RUIDP

GOVT. OF RAJASTHAN

RAJASTHAN URBAN INFRASTRUCTURE DEVELOPMENT PROJECT

HAND BOOK FOR ROAD WORKS

Project Management Unit (PMU) RUIDP

Avs Building, Jawahar Circle , Malviya Nagar, Jaipur- 17

TABLE OF CONTENTS

1 ROAD CLASSIFICATION 1
1.1 Non-urban Roads:: 1
1.2 Urban Roads: Urban roads are classified into the following five categories: 1
2 PLANNING AND DESIGN 2
2.1 Road Network Planning/Traffic Master Plan 2
2.2 Design Criteria and materials 4
2.2.1 Road Work 4
2.2.2 Culverts: - 8
3 CONSTRUCTION 9
3.1 Preliminaries 9
3.1.1 General: 9
3.1.2 Alignment & Bench Mark 10
3.1.3 Materials, Labour and equipment 10
3.1.4 Safety measures 10
3.1.5 Arrangement for traffic during construction 10
3.1.6 Construction programme 10
3.2 Environment Protection 10
3.3 Setting Out 11
3.4 Clearing and Grubbing 11
3.5 Drainage 12
3.6 Earth Work 12
3.6.1 Road way & Drainage Excavation 12
3.6.2 Blasting 12
3.6.3 Pre-splitting technique 13
3.6.4 Preparation of cut formation 13
3.6.5 Excavation for structures 14
3.6.6 Borrow excavation 14
3.6.7 Embankment construction 14
3.6.8 Embankment under special conditions: 15
3.6.9 Surface / Subsurface drains 17
3.7 Sub-bases and Bases (Non-Bituminous) 17
3.7.1 Granular sub-base 17
3.7.2 Water Bound macadam 18
3.7.3 Wet mix macadam: 22
3.8 Bitumen Bound Bases and Surfacing 24
3.8.1 General requirement: 24
3.8.2 Prime Coat 24
3.8.3 Tack-Coat: 24
3.8.4 Bituminous Macadam and Dense Graded Bituminous Macadam 25
3.8.5 Bituminous Concrete and Semi Dense Bituminous Concrete 28
3.8.6 Open-graded premix surfacing 32
3.8.7 Open graded premix surfacing using cationic bitumen emulsion 33
3.8.8 Close graded premix surfacing/mixed seal surfacing: 34
3.8.9 Seal coat – 35
3.9 Concrete Sub-Bases/Bases 36
3.9.1 Dry lean concrete sub-base 36
3.9.2 Concrete base: 38
3.9.3 Joints: 38
3.9.4 Equipment of proportioning and laying 40
3.10 Geo synthetics: 41
3.11 Quality Control for Road Works 42
3.11.1 General guideline for Quality Control for Road Works 42
4 TRAFFIC CONTROL DEVICES 46
4.1 Traffic Signs 46

4.1.1 General 46
4.1.2 Classification of Sign 46
4.1.3 Sizes of Sign 46
4.1.4 Retro-Reflective signs: 47
4.1.5 Shape: 47
4.1.6 Colours : 47
4.1.7 Urban locations: 47
4.1.8 Mandatory/regulatory signs: 47
4.1.9 Cautionary/warning signs: 47
4.1.10 Informatory signs: 48
4.1.11 Guidelines on use of retro-reflective sheetings for road signs 49
4.1.12 Colour Scheme 49
4.2 Road Markings 49
4.2.1 General 49
4.2.2 Types of carriageway marking lines 49
4.2.3 Materials and colours 50
4.3 Centre lines and lane lining: 52
4.4 No overtaking zones: 52
4.5 Road Delineator 53
4.5.1 General 53
4.5.2 Roadway indicators 53
4.5.3 Hazard Markers: 53
4.5.4 Object Markers: 53
4.5.5 Boundary Stones 53
4.6 Traffic Control Lighting Devices 55
4.6.1 Junction 56
4.6.2 Roundabouts 59
5 COMMON TESTS ON MATERIALS AND WORKS 60
5.1 Determination of Moisture Content of Soils (IS: 2720 Pt. II) 60
5.2 Liquid Limit and Plastic Limit (IS: 2720 Pt. V) 60
5.3 Moisture-Density Relationship (IS: 2720, parts VII & VIII) 60
5.4 Laboratory CBR (IS: 2720, part XVI) 60
5.5 Flakiness and Elongation Indices (IS: 2386, part I) 61
5.6 Field CBR (IS:2720, Pt. XXXI) 61
5.7 In-situ Density by Sand Replacement Method (IS: 2720, Pt. XXVIII) 61
5.8 Aggregate Impact Value (IS: 2386, part IV) 61
5.9 Bitumen Penetration Test (IS: 1203) 62
5.10 Marshall Stability Test (ASTN: D 1559) 62
5.11 Stripping Value (IS: 6241) 62
5.12 Tray Test for Control of Rate of Spread of Binder (IRC:SP:11) 62
5.13 Tray Test Rate of Spread of Grit in Surface Dressing (IRC: SP:11) 62
5.14 Binder Content of Paving Mixtures by Centrifuge (IRC:SP:11) 62
5.15 Checking Surface Regularity Using a Straight-Edge (IRC: SP: 11) 63
5.16 Water Sensitivity of Bituminous Mixes (ASTMD 1075-88) 63
5.17 Sand Equivalent Test (IS: 2720, Part XXXVII) 63
5.18 Soundness Test (15:2386, Part-V) 64
5.19 Los Angeles Abrasion Test (IS: 2386, Part-IV) 64
5.20 Swell Test 64
5.21 Water Absorption Test (15:2386, Part III) 65
5.22 Determination of Polished Stone Value (BS: 812, Part 114-1989) 65

GENERAL INFORMATION

1 Road Classification

1.1 Non-urban Roads: Non-urban roads in the country are classified into six categories:

1) Expressways: The function of expressways is to cater for movement of heavy volumes of motor traffic at high speeds. They connect major points of traffic generation and are intended to serve trips of medium and long length between large residential areas, industrial or commercial concentrations and the central business district. They are divided highways with high standards of geometrics and full or partial control of access and provided generally with grade separation at intersections. Parking, loading and unloading of goods and passengers and pedestrian traffic are not permitted on these highways.

2) National Highways: These are main highways running through the length and breadth of the country connection major ports, highways of neighbouring countries, State capitals, large industrial and tourist centres etc.

3) State Highways: These are main arterial routes of a state linking district headquarters and important cities within the state and connecting them with National Highways of the neighbouring states.

4) Major District Roads: These are important roads within a district serving areas of production and markets, and connecting these with each other or with the main highways.

5) Other District Roads: These are roads serving rural areas of production and providing them with outlet to market centres, taluka/tehsil headquarters, block development headquarters or other main roads.

6) Village Roads: These are roads connecting villages or group of villages with each other and to the nearest road of a higher category.

1.2 Urban Roads: Urban roads are classified into the following five categories:

1) Expressways: The function of expressways is the same whether the traverse through urban areas or non-urban areas.

2) Arterial Streets: This system of streets, along with expressways where they exist, serves as the principal network for through traffic flows. Significant intra-urban travel, such as, between central business district and outlying residential areas or between major suburban 'centres takes place on this system. These streets may generally be spaced at less than 1.5 km in highly developed central business areas and at 8 km or more in sparsely developed urban fringes. The arterial streets are generally divided highways with full or partial access. Parking, loading and unloading activities are usually restricted and regulated. Pedestrians are allowed to cross only at intersections.

3) Sub-arterial Streets: These are functionally similar to arterial streets but with somewhat lower level of travel mobility. Their spacing may vary from about 0.5 km in the central business district to 3 - 5 km in the sub-urban fringes.

4) Collector Streets: The function of collector streets is to collect traffic from local streets and feed it to the arterial and sub-arterial streets or vice versa. These may be located in residential neighbourhoods, business areas and industrial areas. Normally, full access is allowed on these streets from abutting properties. There are few parking restrictions except during the peak hours.

5) Local Streets: These are intended primarily to provide access to abutting properly and normally do not carry large volumes of traffic. Majority of trips in urban areas originate from or terminate on these streets. Local streets may be residential, commercial or industrial, depending on the predominant use of the adjoining land. They allow unrestricted parking and pedestrian movements.

Table No. 1.1 Terrain Classification

S.No.	Terrain Classification	Percent cross slope of the country
1	Plain	0-10
2	Rolling	>10-25
3	Mountainous	>25-60
4	Steep	>60

2 Planning and Design

2.1 Road Network Planning/Traffic Master Plan

1) The Road & Bridge works should be properly integrated with the ongoing schemes / sub-project of urban environment improvement project (i.e. Water supply, Sewerage, Drainage etc.) under RUSDIP. The detailed Project report shall be prepared as per the IRC Guidelines.

2) The existing road network system of the city should be taken into account for preparation of traffic master plan for 30years design period i.e. year 2041 and accordingly the proposed improvement scheme shall be planned. The following, activities have to be worked out for preparation of traffic master plan.

- Mid block traffic survey for different roads including parking survey, pedestrian survey
- Traffic survey in junctions including pedestrian movement
- Analysis of traffic survey data
- Fixation of Planning Horizon
- Collection of important features, socio economic data, right of way etc. and Proposed Traffic Plan of the city to avoid traffic congestion in peak hours including safety of traffic, provision of parking, safe movement of Pedestrian & slow moving vehicles etc.
- Any development/expansion plan, tourism etc. shall also be taken into consideration for preparation of traffic master plan
- Projection of proposed traffic

- Improvement schemes i.e. new road, widening of existing road, signaling system, parking facilities, footpath, foot over bridge, Sub-way, ROB, RUB, Bridges etc have to be finalized in line with the traffic master plan.

- Proposed improvement schemes shall be limited to existing right of way or minimum acquisition.

- Preparation of guidelines for passing of utilities considering the minimum damage/ obstruction of road for lying of new utilities & maintenance of utilities.

3) The Socio- Economic structure of the city shall be taken into consideration for future prospects of the city as well as needs for development.

4) Based on Traffic & Socio-Economic analysis, the priority list of improvement scheme shall be prepared to suit the traffic master plan.

5) From the above priority list of improvement. Scheme, the different works shall be phased for .10/20/30 years for smooth traffic flow as well as minimum Environmental hazards.

6) Immediate improvement scheme shall be selected to implement as per their merits and budgetary allocation. The proposed improvement scheme shall be integrated with proposed works under RUSDIP.

7) Based on selection criteria for works under RUSDIP after studying their Feasibility, RUSDIP intends to take up the works of ROB/RUB/high level Bridges as the priority to this sector. In RUSDIP, it is proposed that only very important / priority roads should be considered in accordance to tentative allocation/identified list of works of the town. In general, the construction of road shall be started after completion of works related to sewerage, drainage, water supply etc. for the stretches of the road. As and when roads getting damaged due to sewerage works; road restoration in complete width should be taken under the sewerage packages; whereas, for water supply works the road restoration may be limited to the width of excavation only.

8) Longitudinal Sections and Cross-Sections

- Levels along the final centre line should be taken at all staked stations and at all breaks in the ground.

- Cross-sections should be generally taken at 50 - 100 metre intervals in plain terrain and 50 - 75 metre in rolling terrain depending on the nature of work. Preferred distance for existing roads and built-up situations is 50 m. The interval should be still less in hilly terrain, about 20 m. In addition, cross-sections should be taken at points of beginning and end of spiral transition curves, at the beginning, middle and end of circular curves, and at other critical locations. All cross-sections should be with reference to the final centre line, extend normally up to the right-of-way limit, and show levels at every 2 - 5 metre intervals and all breaks in the profile.

- Centre line profile should normally be continued at least 200 metres beyond the limits of the project. This is intended to ensure proper connecting grades at both ends. With the same objective, profile along all intersecting roads should be measured upto a distance of about 150 metre. Further, at railway level

crossings, the level of the top of the rails, and in the case of subways, the level of the roof should be noted. On existing roads, levels should be taken at all points of intersection in order to help the final fixation of profile.

- While finalizing road, top level of man holes constructed for sewer line and water line should be considered. If it is not possible to flush the road with top of Manholes then raising of level of these manholes should be accounted for in estimation.
- For new roads utility duct along road should be prosed in the city area to pass water, power and other lines
- Proper Plantation on both side of roads should be considered.
- Typical Longitudinal Sections and Cross-Sections appended on Appendix-1

2.2 Design Criteria and materials

2.2.1 Road Work

1) The Specifications for road works are based on the currents Indian Roads Congress Specifications and recommended codes of practice, and ministry of Roads Transport and highways as per IRC specifications.

2) Roads shall be planned for full width of Right of Way (ROW) available. In general, space for utility services / utility corridor may be identified separately in accordance to the future requirements so that the obstruction of road & damage of the pavement shall not be occurred in future. If separate space for utility is not available, a suitable planning for passing of utilities has to be prepared for laying of new utilities & maintenance of utilities.

3) In general, the road pavement is designed for 20 years design period. However, to minimize the initial cost, 10-15 years design period may be adopted for design of road pavement and overlay of BC & DBM for every 5 years shall be recommended for remaining design period. For this case, cost effective study shall be carried out for all cases with proper analysis. In absence of actual traffic growth by suitable method, the annual growth rate of traffic may be adopted as 7.5 percent.

4) The reconnaissance survey of the existing roads should be carried out. All available information of the existing road i.e. year of construction, sub grade CBR, soil characteristics pavement composition and specifications, traffic, pavement performance, overlay history, climatic conditions, location of underground & over ground utilities etc. should also be collected from field visit and line agency i.e. from PWD, PHED, ULB's etc.

5) Land Acquisition plan for approved improvement proposal shall be prepared based on collected revenue map & information.

6) Normally median should not be less than 1.2 m except critical locations and this should usually be unpaved in four or more than four lane carriageway except specific cases due to the width of the right of way limitation.

7) Flexible pavement for new roads should be designed in accordance with IRC: 37-2001. Strengthening requirements either by method provided in IRC: 37- 2001 or the Benkelman Beam Deflection Technique described in IRC: 81-2001.

8) For the purpose of structural design only the number of commercial vehicle of weight of 3 tones or more and their axle loading is considered.

9) Profile correction should be avoided as far as possible. If it is not possible to avoid then it should be taken bare minimum.

10) Effort should be made to have useful cost effective designs. Quality of works is more dependent on adhering to design parameters during construction rather than higher design specification.

11) BC and DBM layers should be bare minimum and it should be designed with the provision of overlay in future. Bitumen of Grade 60/70 or Crumb Rubber Modified (CRM) ~5hall be used for all bituminous work except for mastic asphalt for which 85/25 Grade of Bitumen or CRM shall be used.

12) Rigid pavement should be proposed where carriageway comes in submerges and low lying area. The design shall be done in accordance with IRC Standard No.58.

Table No. 2.1 Design speeds km/h

Road	Class	Plain	Rolling	Mountainous	Steep
1.	NH & SH				
	Ruling	100	80	50	40
	Minimum	80	65	40	30
2.	MDR				
	Ruling	80	65	40	30
	Minimum	65	50	30	20
3.	ODR				
	Ruling	65	50	30	25
	Minimum	50	40	25	20
4.	VR				
	Ruling	50	40	25	25
	Minimum	40	35	20	20

Table No. 2.2 Widths in plain (for National and State Highways)

Item		Plain and Terrain	Rolling	Mountainous and steep terrain	
		Open areas	Built-up areas	Open areas	Built-up areas
1.	Land width (metre)				
	Normal	45	30	24	20
	Range	30-60	30-60		
2.	Building lines (overall width, metres)	80	Distance between building line and road boundary (set-back) should be 3-6 metres		
3.	Control lines (Overall width, metres)	150			
4.	Roadway width (metres)	Single-lane Two-lane	-12.0* -12.0		6.25** 8.80**

Notes:

- For other road categories, see IRC: 73.

- * Reduce to 9 m for SHs having remote possibility of widening to 2-lanes.
- ** Widths are exclusive of parapets (0.6 m) and side drains (0.6 m). In hard rock stretches and unstable locations, the roadway width may be reduced by 0.8 m on two-lane roads and 0.4 m in other cases. However, where such stretches occur in continuous long length on single-lane roads, reduction in roadway width should not be effected unless requisite passing places are provided.
- Passing places where provided should be based on actual needs, generally at the rate of 2-3 per km. These should be 3.75 m wide, 30 m long on the inside edge (i.e., towards the carriageway side) and 20 m long on the farther side.
- On horizontal curves in mountainous and steep terrain, increase roadway equal to extra widening of carriageway.
- For multi-lane highways, the roadway should provide for the requisite number of traffic lanes plus shoulders and median. The shoulder width should in general be 2.5 m. Desirable median width for rural highways is 5 m while the absolute minimum is 1.2 m.

13) The following geometric Standard for roads and culverts shall be adopted:

Table 2.3: geometric Standard

S. No.	**Design Parameters**	**For NH**		**For SH & City road**
		2-Lane road	4-lane road	
1.	Design Speed (kmpH)	80-100	80-100	60-80
2.	Right of Way(m)	30-60	60	20-60
3.	Width of Carriageway (m)	2x3.5	4x3.5	3.5m x no. of lanes
4.	Width of Paved Shoulder(m)	1.5	1.5	As per requirement of' project (Min 1.0)
5.	Width of Unpaved Shoulder(m)	1.0	1.0	1.0
6.	Width of service Road (m)	7.5 to 5.5	7.5 to 5.5	7.5 to 5.5
7.	Median Width (m)	-	4.5 to 1.2	4.5 to 0.6
8.	Minimum width of footpath in meter	1.5	1.5	1.5
9.	Width of roadside parking (m)	No provision		3.0 to 2.5
10.	Width of Bus bay (m)	4.5	4.5	4.5-3.0
11.	Camber (%) of B.T. Surface	2.0-2.5	2.0-2.5	2.0-2.5
12	Sight distance (m) a. Stopping Sight distance b. Intermediate Sight distance c. Safe Stopping Sight distance	 20-180 40-360 250	 20-180 40-360 250	 20-180 40-360 250
13.	Maximum Super elevation (%) $E=V^2/225\ R$	4.0	4.0	4.0
14.	Minimum Radius (m)	Minimum curve length should be 150 meters for 5^o deflection angle and increase or decrease at the rate of 30 m for 1^o		
		Speed Km/ hr	Plain & Rolling Terrain	Hilly & snow bound

S. No.	Design Parameters	For NH		For SH & City road
		35	45	45
		40	60	60
		50	90	90
		65	155	-
		80	230	-
		100	360	-
15.	Minimum turning radius (m) at junction	12	15	10
16.	Length of Transition Curve	Min. Length of Transition Curve > (i) Ls.= $0.0215V^3/CR$ or (ii) Ls.= $2.7V^2/R$ Where V=speed in Km/hr C=80/(75+V) subjected to Max.0.8 and min 0.5		
17.	Extra width (m) Maximum	As per table 12 & clause 10.6 of IRC:86 0.6 -1.5		
18.	Vertical gradient in general (%)	2.5	2.5	2.5
19.	Maximum vertical gradient (%)	3.33	3.33	4.0
20.	Minimum Length of Vertical Curve (m)	60	60	60
21.	Kerb height (m)	0.225	0.225	0.225
22.	Lateral Clearance (m)	0.5-1.0	0.5-1.0	0.5-1.0
23.	Vertical Clearance at under pass Urban Areas (m)	5.5	5.5	5.5

Note: In general, above parameters shall be applicable for new alignment However, the above design standard may be modified suitably considering ground reality / space constraint prior to approval of RUSDIP / concerned department. In case of proposals for cement concrete roads under the slum areas or narrow width lanes, which are not subjected to regular heavy traffic may be kept with 100 mm thick M20 grade concrete finished surface on 100 mm thick M10 grade concrete.

14) Thermo-plastic paints should be used for road marking.

15) Roadside drain should be designed as per IRC Standard. The intensity of rainfall should be taken from the realistic past data. The design calculation for the intensity should be furnished in details along with adopted design procedure.

16) Shifting of utility services should be avoided as far as possible. In case it is not avoidable then effort should be made to minimize the cost by taking minimum required shifting of utilities.

17) Environment & Social impact assessment shall be done to minimize environment & social hazards.

18) Spacing of street light should be designed in accordance to the required width to be illuminate and accordingly capacity of luminaries and height of poles should be decided. Dark patches shall not been seen on the road surface.

19) Use of mechanical Grader for construction of embankment, sub-grade and sub base shall be mandatory. For WMM all the material used shall be crusher broken.

20) Bituminous layers shall be laid by paver finisher. Bitumen of Grade 60/70 or CRM shall be used for all bituminous work.

21) Thermoplastic paint conforming to MORTH specification CL: 803 shall be used.

22) Traffic signs, Bollards, Hazard markers, Raised pavement markers shall conform to relevant IRC specification and provision should be kept in BOQ.

2.2.2 Culverts: -

1) Proper sub soil investigation should be done in advance before preparation of Bid Documents. The investigation for the foundation should be got done and enclosed and clear recommendations of the SBC for the type of foundation proposed should be given. At least one Bore hole should be made at any abutment location. The copy of this report should be enclosed with the tender document. The contractor shall verify the subsoil investigation report at the site before bidding the tender.

2) The levels should generally follow the absolute levels by picking up the reference level from Survey of India Bench Mark or some other established bench mark. The levels should also be checked with base maps being prepared under RUSDIP.

3) In general, the minimum design period for culverts is 50 years.

4) In general, RCC Box (single/multiple cell) with curtain wall of sufficient depth shall be adopted for new/ extension of culverts. Box shall be placed over Bed level. For small drainage, pipe culvert with 900mm (min) diameter NP-4 Pipe shall be provided.

5) The work pertaining to sub structures and superstructures shall conform to guideline given under Clauses 2200 and 2300 respectively of MORTH Specification (Fourth Revision). Requirement of structural concrete shall conform to Clause 1700. Steel Reinforcement (un-tensioned): Only TMT steel reinforcement (un tensioned) conforming to clause 1600 of MORTH specification from original billet manufactures shall be used for all the component of culverts. Materials: Materials for structures shall conform to Clause 1000 of MORTH Specifications (Fourth Revision).

Table No. 2.4 Data to be collected for Culverts

A. NEW CULVERTS

1. **Catchments area:** Marking the watershed on topo sheet and measuring the area, or for smaller catchments finding the watershed by compass survey, or for flat terrain by conducting a local contour survey to demarcate the watershed.
2. **Cross-sections:** Three cross-sections, one at selected site, one at upstream and one at downstream.
3. **Longitudinal section:** Should show bed levels, L.W.L. and H.F.L.
4. **Maximum H.F.L. :** Observation of marks left by flood, local enquiry and comparing with data for any nearby structure.
5. **Velocity observations:** Observed during actual flood.
6. **Trial pits:** Dug upto firm ground. Engineering characteristics of soil and safe bearing capacity at foundation level.

B. EXISTING CULVERTS

1. Type of structure and details of span, vent height-width of roadway, etc.
2. Load carrying capacity.
3. Condition of foundation, sub-structure and super-structure.
4. Signs of silting/scouring, blockage, overtopping, etc.
5. H.F.L., deck level, adequacy of waterway, etc.

3 Construction

3.1 Preliminaries

3.1.1 General:

1) Study in depth the contract drawings, contract conditions and special conditions, specifications, special provisions, the technical note issued by the sanctioning authority, the estimate of quantities, etc. to have a clear understanding of the scope and extent of the project.

2) Check whether the project involves permission or approval of other departments/agencies, e.g., approval for cutting of trees or relocation of utility services, etc.*

- Location of trees, if required to be planted and other landscaping features may also be decided and got approved from the competent authority. Take action to get all these done even prior to award of contract.
- Look into the stipulated contract time for completion vis-à-vis the working seasons and calendar months to ensure that the tasks are completed according to the specified programme. For this purpose, modern project management techniques should be used.

Keep at site:

- Survey and investigation report including material test results.
- Bill of quantities.
- Site order book; Work diaries
- Quality control record book;
- A set of working drawings mounted on cloth and
- Up-to-date construction programme

3.1.2 Alignment & Bench Mark

Have a check on final centre line of stakes, pillars or hubs and replace the missing one. Check the bench mark for levels, and tally these with those given on the drawing

3.1.3 Materials, Labour and equipment

1) List out the materials and their quantities which will be provided by the Department. Similarly, do the exercise for equipment. Take action to procure these for supply in time.

2) Ascertain from the contractor the sources from where he will bring the material for the project, number of labour to be employed and facilities for housing, sanitation, transport, fuel wood and first aid to be provided for them. Details of site laboratory should also be obtained.

3) Ensure that necessary repair facilities, spares, stores and POL are available at site.

3.1.4 Safety measures

Ascertain from the contractor, the measures he proposes to take for safety of workmen including purchase of insurance policies, and ensure that these satisfy the rules and regulations in force. "Guidelines on safety in Road Construction Zones" (IRC: SP: 55) may be referred for further details.

3.1.5 Arrangement for traffic during construction

Proper arrangement for traffic during construction over part width of roadway is to be as per site condition. The temporary diversion may be adopted / constructed where the duration of work is expected to be long and traffic is heavy

3.1.6 Construction programme

Review construction programme given in the project report and see whether it is possible to adhere to this in the light of availability of resources and related factors. If not, prepare a revised programme to reflect the actual situation and revised cost, where necessary' and submit to higher authorities with justification, for approval. The programme should be based on critical Path Method (see IRC: SP-l4 for details) for major works and in the form of bar charts for other cases.

3.2 Environment Protection

All precautions should be taken for safeguarding the environment during the course of construction. The following points need special attention:

1) Borrow pits should not be dug in the right-to-way of the road.

2) During construction, soil erosion should be fully controlled and sedimentation and pollution of natural water courses, ponds, tanks and reservoirs should be avoided.

3) Bituminous hot mix plant and concrete batching plants should be located away from habitation and industrial establishments. All precautions shall be taken to minimise the levels of noise, vibration, dust and emissions from these plants.

4) No material shall be used or generated, during construction, which is hazardous to the health of human beings, animals or vegetation.

5) Nuclear gauges shall be used only after ensuring their safe use in accordance with the regulations in force.

6) All reasonable steps shall be taken to minimise dust nuisance during the construction.

7) All existing highways and roads used by vehicles supplying material or plant should be kept clean and clear of dust, mud or other extraneous materials.

3.3 Setting Out

1) All construction should be with reference to the final centre line of the main location survey.

2) The centre line should be accurately referenced every 50 m interval in plain and rolling terrains, 20 m intervals in hilly terrains and at all curve points, by marker pegs and chainage boards set in or near the fence line. The schedule of reference dimensions should be prepared and marker pegs shall be maintained till the end of the work.

3) Working bench marks tied with the reference bench mark should be established at the rate of four numbers per km and also at or near all drainage structures, other bridge and underpasses. An up to-date record of all bench marks should be maintained and the working bench marks should be checked frequently.

4) On construction reaching the formation level stage, the centre line should again be set out and accurately referenced by marker pegs at the outer limits of the formation posts of timber or steel should be kept one meter from the formation edges showing the finished formation/finished base course/finished road levels. It should be possible to stretch a thread across to verify the finished levels of various courses.

5) All survey monuments, bench marks, beacons, etc. should be maintained accurately during the construction process. A survey file containing the setting out data for traverse points and levels shall be prepared and maintained during the construction process.

6) Precision automatic levels, having a standard deviation or + 2 mm per km and fitted with micrometer attachment shall be used for all double run levelling work. Setting out of the road alignment and measurement of angles shall be done by using theodolite with traversing target, having a accuracy of one second. Measurement of distances shall be done preferably using precision instruments, like, distomat.

3.4 Clearing and Grubbing

1) Demarcate the limits of clearing and grubbing as shown on the drawings.

2) Mark the roadside trees, shrubs, buildings, utility lines, etc. which are not to be disturbed and ensure that the contractor provides suitable safeguards to protect these from injury or damage.

3) Before start of work, examine the contractor's work plan including the procedures to be followed for disposal of waste materials and the precautions proposed against soil erosion, air pollution and water pollution.

4) All trees, stumps, etc. falling within excavation and fill lines should be cut to such depth below ground level that in no case these fall within 500 mm of the sub grade. Also, all vegetation (roots, undergrowth grass, etc.) and other deleterious matters should be removed between fill lines.

5) From embankment/cut areas, remove and store top soil for reapplication later.

6) Have the removed materials of value suitably stacked for reuse or auctioning.

7) Burning should not be permitted in wooden areas.

8) Periodically observe the operations to ensure that damage to adjacent property is being prevented and tree, utilities and structure are being preserved.

3.5 Drainage

The site engineer should have a clear understanding that performance of a road is closely related to drainage, both surface and subsurface. The sources of water involved may be the surface runoff, seepage flow through subterranean channels, ground water movement and moisture transfer within the soil masses, etc. and surplus water should be removed away from the roadway area quickly and effectively.

3.6 Earth Work

Ensure that the specified cross fall for both pavement and shoulder is provided right from sub grade level and maintained during the earth work and ensure that sub grade is sufficiently above the HFL/ ground water table or the natural ground level and should have minimum height o.6 m.

3.6.1 Road way & Drainage Excavation

1) The area for the roadway & drainage excavation should be cleared and grabbed. Set out the limit of excavation to the line & levels. Providing of control pegs for alignments fixation and embankment construction are to be done as per relevant clause of Ministry’s specification.

2) During excavation different grades of materials may be met, best material should be reserve for use in the top 0.5 m height of the embankment.

3) Excavated material which is useable in pavement construction should be stacked, proper measurements and recorded in proper manner.

3.6.2 Blasting

Points needing specific attention are:

1) Blasting operation should be carried out in presence of a competent and experienced supervisor.

2) Blasting should be carried out in fixed hours which have been made known to people in the vicinity.

3) Red flags should be prominently displayed in all directions.

4) If blasting is within 50 m of any railway track, concerned Railway Authority should be notified of the blasting schedule, well in advance.

5) The magazine for the storage of explosives should be located at approved site and built to the specifications of the explosive department. The magazine should have an effective lightening conductor. All necessary precautions as required by explosive Act should be taken.

6) The type of explosives and the plan of drilling and firing should be carefully examined for suitability.

7) The over-burden should be removed and measurements taken before blasting operation is started.

8) Specified procedures should be strictly followed in case of misfire.

9) Maintenance of day-to-day account of explosives.

3.6.3 Pre-splitting technique

1) This blasting technique is defined as the establishment of a specified excavation slope in rock by controlled use of explosives and blasting in properly aligned and spaced drill holes- This technique is recommended for harder rock types.

2) This consists of drilling a series of closely spaced parallel holes (not exceeding 900 mm centre-to-centre) that reasonably conforms to the desired outlines and grade. Production holes should be drilled at least 2.5 m away from the pre-split plane. The pre-split holes are charged and fired prior to the production holes. This provides for a pre-shared face for the primary blast.

3) All over-burden soil and weathered rock along the top of the excavation, for a distance of 5 m to 15 m beyond the drilling line, should be removed before drilling the pre-splitting holes.

4) Normally, this technique should first be applied to short test section to see whether the method has produced acceptable slope without undue shatter.

5) Any blasting technique which results in damage to the pre split surface should be discontinued.

3.6.4 Preparation of cut formation

1) Cut formation requires very close inspection for the reason that it is for the first time that the material gets exposed.

2) Check for suitability of the natural material. Some shales may look hard- when dry but get slushy in presence of water. If such unsuitable materials are met with, have these removed to a depth of at least 0.5 m or as otherwise specified and replaced with suitable material.

3) If density of sub-grade is lower than 97 per cent of the laboratory density determined as per IS: 2720 (Part VIII), it shall be loosened to a depth of 500 mm, watered and re

compacted in 250 mm thick loose layers to a density not less than 97 per cent of the maximum laboratory dry density.

4) In rock formation all dish shaped cavities left out by blasting should be cut out at edges to facilitate drainage. Low areas should be filled up with sub-base material and properly compacted.

5) Any seepage should be intercepted and properly drained.

3.6.5 Excavation for structures

The points which require specific attention are :

1) Setting out true to specified lines and levels.

2) Strength and safety of all temporary shoring, bracing and other earth supporting devices.

3) Normally, open foundation should be laid dry. Dewatering by boiling, pumping, diversion channels and other necessary work should be carried out when seepage flow is met with.

4) The discharged water should not cause damage to the works, crops or property.

5) Detailed examination of the stratum at the foundation level to see whether the soil fits in with the design assumptions, or the material is unsuitable to be left in place.

3.6.6 Borrow excavation

3.6.6.1 General Guideline for Borrow excavation

1) When earth available from the excavation for the roadway formation and drainage excavation falls short of the requirement of embankment construction in the remaining reaches, this should be obtained from approved area(s) outside the land width identified for the purpose.

2) Check for the location, size and depth of borrow pits, where payment is on the basis of borrow measurements, have cross-sections, taken of the area and leave deadmen or cross ridges.

3) The volume of borrow excavation and of compacted embankment will be different if there is variation in the respective dry densities. For example, if the in-situ DBD of borrow soil is 1.6 gm/cc, and that of embankment 1.8 gm/cc, the quantity of borrow excavation will be larger by 1.8/1.6 times.

4) On completion of all measurements for payment, have the borrow pits opened out partly at either ends to facilitate easy drainage.

3.6.7 Embankment construction

3.6.7.1 General Guideline for Embankment construction

1) The stability of an embankment depends upon the foundation, the use of suitable materials, proper placing and compacting of the materials and strict adherence to quality control measures. The suitability of embankment material is shown in Table 3.1. Table 3.2 indicates the compaction requirements.

2) After cleaning and grubbing, the sub grade level should be compacted at least 97 % Proctor Density of determined laboratory Proctor Density as per IS-2720 (Part VIII).

3) Clods or hard lumps of earth should be broke down and embankment and sub grade material should be spread in layer of uniform thickness not exceeding 200 mm compacted thickness over entire width

Table 3.1. Suitability of embankment materials

S. No.	Type of Work	Maximum laboratory dry unit weight when tested as per IS: 2720 (Part VIII)
1.	Embankment upto 3 mts. height, not subjected to extensive flooding	Not less than 15.2 kN/cu.m
2.	Embankment exceeding 3 mts. height or embankment of any height subject to long periods of inundations	Not less than 17.5 kN/cu.m
3.	Sub grade and earthen shoulders /verges /backfill	Not less than 17.5 kN/cu.m

Table 3.2. Compaction requirement for embankment and sub grade

S. No.	Type of Work	Relative compaction as percentage of maximum laboratory dry density as per IS:2720 (Part VIII)
1.	Sub grade and earthen shoulders	Not less than 97
2.	Embankment	Not less than 95
3.	Expansive Clays	
a)	Sub grade and 500 mm portion just below the sub grade	Not allowed
b)	Remaining portion of embankment	Not less than 90

Note:

1. Ordinarily, the materials satisfying density requirements, given above should be employed for construction of embankment and sub grade. The density requirements are not applicable to light weight materials, e.g., cinder, fly ash, etc.
2. The material to be used in sub grade should also satisfy design CBR values. It should preferably have a CBR more than 5 per cent. Material with CBR less than 5 per cent shall not be used in sub-grade.

3.6.8 Embankment under special conditions:

Widening existing embankment or construction against sloping ground

1) End dumping of materials from trucks on widened portions should be avoided as far as possible.

2) If existing side slopes are steeper than 4: 1, cut horizontal benches 0.3 m wide to ensure bond. If the slopes are 4:1 or flatter, the surface may be roughened by ploughing or scarifying.

3) For wet conditions benches with slightly inward fall and sub-soil drains at the lowest point shall be provided before the fill is placed against slopping ground.

3.6.8.1 **Earthwork over existing road surface:**

If within 1m of the new sub grade level, scarify to a depth of 50 mm or more if specified, if the road surface is BT, and completely removed, if of cement concrete. If the level difference is more than one m, allow the existing road surface to stay.

3.6.8.2 **Embankment around structures:**

1) Suspend filling around structures upto a distance of twice the height of the embankment. Permit filling only after the concrete/masonry has been in position for at least 14 days. Bring up the embankment in equal horizontal layers simultaneously on each side to avoid undue thrust and unequal pressure.

2) The material used for backfill should not be an organic soil or highly plastic clay, plasticity index and liquid limit should not be greater than 20 and 40 respectively.

3.6.8.3 **Embankment construction under water:**

Only acceptable granular material or rock should be used for filing-under water. The material should consist of graded hard durable particles of size not exceeding 75 mm. This material should be non-plastic having uniformity co-efficient of not less than 10.

3.6.8.4 **Earthwork high embankment:**

1) Earthwork for high embankment should be carried out by stage construction of fills at controlled rates of filling. The embankment should be surcharged for the specified period.

2) At the stage of formation level, surcharge where used material should be removed. High embankment should remain in place for the required settlement period before excavating footings for structures, like, abutment wing wall, etc.

3.6.8.5 **General Guideline for Construction of rock fill embankment:**

1) In normal circumstances embankment should not be constructed with rock fill aterial. Rock fill should not be used at least for a depth of 500 mm below the formation level. This should be made up of earthen cushion.

2) The rock fill should be hard durable and inert material capable of being deposited in layers.

3) Argillaceous rocks (clay, shale's, etc.), un burnt colliery stock, and chalk should not be used in rock fill.

4) The material for rock fill should not exceed 300 mm in size and percentage finer than 125 mm should not exceed 10.

5) The material shall be spread and levelled in layers. Each layer should be compacted by five passes of vibratory roller (8-10 tonnes). : The compacted thickness of each layer should not exceed 500 mm. Before laying the next layer, the surface voids

should be filled with broken fragments. The top layer of rock fill should be thoroughly blinded with suitable granular material to seal its surface.

3.6.9 Surface / Subsurface drains

Surface or Subsurface drains provided to drain out seepage water from pavement courses or capillary action rise water due to high water table. Grading of materials used as per table 3.3 and 3.4

Table 3. 3. Grading Requirement for filter material for Sub surface Drain

S.No.	Sieve Designation	Per cent passing by weight		
		Class I	Class II	Class III
1.	53 mm	-	-	100
2.	45 mm	-	-	97-100
3.	26.5 mm	-	100	-
4.	22.4 mm	-	95-100	58-100
5.	11.2 mm	100	48-100	20-60
6.	5.6 mm	92-100	28-54	4-32
7.	2.8 mm	83-100	20-35	0-10
8.	1.4 mm	59-96	-	0-5
9.	710 micron	35-80	6-18	-
10.	355 micron	14-40	2-9	-
11.	180 micron	3-15	-	-
12.	90 micron	0-5	0-4	0-3

Table 3. 4.Grading Requirement for Aggregate Drains

S.No.	Sieve Designation	Per cent passing by weight	
		Type A	Type B
1.	63 mm	-	100
2.	37.5 mm	100	85-100
3.	19 mm	-	0-20
4.	9.5 mm	45-100	0-5
5.	3.35 mm	25-80	-
6.	600 micron	8-45	-
7.	150 micron	0-10	-
8.	75 micron	0-5	-

3.7 Sub-bases and Bases (Non-Bituminous)

3.7.1 Granular sub-base

The material for granular sub- base should generally conform to the grading indicated in Tables 3.5 and 3.4 or combination thereof.

Table 3. 5. Grading for coarse-graded granular sub-base materials

IS sieve designation	Percent by weight passing the IS sieve		
	Grading I	Grading II	Grading III
75.0 mm	100	—	—
53.0 mm	80- 100	100	—
26.5 mm	55-90	70-100	100
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80

IS sieve designation	Percent by weight passing the IS sieve		
	Grading I	**Grading II**	**Grading III**
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	15-25	20-35
0.075 mm	3- 10	3-10	3-10
CBR Value (Minimum)	30	25	20

Table 3.6. Grading for coarse-graded granular sub-base materials

IS sieve designation	Percent by weight passing the IS sieve		
	Grading I	**Grading II**	**Grading III**
75.0 mm	100	—	—
53.0 mm	—	100	—
26.5 mm	55-75	50-80	100
9.50 mm	—	—	—
4.75 mm	10-30	15-35	25-45
2.36 mm	—	—	—
0.425 mm	—	—	—
0.075 mm	<10	<10	<10
CBR Value (Minimum)	30	25	20

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

3.7.2 Water Bound macadam

Material for water bound macadam should conform to relevant clause of Ministry's Specification aggregate required have been summarised in Table no. 3.7, 3.8, 3.9 and 3.10.

Table 3.7 Physical requirements of coarse aggregates for water bound macadam for sub base course

Test	Test Method	Requirement
1. *Los Angeles Abrasion Value or *Aggregate Impact Value	IS: 2386 (Part IV) IS: 2386 (Part IV) or IS: 5640**	40 per cent (Max) 30 per cent (Max)
2. Combined Flakiness and Elongation Indices (Total) ***	IS: 2386 (Part I)	30 per cent (Max)

* Aggregate may satisfy requirements of either of the two tests

** Aggregates like, brick metal, kankar, laterite etc. which get softened in presence of water shall be tested for impacts value under wet condition in accordance IS:5640.

*** The requirement of flakiness index and elongation index shall be enforced only in the case of crushed broken stone and crushed slag.

Table 3.8. Grading requirements of coarse aggregates

Grading No.	Size Range	IS sieve designation	Percent by weight passing
1.	90 mm to 45 mm	125 mm	100
		90 mm	90-100
		63 mm	25-60
		45 mm	0-15
		22.4 mm	0-5
2.	63 mm to 45 mrn	90 mm	100
		63 mm	90-100
		53 mm	25-75
		45 mm	0-15
		22.4 mm	0-5
3.	53 mm to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

Note : The compacted thickness for a layer with Grading 1 shall be 100 mm while for layer with other Grading, i.e., 2 and 3, it shall be 75 mm.

Table 3.9. Grading for screenings

Grading Classification	Size of screenings	IS sieve designation	Percent by weight passing the IS sieve
1.	13.2 mm	13.2 mm	100
		11.2 mm	95- 100
		5.6 mm	15-35
		180 micron	0-10
2.	11.2 mm	11.2 mm	100
		5.6 mm	90- 100
		180 micron	15-35

Table 3.10 Approximate quantities of coarse aggregates and screenings required for 100/ 75 mm compacted thickness of Water Bound Macadam (WBM) Sub base/ base course for 10m^2 areas.

Classification	Size Range	Compacted thickness	Loose Qty.	Screenings			
				Stone Screening		Crushable type such as Moorum or gravel	
				Grading Classification & size	For WBM sub-base/ base course (Loose Quantity)	Grading classification & size	Loose qty
Grading 1	90 mm to 45 mm	100 mm	1.21 to 1.43 m^3	Type A 13.2 mm	0.27 to 0.30 m^3	Not uniform	0.30 to 0.32 m^3
Grading 2	63 mm to 45 mm	75 mm	0.91 to 1.07 m3	Type A 13.2 mm	0.12 to 0.15 m3	--do--	0.22 to 0.24 m^3
--do--	--do--	--do--	--do--	Type B 11.2 mm	0.20 to 0.22 m^3	--do--	--do--
Grading 3	53 mm to 22.4 mm	75 mm	--do--	--do--	0.18 to 0.21 m^3	--do--	--do--

3.7.2.1 **General guideline and Procedure for Water Bound macadam:**

1) Thickness of a compacted layer should be 100 mm for 90-45 mm, size aggregates and 75 mm for 63-45 mm or 53-22.4 mm size aggregates.

2) Screenings should generally be of the same material as coarse aggregate. However, if the use of screenings is not feasible, some other non-plastic material, such as, moorum or gravel (other than rounded river borne material) having liquid limit and plasticity index below 20 and 6 respectively may be used provided fraction passing 75 micron sieve does not exceed 10 per cent.

3) Binding maternal need not be used if the layer is to serve as base (or is to receive black topping), or where crushable type of screenings, like, moorum is used.

4) It is a good practice to lay a sub-base of granular/stabilised material before laying WBM. This is particularly important where the sub grade is of clayey type.

5) Where the WBM is to be laid directly over sub grade, a 25 mm thick layer of stone screenings (Grading B) - "inverted choke" - should be spread on the prepared sub grade before the application of aggregate is taken up. In case of fine sand or silty or clayey sub grade it is advisable to lay 100 mm thick insulating layer of screening or coarse sand on the top of fine grained soil. A preferred alternative to inverted choke is the use of appropriate geosynthetics mesh.

6) Arrangements for water, rollers in working order and templates/ other tools and equipment for checking the quality of the materials and work must be available at site before the work of laying is started.

7) The quantities of coarse aggregates and screenings will vary, depending on the actual grading.

8) Arrangements for lateral confinement of aggregates must be provided. This can conveniently be done by raising the shoulders in stages equal in thickness to each layer of WBM.

9) The coarse aggregate should be spread uniformly and evenly on the prepared sub-grade /sub-base by using templates placed across the road about 6 m apart. The thickness of each compacted layer should not be more than 100 mm in grading 1 and 75 mm for grading 2 and 3. Wherever possible, mechanical devices should be used to spread the aggregates uniformly so as to minimise the need for manual rectification afterwards.

10) The spreading should be done from stockpiles or directly from vehicles. No segregation of large or fine aggregates should be allowed.

11) The surface should be checked frequently while spreading and rolling so as to ensure the specified regularity of slopes and camber.

12) The coarse aggregate should not normally be spread more than three days in advance of the subsequent construction operations. Three wheeled power rollers at 80 to 100 kN or tandem or vibratory rollers at 80 to 100 kN static weight should be used for rolling. Except on supper elevated portions, where the rolling should proceed from inner edge to outer edge, rolling should begin from the edge gradually progressing towards centre. Successive passes should uniformly overlap the proceeding by at least one half widths.

13) In case screening are to be applied, rolling should be discontinued when the aggregate are partially compacted with sufficient void space to permit application of screening. During rolling slight sprinkling of water may be allowed. Complete rolling is indicated by a loose stone piece getting crushed under the roller without sinking.

14) After the coarse aggregate has been rolled, screening to completely fill the interstices should be applied gradually over the surface. Screening should not be damp or wet at the time of application. These should not be dumped in piles but applied at a uniform rate, in three or more applications, so as ensure filling of all voids. Dry rolling should be done while the screenings are being spread so that vibrations of the roller cause screenings to settle into the voids of coarse aggregate. Dry rolling should accompanied by brooming. These operations should continue until no more screenings can be forced into the voids of coarse aggregate.

15) Spreading, rolling and brooming of screens shall be carried out in only such lengths which are likely to be completed within one day's operation.

16) After screenings have been applied, the surface should be copiously sprinkled with water, swept with hand brooms and rolled. This operation should be continued with additional screenings, applied as necessary, until the coarse aggregates has been thoroughly keyed, well broomed, firmly set in its full depth and a grout has been formed of screenings.

17) The base or sub grade should not get damaged due to use of excessive quantities of water. In case lime treated soil sub-base, construction of water bound macadam should be taken up only after sub-base has picked up enough strength.

18) Apply binding material, wherever required, in a similar fashion as screening. Continue rolling till full compaction is achieved.

19) After the final compaction of WBM course, the pavement should be allowed to dry overnight. Next morning hungry spots should be filled with screenings or binding material, lightly sprinkled with water, if necessary and rolled.

20) No traffic should be allowed on the road until the macadam has set. The compacted WBM Course should be allowed completely dry and set before the next pavement course is laid over.

21) WBM work should not be carried out when the atmospheric temperature is less than 0^0 C in the shade.

22) Apply binding material, wherever required, in a similar fashion as screening. Continue rolling till full compaction is achieved.

23) After the final compaction of WBM course, the pavement should be allowed to dry overnight. Next morning hungry spots should be filled with screenings or binding material, lightly sprinkled with water, if necessary and rolled.

24) No traffic should be allowed on the road until the macadam has set. The compacted WBM Course should be allowed completely dry and set before the next pavement course is laid over.

25) WBM work should not be carried out when the atmospheric temperature is less than 0^0C in the shade.

26) After application of cut-back, the surface should be allowed to cure for at least 24 hours.

3.7.3 Wet mix macadam:

Wet mix macadam construction is an improvement over the conventional water bound macadam providing speedy and more durable construction. It differs from the water bound macadam in that graded aggregates (conforming to requirements indicated in Table 3.11) and granular materials are mixed with predetermined quantity of water in accordance with the specifications to form dense mass which is spread and wiled to approved lines, grades and cross-section to serve as pavement course(s).

Table 3.11. Physical requirements of coarse aggregates for wet mix macadam for sub-base/base courses

S.No.	**Test**	**Test Method**	**Requirements**
1.	* Los Angeles Abrasion Value	IS:2386 (part IV)	40 per cent (Max)
2.	* Aggregate Impact Value	IS:2386 (part IV) or IS:5640	30 per cent (Max)
3.	Combined Flakiness and Elongation Indices (Total)	IS:2386 (part I)	30 per cent (Max)

* Aggregate may satisfy requirements of either of the two tests

The specified grading for the aggregates as per Table 3.12 and granular materials should be used for mixing. Quantity of water should not vary from OMC determined as per IS: 2720 (Pt. VIII), by more than agreed limit.

Table 3.12. Grading requirements to aggregates for wet mix macadam

S.No.	**IS sieve designation**	**Per cent by weight passing the IS sieve**
1.	53 mm	100

S.No.	IS sieve designation	Per cent by weight passing the IS sieve
2.	45 mm	95 - 100
3.	26.5 mm	-
4.	22.4 mm	60 - 80
5.	11.2 mm	40 - 60
6.	4.75 mm	25 - 40
7.	2.36 mm	15 - 30
8.	600 micron	8 - 22
9.	75 micron	0 - 8

3.7.3.1 **General guideline and Procedure for Wet mix macadam**

1) P.I. value of Materials finer than the 425 micron sieve should be less than 6.

2) The mix should be prepared in approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement, like, pug mill or pan type mixes of concrete batch/plant

3) The mixed material should be uniformly wet and no segregation should be permitted.

4) The mix should be spread uniformly and evenly in required quantities on the prepared sub grade/sub-base either by a ~elf-propelled paver finisher or a motor grader fitted with blades having hydraulic control suitable for initial adjustment and maintaining the same. In no case should the mix be dumped in heaps on the area.

5) The thickness of single compacted wet mix macadam layer should not be less than 75 mm nor more than 100 mm. However, the compacted thickness of single layer of the sub-base may be increased up to 200 mm provided vibratory roller of approved type is used for compaction. The roller speed should not exceed 5 Km / hour.

6) Rolling should continue till density achieved is at least 98 per cent maximum dry density as per IS: 2720 (Part VIII).

7) When surface irregularity of wet mix macadam exceeds permissible tolerance or where the course is otherwise defective (like, sub grade soil getting mixed with the aggregates), the full thickness of the layer should be scarified over the affected area, reshaped with added premixed material as applicable and re-compacted. The area treated in this manner should not be less than 5 m long and 2 m wide.

8) It is not advisable to lay the wet mix macadam during rains and the tempo of work suffers during rains.

9) After construction of the top WMM layer will need immediate sealing with bituminous surfacing.

10) Provision of adequate drainage for the foundation area for the construction courses assumes greater importance in this method of construction.

3.8 Bitumen Bound Bases and Surfacing

3.8.1 General requirement: General requirement on materials, mixing, transporting, laying, compaction, joints and construction of bituminous pavement layers are laid down in Clause 501 of his Ministry's Specifications.

3.8.2 Prime Coat

3.8.2.1 **General guideline for Prime Coat**

1) Prime coat consists of application a single coat of low viscosity liquid bituminous material to a pours granular surface preparatory to the superimposition of bituminous treatment or mix. The choice of printer shall depend upon the porosity of the surface to be printed. Details are available in Clauses 501.2 of this Ministry's Specifications.

2) Bituminous Printer should not be applied on a wet or dusty surface. At the time of application temperature in the shade should not be less than 100C.

3) The primer distributor should be self propelled or towed bitumen pressure sprayer capable of spaying the material uniform ally at the specified rate and temperature. Hand spraying should be resorted to only in small areas and areas inaccessible to the pressure sprayer.

4) After application of cut back, the surface should be allowed to cure for at least 24 hours.

5) The quantity viscosity and temperature of lying should be as specified in table 3.13

Table 3.13. Viscosity requirement and quantity of bituminous primer

Type of surface	Kinematic Viscosity of Primer at 60^0C (Centistokes)	Quantity per 10sq.m (kg)
Low porosity	30-60	6 to 9
Medium porosity	70-140	9 to 12
High porosity	250-500	12 to 15

3.8.3 Tack-Coat:

3.8.3.1 **General guideline for Tack-Coat**

1) The binder for tack coat should be a bituminous emulsion complying with IS: 8887 or cut-back as per IS: 217, to be used restrictively for site at sub-zero temperature or for emergency application.

2) The quantity of binder should be as per Table 3.14.

3) The binder should be applied uniformly with bitumen pressure sprayer capable of spraying bitumen at specified rate and temperature to provide a uniform unbroken spread of bitumen.

4) No more than the necessary tack coat for the day's operation should be placed.

5) The succeeding construction should be made only after curing of the tack coat

Table 3.14. Rate of application of tack coat

S.No.	Type Surface	Quantity of liquid bituminous material in kg per 10 sq.m. area
i)	Normal bituminous surfaces	2.0 to 2.5
ii)	Dry and hungry bituminous surfaces	2.5 to 3.0
iii)	Granular surfaces treated with primer	2.5 to 3.0
iv)	Non bituminous surfaces	
	a) Granular base (not primed)	3.5 to 4.0
	b) Cement Concrete pavement	3.0 to 3.5

Note: Where the material to receive an overlay is a freshly laid bituminous layer that has not been subjected to traffic or contaminated by dust, a tack coat is not mandatory where the overlay is completed within two days.

3.8.4 Bituminous Macadam and Dense Graded Bituminous Macadam

3.8.4.1 General guideline for Bituminous macadam and dense graded bituminous Macadam

1) The work consists of construction of a single layer of compacted crushed aggregates premixed with bituminous binder. Bituminous Macadam is more open graded than the Dense Graded Bituminous Macadam.

2) Physical requirements of aggregate for BM and Dense Graded Bituminous Macadam are given in Table 3.15.

3) The filler shall be graded within the limit in table 3.16.

4) For Bituminous Macadam, the bitumen content for premix should be 3 to 3.5 per cent by weight of total mix except otherwise directed. The composition of Bituminous Macadam should conform to Table 3.17. The manufacturing and rolling temperature are given in Table 3.18. For dense graded bituminous macadam aggregate gradation and requirement of mix are indicated in Table Nos. 3.19 and Marshall Properties should be according table 3.20 .

5) The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 3.21.

6) Job mix formula for Dense Graded Bituminous shall comply with Clause 507.3 of the Ministry's Specifications and should be design in lab or other agency and should get approval from PMU before implementation.

7) The construction operation for Dense Graded Bituminous Macadam including lying of and stress absorbing layer should be in accordance with Clause 507.4 of the Ministry's Specifications.

8) For more detail refer Ministry's specification clause no. 504 for Bituminous Macadam & clause no. 507 for Dense Graded Bituminous Macadam.

Table3.15. Physical requirements for coarse aggregate for Bituminous Macadam and Dense graded bituminous macadam

S.No.	Property	Test	Specification

S.No.	Property	Test	Specification
1.	Cleanliness (dust)	Grain size analysis[1]	Max 5% passing 0.075mm sieve
2.	Particle shape	Flakiness and Elongation Index (Combined)2	Max 30%
3.	Strength*	Los Angeles Abrasion Value)	Max 35%
		Aggregate Impact Value[4] Soundness:[5 n]	Max 27%
4.	Durability	Soundness:[5] Sodium Sulphate Magnesium Sulphate	Max 12% Max 18%
5.	Water Absorption	Water absorption[6]	Max 2%
6.	Stripping	Coating and Stripping of Bitumen Aggregate Mixtures[7]	Minimum retained coating 95%
7.	Water Sensitivity**	Retained Tensile Strength[8]	Min 80%

Notes: 1. IS:2386 Part I
2. IS:2386 Part I
(the elongation test to be done only on non-flaky aggregates in the sample)
3. IS:2386 Part 4*
4. IS:2386 Part 4*
5. IS:2386 Part 5
6. IS:2386 Part 3
7. IS:6241
8. AASHTO *T283***

* Aggregate may satisfy requirements of either of these two tests.

** The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95%.

Table 3.16. Grading requirements for mineral filler

S.No.	IS Sieve (mm)	Cumulative per cent passing by weight of total aggregate
1.	0.6	100
2.	0.3	95 - 100
3.	0.075	85 - 100

Table 3.17. Composition of bituminous macadam

S.No.	Mix designation	Grading I	Grading 2
	Nominal aggregate size	**40 mm**	**19 mm**
	Layer thickness	**80-100 mm**	**50-75 mm**
	IS Sieve <mm	**Cumulative % by weight of total aggregate passing**	
1.	45 mm	100	-
2.	37.5 mm	90 - 100	-
3.	26.5 mm	75 -100	100
4.	19 mm	-	90 - 100
5.	13.3 mm	35 - 61	56 - 68
6.	4.75 mm	13 - 22	16 - 36
7.	2.36 mm	4 - 19	4 - 19
8.	0.3 mm	2 - 10	2 - 10
9.	0.075 mm	0 - 8	0 - 8
Bitumen content, % by weight of total mixture[1]		**3.1 -3.4 %**	**3.3 -3.5 %**
Bitumen grade		35 to 90	35 to 90

Note : Appropriate bitumen contents for conditions in cooler areas of India may be up to 0.5% higher subject to the approval of the Engineer.

Table 3.18. Manufacturing and Rolling Temperatures of BM / DBM

Bitumen Penetration Grade	Bitumen Mixing Temp. (°C)	Aggregate Temp. (°C)	Mixing Temp. (°C) of Mixed	Rolling (°C)	Laying (°C)
35	160-170	160-175	170 Max.	100 Min.	130 Min.
65	150-165	150-170	165 Max.	90 Min.	125 Min.
90	140-160	140-165	155 Max.	80 Min	115 Min.

Table 3.19. Composition of dense graded bituminous macadam pavement layers

S.No.	Grade of Mix	Grading I	Grading 2
	Nominal aggregate size	**40 mm**	**19 mm**
	Layer thickness	**80-100 mm**	**50-75 mm**
	IS Sieve <mm	**Cumulative % by weight of total aggregate passing**	
1.	45 mm	100	-
2.	37.5 mm	90 - 100	100
3.	26.5 mm	63 - 93	90 - 100
4.	19 mm	-	71 - 95
5.	13.3 mm	55 - 75	56 - 80
6.	4.75 mm	38 - 54	38 - 54
7.	2.36 mm	28 - 42	28 - 42

8.	0.3 mm	7 - 21	7 - 21
9.	0.075 mm	2 - 8	2 - 8
Bitumen content, % by weight of total mixture[1]		**Min. 4.0 %**	**Min. 4.50 %**
Bitumen grade		65 or 90	65 or 90

Note : 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.
2. Determined by the Marshall method.

Table 3.20. Marshall Properties Requirements for dense graded bituminous macadam layers

S.No.	Requirement of property of mix from Marshall sample	Standard
1.	Minimum stability (kN at 60°C)	9.0
2.	Minimum flow (mm)	2
3.	Maximum flow (mm)	4
4.	Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
5.	Per cent air voids	3 -6
6.	Per cent voids in mineral aggregate (VMA)	See table 9.28 below
7.	Per cent voids filled with bitumen (VFB)	65 -75

Table 3.21. Minimum per cent voids in mineral aggregate (VMA)

S.No.	Nominal Maximum Particle Size[1]	Minimum VMA, per cent Related to Design Air Voids, per cent[2]		
		3.0	4.0	5.0
1.	9.5 mm	14.0	15.0	16.0
2.	12.5 mm	13.0	14.0	15..0
3.	19.0 mm	12.0	13.0	14.0
4.	25.0 mm	11.0	12.0	13.0
5.	37.5 mm	10.0	11.0	12.0

Note : 1. The nominal maximum particle size is one size large than the first sieve to retain more than 10 per cent.
2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed

3.8.5 Bituminous Concrete and Semi Dense Bituminous Concrete

3.8.5.1 General guideline for Semi Dense Bituminous Concrete and Bituminous Concrete

1) The work consists of construction, in a single or multiple layers of bituminous concrete prepared as per specified job mixed formula, on previously prepared bituminous base. A single layer shall be 25 mm to 100 mm in thickness.

2) The coarse aggregate for semi-dense bitumen concrete should satisfy the criteria laid in Table 3.22. Aggregate gradation is indicated in table 3.23 and SDBC should satisfy the Marshall requirement indicated in table 3.24.

3) The Job mix formula for SDBC should be in accordance with clause 511.3 of Ministry's specifications and should be design in lab or other agency and should get approval from PMU before implementation.

4) The coarse aggregate for bituminous concrete mix should satisfy the requirement mentioned in table 3.25. Composition of bituminous concrete pavement layers and Marshall Properties Requirements for bituminous pavement layers are indicated in table 3.26 and 3.27 respectively.

5) The mix design and construction operations of BC should be confirm to clause 512.3 of Ministry's specifications and should be design in lab or other agency and should get approval from PMU before implementation.

6) For more detail refer Ministry's specification clause no. 511 for Semi Dense Bituminous Concrete and clause no. 512 for Bituminous Concrete.

3.8.5.2 **Fine Aggregate for Semi Dense Bituminous Concrete and Bituminous Concrete**

1) The fine aggregate shall be the fraction passing the 2.36 mm and retained on the 0.075 mm sieve consisting of crusher run screening, natural sand or mixture of both. These shall be clean, hard, durable, uncoated, dry and free from soft or flaky pieces and organic or other deleterious substances.

2) The grading of the fine aggregates inclusive of filler shall be as given in table 3.12.

Table 3.22. Physical requirements for coarse aggregate for Semi-dense graded bituminous macadam

S.No.	Property	Test	Specification
1.	Cleanliness (dust)	Grain size analysis[1]	Max 5% passing 0.075mm sieve
2.	Particle shape	Flakiness and Elongation Index (Combined)2	Max 30%
3.	Strength*	Los Angeles Abrasion Value)	Max 35%
		Aggregate Impact Value[4]	Max 27%
4.	Polishing	Polish stone Value[5]	Min 55
5.	Durability	Soundness:[6] Sodium Sulphate Magnesium Sulphate	 Max 12% Max 18%
6.	Water Absorption	Water absorption[7]	Max 2%
7.	Stripping	Coating and Stripping of Bitumen Aggregate Mixtures[9]	Minimum retained coating 95%
8.	Water Sensitivity**	Retained Tensile Strength[8]	Min 80%

Notes: 1. IS:2386 Part I
2. IS:2386 Part I
(the elongation test to be done only on non-flaky aggregates in the sample)
3. IS:2386 Part 4*
4. IS:2386 Part 4*
5. BS:812 Part114
6. IS:2386 Part 5
7. IS:2386 Part 3
8. AASHTO T283**
9. IS:6241

* Aggregate may satisfy requirements of either of these two tests.

** The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95%.

Table 3.23. Composition of Semi- dense bituminous concrete pavement layers

S.No.	Grade of Mix	Grading I	Grading 2
	Nominal aggregate size	**13 mm**	**10 mm**
	Layer thickness	**35- 40 mm**	**25- 30 mm**
	IS Sieve <mm	**Cumulative % by weight of total aggregate passing**	
1.	19 mm	100	
2.	13.2 mm	90 - 100	100
3.	4.75 mm	70 - 100	90 - 100
4.	2.36 mm	35 - 51	35 - 51
5.	1.18 mm	24 - 39	24 - 39
6.	0.60 mm	15 - 30	15 - 30
7.	0.3 mm	9 - 19	9 - 19
9.	0.075 mm	3 - 8	3 - 8
Bitumen content, % by weight of total mixture[1]		**Min. 4.50 %**	**Min. 5.00 %**
Bitumen grade		65*	65*

Note : 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

3. Determined by the Marshall method.

* Only exceptional circumstances, 80/100 penetration grade bitumen may be used, as approved by the engineer.

Table 3.24. Marshall Properties Requirements for Semi-dense bituminous concrete layers

S.No.	Requirement of property of mix from Marshall sample	Standard
1.	Minimum stability (kN at 60°C)	8.20
2.	Minimum flow (mm)	2
3.	Maximum flow (mm)	4
4.	Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
5.	Per cent air voids	3 -5
6.	Per cent voids in mineral aggregate (VMA)	See table 9.28 below
7.	Per cent voids filled with bitumen (VFB)	65 -78

Table 3.25. Physical requirements for coarse aggregate for bituminous concrete

S.No.	Property	Test	Specification
1.	Cleanliness (dust)	Grain size analysis[1]	Max 5% passing 0.075mm sieve
2.	Particle shape	Flakiness and Elongation Index (Combined)2	Max 30%
3.	Strength*	Los Angeles Abrasion Value)	Max 30%
		Aggregate Impact Value[4]	Max 24%
4.	Polishing	Polish stone Value[5]	Min 55
5.	Durability	Soundness:[6] Sodium Sulphate Magnesium Sulphate	 Max 12% Max 18%
6.	Water Absorption	Water absorption[7]	Max 2%
7.	Stripping	Coating and Stripping of Bitumen Aggregate Mixtures[9]	Minimum retained coating 95%
8.	Water Sensitivity**	Retained Tensile Strength[8]	Min 80%

Table3.26. Composition of bituminous concrete pavement layers

S.No.	Grade of Mix	Grading I	Grading 2
	Nominal aggregate size	**19 mm**	**13 mm**
	Layer thickness	**50- 65 mm**	**30 – 45 mm**
	IS Sieve <mm	**Cumulative % by weight of total aggregate passing**	
1.	26.5 mm	100	
2.	19 mm	79 -100	100
3.	13.2 mm	59 - 79	79 -100
4.	9.5 mm	52 - 72	70 - 88
5.	4.75 mm	35 - 55	53 - 71
6.	2.36 mm	28 - 44	42 - 58
7.	1.18 mm	20 - 34	34 - 48
8.	0.60 mm	15 - 27	26 - 38
9.	0.3 mm	10 - 20	18 - 28
10.	0.15 mm	5 - 13	12 - 20
11.	0.075 mm	2 - 8	4 - 10
Bitumen content, % by weight of total mixture[1]		**Min. 5.0 – 6.00 %**	**Min. 5.00 – 7.00 %**
Bitumen grade		65*	65*

Note : 1. The combined aggregate grading shall not vary from the low limit on one sieve to

the high limit on the adjacent sieve.
2. Determined by the Marshall method.

Table 3.27. Marshall Properties Requirements for bituminous concrete layers

S.No.	Requirement of property of mix from Marshall sample	Standard
1.	Minimum stability (kN at 60°C)	9.00
2.	Minimum flow (mm)	2
3.	Maximum flow (mm)	4
4.	Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
5.	Per cent air voids	3 -6
6.	Per cent voids in mineral aggregate (VMA)	See table 9.28 below
7.	Per cent voids filled with bitumen (VFB)	65 -75
8.	Loss of stability on immersion in water at 60 C (ASTM-D-1075)	Min. 75 % retained strength

3.8.6 Open-graded premix surfacing

Scope: This work shall consist of the preparation, laying and compaction of an open-graded premix surfacing material of 20 mm thickness composed of small-sized aggregate premixed with a bituminous binder on a previously prepared base, in accordance with the requirements of Ministry's Specifications, to serve as a wearing course.

Binder: The binder shall be penetration bitumen of a suitable grade as specified in the contract, or as directed by the Engineer, and satisfying the requirements of IS: 73.

Aggregate: The aggregate shall conform to Clause 504.2.2 of Ministry's specifications except that the water absorption shall be limited to a maximum of l per cent. The polished Stone value, as measured by the test in BS812-(Part 114), shall not be less than 55.

Proportioning of materials: The Proportioning of materials shall be in accordance with Table 3.28 and qty of bitumen as per table3.29.

Construction operations shall conform to clause 509 of the Ministry's Specifications.

Table 3.28. Quantities of materials required for 10 m^2 of road surface for 20mm thick open-graded premix surfacing using penetration bitumen or cutback

(A)	For open-graded Premix Carpet aggregate	Quantity
a)	b) Nominal Stone Size 13.2 mm (passing 22.4 mm 0.18 ml sieve and retained on 11.2 mm sieve)	0.18 m^3
c)	d) Nominal stone size 11.2 mm (passing) 13.2 mm sieve and retained on 5.6 mm sieve)	0.09 m^3
	Total	0.27 m^3
(B)	For Seal Coat	
a)	Liquid Seal Coat:	0.06 m^3

	Crushed fine aggregate 6.7 mm size; passing IS 9.5 mm sieve and retained on 2.36 mm sieve	
b)	Premix Seal Coat: Coarse sand or stone aggregates passing IS 2.36 mm sieve and retained on 180 micron sieve	0.06 m^3

Table3.29. Quantities of penetration bitumen or cutback for 10 m^2 area for 20mm thick open-graded premix

(A)	**For open-graded Premix Carpet aggregate**	**Quantity**
a)	a) For 0.18 m^3 of 13.2 mm nominal size stone at 52 kg bitumen per m^3	9.5 kg
b)	b) For 0.09 m^3 of 11.2 mm nominal size stone at 56 kg bitumen per m^3	5.1 kg
	Total	14.6 kg
(B)	**For Seal Coat :**	
a)	Liquid Seal Coat: Crushed fine aggregate 6.7 mm size; passing IS 9.5 mm sieve and retained on 2.36 mm sieve	9.8 kg.
b)	Premix Seal Coat: Coarse sand or stone aggregates passing IS 2.36 mm sieve and retained on 180 micron sieve	6.8 kg.

3.8.7 Open graded premix surfacing using cationic bitumen emulsion

Scope: This work shall consist of the preparation, laying and compaction of an open-graded premix surfacing of 20 mm thickness composed of small-sized aggregate premixed with a cationic bitumen emulsion on a previously prepared surface, in accordance with the requirements of these Specifications to serve as a wearing course.

Binder: The binder for premix wearing course shall be cationic bitumen emulsion of Medium Setting (MS) grade complying with I.S.:8887 and having a bitumen content 65 per cent minimum by weight. For liquid seal, coat RS grade of cationic bitumen emulsion shall be used. Where expressly specified in the Contract (MS) grade emulsion shall be used or otherwise directed by the Engineer. Slow Setting (SS) grade cationic bitumen emulsion shall be used for premix seal coat.

Aggregate: The requirements of sub para 3, para 3.8.6 shall apply.

Proportioning of materials: The proportionate of materials should be according to quantities given in Tables 3.30 and qty of bitumen as per table3.31.

Construction Operations shall conform to Clause 511 of the Ministry's Specifications.

Table 3.30. Quantities of aggregate and binder for 10 m^2 area for Open graded premix surfacing using cationic bitumen emulsion

(A)	For Premix Carpet	Quantity
a)	Coarse aggregate nominal 13.2 mm size: passing IS 22.4 mm sieve and retained on IS 1 1.2 mm sieve	0.18 m^3
b)	Coarse aggregate nominal 11.2 mm size: passing IS 13.2 mm sieve and retained on IS – 5.6mm sieve	0.09 m^3
(B)	For Seal Coat	
a)	Liquid Seal Coat: Crushed fine aggregate 6.7 mm size; passing IS 9.5 mm sieve and retained on 2.36 mm sieve	0.06 m^3
b)	Premix Seal Coat: Coarse sand or stone aggregates passing IS 2.36 mm sieve and retained on 180 micron sieve	0.06 m^3

Table3.31. Quantities of emulsion binder for 10 m^2 area Open graded premix surfacing using cationic bitumen emulsion

(A)	For Premix Carpet:	20 to 30 kg
(B)	For Seal Coat :	
a)	Liquid Seal Coat: Crushed fine aggregate 6.7 mm size; passing IS 9.5 mm sieve and retained on 2.36 mm sieve	12 to 14 kg
b)	Premix Seal Coat: Coarse sand or stone aggregates passing IS 2.36 mm sieve and retained on 180 micron sieve	10 to 12 kg

3.8.8 Close graded premix surfacing/mixed seal surfacing:

Scope: This work shall consist of the preparation, laying and compaction of a close-graded premix surfacing material of 20 mm thickness composed of graded aggregates premixed with a bituminous binder on a previously prepared surface, in accordance with the requirements of these Specifications of the Ministry to serve as a wearing course.

Close graded premix surfacing shall be of Type A or Type B as specified in the Contract documents.

Binder and Coarse aggregate: The requirements of Para 3.8.6 shall apply.

Fine aggregates: The fine aggregates shall consist of crushed rock quarry sands, natural gravel/sand or a mixture of both. These shall be clean, hard, durable, un-coated, mineral particles, dry and free from injurious, soft or flaky particles and organic or deleterious substances.

Aggregate gradation: The coarse and fine aggregates shall be so graded or combined as to conform to one or the other grading shown in Table 3.32 as specified in the contract.

Table 3.32. Aggregate Gradation

IS Sieve Designation (mm)	Cumulative per cent 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

Proportioning of materials: The total quantity of aggregates used for Type A or Type B close-graded premix surfacing shall be 0.27 cubic metre per 10 square metre area. The quantity of binder used for premixing in terms of straight-run bitumen shall be 22.0 kg and 19.0 kg per 10 square metre area for Type A and Type B surfacing respectively.

Construction Operations shall conform to Clause 511 of the Ministry's Specifications.

3.8.9 Seal coat –

Scope: This work shall consist of the application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade and cross fall (camber). Seal coat shall be or either of the two types specified below :

(A) Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover stone chips.

(B) Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

Binder: The requirements of Para 3.8.6 shall apply.

The quantity of bitumen per 10 square metres shall be 9.8 kg for Type (A), and 6.8 kg for Type (B) seal coat. Where bituminous emulsion is used as a binder the quantities for Type (A) and Type (B) seal coats shall be 15 kg and 10.5 kg respectively.

Stone chips for Type (A) seal coat: The stone chips shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They should be free of soft or disintegrated stone, organic or other deleterious matter. Stone chips shall be of 6.7 mm size defined as 100 per cent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic metres per 10 square metre areas. The chips shall satisfy the quality requirements in Table 9.18 except that the upper limit for water absorption value shall be I per cent.

Aggregate for Type (B) seal coat: The aggregate shall be sand or grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky /elongated material, organic matter or other deleterious substances. The aggregate shall pass 2.36 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cubic metres per 10 square metres area.

Construction Operations shall conform to Clause 513 of the Ministry's Specifications.

3.9 Concrete Sub-Bases/Bases

3.9.1 Dry lean concrete sub-base

3.9.1.1 General guideline and Procedure for Dry lean concrete sub-base

1) Ordinary Portland or Portland slag or Portland puzzolana cement conforming to 15:269 IS: 455 and IS: 1489 respectively may be used. If the sub-grade contains soluble sulphate in excess of 0.5 per cent cement used shall be sulphate resistant and shall conform to IS: 6909.

2) Coarse and fine aggregates shall conform to IS: 383. If required coarse aggregate should be washed and drained. Fine aggregate should be free from soft particles, clay, lignite, shale, loam cemented particles, mica, organic and other foreign matter.

3) Maximum size of aggregate shall be 26.5. The blended aggregate should conform to the grading indicated in Table 3.33.

Table 3.33. Aggregate gradation for dry lean concrete

Sieve Designation	Percentage passing the sieve by weight
26.50 mm	100
19.00 mm	80-100
9.50 mm	55-15
4.75 mm	35-60
600.00 micron	10-35
75.00 micron	0-8

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

5) The mix should have a maximum aggregate cement ratio of 15:1. Optimum moisture content should be determined by trial and construction should be carried out with water content between the optimum and optimum + 2 Per cent.

6) Minimum cement content shall not be less than 150 kg/cu.m of concrete.A trial length, outside main work, having a minimum length of 60 m and full width of pavement and containing at least. One transverse construction joint should be constructed to determine the optimum moisture content, density, and strength of lean concrete.

7) The concrete work should not be carried out if concrete temperature is greater than 300C. If required chilled water or ice flakes should be used.. The work should also not be carried out in adverse conditions, like, high temperature low relative humidity excessive wind velocity imminence of rain or concrete temperature below 50 C.

8) The sub-grade should be finished to proper lines grades and cross-sections. It should not be softened by rain after preparation. For areas with plastic soils, like, BC soil, the soil should be prepared with about 2 per cent of lime. The sub-grade should be given a fine spray of water and rolled one day before laying the lean concrete.

9) Batching and mixing .should preferably be carried out in a force action central batching and mixing plant. The average compressive strength of the lean concrete

should not be less than 10 MPa at seven days. In addition, the minimum compressive strength of any individual cube should not be less than 7.5 Mpa at seven days.

10) The concrete should, be transported by tipping trucks ensuring that no segregation takes place. Some practical measures for reducing segregation are listed below:

i) The maximum size of the aggregates should be restricted to 25 mm.
ii) While stockpiling aggregates the height of layer should be restricted to 1-2 meters and each layer should be spread horizontally.
iii) Dumpers should be moved back and forth to stagger heaps.
iv) Use of down-pipe from conveyor belt to dumper in reducing segregation may be considered, where applicable.
v) If a paver is employed, it should be operated at moderate speed. At higher speeds, coarser fraction tends to move towards edges.

11) Concrete should be spread over the full width preferably with a paver with electronic sensors. The minimum dry density shall be 97 per cent of that achieved during the trial length construction as described below. The density achieved at 0.5 m from the edge should not be less than 95 per cent of that achieved during trial construction.

12) The time between mixing of the first batch of concrete and final finishing time should not exceed 90 minutes when the concrete temperature is between 250 C and 300 C and 120 minutes when the concrete temperature is less than 250 C. This period may be reviewed in the light of results of the trial run.

13) Mixing and placing of concrete shall progress only at such rate as to permit proper finishing, protecting and curing of the pavement.

14) 80 to 100 kN static weight are suitable for rolling dry lean concrete. In addition, to the number of passes required for compaction there should be a preliminary pass without vibration for bedding and a final pass without vibration to remove roller marks. Special care should be exercised during compaction near joints, kerbs, channels, side forms, around gullies and manholes. If necessary plate vibrators may be used at these locations.

15) Immediately after the compaction, curing should commence either by spraying with liquid curing compound and covering with wet Hessian for three days, after the compound looses tackiness, or directly covering the surface with wet Hessian kept moist for seven days.

16) As far as possible transverse joints should be at right angles to the pavement edge. Also, the transverse joints should be provided in line with the joints in the slab of the adjoining lane.

17) Sufficient forms should be available to atleast 200 metres length at all times. This should be set to the required alignment in advance of paving operation for 200 meters length or anticipated length of pavement to be laid in next 24 hours, whichever is more.

18) A separation membrane should be provided between concrete slab and sub-base to obviate stresses developing at the interface as a result of temperature changes in the concrete slab. This should be 125 microns thick impermeable plastic Sheet laid flat without creases and nailed to the lower layer with concrete nails. The overlap in plastic sheet, where necessary, should be at least 300 mm.

3.9.2 Concrete base:

3.9.2.1 General guideline and Procedure for Concrete base pavement

1) Concrete base should be laid over a sub-base discussed in para 9-10.1. If the sub-base is found damaged at some places or has cracks wider than 10 mm it should be repaired with fine cement concrete or bituminous concrete before laying separation layer. Prior to lying of concrete it should be ensured that separation membrane is in position and is clean of dirt to or other extraneous material and free from any damage.

2) Ordinary Portland cement of grades 33, 43 or 53 conforming respectively to IS: 269, IS: 8112 and IS: 12269 should be used. If the soil has soluble salts, like, sulphate in excess of 0.5 percent, the cement used shall be sulphate resistant and shat conform to IS: 12330.

3) Guidance regarding matching the strength of cement with the designed strength of concrete may be obtained from IS: SP: 23, "Handbook for concrete Mixes". Cement content should be between 350 and 425 kg/cum of concrete.

4) Admixtures conforming to IS: 6925 and IS: 9103 may be used to improve workability of concrete or extension of setting time. If air entrained admixture is used, the total quantity of air-in-air entrained concrete as a percentage of the volume of the mix should be 5 ± 1.5 per cent. The aggregate should comply with provisions of IS: 383 and in addition, should have a Los Angeles. Abrasion test value less than 35 per cent, chloride in less than 0.06 per cent by weight, Sulphuric anhydride less than 0.25 per cent by weight, water absorption less than 2 per cent and a loss of less than 12 per cent in soundness test with sodium sulphate 18 per cent for magnesium sulphate).

5) Fine aggregate and water should conform to the requirements already mentioned in para 3.9.1.

6) Mild steel dowels and tie bars should conform to the relevant requirements of IS:432, IS: l 139 and IS: 1786. The dowel bars should conform to grade S 240 and tie bars to grade S 415 of IS.

7) The concrete should be prepared after proper mix design using methods mentioned in IS: 1026 “Recommended Guidelines for Mix Design”. Workability of the concrete should be established by slump test. A slump of 30+15 mm is considered reasonable.

8) Placing of concrete may be taken up in weather conditions already described in para 9.10.1. The concrete base may be constructed by fixed form paver, or a slip form paver. Only where such placing is not possible, construction should be taken up by hand guided methods.

9) After the placing of the slab and before the application of the curing membrane, the surface shall be brush textured-in accordance with the prescribed specifications.

10) In cases where side forms are used as soon as side forms are removed, edges of the slab shall be corrected wherever irregularities have occurred by using fine aggregate composition of one part of cement and three parts of chips.

3.9.3 Joints:

Provisions of joints are necessitated due to:

1) expansion, contraction and warping of concrete slabs resulting from temperature and moisture changes;
2) facilitate a break in the construction at the end of day's work or for any unexpected interruption to work progress; and
3) Construction of pavements in lanes of convenient width.

Types of Joints

Transverse joints are of the following types:

a) Expansion Joints

These provide for space in concrete to allow for expansion of slab. The practice with regard to spacing of expansion joints vary from 20 metres to a few hundred metres. Recent practice is to omit expansion joints and provide the same at junctions of roads with structure, like, bridges, etc.

b) Contraction Joints

These joints are provided in concrete pavements to prevent stresses induced as a result of ambient temperature falling below the laying temperature. These are normally 3 to 5 mm, width and provided upto 1/3rd to l/4th the slab thickness. Spacing of contraction joints is generally 5 metres. For reinforced concrete pavements the maximum spacing varies from 7.5 m to 17.0 m depending upon thickness of slabs.

c) Construction Joints

These joints are provided at the end of a day’s work or when the work is stopped unexpectedly due to interruption for more than 30 minutes. These are either contraction joints or expansion joints.

d) Longitudinal Joints

These are required when the width of concrete pavement is more than 4 metres wide. These are intended to Provide for warping and even uneven settlement of subgrade. Generally, the joints are butt type dummy type joints are also used. These are saw cut joints for at least l/3rd of the depth of slab.

3.9.3.1 **General guideline and Procedure for Joints**

1) All foreign material in the joints should be removed first. The manual cleaning of the joints is done with a raker followed by coir brushing. The fine particles are removed with the help of air compressor. After the joints have been cleaned, primer is used. The primer has very low viscosity and penetrates in the pores of the concrete. This is followed by joint filler and finally sealing compound is used. The primer used earlier helps to improve bond between sealing compound and concrete

2) The joints should be sealed flush with the adjacent pavement surface on either side in summer and should be filled to a depth of 3-4 mm below the surface in winter so that they may become flush on expanding during hot weather.

3) Dowel bars are required for the transverse joints to

   i) transfer part load across the adjacent slab
   ii) stresses becoming critical

iii) assist in the event of loss of sub grade support at the location of joint

4) Dowel bars are generally mild steel round bars embedded and bonded into concrete on one side of the joint and the other half length deliberately prevented from bonding with concrete on that side. A recess is provided at the sliding end for free movement of slab when used in the expansion joints.

5) The dowel bar should be supported on cradles/dowel chairs in pre-fabricated joint assemblies positioned prior to the construction of the slabs or mechanically inserted with vibration into the plastic concrete by method which ensures correct placement of the bars besides full re-compaction of the concrete around the dowel bars.

6) Dowel bars should be positioned at mid depth of the slab, and centred equally about intended lines of the joint. They should be aligned parallel to the finished surface of the slab and to the centre line of the carriageway and to each other.

7) Dowel bars should be covered by a thin plastic sheath for at least two-thirds of the length from one end for dowel bars in contraction joints or half the length plus 50 mm for expansion joints. The sheath shall be tough, durable and of and average thickness not greater than 1.25 mm. The sheathed bar shall comply with the specified pullout tests.

8) For expansion joints, a closely fitting cap 100 mm long consisting of waterproofed cardboard or an approved synthetic material, like, PVC or GI pipe should be placed over the sheathed end of each dowel bar. An expansion space at least equal in length to the thickness of the joint filler board should be formed between the end of the cap and the end of the dowel bar by using compressible sponge to block the entry of cement slurry between dowel and cap. It may be taped.

9) Tie bars are provided to prevent adjacent slabs from separating, particularly on curves or at fills. The tie bars are not meant to add structural capacity of the slabs and are designed to withstand only tensile stresses.

10) Tie bars in longitudinal joints should be deformed steel bars of strength 415 Mpa complying with IS: 1786.

11) Tie bars projecting across the longitudinal joint shall be protected from corrosion for 75 mm on each side of the joint by a protective coating of bituminous paint.

12) Tie bars in longitudinal joints shall be made up into rigid assembles with adequate supports and fixings to remain firmly in position during the construction of the slab. Alternatively, tie bars at longitudinal joints may be mechanically or manually inserted into the plastic concrete from above by vibration using a method which ensures correct placement of the bars and re-compaction of the concrete around the tie bars.

13) Tie bars shall be positioned to remain within the middle third of the slab depth approximately parallel to the surface and perpendicular to the line of joint with a minimum cover of 30 mm below the joint groove.

3.9.4 Equipment of proportioning and laying

3.9.4.1 General guideline and Procedure for Equipment of proportioning and laying

1) The batching and mixing plant should include minimum four bins, weighing hoppers with automatic weighing devices using load cells and scales for the fine aggregate and

for each size of coarse aggregate. If cement is used in bulk a separate scale for cement should be included.

2) The weighing hopper should be properly sealed and vented to preclude dust during operation. Approved safety devices shall be provided and maintained for the protection of all personal engaged in plant operation, inspection and testing.

3) Bins with minimum number of four adequate separate compartments should be provided in the batching plant.

4) Batching plant should be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells.

5) Each stationary mixer should be equipped with an approved timing device, capable of making audible warning signal which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period.

6) The mixers should be cleaned at suitable intervals. The pickup and throw-over blade in the drums should be repaired or replaced when they are worn-down 20 mm or more.

7) Batching Plant should be calibrated in the beginning and thereafter at suitable interval not exceeding one month.

8) Mixers should be of pan type, reversible type or any other mixer capable of combining the aggregates, cement and water into a thoroughly mixed and uniform mass within specific mixing period and discharging the mixture without segregation.

9) The accuracy of weighing devices should be $\pm$ 2 per cent in case of aggregates and $\pm$1 per cent for water and cement.

10) The capacity of batching and mixing plant should be at least 25 per cent higher than the city of laying/paving equipment.

11) The design features of batching plant should be such that shifting operations should not take very long time.

12) The concrete should be placed with an approved fixed form or slip form paver with independent units designed to (i) spread (ii) consolidate, screed and float-finish and (iii) texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the specifications. The paver should be equipped with electronic controls to control/sensor line and grade from either or both sides of the machine. Vibrators should operate at a frequency of 8300 to 9600 impulses per minute under load at a maximum spacing of 60 cm.

13) Saw machine shall be either electric or petrol/diesel driven type. A water tank with flexible hoses and pump shall be made available in this activity on priority basis. The concreting work should not commence if the saws are not in working condition.

3.10 Geo synthetics:

Refer the ministry's specification Chapter no. 700 for Geo synthetics

3.11 Quality Control for Road Works

3.11.1 General guideline for Quality Control for Road Works

1) It is the prime responsibility of the Engineer-in-charge to ensure that the work performed and all the materials incorporated in the work conform to the specification requirements. Objective tests for checking the quality of materials are available, but he should not wait till materials are delivered at site. Some of the actions he could take are:

   i) Obtain the test certificates of manufactured materials from the sources from where these are to be procured.
   ii) For manufactured items for which I.S.I. marking facilities are not available, he should inspect the place of manufacture to ensure that the materials used and the processes adopted can turn out products satisfying the specification requirements.
   iii) In the case of mineral aggregate, he should inspect the quarry, or even station his representative there to ensure that only approved rock is crushed to the required sizes.
   iv) For works involving processing (e.g., stabilisation) or compaction involving equipment, he may, if so provided for in the contract, ask the contractor to do the work on a trial stretch to ensure that the equipment and procedures used can turn out quality work.

2) Constructions organisations should preferably have quality control units independent of the construction staff. These units are intended to bring out any deficiency in the material or work to the notice of the Engineer-in-charge, as a second check. Presence of these units will not, however, absolve the Engineer-in-charge of his prime responsibility.

3) Details of the quality control tests, their frequency, the method of rectifying the defects, etc., are contained in IRC: SP: 11 “Handbook of Quality Control for Construction of Roads and Runways.”

4) It is essential that the results of all quality control tests and observations should be systematically recorded and carefully preserved.

5) The frequency of control tests on embankment construction, non-bituminous bases and bituminous bases are included in Table Nos. 3.34, 3.35 and 3.36.

Table 3.34 Quality control tests and their frequency for embankment construction

S.No.	Particulars	Frequency
1.	Borrow Material	
a)	Sand content [IS: 2720 (Pt. IV)]	Two test per 3,000 m^3 of soil
b)	Plasticity test [IS: 2720 (Pt. V)	Each type to be tested, 2 tests per 3,000 m^3
c)	Density test [IS: 2720 (Pr. VII)	Each type to be tested, 2 tests per 3,000 m^3
d)	Deleterious content [IS: 2720 (Pt. XXVII)]	As required
e)	Moisture content test : [IS: 2720 (Pt. II)]	One test per 250 m^3
f)	CBR (for material to be placed in sub grade) [IS: 2720 (Pt. XVI)]	As required
2.	Compaction Control** (density test)	
a)	Body of embankment	At least one test per 1,000 m^2 for each layer
b)	Sub grade and shoulders	At least one test per 500 m^2 for each layer

** Control should be based on the mean value of a set of 5-10 density measurements in case of embankment body and 10 measurements for subgrade and shoulders. Acceptance shall be subject to the conditions that the mean dry density equals or exceeds the specified density and the standard deviation is below 0.08 gm/cc.

Table 3.35. Control tests and their minimum frequency for sub bases and bases (excluding bitumen bound bases)

S. No.	Type of Construction	Test	Frequency (Minimum)
1.	Earthwork for Embankment, Sub grade and cut formation	i. Sand Content (IS:2720 part-4)	Two test per 3000 m^3 for each type of soil
		ii. Plasticity Test (IS:2720 part-5)	Two test per 3000 m^3 for each type of soil
		iii. Density Test (IS:2720 part-8)	Two test per 3000 m^3 for each type of soil
		iv. Deleterious Content (IS:2720 part-27)	As required
		v. Moisture Content Test (IS:2720 part-2)	One test per 3000 m^3 of soil
		vi. CBR Test soaked/ un soaked sample (IS:2720 part-16)	One CBR test per 3000 m^3 of soil at least and may increase frequency as required
2.	Granular	vii. Gradation	One test per 200 m^3
		viii. Atterberg limits	One test per 200 m^3
		ix. Moisture content prior to	One test per 250 m^3
		x. Density of compacted layer	One test per 500 m^3
		xi. Deleterious constituents	As required
		xii. C.B.R.	As required
3.	Lime/Cement stabilised soil sub base	i. Quality of lime/cement	One test for each consignment subject to a minimum of one test per 5 tonnes
		ii. Lime/cement content	Regularly through procedural

S. No.	Type of Construction	Test	Frequency (Minimum)
			checks
		iii. Degree of pulverisation	Periodically as considered necessary
		iv. CBR or Unconfined Compressive Strength test on a set of 3 specimens	As required
		v. Moisture content prior to compaction	One test per 250 m^3
		vi. Density of compacted layer	One test per 500 m^3
		vii. Deleterious constituents	As required
4.	Water Bound Macadam	i. Aggregate Impact Value	One test per 200 m^3
		ii. Grading	One test per 100 m^3
		iii. Flakiness and Elongation Index	One test per 200 m^3 of aggregate
		iv. Atterberg limits of binding material	One test per 25 m^3 of binding material
		v. Atterberg limits of portion of aggregate passing 425 micron sieve	One test per 100 cubic metre of aggregated
5.	Wet Mix Macadam	i. Aggregate Impact Value	One test per 200 m^3 of aggregate
		ii. Grading	One test per 100 m^3 of aggregate
		iii. Flakiness and Elongation Index	One test per 200 m^3 of aggregate
		iv. Atterberg limits of portion of aggregate passing 425 micron sieve	One test per 100 m^3 of aggregate
		v. Density of compacted layer	One test per 500 m^3 of

Table 3.36. Control tests and their minimum frequency for bituminous works

S. No.	Type of Construction	Test	Frequency (Minimum)
1.	Prime Coat/ Tack Coat	i. Quality of binder	Two samples per lot to be subjected to all or some tests as directed by the Engineer
		ii. Binder temperature for application	At regular close intervals
		iii. Rate of spread of Binder	Two tests per day
2.	Seal Coat/ Surface Dressing	i. Quality of binder	Two samples per lot dressing to be subjected to all or some tests as directed by the engineer
		ii. Aggregate Impact Value	One test per 50 m^3 of aggregated
		iii. Flakiness and Elongation Index	--do--
		iv. Stripping value of aggregate	Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates
		v. Water absorption of aggregates	--do--
		vi. Grading of aggregate	One test per 25 m^3 of aggregated
		vii. Stone polishing value	As required
		viii. Temperature of binder at application	At regular close intervasl
		ix. Rate of spread of	One test per 500 m^3 of aggregated

S. No.	Type of Construction	Test	Frequency (Minimum)
		materials	
3.	Open graded Premix Carpet/ Mix Seal Surfacing	i. Quality of binder	Two samples per lot to be subjected to all or some tests as directed by the Engineer
		ii. Aggregate Impact Value	One test per 50 m^3 of aggregated
		iii. Flakiness and Elongation Index	--do--
		iv. Stripping value of aggregate	Same as mentioned under S. No. 2
		v. Water absorption of aggregates	Same as mentioned under S. No. 2
		vi. Grading of aggregate	One test per 25 m^3 of aggregated
		vii. Stone polishing value	As required
		viii. Temperature of binder at application	At regular close intervals
		ix. Rate of spread of materials	Two tests per day regular control through check on materials and layer thickness
4.	Bituminous Macadam	i. Quality of binder	Two samples per lot to be subjected to all or some tests as directed by the Engineer
		ii. Aggregate Impact Value	One test per 50 m^3 of aggregated
		iii. Flakiness and Elongation Index	--do--
		iv. Stripping value of aggregate	Same as mentioned under S. No. 2
		v. Water absorption of aggregates	Same as mentioned under S. No. 2
		vi. Grading of aggregate	Two tests per day per plant, individual as well mixed aggregate from dryer.
		vii. Binder Content	Periodic subjected to minimum 2 test per day per plant
		viii. Temperature of binder and aggregates and mixed material at the time mixing, laying and rolling	At regular close intervals
		ix. Rate of spread of materials	Two tests per day regular control through check on materials and layer thickness
5.	Dense Bituminous Macadam/ Semi-dense bituminous concrete and bituminous concrete	i. Quality of binder	Two samples per lot to be subjected to all or some tests as directed by the Engineer
		ii. Aggregate Impact Value	One test per 50 m^3 of aggregated
		iii. Flakiness and Elongation Index	--do--
		iv. Stripping value of aggregate	Same as mentioned under S. No. 2
		v. Water absorption of aggregates	Same as mentioned under S. No. 2
		vi. Mixed Grading of aggregate	One set of test on individual and as well mixed aggregate from dryer

S. No.	Type of Construction	Test	Frequency (Minimum)
			for each 400 tonne of mix subjected to Two tests per day per plant,.
		vii. Binder Content	One test for each 400 tonne of mix subjected to Two tests per day per plant,.
		viii. Sand equivalent test	As required
		ix. Temperature of binder and aggregates and mixed material at the time mixing, laying and rolling	At regular close intervals
		x. Rate of spread of materials	Regular control and through check on weight of mix and area of layer spread with thickness
		xi. Stone Polishing Value	As required for SDBC and BC
		xii. Water Sensitivity of mix	As required for BC
		xiii. Stability of mix	For each 400 tonne of mix, a set of 3 Marshall specimens to be prepare and tested stability, flow value, density and voids content subjected to 2 test per day per plant
		xiv. Swell test on the mix	As required for BC
		xv. Density of compacted layers	One test per 250 Sqm area

4 TRAFFIC CONTROL DEVICES

4.1 Traffic Signs

4.1.1 General

Complete details of the signs including guidelines on their erection are contained in IRC:67 "Code of Practice for Road Signs". Brief particulars of the sign system are given below:

4.1.2 Classification of Sign

4.1.2.1 **Mandatory/regulatory:** These inform the road users of laws and regulations. Violation is a legal offence.

4.1.2.2 **Cautionary/ warning:** Warn road users of the existence of certain hazardous conditions.

4.1.2.3 **Informatory :** For information and guidance of road users.

4.1.3 Sizes of Sign

The recommended sizes for the traffic signs are shown in Table 4.1. Two sizes of mandatory and cautionary signs have been prescribed. The normal size is to be used for main roads in rural areas, and the smaller size for less important roads in rural areas and roads in urban areas. On expressways, bigger than normal sizes may be used.

Table 4.1 Sizes and shape for traffic signs

S.No.	Type of Sign	Shape	Height/Diameter/Side	
			Normal sized in cm	Small sized in cm
1	Mandatory	Stop Sign	90	60
		Give way	90 (side)	60
		Others (circular)	90 (dia)	60 (dia)
2	Warning	Triangular	90 (side)	60 (side)
3	Rectangular	Rectangular	80 x 60	60

4.1.4 Retro-Reflective signs: As far as possible Retro-reflective Signs made of Engineering Grade Sheeting or of High Intensity Grade Sheeting with encapsulated lens as per Ministry's Specification may be used.

4.1.5 Shape: For mandatory signs, the general shape is circular except for STOP (Octagonal) and GIVE WAY (inverted triangle). The warning signs have the shape of equilateral triangle with apex pointing upwards, red border and black symbols on white background. The informatory signs are generally rectangular in shape.

4.1.6 Colours : Colours of signs should be as shown on detailed drawings, IRC:67. The reverse should be painted grey. The sign posts (except for level crossing signs) should be painted in 25 cm wide bands alternately black and white.

4.1.7 Urban locations: In urban locations, the warning signs should be located at about 50 metre away from the points of hazard. Distance may be increased or decreased to suit site conditions. The sitting of signs may be made as indicated in Table 4.12

4.1.8 Mandatory/regulatory signs: Some of the mandatory signs are shown in Fig. 4.1.

4.1.9 Cautionary/warning signs: A few of the Cautionary/ Warning signs are shown in Fig. 4.2. (a, b and c).

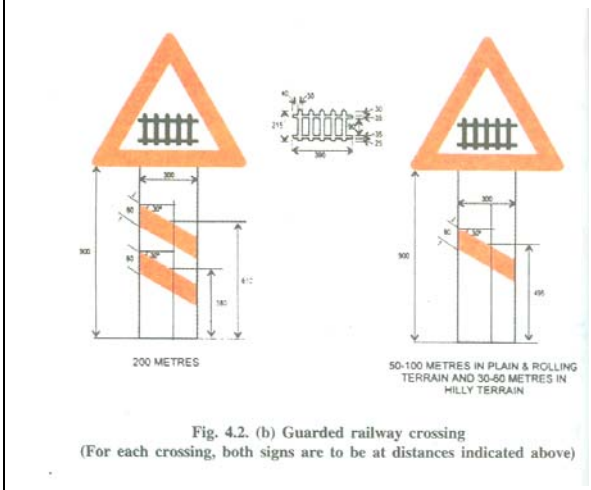


Fig. 4.2. (b) Guarded railway crossing
(For each crossing, both signs are to be at distances indicated above)

Fig. 4.2. (b).Guarded railway Crossing Sign

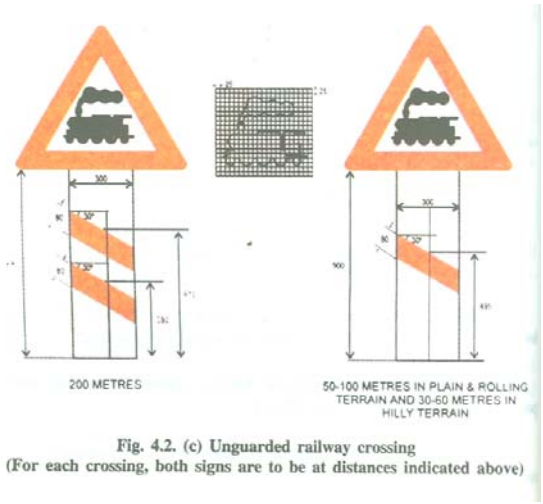


Fig. 4.2. (c) Unguarded railway crossing
(For each crossing, both signs are to be at distances indicated above)

Fig.4.2. (c)Unguarded railway Crossing Sign

Fig. 4.1. Some of the mandatory/regulatory signs

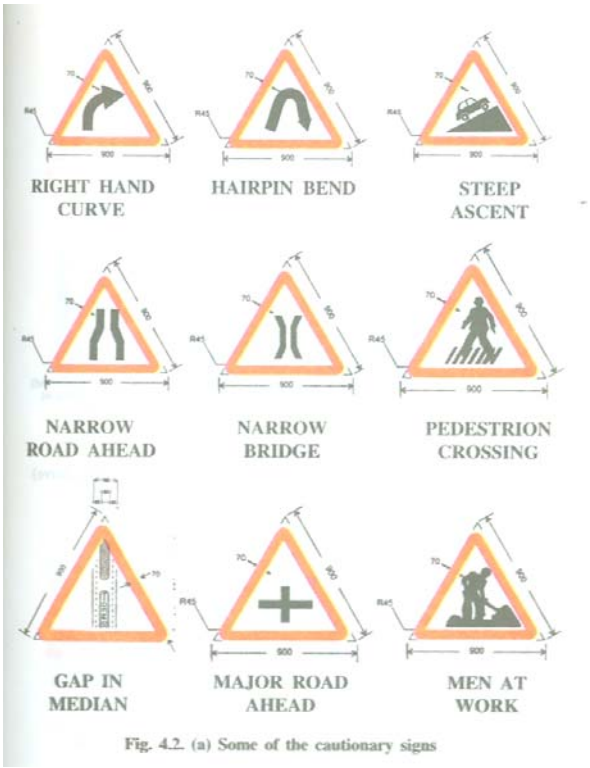


Fig. 4.2. (a) Some of the cautionary signs

Fig. 4.1 Some Mandatory/Regulatory Signs **Fig. 4.2. (a) Some Cautionary Signs**

4.1.10 Informatory signs: A few of the Informatory signs are shown in Fig. 4.3.

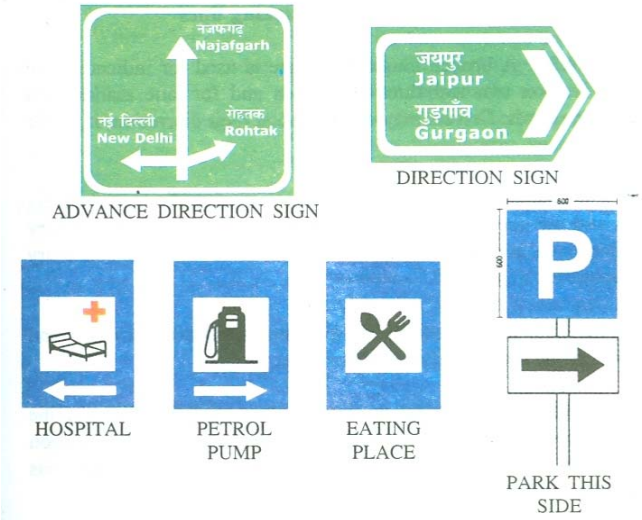


Fig. 4.3. Some of the informatory signs

Fig. 4.3. Informatory signs

Table 4.2. Sitting of signs

Description	Kerbed roads	Un-kerbed roads
Min. lateral clearance from carriageway edge	60 cm	2-3 m
Min. vertical clearance	2 m above kerb	1.5 m above pavement crown

4.1.11 Guidelines on use of retro-reflective sheetings for road signs

4.1.11.1 Retro-reflective sheetings of high intensity grade shall be used for :

1) All road signs on 4-lane National Highway Sections and two-lane sections which are to be widened to four-lanes.

2) Mandatory/regulatory and cautionary/warning signs on two-lane National Highway section.

3) All overhead signs.

4.1.11.2 Retro-reflective sheetings of 'engineering grade' shall be used for informatory signs for two-lane National Highway sections.

4.1.12 Colour Scheme

1) Colour scheme for mandatory/regulatory and cautionary warning signs shall be conform to IRC:67 "Code of Practice for Road Signs".

2) Direction, Destination and place identification signs have been green background, while messages and borders.

3) Colour scheme for facility information signs and parting signs shall be as per IRC:67.

4.2 Road Markings

4.2.1 General

Markings on the carriageway and on the objects within and adjacent to the roadway are used as a means of guiding and controlling the traffic. They promote road safety and ensure smooth flow of traffic into the required paths of travel. Complete details of the Road Markings and guidelines for their usage are contained in IRC:35 "Code of Practice for Road Markings" and Ministry's "Specifications for Road and Bridge Works (Fourth Revision)".

4.2.2 Types of carriageway marking lines

4.2.2.1 A broken longitudinal line is used for indicating the centre line on two and three-Iane roads and for lane marking on multi-lane roads. Drivers may cross these at their discretion, if traffic permits.

4.2.2.2 Longitudinal solid lines are used as guiding or regulating lines and are not meant to be crossed by the driver except for entry or exit from a premises or a side road or to avoid a stationary obstruction.

4.2.2.3 Double solid lines indicate maximum restriction and are not to be crossed except in emergent usage.

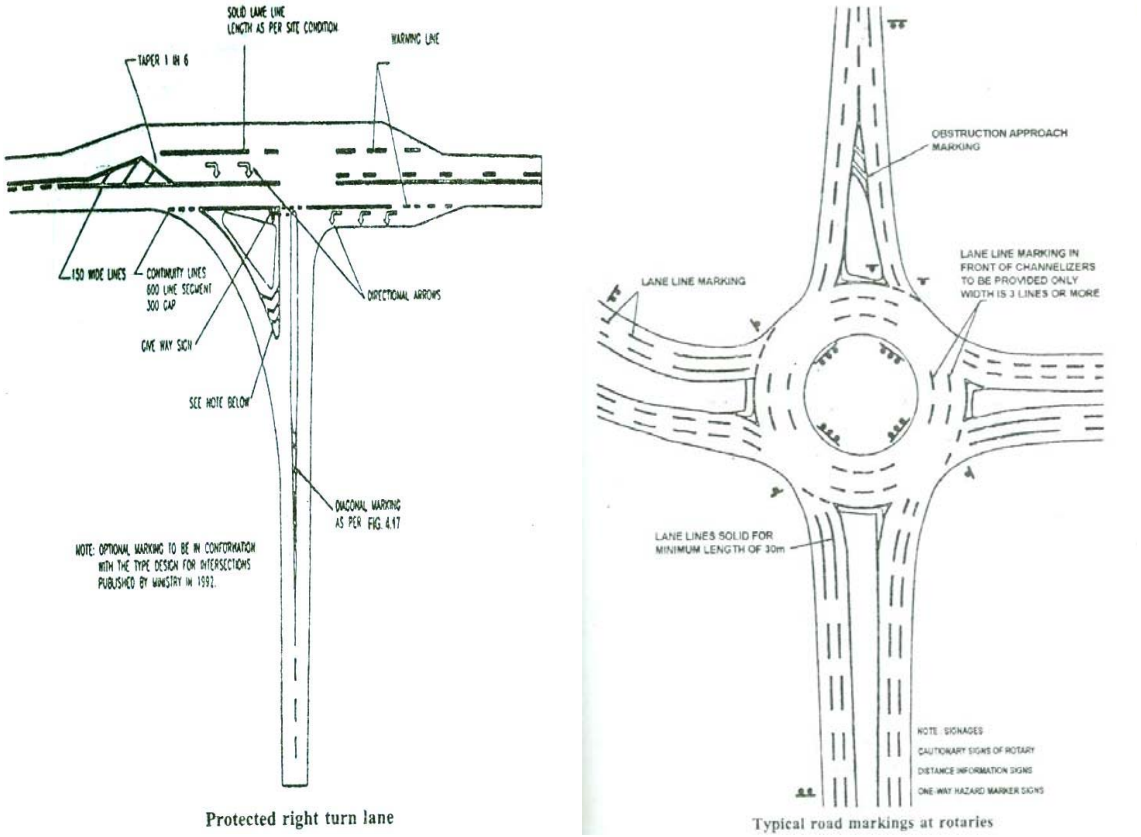
4.2.2.4 In a combination of broken and solid lines, a solid line may be crossed, with discretion, if the broken line of tile combination is nearer to the direction of travel. Vehicles from opposite directions are not permitted to cross the solid lines.

4.2.2.5 Solid lines either parallel to the intersecting roadway or at right angles to the direction of approaching traffic mark the position of a stop line before the road junction. Stop line indicates the position beyond which the vehicles should not proceed when required to stop by the traffic police, traffic signals or other traffic control devices. Stop lines shall not be used unless traffic control by any one of these means exit.

4.2.3 Materials and colours

4.2.3.1 The material commonly employed for pavement kerb and object marking is paint. Reflectorised paints have better night visibility and last longer and, therefore, not applied thermoplastic paints instead of ordinary paints, wherever feasible, may be used. For specifications on road marking materials including thermoplastic paints, reference made to clause 803 of the Ministry's specification.

4.2.3.2 The Commonly used colour for road marking are yellow, white and black.Road markings shall be of ordinary road marking paint, hot applied thermoplastic compound, or reflectorised paint as specified in the item and the material shall meet the requirements as specified below.



Protected right turn lane

Typical road markings at rotaries

Fig. 4.3. Typical road marking at Junctions, Rotaries

Table 4.3. Colour of road markings as per Indian practice

S.No.	Colour of road markings	Uses
1	white	All carriageway markings except those intended for parking restrictions, obstruction approach, no overtaking zone and continuous centre line. Objects adjacent to carriageway, such as, guard rails, guard stones or drums and trees. Trees shall be painted solid white upto a height of 1.25 m above the road level with a 300 mm band in black paint in the middle of this height for enhanced visibility that are not likely to be hit unless a vehicle runs off the carriageway.
2	yellow	i) Markings intended for parking restrictions. ii) Continuous centre and barrier line markings
3	Alternating black and yellow stripes	Markings on obstructions in the carriageway
4	Alternating white, black and stripes	Markings on kerb and adjacent to carriageway (e.g., subway piers and abutments culvert head walls, poles)

4.2.3.3 **Ordinary Road Marking Paint**

1) Ordinary paint used for road marking shall conform to Grade I as per IS : 164.

2) The road marking shall preferably be laid with appropriate road marking machinery.

3) Laying thickness of road marking paint shall be as specified by the Engineer.

4.2.3.4 **Hot Applied Thermoplastic Road Marking**

1) The work under this section consists of marking traffic stripes using a thermoplastic compound meeting the requirements specified herein.

2) The thermoplastic compound shall be screeded/extruded on to the pavement surface in a molten state by suitable machine capable of controlled preparation and laying with surface application of glass beads at a specific rate. Upon cooling to ambient pavement temperature, it shall produce an adherent pavement marking of specified thickness and width and capable of resisting deformation by traffic.

3) The colour of the compound shall be white or yellow (IS colour No. 356) as specified in the drawings or as directed by the Engineer.

4) Where the compound is to be applied to cement concrete pavement, a sealing primer as recommended by the manufacturer, shall be applied to the pavement in advance of placing of the stripes to ensure proper bonding of the compound. On new concrete surface any laitance and/or curing compound shall be removed before the markings are applied.

4.2.3.5 **Thermoplastic Material**

1) The thermoplastic material shall be homogeneously composed of aggregate, pigment, resins and glass reflectorizing beads.

2) The pigment, beads, and aggregates shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in Table 4.4

Table 4.4 Proportions Of Constituents Of Marking Material

(Percentage by weight)

Component	White	Yellow
Binder	18.0 min.	18.0 min.
Glass Beads	30-40	30-40
Titanium Dioxide	10.0 min.	-
Calcium Carbonate and Inert Fillers	42.0 max.	See
Yellow Pigments	-	Note

Note: Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provided all other requirements of this Specification are met.

3) The properties of thermoplastic material, when tested in accordance with ASTM D36/BS–3262–(Part I), shall be as below:

(**a) Luminance:**

White: Daylight luminance at 45 degrees – 65 per cent min. as per AASHTO M 249

Yellow: Daylight luminance at 45 degrees - 45 per cent min. as per AASHTO M 249

(b) Drying time: When applied at a temperature specified by the manufacturer and to the required thickness, the material shall set to bear traffic in not more than 15 minutes.

(c) Skid resistance: not less than 45 as per BS 6044.

(d) Cracking resistance at low temperature: The material shall show no cracks on application to concrete blocks.

(e) Softening point: 102.5 ± 9.5^{o} C as per ASTM D 36.

(f) Flow resistance: Not more than 25 per cent as per AASHTO M 249.

(g) Yellowness index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249

4.3 Centre lines and lane lining:

A centre line marking is employed for separating traffic in opposite directions, whereas, lane lines divide wide carriageway into separate lanes on either side of the centre line to regulate traffic into proper lanes and curb the meandering tendency of the drivers, thereby promoting safety and ensuring '1laximum capacity. Figs. 4.4. to 4.7 show the recommend practice of centre lines and lane lines.

4.4 No overtaking zones:

No overtaking zones on horizontal and vertical curves are marked in Figs. 4.8 (a) and 4.8 (b) respectively. Barrier distance on no overtaking zone is given in Table 4.5.

Table 4.5 Barrier line distance on no-overtaking zone

S.No.	85 percentile speed (kmph)	Intermediate sight Distance (m)	Barrier line Distance (m)
1	Upto 45	120	75
2	46-55	150	100
3	56-65 .	180	120
4	66-75	210	145
5	76-85	240	170

6	86-95	270	190
7	96-105	300	215
8	More than 105	330	240

4.5 Road Delineator

4.5.1 General

1) The role of delineators is to provide visual assistance to drivers about alignment of the road ahead, especially at night. Reflectors are used on the delineators for better night visibility. Delineators are classified under three types:

2) The design, materials to be used and the location of the road delineators shall conform to Recommended Practice for Road Delineators, IRC : 79, and to relevant drawings or as otherwise directed by the Engineer.

4.5.2 Roadway indicators

These are intended to delineate the edges of the roadway so as to guide drivers about the alignment ahead, particularly where it might be confusing for some reason. As a general rule, delineators posts should be erected at the edge of usable shoulder, and in the case of kerbed sections at a distance of 0.6 m to 1.5 m from the kerb face on hill roads, these may be placed either on the parapet or at the edge of the shoulder. Roadway indicators have been shown in Fig. 4.33.

Roadway indicators hall be constructed of Grade M25 reinforced cement concrete as shown on the drawings. All roadway indicators shall have reflectors attached to both sides as shown on the drawings. Reflection shall be in accordance with IRC 79-1981 and shall be firmly fixed to the roadway indicators by a method which discourages theft and is approved by the Engineer. Stone posts shall be constructed in accordance with IRC 25 “Type Designs of Boundary Stones” and the details shown on the drawings.”

4.5.3 Hazard Markers:

These are to define obstructions, like, guard-rails and abutments adjacent to the carriageway, for instance at culverts and bridges which are narrower than the roadway width at approaches. Hazard-markers are shown in Fig. 4.34.

4.5.4 Object Markers:

These are used to indicate hazards and obstruction within the vehicle flow path, for example channelising island close to intersections.

4.5.5 Boundary Stones

The work comprises of supplying and fixing boundary stones as per designs and Specifications given in IRC : 25 “Type Designs for Boundary Stones” and at locations indicated in the drawings or as directed by the Engineer.

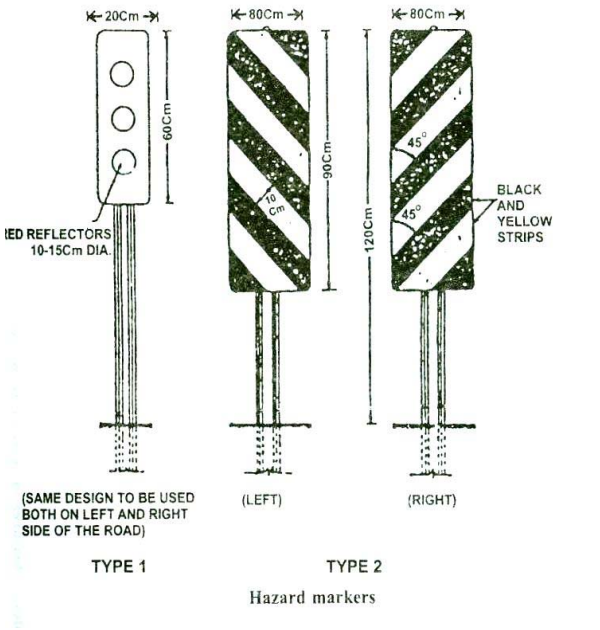


Fig. 4.4. Hazard Markers

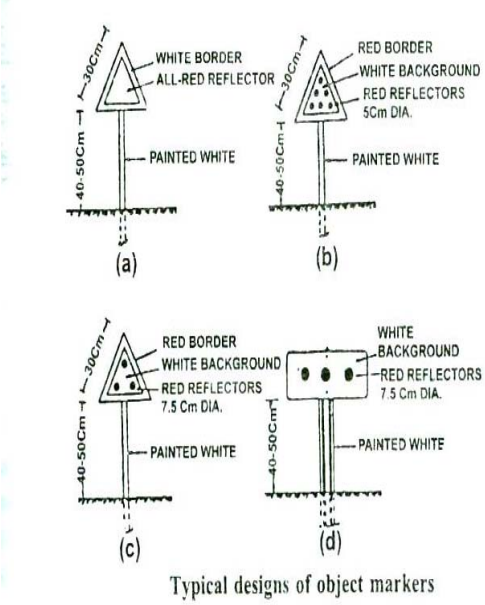
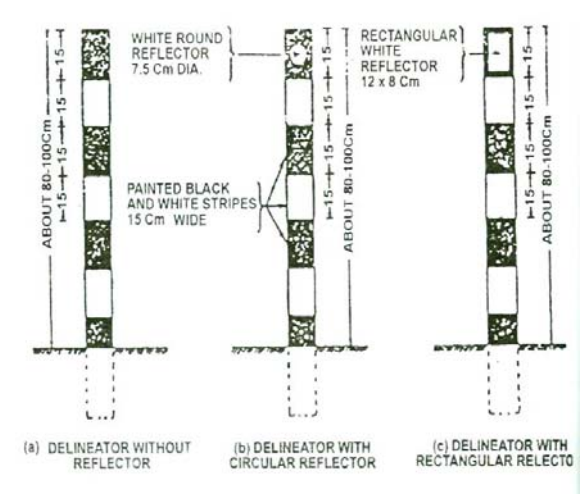


Fig. 4.5. Typical design of Object Markers



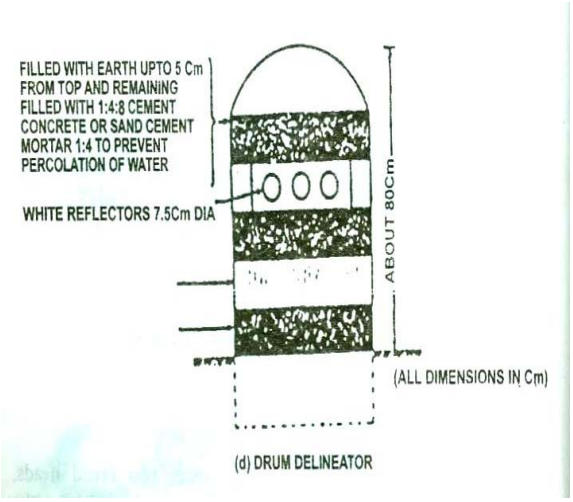
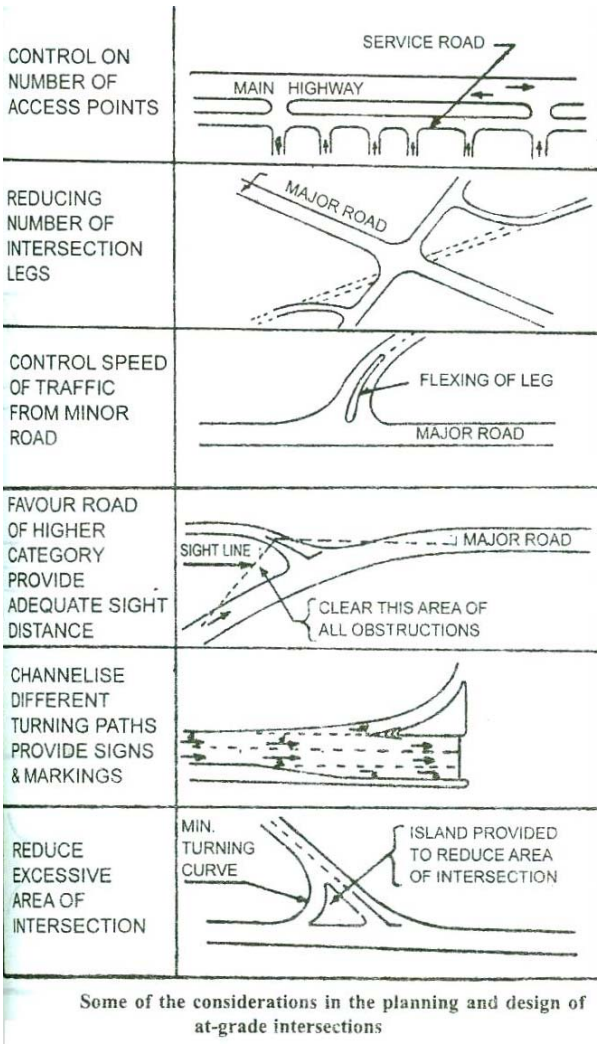
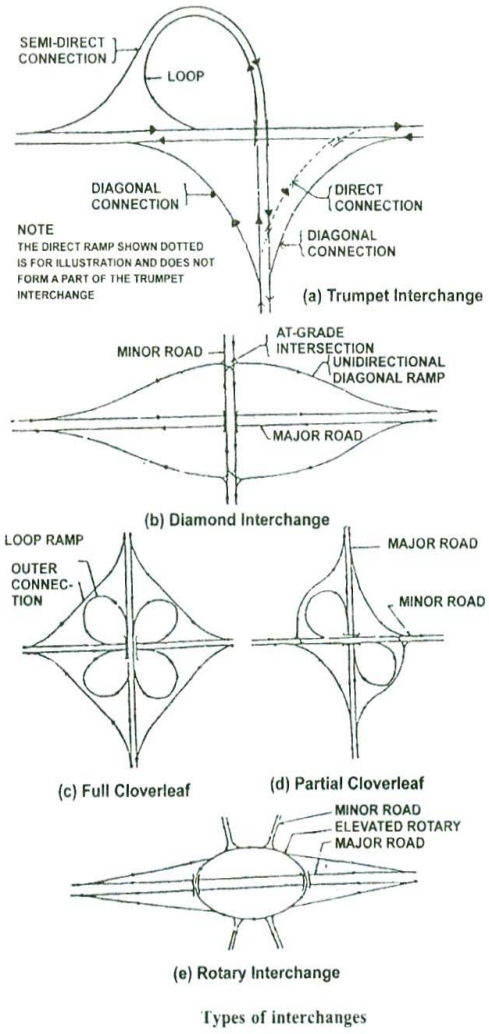


Fig. 4.6. Road Indicators



Some of the considerations in the planning and design of at-grade intersections

Fig. 4.6. Some Typical grade Intersections



Types of interchanges

Fig. 4.6. Some type Interchanges

4.6 Traffic Control Lighting Devices

1) Layout for Roads - The design, spacing and column heights are governed by the road-width and the classification of the roads. Typical layouts for various road width are given

2) Layout for Flyovers - The design .and column heights for flyovers are governed by the layout of flyovers. height above normal ground level and the:: width of the low level roads. The spacing may he governed by the. Structural design of the flyover. The layout of typical flyover is given in Figs.

3) The layout with recommended arrangement, column height and spacing for various road width on flyover are given in Table

4) The layout with recommended arrangement, column height and spacing for various widths of low level road are given in Table

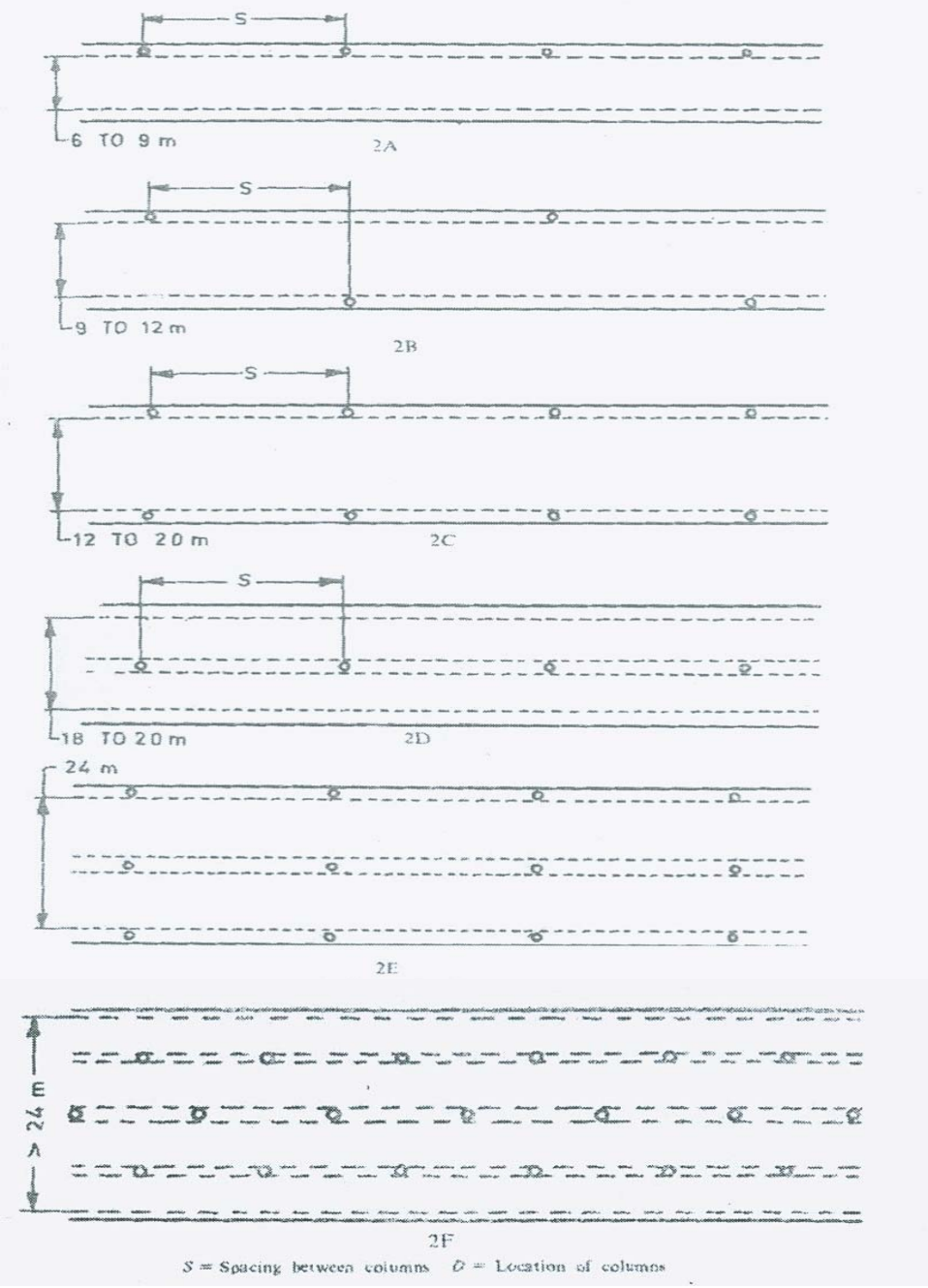


Fig.4.7 Standard Lighting Layout for Roads (Six Alternatives)

4.6.1 Junction

Spacing of the junction columns should be 50-75 percent of normal spacing of columns on the main roads. these columns may be installed on the traffic islands located at the junctions.

4.6.1.1 The level of illumination of the junction should be substantially different from the nearby road. The junction may be lighted by either of following methods:-

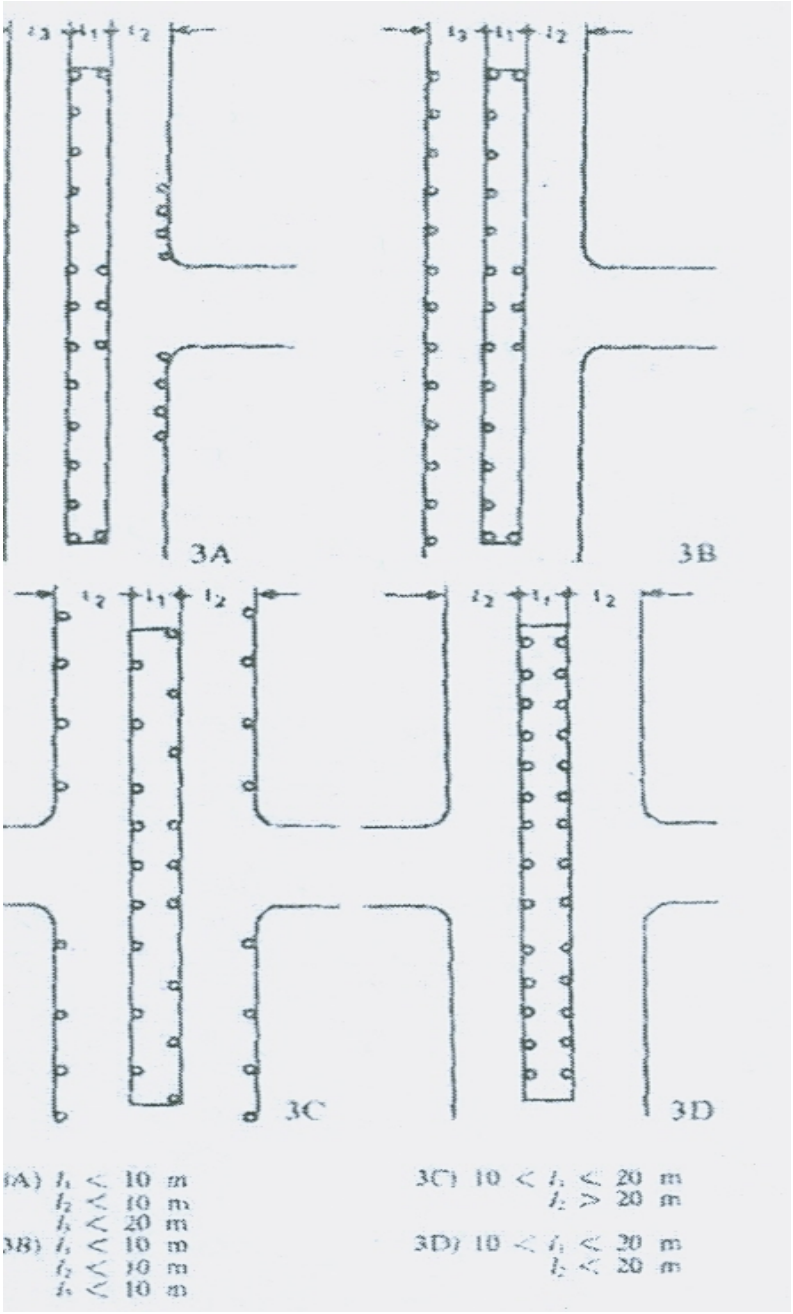


Fig.4.8 The Standard Lighting Layout of Flyover

Table No 4.6 Classification of roads and recommended arrangement of column

Width of carriageway (m)	Group	Arrangement as in fig	Column Height	Spacing
24	A1	2F	9-14	2.5 TO 3.0H
	A2	2E	9	2.5H
18-20	A1	2D	9-14	2.5 TO 3.0H
		2C	9	2.5H
	A2	2D	9	2.5 H
		2C	9	3.5H
	B1	2C	9	3.0 H
12	A2	2C	9	2.5H

	B1	2C	9	3.0H
	B2	2B	9	3.0H
	C	2B	9	2.0H
9	B2	2B	9	3.0H
	C	2B	7	3.5H
6	C	2C	7	3.5H

Table No 4.7 Recommended arrangement of Columns on flyovers

Width of carriageway (m)	Group	Arrangement as in fig	Column Height (Above flyover road level)	Spacing
12	D	3C	9	2-2.5H
	D	3B	9	2H
9	D	3A	9	2H

Table No 4.8 Recommended arrangement of Columns on Flyovers (Low level Roads)

Width of carriageway (m)	Group	Arrangement as in fig	Column Height (Above flyover road level)	Spacing
Over 20	D	3C	9	2.5H
10 to 20	D	3D	14	1.5H
Upto 10	D	3A	9	2.5H

- Higher level of illumination - In case this scheme is adopted the level of illumination should be 150 percent of the roads.

- Change in height of columns – The size of columns adopted at the junction should be higher than those adopted in roads. Recommended size are given in Table.

- Change in the colour of the light source – In case the main road is lit by HPMV lamps the junction could be lit by HPSV lamp or vice versa.

Table No4.9 Recommended variations in height of Column Junctions

Height Of Column on Roads(m)	Recommended Height of columns at Junctions m
7	9
9	14
14	High mast

4.6.1.2 The different type of junctions commonly encountered are discussed below in details as they require special consideration:

- Simple two road junction – this type of junction should be illuminated by locating the columns in such configuration that the junction is noticed by fast moving traffic. the design would depend upon existence of traffic islands at the junctions. typical layout of such junctions are shown in Fig.

- Junction of two major roads – these junctions would generally be provided with traffic island at suitable location to regulate flow of traffic. The lighting columns could be located in the island to advantage. However if the junctions are- too wide or the island. do not permit planting of poles within the desired

spacing, special considerations are required. Typical layout of such junctions are shown in Fig.

- Multi Road Junction The lighting of multiple road Junction would depend upon the geographical layout of the roads, the width of the various roads and most important, the traffic conditions. At such junctions invariable entry for traffic may not be per mined on all the roads. Similarly, the traffic islands design would change from location to location. Special consideration will have to be given to the design of lighting of such junction. Typical layout of such junctions are shown in Fig.

4.6.2 Roundabouts

4.6.2.1 Multiple road junctions with roundabout are much easier to design as a definite central roundabout is available to locate the columns. Two types of roundabouts are discussed below.

- Islands which are clear or have only parking lots - The lighting of these could be advantageously achieved by use of high mast as given in Fig. and semi-high mast lighting as in Fig, and .

- Islands which have gardens or other constructions which would be obstruction to line of vision of traffic – lighting of these could be either by semi-high mast or conventional lighting as in Fig. and

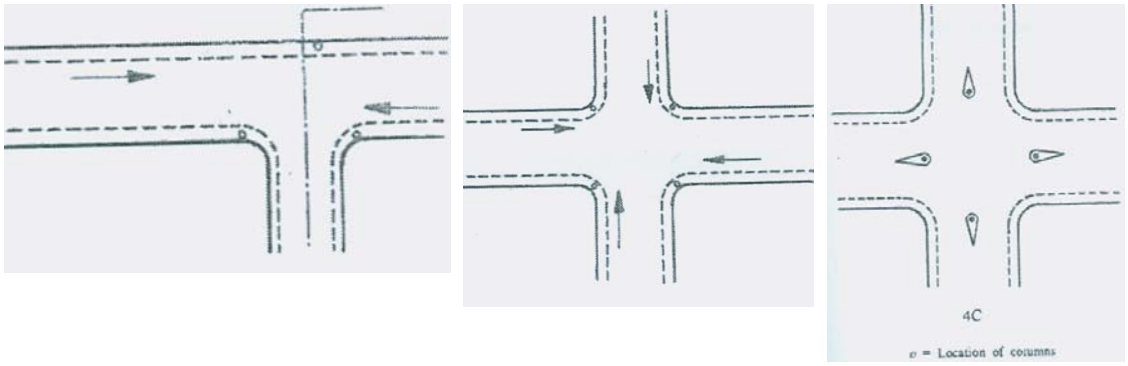


Fig.4.9Lighting layout of Sample two road Junctions (Three Alternatives)

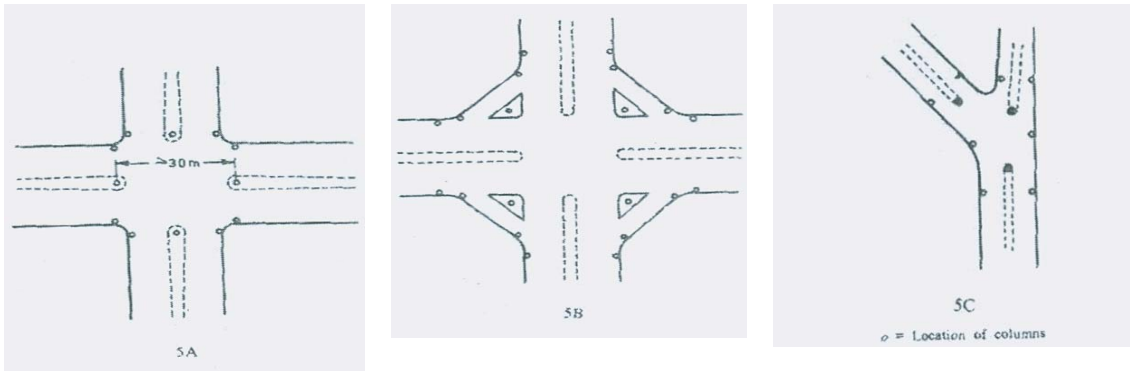


Fig.4.10Lighting layout of Junctions of two major road (Three Alternatives)

5 Common Tests on Materials and Works

A large number of tests are required to be conducted on materials incorporated and work performed in a highway project. 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 B.I.S. or other authorities as applicable.

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

1) Where facilities are available, the method consists of drying a sample of the soil in the oven at 105^0 C-110^0 C for a period (normally, not more than 24 hours) till the dry weight of the soil becomes constant.

2) 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 away of the spirit, the dish is cooled and weighed.

5.2 Liquid Limit and Plastic Limit (IS: 2720 Pt. V)

1) The liquid limit test is conducted on the standard instrument with soil specimens at various moisture contents. The liquid limit is taken as that moisture content where the standard groove will close under an impact of 25 blows.

2) The plastic limit is the water content at which the soil will begin to crumble when rolled into a thread of 3 mm in diameter. The plasticity index is taken as the difference between liquid limit and plastic limit.

5.3 Moisture-Density Relationship (IS: 2720, parts VII & VIII)

1) Two degrees of compaction, light compaction (IS: 2720, part VII) and heavy compaction (IS: 2720, VIII) are usually specified. The former compaction also goes by the term Proctor compaction and latter by the term modified Proctor.

2) In light compaction, the wet soil is compacted in three equal layers by the rammer of weight 2.6 kg and free fall 31 cm with 25 evenly distributed blows on each layer. In heavy compaction, rammer weights 4.89 kg and the free fall is 45 cm. Compaction is done in 5 equal layers, each being given 25 blows.

3) 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 (CMC).

5.4 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 cylindrical plunger of 5 cm collar and diameter gauges for measuring the expansion on soaking and the penetration values. Briefly, the test consists of causing the plunger to penetrate the compacted specimen with specified

surcharge in the mould at 1.25 mm/minute under 4 days soaked or un soaked condition. A load penetration graph it plotted correction is applied and the load corresponding to 2.5 and 5 mm penetration values are found. 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 mm penetrations are 1370 kg and 2,055 kg respectively. The CBR usually selected is at 2.5 mm penetration. For this test, only the material passing 20 mm sieve is used.

5.5 Flakiness and Elongation Indices (IS: 2386, part I)

1) The flakiness of an aggregate is defined as percentage by weight of particles in it whose least dimension (thickness) is less than three-fifths of their mean dimension. The elongation index of an aggregate is defined as the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifths times their mean dimension. The flakiness index is first determined and the elongation index is then carried out on the remaining non-flaky stone particles.

2) The representative sample of aggregates to be tested is washed dried and weighed in accordance with the prescribed method. Each particle is gauged in turn for thickness on a metal gauge of specified pattern. The cumulative total of particles passing through slots width-wise for each fraction is determined and flakiness index calculated as sum total expressed as percentage of total weight. The remaining non-flaky stone aggregates are then checked length-wise and elongated particles separated. The elongation index is the sum total weight of particles retained on slots length-wise in each fraction divided by the total weight of non-flaky stone aggregates.

5.6 Field CBR (IS:2720, Pt. XXXI)

1) The method consists of preparing the surface on which the test is to be carried out, applying the load gradually and noting down the penetration values. To reproduce the actual surface conditions it may be necessary to soak the surface to be tested to the desired degree.

2) Truck, tractor, truss or any other suitable equipment is used for providing reaction for loading. A mechanical screw loading jack with swivel head is used for applying the load to the penetration piston. For loading, the procedure is more or less same as for Laboratory CBR determination.

5.7 In-situ Density by Sand Replacement Method (IS: 2720, Pt. XXVIII)

1) 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.

2) A hole roughly 10 cm dia and 15 cm deep is made and the excavated soil is carefully collected and weighed. Sand pouring is placed on the hole and the sand allowed to run to fill up the hole.

5.8 Aggregate Impact Value (IS: 2386, part IV)

The apparatus consists of a metal base and a cylindrical steel cup of internal dia. 10.2 cm and depth 5 cm in which the aggregate specimen is placed. Metal hammer 13.5 – 14 kg weight having a free fall from a height of 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 up 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 value is expressed as the percentage of fines formed in terms of the total weight of the sample.

5.9 Bitumen Penetration Test (IS: 1203)

Test determines the hardness or softness of bitumen by measuring the depth in tenths of millimetre to which a standard loaded needle will penetrate vertically in, 5 seconds. The sample is maintained at 25^0C. The penetrometer consists of a needle assembly with a total weight of 100 grams and a device of releasing, and locking it in any position.

5.10 Marshall Stability Test (ASTN: D 1559)

1) This test is generally applicable for dense-graded hotmix asphalt mixes. The apparatus consists of a cylindrical mould of 10.16 cm dia. and 6.35 cm height with a base plate collar. The specimen is compacted by a hammer of 4.54 kg weight and having a free fall of 45.7 cm. Seventy five blows of the hammer are given on each face of the specimen for compaction.

2) The specimen is tested by applying a load on its peripherry perpendicular to its axis in a loading machine of 5 tonne capacity at the rate of 5 cm per minute. The flow value is measured as deformation in units of 0.25 mm. The test is carried out when the maximum load taken by a specimen is a temperature of 600 C. The stability value is the maximum load taken by specimen, and the flow value is deformation at this load.

5.11 Stripping Value (IS: 6241)

200 grams of aggregate passing 20 mm sieve and retained on 12.5 mm sieve is mixed with 5 per cent binder by weight heated to 1600 C. The aggregates are also heated to 1500 C prior to mixing. After complete coating, the mixture is transferred to 500 ml beaker and allowed to cool at room temperature. Distilled water is added to immerse the coated aggregates. The beaker is covered and kept at 400 C. After expiry of 24 hours, it is cooled to room temperature and the extant of stripping is estimated visually while the specimen is still under water.

5.12 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. Tests with such trays at a number of locations can also indicate the uniformity of distribution.

5.13 Tray Test 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.

5.14 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 apparatus 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 200 ml of the benzene is added and the procedure is repeated. The filter ring from the bowl is removed, dried in air and then in oven to constant weight at 1150 C and weighed.

5.15 Checking Surface Regularity Using a Straight-Edge (IRC: SP: 11)

1) 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 shod with a metallic plate. The wedge should preferably 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.

2) 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.

5.16 Water Sensitivity of Bituminous Mixes (ASTMD 1075-88)

1) At least six test specimens of 4 inches in diameter by 4 inches in height (or 101.6 mm x 101.6 mm) are made as per the standard procedure. Each set of six test specimens are sorted into two groups of three specimens each so that the average bulk specific gravity of the specimen in Group I is essentially the same as per Group 2.

2) Group 1 - The test specimens are brought to the test temperature of 77 $\pm$ 1.80 F (or 25 $\pm$ 1^0 C) by storing them in air bath maintained at the test temperature for not less than 4 hours and the compressive strengths are determined as per standard procedure.

3) Group 2 - The test specimen are immersed into water for four days at 120 + 1.80^0 F (or 49 + loc). After four days these are transferred to the second water bath maintained at 77 $\pm$ 1.8^0 F (or 25 + loc) and stored there for 2 hours. Thereafter, the compressive strengths of the specimen are determined as per the standard procedure.

4) The numerical index of resistance of bituminous mixtures to the detrimental effect of water is then calculated as percentage of original strength that is retained after immersion period as below:

Index of retained strength % = $\frac{S_2}{S_1}$ x 100)

Where

S1 = Compressive strength of immersed specimen (Group 2)

S2: Compressive strength of dry specimen (Group l)

5.17 Sand Equivalent Test (IS: 2720, Part XXXVII)

Sand equivalent may be defined as a measure of silt or clay contamination in fine aggregate as determined by test. The test provides a rapid field method for determining qualitative changes in the aggregates during production or placement.

A measured quantity of clean fine aggregate passing 4.75 mm IS sieve is poured in a graduated acrylic plastic cylinder of 32 mm inside diameter and 430 mm height. A

siphon assembly fitted in 4 litres bottle of working sodium chloride solution is placed 915 + 25 mm above the work surface. A quantity of 100 +2 mm of working calcium chloride solution is siphoned into the graduated cylinder followed by tapping of the cylinder on palm of the hand for expulsion of air bubbles. The specimen is then irrigated with irrigator tube for flushing fines upwards until the final level in the cylinder stands at 380 mm. Stabbing and twisting with irrigator tube is continuously done to ensure that the clay-like-material is forced into suspension above the sand. After the prescribed sedimentation period of 20 minutes the height of flocculated clay is read and height of sand in the cylinder is determined. Sand equivalent is calculated as follow:

$$SE = \frac{Sr}{Cr} \times 100$$

Where

SE: Sand Equivalent
Sr : Sand reading
Cr : Clay reading

Note :Certain precautions are necessary for the test which maybe followed to arrive at reliable results.

5.18 Soundness Test (15:2386, Part-V)

Clean, dry aggregates are sieved through a set of sieve and separated into different sizes. Each fraction is weighed and immersed in the saturated solution of sodium sulphate or magnesium sulphate for 16 to 18 hours, and thereafter dried in an oven at 105-100^0 c to a constant weight, thus making one cycle of immersion and drying. The test is repeated on each fraction for specified number of cycles. After completing the, last cycle, the sample is dried and each fraction of the aggregate is examined visually to see if there is any evidence of excessive splitting crumbling or disintegration of the grains. Each fraction is sieved through specified sieve size and percentage of sample passing through the sieve is recorded as a loss. The weighted average loss is then calculated as prescribed.

5.19 Los Angeles Abrasion Test (IS: 2386, Part-IV)

This test is for measuring abrasion resistance of aggregates. Apparatus consists of a circular drum of internal diameter of 700 mm and length 500 mm mounted on horizontal axis. An abrasive charge consisting of cast iron spherical bails of 48 mm dia (weight 390-445 gm) which is placed in the drum along with the aggregates (weight 5-10 kg). The drum is rotated with a speed of 30-33 R.P.M. for 500-1000 revolutions, depending upon the gradation of the material. After specified revolutions, the material passing through 1.7 mm sieve (fines) is separated. The weight of fines expressed as percentage of the total weight of the sample is the Los Angeles Abrasion value.

5.20 Swell Test

1) Two specimens are prepared using the estimated optimum bitumen content. The specimen are compacted at 110^0 C using a kneading Compactor, with a circular ram the pressure of which increases without impact and maintained for about 0.4 seconds and then released.

2) The compacted specimen is allowed to stand at room temperature for at least one hour to permit rebound after compaction before it is subjected to Swell Test. For the test the mould together with a specimen is placed in 190 mm diameter × 64 mm deep aluminium pan with perforated bronze disc on the specimen. Then a tripod fitted with dial gauge assembly is attached to the bronze disc to give reading of 2-54 mm on the dial gauge. This is followed by addition of 500 ml of water on the top of the specimen and the distance from the top of mould to the surface of water is measured. After twenty-four hours the dual gauge is again read nearest to 0.025 mm and the change in the reading is recorded as well. Also, the distance from top of the mould to surface of water is measured with the graduated scale and the change recorded as permeability or amount of water in millilitres that percolates into the test specimen.

5.21 Water Absorption Test (15:2386, Part III)

A sample of stone aggregate of weight not less than 2000 gm is placed in wire basket and immersed in distilled water at temperature between 22^0 C and 32^0 C with a cover of at least 5 cm above the top of the basket. Immediately, after immersion the entrapped air is removed and the sample is kept immersed in water for 24 + ½ hours. The basket containing the sample is weighed in Water (Weight A_1). Thereafter, the basket is emptied and weighed in water (Weight A_2). The aggregate are then surface dried and weighed in air (Weight B). Now the aggregates are oven dried and cooled, and weighed (Weight C) in air.

Specific gravity: C/(B-A)

Apparent specific gravity: C/(C-A)

Water Absorption: $\frac{100\ (B-C)}{C}$

Where,

A : Weight in gm of saturated aggregate in water (A_1- A_2)

B : Weight in gm of saturated aggregate in air

C : Weight in gm of oven-dried aggregate in air

5.22 Determination of Polished Stone Value (BS: 812, Part 114-1989)

Refer relevant Code.

REFERENCES
(A) List of IRC Publications referred to in this Pocket Book

Number Designation	Title
IRC: 10-1961	Recommended Practice for Borrow pits for Road Embankments Constructed by Manual Operation
IRC: 12-1983	Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling and Motor-Fuel Filling-cum-Service Stations (Second Revision)
IRC: 32-1969	Standard for Vertical and Horizontal Clearances of overhead Electric Power and Telecommunication Lines as Related to Roads
IRC: 35-1997	Code of Practice for Road Markings (with Paints) (First Revision)
IRC: 37-2001	Guidelines for the Design of Flexible Pavements (Second Revision)
IRC: 38-1988	Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)
IRC: 39-1986	Standards for Road-Rail Level Crossings (First Revision)
IRC: 41-1997	Type Designs for Check Barriers (First Revision)
IRC: 52-2001	Recommendations About the Alignment Survey and Geometric Design of Hill Roads (Second Revision)
IRC: 53-1982	Road Accident Forms A-1 and 4 (First Revision)
IRC: 62-1976	Guidelines for Control of Access on Highways
IRC: 64-1990	Guidelines for Capacity of Roads in Rural Areas (First Revision)
IRC: 65- 1976	Recommended Practice for Traffic Rotaries
IRC: 66-1976	Recommended Practice for Sight Distance on Rural Highways
IRC: 67-2001	Code of Practice for Road Signs (First Revision)
IRC: 73-1980	Geometric Design Standards for Rural (Non- Urban) Highways
IRC: 77-1979	Tentative Guidelines for Repair of Concrete Pavements Using Synthetic Resins
IRC: 78-2000	Standard Specifications and Code of Practice for Road Bridges, Section VII- Foundations & Substructure (Second Revision)
IRC : 81-1997	Tentative Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique (First Revision)
IRC : 92-1985	Guidelines for the Design of Interchanges in Urban Areas
IRC : 99-1988	Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads
IRC : 102-1988	Traffic Studies for Planning Bypasses Around Towns
IRC : 103-1988	Guidelines for Pedestrian Facilities
IRC: 106-1990	Guidelines for Capacity of Urban Roads in Plain Areas
IRC : 108-1996	Guidelines for Traffic Prediction on Rural Highways
IRC : SP: 11-1988	Handbook of Quality Control for Construction of Roads and Runways (Second Revision)
IRC : SP: 14-1973	A Manual for the Applications of the Critical Path Method to Highway Projects in India
IRC : SP: 19-2001	Manual for Survey, Investigation and Preparation of Road Projects (Second Revision)

IRC: SP: 21-1979	Manual on Landscaping of Roads
IRC: SP: 41-1994	Guidelines on Design of At Grade Intersections in Rural & Urban Areas
IRC: SP: 48-1998	Hill Road Manual
IRC: SP: 53-2002	Guidelines on Use of Polymer and Rubber Modified Bitumen in Road Construction (First Revision)

(B) List of Indian and Foreign Standards Referred to in this Pocket Book
(a) Indian Standards

IS: 73-1992	Paving Bitumen Specification (Second Revision)
IS: 210-1993	Grey Iron Castings (Fourth Revision)
IS: 217-1988	Cutback Bitumen-Specification (Second Revision)
IS: 226-1975	Superseded by IS: 2062
IS: 269-1989	33 Grade Ordinary Portland Cement (Fourth Revision)
IS: 383-1970	Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision)
IS: 432-1982	Mild Steel and Medium Tensile Steel Bars and Hard-drawn Steel Wire for Concrete Reinforcement
(Part-l)	Mild Steel and Medium Tensile Steel Bars (Third Revision)
IS: 455-1989	Portland Stag Cement (Fourth Revision)
IS: 456-2000	Code of Practice for Plain and Reinforced Concrete (Fourth Revision)
IS: 458-1988	Precast Concrete Pipes (with and without Reinforcement) (Third Revision)
IS: 460-1985	Test Sieves
IS: 702-1988	Industrial Bitumen (Second Revision)
IS: 808-1989	Dimensions for Hot Rolled Steel Beam, Column Channel and Angle Sections (Third Revision)
IS: 961-1975	Superseded by IS: 8500
IS: 1030-1998	Carbon Steel Castings for General Engineering Purposes (Fifth Revision)
IS: 1077-1992	Common Burnt Clay Building Bricks (Fifth Revision)
IS: 1139-1966	Superseded by IS: 1786
IS: I 148-1982	Hot Rolled Rivet Bars (upto 40 mm dia) for Structural Purposes (Third Revision)
IS: 1149-1982	High Tensile Rivet Bars for Structural purposes (Third Revision)
IS: 1161-1979	Steel Tubes for Structural purposes (Third Revision)
IS: 1199-1959	Method of Sampling and Analysis of Concrete
IS: 1203-1978	Determination of Penetration (First Revision)
IS: 1205-1978	Determination of Softening Point (First Revision)
IS: 1212-1978	Determination of Loss of Heating (First Revision)

IS: 1216-1978	Determination of Solubility in Carbon Disulphide or Carbon Tetra chlorate or Trichloroethylene (First Revision)
IS: 1217-1978	Determination of Mineral Matter (Ash) (First Revision)
IS: 1239-1990 (Part l)	Mild Steel Tubes (Fifth Revision)
IS: 1239-1990 (Part 2)	Mild Steel Tubular and other Wrought Steel pipe Fittings (Third Revision)
IS: 1489- 1991 (Part l)	Portland-Pozzolana Cement Fly Ash based (Third Revision)
IS: 1498-1970	Classification and Identification of Soils for General Engineering Purposes (First Revision)
IS: 1514-1990	Methods of Sampling and Test for Quick Lime and Hydrated Lime (First Revision)
IS: 1730-1989	Dimensions for Steel Plates, Sheets Strips and Flats for General Engg. Purposes (Second Revision)
IS: 1731-1971	Dimensions for Steel Flats for Structural and General Engg. Purposes
IS: 1732-1989	Dimensions for Round and Square Steel Bars for Structural and General Engineering purposes (Second Revision)
IS: 1785- 1983	Plain Hard-drawn Steel Wire for Pre stressed Concrete
(Part II)	As Drawn Wire (First Revision)
IS: 1786-1985	High Strength Deformed Steel Bars and Wires for Concrete Reinforcement (Third Revision)
IS: 1852-1985	Rolling and Cutting Tolerances for Hot Rolled Steel Products (Fourth Revision)
IS: 1875-1992	Carbon Steel Billets, Blooms, Slabs and Bars for Forgings (Fifth Revision)
IS: 1938-1990	Cotton Cambs for Use in Jute Looms (Second Revision)
IS: 1978-1982	Line Pipe (Second Revision)
IS: 2004-1991	Carbon Steel Forging for General Engineering Purposes (Third Revision)
IS: 2062-1999	Steel to General Structural Purpose (Fifth Revision)
IS: 2090-1983	High Tensile Steel Bars Used in Pre stressed Concrete (First Revision)
IS: 2132-1986	Code of Practice for Thin Walled Tube Sampling of Soils (Second Revision)
IS: 2386-1963	Methods of Test for Aggregates for Concrete
(Part 1)	Particle Size and Shape
(Part 3)	Specific Gravity, Density, Voids, Absorption and Bulking
(Part 4)	Mechanical Properties
(Part 5)	Soundness
IS: 2586-1986	Bench Vices (Second Revision)
IS: 2720	Methods of Test for Soils
(Part 2)-1973	Determination of Water Content (Second Revision)
(Part 4)-1985	Grain Size Analysis (Second Revision)
(Part 5)-1985	Determination of Liquid and Plastic Limits (Second Revision)

(Part 7)-1980	Determination of Moisture Content/Dry Density Relation Using Light Compaction (Second Revision)
(Part 8)- 1983	Determination of Water Content-Dry Density Relation Using Heavy Compaction (Second Revision)
(Part 11)-1993	Determination of the Shear Strength Parameters of a Specimen Tested in Unconsolidated Untrained Tri axial Compression without the Measurement of Pore Water Pressure (First Revision)
(Part 12)-1981	Determination of Shear Strength Parameters of Soil from Consolidated Untrained Tri axial Compression Test with Measurement of Pore Water Pressure (First Revision)
(Part 13)-1986	Direct Shear Test (Second Revision)
(Part 15)-1986	Determination of Consolidation Properties (First Revision)
(Part 16)-1987	Laboratory Determination of CBR (Second Revision)
(Part 27)-1977	Determination of Total Soluble Sulphates (First Revision)
(Part 31)-1990	Field Determination of California Bearing Ratio (First Revision)
(Part 37)-1916	Determination of Sand Equivalent Values of Soils and Fine Aggregates
(Part 38)-1976	Compaction Control Test (Hilp Method)
IS: 4923-1985	Hollow Steel Sections for Structural Use (First Revision)
IS: 5640-1970	Method for Determining the Aggregate Impact Value of Soft Coarse Aggregate
IS: 6006-1983	Uncoated Stress Relieved Strands for Pre stressed Concrete (First Revision)
IS: 6241-1971	Methods of Test for Determination of Stripping Value of Road Aggregates
IS: 6603-1972	Stainless Steel Bars and Flats
IS: 6909-1990	Super sulphated Cement
IS: 691 l-1992	Stainless Steel Plate, Sheet and Strip (First Revision)
IS: 6925-1973	Methods of Test for Determination of Water Soluble Chlorides in Concrete Admixtures
IS: 8041-1990	Rapid Hardening Portland Cement (Second Revision)
IS: 8112-1989	43 Grade Ordinary Portland Cement (First Revision)
IS: 8500-1991	Structural Steel - Micro alloyed (Medium and High Strength Qualities) (First Revision)
IS: 8887- 1995	Bitumen Emulsion for Roads (Cationic Type)-Specification (First Revision)
IS: 9103- 1999	Admixtures for Concrete (First Revision)
IS: 10262-1982	Guidelines for Concrete Mix Design
IS: 12269-1987	Specification for 53 Grade Ordinary Portland Cement
IS: 12330-1988	Specification for Sulphate Resisting Portland Cement
IS: 13326 (Part I)-1992	Evaluation of Interface Friction between Geo synthetics and Soil-Method of Test, Part I: Modified Direct Shear Technique
IS: 13320-1993	Fusion Bonded Epoxy Coated Reinforcing Bars
IS: SP: 23-1982	Handbook on Concrete Mixes (Based on Indian Standards)

(b) Foreign Standards

ASTM: D 977-91	Standard Specification for Emulsified Asphalt
ASTM: D-1075	Effect of Water on Cohesion of Compacted Bituminous Mixtures
ASTM: D-1559	Test for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM: D-2172-95	Standard Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM: D 2397-94	Standard Specification of Cationic Emulsified Asphalt
ASTM: D 3910-90 (Re approved 1995)	Standard Practice for Design, Testing and Construction of Slurry Seal
ASTM: D-4533	Test Method for Trapezoid Tearing Strength of Geo textiles
AASHTO:	Resistance of Compacted Bituminous Mixture to
T283-89	Moisture Induced Damage :
BS: 410-1969	Test Sieves
BS: 434 Part I	Bitumen Road Emulsions (Anionic and Cationic)
BS: 729-1971	Hot Dip Galvanized coating on Iron and Steel Articles
BS: 812-1975	Testing Aggregates
Part 114-1989	Method for Determination of the Polished-Stone Value
BS: 1449-1956	Steel Plate, Sheet and Strip
Part 1-1972	Carbon Steel Plate, Sheet and Strip
Part 2-1967	Stainless and Heat Resisting Plate, Sheet and Strip
BS: 1410-1972	Wrought Aluminium and Aluminium Alloys for General Engineering Purposes - Plate, Sheet and Strip
BS: 2000	Methods of Test for Petroleum and its Products :
Part 397-1995	Recovery of Bitumen Binders-Dichloromethane Extraction Rotary Film Evaporator Method
BS: 2870	Rolled Copper and Copper Alloys : Sheet' Strip and Foil
BS: 6906	Methods of Test for Geo textiles
Part 1	Determination of the Tensile Properties Using a Wide Width Strip
Part 3	Determination of Water Flow Normal to the Plane of the Geo textile under a Constant Head
Part 4	Determination of the Puncture Resistance (CFR Puncture Test)

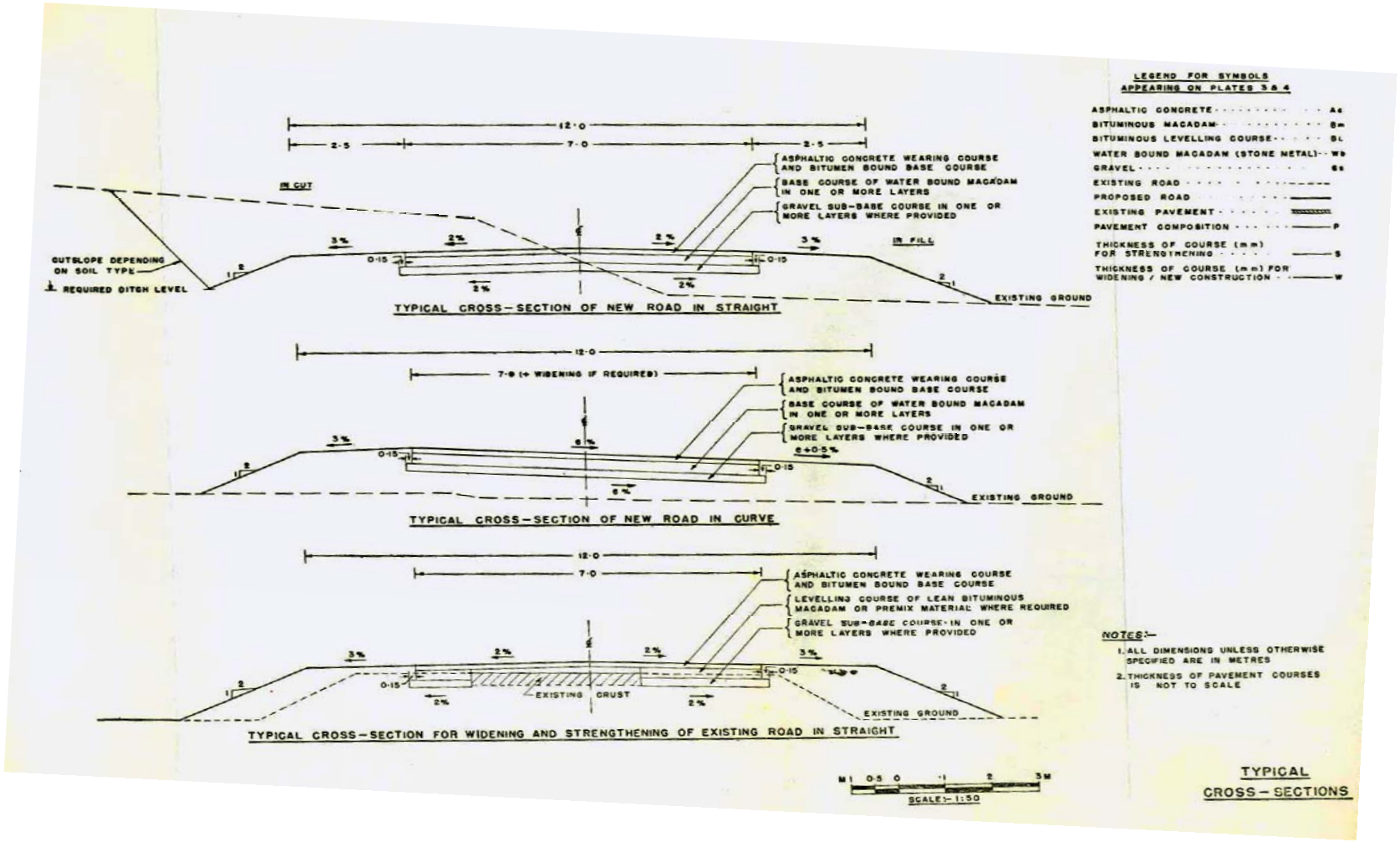


Fig. 4.11 Typical Cross Sections of Road

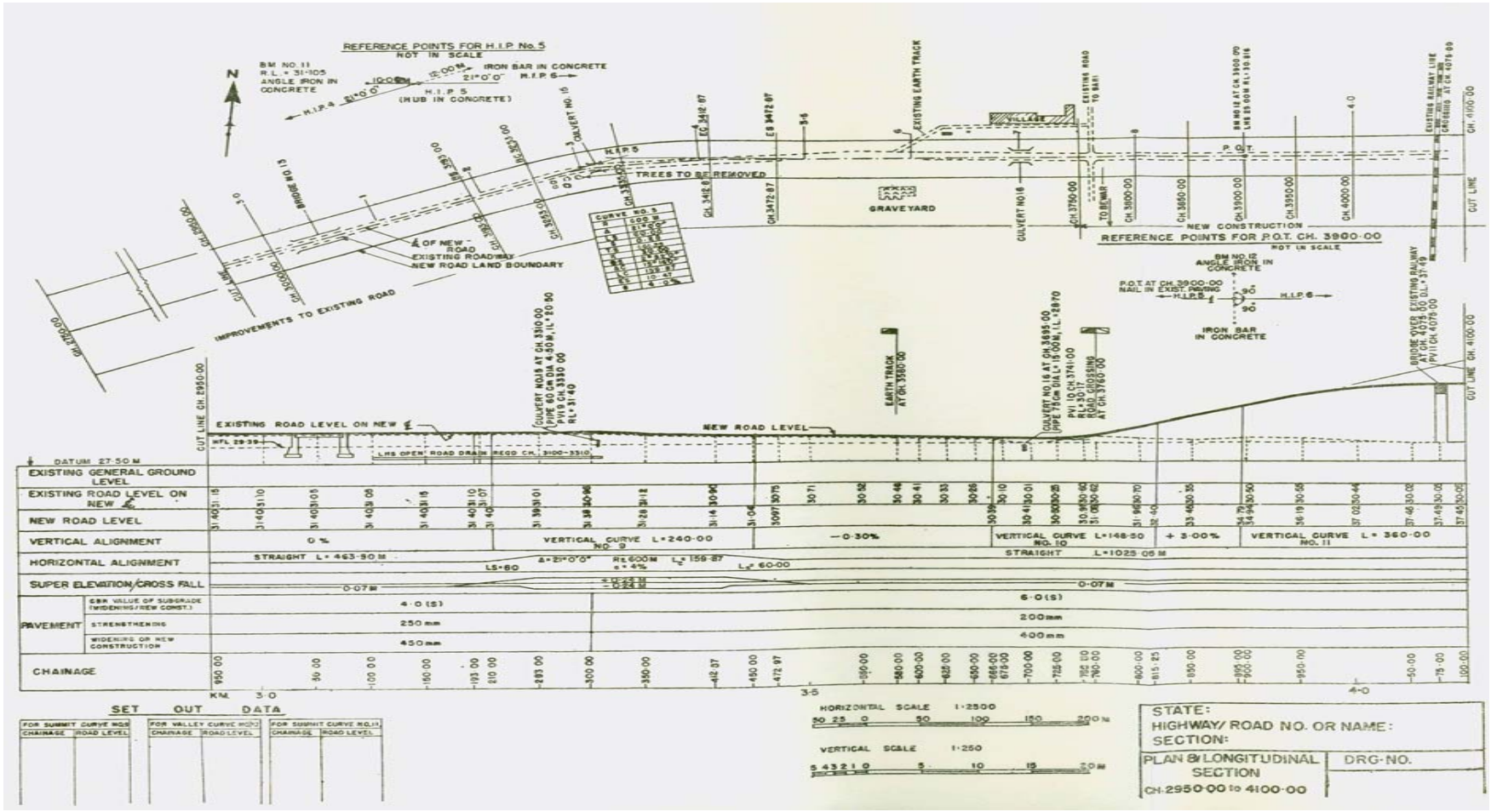


Fig. 4.12 Typical Longitudinal Section and Plan of Road

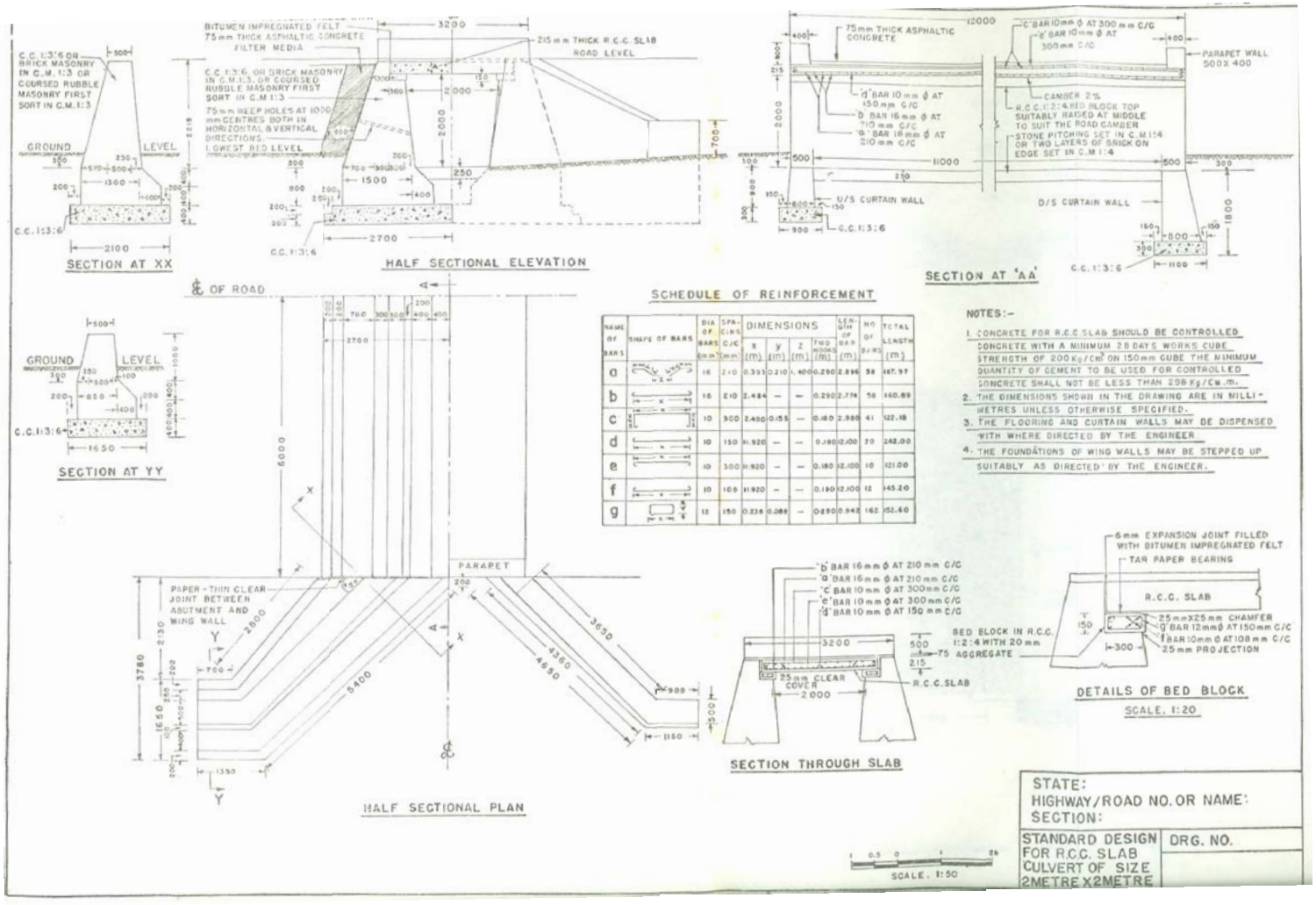


Fig. 4.13 Standard drawing of RCC slab culvert single span

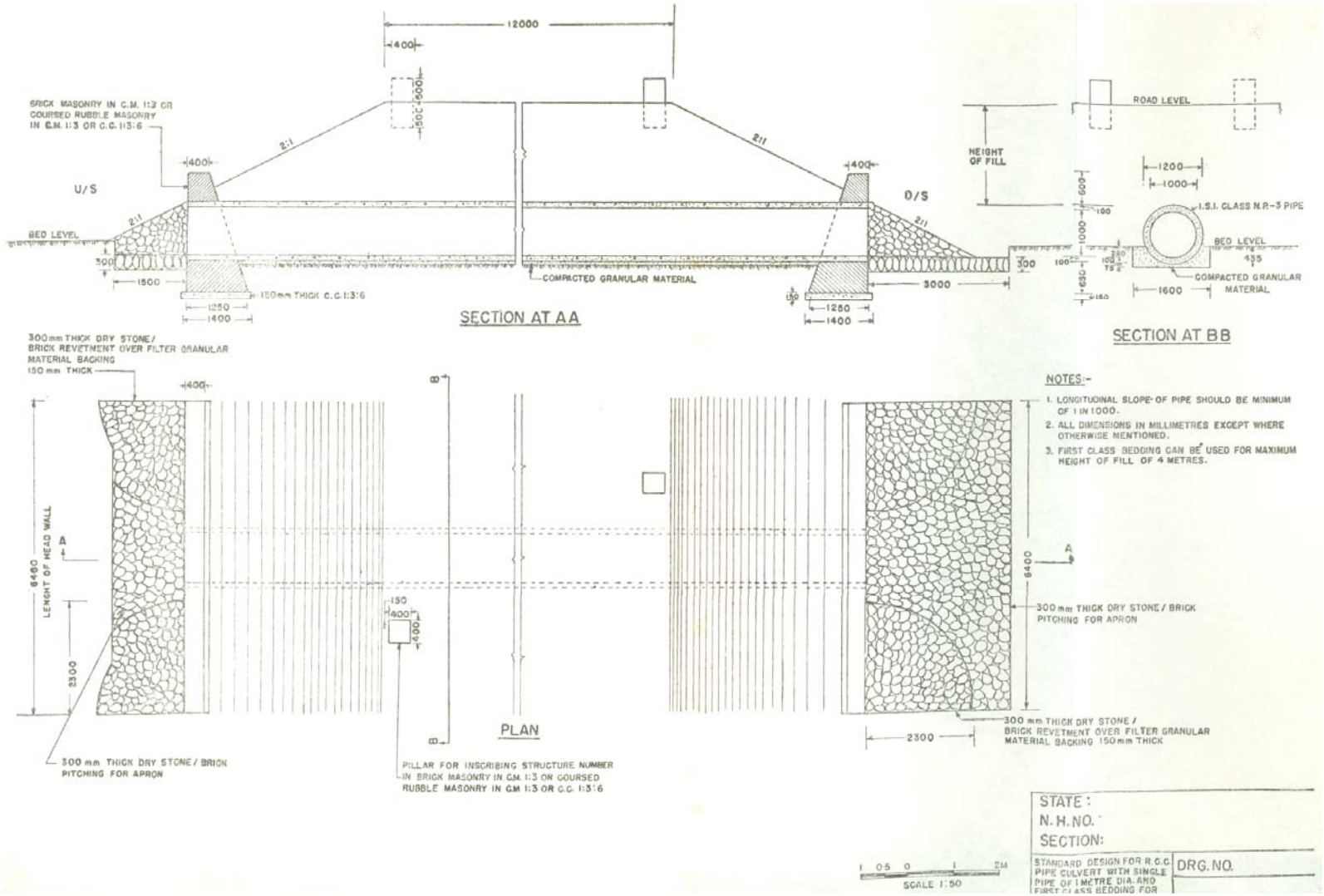


Fig. 4.14 Standard drawing of Pipe culvert

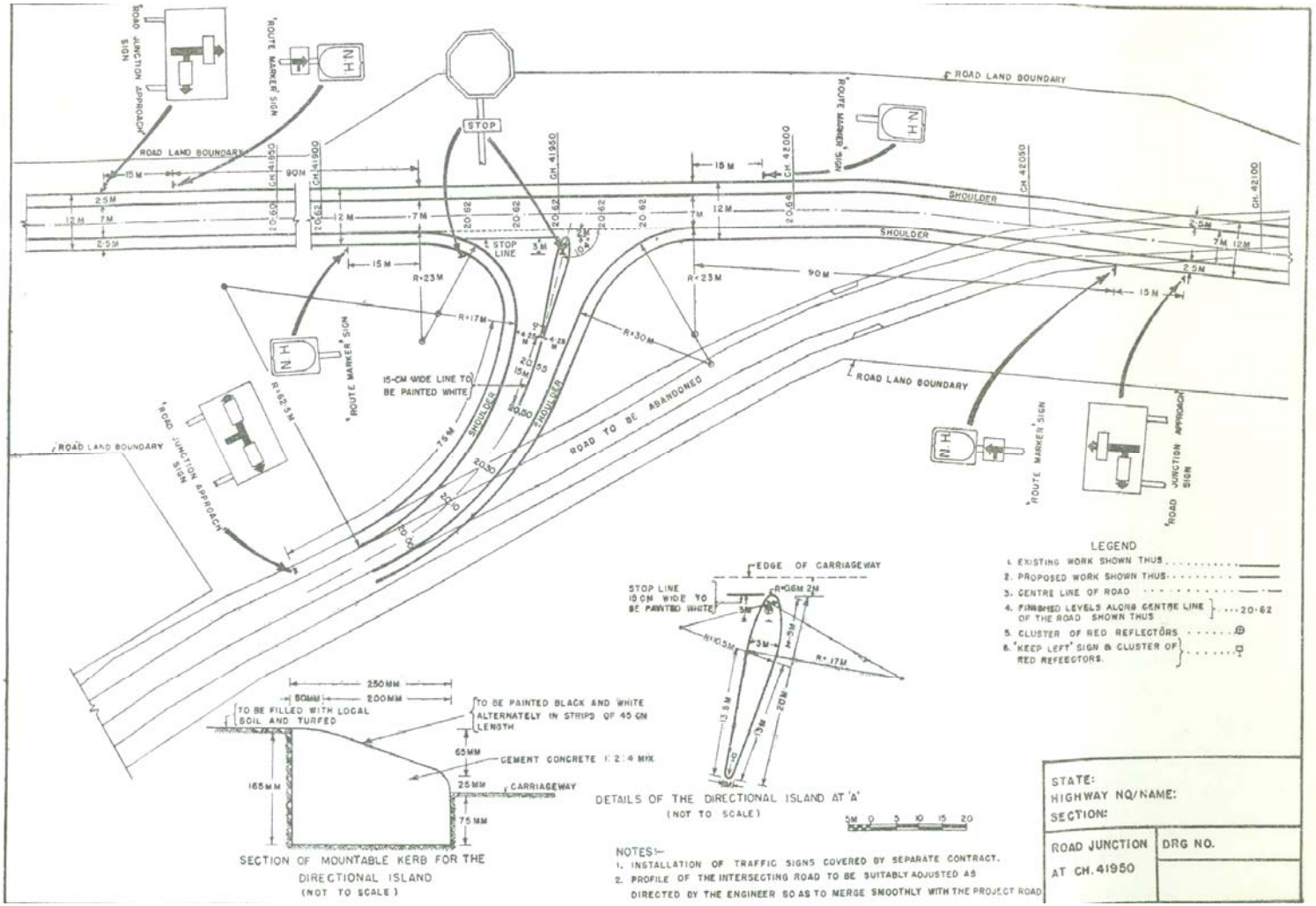


Fig. 4.12 Typical Layout Plan of Y-Junction