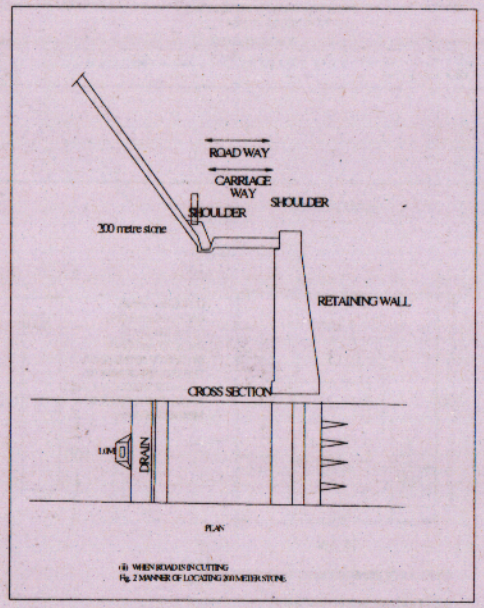
(2 NOS.Bars 6mm#)
EACH 1400 mm LONG
(5 Nos.Bars 6mm#)
EACH 375 mm LONG
IN CASE OF STONE SLABS
THE THICKNESS MAY BE
100 mm OR WHAT IS LOCALLY
AVAILABLE SUBJECT TO A
MINIMUM oF 50mm

SCHEDULE OF REINFORCEMENT WHEN RCC IS USED

FIG. 1 Type Design for 200 - meter Stones
(ALL DIMENSIONS IN MM)



(i) WHEN ROAD IS IN EMBANKMENT
Fig. 2 MANNER OF LOCATING 200-METRE STONE



(ii) WHEN ROAD IS IN CUTTING
Fig. 2 MANNER OF LOCATING 300 METER STONE

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CHAPTER 22

MAINTENANCE ACTIVITIES

22.1 Introduction

Road maintenance is a routine work performed to upkeep pavement, shoulders and other facilities provided for road users, as nearly as possible in its constructed conditions under normal conditions of traffic and forces of nature. The maintenance is essential to get optimum service from the pavement structure during its life period. All pavements require maintenance as they are subjected to the traffic and environmental effects. Maintenance helps in preserving the pavement surface, and prevents untimely rehabilitation. Also, the maintenance of shoulders, CD works and road furniture is equally important. Unsealed roads get deteriorated at faster rates as compared to the sealed roads and hence needs greater attention.

Also maintaining the cross profile (for proper surface drainage) and repair of pot holes need special attention. Maintenance requirements are also dependent on traffic, terrain, soil type etc. However, there are proven maintenance methods, which are applicable to the different regions of country.

22.2 Distresses/Defects in pavements :

Various types of distresses/defects of pavements are listed below:

I. Flexible Pavements

(i) **Cracks:** Separation of pavement due to natural causes, traffic action, or reflections from an underlying pavement.

(ii) **Alligator cracks:** Interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken wire mesh.

(iii) **Bleeding:** The upward movement of bitumen in a bituminous pavement resulting in the formation of a film of bitumen on the surface.

(iv) **Corrugations :** A form of plastic movement typified by ripples across the pavement surface.

(v) **Depression/Settlement:** Localised low areas of limited size that may or may not be accompanied by cracking.

(vi) **Disintegration:** The breaking up of a pavement surface from its original shape.

(vii) **Raveling:** The progressive separation of aggregate par ticles in a pavement from the surface downward or from the edges inward.

(viii) **Rutting:** Channelised depressions that may develop in the wheel tracks of the bituminous pavement.

(ix) **Potholes:** Bowl shaped holes of varying sizes in the pavement, resulting from localised disintegration.

(x) **Shoving:** A form of plastic movement resulting in localised bulging of pavement.

(xi) **Upheaval:** The localised upward displacement of a pavement due to swelling of the sub grade or some portion of the pavement structure.

II. Semi-Rigid and Rigid Pavements

(i) **Blow-up:** The localised buckling or shattering of a rigid pavement occurring usually at transverse crack or joint.

(ii) **Pumping:** The ejection of mixture of water, sand, clay and/or silt under passing wheel loads, along transverse or longitudinal joints and cracks along pavement edges.

(iii) **Reflection Cracks:** Cracks in the asphalt overlays that reflect the crack pattern in the rigid pavement structure underneath.

(iv) **Scaling:** The peating away or disintegration of cement concrete pavement.

(v) **Sapling:** The excessive joint deformation in concrete pavement leading to over-hang of slabs at joints and subsequent cracking.

22.3 Definitions of Maintenance Activities

Some of the terms related to the maintenance activities are defined below:

(i) **Fog Seal:** A light application of slow setting asphalt emulsion diluted with water. It is used to renew old asphalt surfaces and to seal small cracks and surface voids.

(ii) **Prime Coat:** An application of single coat of liquid bituminous material, like emulsified asphalt (low viscosity cutback in case of locations at sub-zero temperatures). It is used only on an untreated base prior to placement of the asphalt pavement.

(iii) **Seal Coat:** A thin asphalt surface treatment used to waterproof and improve the texture of an asphalt wearing surface depending on the purpose, seal coats may or may not be covered with aggregate. The main types of seal coats are fog seals, aggregate seals, slurry seals and sand.

(iv) **Bituminous Surface Treatments:** Applications of bituminous materials to any type of road or pavement surface, with or without a cover of mineral aggregate that improves the surface condition and produce an increase in thickness of less than 25 mm.

(v) **Tack Coat:** A very light application of bituminous material applied to an existing bituminous or cement concrete surface, used to ensure a bond between the surface being paved and the overlying course. Bituminous emulsion diluted with water is the preferred bituminous material.

22.4 Inventory of Road and Inspection

Frequent close inspection of pavement (at least once in 3 months) is necessary to ascertain the needs of the main tenance of the pavement. Generally, there should be a pre and post-monsoon inspections of road to access the maintenance requirements. An important step towards planning of maintenance activities and working out their relative priorities is to have inventory of different roads in a

given area in terms of categories, physical features, condition, structural capacity, etc. to cover the following:

(i) Classification/category of road.
(ii) Location of protection works, streams, CD works, etc.
(iii) Types of surface.
(iv) Lane width of the road.

Apart from visual inspection the evaluation of pavement may be made on the basis of deflection, roughness etc. to decide about rehabilitation for high traffic roads.

22.5 Types of Maintenance

The maintenance activities are divided into two categories:

(i) Preventive maintenance.
(ii) Corrective maintenance.

Preventive maintenance activities includes repairs to small sized potholes, crack sealing, maintenance of shoulders, drainage systems, etc. Corrective maintenance includes patch repairs, surface treatments, renewal and overlays.

22.6 Classification of Maintenance Activities.

As per IRC: 82, maintenance operations can be classified as:

(a) Routine maintenance, Such as, pothole filling, filling the cracks, etc. round the year. Following are the points covered under Routine maintenance:

(i) Routine maintenance and up-keep of road components such as road formation, retaining walls, breast walls, culverts, bridges, causeways, pavement and other appurtenances.

(ii) Clearance of landslides/slips caused by rains or other natural causes in hilly terrain.

(iii) Clearance of snow in high altitude/snow bound areas. Periodicity of various activities under routine maintenance is given in Table No. 21.1

Table 22.1 Periodicity of Rutine Maintanance Activity

(Appendix 11.1 of IRCSP 20)

S. No.	Name of Item	Frequency of operation in the year.
1.	Clearing of road side gutters	Twice
2.	Pothole filling (WBM & BT)	Once
3.	Filling of edges of asphalt surface of excavating borrow pit.	(i) Single Lane (a) T.I. 0-1000 Twice (b) T.I. 1000-5000 Four times (ii) One and Half Lane T.I. 0-1000 Once T.I. 1000-5000 Twice T.I. Over 5000 Four times (iii) Two Lane T.I. 1000-5000 Once T.I. Over 5000 Twice
4.	Dressing of berms	Once
5.	White washing guard stones	Twice
6.	Fixing disturbed caution board/ village name board/ Speed limit board, etc.	Once
7.	Re-fixing displaced guard stones.	Once
8.	White washing and geroo painting of trunks of trees.	Once
9.	Cutting of branches of trees, etc.	Once
10.	Topping of W.B.M.blindage operation including picking of loose metal.	18 times
11.	Maintenance of catch water drains.	Once
12.	Clearance of C.D. works.	Twice
13.	Clearing of wild seasonal growth on berms.	Once
14.	White washing parapets of C.D. works.	Once
15.	Earthwork in berms, desilting of drains, etc.	As per requirement

Note: *T.I. Stands for Traffic Intensity in tones per day.*

(b) Periodic maintenance covering renewals, which are required to be done at periodic interval every few years. Periodical activities will include those activities which are not of routine nature and are taken up at certain periodicity, specified or other wise, to maintain the health of the road components. One such periodical activity is the renewal of wearing course of carriage way based on guidelines on life cycle and specifications of the road.

(c) Rehabilitation and strengthening, includes major restoration or upgradation of pavement through reconstruction or application of overlays to correct the structural deficiencies. Damages resulting from usage, accident, comprising of repairs and rehabilitation, which can be covered under the scope of ordinary repairs/routine maintenance, but of a relatively large magnitude is included as special repairs.

22.7 Assessment of defects and maintenance measures

The unsealed roads deteriorate fast as compared to sealed, roads under traffic. Various defects and their measurements are as under.

(i) Loss of Profile, Camber and Cross Fall.
(ii) Corrugations
(iii) Rut Formation
(iv) Ditchers and Potholes
(v) Dust
(vi) Erosion Gully

(i) Loss of Profile : The camber is measured using 2 m camber board ot template fitted with a sprit level. The measurements should be made on both sides of the centre line. The loose material from the sides can be scrapped and filled to ruts, deep potholes and the profile can be re-sanctioned properly with the help of spade, pick-axes, or grader etc. The loose material is then rolled properly after sprinkling of water over it. If required, the top layer can be provided with admixture of sand and moorum.

Such a treatment would provide adequate strength to the top layer. It is essential that only non-plastic type of moorum should be used, at least for the top layer.

(ii) Corrugations : Corrugations are transverse undulations located closely at regular intervals. These are formed under dry condition due to cyclic pounding action of tyres of the vehicles crossing irregularities. Corrugations are measured at 200 m interval along the road. The depth of corrugations is measured with a calibrated wedge.

(iii) Rut formation : The ruts are the longitudinal depressions that tend to follow the path of rolling vehicular wheels usually associated with the settlement of pavement under traffic stress and/or the dislodging of material. The depth of rut is measured using a straight edge and wedge scale. Measurements are made at 200 m interval along the road. The straight edge is placed transversely across each wheel track and the rut depth is measured with calibrated wedge.

(iv) Potholes : These are irregularly shaped depressions of various size and depth on the road surface and result from variety of causes, like.

- Poor initial compaction.
- Poor quality of material.
- Infiltration of water.
- Degradation of pavement surface.

Potholes are counted and recorded for every 100 m length of road. The counts are recorded as the number of potholes per 100 m length of the road.

(v) Dust : One of the most common defects of the unpaved road is dust. Dust comprising of the fine particles of soil rise up to the air under moving action of the vehicles. At high speeds the dust particles form a cloud of dust thereby reducing the visibility of the driver. The dust problem is maximum in the summer. It is more prominent with the earth road as compared the WBM road.

(vi) **Erosion gully :** Erosion gullies are formed on earth/ gravel roads on shoulders/slopes by rainwater. Gully formation is a complex process. The size and shape of the gully depends on the quantum of runoff. In general the gullies are deep when the rainfall is high and concentrated.

22.7.1 Maintenance measures :

The following various measures are suggested to rectify defects of various types of unsealed roads

(a) Earth roads :

Dust Controls : To check the dust nuisance on the earth roads, the following measures are recommended.

- Applications of calcium chloride in solution or in powder form at the rate of 0.25 to 1.25 kg/cum depending upon the climatic conditions.
- Crude oil/used crude oil heated to 95°C is applied with sprayers at the rate of 2.5 to 4 lit. per sqm.
- Waste from sugar mills, pulp and paper mill is applied uniformly over the road surface. Then surface is scarified to some extent and the waste material is thoroughly mixed. The surface is then compacted at or near OMC.

Patches Repairs, Ruts, Potholes, Corrugations Erosion Gullies :

These defects can be rectified by patching or grading the road surface.

- Depression is filled with earth of same quality as that of earth road and water is sprinkled if needed, followed by compaction with light roller or ram with hand tamper.

(b) Gravel roads : Gravel for repair work should be at least as good in quality as that of material used in the construction. The suggested measures are as below :

Dust Controls : To check the nuisance on the gravel roads, the following measures are recommended.

Calcium chloride is applied in solution or in powder form at the rate of 0.25 to 1.25 kg/sqm depending upon the climatic conditions.

Patching : The following steps should be followed.

- Gravel is stacked on the shoulder near the spot.
- Loose material and water are removed from the patch to be repaired.
- The sides are cut vertical to reach the sound base.
- Patch should be filled with gravel of 100 mm thickness.
- If material is too dry, water is sprinkled to facilitate compaction and the layer is then compacted by a roller or hand tampers.
- Procedure is repeated as above to fill the entire patch.
- Finally the patch is filled with gravel upto 30 mm above the road surface spread and raked to correct shape.
- Finally the layer is compacted by a roller or hand tamper to give surface slightly producing above the surrounding levels.

Loss of Shape, Corrugation, Potholes, Ruts :

These can be rectified the same way as given under patch repair for earth roads as above.

Renewal of Gravel Roads :

Renewal of surface is done when the surface is badly damaged due to potholes, corrugations and ruts and it is uneconomical to repair the defect individually. Gravel of the same quality as used in the road construction is obtained from the borrow area. The surface to be renewed is scarified and the material is collected. Collected material is mixed with fresh material to the estimated quantity. To this mixed material water is added to achieve the desired water content. The wet mixed material is then laid on the surface to the required loose thickness and then compacted with 8 to 10 tonne.

roller or manually. The required camber and profile is maintained.

Resurfacing :

Initial pass is made on each side of the roadway with motor grader scarifying/cutting the surface to depth of 100 mm.

- Material is placed to required depth.
- Material is spread with a blade to the required cross slope.
- Water (if needed) is sprinkled and compacted using a roller.
- It is ensured that the cross slope of shoulder is the same as that isrequired.
- The road surface is then cleaned.

The repairs to other defects shall be the same as for earth roads.

(c) WBM roads :

A sizeable length of rural road falls under this category. WBM surface develops various defects like potholes, ravelling, corrugations etc., as the surface undergoes various stresses due to grinding action of solid iron-wheeled carts and also abrasion and pumping action due to fast moving pneumatic tyred traffic. Once a portion of WBM surface is distributed, loose metal inflicts further damage to the adjoining WBM surface and thus a chain of damaging effects sets in. If the filler used for WBM surface is excessive and plastic in nature as in dry areas, the situation gets further aggravated in adverse weather conditions. Timely removal of the dislodged metal from the surface and blinding the surface with appropriate material like sand or moorum can save the road from deterioration. The works to be carried our under ordinary repairs and routine maintenance of WBM road can be listed as under.

(a) Collecting and stacking the picked up metal and periodically blinding the surface with binder.

(b) Filling of potholes.

(c) Re-sectioning of surface by pick and roll method.

(d) Collecting and stacking the picked up metal and blinding the surface by screening periodically.

Periodical Blinding :

It is observed that particularly in dry season the dry the metal from the WBM surface gets dislodged. Due to traffic this loose metal abrades with the WBM layer and further dislodgement of metal takes place. In due course of time, the whole stretch of the road gets damaged. It is therefore, essential to pick-up this loose metal and stack it properly by the roadside. This metal can be further used for filling of potholes. After picking up of the loose metal the surface should be covered with a thin layer of binder such as sand or moorum. Timely provision of binder would provide good riding quality to the road surface.

Filling of Potholes :

The following procedure should be followed.

(i) The loose material in the affected spot is removed up to firm base.
(ii) The sides of potholes are trimmed vertical and the area is shaped to rectangular as far as possible.
(iii) The cavity is then filled-up with stone aggregates (similar in size used originally) keeping the filling slightly above the surrounding area.
(iv) The filler material (screenings/moorum/sand) is then spread on the filled-up aggregate.
(v) The aggregate layer is compacted by hand rammer.
(vi) Water is sprinkled on the hand compacted aggregate layer.
(vii) The layer is again compacted by hand ramming followed by road roller, if available.

Repairs to Ravelling by Pick and Roll Method :

When the ravelling of the roads surface is quite prominent and when the funds are not adeq uate to carry out full-fledged periodical renewal, resurfacing by 'pick and roll method' is resorted to. This is a cost effective solution for maintenance of WBM surface to rural roads. Measures applicable to unsealed roads are given in Table 21.2 in case of minor raveling, patch repairs may be carried out.

(i) The stretch, which craves for resurfacing is, selected which should preferably be of adequate workable length. In this length about 20-30 percent of the quantity of the aggregates required for providing full-fledged renewal of WBM coat is collected depending on the extent of ravelling. The required quantity of moorum/screenings is also collected as filler.

(ii) The whole surface is then picked up with a pickaxe to a depth of 40-50 mm as is done during resurfacing.

(iii) The depressions ruts and potholes are filled-up with the metal collected earlier and the surface is brought to the desired grade and camber.

(iv) The surface is then rolled in dry condition with the help of 8-10 tonne roller.

(v) The moorum/screenings are then spread over the compacted surface. The surface is then adequately watered.

(vi) The wet rolling of the surface is carried out.

(vii) The balance quantity of moorum is provided as a binder to the surface.

This type of resurfacing has proved to be very cost effective. However, this treatment may not be adequate in heavy BC soil/clayey soils, water logged areas and sugarcane areas. In such areas periodical renewal may be the only way of maintaining the WBM road.

Periodical Renewal of WBM :

In this process fresh WBM layer is provided over the existing deteriorated WBM surface. With the advent of pneumatic tyre vehicles, WBM surface deteriorates fast and the renewal of existing surface (after every 2-3 years) become necessary. The process of periodical renewal is the same as that of construction of new WBM layer. Until now, 8-10 tonne static rollers were being used for WBM compaction. If vibratory rollers are used for WBM consolidation, the life of the renewed surface may be increased to some extent.The common defects, their causes and needed maintenance

Table 22.2 Common Defects, Cause and maintenance Measures in Unsealed Roads.

Defect	Cause	Maintenance Measure
Ditch cross-section destroys	Plying of ceficle/movement of animals	Reshaping/re-grading of ditch
Ponding in ditch and on shoulder	Insufficient ditch cross-section	Deeping of ditch
Silting of drain	Water flows Slowly as the invert slope	De-silting of ditch and/or provision of turn out
Uneven ditch invert	Blockage caused by debris/vegetation	Cleaning, Clearing and regrading
Erosion of sided and bottom of ditch	Top steep gradient	Reinforcing of ditch slopes regrading or realignment of drain, ditch
Destruction of lined or precast drain	Poor alignment or change in flow direction	Erosion control and realignment of drain
Ditch lining damaged	Settlement/erosion of soil under ditch	Erosion repair and lining repair
Ponding, ersoing	Insufficient lateral drainage	Provision of lateral drainage
Silting, blockage by debris of culvert	Too flat gradient, incorrect positioning of culvert	Cleaning of debris and provision of debris arnester

22.7.2 Sealed roads :

Requirement of maintenance of sealed roads may not be same as that of unsealed roads. Major maintenance activities include :

- Maintenance of shoulders, drainage and structures.
- Maintenance of surface defects.
- Renewals and rehabilitation.

22.7.2.1 Maintenance of shoulders, drainages structures and causeways :

The detailed information on maintenance of shoulders, drainage, structures and causeways is given below :

1. Maintenance of Shoulders

1.1 Properly built up and well maintained shoulders provide lateral support to the pavement. The slow moving vehicles, like bullock carts or hand driven carts tend to ply over the shoulders. The shoulders are also used for parking of vehicles.

1.2 The shoulders shall be kept free from obstructions, like, logs, shrubs, deep cuts, boulders, etc. The wild growth on them shall also be removed from time to time. In hill roads located in high rainfall zones, the overgrowths on both the hillsides and the valley side must be cleared twice a year, at least once before the onset of winter. The extent of clearance area should be enough to provide six hours of sunshine to the road surface during fair weather. It must, however, be seen that the roots of the grass are not removed, so that rains hitting on the exposed surface do cause erosion and induce land slides. The debris of leaves, branches and stems of the cut trees shall be cleared from the drain, pavement and the shoulder of the road and removed beyond the road edge on the valley side by at least 2 m. The shoulders should be kept flush with the pavement edge and then given slightly steeper slopes than the pavement to facilitate effective drainage of rain water flowing across the pavement. The shoulders shall be maintained by filling moorum or sand and scraping the heaved-up portion wherever necessary.

Since the shoulders also form part of the body of the road, they shall be kept free from encroachments.

2. Maintenance of Road Furniture

2.1.1 Traffic signs are the principal means of conveying information about the road to users. Signs which are erected at proper places and which are in good condition free from any obstruction can be properly understood nd they inspire confidence in the minds of the road users.

Damaged, missing or obliterated signs shall be replaced promptly.

signs shall be inspected and cleaned at least twice a year. The junctions of two or more roads proper information boards or information pillars giving information about various destinations would be of immense help. They shall preferably be located at least 200 m ahead of the junctions to guide the road users.

2.1.2 Guard rails, guard walls, parapets of bridges, guard stone delineators, etc. shall also be maintained properly. If they are damaged due to moving vehicles, the same shall be repaired or replaced promptly.

2.1.3 Kilometre/200-metre/boundary stones shall be painted twice a year. the wild growth along the kilometer/200 meter boundary stones, which obstructs the visibility shall be removed. Delineators and header stones on the curves shall be properly painted and kept in good condition to guide the driver properly at these locations.

3. Maintenance of Cross Drainage Structures

3.1 Structures are provided for effective drainage of runoff water etc. It is, therefore, essential that the cross drainage structures shall be maintained effectively and it shall be ensured those drainage elements, waterways remain free of obstructions and retain their intended cross-sections and grades. They must function properly so that surface water and ground water can drain freely and quickly away from the road or under the road. Water is the worst enemy of every road element. It can erode soil, weaken the pavement and sub grade and destroy shoulder and slope, even wash out cross drainage structures or bridges.

3.2 The parapet, railing, guards stone etc. of the CD work should be repaired if broken. These should be properly painted for improving visibility during night.

3.3 In the following paragraphs maintenance of mainly culverts and causeways is discussed as these are usually used as cross drainage structures on rural roads.

3.4 **Inspection :** Inspection of drainage system and structure shall be a routine task. If it is not possible then the inspection should be carried out promptly at least on four occasions. Firstly before onset of monsoon, secondly during monsoon

particularly after first flash floods, thirdly after heavy floods and fourthly after monsoon.

3.4.1 Inspection before monsoon : Following points shall be inspected:

(i) Waterway is clear and not blocked by debris or silt
(ii) Settlement cracks in foundations or in superstructures
(iii) Cracks or damages in pavement
(iv) Guide stones are properly fixed and pointed
(v) Warning signs are placed in both sides of cross drainage structures giving clear warning that when water is flowing above the guide stones, vehicle shall not cross the drainage structure.
(vi) Approaches are in sound condition and there is not erosion.
(vii) Debris arrestors if provided is properly fixed.

3.4.2 Inspection after first flash flood :

It is generally observed that during first flash flood or during next two, three spells, there is substantial load of floating debris along with floodwater. If the vents are not of sufficient opening, then waterway is blocked by the debris and water starts flowing on approaches or by breaching the adjoining road sections. It is, therefore, essential to remove this blocked debris from pipe vents or waterway immediately so that there will be minimum damages in subsequent floods. In view of this, close and repeated inspection are essential during rainy season.

3.4.3 Inspection after heavy flood :

During heavy floods, causeways are generally over topped. This results in heavy damages to pavement, approaches as well as scouring on downstreamside of structures. In some case there is breaching of approaches. All these points shall be closely inspected after every heavy flood, so that timely protective measures can be taken.

3.4.4 Inspection after monsoon :

Once the monsoon season is over, the structures shall be inspected closely for any damage, any heavy silting or scouring to pavement damages to guide stones etc. Repairs to these damages shall be carried out.

4. Maintenance of Culverts :

4.1 Defect : Silting, Sanding and Blockage by debris

If a culvert structure is constructed too low, resulting in deposition of silt or sand, Vegetation or floating debris gets blocked in vents of culverts. Blockage of waterway leads to ponding and heading up of flood water, which results in over flooding the embankment. This damages the embankment or causes breaching in roadway.Slopes of bed shall be corrected by Nalla training properly; Debris arrestors shall be provided on upstream side so that floating debris will not enter the vents and there will be no blockage of vents. It is also comparatively easy to clear the debris from arrestors.

4.2 Defect : Erosion of Stream bed on Downstream Side

Due to flowing water or overtopping of water from culvert, the downstream side bed sometimes gets eroded. Due to heavy scouring, the foundations of headwalls are also exposed and endangered. Due to steep slope of bed or vents or due to inadequate waterway, the velocity of flowing water increases on downstream side and results in erosion below headwalls, wings wall or even approaches.This may result in collapse of downstream side or wing walls in due course of time. Protection work of the bed with properly designed apron shall be provided. Also adequate waterway shall be provided.

4.3 Defect : Settlement Cracks in Masonry Structure

Settlement of foundations, take place due to weak founding strata. If the settlement is negligible then the damages can be checked and repaired. But, if the settlement is major in nature, then reconstruction of structure will be only the remedial measure.

5. Maintenance of Causeways :

5.1 Defect : Cracks in Paved Surface

Settlement of fill below pavement dislocation of stones, in stone set pavements, scouring of filler material due to eddy currents. Damaged area shall be opened, refilled and compacted properly and the n pavement shall be re-laid. In case of stone pavements, provided in a rural road as the case may be, shall be cleared of any dislocated stones shall

be re-fixed properly. If there is scouring below fill, then it shall be sealed properly so that there will be no damage due to eddy current.

5.2 Defect : Blockage of Vents Due to Debris

Floating debris block the vents Debris arrestors shall be provided on upstream side.

5.3 Defect : Damages Due to Overtopping of Water

Structure is not properly designed or provision of inadequate waterway or inadequate protection measures. The geometry of the structure shall be properly designed. Water way shall be provided in such a way that it shall effectively pass at least 20 percent of high flood discharge. The Road Top Level shall be properly protected with pitching on upstream and down stream side as well as top of formation extending up to high flood level. If possible RCC wearing Coats must be provided.

5.4 Defect : Damages to Guide Stones, Information Boards

Due to flood water or due to vandalism such damages are experienced. Guide stones, information boards, and kerbstones shall be a replaced promptly. If neglected, when the pavement gets submerged during floods the edge of pavement can not be seen, more over if guide stones are missing, the depth of water on road top level can not be judged. This may result in serious accidents.

6. Maintenance of Drainage Features

For proper upkeep of drainage features, maintenance should take care of the following :

Camber : A proper camber needs to be maintained for surface water. Whereas it is found improper or inadequate, corrective measures need to be taken. In case of unsealed roads, grading and shaping may be required. For sealed roads, a profile corrective course may be provided on the existing surface.

Shoulder and Side Slope : The shoulder on both sided should have required outward slope starting from the edge of pavement. Also, edge slope is to be maintained at the end of shoulders, especially on high embankment.

Longitudinal Drainage : A lined or unlined longitudinal drain accumulates debris. The blockage of the drains by silting also may be cleared regularly.

22.7.2.2 Maintenance and Repairs of Surface Defect & Table 11.2

The more common defects of bituminous surface of rural roads are :
(i) Potholes (ii) Deformations (iii) Cracking
(iv) Edge damages (v)Ravelling and bleeding

The roads length to be maintained should be inspected at suitable interval to determine.

- Location where the defect usually appear
- Number and size of defect
- Apparent cause leading to defect
- Consequences likely if not repaired immediately
- Remedies to be applied
- Quality/type of material needed

The defects commonly occurring in bituminous surface roads .
Table 22.3 :

Defect	Cause	Maintenance Measure
Bleeding Surface	Excess/Unsuitable binder	Spreading of aggregate chips
Surface and cracks	Poor quality of material/workmanship	Local sealing or filling in of
pavement Structure cracks Ruts and depression	Insufficient pavement crust excessive loads Poor quality of material inadequate pavement of sub-grade strength	strengthening Slight rutting : filling Deep rutting : local restoration of pavement
Edge subsidence	Inadequate or badly maintained shoulders	Slight subsidence, filling of ruts and depressions and restoration of shoulders
Rutting	Loss of strength due to water penetration	Deep subsidence : Local restoration of pavement, improvement of drainage
Edge damage	Poor drainage Narrow road. Shoulder damage due to action of water	Local restoration of pavement repairs of shoulder
Potholes	Degradation of pavement structure. Poor quality of material, Infiltration of water Traffic	Cutting and removal of material upto affected depth, filling and compaction by ramming
Shoving	Failure of sub-grade, sub-base. water ingress, poor materials, Poor workmanship Heavy traffic	Cutting and removal of material upto full depth of affected area and refilling with appropriate materials in layers and compactiong

Repairs of Potholes :

If the bituminous surface is defective, then shallow potholes will develop on roads. The affected area is cut into a regular shape, preferably a rectangle with vertical sides. All the loose material is removed and tack coat of bitumen emulsion is thoroughly applied on the exposed surface. The premixed material prepared by mixing metal chips and bitumen is then placed layer by layer. The surface filled-up with premixed material is kept slightly proud of the surrounding area. The surface is then compacted by hand rammer followed by road roller, if available. The liquid seal coat or bitumen surface dressing is then applied to seal the surface, properly cleaned with wire brush. The potholes are then filled-up by grouting method. The tack coat is applied at the base as well as on all sides of the potholes.The stone metal of 40 mm size is then spread and compacted, and then grouted by pouring required quantity of bitumen on it and then key aggregates are spread over it. Again, the required quantity of bitumen is applied to grout these layers. The material is compacted with hand rammer. This method is resorted to fill the potholes layer by layer till the finished surface of the potholes filling stands raised to the surrounding area. The top layer is then covered with a suitable bituminous mix and rolled by roller into the proper camber and profile.

Rectification and Deformations :

- **Depressions :**

The surface of the affected area should be scarified properly. The sides of the depressions are then cut to vertical. The tack coat is applied to the cut area and the depression is filled-up with premix bituminous material. The filling is then rolled properly with the power roller and the top surface is sealed by liquid seal coat. If the depression is large such as due to failure of sub-grade/base/sub-base, proper strengthening of the base or sub-base, as the case may be, is resorted to provide proper drainage later, if required.

- **Hump or heaving :**
  During high temperature, the bitumen from top layer flows to sides because of pressure of wheels especially in hot weather. This results into formation of humps at the edges and depressions at the centre.

  Such humps are to be removed by pick axes. The exposed surface is then properly treated with premix material and the road is brought to desired level then rolled properly.

- **Camber correction :**
  The camber correction or cross slope of the pavements should be brought to the required standards with suitable bituminous levelling course. The thickness of layer depends on the extent of correction. Separate provision of profile correction layer should be made in the estimate. The camber correction must be made so that there is no stagnation of water on pavement surface during rainy season as it may lead to deterioration of the flexible pavement.

Sealing of Cracks :

The cracks are opened and cleaned with brush. Tack coat or hot bitumen is then applied under pressure to fill-up the cracks. The treated surface is then covered with premix material. Hair cracks can be repaired by applying slow setting cationic emulsion evenly at the rate 5 to 9 kg/sqm. Light tamping to the coat of bituminous emulsion is recommended.

Repair of edge damages :

Edge damages are observed in the following forms :

- Cutting of edges
- Sinking of edge strips and depressions
- Cutting of edges takes place when the road is narrow or proper side support is not available to the edge of the road from the well-compacted shoulders. If the shoulders are in bad shape or depressed, the edges are damaged badly under moving wheels. These are repaired by cutting the damaged edges or digging the crust under the damaged portion. the crust is then rebuilt by grouting

the metal layer and repairing the edge with [premix bituminous mix. The shoulders are built-up simultaneously with moorum and duly compacted.

- When edge strips sink heavily the reason could be that the shoulders are built-up in impervious material and they are preventing draining out of water from the sub-grade. In such an eventuality the damaged portion needs to be opened up right up to sub-base layer. The layer shall then be removed and replaced with material having good drainage proprieties. Cross shoulder drains shall also be built to proper slopes to drain out sub-soil water effectively. The crust is then built-up layer by layer after proper compaction with a power roller. The shoulder shall also be built-up simultaneously. The top layer is then provided with BM layer, which is further, covered with a premix carpet layer.

Ravelling :

If ravelling of the road surface is observed, then emulsified bitumen is applied to the surface which is then topped with sand or slurry seal.

Bleeding :

When excess quantity of binder is used in the surfacing, it tends to come to the top and then spreads side ways. The spot or patch where bleeding has occurred becomes soft. The corrective measure are taken by spreading fine sand or metal chips over the soft spots and ramming it by hand rammer or r olling it with power roller, if available.

Periodical renewals :

Periodical renewal consists of provision of a surfacing layer over the existing surface of the pavement at regular interval of time so as to preserve the required serviceability of pavement and offset the wear and tear caused by the traffic and climate stress. Based on the experience in the country, the following specifications are suggested for periodical renewals of rural roads.

- Single coat or two coat surface dressing as per IRC:17
- 20 mm thick premix carpet with seal coat as per IRC :14
- Mix seal surfacing as per Clause 508 of MoRT & H Specifications.

The specifications and thickness of renewal course should be such that the road surface is restored close to its original condition as far as possible. The following broad guidelines are recommended for the type and periodicity of renewals given in the Table 22.4

Table 22.4 Type and Periodicity of Renewals

Traffic CVPD	Type and periodicity of renewal		
	Low Rainfall (1500 mm/year)	Medium Rainfall (1500-3000 mm/year)	High Rainfall (> 3000 mm/year)
< 150	Surface dressing; 6 years	Surface dressing; 6 years	Surface dressing; 6 years
150-450	Surface dressing; 5 years	Surface dressing; 4 years	Surface dressing; 3 years
>450	OGPC/MSS; 6 years	OGPC/MSS; 5 years	OGPC/MSS; 4 years

Note : *The table is adopted from the Report of the Committee on Norms for Maintenance of Roads in India, Ministry of Road Transport and Highways, Govt. of India, October 2000.*

Special Repairs :

Under special repairs, the repairs, such as, filling of large potholes, side settlements, pavement rectification, etc. are carried out. The type of treatment to be adopted for special repairs needs to be carefully designed, so as to avoid recurrence of particular damage. Also repairs are carried out as per the requirements, it helps in sustaining the life of pavement.

Rebuilding and strengthening of existing pavement :

The road pavements are designed for a particular design life. After this period, the pavement needs to be rebuilt or strengthened. Under rebuilding, a new pavement is constructed. In case of strengthening of existing pavement, overlays are laid over the existing road pavement for increasing the strength of existing pavement. The requirement of overlays for strengthening of the existing pavement needs to be work out on the basis of CBR method (IRC: 37) of pavement design or Benkelman Beam Deflection method (IRC : 81) based on the surface deflection measured normally on sealed roads. For these, separate IRC guidelines are available. The design of strengthening of the existing road pavement should also include the correction to the drainage facilities of the existing pavement, if any. The design of strengthening of existing pavement needs to be done by an experienced road engineer.

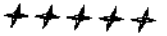
Table 22.5 : Common defects, Causes and Maintenance Measures In Surfaced Roads

Defect	Cause	MaintenanceMeasure
Bleeding Surface	Excess/Unsuitable binder	Spreading of aggregate chips
surface & Pavement	Poor quality of material/	Local sealing or filling of pavement
structure cracks	workmanship. Insufficient Pavement crust excessive loads	cracks strengthing.
Ruts & depression	Poor quality of material Inadequate pavement or subgrade strength	Slight rutting : filling Deep rutting : Local restoration of pavement
Edge subsidence	Inadequate or badly maintained shoulders	Slight subsidence : filling of ruts and depression and restoration of shoulders
Rutting	Loss of strength due to water penetration	Deep subsidence; local restoration of pavement, improvement of drainage
Edge damage	Poor drainage & Narrow shoulder damage due to action of water	Local restoration of pavement, repair of shoulder
Potholes	Degradation of pavement structure, Poor quality of material, infiltration water, traffic	Cutting and removal of material upto affected depth, filling and compaction by ramming.
Shoving	Failure of subgrade/sub-base, water ingress, Poor materials, Poor workmanship, Heavy Traffic	Cutting and removal of material upto full depth of affected area and refilling with appropriate materials in layers and compacting.

Table 22.6 : Periodicity of Routine Maintenance Activities

No.	Name of item	Frequency of operation in the Year
1.	Clearing of road side gutters.	Twice
2.	Pothole filling (WBM & BT)	Once
3.	Filling up edges of asphalt surface of excavating borrow pit.	(i) Single lane (a) T.I. 0--1000 Twice (b) T.I. 1000-5000 Four times.
4.	Dressing of berms	Once.
5.	White washing guard stones	Twice.
6.	Fixing disturbed caution board/village name board/ speed limit board etc.	Once.
7.	Refixing displaced guard stones.	Once
8.	White washing and geroo painting of trunks of trees	Once
9.	Cutting of branches of trees etc.	Once
10.	Topping of WBM Blindage operation including picking of loose metal.	18 times.
11.	Maintenance of Catch water drains.	Once.
12.	Clerance of CD works	Twice.
13	Clearing of wild seasonal growth of berms	Once.
14.	White washing parapets of C.D. works	Once.
15.	Earthwork in berms, desilting of drains etc.	As per requirement

Note : T.I. Stands for Traffic Intensity in tonnes per day.



CHAPTER 23

Pavement Condition Index (PCI)

1. Background

The measurement of the condition-rating of Rural Roads can be done by several methods. Automated equipment like Bump Integrator are perhaps more accurate but given the huge length of the network and the fact that the condition rating is used as a qalitative and relativistic parameter rather than as a quantitative parameter in the context of the investment resource scarcity, simple and low cost method may be used to initiate a Pavement Management System. Once the system stabilises and the utility of the condition rating becomes more important, it may be appropriate to switch over to more intensive and accurate measurement methods. Accordingly 3 simple, low cost methods are suggested for the present, which can be done by the PIU staff without much equipment.

2. Methods suggested

(i) Measurement based on Visual Inspection only

An experienced engineer can rate the PCI by visual inspection of the pavement for each kilometre, a pavement condition Index (PCI) of 1 to 5 is adopted, as under:

Description of Surface Condition	PCI
Very Good	5
Good	4
Fair	3
Poor	2
Very poor	1

(ii) Based on Riding Comfort

A jeep or car is driven at 50 km per hour and riding comfort noted for each kilomere. Based on 'Riding Comfort' while driving at the design speed of 50 km/hr, the PCI is assessed as under:

Riding Comfort @ 50 km/hr.	PCI
Smooth and pleasant Ride	5
Comfortable	4
Slightly Uncomfortable	3
Rough and Bumpy	2
-Dangerous	1

(iii) Based on comfortable Driving Speed possible

The driver is instructed to drive at most comfortable and safe speed possible on the road. The PCI then assessed for each kilometre based on the Normal Driving Speed, as under

Normal Driving Speed	PCI
Over 40 Km/hr	5
30 to 40 Km/hr	4
20 to 30 Km/hr	3
10 to 20 Km/hr	2
Less than 10 Km/hr	1

3. Determination of PCI for a Road

In order to get the PCI of the road, the airthmetic mean of the condition assessed for each km is taken if the kilometre wise PCI is varying within a small range. However, if the variation of PCI is large from section to section of the road under consideration, the road is to be divided into homogeneous sections and the arithmetic mean of PCI is taken for each section.

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CHAPTER 24

COMMON TESTS ON MATERIALS AND WORK

A large number of tests are required to be conducted on materials incorporated and work performed in a highway project. Frequencies of the test require are given in *Appendix-I.* Outlines of some of the commonly used tests are given in the following paragraphs. It should, however, be understood that these outlines are intended to draw the attention of the site engineers and not to serve as the procedure for such tests. For detailed procedure of the individual tests, reference may be made to the relevant standards of I.S.I. or other authorities as applicable.

24.1 Sieve Analysis (IS : 2720- Part 4 & IS : 2386- 1963 Part I) :

The test procedure is described in the required quantity of sample of soil or aggregates is sieved manually or mechanically on a standard set of sieves depending upon the maximum size of soil or aggregates and the percentage retained on each sieve is determined. The test results are expressed as per cent by weight passing each sieve. Sieve analysis test gives the particle size distribution in a sample of soil or aggregate.

24.2 Determination of Moisture Content of Soils (IS : 2720, Pt. II) :

Where facilities are available, the method consists of drying a sample of the soil in the oven at 105 - 110°C for a period (normally not more than 24 hours) till the dry weight of the soil becomes constant in the field, the alcohol method, though less accurate, can be used as a quick test. It consists of taking the soil specimen in a evaporating dish, pouring over it methylated spirit at the rate of about one millilitre for each gram of soil, mixing the two materials and igniting the spirit. After burning way of the spirit, the dish is cooled and weighed.

24.3 Plasticity Index (IS : 2720, Pt. 5) :

24.4 Moisture- Density Relationship (IS : 2720 : Parts VII & VIII) :

Two degrees of compaction, (IS : 2720 Part VII) and heavy compaction (IS : 2720, Part VIII) are usually specified. The former compaction also goes by the term Proctor compaction. In the light compaction, the wet soil is compacted in three equal layers by the rammer of weight 2.6 kg and free fall 31cm with 25 evenly distributed blows on each layer. In heavy compaction, rammer weighs 4.89 kg and the free fall is 45 cm. Compaction is done in 5 equal layers, each being given 25 blows.

The procedure is to compact the soil with different moisture contents and drawing a moisture density curve to find out the maximum dry density and the corresponding moisture content (OMC).

24.5 Laboratory CBR (IS : 2720, Part XVI) :

The apparatus consists of a mould 15 cm diameter with a base plate and collar, a loading frame with cylinderical plunger of 5 cm diameter and dial gauges for measuring the expansion on soaking and the penetration values. Briefly, the test consists of causing the plunger to penetrate the compacted specimen in the mould at 1.25 mm / minute. The load for 2.5 mm or 5 mm penetration is recorded. This load is expressed as a percentage of the standard load at the respective deformation level to obtain the CBR value. The standard loads for 2.5 mm and 5.0 mm penetrations are 1,370 kg and 2,055 kg respectively. A load penetration graph is plotted and the load corresponding to 2.5 and 5 mm penetration values are found. The CBR usually selected is at 2.5 mm penetration. For this test, only the material passing 20 mm sieve is used.

24.6 In-situ Density by Sand Replacement Method (IS : 2720,Pt. XXVIII): The principle of the method is to find the volume of a hole cut

in the layer to be tested by filling it up with sand of known density. Moisture content of the soil sample is determined to work out the dry density. A hole roughly 10 cm dia. and 15 cm deep is made and the excavated soil is carefully collected and weighed. Sand pouring cylinder is placed on the hole and the sand allowed to run to fill up the hole.

24.7 Flakiness Index (IS : 2386, Part I) :

Flakiness Index or aggregate is percentage by weight of aggregate particles whose least dimension / thickness is less than three-fifths of their mean dimension. Standard thickness gauge is used to gauge thickness of the samples which have been sieved through a set of sieves and separated into specified size ranges. The flaky materials passing the appropriate slots for each size range are added up and expressed as percentage of the total weight of the sample.

24.8 Aggregate Impact Value (IS : 2386, Part IV) :
The apparatus consists of a metal base and a cylinderical steel cup of internal dia. 10.2 cm and depth 5 cm in which the aggregate specimen is placed. Metal hammer 13.5 - 14.0 kg weight having a free fall from a height 38 cm is arranged to drop through vertical guides. Aggregate sample passing 12.5 mm sieve and retained on 10 mm sieve is filled in the steel cup in three layers by tamping each layer with 25 blows. After subjecting the test specimen to 15 blows, the crushed aggregate is sieved through 2.36 mm sieve. The Aggregate Impact in terms of the total percentage of weight of the sample.

24.9 Specific Gravity :
Specific gravity is the ratio of the mass of a given absolute volume of aggregates to the mass of an equal volume of water at a specified temperature. The test procedure is given in IS:2386-1963 (Part-3). The specific gravity value of aggregates required in computation of voids in bituminous mixdesign.For coarse aggregates, the wire basket method is used for determination of specific gravity, while for fine aggregates, the cyclometer method is used. For filler materials, specific gravity bottle is used.

24.10 Water Absorption :

Water absorption is the difference in weight of aggregates between 24 hours water-saturated surface-dry condition and oven-dry condition expressed as percentage of the latter. The test procedure is given in IS : 2386-1963 (Part-4). Water absorption is high for porous aggregates. It is necessary to provide extra binder in a bituminous premix at the rate of 0.5 percent for every 1 percent, water absorption in excess of 2 percent.

24.11 Soundness :

The test indicates the susceptibility of aggregates to disintegration under the action of water containing sodium and magnesium. The test procedure is described in IS : 2386-1963 (Part-5). Washed aggregates of specified size are immersed in saturated solution of sodium sulphate/ magnesium sulphate for 16 to 18 hours. The sample is then removed and dried to constant weight. This forms one cycle. The test is repeated for 5 cycles. After 5 cycles, the sample is washed, dried in an oven and re-sieved on those very sieves which were used before the test. The material retained on each of the sieves before and after the test is the loss due to disintegration and is expressed as percentage of total initial weight of the sample. The permissible value for loss in sodium sulphate and magnesium sulphate after 5 cycles are 12 percent and 18 percent respectively. If the loss is more, then the aggregates are likely to disintegrate by water containing such salts.

24.12 Stripping Value :

Striping is the displacement of bitumen film from a coated road aggregate particle in presence of water. The details of test procedure are given in IS : 6241-1971. In this test, 20 to 12.5 mm size aggregates are coated with 5 percent bitumen under specified conditions and immersed in distilled water 40°C for 24 hours. The average percent area of aggregate surface stripped is assessed visually, while the aggregates are under water. The amount of stripped area expressed as percent, is the stripping value.

24.13 Tray Test for Control of Rate of Spread of Binder (IRC : SP : 11):

Light metal trays of about 20 cm x 20 cm and 3 cm deep, previously weighed and numbered are placed at intervals along the road in the path of the binder distributor. After passing of the distributor, the trays are removed to find out the rate of spread of binder. Test with such trays at a number of locations can also indicate the uniformity of distribution.

24.14 Tray Test for Rate of Spread of Grit in Surface Dressing (IRC : SP : 11):

The principle is similar to that of finding the rate of spread of binder mentioned at (12) above.

24.15 Binder Content of Paving Mixtures by Centrifuge (IRC : SP : 11):

A representative sample of about 500 grams is exactly weighed and placed in the bowl of the extraction appartus and covered with commercial grade benzene. The mixture is allowed to stand for about one hour before starting the centrifuge. The machine is revolved at speeds upto a maximum of 3,600 rpm. The speed is maintained till the solvent ceases to flow from the drain. The machine is allowed to stop and another 20 ml of the benzene is added and the procedure it repeated. The filter ring from the bowl is removed, dried in air and then in oven to constant weight at 115°C and weighed.

24.16 Checking Surface Regularity using a Straight-Edge (IRC:SP: 11):

The test is made with 3 metre straight-edge made of steel or seasoned hard wood. If made of wood, the test face should be a metallic plate. The wedge should perferably be metallic but may be of seasoned hard wood. It should be graduated to read undulations upto 25 mm with a least count of 3 mm.

For recording undulations in the longitudinal profile, the straight-edge is placed parallel to the centre line of the road and the wedge inserted where the gap is maximum and the reading taken. The straight-edge is then slided forward by about half the length and the wedge reading repeated.

Testing of Bituminous Materials

IS : 73-1992 specify the requirements of penetration grade bituminous binders. All the test are detailed in IS : 1201, IS : 1220, IS : 10512 and IS : 9381, IS : 8887-1995 has specified requirement of cationic bitumen emulsions. A few important test and their significance are briefly described below :

(A) Test of Bitumen

(i) **Specific Gravity :** Details of test are given in IS : 1202-1978. It is defined as the ratio of the mass of a given volume of the bitumen to the mass of an equal volume of water 27°C. It is used to compute the volume of bitumen and determination of voids in compacted bitumen mixture in Marshall Method of mix design. It is determined by pyknometer.

(ii) **Water Content Test :** This test is specified in IS : 1211 – 1978. Water content is determined using Dean and Stark method. It is desired that bitumen should contain minimum water content. The maximum limit is 0.2 percent as per IS : 73-1992. Water Content more than the specified limit causes frothing during heating.

(iii) **Flash and Fire Point by Cleveland Open Cup :** This test is specified in IS : 1209-1978. It is defined as the lowest temperature in C° at which the heated bitumen catches fire momentarily in the form of flash. The fire point is the lowest temperature in C° at which the vapour of bitumen ignites on application of flame

at least for 5 second. The heating rate 5° C/minute. This test is indicative of fire hazard, if bitumen is heated beyond flash point. The fire point is usually 5-10°C higher than flash point. The minimum limit of flash point is 220°C.

(iv) **Softening Point Test (Ring and Ball) :** Details of apparatus and procedure are given in IS : 1205-1978. Softening point is a temperature measured in °C, at which a bituminous binder attains a particular degree of softness specified test conditions. Distilled water is used as bath medium for bitumens with softening point value below 80°C and glycerol for value beyond 80°C. The temperature of bath is raised at 5°C/minute from 5°C in case of water and from 35°C in case glycerol. The temperature, at which a standard steel ball (3.5g) placed over bitumen touches a base plate 25 mm below the ring, is recorded as softening point. It signifies the temperature at which bitumen passes from semi-0solid state to liquid state and indicate the atmospheric temperature at which the bitumen is likely to bleed. Hence, softening point of bitumen should be 5-10°C higher than the maximum atmospheric temperature.

(v) **Penetration Test :** The test is specified in IS : 1203-1978. It is conducted to measure consistency and identify the grade of bitumen. It is defined as vertical distance traversed by a standard needle in 0.1 mm unit under a known load (100g), at a fixed temperature (25°C), for a known time (5 second). The distance in 0.1 mm units is known as penetration. Therefore, the greater the penetration of needle the softer the bitumen. For each test three measurements are needed at 10 mm apart on bitumen surface.

Repeatability - if penetration is less than 50, 1 unit.
if penetration is less than 50, 3% of mean.
Reproducibility - if penetration is more than 50, 4 unit.
if penetration is more than 50, 8% of mean..

(vi) **Ductility Test :** Standard test procedure is described in IS : 1208-1978. Ductility is measured in cm and is defined as the distance in cm to which a briquette bitumen specimen will elongate before breaking when it is pulled apart at 5 cm/min. rate at 27°C. The cross-section at minimum width of specimen is 10 mm x 10 mm. Sample is to be prepared in standard mould and to be placed at 27°C for minimum 90 minutes. It signi fied the property by virtue of which bitumen can exist in a thin film without breaking.

(vii) **Viscosity Test :** Viscosity of bitumen plays a vital role for different operations of bituminous road construction.

The suggested viscosity values are given below :

Operations	Viscosity
Pumping	600-800
Spraying	50-200
Mixing	150-300
Laboratory mixing	150-190
Laboratory compaction	250-310
Rolling	1000-10,000

From the viscosity temperature relationship, the appropriate temperature for various operation of bituminous road construction can be determined. It is standard test specified in IS : 1206-1978. Viscosity is defined as resistance to flow due to internal friction of bitumen. In Industrial units, it is measured by time in second taken by specified volume of bitumen/cutback, bitumen/emulsion to flow from 10 mm /4mm orifice cup of standard

tar viscometer or saybolt-furol viscometer, there are several cup viscometers available which differs mainly in the size of opening through which bitumen is drained. Absolute viscosity = flow time x density x K. The value of K for 4 mm cup (STV), 10 mm cup (STV), and saybolt-furol viscometer are 0.0132, 0.400 and 0.00218 respectively. The test result may be expressed as : kinematics viscosity = flow time x K. It can measure viscosity between 320-5600cST. Kinematics viscosity is expressed as time in seconds required for fixed quantity of material viscosity by density. It is measured by recording time in seconds required for fixed quantity of material to flow through a glass capillary viscometer at a given temperature. The product of time flow and calibration factors given the kinematics viscosity.

(viii) **Loss on Heat Test :** This test is specified in IS : 1212-1978. It is defined as the percent loss in weight (exclusive of water content) of volatiles, when a sample of bitumen (50g) is heated at a standard temperature (163°C) under specified test conditions. Sample is prepared in a penetration cup (55 mm dia and 35 mm depth) and placed in an oven for 5¼ hours on rotating self heating. This test signified the resistance of bitumen to hardening during construction. The loss in weight and percent retained penetration values are reported.

$$\text{Percent loss in weight} = \frac{\text{Wt. of bitumen before heating} - \text{Wt. of bitumen after heating}}{\text{Wt. of bitumen before heating}} \times 100$$

$$\text{Retained Penetration, percent} = \frac{\text{Penetration after heating}}{\text{Penetration, before heating}} \times 100$$

(ix) **Solubility in Trichloroethylene (TCE) :** Details of test are given in IS : 1216-1978. It is a measure of the purity of bitumen (1-2g) in the solvent and separating the insolubles by filtering over asbestos mat in gooch crucible. The limit for solubility of bitumen in TCE is minimum 99 percent.

(x) **Stripping Test :** Stripping is the displacement of bitumen film from a coated road aggregate particle in the presence of water. In this test, 20 to 12.5 mm size aggregates are coated with 5 percent bitumen under specified conditions and immersed in distilled water 40°C for 24 hours. The average percent area of aggregate surface stripped is assessed visually. The amount of stripped area expressed as percent, is the stripping value. The permissible maximum value is 15 percent.

(B) Tests on Biturnen Emulsions (IS : 8887) :

(i) **Sieve Test on IS 600 Micron Sieve :** The test complements the settlement test. It is a stability test, used to find out amount of bitumen in the form of larger globules in a emulsion, which cannot be determined by settlement test. The larger drops can clog spraying equipment and will not provide uniform coating. A specified amount of sample is poured through an IS 600 micron sieve. After rinsing with distilled water, the sieve and bitumen are dried in oven. The amount of retained bitumen is determined by weighing and reported as residue on sieving.

(ii) **Binder Content :** The binder content in bitumen emulsion can be determined by a distillation test. A specified quantity of emulsion sample (50g) is distilled under specified test conditions. The binder content is determined by subtracting percentage of water content from 100. The residue is used for further testing to check quality of bitumen in a emulsion.

(iii) **Stability to Mixing with Coarse Aggregates :** This test has a three fold purpose. It determines the ability (i) to coat the aggregate (ii) to with stand mixing action while specified test conditions. The method is used to determine coagulation value aggregate (200 g) and emulsion (50 g).

(iv) **Viscosity by Standard Saybolt-Furol Viscometer (IS : 3117) :** Viscosity is defined as a fluid's resistance to flow. In the case of emulsion, the saybolt-furol viscosity test is used a measure of consistency. Results are reported in Saybolt-Furol seconds. The viscosities of RS (Rapid Setting) and MS (Medium Setting) emulsions are determined in seconds at 50°C and of SS (Slow Setting) emulsions at 25°C respectively.

(v) **Storage-Stability Test :** This test is used to determine the ability of an emulsion to remain as a uniform dispersion storage. A measured quantity of sample is placed in two cylinders (Stoppered) and allowed to stand for 24 hours. A specified sample is siphoned from the top and placed in oven for a set time at a specified temperature. They are removed, allowed to cool and weighed after to sample is removed but a small portion of bitumen emulsion remaining in each cylinder is siphoned off. A specified portion that is left is put through the same procedure as for the top sample. The storage stability is expressed as the numerical difference between the average percentage of bituminous residue found in two top samples and two bottom samples.

(vi) **Particle Charge :** The particle charge test is conducted to identify cationic emulsion by its positive charge. It is performed by immersing two copper Plates 25x75 mm which are connected to a 12 volt circuit. At the end of specified period of 2 minutes, an appreciable quantity of bitumen is deposited on cathode indicating a cationic emulsion.

(vii) **Miscibility with Water :** This test finds, if MS and SS emulsion can be mixed with water. It is not applicable for RS emulsions. After adding and stirring with distilled water, the emulsion sample is allowed to stand for two hours. It is then examined for any appreciable coagulation of the bitumen droplets in an emulsion. This test is a measure of quality of emulsion.

(viii) **Stability with Cement :** The cement mixing does the same for SS emulsion, as the test does for RS emulsions. In the cement mixing test, a sample is mixed with finely-ground Portland cement and mixture is washed over a IS 1.4 mm Sieve. The amount of material retained may be recorded as percent coagulation.

(ix) **Test on Residue :** Penetration, ductility and solubility in trichloroethylene test are conducted after distillation test to check the quality of bitumen. These tests are conducted as per procedures specified in IS : 1201-1220.

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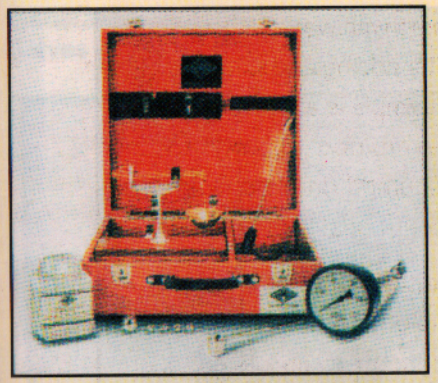
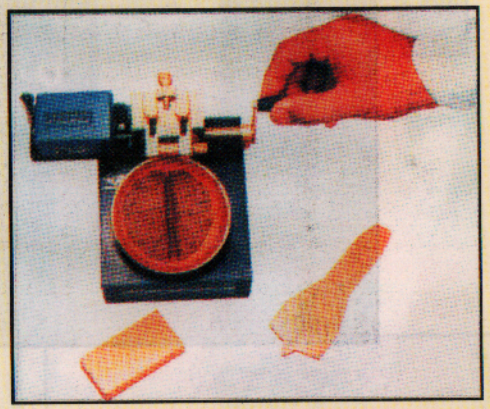
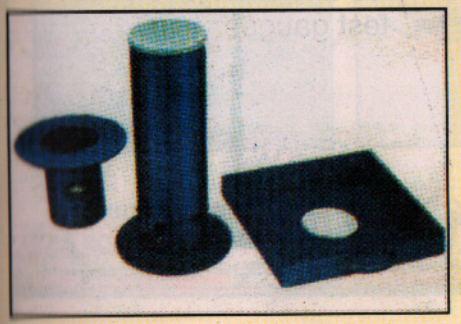
For testing of soils



(a) Water still (Capacity 4 litre per hour)
(b) Rapid Moisture Meter

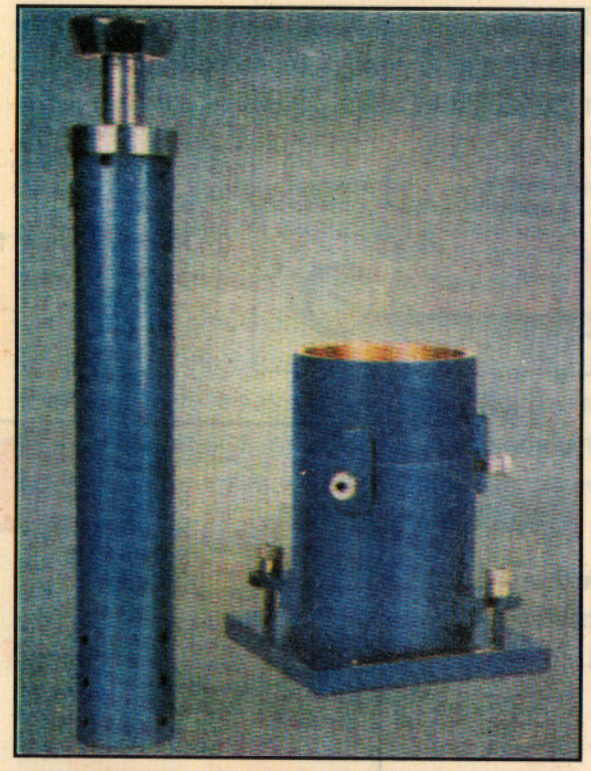
(c) Liquid limit device with casagrande and grooving tools

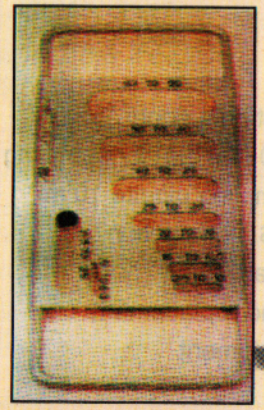




(d) Post hole auger (100 mm dia) for sampling
(e) Sampling pipette 10 ml
(f) B. S. compaction apparatus
(g) Sand replacement equipment

For testing of soils

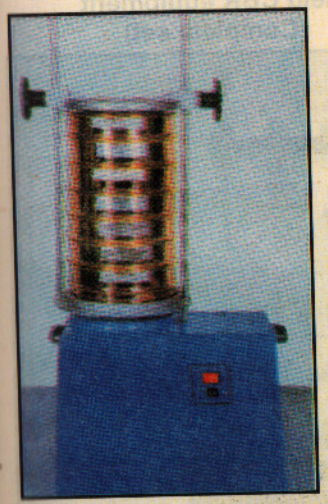


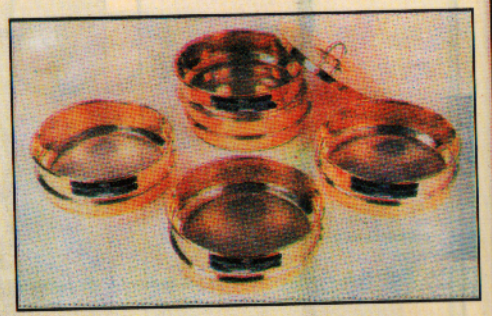


Flakiness and Elongation test gauges

Equipment for Field Laboratory

General Equipment
Sieves & Sieve Shaker :

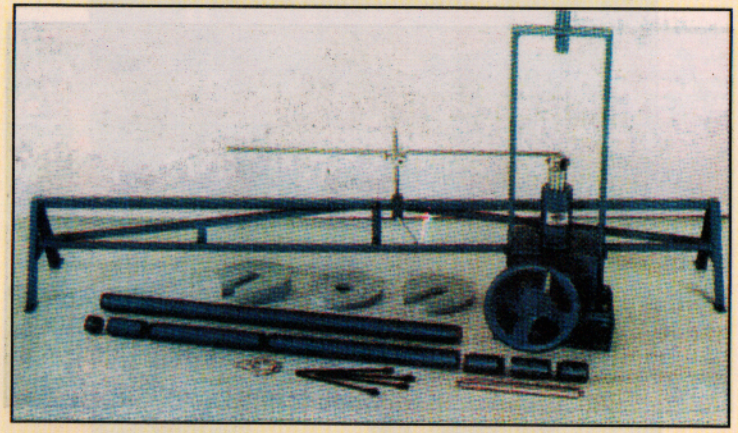




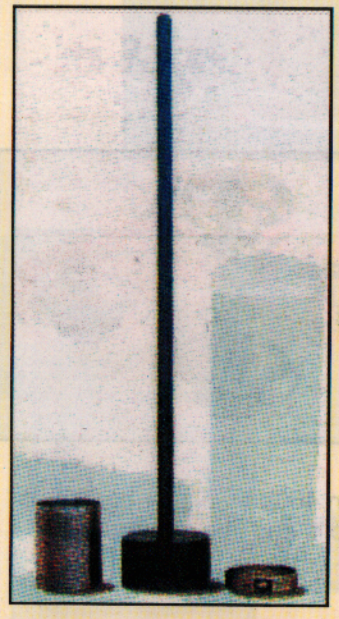
Standard set of sieves, lid and pan 450 mm dia for coarse aggregates and 200 mm dia for soils and fine aggregates, Sieve Shakers.

Sampling tins with lids 100 mm dia, 50 mm height

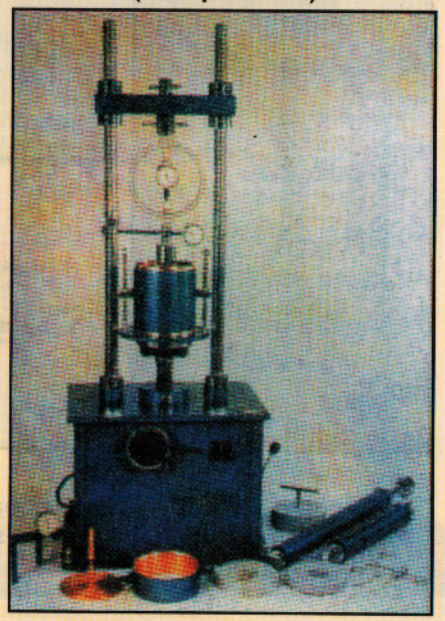
Lab CBR equipment (complete set)



Core cutter

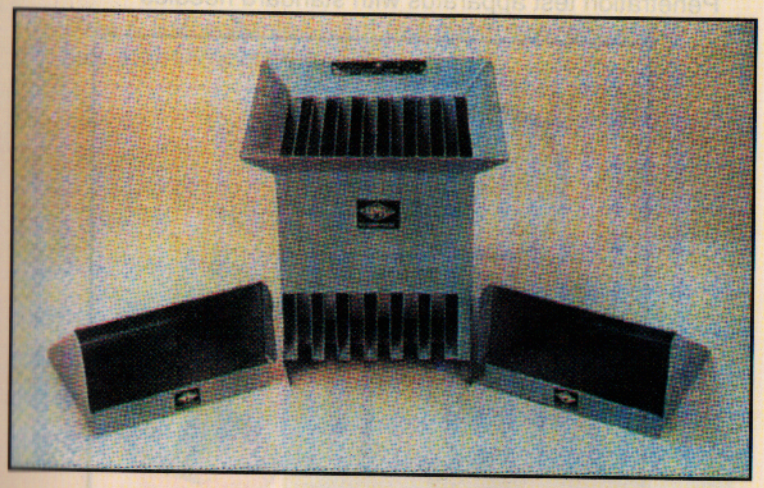


Field CBR equipment (Complete set)



For testing of aggregates

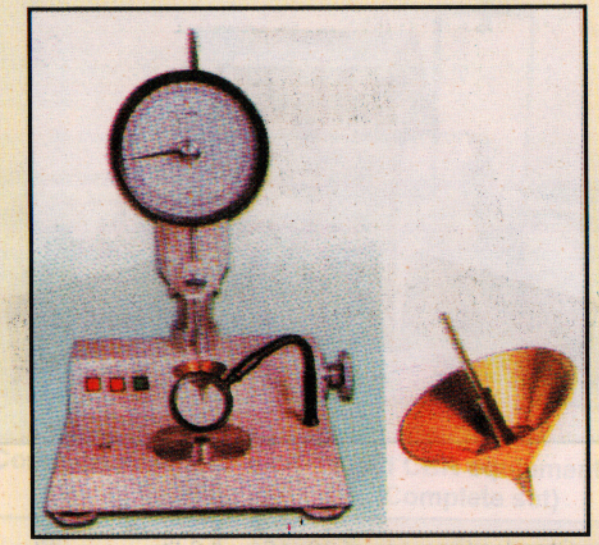
Riffle boxes for sampling of coarse and fine aggregates



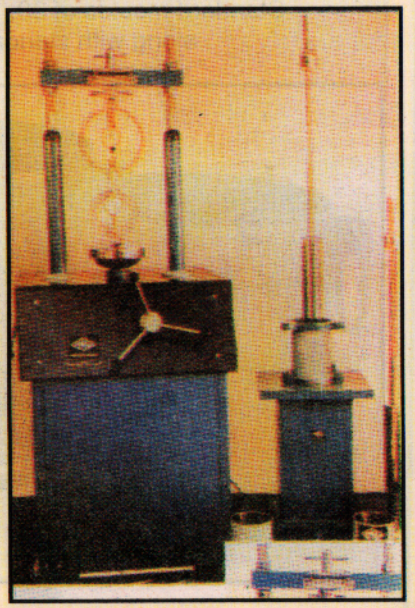
Standard moulds of 30, 15 and 3 litres capacity along with standard tamping rod

For testing of bitumen and liquid bitumens

Penetration test apparatus with standard needles



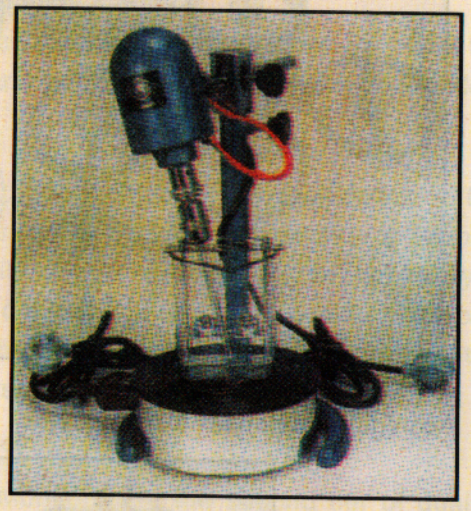
Complete Marshall Stability Test apparatus electrical operated loading unit, Flowmeter, automatic compactor, testing head assembly, providing rings with dial guage, specimen moulds, base plates, compaction hammers, specimen, cetractor, water bath and other accessories

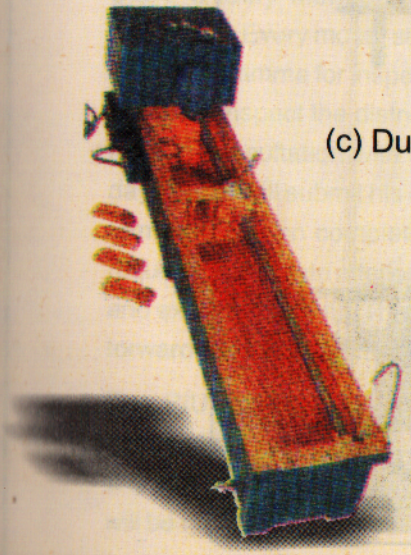


For testing Bitumen

(a) Penetration test apparatus with standard needles

(b) Ring & Ball softening point test apparatus with ring, ball, thermometer, etc.

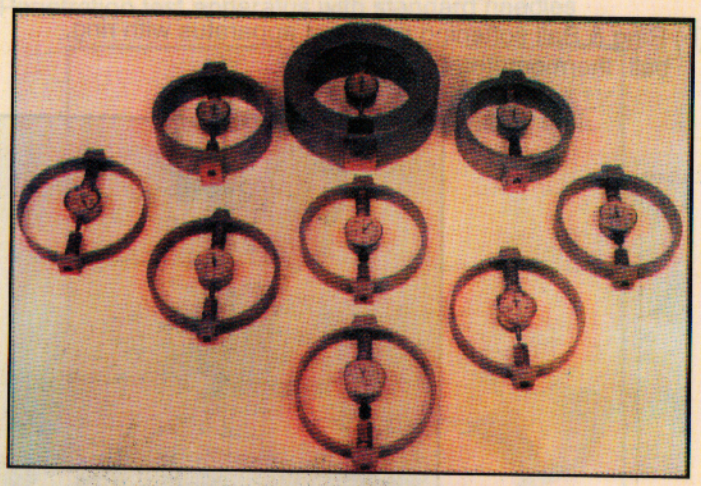




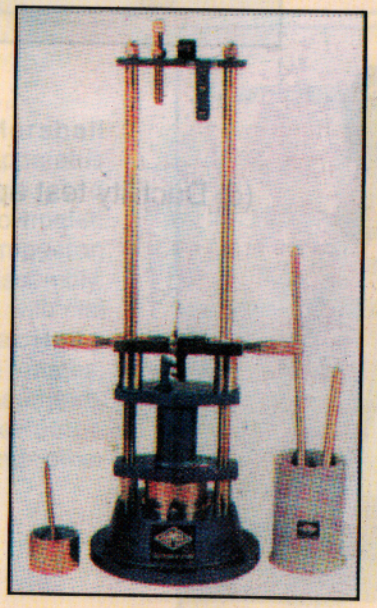
(c) Ductility test apparatus

Proving rings

- 10 kg, 50 kg, 100 kg capacity



Aggregate soundness test apparatus



CHAPTER 25

GUIDELINES ON QUALITY MONITORING AND CONTROL MECHANISM FOR PRADHAN MANTRI GRAM SADAK YOJNA (PMGSY) FOR THE STATE OF MADHYA PRADESH

1. The Pradhan Mantri Gram Sadak Yojana envisages three tier quality control and quality monitoring mechanism as under :

1.1 The First Tier :

P.I.U. is the first tier which is the executing agency at the work level. It is the responsibility of the PIU to perform mandatory quality control tests and to ensure authenticity of test results.The consultant and their Engineers are also part of this tier and their role will be assistance in quality control to PIU Engineers.

1.2 The Second Tier :

State Quality Monitors are the second tier of quality assurance. Every month state quality co-ordinator (SQC) will issue programme for inspection of work in various PIUs. The SQM will inspect the district/PIU at a convenient time to be fixed in consultation with PIU. The inspection will be for 3 days. SQM will submit his report of observatons in standard format to PIU on completion of his inspection. The points requiring immediate attetion of PIU will be discussed mutually and explained to PIU. The copy of inspection report may be forwarded to SQC for further necessary action.

The PIU will submit Action Taken Report (ATR) on the observations of SQM with in 15 days of receipt of report. If any observation requires more time to rectify, the time limit will be mentioned in ATR.

1.3. The Third Tier :

The National Quality Monitors which are engaged by NRRDA are the third tier. The National Quality Monitors are to carry out quality testing of PMGSY works on random sampling basis, mainly in order to ensure that the Programme Implementation and State Quality control system is working satisfactorily. The NQMs are expected to make constructive suggestions relating to procedural aspects in addition to locating problems at individual work levels.

GRADING OF WORKS

The grading of report of NQM will be done at NRRDA and the report will be graded on three parameters namely 1. Management standard, 2. Contract management, 3. Quality of work. On the basis of these three parameters the reports will be graded as satisfactory (S) or un- satisfactory (U). Accordingly the report can be either "S" or "UQW", "UCM", "UMS". All the 3 parameters will require attention at PIU level.

Action on Grading:

- The above overall grading will be communicated to the State Quality Coordinator. The action in respect of institutional issues i.e. **UMS** will be taken by the SRRDA and ATR will be communicated to NRRDA.
- The action in respect of **UCM** i.e. contract management issues will be taken by PIU and the ATR will be communicated to NRRDA through the SQC. If the work is graded as **UCM** the ATR is expected to include details of action taken against the Contractor and/or PIU.

- The action in respect of **UQW** i.e. work quality issues will be taken by PIU and the ATR will be communicated to NRRDA through the SQC.If the work is graded as **UQW** the ATR is expected to include details of action taken against the Contractor and/or the staff of PIU in addition to rectification of work. The work or any of its items graded as unsatisfactory will be required to be re-done unless in-situ rectification is possible. While furnishing the ATR, the head of PIU will clearly mention that whether the item of work graded as unsatisfactory has been removed and re-done and if in-situ rectification has been done, the process of rectification will be explained in sufficient details.

ACTION TAKEN REPORT

At PIU level the following action shall be taken (unless for reasons to be recorded, it is proposed not to act on any portion of the NQM Report).

i. After the inspections in the district are over and copy of report are handed over by the NQM to the PIU, copies will be sent to the state Quality Coordinator and NRRDA within 10 days after completing inspection. Unless the PIU disagrees with the conclusion/ recommendation, rectification work should be ordered immediately by the PIU. In case General Manager PIU feels that any portion of the inspection report or the suggested rectification is not appropriate, he shall make a full report to the State Quality Co-ordinator.

ii. The Action Taken Report will be prepared by General Manager PIU in the prescribed Format and will be sent to the State Quality Coordinator. The State Quality Coordinator will mention his remarks and send a copy of Action Taken Statement to NRRDA.

The Action taken report submitted should be comprehensive, i.e. merely writing letter to the Contractor or to the subordinate doesn't constitute action taken and should not be treated as ATR.

Quality Control Hand Book and Quality Control Registers

The NRRDA has published a Quality Control Handbook, which should be followed for ensuring Quality. Quality Control Registers shall invariably be maintained for each of the road works under the Programme. Payment shall not be made to the Contractors unless the mandatory tests prescribed in Rural Roads Manual and the Quality Control Handbooks have been conducted and results have been found in accordance with the specifications. Quality Control Registers will be maintained in two parts. The first part will be Quality Control Register - Record of Tests and the second part will be the Record of Abstract of Tests and Non-Conformance Reports.

a. Register Part-I: The first part of the register is the register of all Quality Control Tests conducted by the person who is responsible for the basic Quality Control Testing .As per provision of Quality Control by Contractor in the contract document, the Quality Control Register will be issued to the Contractor for every road work. This register will always be available at the work site. The register will not be taken away from the site in any case. The first part of the register will have following three sections:

Section 1:Earthwork
Section 2:Granular Construction
Section 3:Bituminous construction

b. Register Part-II: The second part of the register is the record of abstract of the tests conducted and Non Conformance reports. It will be maintained by the site in charge officer not below the rank of Assistant Engineer.

c. The QC Register will be issued in the same manner as the Measurement Book is issued to the work. Every register should be page numbered and no page should be removed. The register of issue of the Quality Control Register will be maintained by the head of the PIU.

d. In case of hill roads, where the work of only formation cutting may be executed, all the tests shown in the Earthwork section may not be required excepting tests for CBR and compaction. In such cases, the formats may not require.

The filling of tests formats of Part 1 and Part 2 shall be as per the guidelines of Quality Control Handbook

CHAPTER 26

CHECK-LIST

SETTING OUT & PREPARATORY WORK

1 क्या मार्ग का निरीक्षण कर डी.पी.आर. के प्रावधानों को चैक कर लिया गया है।

2 क्या मार्ग पर भूमि उपलब्धता हेतु आवश्यक कार्यवाही कर ली गई है।

3 क्या जंगल सफाई के पूर्व मार्ग की वीडियोग्राफी / फोटाग्राफी करा ली गई है।

4 क्या जंगल सफाई के पश्चात् प्रत्येक कि.मी. में 4-4 Working Bench Mark तथा प्रत्येक क्रास ड्रेनेज के निकट 1 वर्किंग वेन्च मार्क स्थापित कर लिये गए हैं ?

5 क्या स्थापित किए गए बैंच मार्कों की लिस्ट इंजीनियर से अनुमोदित करा ली है

6 क्या रोड की सेन्टर लाइन (Center Line) मार्क कर ली गई है ?

7 क्या प्रत्येक मार्ग के एक निश्चित चैनेज पर निश्चित कोण से फोटोग्राफ ले लिए गए है।

8 क्या लाभान्वित होने वाले ग्रामों का पैदल चलकर सोशल सर्वे कर लिया गया है।

9 क्या फारमेशन की ऊँचाई के अनुसार उपरोक्त पेग के समकक्ष टो लाइन के पेग लगा दिए गए हैं ?

10 क्या साइट क्लीयरेन्स के उपरान्त Initial Level ले लिए गए है ?

11 क्या Initial Levels की चैकिंग कन्सलटेंट टीम तथा PIU टीम द्वारा की गई है ?

12 क्या पेग पर पूर्व निर्धारित Embankment, Sub Grade, GSB, G-II & G-III के लेबिल के चिन्ह अंकित कर लिए गए हैं ? जो कि मार्ग पूर्ण होने तक स्थापित रहेंगे।

13 क्या वर्क प्लॉन तैयार कर उसका अनुमोदन करा लिया गया है ?

14 क्या ठेकेदार की प्रयोगशाला में आवश्यक उपकरण उपलब्ध है ?

15 क्या Formation Line को मार्क किया जाकर L-Section & Cross Section ठेकेदार को कंसल्टेंट / प.क्रि.ई. द्वारा अनुमोदित कर दे दिए गए हैं ?

16 क्या रोड किनारे उपलब्ध मिट्टी की Liquid Limit, Plasticity Index, Free Swelling Index, MDD, OMC, CBR का टेस्ट कर लिया है ?

17 क्या CBR mould पर्याप्त संख्या में है, जिससे 4 – 5 sample एक साथ टेस्ट किए जा सकें ?

18 क्या कंसलटेंट की लेब में अनुबंधानुसार उपकरण उपलब्ध है ?

19 क्या उपलब्ध उपकरणों के केलीब्रेशन करा लिए गए हैं ?

20 क्या रोड के लिए आवश्यक सामग्री की मात्रा का आंकलन कर उनके प्राप्ति स्थलों का चयन कर लिया गया है ?

21 क्या मार्ग में उपयोग में आने वाली सामग्री का परीक्षण कर उसे महाप्रबंधक अनुमोदन करा लिया गया है ?

22 क्या प्रत्येक स्तर पर किस समय कितनी प्लान्ट मेशनरी की आवश्यकता होगी, इसका आंकलन कर लिया गया है ?

23 क्या रोड पर प्रत्येक कि.मी. में 4 Bench Mark तथा प्रत्येक क्रास ड्रेनेज के निकट वेन्च मार्क स्थापित कर लिया गए हैं ?

24 क्या रोड की सेन्टर लाइन (Center Line) मार्क कर ली गई है ?

25 क्या रोड की सेन्टर लाइन (Center Line) के दोनों ओर 6.5 – 6.5 मीटर की दूरी पर समतल में प्रत्येक 100 मीटर पर तथा घाट व मोड़ों पर प्रत्येक 20 मीटर पर पेग लगा दिए गए हैं ?

26 क्या फारमेशन की ऊँचाई के अनुसार उपरोक्त पेग के समकक्ष टो लाइन के पेग लगा दिए गए हैं ?

27 क्या साइट क्लीयरेन्स के उपरान्त Initial Level ले लिए गए है ?

28 क्या Initial Levels की चैकिंग कन्सलटेंट टीम तथा PIU टीम द्वारा की गई है ?

29 क्या पेग पर पूर्व निर्धारित Embankment, Sub Grade, GSB, G-I, G-II & G-III के लेबिल के चिन्ह अंकित कर लिए गए हैं ?

EARTH WORK / SUB GRADE

1 क्या रोड के किनारे उपलब्ध मिट्टी की Liquid Limit, Plasticity Index, Free Swelling Index, MDD, OMC, CBR का Test कर लिया गया है ?

2 क्या रोड के किनार लगाए गए Pegs में Embankment / Sub grade के Level के चिन्ह अंकित किए गए हैं ?

3 क्या पुलियों के स्थल का चयन कर लिया गया है ?
4 क्या पुलियों का ले आउट कर लिया गया है ?
5 क्या पुलियों का कार्य प्रारंभ कर दिया गया है ?
6 क्या Embankment तथा Sub grade में उपयोग होने वाली मिट्टी की गुणवत्ता CBR, LL, PI, OMC, MDD का परीक्षण कर लिया गया है ?
7 क्या Embankment मे काली मिट्टी का उपयोग तो नहीं किया जा रहा है ?
8 क्या Subgrade में उपयोग होने वाली मिट्टी की CBR 7% से अधिक है ?
9 क्या यह निश्चित किया गया है कि Embankment में उपयोग होने वाली मिट्टी में 75 mm से बड़े coarse material तथा Sub grade में उपयोग होने वाली मिट्टी में 50 mm से बड़े Coarse material उपलब्ध तो नहीं है ?
10 क्या मिट्टी डालने से पूर्व सतह को समतल कर पानी का छिड़काव कर रोलिंग की गई है ?
11 क्या रोड़ के किनारे निर्धारित दूरी पर नाली खोदी गई है ?
12 क्या बाजू में खोदी गई नालियों की गहराई 45 से.मी. या उससे कम है ?
13 क्या Formation के Toe line से मिट्टी का भराव 20 cm के लेयर में किया गया है?
14 क्या मिट्टी के ढेले तोड़ लिए गए हैं तथा मिट्टी की ऊपरी सतह को केम्बर में कर लिया गया है ?
15 क्या मिट्टी में पानी की मात्रा का परीक्षण कर लिया गया है ?
16 क्या पानी की मात्रा OMC से अधिक पाए जाने पर उसे कम करने के लिए छोड़ा गया है ?
17 क्या मिट्टी में पानी का प्रतिशत OMC से कम पाए जाने पर पानी का छिड़काव आवश्यकता का आंकलन कर किया गया है ?
18 क्या पानी की मात्रा की प्रति वर्गमीटर की आवश्यकता की गणना कर ली गई है ?
19 क्या निर्धारित आवश्यकता में पानी का छिड़काव किया गया है ?
20 क्या अंतिम रूप से यह परीक्षण कर लिया गया है कि मिट्टी में पानी की मात्रा OMC के समकक्ष है ?
21 क्या मिट्टी की रोलिंग किनारे से प्रारंभ कर मध्य की ओर की गई है ?
22 क्या Super elevation के भाग में रोलिंग अंदर से बाहर की ओर की गई है ?
23 क्या Compaction के लिए आवश्यक मात्रा में रोलर चलाया गया है ?

24 क्या रोलिंग के मध्य depressions तथा Camber की चेंकिंग कर सुधारा गया है ?
25 क्या रोलिंग के उपरांत Field density का परीक्षण किया गया है ?
26 क्या Field density उपयुक्त पाई गई है ?
27 यदि Field density उपयुक्त नहीं पाई गई है तो क्या इसका सुधार कर लिया गया है?
28 क्या उपरोक्त प्रक्रिया प्रत्येक Layer के मिट्टी के कार्य में अपनाई गई है ?
29 क्या Earth Work /Sub grade के Top level का मिलान Pegs में बनाए गए चिन्ह अर्थात निर्धारित लेबिल से किया गया है ?
30 क्या अंतिम Layer का Camber चेक कर लिया गया है ?
31 क्या अगली लेयर को कार्य प्रारंभ करने के पूर्व सहायक प्रबंधक से अनुमोदन प्राप्त कर लिया है ?
32 क्या Side Slope 1 : 2 के Slope में है एवं Side Slope की ट्रेसिंग की गई है ?
33 क्या Earth Work के माप लेकर माप पुस्तिका में लिखे गए है ?

GRANULAR SUB-BASE

1 क्या Sub grade निर्देशानुसार किया जाकर परीक्षण परिणाम उपयुक्त पाए गए हैं ?
2 क्या GSB में उपयोग की जाने वाली सामग्री की CBR 20% से अधिक पाई गई है ?
3 क्या GSB Material की ग्रेडिंग निर्धारित मापदण्ड के अनुरूप है ?
4 क्या GSB Material की Liquid Limit 25 से कम तथा Plasticity index 6 से कम पाया गया है ?
5 क्या GSB में उपलब्ध Coarse material का water obserption 2% से अधिक है ?
6 क्या GSB material laying से पूर्व Sub grade पर पानी का छिड़काव कर रोलर के दो पास से compact किया गया है ?
7 क्या GSB material को पूर्व निर्धारित मोटाई में बिछाया गया है ? जिससे Compacted Thickness प्राप्त हो सके।
8 क्या GSB दो भिन्न प्रकार के Material को मिक्स करके बनाया जा

रहा है ?

9 यदि GSB दो भिन्न प्रकार के मटेरियल को मिलाकर बनाया जा रहा है तो क्या दोनों मटेरियल की निर्धारित मात्रा Mix की गई है ?

10 क्या mixed material की mixing इस स्तर तक की गई हे कि homoge neous mix प्राप्त हुआ है ?

11 क्या बिछाए गए मटेरियल का water content कर लिया गया है ?

12 यदि water content के परिणाम OMC से 1% से अधिक है तो क्या इसे सूखने के लिए छोड़कर पानी की सही मात्रा प्राप्त की गई है ?

13 यदि water content के परिणाम OMC से 2% से कम है तो क्या गणना कर पानी की अतिरिक्त मात्रा का छिड़काव कर mixing की गई है ?

14 क्या OMC के लिए उपयुक्त परिणाम प्राप्त होने पर रोलिंग किनारे से मध्य की ओर की जा रही है ?

15 क्या super elevation पर रोलिंग अन्दर से बाहर की ओर की जा रही है ?

16 क्या रोलिंग के समय camber, depression तथा high-spot की जांच की गई है ?

17 क्या camber, depression तथा high-spot का सुधार किया गया है ?

18 क्या रोलिंग के प्रत्येक pass में पूर्व pass की एक तिहाई चौड़ाई तक overlap की गई है ?

19 क्या Compacted sub base की density test की गई है ?

20 क्या density MDD के अनुपात में 98% से अधिक है ?

21 यदि density 98% से कम है तो क्या सुधार के लिए पुनः compaction किया गया है?

22 क्या density पुनः चेक की गई है ?

23 क्या उपयुक्त परिणाम पाए गए हैं ?

24 क्या compacted surface के लिए surface regularity के परीक्षण कर लिए गए हैं ?

25 क्या surface regularity निर्धारित सीमा है ?

26 यदि नहीं तो क्या इसमें सुधार कर लिया गया है ?

27 क्या Compaction के उपरांत Layer की मोटाई प्रावधान के अनुसार प्राप्त हुई है ?

28 क्या माप पुस्तिका में अंकित किए गए हैं ?

WATER BOUND MACADAM GRADE II

1 क्या WBM का कार्य प्रारंभ करने के पूर्व GSB की Line, Grade, Cross-Section, Camber का परीक्षण कर लिया है ?

2 क्या GSB कार्य की Line, Grade, Cross-Section, Camber का क्षतिग्रस्त कार्य सुधार लिया है ?

3 क्या WBM कार्य में गिट्टी बिछाने के पूर्व हल्का पानी का छिड़काव कर रोलर से दो पासकर दबाया है ?

4 क्या WBM में उपयोग की जाने वाली गिट्टी की इम्पेक्ट वेल्यू 30% से कम है?

5 क्या WBM में उपयोग की जाने वाली गिट्टी की ग्रेडिंग Coarse के अनुरूप की ग्रेडिंग G-II से मेल खाती है ?

6 क्या WBM में उपयोग की जाने वाली गिट्टी की Flakiness तथा Elongation indices सम्मलित रूप से 30% से कम है ?

7 यदि Stone Screening उपयोग की जा रही है तो क्या उसकी ग्रेडिंग G-II Coarse के लिए Type A 13.2 mm की ग्रेडिंग से मेल खाती है ?

8 यदि Stone Screening उपयोग की जा रही है तो क्या यह उसी मटेरियल की है जिसका उपयोग Coarse aggregate में किया जा रहा है ?

9 यदि Crushable type screenings उपयोग की जा रही है तो क्या वह वास्तविक रूप से Crushable है ?

10 क्या Crushable Screenings की Liquid Limits तथा Plasticity Index क्रमशः 20 तथा 6 की सीमा के अंदर है ?

11 क्या Crushable Screenings की Grain Size Analysis में 75 micron से 10% से अधिक अंश Pass तो नहीं होता ?

12 क्या Crushable Screenings मे Rounded River Borne Material तो नही है?

13 क्या Binding Material का पृथक से उपयोग आवश्यक है ?

14 यदि Binding Material का पृथक से उपयोग आवश्यक है, तो क्या इस Material की PI value 6 से कम पाई गई है ?

15 क्या Coarse Aggregate बिछाने से पूर्व नीचे की सतह को परखा गया

है, इस सतह के Disturbed भागों के पुनः ठीक कर लिया गया है ?

16 क्या Coarse Aggregate को आवश्यक Loose Thickness में निर्धारित Camber तथा Grade में बिछाया गया है ?

17 क्या Coarse Aggregate बिछाने के उपरांत Hand Packing कर ली गई है ?

18 क्या बिछाए गए Coarse Aggregate में छोटी बड़ी गिट्टी के पृथक–पृथक Pocket तो नहीं बने है ? यदि हाँ तो क्या इसे Uniform किया गया है ?

19 क्या गिट्टी के मध्य दूसरी गिट्टी के लिए जगह तो नहीं है ?

20 क्या Hand Packed, Homogeneous बिछाए गए Layer की Thickness, Camber तथा Longitudinal Profile चेक कर ली गई है ?

21 क्या WBM की Thickness के मान से आवश्यक Shoulder की कार्यवाही Earthwork / Sub grade अथवा GSB के अनुसार जैसा प्रावधान हो उसी अनुरूप कर ली गई है ?

22 क्या रोलिंग Curve के भाग पर inner edge में outer edge की ओर तथा शेष भाग में edge से Centre की ओर की जा रही है ?

23 क्या रोलिंग के समय थोड़े पानी का छिड़काव किया जा रहा है ?

24 क्या रोलिंग के समय एक बार में दबाए भाग की आधी चौड़ाई दूसरी बार रोलिंग में दबाई जा रही है ?

25 क्या रोलिंग में यह ध्यान रखा गया है कि aggregate आंशिक रूप से ही Compact हुआ है, जिसमें screenings का अंदर जाना संभव हो सके ?

26 क्या आंशिक रोलिंग किए surface पर निर्धारित Grid के निशान लगा लिए गए हैं ?

27 क्या इस ग्रिड के लिए आवश्यक screenings की मात्रा की गणना कर ली गई है ?

28 क्या screening की आवश्यक मात्रा को 3, 4 अथवा 5 भागों (गणना में) में बांट लिया गया है ?

29 क्या Screening का एक भाग प्रति ग्रिड के अनुसार uniform rate में फैलाया गया है?

30 क्या screening फैलाने के उपरांत rolling तथा brooming (झाड़ू लगाने) के कार्य को निरंतर कर screening को voids में प्रवेश करा दिया गया है ?

31 क्या उपरोक्तानुसार screening के शेष भाग भी एक–एक कर फैलाए जाकर rolling तथा brooming द्वारा voids में समाए गए है तथा क्या अब

screening को coarse aggregate में प्रवेश कराना संभव नहीं है ?

32 क्या dry rolling की उपरोक्त कार्यवाही के उपरांत पर्याप्त मात्रा में पानी का छिड़काव कर rolling तथा brooming की गई है, जिससे coarse aggregate सही तरीके से key हो जावे तथा screening से grout हो जावे ?

33 क्या coarse aggregate में उपयोग होने वाली गिट्टी को रोलर के सामने विभिन्न स्थलों पर फैंक कर यह सुनिश्चित कर लिया है कि यह गिट्टी पूरी तरह पिस जाती है तथा इसका कोई भाग रोल किए डब्ल्यू.बी.एम. में नहीं समाता, डब्ल्यू.बी.एम. के किसी हिस्से पर इस गिट्टी के ऊपर से रोलर निकलने पर कोई दबाव का चिन्ह तो नहीं बनता है ?

34 क्या rolled surface का camber, super elevation तथा longitudinal profile चेक कर ली गई है।

35 क्या निर्धारित से ऊचे अथवा नीचे पाए गए हिस्सों को पूर्ण रूपेण सुधार कर सही तरीके से पुनः रोल कर लिया गया है ?

36 यदि Binding material का उपयोग किया जाना है तो इसे दो या तीन परतों में फैलाते हुए, प्रत्येक परत के ऊपर पर्याप्त पानी डालकर rolling तथा brooming की गई है ?

37 क्या watering, rolling तथा brooming से बनी slurry WBM के छिद्रों में प्रवेश कर गई है ?

38 क्या slurry के छिद्रों में प्रवेश के उपरांत slurry की एक wave रोलर के आगे चलती रही है ?

39 क्या rolling के उपरांत WBM की मोटाई निर्धारित के अनुसार प्राप्त हुई है ?

40 क्या कार्य के दूसरे दिन परीक्षण में कोई छिद्र या छिद्र का समूह पाया गया है ?

41 यदि छिद्र पाए गए हैं तो क्या इन्हें screenings तथा Binding material डालकर पुनः roll कर ठीक किया गया है ?

42 क्या माप पुस्तिका में अंकित किए गए हैं ?

WATER BOUND MACADAMGRADE- III

1 क्या WBM, G-2 का Line, Grade, Camber का परीक्षण कर लिया है ?

2 क्या WBM, G-2 के क्षतिग्रस्त कार्य का सुधार कर लिया है ?

3 क्या WBM में उपयोग की जाने वाली गिट्टी की इम्पेक्ट वेल्यू 30% से

कम है?

4 क्या WBM में उपयोग की जाने वाली गिट्टी की ग्रेडिंग Coarse के अनुरूप की ग्रेडिंग G- III से मेल खाती है ?

5 क्या WBM में उपयोग की जाने वाली गिट्टी की Flakiness तथा Elongation indices सम्मलित रूप से 30% से कम है ?

6 यदि Stone Screening उपयोग की जा रही है तो क्या उसकी ग्रेडिंग G- III Coarse के लिए Type B 11.2 mm की ग्रेडिंग से मेल खाती है ?

7 यदि Stone Screening उपयोग की जा रही है तो क्या यह उसी मटेरियल की है जिसका उपयोग Coarse Aggregate में किया जा रहा है ?

8 यदि Crushable type screenings उपयोग की जा रही है तो क्या वह वास्तविक रूप से Crushable है?

9 क्या Crushable Screenings की Liquid Limits तथा Plasticity Index क्रमशः 20 तथा 6 की सीमा के अंदर है?

10 क्या Crushable Screenings की Grain Size Analysis में 75 micron से 10% से अधिक अंश Pass तो नहीं होता ?

11 क्या Crushable Screenings में Rounded River Borne Material तो नही है?

12 क्या Binding Material का पृथक से उपयोग आवश्यक है ?

13 यदि Binding Material का पृथक से उपयोग आवश्यक है, तो क्या इस Material की PI value 6 से कम पाई गई है ?

14 क्या Coarse Aggregate बिछाने से पूर्व नीचे की सतह को परखा गया है, इस सतह के Disturbed भागों को पुनः ठीक कर लिया गया है ?

15 क्या Coarse Aggregate को आवश्यक Loose Thickness में निर्धारित Camber तथा Grade में बिछाया गया है ?

16 क्या Coarse Aggregate बिछाने के उपरांत Hand Packing कर ली गई है ?

17 क्या बिछाए गए Coarse Aggregate में छोटी बड़ी गिट्टी के पृथक – पृथक Pocket तो नहीं बने है ? यदि हाँ तो क्या इसे Uniform किया गया है ?

18 क्या गिट्टी के मध्य दूसरी गिट्टी के लिए जगह तो नहीं है ?

19 क्या Hand Packed, Homogeneous बिछाए गए Layer की

Thickness, Camber तथा Longitudinal Profile चेक कर ली गई है ?

20 क्या WBM की Thickness के मान से आवश्यक Shoulder की कार्यवाही Earthwork / Sub grade अथवा GSB के अनुसार जैसा प्रावधान हो उसी अनुरूप कर ली गई है ?

21 क्या रोलिंग Curve के भाग पर inner edge में outer edge की ओर तथा शेष भाग में edge से Centre की ओर की जा रही है ?

22 क्या रोलिंग के समय थोड़े पानी का छिड़काव किया जा रहा है ?

23 क्या रोलिंग के समय एक बार में दबाए भाग की आधी चौड़ाई दूसरी बार रोलिंग में दबाई जा रही है ?

24 क्या रोलिंग में यह ध्यान रखा गया है कि aggregate आंशिक रूप से ही Compact हुआ है, जिसमें screenings का अंदर जाना संभव हो सके ?

25 क्या आंशिक रोलिंग किए surface पर निर्धारित Grid के निशान लगा लिए गए हैं ?

26 क्या इस ग्रिड के लिए आवश्यक screenings की मात्रा की गणना कर ली गई है ?

27 क्या screening की आवश्यक मात्रा को 3, 4 अथवा 5 भागों (गणना में) में बांट लिया गया है ?

28 क्या Screening का एक भाग प्रति ग्रिड के अनुसार uniform rate में फैलाया गया है?

29 क्या screening फैलाने के उपरांत rolling तथा brooming (झाड़ू लगाने) के कार्य को निरंतर कर screening को voids में प्रवेश करा दिया गया है ?

30 क्या उपरोक्तानुसार screening के शेष भाग भी एक–एक कर फैलाए जाकर rolling तथा brooming द्वारा voids में समाए गए है तथा क्या अब screening को coarse aggregate में प्रवेश कराना संभव नहीं है ?

31 क्या dry rolling की उपरोक्त कार्यवाही के उपरांत पर्याप्त मात्रा में पानी का छिड़काव कर rolling तथा brooming की गई है, जिससे coarse aggre gate सही तरीके से key हो जावे तथा screening से grout हो जावे ?

32 क्या coarse aggregate में उपयोग होने वाली गिट्टी को रोलर के सामने विभिन्न स्थलों पर फैंक कर यह सुनिश्चित कर लिया है कि यह गिट्टी पूरी तरह पिस जाती है तथा इसका कोई भाग रोल किए डब्ल्यू.बी.एम. में नहीं समाता, डब्ल्यू.बी.एम. के किसी हिस्से पर इस गिट्टी के ऊपर से रोलर

निकलने पर कोई दबाव का चिन्ह तो नहीं बनता है ?

33 क्या rolled surface का camber, super elevation तथा longitudinal profile चेक कर ली गई है।

34 क्या निर्धारित से ऊंचे अथवा नीचे पाए गए हिस्सों को पूर्ण रूपेण सुधार कर सही तरीके से पुनः रोल कर लिया गया है ?

35 यदि Binding material का उपयोग किया जाना है तो इसे दो या तीन परतों में फेलाते हुए, प्रत्येक परत के ऊपर पर्याप्त पानी डालकर rolling तथा brooming की गई है ?

36 क्या watering, rolling तथा brooming से बनी slurry WBM के छिद्रों में प्रवेश कर गई है ?

37 क्या slurry के छिद्रों में प्रवेश के उपरांत slurry की एक wave रोलर के आगे चलती रही है ?

38 क्या rolling के उपरांत WBM की मोटाई निर्धारित के अनुसार प्राप्त हुई है ?

39 क्या कार्य के दूसरे दिन परीक्षण में कोई छिद्र या छिद्र का समूह पाया गया है ?

40 यदि छिद्र पाए गए हैं तो क्या इन्हें screenings तथा Binding material डालकर पुनः roll कर ठीक किया गया है ?

41 क्या माप पुस्तिका में अंकित किए गए हैं ?

प्राइम कोट

1. क्या प्राइम कोट का कार्य करने के पूर्व WBM कार्य की Line, Grade, Cross-Section, Camber का परीक्षण किया गया है ?
2. क्या क्षतिग्रस्त कार्य की मरम्मत करवा ली गई है ?
3. क्या प्राइम कोट कार्य करने के पूर्व प्रति लाट Emulsion की Viscosity Test कर ली गई है ?
4. क्या प्राइम कोट हेतु Slow Setting Emulsion का उपयोग किया गया है ?
5. क्या प्राइम कोट करने के पूर्व WBM Layer की सफाई तार के ब्रुश से कर, धूल तथा Loose Particle सतह से हटा दिए है ?
6. क्या प्राइमर डालने के पूर्व WBM की सतह को पानी छिड़ककर हल्का गीला कर लिया है ?
7. क्या Emulsion में 25 प्रतिशत या इससे कम पानी मिलाया गया है ?
8. क्या Emulsion Spray करने का कार्य Mechanical Spray से किया

गया है ?

9. क्या प्रति 10 वर्ग मीटर में 9 किलो Emulsion Spray किया गया है ?
10. क्या प्रति 1000 वर्ग में 2 टेस्ट के मान से Emulsion का Rate of Spread टेस्ट किया गया है ?
11. क्या Prime Coat की Curing 24 घंटे की गई है ?
12. क्या माप–पुस्तिका में माप अंकित किए गए है ?

टेक कोट

1. क्या Tack Coat कार्य करने के पूर्व सतह की अच्छी तरह सफाई की गई है ?
2. क्या Tack Coat कार्य करने के पूर्व Emulsion की Viscosity Test करा ली गई है ?
3. क्या Tack Coat हेतु Medium Setting Emulsion उपयोग में लाया गया है ?
4. क्या Emulsion Spray करने का कार्य Mechanical Sprayer से किया गया है ?
5. क्या प्रति 1000 वर्ग मी. में 2 टेस्ट के मान से Emulsion Spray करने का कार्य किया गया है ?
6. क्या Tack Coat करने के तत्काल बाद ही डामरीकरण का कार्य प्रारंभ कर दिया है ?

प्री–मिक्स कारपेट

1. क्या Tack Coat के तत्काल पश्चात् PMC का कार्य किया गया है ?
2. क्या PMC के कार्य में उपयोग लाई जाने वाली गिट्टी की इम्पेक्ट वेल्यू 30% से कम है ?
3. क्या PMC के के कार्य में उपयोग लाई जाने वाली गिट्टी की पानी सोखने की क्षमता 2% से कम है ?
4. क्या Stone Chips 13.2 मि.मी. की मात्रा प्रति 10 वर्ग मी. में 0.18 घन मीटर है ?
5. क्या Stone Chips 11.2 मि.मी. की मात्रा प्रति 10 वर्ग मी. में 0.09 भी है ?
6. क्या Stone Chips की Stripping Value Test किया गया है एवं उसकी Value 15% से कम है ?
7. क्या Stone Chips का Combine Flakiness and Elongation Index

Test किया गया है एवं उसकी Vaule 25% से कम है ?

8. क्या Bitumen के लिए Pentration Test किया गया है ?
9. क्या Bitumen का Ductility Test किया गया है ?
10. क्या Bitumen का Specific Gravity Test किया गया है ?
11. क्या Bitumen का Water Content Test किया गया है ?
12. क्या Bitumen का Flash Point Test किया गया है ?
13. क्या Bitumen का Viscosity Test किया गया है ?
14. क्या Bitumen का Mixing Temp 150°C से 165°C के बीच में है ?
15. क्या गिट्टी एवं विटुमन को गरम करते समय इनका तापमान में 14°C का अंतर रखा गया है ?
16. क्या Bitumen Mix का तापमान डम्पर में भरते समय 130°C से 160°C के मध्य है ?
17. क्या Bitumen की मात्रा प्रति 10 वर्ग मीटर क्षेत्र के लिए 14.60 किलो या इससे अधिक है ?
18. क्या Mix बिछाने के कार्य के समय तापमान 100°C से अधिक है ?
19. क्या Mix को बिछाने का कार्य पेवर से किया गया है ?
20. क्या PMC को बिछाने के बाद loose thickness 27 मि.मी. या इससे अधिक है ?
21. क्या रोलिंग का कार्य 8–10 टन वजनी रोलर से किया गया है ?
22. क्या रोलिंग Curve की मात्रा में Inner edge to Outer edge तथा शेष में Outer Edge to Center तक की गई है।
23. क्या High Spots या Depression वाले हिस्सों को काटकर या भरकर सुधारकर रोलर से दबाया गया है ?
24. क्या रोलर की स्पीड 5 कि.मी. प्रति घंटा से कम रखी गई है ?
25. क्या रोलर से दबाई का कार्य संतोषप्रद है ?
26. क्या PMC बिछाने तत्काल बाद सीलकोट का कार्य कर दिया गया है ?

सीलकोट

1. क्या PMC कार्य के तत्काल बाद Seal Coat कार्य किया गया है ?
2. क्या Stone Chips की Size 2.36 मि.मी. से कम है ?
3. क्या Stone Chips की Size 180 माइक्रॉन से अधिक है ?
4. क्या Seal Coat Mix में Binder की मात्रा प्रति वर्ग मीटर 6.80 किलो या

इससे अधिक है ?

5. क्या गिट्टी एवं विटुमन को गरम करते समय इनके तापमान में 14°C का अंतर रखा गया है ?
6. क्या Seal Coat Mix का Discharge Temperature 130°C से 160°C के बीच है ?
7. क्या Seal Coat mix की Rolling के समय तापमान 100°C से अधिक है ?
8. क्या Seal Coat Mix का कार्य PMC कार्य के तत्काल बाद किया है ?
9. क्या Seal Coat Mix की मोटाई 6 मि.मी. है ?
10. क्या Mix की रोलिंग Curves Portion मे Inner Edgae to Outer Edge तथा शेष भाग में Outer Edge to Center की गई है ?
11. क्या रोलिंग का कार्य भली–भाँति किया गया है ?
12. क्या माप–पुस्तिका में माप दर्ज कर लिए है ?

कलवर्ट

1. क्या पुलियों के स्थल का चयन कर लिया है ?
2. क्या नाले के डिस्चार्ज का आंकलन कर ड्राईंग अनुसार पुलिया का रूपाकन की जांच कर ली है ?
3. क्या पुलियों का ले–आऊट कर दिया है ?
4. क्या पुलियों के लिए लाए गए Hume Pipe के Test Certificate प्राप्त कर लिए है ?
5. क्या Hume Pipe की स्थल पर आने के उपरान्त दृष्टि जांच की गई है ?
6. क्या Hume Pipe में Repair के चिन्ह तो नहीं पाए गए है ?
7. क्या Hume Pipe में Crack तो नहीं है ?
8. क्या नींव Bed के Bed की कंक्रीटिंग के पूर्व OMC पर Hand Rammer से अच्छी तरह कुटाई कर ली गई है ?
9. क्या Hume Pipe के नीचे बनाये गए Bed में न्यूनतम 1/1000 का स्लोप रखा गया है ?
10. क्या गिट्टी की Impact Value 30% से कम है ?
11. क्या गिट्टी का Combine Flakiness and Elongation Index 25% से कम है ?

12. क्या गिट्टी की Grading, Rural Road Sepcification की तालिका 800.1 (40 mm Graded) के अनुसार है ?
13. क्या रेत का Fineness Modules 2.0 से 3.50 के मध्य है ?
14. क्या रेत की Grading, Rural Road Sepcification की तालिका 800. 2 के अनुसार है ?
15. क्या रेत का Silt Content परीक्षण किया गया है ?
16. क्या आर्डिनरी पोर्टलेण्ड सीमेन्ट का उपयोग किया गया है ?
17. क्या सीमेन्ट के लिए Fineness, Setting Time, Soundness एवं Compressive Strength के टेस्ट किए गए है ?
18. क्या कंक्रीट मिक्स के लिए हापर युक्त मिक्स उपयोग में लाया गया है ?
19. क्या रेत, गिट्टी का नाप लोहे के डिब्बे से किया गया है ?
20. क्या क्या वाटर/सीमेन्ट का अनुपात 0.45 रखा गया है ?
21. क्या Formwork इतना मजबूत है कि वह कंक्रीट का भार एवं Vibrator का Impact सहन कर सकें।
22. क्या रेत, गिट्टी, सीमेन्ट तथा पानी का मिश्रण अच्छी तरह से हो गया है ?
23. क्या प्रतिदिन के कार्य के 6 क्यूब बनाये गए है ?
24. क्या 7 दिवस एवं 28 दिवस के क्यूब की Strength निकाली गई है ?
25. क्या कंक्रीट Pin Vibrator से 30 से.मी. की लेयर में Compaction किया गया है ?
26. क्या Hume Pipe के बिछाने के बाद उसके Slope की जांच की गई है ?
27. क्या Hume Pipe के ऊपर 60 से.मी. का Cusion दिया है ?
28. क्या के Hume Pipe के ऊपर, आजू–बाजू एवं Back Filling में Granular Material भरा गया है ?
29. क्या माप–पुस्तिका में माप अंकित किए गए है ?

सीमेन्ट कांक्रीट पेवमेन्ट

1. क्या WBM Layer की Line, Grade, Cross-Section तथा Camber

   की जांच कर ली गई है ?
2. क्या क्षतिग्रस्त WBM कार्य का सुधार कर लिया है ?

3. क्या गिट्टी का Combine Flakiness and Elongation Index 25% से कम है ?
4. क्या गिट्टी की Grading, Rural Road Sepcification की तालिका 800.1 (40 mm Graded) के अनुसार है ?
5. क्या रेत का Fineness Modules 2.0 से 3.50 के मध्य है ?
6. क्या रेत की Grading, Rural Road Sepcification की तालिका 800. 2 के अनुसार है ?
7. क्या रेत का Silt Content परीक्षण किया गया है ?
8. क्या आर्डिनरी पोर्टलेण्ड सीमेन्ट का उपयोग किया गया है ?
9. क्या सीमेन्ट के लिए Fineness, Setting Time, Soundness एवं Compressive Strength के टेस्ट किए गए है ?
10. क्या गिट्टी, रेत, सीमेन्ट के परीक्षणों उपरान्त महाप्रबंधक से अनुमोदन प्राप्त किया गया है ?
11. क्या M-30 का Mix Design कर प्रति घन मीटर कंक्रीट हेतु सीमेन्ट, रेत, गिट्टी एवं पानी की मात्रा की गणना की गई है ?
12. क्या Design Mix महाप्रबंधक से अनुमोदित कराया है ?
13. क्या Pavement के दोनो तरफ Mild Steel Channel या Fabricated Plate की Shuttering उपयोग में लाई गई है ?
14. क्या 4.57 मीटर के अन्तराल Contraction Joint में बनाए गए है ?
15. क्या Contraction Joint की चौड़ाई 10 मि.मी. या इससे कम है ?
16. क्या Contraction Joint की गहराई 5 से 7 से.मी. है ?
17. क्या 32 मीटर के अन्तराल में Expansion Joint दिए है ?
18. क्या Expansion Joint की चौड़ाई 25 मि.मी. है ?
19. क्या Expansion Joint में Filler Board लगाई है ?
20. क्या Expansion Joint में Dowel Bars, Drawings अनुसार लगाए गए है ?
23. Concrete Mixing हेतु Power Driven हापर युक्त मिक्सर का उपयोग किया गया है ?
24. क्या Mix बनाने के लिए सीमेन्ट, रेत, गिट्टी, पानी नापने के लिए Measuring Box का उपयोग किया गया है ?
25. क्या कंक्रीट मिक्स का मिश्रण Homogenious है ?

26. क्या मिक्सर से निकलने के बाद 20 मिनिट के अंदर कंक्रीट मिश्रण को बिछा दिया गया है ?
27. क्या कंक्रीट मिश्रण बिछाने के 30 मिनिट के अंदर इसका काम्पेक्शन कर दिया गया है ?
28. क्या काम्पेक्शन हेतु Screed Vibrator का उपयोग किया गया है ?
29. क्या कंक्रीट पश्चात् ऊपर सतह का परीक्षण किया गया है ?
30. क्या High Spots /Depressions को सुधार दिया है ?
31. क्या कंक्रीट कार्य समाप्त होने के 1 घंटे पश्चात् कंक्रीट सरफेस को Gunny Bages अथवा तिरपाल से ढांक दिया है ?
32. क्या कंक्रीटिंग के दौरान Rural Road Sepcification की तालिका 800.10 के अनुसार सेम्पल लिए गए है ?
33. क्या सेम्पल का परीक्षण किया गया है ?
34. क्या Pavement की Pond Curing, 14 दिवस तक की गई है ?
35. क्या माप–पुस्तिका में माप अंकित किए गए है ?

CHAPTER 27

APPENDIX

APPENDIX A

Cumulative ESAL Applications for 10-year Design Life

ADT	CVPD	Break-up of commercial Vehicles		Cumulative ESAL Applications
		HCV	MCV	
100	25	0	25	19,380
150	35	5	30	60,969
200	50	10	40	96,482
300	75	15	60	1,49,952
400	100	20	80	1,92.961
500	125	25	100	2,57,225
1000	300	60	240	6,63,120

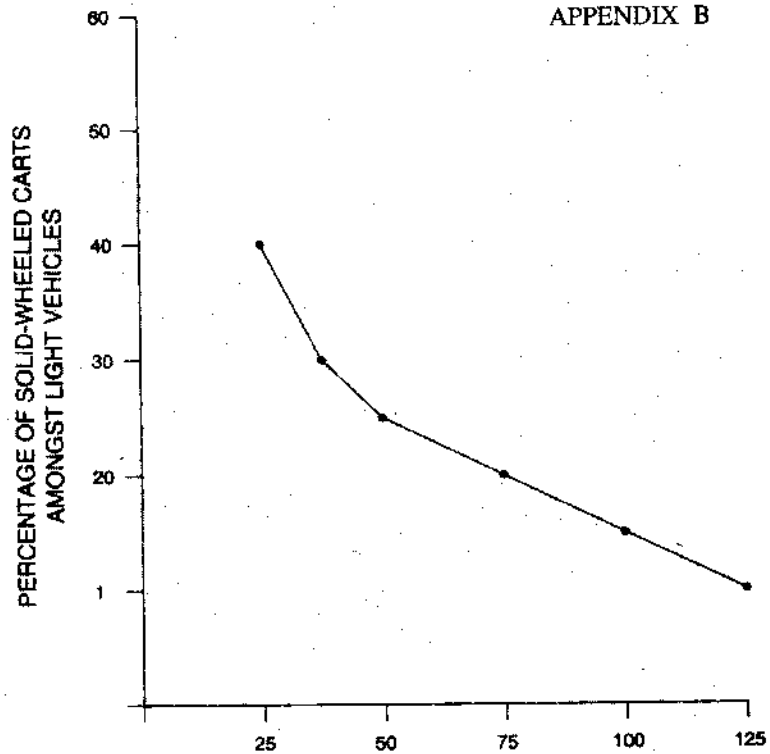
Assumptions

1. A commercial vehicle (CV) is defined as a vehicle of gross laden weight of 3 tonnes or more, For purpose of pavement design, the commercial vehicles comprise of the following categories :

   . Heavy commercial Vehicles (HCV) comprising heavy trucks and full-sized buses.

   . Medium-heavy Commercial Vehicles (MCV) comprising Tractor-trailers/Jugads, Mini buses, Pick-up Vans. Since the extent of loading of commercial vehicle is difficult to determine, the single Axle Loads (Rear Axle) of laden and unladen (including partially loaded) vehicles in the HCV category can be assumed as 10.2 tonnes and 5 tonnes respectively.

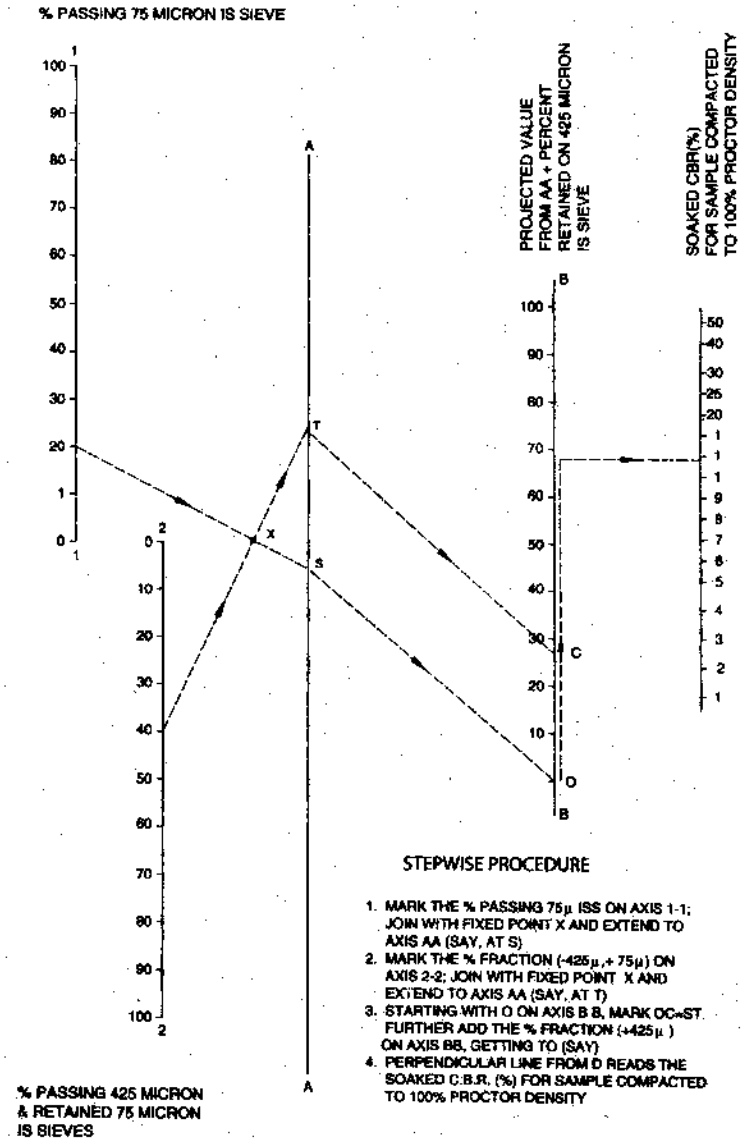
2. For the MCV, the Single Axle Loads (Rear Axle) a laden and unladen (including partially loaded)vehicles can be assumed as 6 tonnes and 3 tonnes respectively. The light vehicles (LV) even when fully laden will have a gross laden weight of less than 3 tonnes and hence need not be considered for pavement design.
3. Amongst the commercial vehicles per day (CVPD), the HCV vary from 0 to 20 % of CVPD while MCV constitute over 80 % of CVPD.
4. Ten(10) percent of CVPD are overloaded to the extent of 20% of the maximum permissible load.
5. for traffic upto ADT=100, it is assumed that no HCV ply on the road i.e. HCV=0.
6. Laden and Unladen Vehicles under each category are equal in number.



CORRECTION FACTOR FOR SWC TRAFFIC

AADT	CORRECTION FACTOR FOR SWC TRAFFIC
100	1.70
150	1.25
200	1.20
300	1.15
400	1.10
500	1.07

APPENDIX C



Nomograph for Computing Soaked CBR Value from Sieve Analysis Data (Ref. 6)

APPENDIX D

QUICK ESTIMATION OF CBR (Ref.18)

Plastic Soil

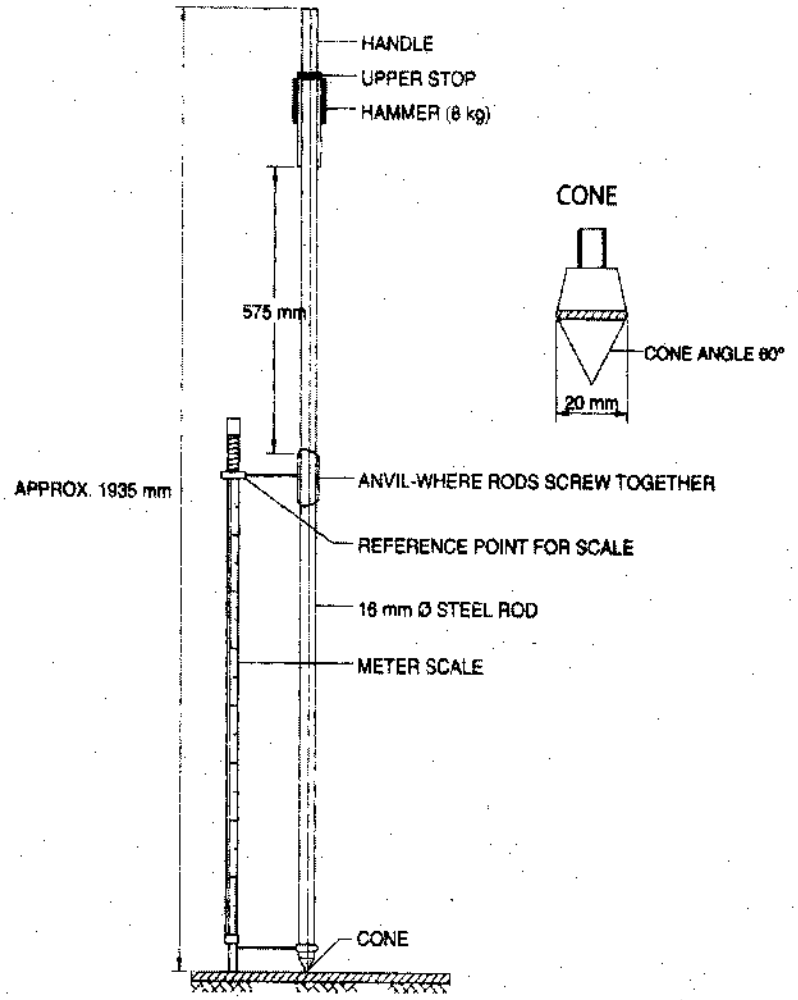
CBR = 75/(1+0.728 WPI), R^2= 0.67

Where WPI = Weighted Plasticity Index = $P_{0.075}$ x PI
$P_{0.075}$ = % Passing of 0.075 mm sieve in decimal
PI = Plasticity Index of the soil, %

Non-Plastic soil

CBR = 28.091 $(D60)^{0.3581}$, R^2 = 0.84

Where D_{60} = Diameter in mm of the grain size corresponding to 60% finer.
Soil Classification can be used for preliminary report prepration.



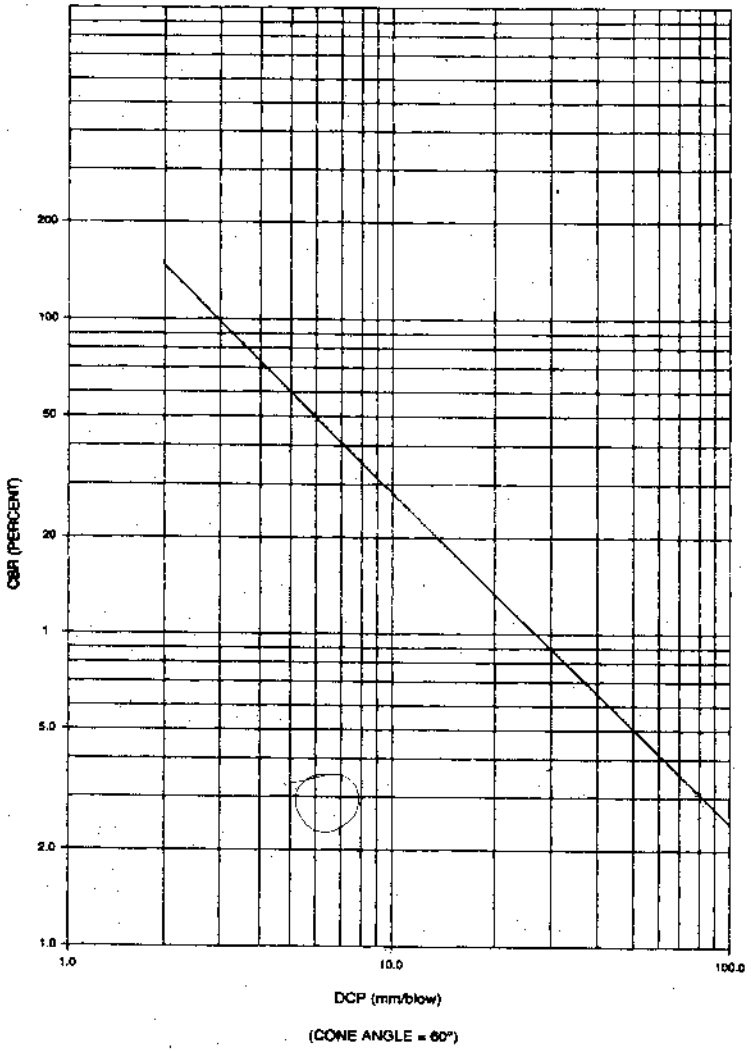
A Typical Dynamic Cone Penetrometer (DCP)

SALIENT FEATURES OF DCP TEST

The Dynamic Cone Penetrometer is a simple device developed in UK for rapid in situ strength evaluation of subgade and other unbound pavement layers. Essentially, a DCP measures the penetration of a standard cone when driven by a standard force, the reported DCP value being in terms of the penetration of the standard cone, in mm per blow of the standard hammer. The figure above shows a typical DCP. The standard steel cone with an angle of 60° has a diameter of 20 mm. The standard 8 kg drop hammer slides over a 16 mm dia steel rod with a fall height of 575 mm.

Basically, the penetration (in mm) per blow is inversely proportional to the strength of the material. Thus, higher the CBR value of a material being tested, lower will be the DCP value in mm/below. Besides the measurement of subgrade strength, the DCP tests can be conducted to determine the boundries between pavement layers with different strengths and their thicknesses. the measurements can be taken upto 1.2 m depth with an extension rod.

While one person holds the DCP instrument in a vertical position, another person carefully drops the weight and the third takes the readings of penetration. the penetration of the cone can be measured on a graduated scale. The readings are taken with each blow of the weight. The field data is reduced in terms of penetration versus corresponding number of blows. The number of blows and depth readings are recorded on the Dynamic Cone Penetrometer Test form. The cone is case-hardened but requires replacing. When used on subgrade materials the cone can be expected to last 30 to 40 tests before replacement.



DCP-CBR Relationship (Ref. 5)

The DCP test is specially useful for bituminous pavement rehabilitation design and is being used extensively in several countries.

ILLUSTRATIVE EXAMPLE

Twenty four hour traffic counts over a period of 3 days taken on a single lane rural road during the peak harvesting season, yielded the following results for the Average Daily Traffic:

Animal-drawn carts(Pneumatic Tyred)	25
Bicycles	457
Full-sized Trucks	9
Agricultural Tractor-trailers and Jugads	55
Cars & Jeeps	15
Motor Cycles	200
Total	761

(Motorized and Non-Motorized Vehicles per day)

There are two harvesting seasons in the area, each having a duration of about 2½ months, the harvesting season traffic remaining at its peak for 15 days. The above traffic count data was collected 2 years before opening the road to traffic.

The depth of the Ground Water Table was found to be about 10 m below Ground Level. The average annual rainfall in the region is of the order of 750 mm. The soil survey results show the subgrade soil type to be CL with a plasticity index of 13. The maximum dry density and optimum moisture content

were found to be 1.68 gm/cc and 12% resepectively. The CBR sample prepared at OMC, and compacted to MDD, yielded a CBR of 5. The locally available materials include river gravel and sand besides an overly plastic moorum with excessive fines. Determine the most appropriate pavement thickness and compostion requiremnets.

Design Calculation

1. Computation of the Design Traffic Parameter

Since the lean-season traffic data is not available, it is assumed that the peak harvesting season traffic is double the traffic during the non-harvesting season. Referring to Fig. 1, n=1, t=75 days. (on page 14 of this book.)

Average Daily Traffic during the non harvesting season = 761/2=380

$$AADT = 380 + \frac{1.2 \times 380 \times 75}{365}$$

$$= 380 + 94 = 474$$

Before opening of the road to traffic, AADT = $474(1.06)^2$=532, assuming an initial growth rate of 6%

from the given traffic count data, the proportions of HCV and MCV out of the ADT of 532 work out as under :

Heavy Commercial Vehicles (HCV)=6

Medium Heavy Commercial Vehicles (MCV)=38

The animal-drawn carts being pneumatic tyred have not been considered for design purposes.

Therefore, commercial Vehicles Per Day (CVPD) to be considered for design purpose=6+38=44. Since the traffic count data does not give the proportion of unladen and laden vehicles, it is assumed that these are equal in number.

Taking the VDF values from para 3.4.4, the ESAL applications per day = 16.35

Cumulative ESAL applications over 10 years @ 6% growth rate.

= 4811 x 16.35

= 78,660

2. Evaluation of Subgrade Strength

Since the GWT is too deep to influence the subgrade moisture, the design moisture may be close to the optimum moisture content. Referring to the Nomograph in Fig. 2, for insitu dry density of 1.68 gm/cc, GWT depth of 10 m, PI of 13 and average annual rainfall of 75 cm, the Equilibrium Moisture Content works out to about 11%. The optimum moisture content of 12% being higher, the CBR value of 5 may be taken for subgrade strength

3. Pavement Thickness and Composition

For cumulative ESAL applications of 78,660, referring to the Traffic category in the range 60,000 to 1,00,000 and the Subgrade category of CBR 5 to 6, in Fig. 4, a 275 mm Gravel Base should be provided. The specifications for a Gravel Road as per Clause 402 of the Specifications for Rural roads should be adopted.

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