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01-07-2019 ൽ മറുപടിക്ക്

വണ്ടൂർ നിയോജകമണ്ഡലത്തിലെ കിഫ് ബി പദ്ധതികൾ

ചോദ്യം ശ്രീ. എ.പി. അനിൽ കുമാർ	മറുപടി ശ്രീ. ടി.എം. തോമസ് ഐസക് (ധനകാര്യവും കയറും വകുപ്പ് മന്ത്രി)
(എ) വണ്ടൂർ നിയോജകമണ്ഡലത്തിൽ കിഫ്ബിയിൽ ഉൾപ്പെടുത്തി എത്ര പ്രവൃത്തികൾക്ക് അനുമതി നൽകിയിട്ടുണ്ട്; വിശദാംശങ്ങൾ നൽകുമോ;	വണ്ടൂർ നിയോജകമണ്ഡലത്തിൽ നടപ്പിലാക്കുന്നതിനായി കിഫ്ബി ധനാനുമതി നൽകിയിട്ടുള്ള പ്രവൃത്തികളുടെ വിശദാംശങ്ങൾ അനുബന്ധം 1 ആയി ചേർക്കുന്നു. ഈ നിയോജകമണ്ഡലത്തെ സംബന്ധിക്കുന്ന കിഫ്ബി അംഗീകാരം നൽകിയ 9 പദ്ധതികളിൽ 3 പദ്ധതികളുടെ നിർമ്മാണ പ്രവർത്തികൾ അരംഭിച്ചിട്ടുണ്ട്. 4 പദ്ധതികളുടെ ടെണ്ടർ നടപടിയും ബന്ധപ്പെട്ട പദ്ധതി നിർവ്വഹണ ഏജൻസി സ്വീകരിച്ചിട്ടുണ്ട്. ബാക്കി 2 പദ്ധതികൾക്ക് കിഫ്ബി അംഗീകാരം നൽകിയിട്ടുണ്ട്. ഇടർ നടപടി ബന്ധപ്പെട്ട പദ്ധതി നിർവ്വഹണ ഏജൻസി സ്വീകരിക്കുന്നതാണ്.
(ബി) കിഫ്ബി പദ്ധതിയിൽ അനുവദിച്ച റോഡ് പ്രവൃത്തികൾക്കുള്ള മാനദണ്ഡങ്ങളിൽ എന്തെങ്കിലും മാറ്റം വരുത്തിയിട്ടുണ്ടോ; ഉണ്ടെങ്കിൽ അവ എന്തെല്ലാമാണ്; വ്യക്തമാക്കാമോ?	കിഫ്ബി പദ്ധതിയിൽ അനുവദിച്ച റോഡ് പ്രവൃത്തികൾക്കുള്ള മാനദണ്ഡങ്ങൾക്ക് കിഫ്ബിയുടെ 33 ാമത് ബോർഡ് യോഗം അംഗീകാരം നൽകിയിരുന്നു. ആയതിന്റെ പകർപ്പ് അനുബന്ധം 2 ആയി ചേർക്കുന്നു. അനുബന്ധത്തിലെ പേജുകളുടെ എണ്ണം അധികമായതിനാൽ ടി അനുബന്ധം സോഫ്റ്റ് കോപ്പി ആയി സമർപ്പിക്കുന്നു.

സെക്ഷൻ ഓഫീസർ

അനുബന്ധം-1

KIIFB Projects in Wandoor Constituency

Main Project	Project Name	KIIFB approved Amount (Rs in crore)	Status
PPE Mission- Upgradation of one school in each constituency	Thuvur Govt. H.S.S	5	Work Started
Hill Highway	Pookottumpadam – Kalikavu – Kerala estate – Kizhakkethala Karuvarakundu - Chirakkal – Pulvetta – Karinkanthoni – Ponapara in Malappuram District (in Wandoor and Nilambur Constituency)	103.11	KIIFB Approved
Distribution system in 9 projects	CWSS to Thiruvali & Adjoining Villages-Phase I & II-Thiruvali and Wandoor Part-1	22.20	Work Started
Betterment of infrastructure facilities in 229 schools	Thiruvaly GHSS	3	Work Tendered
	GHSS Karuvarakundu	2.83	
	GHSS, Vaniyambalam	3	
	GHS Anchachavady	3	
	GGVHSS Wandoor	3	Work Started
182 Roads	Improvements and Providing BM&BC Works between km 4/350-11/900 of Poolamanna - Thaliyamkundu-Vaniyambalam Road in Malappuram District.	21.4	KIIFB Approved

GUIDELINES FOR PLANNING AND DESIGN FOR ROADS & HIGHWAY PROJECTS FUNDED BY KIIFB

Version 1.0

02 July 2018

CONTENTS

1. TYPES OF ROADS FUNDED BY KIIFB

KIIFB shall undertake the funding of two main types of road/highway projects viz., new formation and upgradation of road/highway projects which include improvement/strengthening and/or widening works.

Among the afore mentioned types of road/highway projects, the funding shall be restricted to the following categories of road/highway projects

- State Highways
- Bypass (to NH / SH / MDRs) / Ring road Projects
- Hill Highway
- Coastal Highway
- Other KIIFB Roads
- City Roads (Arterial Roads)

2. STAGES IN PROJECT PREPARATION

The stages involved in the preparation and sanction of road projects are:

a) Pre-feasibility study

The pre-feasibility study is necessary to enable the funding agency to appreciate the features of the project. This is to be done based on reconnaissance survey by collecting information based on the present status of the road and the anticipated traffic after development/improvement

b) Feasibility study /Preliminary project report preparation

The feasibility study is intended to establish whether the proposal is acceptable in terms of soundness of engineering design and expected economic benefits from the project for the investment involved.

c) Detailed engineering and plan of construction

Detailed engineering covers detailed alignment surveys, soil and materials surveys, pavement design studies, drainage studies, environmental management plan based on environmental impact assessment studies (if required), detailed drawings, estimates and implementation schedules and documents.

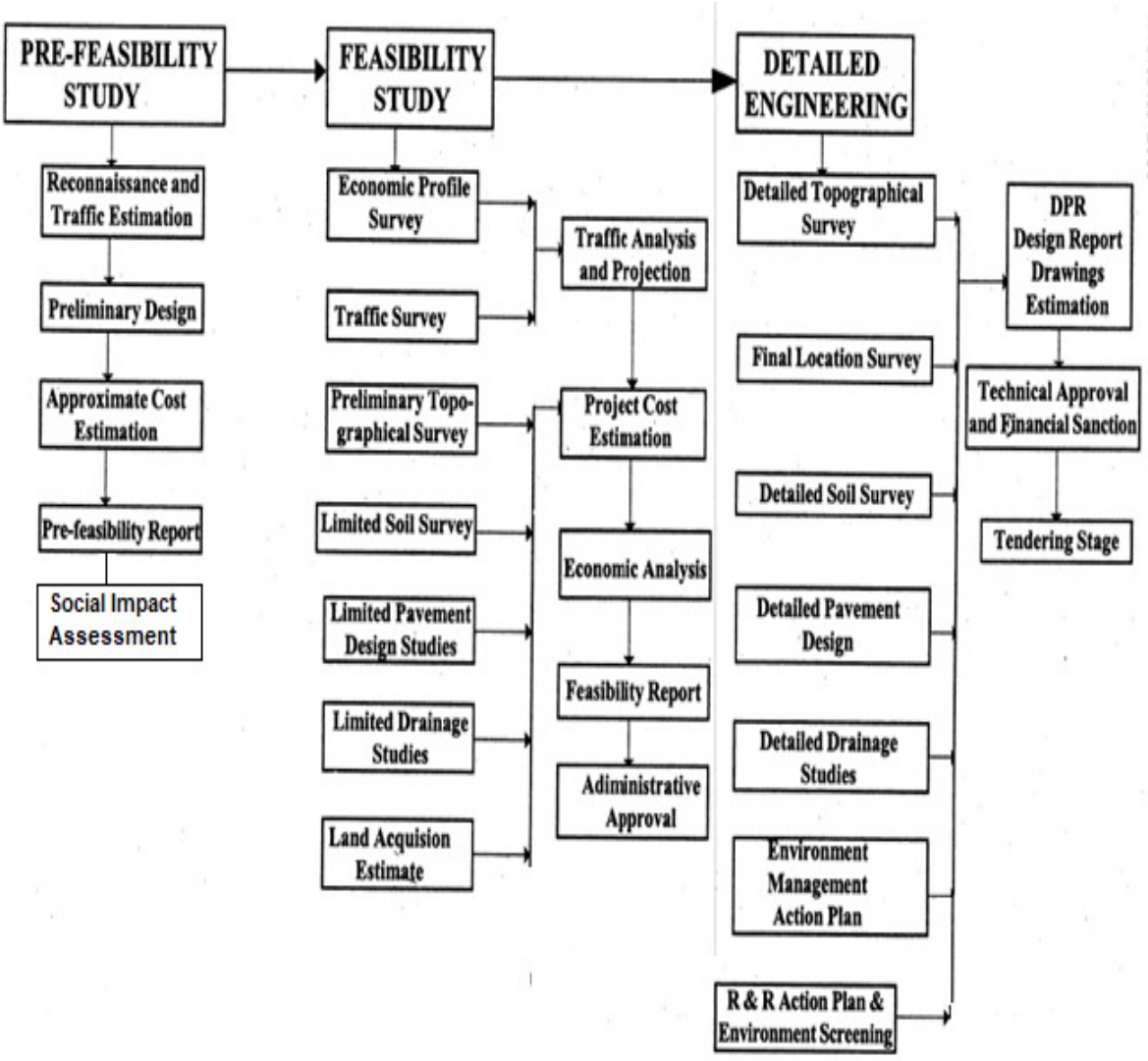


Figure: 1. Steps involved in Road project preparation

3. REQUIREMENTS FOR DEMAND ANALYSIS STUDY

The codes, standards and technical specifications applicable for the design of project components are

- Indian Roads Congress (IRC) standards and specifications(Latest).
- Specifications for Road and Bridge Works, Ministry of Road Transport & Highways herein after referred to as MoRTH Specifications Fifth Revision, 2013
- Any other standards referred to in the manual and any supplement issued with the bid document.
- The latest version of the codes, standards, specifications, etc. notified/published at least 60 days before the last date of bid submission shall be considered applicable.

- In the absence of any specific provision on any issue in the aforesaid codes or specifications read in conjunction with the specifications and standards contained in this Guidelines, the following standards shall apply in the order of priority:

  (i) Bureau of Indian Standards (BIS).

  (ii) British Standards, Australian Standard, American Association of State Highway and Transportation Officials (AASHTO) Standards and American Society for Testing and Materials (ASTM) Standards.

  (iii) Any other specifications/standards proposed by the concessionaire/contractor and concurred by the Technical Sanction Authority and KIIFB.

  (vi) The DPR should be prepared strictly as per IRC: SP:19-2001

Table: 1. List of study reports that are required to be submitted along with DPRs

Type of reports	New formation	Improvement works
Classified traffic volume Count	-	Yes
Traffic survey for Junction designing	-	Yes
Traffic survey for RoBs/Subways	-	Yes
Origin Destination Survey	Yes	Desirable
Speed and Delay studies	Desirable	Yes
Axle load survey	Desirable	Desirable
Accident Records	-	Desirable
Hydrological studies	Desirable	Desirable
Pavement condition survey	-	Yes
Pavement evaluation	-	Yes
Soil Investigation	Yes	Yes
Pavement design	Yes	Desirable
Strengthening/Rehabilitation Design	-	Yes

a) Traffic volume count to be conducted for a minimum of three consecutive days that may include working day and market day. Classified traffic volume count is carried out as per IRC: SP:19-2001 and the design traffic estimated as per Clause 4.6 of IRC:37-2012 or as per IRC: SP:72-2015, depending on the volume of traffic.

b) O-D survey, speed & delay studies shall be conducted in improvement works where extensive improvements are being undertaken (for example: bypass/ring road, etc). The survey shall conform to IRC: 102.

c) Traffic survey for the design of road junction/at-grade intersections shall conform to IRC: SP-41.

d) One-day axle load survey should be conducted, for road improvement projects, as per IRC:37-2012 / IRC: SP:19. For all roads that are expected to carry design traffic more than 5 msa, axle load survey shall mandatorily be conducted. For low volume roads, indicative VDF values as per IRC:37-2012 may be considered.

e) Traffic growth rate for the traffic projection to be followed as per IRC: 108.

f) In case of low volume roads, the relevant IRC viz., IRC: SP:72-2015 may be referred for the design of the pavement thickness.

4. REQUIREMENTS FOR SURVEY AND INVESTIGATIONS

4.1Reconnaissance survey

Reconnaissance survey is done to be examine the general characteristics of the area for determining the most feasible route or routes for furthermore detailed investigations. Reconnaissance survey of the roads are to be conducted for the general assessment of the existing situation and level of improvement needed.

Table:2. Types of survey and investigation

Types of survey and investigation	New formation	Improvement/Strengthening works
Road inventory	-	Mandatory
Pavement Condition Survey	-	Mandatory
Pavement Evaluation Survey	-	Mandatory
Soil investigation	Mandatory	Mandatory
	Detailed investigation of landslides may be done compulsorily in Hill highways. Reference may be made to IRC SP:15	
Soil tests including Atterberg limits, wet sieve analysis, max dry density and OMC tests, California Bearing Ratio (CBR) test (soaked/ un-soaked or both) of the existing soil subgrade	Mandatory	Mandatory when widening or full depth reinstatement is proposed

a) Topographic surveys are conducted preferably using LIDAR and the data used to plot the LS and CS. The finished road level and the subgrade level should be fixed as per IRC:34-2011.

b) The structural and functional condition of the pavement along with the details of the distresses should be presented in a tabular form with chainages. Photos should be provided.

c) Pavement Condition Surveys refer to activities performed to give an indication of the serviceability and physical conditions of the pavements.

d) Pavement evaluation survey conducted for Structural and Functional Evaluation of existing road.

e) The properties of soil at subgrade level are required for road construction works. The common soil test for road construction includes classification of soil, particle size distribution, moisture content determination, specific gravity, liquid limit and plastic limit tests.

f) The Subgrade soil is to be tested for its properties @ 1 trial pit/km and as per IRC:37-2012, if the length of the road is more than 10km. For shorter roads, a minimum of 2 trial pit/km shall be staggered and taken. All basic tests viz., Atterberg's limits, Proctor density (IS:2720-Part-8), OMC, Soaked CBR at max dry density and OMC, free Swell Index along with Wet sieve analysis results shall be conducted and form part of the DPR. Where ever required, effective CBR should be determined as per IRC:37-2012 Clause 5.2.

5.ROAD INVENTORY

Road inventory is conducted for collecting data by directly measuring the conditions of road.

Steps shall be followed for road inventory.

a) Categorise the road based on traffic.

b) Photographs of the road shall be taken for showing existing road conditions as well as specific landmarks; during site investigations using visual inspection or Drone- based/LIDAR based surveys

c) Existing Carriageway (ECW) and Right of way (RoW) of project corridors.

d) Visual pavement condition survey Recommendations as per IRC:81

Table: 3. Criteria for Classification of Pavement Sections

Classification of road	Pavement condition
Good	No cracking, rutting less than 10mm
Fair	No cracking or cracking confined to single crack in the wheel track with rutting between 10mm and 20mm
Poor	Extensive cracking and/or rutting greater than 20 mm. Sections with cracking exceeding

e) Terrain classification as per IRC:73 shall be followed:

Table: 4. Terrain Classification

Terrain classification	**Cross slope (%)**
Plain	0-10
Rolling	10-25
Mountainous	25-60
Steep	Greater than 60

f) Major/minor junctions passing through and byroads with all physical details.

g) Existing Cross drain and drainage details, checking of land availability at curves for extra widening.

h) Existing retaining structure details.

i) Suggestions, location identification for bus bay improvement/shifting

j) Identification of locations for overtaking zone.

k) Off-street parking spaces for trucks, taxis and auto rickshaws.

l) Bridge inventory carried out with the recommendation of IRC: SP-52

m) Drainage and cross drainage inventory shall be conducted to collect present conditions of the structure with reference of Tables 5 & 6.

Table:5. Culvert Inventory Details

CULVERT						
Sl. No	**Chainage**	**Type**	**Dimension**	**Direction of flow**	**Discharge conditions**	**Remarks**

Table6. Drainage inventory details

DRAINAGE						
Rt/Lt	**Chainage**	**Type**	**Dimension**	**Condition**	**Discharge point**	**Remarks**

6. GEOMETRIC DESIGN AND ALIGNMENT PLANNING

6.1 Right of Way guidelines

The following guidelines for Right of Way (RoW) proposed shall be adopted as a minimum considering the nature of the roads funded by KIIFB, climatic conditions, the limited land availability and nature of traffic in Kerala.

Table: 7. Right of Way Guideline

Road Classification	Parameters							
	Carriage-way (m)	Shoulder (Both sides) – Paved / Interlocks (m)	Drain cum Footpath / Utility (m)	Cycle track (m)	Avenue Plantation (m)	Median (m)	Right of Way (m)	Annexure No.
State Highway	7	3(2x1.5)	3.6(2x1.8)	0	0	0	13.6	3
Hill Highway	7	3 (2x1.5)	3.6(2x1.8)	0	0	0	13.6	3
Coastal Highway	7	3(2x1.5)	3.6(2x1.8)	2@	2$	0	15.6/17.6	4, 6
Junction / Bus Bays	10	3(2x1.5)	3.6(2x1.8)	0	0	0	16.6	5
Bypass/ Ring road (Two Lane)	7	3(2x1.5)	3.6(2x1.8)	0	(2x2)$	0	13.6/17.6	3, 6
Bypass/ Ring road (Four Lane)	2 x 7	3 (2x1.5) +0.5 (2x0.25)	4(2x2)	0	(2x2)$	1.5	23 / 27	7
City Roads (12m Arterial)	5.5	0.5 (2x0.25)	3.6(2x1.8)	0	2x1.75$	0	9.6/13.1	
City Roads (20m Arterial)	2 x 5.5	0.5 (2x0.25)	2 x 2.5	0	2x1.75$	0.5	17/20.5	
City Roads (24m Arterial)	2 x 5.5	0.5 (2x0.25)	2 x 2.5	2 x 2	2x1.75$	0.5	22/24.5	8
Other KIIFB Road (<5000) PCU	5.5	1.5 (0.75+0.75)	3(2x1.5)	0	0	0	10	1
Other KIIFB Road (5000-18000) PCU	7	3(2x1.5)	3.6(2x1.8)	2	(2x1)$	0	13.6/17.6	3, 6

Other KIIFB Road (>18000) PCU	2 x 7	3(2x1.5) +0.5(2x0. 25)	4(2x2)	0	0	1.5	23	7

a) At land restricted or low volume roads, shoulder width may be restricted to 2 m (1m +1m) on either side.

b) At land constraints prevail, a limiting value of 1.5 m wide walkway can be adopted

c) * Footpaths are mandatory at thickly populated locations and towns, limits where educational institutions, hospitals, Government offices and other public amenities are located.

d) Concrete / Paver block shoulders can be provided in such cases where the required camber and drain condition are available.

e) $ Avenue plantation to be provided based on land availability

f) @ Cycle track of minimum 2m width (2.5m preferred) may be provided at select stretches

g) Typical cross section for different types of roads included in Annexure

h) Guidelines are given for minimum requirement of Right of Way and features to be provided. The required RoW may be adopted based on the terrain of land wherever side slopes, retaining wall etc need to be provided. The cross-sectional parameters shall be retained as per the minimum specifications provided in the table above.

i) Based on the importance or roads and specific nature of any particular roads, case by case variations may be adopted and shall be pre-approved by KIIFB during concept design stage.

6.2 Design Speed guideline

Table: 8. Minimum Design Speed requirements for different classification of roads.

Sl No	**Nature / Classification**	**Design Speed (km/h)**								
		Plain		**Rolling**		**Mountainous**		**Steep**		**Corresponding category in IRC**
		Ruling	Min.	Ruling	Min.	Ruling	Min.	Ruling	Min.	
1	Coastal Highway	65	50	50	40	30	25	25	20	ODR in Non-Urban Highways
2	Hill Highway	80	65	65	50	40	30	30	20	MDR / MDR in Hill Roads
3	State Highways / By Pass / Ring roads (NH & SH)	100	80	80	65	50	40	40	30	State Highway
4	Other KIIFB Roads (ODR)	65	50	50	40	30	25	25	20	ODR in Non-Urban Highways
5	Other KIIFB Roads (MDR)	80	65	65	50	40	30	30	20	MDR in Non-Urban Highways

a) In general, the ruling design speed shall be adopted for the various geometric design features of the road.
b) The minimum design speed shall be adopted only where site conditions are restrictive and adequate land width is not available.
c) Mandatory signs for speed breakers shall be provided wherever minimum design speed is adopted.

6.3 Horizontal Alignment

While designing the horizontal alignment, the following general principles shall be kept in view:

a) Alignment shall aesthetically merge and blend with the surrounding topography.
b) For new roads, the curves shall be designed to have a largest practically possible radius, but in no case less than the ruling minimum radius corresponding to ruling design speed.
c) The curves shall be sufficiently long, and they should have suitable transitions to provide riding safety and pleasing appearance.
d) Long tangent sections exceeding 3km in length shall be avoided as far as possible.
e) Reverse curves shall be avoided as far as possible. Where unavoidable, sufficient length between the two curves shall be provided for introduction of requisite transition curves.
f) Curves in the same direction, separated by short tangents known as broken back curves, shall be avoided as far as possible.
g) Hairpin bends on hilly terrain shall be avoided as far as possible. They should be designed as per the Hill Roads Manual/relevant IRC

6.3.1 Transition curves

Transition curves are necessary for the vehicle to have a smooth entry from a straight section into a circular curve.

a) To improve the aesthetic appearance of the road beside
b) At the horizontal curves permitting gradual application of the superelevation and extra widening of carriageway
c) Spiral curves are used as transition curves.
d) The geometric design standards for rural roads viz: IRC:73 / KIIFB guidelines should be followed.
e) Geometrical design for curves etc shall be as per MoRTH / IRC applicable for minimum ODR Standards

Length of transition curves selected based on curve radius, design speed and terrain as per

- IRC:86 for Urban Highway
- IRC:73 for Non-Urban Highway

6.3.2 Extra widening

The extra width of pavement at Horizontal curves provided due to Mechanical and Psychological parameters.

Table: 9. Extra width provided corresponding to radius of curve in two lane road as per IRC: 73

Radius of Curve	Extra Width
Below 40	1.5m
40 - 61m	1.2m
61-100 m	0.9 m
101-300 m	0.6 m
Above 300m	nil

a) For multi-lane roads, the pavement widening may be calculated by adding half the widening for two-lane roads to each lane.
b) Should increase the width at an approximately uniform rate along the transition curves.
c) Extra width should be continued over the full length of the circular curve.
d) At curves with no transition provide widening with two-third being attain on the straight section before the start of the curve and one-third on the curve.
e) Widening should be applied equally on both sides of the carriageway, except hill roads.
f) On hilly roads, entire widening is to be done only on the inside of curve.

6.4 Cycle track

A dedicated cycle track of minimum width of 2m (2.5m preferred) should be provided along the carriageway, according to demand. Cycle tracks should be colored in addition with mandatory and cautionary markings. Recommendations from IRC: 11 can be considered for the cycle track design. Cycle tracks shall be provided in select stretches of roads provided land is available or can be obtained at free of cost or can be acquired with reasonable cost.

6.5 Overtaking Zone

For a higher level of service on undivided roads, it is necessary that vehicle moving at design speed should be frequently able to overtake vehicle slower than them. Since overtaking maneuver involves the occupation of road space normally used by opposing traffic, drivers must have sufficient sight distance available to them so that the whole operation can be accomplished. The overtaking sight distance can be adopted corresponding to the design speed as per IRC: 66

Table: 10. Overtaking distance corresponding to design speed as per IRC :66

Speed (kmph)	Safe over taking sight distance
40	165
50	235

60	300
65	340
80	470

Overtaking zones are provided when Overtaking Sight Distance (OSD) is not possible to be provided throughout the length of the highway especially in hilly roads. These are zones dedicated for overtaking operation, marked with wide roads. The desirable length of overtaking zones is 5-time Overtaking Sight Distance and the minimum is 3- times Overtaking Sight Distance.

6.6 Vertical Alignment Design

The vertical alignment should provide for a smooth longitudinal profile consistent with the category of the road and lay of the terrain.

a) Grade changes should not be too frequent as to case kinks and visual discontinuities in profile.
b) Broken back guideline, i.e. two vertical cures in the same direction separated by small tangent should avoid due to poor appearance and preferably replaced by a long curve.
c) Deck of small cross drainage structures (i.e. culverts and minor bridges) should follow the same profile as the flanking road section, without any break in grade line.
d) While designing a road the amount of material from cuts roughly matches the amount of fill needed so as to minimize the amount of material and construction.

6.6.1 Grade

The grade should be carefully selected keeping in view design speed, terrain conditions and nature of traffic expected on road.

Table: 11. Gradients of the road in different terrain as per IRC:73

Terrain	Ruling gradient	Limiting gradient	Exceptional gradient
Plain or rolling	3.3 percentage (1 in 30)	5 percentage (1 in 20)	6.7 percentage (1 in 15)
Mountainous terrain and steep terrain having elevation more than 3000 from mean sea level	5 percentage (1 in 20)	6 percentage (1 in 16.7)	7 percentage (1 in 14.3)
Steep terrain upto 3000m above mean sea level	6 percentage (1 in 16.7)	7 percentage (1 in 14.3)	8 percentage (1 in 12.5)

Provide sufficient grade compensation at curves on hill roads where gradient more than 4 percent, and gradient compensation correction need not be eased beyond 4 percent as per IRC:73

6.6.2 Vertical Curves

Vertical curves are introduced for a smooth transition at grade changes. Convex vertical curves are known as summit curves and concave vertical curves as valley or sag curves. Both of these should be designed as per relevant IRC.

The length of the vertical curves is controlled by sight distance requirements, but curves with greater length are aesthetically better. For the satisfactory and smooth drive, a minimum length of vertical curves should be provided.

Table: 12. Minimum length of vertical curves

	Design Speed, (kmph)	**Minimum length of curve, (m)**	**Maximum Grade change, (%)**
Minimum Length of Vertical Curves (as per IRC:73)	35	15	1.5
	40	20	1.2
	50	30	1.0
	65	40	0.8
	80	50	0.6

6.6.3 Sight Distance Considerations

The safe and efficient operation of vehicles on the road depends on the visibility of the road ahead of the driver. Thus, the geometric design of the road should be done such that any obstruction on the road length could be visible to the driver from some distance ahead.

Table: 13. Length of vertical curves for different speed when the length of curves is greater than sight distance. (as per IRC: SP:23)

	Design Speed, (kmph)	**Length of vertical curves, (m)**	
		Crest	**Sag**
Length of the vertical curve in Crest vertical curve /Sag vertical curve	80	32.6A	25.3A
	65	18.4A	17.4A
	50	8.2A	10A
	40	4.6A	6.6A
	30	2.0A	3.5A
	Where, A is the algebraic difference between grades expressed as a percentage		

6.6.4 Camber/cross fall

The camber on straight sections of roads shall be as indicated in the table for various types of surfaces

Table: 14. Camber/Cross fall slope values for different road surface types.

Sl. No.	Surface Type	Camber/Cross fall
1	Thick type bituminous surfacing (more than 40 mm) or cement concrete surfacing	1.7-2.0 percent (1 in 60 to 1 in 50)
2	Thin bituminous surfacing (Less than 40mm)	2.0-2.5 percent (1 in 50 to 1 in 40)
3	Shoulders along unkerbed pavements	At least 0.5 percent steeper than carriageway pavement

6.7 Superelevation

i. Superelevation shall be provided on curves as per details are given in IRC: 73 corresponding to the design speed adopted.

ii. Superelevation shall be limited to 7 percent if the radius of the curve is less than the desirable minimum.

Radii of Horizontal & Transition curve shall be designed and be in conformance with IRC specifications.

7. PAVEMENT AND ENGINEERING DESIGN

New pavements shall be designed in accordance with the method prescribed in IRC:37-2012 or any alternative pavement composition methods or improvements methods to reduce pavement thickness. Otherwise, pavement composition shall not be less than the minimum requirement specified in IRC:37 2012/ IRC: SP:72-2015 depending on the projected traffic for the design life.

Table: 15. Mandatory data requirements for improvement and new formation of road

Type of data required	New Formation	Improvement/Strengthening
Traffic volume	Mandatory	Mandatory
Pavement evaluation (BBD test results)	-	Mandatory

Pavement Thickness and composition	-	Existing details mandatory
International Roughness index /Bump integrator / Roughometer	-	Mandatory
Soil investigation	Mandatory	Mandatory
Hydrological studies for cross drainage structures	Mandatory	Mandatory
Drainage studies • HFL • Depth of water table • Amount of surface runoff • Seepage of irrigation water (to account for capillary rise) • Discharge condition and points	Mandatory	Mandatory
Functioning of existing drain structure	-	Mandatory

The following aspects should consider while designing pavement to achieve better performance.

a) The select soil forming the subgrade should have a minimum CBR of 8 per cent for roads having traffic of 450 commercial vehicles per day or higher.
b) A minimum of 15 year design life should be considered.
c) Computation of effective CBR of subgrade for pavement design as per IRC:37-2012.
d) Use of rut resistant surface layer in case of high trafficked highways
e) Use of fatigue resistant bottom bituminous layer in case of high trafficked highways
f) Selection of surface layer to prevent top down cracking
g) Use of bitumen emulsion/foamed bitumen treated reclaimed asphalt pavements in base/ binder course.
h) Consideration of stabilized sub-base/ base course with locally available soil and aggregates.
i) Design of subsurface drainage layer
j) Computation of design traffic as per IRC:37-2012/IRC: SP:72-2015
k) Design of perpetual pavements with deep strength bituminous layer.
l) Use of Geosynthetics in pavement layers
m) Ground improvement should be considered wherever necessary
n) Soil nailing / RE walls should be adopted where necessary

7.1 Soil investigation

The design and construction of road subgrade shall meet the requirements, standards and specifications given by IRC and MORTH. Necessary soil surveys, field and laboratory investigations are to be carried out on the subgrade soil for identifying and treating problematic

ground locations, if any, and for establishing improved ground properties and for finalizing structural features and design of the subgrade and pavement thereafter.

For planning and execution of earthwork should follow the guidance of IRC: 36 “Recommended practice for the construction of earth embankments and sub-grade for roadworks”. All the specified laboratory tests need to conduct as per the relevant Indian Standard Codes of Practice.

- Grain size analysis (wet sieve analysis) – IS:2720 (Part 4)
- Atterberg limits – IS: 2720 (Part 5)
- Modified Proctor Test (OMC & MDD) – IS:2720 (Part 8)
- CBR – IS:2720 (Part 16)

7.2 Traffic Volume

a) A classified volume count required as per IRC: 9 /IRC: SP:19
b) Traffic volume count to be conducted for minimum of three consecutive days that may include working day and market day.
c) The count stations should be such that the results represent the traffic flow of a homogenous section of the road.
d) If projected traffic is more than 5 msa CVPD, one - day axle load study shall be conducted as per IRC SP-19 & IRC-37-2012.

7.3 Pavement Thickness and Composition

Indian Roads Congress has specified the design procedures for the design of flexible pavements based on CBR values.

a) The pavement designs are given in IRC: 37- 2012, are applicable to design traffic upto150 million standard axles(msa).
b) Roads having design traffic below 2 msa shall be considered as low volume road and for such roads, the pavement design shall be as per IRC SP: 72-2015.
c) City roads shall be designed for a minimum 5 msa traffic.
d) Subgrade layers shall have a minimum CBR of 8%. Wherever the values are lower, appropriate soil stabilization or ground improvement methods shall be adopted.
e) If the subgrade soil has a very low CBR value appropriate ground improvement methods should be adopted.
f) Complete reconstruction of full depth pavement with the reclamation of materials and strengthen the subgrade to minimize aggregate quantity adopting Full-Depth Reclamation (FDR) technology may be considered where feasible. Mix design for FDR with cement/lime for the desired strength shall be conducted, as per IRC guidelines.
g) Pavement design method considers traffic in terms of the cumulative number of standard axles (8160 kg) to be carried by the pavement during the design life.

h) This requires the following information:
    a. Initial traffic in terms of Commercial Vehicle per Day (CVPD)
    b. Traffic growth rate during the design life as per IRC:108
    c. Design life in a number of years- minimum 15 years/ as per IRC
    d. Vehicle damage factor (VDF)
    e. Distribution of commercial traffic over the carriageway.
i) The pavement layer thickness shall be selected from corresponding CBR plate and traffic and supplemented with results/output from IITPAVE software.
j) The CBR plates and traffic selected for design shall be included with the pavement design.
k) Where required soil stabilization should be considered as per IRC: SP:89-2010.

7.4 Pavement Evaluation

Strengthening of existing pavements shall be designed based on the procedure outlined in IRC: 81, using Benkelman beam deflection studies and analysis or by adopting Falling Weight Deflectometer as per IRC:115.

The characteristic deflection of road stretches shall be found out using BBD/FWD survey and analysis with necessary corrections for temperature, subgrade moisture content and seasonal corrections.

Considering the mean deflection (X), and the standard deviation (σ) the characteristic rebound deflection 'D_C' is to be worked out as per the guidelines given in IRC: 81

$Dc = X+2\sigma$---------- (1) for major arterial roads (like SH)

$Dc = X+\sigma$ ---------- (2) for all other roads

From IRC: 81 the design curves relating characteristic deflection and cumulative number of standard axles to be carried over the design life to find the overlay required. The overlay thickness materials can only be Dense Bituminous Macadam (DBM Grade-II), Bituminous Concrete. The binder for the layers can be VG-30/PMB/CRMB.

By conducting core log test on existing pavement, the types layers and thickness should be found and reported. Improvement works shall be carried out by using the possible amount of reclamation of scarified pavement materials.

7.5 Alternate Pavement Design

The following are suggested alternatives for the design of pavements. The proposals submitted shall include detailed evaluation of alternatives and shall arrive at the most optimal design in context of road development in Kerala.

a) Full Depth Reclamation
    a. Helps in reducing the consumption of construction materials in the wake of shortage of the same in Kerala
    b. Serves as an environment-friendly and sustainable construction method.
b) Alternate modes of subgrade improvement
    a. Geotextiles/geogrids can substantially improve the CBR values of Subgrade
    b. Composite layers
c) As per the guidelines in IRC: SP: 59 uses of geotextile in pavements and associated works.
d) Detailed design methodology along with the analysis should be submitted with the design.

7.6 Footpath

As a minimum guideline, the width of the footpath shall be as per table 7 of this manual. However, based on the volume of pedestrian traffic, the footpath width shall be provided as per IRC:103-2012.

a) Footpath should be designed with Interlocking Concrete Paver Blocks as per IRC: SP:63
b) The width of footpath shall be adopted corresponding to pedestrian volume as per IRC: 103.
c) Utility or drain slab shall be used as footpath otherwise paved tiles or interlock tiles shall be provided at the footpath area.
d) Raised footpath with universal design provision for accessibility shall be provided with considering access to the differently abled person.
e) Footpath shall be provided with guard rails at unsafe maneuver crossing areas and heavily built-up areas especially in town areas.
f) The design of Interlocking Concrete Paver Blocks should be as per IRC: SP:63-2004

7.7 Road Side Drainages and Utility Duct

a) A road drainage system designed as per IRC: SP:42- 2014 and must satisfy two main criteria if it is to be effective throughout its design life:
b) It must allow for a minimum of disturbance of the natural drainage pattern.
c) It must drain the surface and subsurface water away from the roadway and dissipate it in a way that prevents the excessive collection of water in unstable areas and subsequent downstream erosion.
d) The depth of drain may be varying according to the storm water drainage characteristics and lead to the nearest discharge point.

e) Provision for adequate drainage is of paramount importance in road design
f) Drainage design is most appropriately included in alignment and gradient planning.
g) Natural drainage characteristics of a hillslope shall not be changed
h) To avoid frequent damage to roads by digging roads for utility flow and crossing propose a conduit for utilities including optical cables as a part of road design.
i) Utility ducts are designed with depth more than drainage for providing cross duct without obstructing the drainage flow.
j) The road drainage should be designed as per IRC: SP:42-2014.

7.8 Hydrology Studies

The function of the drain is to drain surface and subsurface water away from the roadway, before the design of drainage and cross drain structures the amount of runoff from the road surface to be estimated. For better performance and long life, the drainage design shall be followed as per the standards.

(i) Natural drains and conditions shall be considered for the proper drainage as well as economical design.
(ii) If newly constructing drain length more than 75% length of road, a proper hydrology study shall be conducted for validation of drain use.
(iii) Type of hydrology studies includes
- Rainfall analysis
- Runoff analysis
- Condor studies

7.9 Bus Bays and Bus Shelters

The pavement in the lay-by area of bus bay shall be provided with adequate crust thickness with respect to the wheel load expected. Also, the surface shall be strong enough to withstand forces due to frequent braking and acceleration by the bus. The laydown area of bus bay shall have proper drainage facilities to drain of excess water. Design of bus bay with the guidelines of IRC: 80-Type Designs for Pick-up Bus Stops on Rural (i.e., Non-Urban) Highways. The location or shifting of a bus bay/bus shelter shall be decided with the consultation of local administration and the local police to avoid conflicts during the execution. However, safety shall be given priority in conjunction with the convenience. Bus bays with designed bus shelters at all important locations where, a large number of people depend on the public transport system. Bus stops should normally be located 50-100m after the junction. No bus stop should be permitted at the intersection. As far as possible, segregated bus stops should be allowed on new roads.

7.10 Landscaping and avenue plantation

1) Area where foot paths are not essential, buffalo grass turfing may be considered between the edge of ROW line and end of Paved shoulders to facilitate the limited pedestrian movement and smooth natural drainage.
2) Avenue plantation with Kanikkonna and / or Jack fruit trees at a spacing of 10 m c/c at select stretches of roads provided land is available or can be obtained at free of cost or can be acquired with reasonable cost.

8. TRAFFIC FURNITURE

8.1 Mandatory Road Furniture

i. Road signs - All Necessary Road signs shall be in accordance with IRC: 67.
ii. Road Markings - All road markings shall pertain to IRC: 35
iii. Directional boards - Signages, Information panels as per traffic and transportation requirements including junction facilities, landscaped islands and medians wherever technically feasible.
iv. Guideposts
v. Safety Barriers
vi. Light and utility poles - Smart street lighting system with solar power source at all technically feasible road stretches.
vii. Boundary Fences
viii. Raised road markers

8.2 Mandatory Road Safety Barriers

Traffic safety barriers shall pertain to IRC: 119, the mandatory traffic safety barriers are;

i. Road Markings
White color Centre line and yellow color edge line with thermoplastic compound solid road marking should be provided. Continues center line at curves and discontinues line at straight road stretch are required.
ii. Pedestrian crossing
Marking for pedestrian crossing mostly used in the zebra pattern consisting of equally spaced white stripes generally 450mm wide in accordance with IRC:103 should be provided at required areas.
iii. Road Studs
Reflective Road studs (Raised pavement marking) should be fixed in centre line with white reflector, edge line with red and white reflector corresponding to traffic direction and red reflective at stop and zebra lines.

iv. Delineators

Delineators with red, white and yellow colors are using as safety measures in the road.

(a) White - On the right side of two-way roadways i.e. single carriageway.

(b) Yellow - On the right side of one-way roadways i.e. dual carriageway.

(c) Red - On the left side of the roadway.

v. Guard stone

Guard stone should provide road embankments with higher land fill or steep slope more than 1.5m.

vi. W - Beam crash barriers

W-Beam crash barrier like semi-rigid crash barriers should provide at,

- Embankment land fill height or steep slope more than 0.6m
- Near road side obstacles
- Dangerous ditches
- Steep gradient
- Hill roads
- Grade separator structures
- At special locations to ensure the safety Pedestrians

vii. Rigid crash barriers

Rigid crash barriers with reflecting component should provide embankment land filling or steep slope more than 3m height

viii. Hazardous markers

Hazardous road mark should be provided at culvert parapets, post, bridge structure, median opening, other traffic obstacles, etc.

ix. Chevron signs

Chevron signs should be provided at curves to inform the sharpness of curves. Chevron sign spacing provided as per IRC:67 recommendation

9. PARKING AREA AND PUBLIC UTILITIES

a) The parking shall be marked for the physically challenged at the ratio of 2:25 of the total number of parking.

b) Two accessible parking lots with an overall minimum dimension of 3600 mm wide and 5000mm length (including aisle space), shall be provided.

c) There shall be directional signs guiding people to the accessible parking.

d) Dedicated parking slots at select stretches considering the traffic requirements and importance of the road stretch.

e) Mini amenity centres with public toilets and kiosks shall be provided even at every 10km along by considering basic way-side amenities provided at hotels and petrol bunkers

f) Modern amenity centres with toilet, refreshments, Wi-Fi facility etc at distance of not more than 25 km.

g) Based on demand assessment, organised parking space for auto/taxi to be provided.

h) Off-street parking for commercial vehicles should be provided.

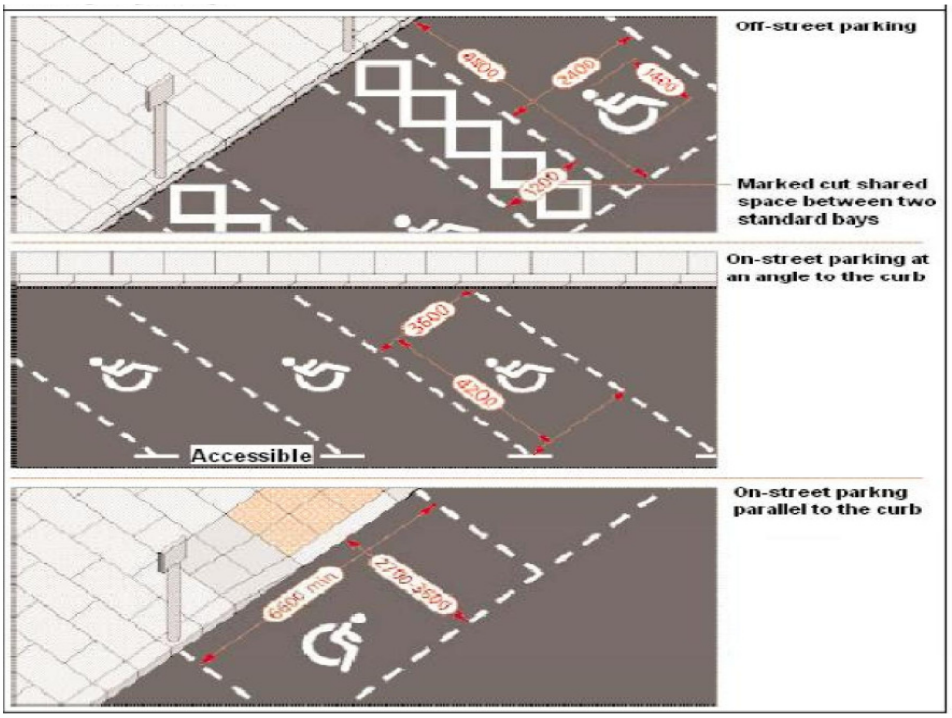


Figure 2 layout for universal parking space

10. ROAD PROJECT AUDITINGS

10.1 Road Safety Auditing

Road safety audit shall mandatorily be conducted by a third party certified road safety auditor, as per IRC: SP- 88, for all roads developed under KIIFB funding, as per standard practices and all provisions shall mandatorily be included in the DPR & estimate. The road safety audit should be conducted during construction and operational stages also.

A road safety audit is a term used internationally to describe an independent review of a future road project to identify anything that may affect the road's safety. The audit team considers the safety of all road users and qualitatively reports on road safety issues and opportunities to improve safety.

Specific aims of Safety Audit;

i. To minimize the risk of accidents likely to occur/occurring on the project facility and to minimize their severity.
ii. To minimize the risk of accidents likely to occur/occurring on adjacent roads i.e., to avoid creating accidents elsewhere on the network.
iii. To recognize the importance of safety in highway design to meet the needs and perceptions of all types of road users; and to achieve a balance between needs of different road user types where they may conflict with one another.
iv. To reduce long-term costs of a project facility, bearing in mind that unsafe designs may be expensive or even impossible to correct at a later stage.
v. To increase awareness about safe design practices among all those involved in the planning, design, construction, and maintenance of roads,

Typical Activities in Road Safety Auditing.

i. Minimize the likelihood of crashes occurring through safety conscious planning and design
ii. Identification of Black spots
iii. Ensure that, if crashes occur, then the likelihood of injury is minimized (Such as provision of anti-skidding surface and safety barriers)
iv. Ensuring that safety-related design criteria (eg. Critical sight distance) have been met.
v. Managing risk, such that the risk of occurring major safety problem is less than the risk of minor safety problems occurring.
vi. Reducing whole life cycle cost of a design (unsatisfactory designs are expensive to correct after built.)
vii. Minimize the risk of crashes occurring in the adjacent road network.

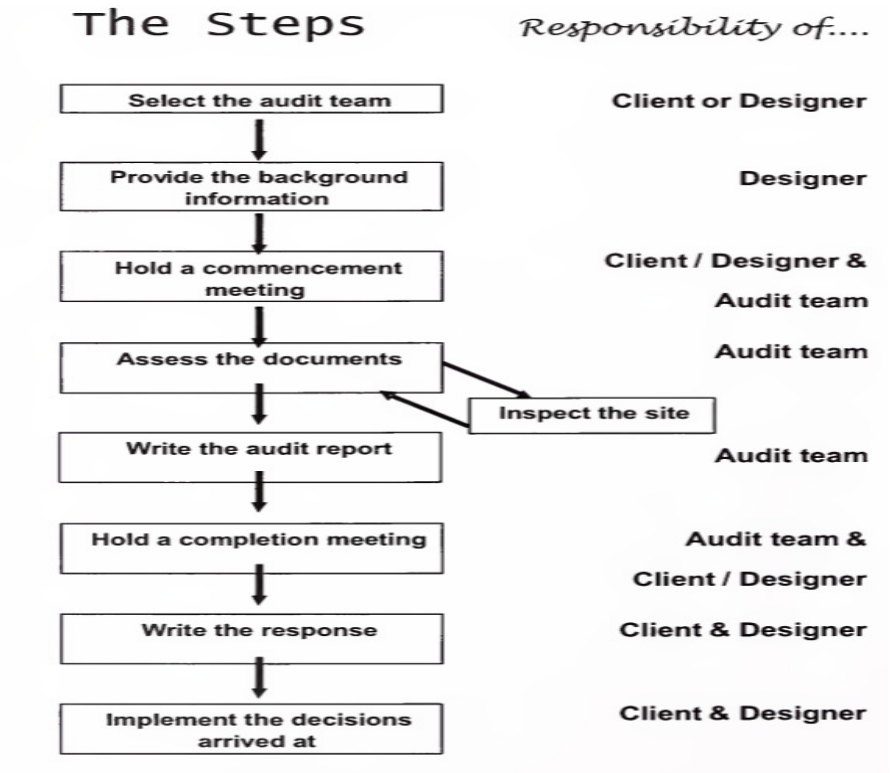


Figure: 3. Steps involved in road safety auditing as per IRC: SP-88

10.2 Social Auditing

Social Audit is a monitoring process through which project information is collected, analyzed and shared publicly in a participatory fashion. Social audits may go beyond the oversight of project finances and procurements to examine all aspects of the project, including the level of access to information, accountability, public involvement, project outputs, and outcomes. Social audits are typically carried out by community volunteers (social audit teams/committees) and findings are presented at a public forum/hearing. Steps involved in the social auditing process

1. Define the scope of the audit
2. Information gathering and analysis
3. Public disclosure and evidence-based dialogue
4. Social audits institutionalized and repeated regularly

A social audit helps to reduce the gaps between vision and reality, between efficiency and viability. It values the voice of stakeholders, including marginalized/poor groups whose voices are rarely heard. Social auditing is taken up for the purpose of enhancing rehabilitation by local governance, particularly for strengthening accountability and transparency in local bodies. Social auditing shall be conducted as per prevailing KPWD / CPWD / MoRTH / IRC rules before commencing of the project to evaluate the demand and requirement of the project.

10.3 Environmental Auditing

Environmental auditing is essentially an environmental management tool for measuring the effects of certain activities on the environment against set criteria or standards. These are used to help improve existing human activities, with the aim of reducing the adverse effects of these activities on the environment. Environmental auditing shall be conducted as per prevailing KPWD / CPWD / MoRTH / IRC rules before commencing of the project to evaluate the demand and requirement of the project. Environmental auditing must be conducted by considering,

1. Air Quality
   – recommended for dust control and mitigative measures
2. Noise control
   – recommended for an adopt noise reduction method of working and equipment's
3. Water Quality
   – recommended for mitigating measures to minimize water control during the construction phase.
4. Resource management (waste management, deforestation, etc.)
   - recommended for avoidance and minimization of waste generation
   - recommended for reuse of materials
   - recommended following relevant environmental protection and pollution laws.

REFERENCES:

IRC :9 - Traffic Census on Non-Urban Roads

IRC: 11 – Design & Layout of cycle Tracks

IRC: 23 - Vertical Curves for Highways;

IRC:34 – Recommendations for road construction in areas affected by water logging, flooding and/or salts infestation (first revision)

IRC: 35 - Code of Practice for Road Markings;

IRC: 36 - Recommended practice for the construction of earth embankments and sub-grade for road works;

IRC: 37- Guidelines for the Design of Flexible Pavements;

IRC: 38 - Guidelines for Design of Horizontal Curves for Highways and Design Tables;

IRC: 64- Guidelines for Capacity of Roads in Rural Areas;

IRC: 66–Recommended Practice for Sight Distance on Rural Highways;

IRC: 67–Code of Practice for Road Signs;

IRC: 72- Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads;

IRC: 73- Geometric Design Standards for Rural (Non-Urban) Highways;

IRC: 79-Recommended practice for Road Delineators;

IRC: 80-Type Designs for Pick-up Bus Stops on Rural (i.e., Non-Urban) Highways;

IRC: 81-Guidelines for the strengthening of flexible road pavements using Benkelman Beam Deflection Technique;

IRC: 86 -Geometric design standards for urban roads in plains.

IRC: 93 - Guidelines on Design and Installation of Road Traffic Signals;

IRC: 103- Guidelines for Pedestrian Facilities;

IRC: 108 - Guidelines for Traffic Prediction on Rural Highways;

IRC: 115 - Guidelines for Structural Evaluation and Strengthening of Flexible Road Pavements Using Falling Weight Deflectometer (FWD) Technique;

IRC: 119 – Guidelines for Traffic safety barriers

IRC: SP-13- Guidelines for the design of small Bridges and Culverts;

IRC: SP-15 – State of the art: Landslide correction techniques.

IRC: SP-19 - Manual for Survey, Investigation and Preparation of Road Projects

IRC: SP-41- Guidelines on Design of At-Grade Intersections in Rural & Urban Areas;

IRC: SP-42 - Guidelines on Road Drainage;

IRC: SP-50 - Guidelines on Urban Drainage;

IRC: SP-59 - Guidelines for use Geotextile in road pavement and associated works;

IRC: SP-63 - Guidelines for the use of interlocking concrete block pavement;

IRC: SP:72- Guidelines for the Design of Flexible Pavements for Low-volume Rural Road

IRC: SP-73 – Manual of specification & standards for two laning of highways with paved shoulder

IRC: SP-88 - Manual on road safety auditing;

IRC: SP:89- Guidelines for soil and granular material, stabilization using cement lime& fly ash

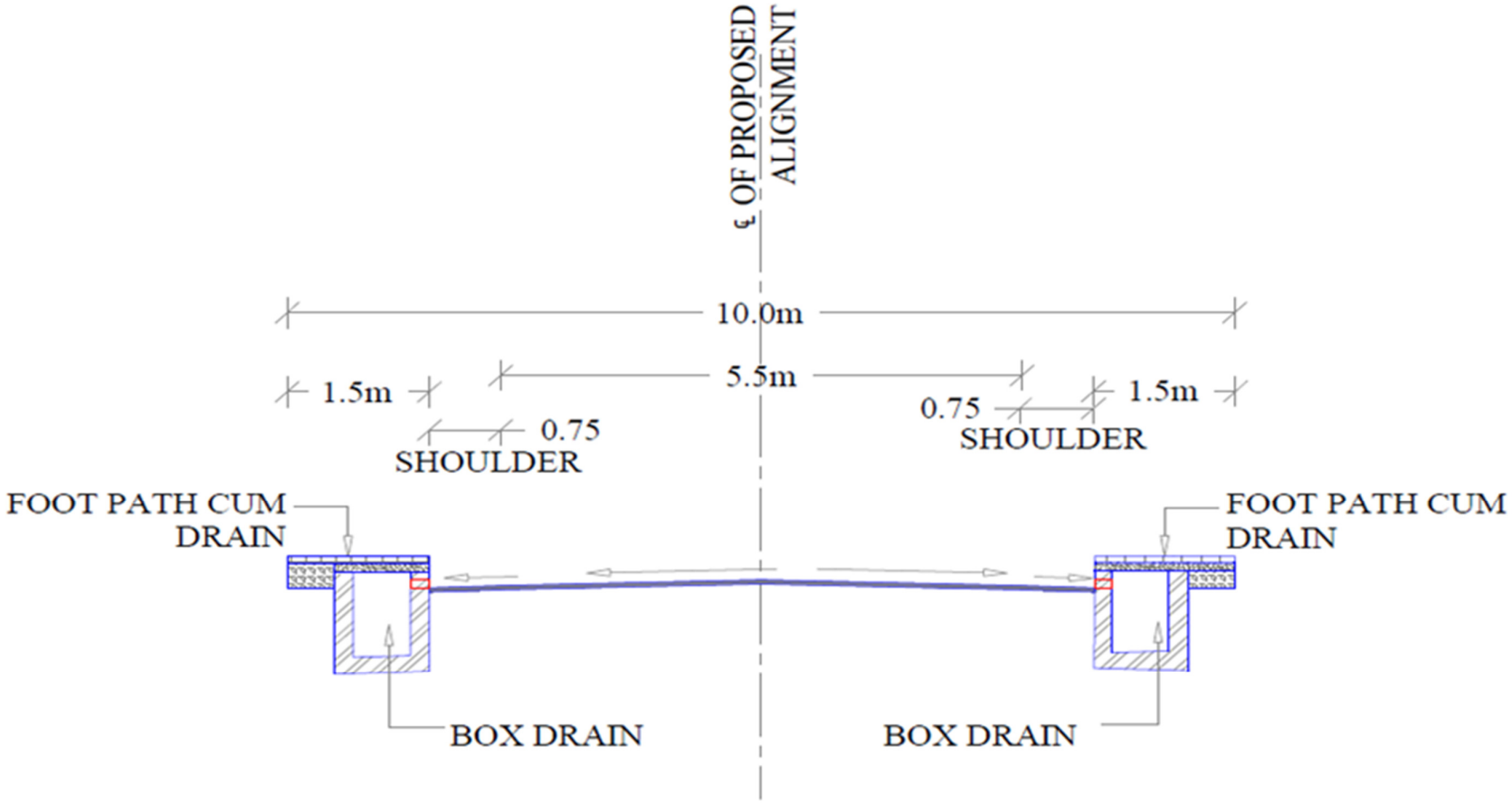
IS: 2720 (Part 4) - Grain size analysis

IS: 2720 (Part 5) - Atterberg limits

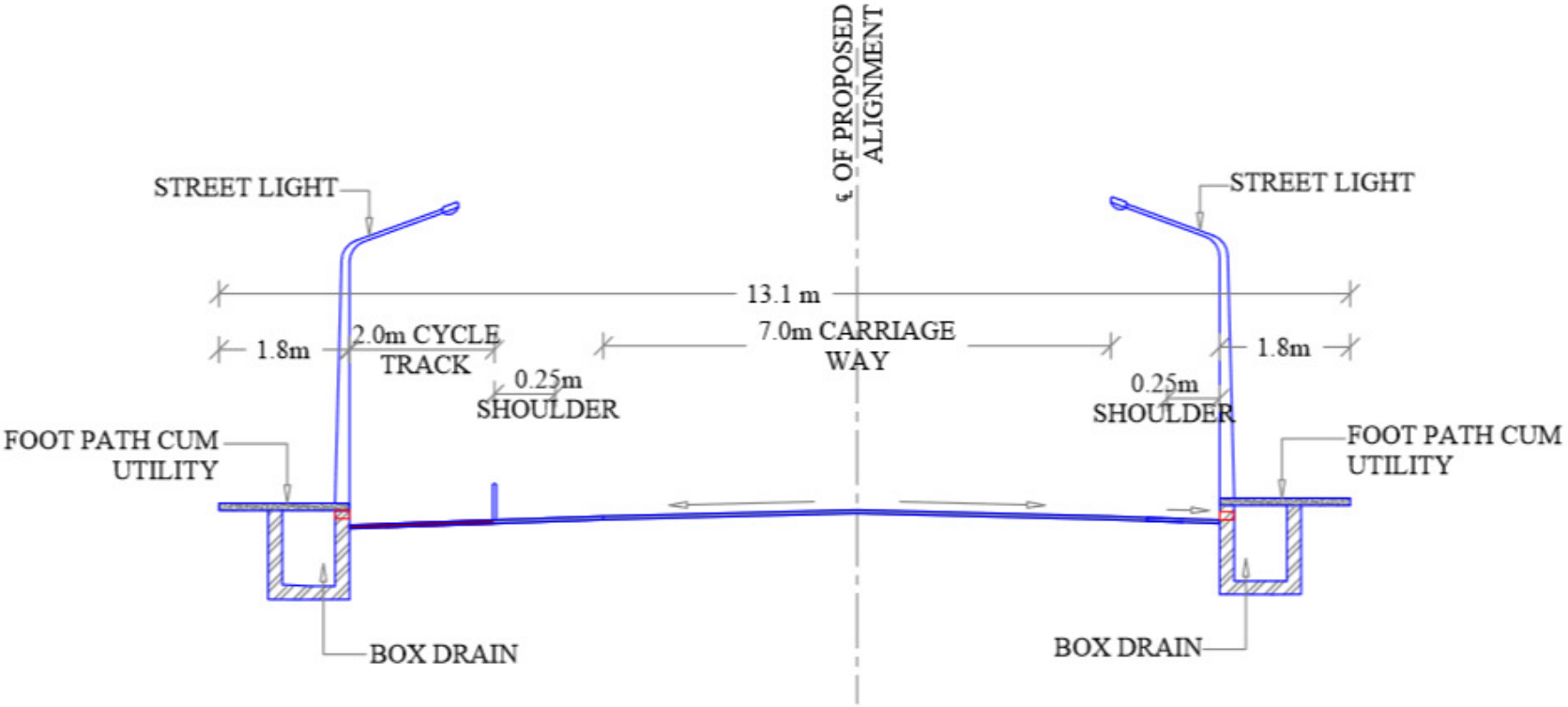
IS: 2720 (Part 8) - Modified Proctor Test (OMC & MDD)

IS: 2720 (Part 16) - California Bearing Ratio

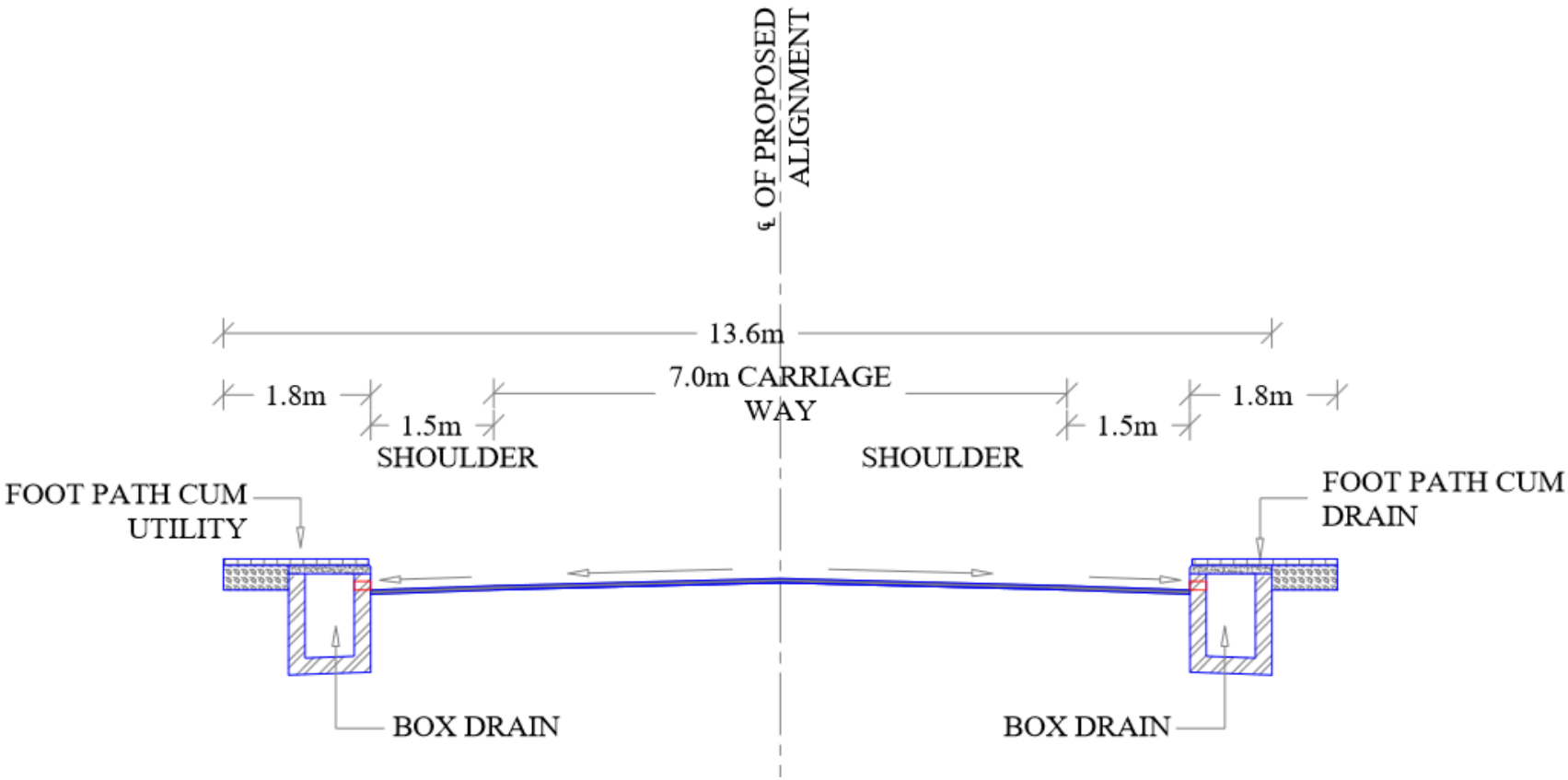
ANNEXURE 1 – Typical Cross Section with 10m RoW



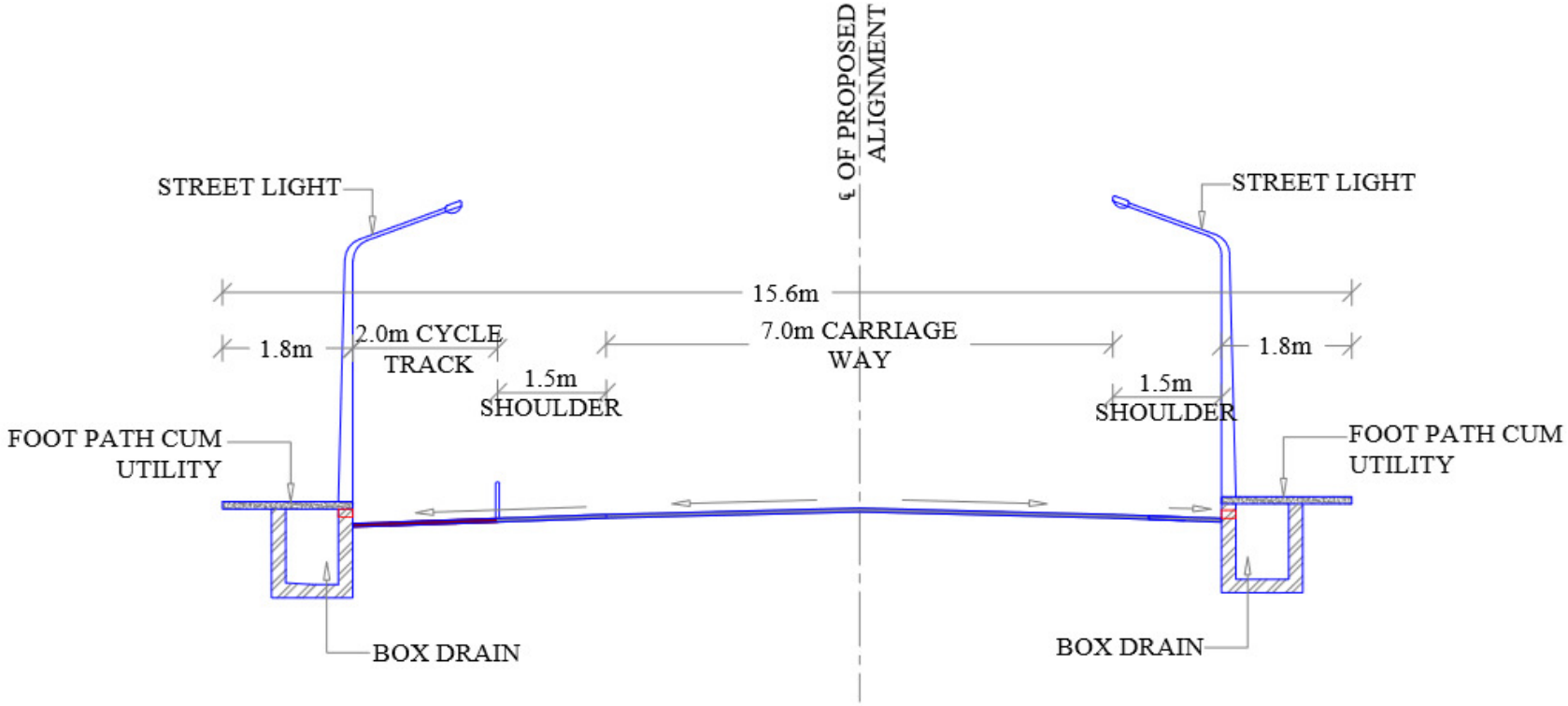
ANNEXURE 2 - Typical Cross Section with 13.1m RoW & cycle track



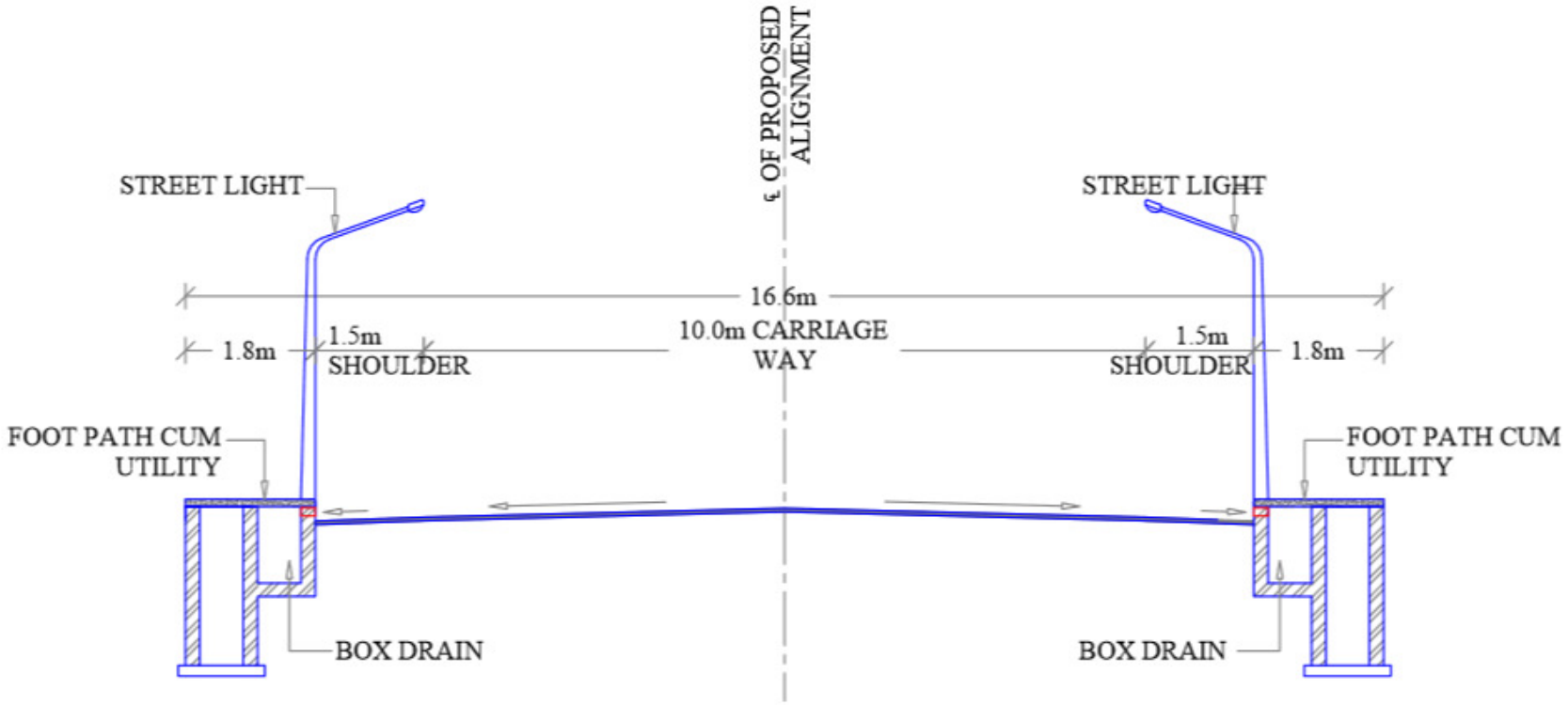
ANNEXURE 3 - Typical Cross Section with 13.6m RoW



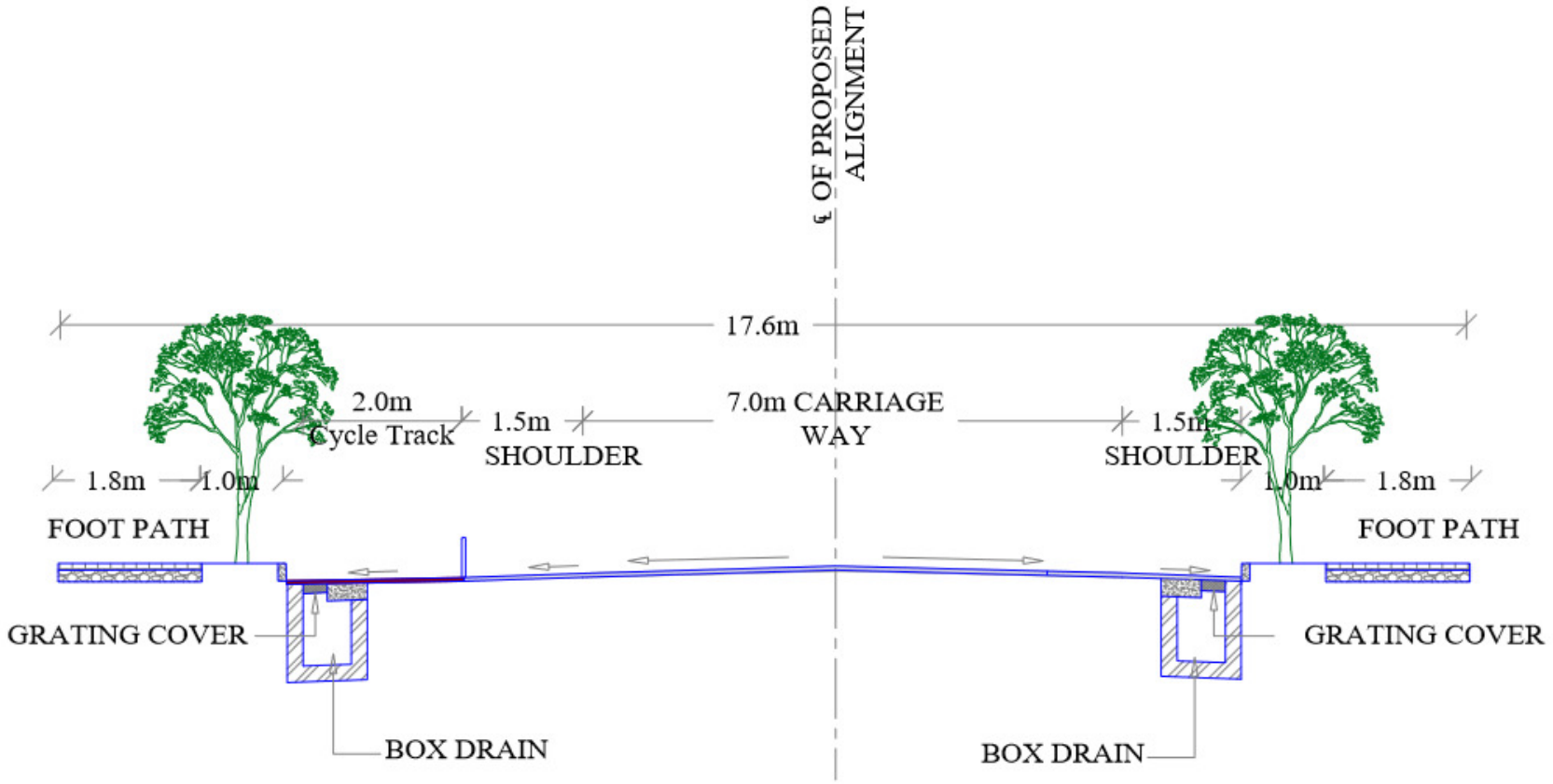
ANNEXURE 4 - Typical Cross Section of Coastal Highway / Road with cycle track



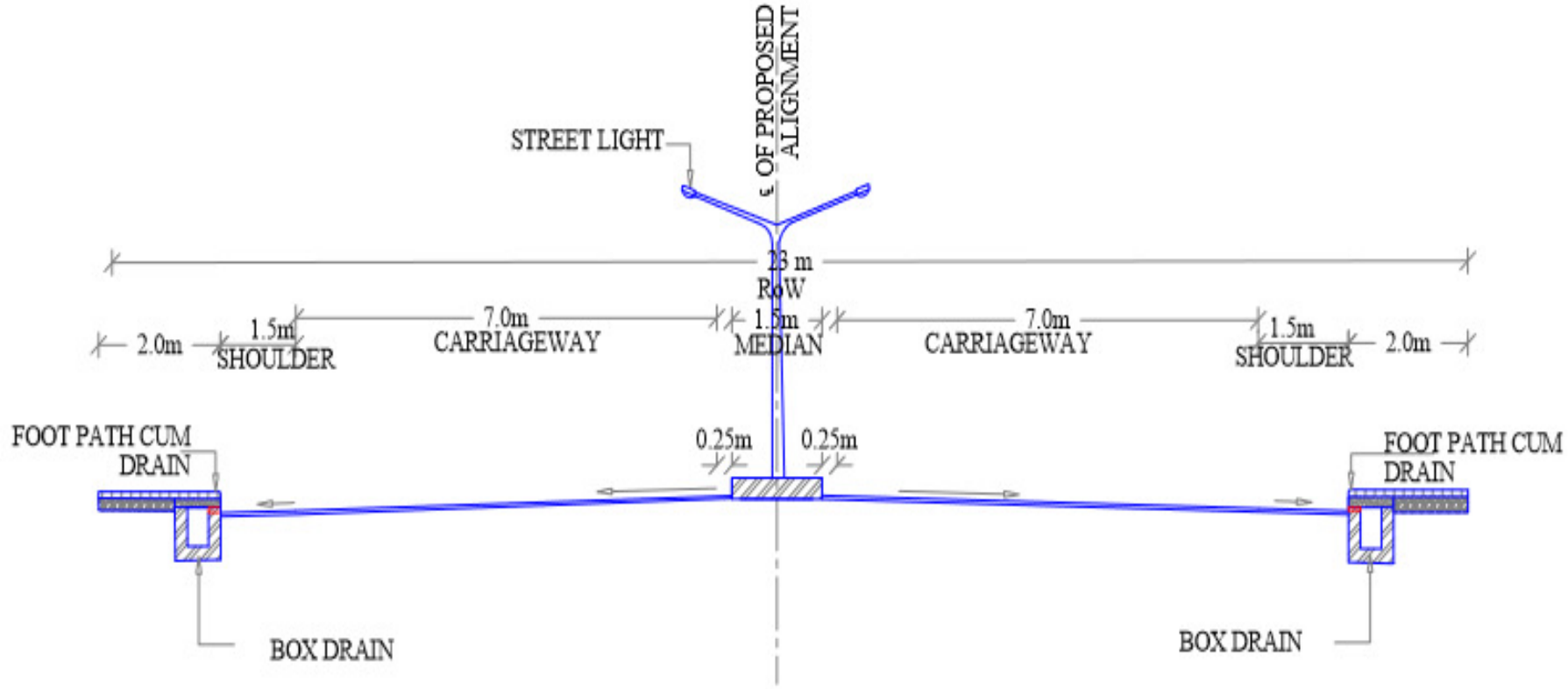
ANNEXURE 5 - Typical Cross section with 16.6 m RoW at undivided junctions



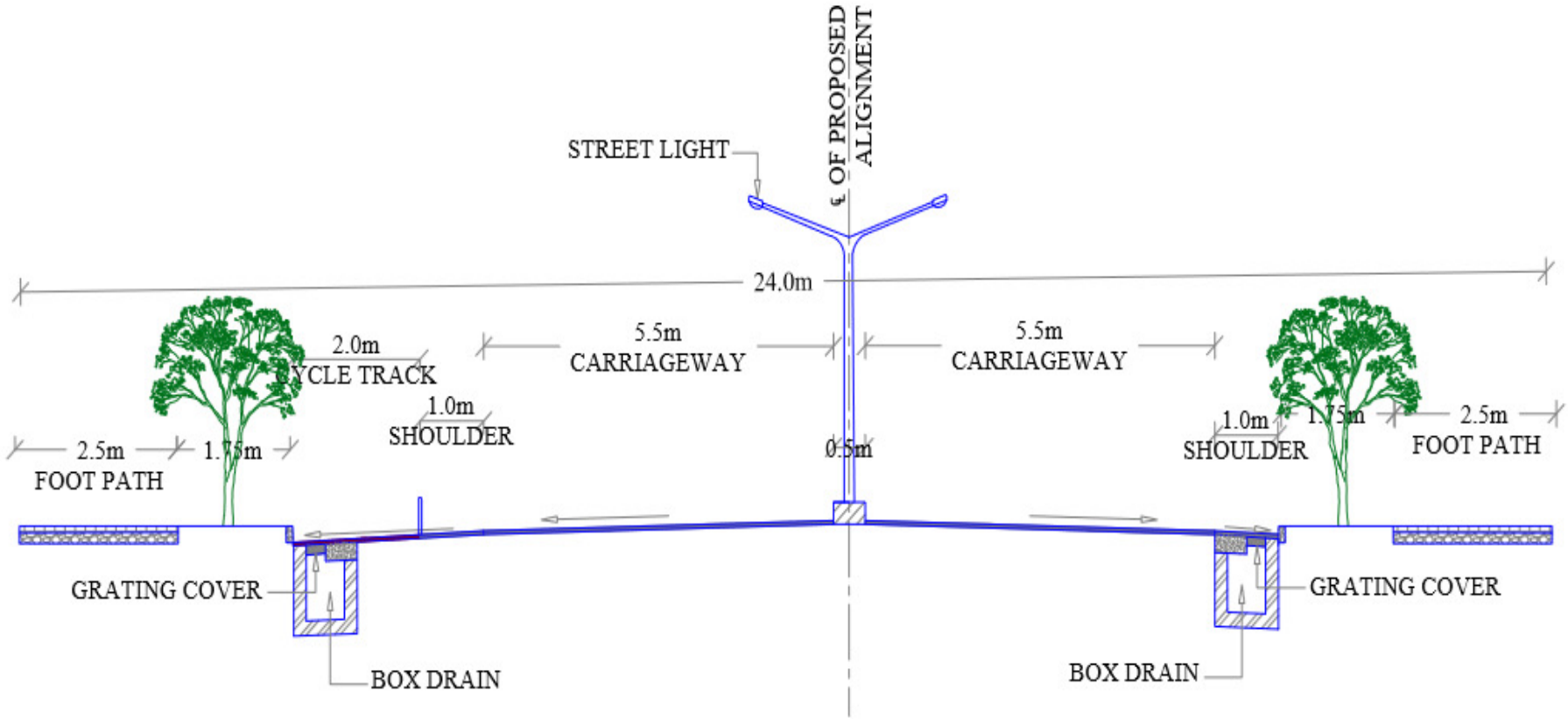
ANNEXURE 6 - Typical Cross section with 17.6m RoW Road & avenue plantation



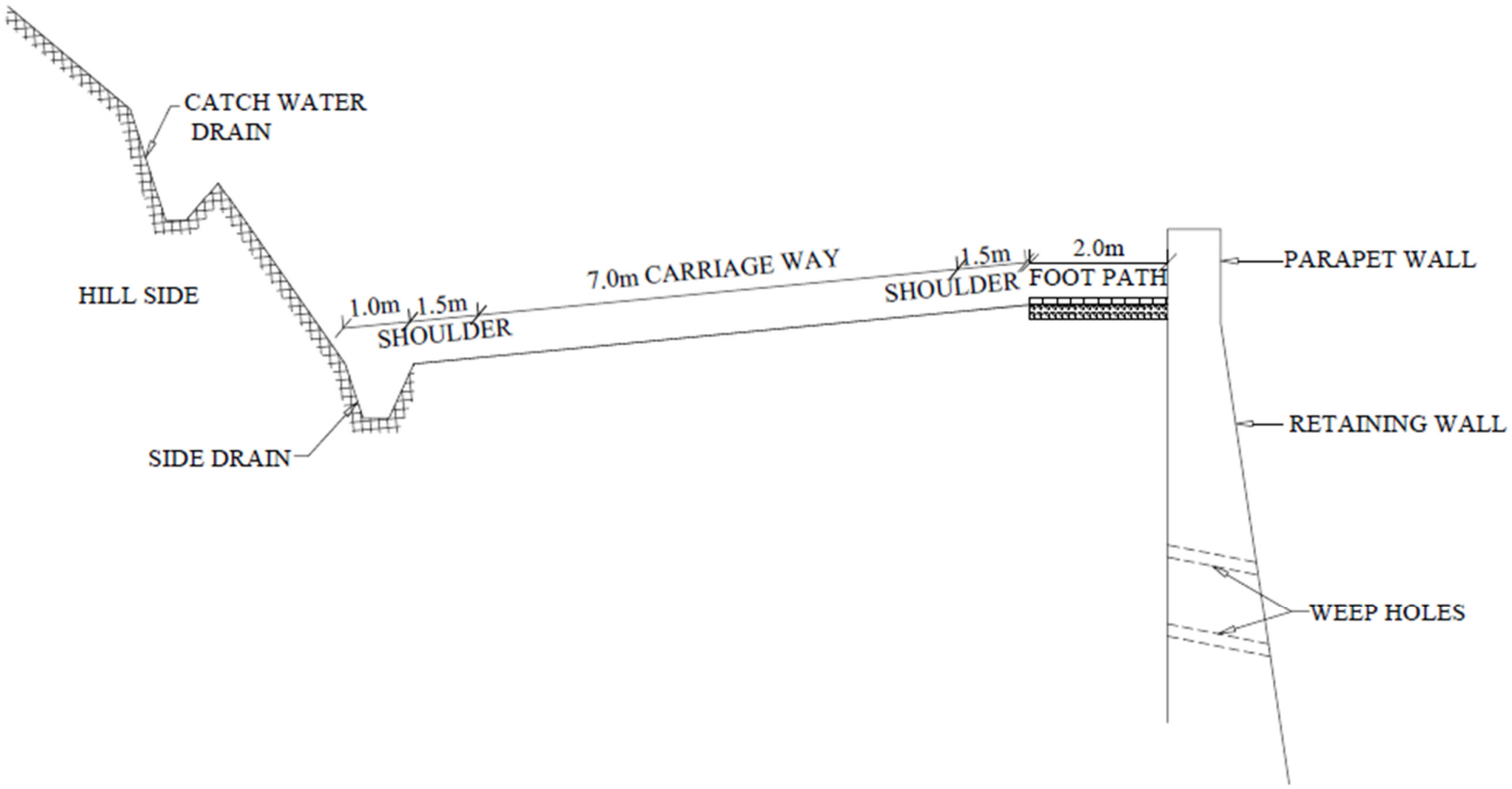
ANNEXURE 7 - Typical Cross Section of four lane road with median (23m)



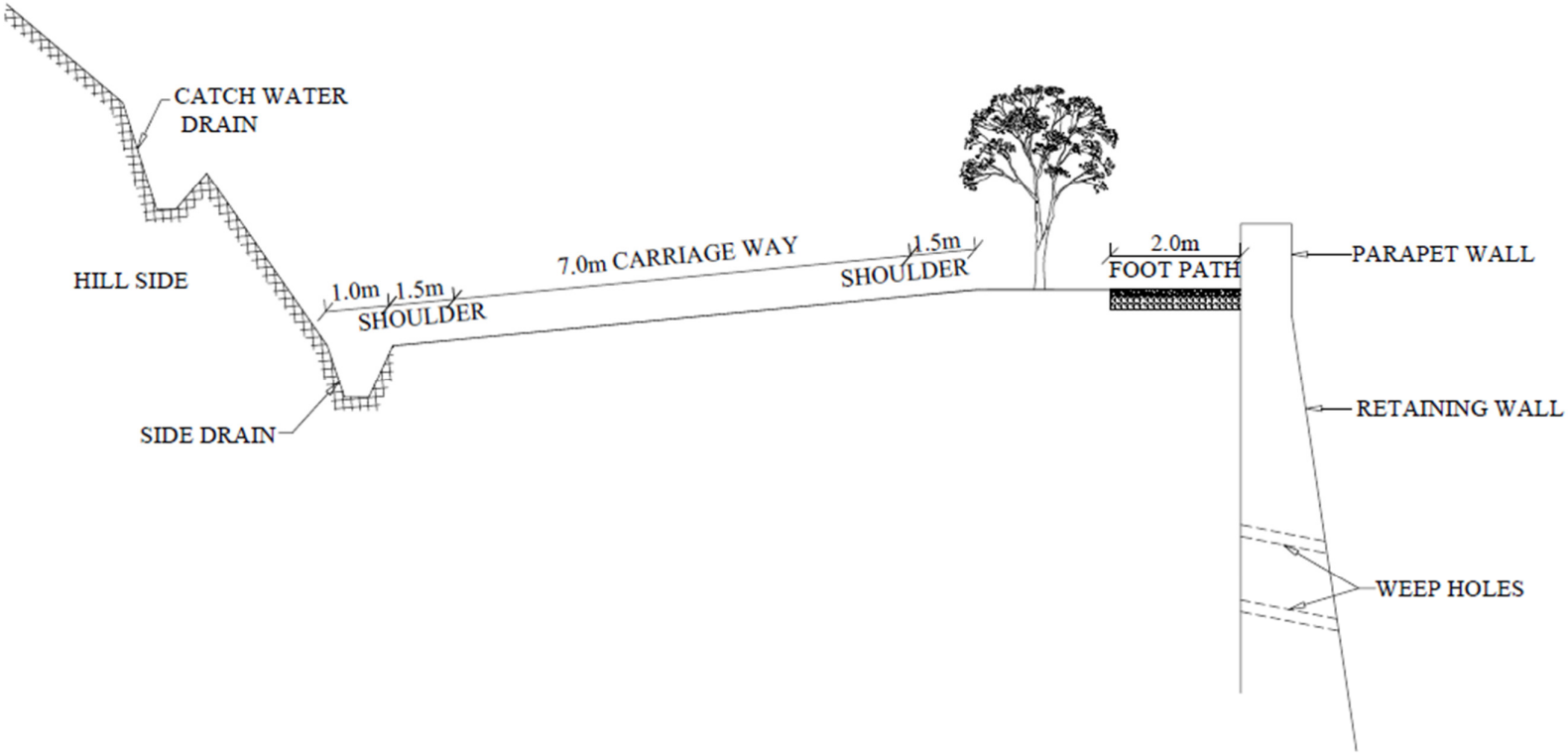
ANNEXURE 8 - Typical Cross Section of City Road with 24m RoW



ANNEXURE 9 - Typical Cross section of two lane road at Hilly Terrain with 13m RoW



ANNEXURE 11 - Typical Cross section of two lane road at Hilly Terrain with >13m RoW



Template for Preparation of Detailed Project Report (DPR) in r/o Roads for KIIFB Assistance

Guidelines for preparing Detailed Project Report

A detailed Project Report is an essential component of the project. It should be prepared carefully. Before finalising the DPR, importance should be given to carry out the needed surveys investigations and designs as per the standard guidelines and best practices. Adequate details should be included in the DPRs to ensure timely appraisal, approval and implementation. Considering the importance of DPR preparation, a document intended for reference is detailed along with. The guidelines provided in this document shall be adhered to strictly. In addition, SPV can incorporate specific additional relevant details to supplement the base data.

The detailed project report shall strictly be prepared in line with the "GUIDELINES FOR PLANNING AND DESIGN FOR ROADS & HIGHWAY PROJECTS FOR CONSIDERATION FOR FUNDING BY KIIFB" as per the latest version of the guideline and its associated circulars issued if any from time to time.

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	Indicative cost / km of the project		
	Indicative cost / km of the carriageway		
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21	Details of contract management strategy	
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23	Details of statutory clearances	
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25	Operations & Maintenance (O&M) arrangements of the project after completion	
26	Details of attached drawings	
27	Other attachments	

EXECUTIVE SUMMARY:

- This section shall contain brief details of all relevant details discussed in the following chapters.

1. INTRODUCTION

- This section should provide a general introduction of the project being submitted General introduction shall include write up on: type of the road project, location of the project area, general description of topography, physiography and geology of the project area, historical background of the project, need for the project, etc.
- Aims and objectives of the project shall also be briefed in the section.
- This section shall clearly mention the existing category of road (NH/ SH/ MDR/ ODR/ VR/ City Road) etc and its current terrain type (plain / rolling / mountainous/ steep)

2. STATUS OF FEASIBILITY STUDIES

- Description of any feasibility study conducted earlier and their outcome shall be discussed in this section.

3. REQUIREMENT/ DEMAND ANALYSIS

- This section should present the specific problem(s) or issue(s) faced by stakeholders like citizens, businesses or governments that would be addressed by means of provision of improved services through the proposed project.
- In this section, describe the project proposed in terms of the rationale behind the project, clearly focusing on the existing condition (how it will help in improving the situation and bring benefits to the stakeholders).
- The rationale could be broad based and supplemented with facts and figures. Information based on objective research, not subjective impressions, should be provided to justify the need or problem. The rationale should be written in a way that would lead to objectives.
- A social audit as per the requirements shall be conducted as per prevailing KPWD / CPWD / MoRTH / IRC rules before commencing of the project to evaluate the demand and requirement of the project.

4. FUNCTIONAL DESIGN

- This section should present an analysis of different options available to achieve the objective and the reasons for selecting the proposed option should be substantiated.
- The functional design of the project is mainly achieved through field study and documentation using existing information and specifications from various standards
- The details of the existing road shall be provided covering the following as a minimum:
    - Average width of ROW, carriageway and shoulder details
    - Existing pavement layers thickness and type of road surface
    - Chainagewise height of embankment type and condition
    - Location of Cross Drainage structures and its present condition
    - Side Drain details and present condition with outlet details
    - Water logging conditions
    - Chainagewise details of retaining walls and present condition
    - Utilities and trees within the boundary
    - Seasonal temperature variation details
    - Environmental profile of the area
    - Bus bay locations and existing road safety features, if any and its condition
    - Existing sub grade condition with position of water table, HFL (High Flood Level) etc if the project demands
- The details of the proposed RoW with all its features shall be clearly mentioned. (Proposed carriageway, shoulders, drain cum utility duct, footpath locations, protection works, cross drainage structures, bus bays etc). The provisions for horizontal & vertical curves as per the guidelines shall be followed and land acquisition requirements shall be clearly demarcated.
- The detailed design for geometric elements shall cover, but not be limited to the following major aspects:
    - Horizontal Alignment
    - Longitudinal Alignment
    - Cross-Sectional Elements
    - Cross Drainage structures and Protection Works
    - Junctions, intersections and interchanges
    - Bus Shelters, Bus Bays, Parking areas, rest areas, weighing stations, etc.
- The details for at-grade junction improvements shall be adopted as alternative to the grade-separated structures. The geometric design of interchanges shall take into account the site conditions, turning movement characteristics, level of service, overall economy and operational safety.

- This section shall also clearly mention about the features of the proposed road, longitudinal and cross sections at critical locations, drawings of cross drainage structures, drains, cross duct, utility ducts, retaining walls, road furniture, road safety provisions included etc.
- The alignment of a new road shall be fixed with a view to serve maximum population and to achieve the maximum utility of the existing road system, if any. The alignment shall preferably be one which demands minimum land acquisition and avoiding problematic soils, too many cross-drainage works, landslide susceptible slopes etc.
- The proposed alignment should achieve the least overall cost on transportation, having regard to the costs of initial construction of the road facility, its maintenance, and road user cost, while at the same time, satisfying the social and environmental requirements.
- Where the project involves improvements to an existing road, every effort should be directed towards the inherent deficiencies with respect to: plan and profile, sight distance/visibility in horizontal as well vertical plan, carriageway, shoulder and roadway width, cross-drainage structures, road side drainage provisions as well as area drainage consideration and safety features.
- The field study shall include traffic surveys and documentation which may be done as per the latest revisions and amendments of the relevant guidelines of MoRTH, publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS).
- Information about traffic is indispensable for any road project since it would form the basis for the design of the pavement, fixing the number of traffic lanes, design of intersections etc.
- Traffic surveys required to be conducted in connection with the preparation of road project are: Classified Traffic Volume Counts, Origin-Destination Surveys, Speed and delay studies, Traffic Surveys for the Design of Road Junction, Axle Load Surveys, and Accident Records etc.
- All results shall be presented in tabular and graphical form. The survey data shall be analysed to bring out the hourly and daily variations. The traffic volume count per day shall be averaged to show a weekly Average Daily Traffic (ADT) by vehicle type. The Annual Average Daily Traffic (AADT) shall be worked out by applying seasonal factors. The number of Commercial Vehicles per Day (CVPD) shall be computed from ADT or AADT.
- Relevant traffic volume data from secondary sources also may be compiled and the salient features of traffic volume characteristics shall be detailed.
- Traffic Demand Estimation shall be conducted with due detailing and shall establish possible traffic growth rates in respect of all categories of vehicles. Overall traffic forecast and projected PCU shall include the analysis for network road development and the data thus made shall form the basis for the design of the cross-sectional elements, and other facilities/ancillary works.

- Turning Movement Surveys for estimation of peak hour traffic shall be carried out at the important intersections. The details regarding composition and directional movement of traffic shall be furnished.
- One-day axle load survey should be conducted, for road improvement projects, as per IRC:37-2012 / IRC: SP:19. For all roads that are expected to carry design traffic more than 5 msa, axle load survey shall mandatorily be conducted. For low volume roads, indicative VDF values as per IRC:37-2012 may be considered.
- The axle load surveys shall normally be done using axle load pads or other sophisticated instruments. The location(s) of count station(s) and the survey methodology including the data formats and the instrument type to be used shall be documented before taking up the axle load surveys.
- The axle load data should be collected axle configuration-wise. The number of equivalent standard axles per truck shall be calculated on the basis of results obtained. The results of the survey should bring out the VDF for each axle configuration. Local enquiries about the exceptional live loads that have occurred in the past may also be analysed and documented.
- Pavement Design shall preferably be validated using IITPAVE software and its documentary design notes submitted.
- Raised footpath with universal design provision for accessibility shall be provided with considering access to the differently abled person.
- Pedestrian Count & Cross Traffic Surveys may be conducted to determine the requirement for footpaths, provisions required for pedestrian crossings, locations for underpasses / overhead crossings etc for pedestrians to improve the traffic safety.
- The details of all important physical features & utilities along the alignment shall be collected and a comprehensive utility relocation plan based on important physical features along the entire project corridor shall be performed. The features which affect the project proposals should normally include buildings and structures, educational institutions, monuments, burial grounds, cremation grounds, places of worship, railway lines, stream/river/canal, water mains, severs, gas/oil pipes, crossings, trees, plantations, utility services such as electric and telephone lines (O/H & U/G) and poles, optical fibre cables (OFC) etc. The survey would cover the entire proposed RoW of the road on the adequate allowance for possible shifting of centrelines at some of the intersection locations.
- Land Acquisition Plan shall include detailed schedules about acquisition of land holdings, and their locations in a strip plan and also the costs as per district authorities and the market rate basis. It should also include plan of compensating afforestation, its land requirement with specific locations and cost involved for undertaking all such activities in this regard. It should also take into consideration leasehold and land to be temporarily acquired for the project. Land acquisition should include space for accommodating utility equipments such as transformer, junction boxes, telephone pillars etc.

- These details regarding the land acquisition plan shall be submitted as a minimum:
    - Details of the Centre line of the proposed road along the proposed right-of-way clearly marking the requirements of land acquisition;
    - Detailed schedules for acquisition of additional land and additional properties in consultation with the revenue authorities; and, this shall be attached with a detailed listing of all built structures within the proposed right of way and the valuation associated. Outcomes of the Social Impact Assessment (SIA) conducted shall be clearly accommodated in the schedules, while preparing the LA plan.
    - The strip plans and land acquisition plan shall be prepared on the basis of data from environmental / social screening, revenue records and detailed topographic surveys.
- The Report accompanying the strip plans should cover the essential aspects as given under:
    - Land Acquisition Plan (LAP) and schedule of ownership thereof and Costs as per Revenue Authorities and also based on realistic rates.
    - Details of properties, such as building and structures falling within the right of way and cost of acquisition/resettlement/relocation based on actual market rates.
    - Corridor wise accounting regard to felling of trees of different type and girth and value estimate of such trees based on realistic rates obtainable from concerned District forest office.
    - The strip plans shall clearly indicate the scheme for widening. The views and suggestions of the concerned authorities and stakeholders shall be duly taken into account while working out the widening scheme (left, right or symmetrical)
    - Kilometre-wise strip plans for each segment shall be prepared separately
- Arboriculture and Landscaping – The appropriate plan for planning of trees (specifying the type of plantation), horticulture, floriculture on the surplus land of the right-of-way with a view to beautify the roads / highway and making the environment along the highway pleasing shall be explored and provisions included. The existing trees/plants shall be retained to the extent possible.
- Details of way side amenities provided and its facilities

5. ENGINEERING SURVEYS AND INVESTIGATIONS

- Topographic surveys to be conducted preferably using LIDAR and the data used to plot the LS and CS. The finished road level and the subgrade level should be fixed as per IRC:34-2011.
- Levelling Survey with GPS stations and coordinates, a brief methodology of levelling survey, accuracy adopted, nearest GTS bench mark etc.
- The width of the survey corridor should take into account the layout of the alignment including the extent of embankment and cut slopes and the general ground profile. While

carrying out the field surveys, it should be borne in mind that the topographical surveys should cover sufficient width beyond the centreline of the proposed carriageway.

- Where existing roads cross the proposed road, the survey shall extend a minimum of 100 m either side of the road center line and the data should be sufficient to allow improvements, including at grade intersections, grade separators, to be designed.
- The topographical surveys for longitudinal and cross-sections shall cover the following as a minimum:
    - Longitudinal section levels along final centre line at every 25m interval, at the locations of curve points, small streams, intersections and at the locations of change in elevation.
    - Cross sections at every 25m interval in full extent of survey. Cross sections shall be taken at closer interval at curves.
    - Longitudinal section for cross roads for length adequate for design and quantity estimation purposes.
- Soil and Materials Survey:

  The Subgrade soil is to be tested for its properties @ 1 trial pit/km and as per IRC:37-2012, if the length of the road is more than 10 km. For shorter roads, a minimum of 2 trial pit/km shall be staggered and taken. A minimum of three samples should be tested corresponding to each homogenous segment. All basic tests viz., Atterberg's limits, Proctor density (IS:2720- Part-8), Optimum Moisture Content (OMC), Soaked CBR at max dry density and OMC, free Swell Index along with Wet sieve analysis results.

    i. Soil investigation report including CBR details
    ii. Borrow area and quarry details ensuring the quality and quantity of materials, construction water sources
    iii. Soil sample collection and Testing
- For problematic soils the testing shall be more rigorous. The characteristics with regard to permeability and consolidation shall also be determined for these soils. The frequency of sampling and testing of these soils shall be finalized in consultation with the client.
- Materials Report with the details concerning the proposed borrow areas and quarries for construction materials and possible sources of water for construction purposes shall be furnished. The report shall include details on locations of borrow areas and quarries shown on maps and charts and also the estimated quantities with mass haul diagram including possible end use with lead involved, the details of sampling and testing carried out and results in the form of important index values.
- Other surveys if any, shall be performed as its detailed report submitted as per the guidelines for planning and design, issued by KIIFB

6. ENGINEERING DESIGN

- This section should elaborate the technology choices, structural aspects, pavement layer options and evaluation of the technology option, as well as the basis for the technology for the proposed project.
- Detailed description of site including topographical and geotechnical investigations adequate to design the road cross sections shall be furnished.
- The design of new pavement sections, and of strengthening measures (overlay) for the existing pavement shall be carried out in accordance with the criteria, standards and specifications given the latest publications of Indian Roads Congress (IRC) and MoRTH.
- Before strengthening treatment is prescribed, a detailed pavement condition survey and evaluation shall be carried out in accordance with IRC: 81 / IRC:115 to determine the extent of distress and nature of deficiency in the existing pavement structure and whether any special treatments e.g. provision for remedying reflection cracking, pavement internal drainage, sub grade improvement/ reconstruction, or rectification of any other deficiencies are warranted.
- The detailed design of pavement shall involve the design of pavement for the carriageway and design of paved shoulders. The design of pavement shall be rigorous and shall make use of the latest Indian and International practices. The design option shall be established on life-cycle costing, alternate pavement designs and techno-economic considerations taking design period of 15 years for flexible pavement.
- While designing the pavement, specific aspects of the terrain and topographic conditions, weather conditions, etc. shall be duly considered and suitably incorporated in design so that pavement is able to perform well for the design traffic and service life.
- The shoulders shall be designed as integral part of the pavement for the main carriageway. The design requirements for the carriageway pavement shall, therefore, be applicable for the design of the shoulder pavement. The design of granular shoulder, if adopted should take into account the drainage considerations besides the structural requirements and shall follow the specifications as stipulated in IRC publications.
- The pavement design task shall also document the maintenance and strengthening requirements and periodicity and timing of such treatments including overlay requirements.
- Traffic safety features and road furniture including traffic signals, signs, markings, overhead sign boards, chevrons, crash barriers, delineators etc shall be analysed. The locations of these features shall be given in the reports and also shown in the drawings.
- Report of the third-party road safety auditor, as per IRC: SP- 88, shall be included as an appendix. The audit team shall consider the safety of all road users and qualitatively reports on road safety issues and opportunities to improve safety. The provisions shall be included in the estimate as required as an outcome of the audit.

- Detailed analysis, including evaluation of alternate options and design for all embankments of height greater that 3m shall be performed. The design of embankments should include the requirements for protection works and traffic safety features.
- The Drawings Volume covering the following aspects shall be prepared and submitted and the volume shall be 'good-for-construction' drawings. All plan and profile drawings shall be prepared in scale 1:100 (V) and 1:1000 (H) scale. The following drawings shall be provided, but not limited:
    - Key map of the project
    - Horizontal Alignment showing existing tar edge, proposed C/W, ROW, existing and proposed culverts, retaining structures, cross ducts and bus bays and Longitudinal Profile including existing and proposed culverts, by-roads
    - Cross Section @25m interval along the alignment within the RoW with details of protection works if provided
    - Typical cross-sections of all features in the entire RoW including pavement layers
    - Detailed Working Drawings for individual culverts and Cross drainage structures.
    - Detailed Working Drawings for individual Bridges and Structures.
    - Detailed Drawings for at-grade and grade-separated Intersections and interchanges.
    - Drawings for Road Sign, Markings
- Schematic Diagrams (Linear chart) indicating but be not limited to the following
    - Alignment, Existing RoW and Proposed ROW. Locations of median openings, intersections, interchanges, underpasses, overpasses, bypasses.
    - Location of traffic signals, traffic signs, road markings, safety features; and
    - Locations of bus bays, bus stops, parking areas, street lighting etc.
- All drawings shall be prepared preferably in A3 size sheets. The drawings shall include details of all Benchmarks and reference pillars, control points, Horizontal & Vertical Intersection Points The coordinates of all points should be referenced to a common datum, preferably, WGS 84 referencing system.
- The drawings shall also include the locations of all traffic safety features including traffic signals, signs, markings, crash barriers, delineator and rest areas, bus bays, parking areas, street lighting requirements etc.
- The typical cross-section drawings should indicate the scheme for future widening of the carriageway. The proposed cross-sections of road segment passing through urban areas should indicate provisions for pedestrian movements and suitable measures surface and sub-surface drainage and lighting, as required.
- The Strip plans shall be prepared on the basis of data from reconnaissance and detailed topographic surveys covering the following details
    - Details of the centre line of the proposed road along with the proposed right-of way limits to appreciate the requirements.

- The details captured in the land acquisition plan should be such that the concerned authorities could readily initiate the proceedings of acquisition
- Strip plans showing the position of existing utilities and services indicating clearly the position of their relocation
- Separate strip plan showing shifting / relocation of each utility services in consultation with the concerned local authorities
- Strip plan shall indicate the proposed retaining walls & slope protection adopted
- The utility relocation plans should clearly 'show proposed right-of-way and pertinent topographic details including buildings, major trees, fences and other installations such as water-mains, telephone and electricity poles, and suggest relocation of the services along with their crossings the highway at designated locations as required and prepare necessary details for submission to the Service Departments;

7. FINANCIAL ESTIMATES & COST PROJECTIONS

- This section should focus on the cost estimates, budget for the project, means of financing and phasing of expenditure.
- Cost estimates have to be worked out on the basis of detailed bill of quantities (with detailed measurements of length, breadth, and depth / height for each item), using the current Schedule of Rates of the State Government (PRICE) or relevant SOR as applicable.
- Applicable taxes, contingencies including any O&M cost for a specific period shall be clearly specified.
- Details of land acquisition including the survey details, type of land, fair value etc shall be provided in detail.
- Details of utility shifting shall be provided in detail included the expected nos. of utilities to be shifted, various agencies involved and realistic estimate of cost.

8. REVENUE STREAMS

- Options for cost recovery, if any, should be explored
- Innovative ideas for additional revenue generation, including potential for advertisements, revenue recovery options by creating commercial value oriented investments adjacent to the roads, wayside amenities etc may be indicated.

9. COST BENEFIT ANALYSIS & INVESTMENT CRITERIA

- Cost Benefit Analysis (CBA) is a technique whereby the costs of and benefits from a scheme are quantified over a selected time horizon and evaluated by a common yardstick.
- Cost Benefit Ratio (CBR - benefit to cost ratio), EIRR (Economic Internal Rate of Return) etc. shall be worked out in detail with all supporting primary and secondary data conforming to the guidelines of IRC: SP 30 - 2009.

- The project cash flow projections for the life cycle along with underlying assumptions have to be presented.

10. ENVIRONMENTAL & SUSTAINABILITY ASPECTS

- An Environmental Management Plan (EMP) is to be developed explaining the possible environmental issues which may arise during the construction and operation of the infrastructure and associated facilities depending upon the size of the project.
- An environmental auditing for measuring the effects of certain activities on the environment against set criteria or standards. For considering Air quality, noise quality, water quality and resource management.
- Environmental impact assessment study if mandatory and measures identified to mitigate the adverse impact, if any shall be conducted and documented in detail.
- Issues relating to land acquisition, diversion of forest land, wildlife clearances, rehabilitation and resettlement should be addressed in this section.
- The study shall also evaluate the environmental impact, if any, due to developments of the roads with special reference to whether it would affect any hills, water bodies the free flow of any natural streams/canals etc due to development of roads.
- The study shall also cover the socio-economic impact that can be achieved by the development of the roads selected. It may include the details of commercial activities, agriculture, industries, pilgrim centres, tourist spots, S.C./S.T. colonies etc. along the sides of the roads and evaluate the developments that will accrue to these categories on a long term basis by the upgradation of those roads.
- Inclusion of international best practices in sustainable infrastructure management including potential low carbon emission, low energy, zero pollution etc. is desirable.

11. RISK ASSESSMENT AND MITIGATION MEASURES

- For those projects which involve large capital outlay and various issues relating to land acquisition, environmental aspects, a detailed and systematic risk analysis may be resorted.
- Identification and assessment of implementations risks which can lead to time overrun, cost escalation, scope reduction etc. is the primary stage in risk assessment.
- Risk analysis could include legal/contractual risks, environmental risks, revenue risks, project management risks, regulatory risks etc.
- The mitigation plans including risk avoidance, risk transfer, and risk elimination are to be well analysed and documented.
- For complex projects with multiple risk profiles, numerical modelling and simulation may be adopted.

12. PROJECT MANAGEMENT ORGANISATION

- Responsibilities of different agencies for project management of the said project should be elaborated. The organization structure at various levels, human resource requirements, as well as monitoring arrangements should be clearly spelt out.
- Management arrangements refer to the institutional structures and mechanisms that would be set up for ensuring effective project management. The involvement of external consultant if any shall be documented

13. CONTRACT MANAGEMENT STRATEGY

- Contracting methodology for the execution of the project should be specified in detail. (item rate, lump sum, design and execute, EPC etc.)
- The system followed in the bidding document and manuals of reference etc. shall be explained (PWD/CPWD/ FIDIC) etc.
- Any variation proposed from the current practices acceptable under Govt. of Kerala (Arbitration, escalation etc.) in the system due to any specific technical aspects associated with the project need to be explained with justification.
- Any contract clause which may likely to lead to additional financial liability shall be identified and reported with suggestions to overcome such issues.
- The detailed plan for the traffic management and safety during the construction period shall be detailed.

14. IMPLEMENTATION SCHEDULE & WBS

- The time bound work schedule is an important part of every project because it helps in better handling of projects in planning, implementation etc.
- This section should indicate the propose zero date of commencement and also provide a Bar chart / Project Schedule, wherever relevant.
- Phasing of project activities, proposed contract packages and schedule of implementation for each phase.
- Identify critical dependencies in the project and expected timelines for completion of key milestones and associated process indicators for the same.
- The DPR should provide a time-bound action plan including tendering, appointment of contractors, construction schedule, quality assurance & quality control and post-construction activities, including project delivery.

15. STATUTORY CLEARANCES

- This section should elaborate the statutory clearances to be obtained from the various authorities.
- Statutory approvals as per bye laws, master plan, fire safety norms, environmental clearance etc. as applicable for the project are to be taken.

16. QUALITY MANAGEMENT PLAN

- The DPR shall include information relating to the institution to be engaged in the quality assurance & quality control of the project execution.
- Methodology to be adopted to ensure the quality of construction should be clearly mentioned in the report.
- Quality management plan including the internal inspection and testing procedure shall be documented.
- Third party quality control mechanism if adopted its structure and plan shall be specified in detail.

17. OPERATIONS & MAINTENANCE PLAN

- The DPR shall incorporate/include information relating to the institution to be engaged in the O&M of the created infrastructure asset/enhanced infrastructure assets.
- Brief description/analysis of the key issues and obstacles in regard to O&M (including billing/collection issues) and proposed countermeasures to overcome them for the project should be contained.
- Requirement of funds for operation and maintenance of assets should also be included in the report.

ANNEXURES

I. KEY MAP OF THE PROJECT LOCATION
II. CHAINAGE WISE PROFORMA AS PER TEMPLATE 2
III. INVENTORY OF EXISTING FEATURES LIKE CULVERTS, BUS BAYS & SHELTERS ETC
IV. DRAWINGS VOLUME INCLUDING PLAN & PROFILE DRAWINGS, STRIP PLAN AND ALL OTHER DRAWINGS AS INDICATED IN SECTION 6 OF THIS TEMPLATE
V. GEO-TECHNICAL INVESTIGATION REPORT (CBR, SOIL TEST RESULTS ETC)
VI. BBD / FWD TEST RESULTS
VII. LAND ACQUISITION PLAN CLEARLY MARKED IN THE ALIGNMENT DRAWING
VIII. PAVEMENT LAYER COMPOSITION
IX. ESTIMATE SUMMARY, GENERAL & SPECIFICATION ABSTRACT, DETAILED ESTIMATE
X. PAVEMENT EVALUATION & DESIGN REPORT
XI. COPIES OF STATUTORY APPROVALS
XII. SAFETY, ENVIRONMENTAL AND SOCIAL AUDIT REPORTS
XIII. ROAD SAFETY AUDIT REPORT
XIV. ROAD SAFETY STRIP PLAN
XV. ROAD MARKINGS & FURNITURES

TEMPLATE 2 - CHAINAGE WISE PROFORMA FOR SITE DETAILS

Name of the Project:

Project Code:

Cost:

Length of Road:

Land Required (Free Surrender /Land Acquisition):

Type of work (Widening / Improvement / New Formation):

Minimum distance of 1km shall be followed while preparing the sheet. If any key change in feature is noted, smaller chainage length shall be adopted

	Chainage	Ch: 0/000 to Ch: 1/000	Ch: 1/000 to Ch: 2/000	Ch: …… to Ch: ……
Project Details	Name of town/Village			
	Location Description			
Design Basis	CBR			
	MSA			
	Deflection			
	Traffic Data (PCU/day)			
	CVPD			
Existing Road Details	Type of existing road			
	Average ROW in m			
	Carriage way in m			
	GSB in mm			
	WMM in mm			
	DBM in mm			
	BC in mm			
	WBM in mm			
	Chipping Carpet in mm			
Proposed Road Details	Type of road			
	ROW in m			
	Carriage way in m			
	Type of shoulder (Earthen/ Bitumen/ Concrete/ Interlocking)			
	Width of shoulder in m			
	Length of shoulder in m			

Functional requirement	2 Lane / 4 lane / 6 Lane			
	Cutting			
	Filling			
	Height of Embankment			
	Slab Culverts (Existing / Proposed)			
	Box Culverts (Existing / Proposed)			
	Drain Type (OD/FC/ID/LD)			
	Drain Length (L/R)			
	Utility Ducts Type			
	DR retaining wall with height (L/R)			
	RCC retaining wall with height (L/R)			
	CC retaining wall with height (L/R)			
Pavement design	GSB in mm			
	WMM in mm			
	DBM in mm			
	BC in mm			
	Pavement thickness in mm			
Road Furniture	Traffic Sign, Road Marking and Other Appurtenances			
	Boundary Stone laying			
	Safety Barriers			
	Bus Bays			
	Bus Shelter			
Repairs and Miscellaneous	Extension of Bridge			
	Repair and Rehabilitation of Bridges			
	Land Acquisition (L/R) m^2			
	Utility Shifting (EP/TP/TF/PUB.TAP)			
Additional Details if any				

GUIDELINES FOR EXECUTION AND QUALITY MANAGEMENT OF ROADS/HIGHWAY PROJECTS FUNDED UNDER KIIFB

Version 1.0

15-Oct-2018

Abbreviations

Following abbreviations shall have the meaning as set forth below: -

3D -	3 Dimensional
AASHTO-	American Association of State Highway and Transportation Officials
BM-	Bituminous Macadam
BS-	British Standards
CBR-	California Bearing Ratio
CE-	Carbon Equivalent
Cl-	Clause
DBM-	Dense Bituminous Macadam
GSB-	Granular Sub Base
HDPE-	High-Density Poly Ethylene
IRC-	Indian Road Congress Publication
IRC: SP-	Indian Standard Code Special Publication
IS-	Indian Standard
ISO-	International Organization for Standardization
KIIFB-	Kerala Infrastructure and Investment Fund Board
LL-	Liquid Limit
MARV-	Minimum Average Roll Values
MC-	Medium Curing
MDD-	Maximum Dry Density
MoRTH-	Ministry of Road Transport and Highways
OMC-	Optimum Moisture Content
PE-	Poly Ethylene
PP-	Poly Propylene
PTR -	Pneumatic Tyre Roller
PVC-	Poly Vinyl Chloride
PVD-	Prefabricated Vertical Drains
RFCH -	Reduction Factor for Chemical/Environmental Effects.
RFCR -	Reduction Factor for Creep.
RFID -	Reduction Factor for Installation Damage.
RFW -	Reduction Factor for Weathering.
RS-	Rapid Setting
SPV-	Special Purpose Vehicle
SS-	Slow Setting
UCS-	Unconfined Compressive Strength
VG-	Viscosity Grade
WMM-	Wet Mix Macadam

Contents

1. Preparation of Project Execution Document (PED)

The SPV shall prepare the Project Execution Document (PED) prior to implementation of the project and succeeding the technical sanction. The PED shall contain the following documents and drawings and shall be kept in custody of the SPV and at the project site for ready reference.

a) Copy of the Detailed Project Report (updated with any modifications engaged during the appraisal process by KIIFB & Technical Sanction)
b) Copies of Statutory Clearances
c) Work Breakdown Structure (WBS) and construction programme schedule (latest updated baseline)
d) Environmental Management Plan including site environmental features
e) Health & Safety Plan
f) Organization and Management Responsibility
g) Method Statement for critical items of construction
h) Arrangement for traffic during construction and maintenance
i) Quality Assurance Plan
j) Copy of Technical Sanction including
    a. Copy of TS Slip / Order
    b. Copy of Abstract of estimate, Abstract of items, Detailed Estimate
k) Drawings Volume as mentioned below

The PED shall also cover all stages of work such as setting out, selection of materials, selection of construction methods, deployment of personnel and supervisory staff, quality control testing mechanisms proposed etc. The Quality Assurance plan in PED shall cover the details as per IRC SP: 47: Guidelines on Quality Systems for Road Bridges & IRC SP 57: Guidelines for Quality Systems for Road Construction. These shall broadly cover QA of all services rendered, all items to be supplied and all activities to be performed under the contract including temporary structures and equipment which shall influence the quality of completed works or the progress of the contract.

The Drawings Volume covering the following aspects shall be prepared and submitted and the volume shall be 'Good-For-Construction' drawings. All plan and profile drawings shall be prepared in scale 1:100 (V) and 1:1000 (H) scale. The following drawings shall be provided:

- Key map of the project
- Horizontal Alignment showing existing tar edge, proposed C/W, ROW, existing and proposed culverts, retaining structures, cross ducts and bus bays and Longitudinal Profile including existing and proposed culverts, by-roads
- Cross Section @25m interval along the alignment within the RoW with details of protection works if provided
- Typical cross-sections of all features in the entire RoW including pavement layers

- Detailed Working Drawings for individual culverts and Cross drainage structures.
- Detailed Working Drawings for individual Bridges and Structures.
- Detailed Drawings for at-grade and grade-separated Intersections and interchanges.
- Drawings for Road Sign, Markings

- Schematic Diagrams (Linear chart) indicating but be not limited to the following
  - Alignment, Existing RoW and Proposed ROW. Locations of median openings, intersections, interchanges, underpasses, overpasses, bypasses.
  - Location of traffic signals, traffic signs, road markings, safety features; and
  - Locations of bus bays, bus stops, parking areas, street lighting etc.
- All drawings shall be prepared preferably in A3 size sheets. The drawings shall include details of all Benchmarks and reference pillars, control points, Horizontal & Vertical Intersection Points The coordinates of all points should be referenced to a common datum, preferably based on GTS bench mark referencing system.
- The drawings shall also include the locations of all traffic safety features including traffic signals, signs, markings, crash barriers, delineator and rest areas, bus bays, parking areas, street lighting requirements etc.
- The typical cross-section drawings should indicate the scheme for future widening of the carriageway. The proposed cross-sections of road segment passing through urban areas should indicate provisions for pedestrian movements and suitable measures surface and sub-surface drainage and lighting, as required.
- The Strip plans shall be prepared on the basis of data from reconnaissance and detailed topographic surveys covering the following details
  - Details of the centre line of the proposed road along with the proposed right-of way limits to appreciate the requirements.
  - The details captured in the land acquisition plan should be such that the concerned authorities could readily initiate the proceedings of acquisition
  - Strip plans showing the position of existing utilities and services indicating clearly the position of their relocation
  - Separate strip plan showing shifting / relocation of each utility services in consultation with the concerned local authorities
  - Strip plan shall indicate the proposed retaining walls & slope protection adopted

The utility relocation plans should clearly 'show proposed right-of-way and pertinent topographic details including buildings, major trees, fences and other installations such as water-mains, telephone and electricity poles, and suggest relocation of the services along with their crossings the highway at designated locations as required and prepare necessary details for submission to the Service Departments.

a) Preparation of Working Drawings

Working drawings shall be prepared by the site Engineers of the contractor and may be adopted with the approval of the engineer in charge. Examination and approval by the engineer of any drawings or other documents submitted by the contractor shall not relieve the contractor of his responsibilities or liabilities under the contract.

2. Traffic Management in Work Zone Area

Safe and effective traffic control is vital for the safety of the traveling public. The traffic control guidelines in this manual provides consistent guidance for the vehicular traffic through work zones. These procedures will also reduce the risk to maintenance workers who are exposed to potential traffic hazards.

The contractor shall at all time carry out work on the highway in a manner creating least interference to the flow of traffic while consistent with the satisfactory execution of the same. For all works involving improvements to the existing highway, SPV should prepare and implement a traffic management plan for all road works. The contractor should implement the traffic management plan with the guidance of the Engineer in charge. Particularly attention should be paid to requirements for smooth and safe pedestrian flow.

The plan should include the following:

i. Provision of a qualified safety officer with support staff to serve as a site safety team
ii. Provision of traffic safety devices and road signs in construction zones as per IRC: SP:55 and other relevant IRC codes and MoRTH Cl:112.4
iii. Safety measures for the workers engaged including personal protection equipment
iv. First aid and emergency response arrangements
v. Details and drawings of arrangements in compliance with other sub sections of this section.

Principles to enhance motorist and worker safety in the work zone are

- Develop a comprehensive traffic control strategy that can be implemented at the work site. Evaluation of the work operation, site, and traffic conditions should determine the traffic control measures to be utilized.
- Maintain traffic flow as close to normal highway situations as possible.
- Do not surprise the motorist. Locate and place devices to maintain adequate sight distance for driver recognition and reaction on straight highway sections if possible.
- Prepare, understand, and implement a traffic control plan. Do not routinely rely on minimum standards. Evaluation of the work operation, site and traffic conditions should be determined to the appropriate level of traffic control measures.
- Avoid frequent and abrupt changes in alignment.
- Minimize worker exposure time to traffic.
- Provide adequate warning, delineation, and channelization.
- Remove inappropriate pavement markings on long-term projects. (Work occupying a location three day or more)
- Provide flagging only when other methods of traffic control are inadequate
- Inspect traffic set-up control measures prior to work.

- Monitor traffic control and modify where changing traffic conditions warrant.
- Remove, cover, or turn control devices away from traffic when not needed or not in use.
- Channelize traffic with pavement markings, signages, cones, plastic barrels, water filled barriers, or lightweight devices.
- Sand bags may be used for sign ballast. Do not use heavy, solid weights, (e.g., concrete blocks) for stabilizing portable sign supports.
- Traffic control measures must be selected and implemented with the drivers' perspective in mind. Credible messages must be sent to the driver to provide a reasonable expectation that the driver will comply.
- Plan for work operations and the associated traffic control. Do not rely completely on standard devices and procedures when more effective measures should be considered.
- Use traffic control devices (cones and barrels) to define the closed portion of the roadway that is the work zone. Even short-term operations can realize a safety benefit from placing cones in a manner that sends an obvious message to drivers that a portion of the road is closed, and they must divert around the work zone.

2.1. Traffic Control Zones

The traffic control zone is the work area between the first advance warning sign and the point beyond where traffic is no longer affected. Traffic control zones are divided into the following areas:

- Advance Warning Area
- Transition Area (for lane or shoulder closures)
- Buffer Space
- Work area
- Termination area

2.1.1. Advance Warning Area

The advance warning signs are located before the transition area to provide ample opportunity for motorists to accomplish a desired maneuver. The first sign to appear in the advance warning area tells motorists they are approaching a work zone (e.g., ROAD WORK AHEAD).

The next sign display provides more detailed information about the situation ahead (e.g., ONE LANE ROAD AHEAD), and the third sign states what action to take (e.g., BE PREPARED TO STOP).

2.1.2. Transition Area

This is the zone where the lane and/or shoulder is closed by channelizing devices. If restricted sight distance is a problem (e.g., sharp vertical or horizontal curve), begin the lane closure well in advance of the view obstruction. Do not hide the beginning of lane closures behind curves.

2.1.3. Buffer Space

This is the unoccupied space between the transition and work areas. It is there to provide a margin of safety for both traffic and workers.

2.1.4. Work Area

Where equipment and workers perform their construction functions.

2.1.5. Termination Area

Allows traffic to resume normal driving immediately after leaving the work area

2.1.6. Traffic Control Devices

Traffic control devices are used to warn, regulate, and guide traffic. They include signs, signals, lighting devices, pavement markings, delineators, channeling devices, hand signaling devices, and temporary barriers.

2.1.7. Channelizing Devices

Channelizing devices are used to direct traffic away from or around a work area, or to separate two-way traffic. Channelizing devices must be reflective for night use. Usually this is done by using Traffic cones, Delineators, Barricades, Warning tapes, Cautionary Board etc.

2.1.8. Passage of Traffic along a part of Existing Carriageway Under Improvement

For widening/strengthening existing carriageway where part width of the existing carriageway is proposed to be used for passage of traffic, treated shoulders shall be provided on the side on which work is not in progress. The surface shall be maintained throughout the period during which traffic uses the same till the completion of the project.

2.1.9. Traffic Safety and Control

The Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, markings, flags, lights and flagmen as may be required by the Engineer in charge for the information and protection of traffic approaching or passing through the section of the highway under improvement. Before taking up any construction, an agreed phased program for the diversion of traffic on the highway shall be drawn up in consultation with the Engineer in charge. The barricades erected on either side of the carriageway/portion of the carriageway closed to traffic, shall be of strong design to

resist violation, and painted with alternate black and white stripes. Red lanterns or warning lights of similar type shall be mounted on the barricades at night and kept lit throughout from sunset to sunrise.

2.1.10. Maintenance of Diversions and Traffic Control Devices

Signs, lights, barriers and other traffic control devices, as well as the riding surface of diversions shall be maintained in a satisfactory condition till such time they are required as directed by the Engineer in charge. The temporary travel way shall be kept free of dust by frequent applications of water, if necessary.

3. Setting Out and Re-establishment of Control Points

Before starting any work, the work shall be set out on the ground as per approved plans. The responsibility for setting out a work is that of the contractor as per terms of contract. It is however necessary that the setting out is checked and approved by the Engineer in charge of the work. If in the course of checking, the Engineer in charge feels that the advice of any higher authority is necessary he shall refer the matter to such higher authority and abide by their instructions. The Agreement Authority may in the case of major works, direct that the setting out shall be got checked and approved by an officer of rank higher than that of an Engineer in charge. Benchmarks to be adopted for a work shall be of a permanent nature. It is desirable to have more than one benchmark and these shall be properly interconnected to enable checking on a future date. The position of these benchmarks and setting out marks shall be shown in a sketch drawn with its coordinates in all directions.

To establish firm vertical control for location, design and construction, permanent bench marks should be established at intervals of 2 km and temporary bench marks has intervals of 250 metres (exceptionally 500 metres), and at or near all drainages or underpass structures. It is particularly important that a single datum, preferable GTS datum, should be used to tie up all the levels. For bench mark levelling, check levels should be run over the entire line back to the first bench mark (ref: IRC SP:19-2001)

The lines and levels of formation, side slopes, drainage works, carriageways and shoulders shall be carefully set out and frequently checked, care being taken to ensure that correct gradients and cross sections are obtained everywhere based on GTS datum. The contractor will be the sole responsible party for safe- guarding all survey pillars, bench marks, beacons, etc. The Engineer in charge will provide the Contractor with the data necessary for setting out of the centre line. After obtaining approval of the Engineer in charge, work on earthwork can commence and the profile and cross-sections shall form the basis for measurements and payment. The work of setting out shall be deemed to be a part of general works, preparatory to the execution of work and no separate payment shall be made for the same. Precision automatic levels, having a standard deviation of ±2 mm per km, and fitted with micrometer attachment shall be used for all double run leveling work. (ref: MoRTH, section 100, Clause: 109)

4. Shifting of Existing Utility

The Engineer in charge shall prepare drawing showing the affected services like water pipes, sewers, oil pipelines, electric lines and posts, telephone lines, OFC pillars and cables, gas ducts etc owned by various authorities including Public Undertakings and Local Authorities. He shall do this by collecting necessary details of such utilities in the site or in consultation with the concerned departments and joint inspection wherever necessary. These drawings shall be finalized during the tender stage and utilities are to be shifted before the commencement of the work. The shifting of utilities shall be executed as per the prevailing rules in the public works execution or as per the latest guidelines issued by KIIFB or concerned departments from time to time.

5. Dismantling of Existing Pavement and Other Structures

This work shall consist of removing, as hereinafter set forth, existing culverts, pavements, kerbs and any other structures within the RoW. Existing culverts, drains, retaining wall, pavements and any other structures which are within the highway and which are designated for removal, shall be removed upto the limits and extent specified in the drawings or as indicated by the Engineer in charge.

Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed, adjacent pavement, structures and any other work to be left in place. All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

- Engineer in charge shall ensure that dismantling structures are quantified/measured as per BOQ

5.1. Disposal of Materials

All materials obtained from dismantling operations which, in the opinion of the Engineer in charge, cannot be used or auctioned shall be disposed of as directed by the Engineer in charge with all lifts and upto a lead of 1000 m.

6. Earth works

This work shall consist of excavation, removal and satisfactory disposal of all materials necessary for the construction of roadway, side drains and waterways in accordance with the lines, grades and cross sections shown in the drawings or as indicated by the Engineer in charge. Excavation for road works shall confirm to the specification of section 300 of MoRTH. It shall include the hauling and stacking of or hauling to sites of embankment and subgrade construction, suitable cut materials as required, as also the disposal of unsuitable cut materials in specified manner, trimming and finishing of the road to specified dimensions or as directed by the Engineer in charge.

6.1. Classification of Excavated Material

The excavated materials are basically classified as soil, ordinary rock, hard rock, marshy soil etc. which is specified in section 301.2.1 of MoRTH 5th Revision.

6.2. Authority For classification

The classification of excavation shall be done by the Engineer in charge

6.3. Road Formation in Cutting

Where hard strata are available, and the formation level is below existing ground level, excavation shall be done with due consideration of the stability of slopes. In case of rocks the provisions of clause 301.3.5 and 301.6 of MoRTH shall apply.

- For widening of existing pavement, the existing shoulders shall be removed to their full width and up to subgrade level to enable proper compaction in the widened portions.
- The Engineer in charge shall ensure that the Contractor had taken adequate protective measures to see that the excavation operations do not affect or damage adjoining structures. For safety precautions, guidance may be taken from IS: 3764.
- In rocky formation, the surface irregularities shall be corrected with granular base material to achieve the specified profile and levels
- Where blasting is involved for rock cutting, guidelines given in Clause 302 of MoRTH Specifications shall be followed
- The edges of the roadway as constructed should be correct within a tolerance limit of ±40 mm in plain and rolling terrains and ±50 mm in hilly terrain.
- No point on the slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope (300 mm in case of rock excavation). The same shall be ensured by Engineer in charge.

6.4. Disposal of excavated materials

All the excavated materials are the property of the Kerala PWD. The material obtained from the excavation of roadway, shoulders, verges, drains, cross drainage works etc., shall be used for filling up of roadway embankment, the existing pits in the right -of-way and for landscaping of the road as directed by the Engineer in charge, including levelling and spreading with all lifts and lead upto 1000 m and no extra payment shall be made for the same. All hard materials, such as hard rocks, rubble, etc., not intended for use as above shall be stacked neatly on specified land as directed by the Engineer in charge with all lifts and lead upto 1000 m. Unsuitable and surplus material not intended for use within the lead specified above shall also, if necessary, be transported with all lifts and lead beyond initial 1000 m, disposed of or used as directed by the Engineer in charge.

6.5. Embankment / Subgrade Construction

The following points should be noted while embankment construction.

- Engineer in charge shall ensure that only suitable material is used in the construction of fill and that the required density is achieved at the expected moisture content
- Embankment construction in waterlogged and marshy areas shall be in accordance with IRC: 34-2011
- Spreading of material shall be done by means of motor grader or other approved mechanical means
- Generally, embankments shall be constructed in 250 mm compacted layers parallel to the finished grade of the road.
- The samples of soil brought to site shall be tested to determine the laboratory maximum dry density (MDD) and optimum moisture content (OMC) in accordance with IS: 2720 (Part 8).
- Moisture content at site shall be checked by using rapid moisture meter, deficiency in moisture content will be made +/-2% either at borrow area or after spreading
- If moisture content is made +/-2% after spreading, mixing of material shall be done by means of disc harrows fitted with motor grader
- After attaining OMC, vibratory roller shall be used for compacting to attain required degree of compaction
- For each completed layer the field density shall be checked (One test for each 1,000 square meters) by laboratory personnel. If test results show the required density is not achieved further compaction is necessary (density requirements is mentioned in table 6.1 and compaction requirement is mentioned in table 6.2)

Table 6.1: Density requirements of embankment and subgrade material.

Sl. No.	Type of work	Maximum laboratory dry density when tested as per IS: 2720 (Part 8)
1	Embankments up to 3.0 m height, not subjected to extensive flooding.	Not less than 15.2 kN/m3.
2	Embankments exceeding 3.0 m height or embankments of any height subjected to long periods of inundation.	Not less than 16.0 kN/m3.
3	Subgrade, earthen shoulders, verges/backfill.	Not less than 17.5 kN/m3.

Table 6.2: Compaction Requirement for Embankment and Sub-grade

Sl. No.	Type of work/Material	Relative compaction as percentage of max. laboratory dry density as per IS:2720(Part 8)
1	Subgrade and earthen shoulders.	Not less than 97%
2	Embankment	Not less than 95%
3	Expansive Clays a) Subgrade and 500mm portion just below the subgrade b) Remaining portion of embankment	 Not allowed 90-95%

The subgrade must be prepared over the full width of the embankment. This is generally carried out in lengths of greater than 100 metres. In some cases, to maintain traffic, part width working may be necessary. When the road is to be placed on existing material (excavated material can be reused in this section), this shall be fully loosened to a depth of 150 mm below the subgrade level. Any lumps shall be removed or broken up to be less than 50 mm in size. The subgrade must be compacted uniformly by use of adequate and appropriate compaction equipment.

In case of sub grade preparation, a greater number of passes is required using vibratory roller to attain required field density. Final layer shall be checked by means of templates and rectification if any will be done by making up the deficiency or by loosening and further compacted

Construction of rockfill embankment is suitable when the foundation conditions are poor. Special rock equipment and procedures are to be followed for rock borrowing, hauling, placing and compaction.

All embankments, subgrades, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the lines, grades, and cross-sections shown on the drawings or as directed by the Engineer in charge. It shall follow the specification as per clause 305 of MORTH 5th revision

7. Ground Improvement/ Soil Stabilization

7.1. Ground Improvement using PVD with Surcharge

Using geosynthetic drains viz., Prefabricated Vertical Drains (PVD) with surcharge, weak embankment foundations having problematic sub-soil conditions can be improved to carry the design load of the embankment. The design and construction of PVD with surcharge is carried out as per IS: 15284 (Part 2). The details of materials and installation are given in Clause 314.2 of MoRTH Specifications for Road and Bridge works.

a. Engineer in charge shall ensure that the geosynthetic band drain is stored in such a way that it is protected from UV light. As storage and handling is done as per ASTM D 4873
b. Engineer in charge should ensure that the blanket of granular coarse sand is spread over the entire area and covered with geotextile layer on top and bottom
c. Engineer in charge shall be ensured that the geotextile has not been damaged during installation. Should give directions to replace the damaged ones from site
d. The surcharge shall be placed with approved embankment material with adequate side slopes.
e. Engineer in charge shall specify the locations where shear strength parameters of sub soil is to be measured

7.2. Rammed Stone Columns for Ground Improvement

a. The design and construction of this is carried out in accordance with IS: 15284 (Part 2).
b. The details of materials and installation are given in Clause 314.3 of MoRTH Specifications for Road and Bridge works.
c. Before starting the installation, the Engineer in charge shall verify the installation procedure submitted by the contractor and modification if need any shall be suggested
d. Engineer in charge shall ensure that the installation procedure for the stone column is as per the procedure submitted earlier

7.3. Ground Improvement using Geosynthetic

Geogrid has been used to reinforce road sections. The inclusion of geogrid in subgrades changes the performance of the roadway in many ways. Tensile reinforcement, confinement, lateral spreading reduction, separation, construction uniformity and reduction in strain have been identified as primary reinforcement mechanisms. Empirical design and post-construction evaluation have lumped the above described benefits into better pavement performance during the design life. Geogrid with reduced aggregate thickness option is designed for roads.

a. Clearing and grubbing should conform to the requirement of 'Specification for Road and Bridge Works, MORTH'.
b. The top foundation soil shall be free from undulations and prepared to the level as indicated in the construction working drawings or as directed by the Engineer in charge.

c. If geotextiles or low strength geogrids are used, a cushion layer of sand must be given for minimizing installation damages. Sand layer shall be compacted to specified design modified proctor density.

d. Slack/wrinkles in the reinforcement layer shall be removed manually. Direct movement of vehicles on the reinforcement shall be prevented.

e. The reinforcement should not be exposed to sunlight for more than the maximum duration permitted in the approved drawing/installation methodology.

f. Required overlapping length must be detailed in the drawing by the designer

g. An overlap of 300 mm or as indicated by Engineer in charge shall be provided between the adjacent rolls. There should be no joints or seams along the principal strength direction of the basal reinforcement.

h. Where reinforcement is to be anchored by passing it round an anchorage block (thrust block), such as a gabion basket, and back on itself, then the reinforcement should be pulled tight around the block and secured by pinning or weighting until fill around the block has been placed

i. Reinforcement layer should be covered with well graded sand having angle of internal friction as per approved drawings.

j. All filling shall be done in layers of 200 mm thickness. If ground water table is encountered proper dewatering arrangement shall be arranged

k. Fill in immediate contact with the reinforcement should be placed and spread in the longitudinal direction of the reinforcement only.

l. Under no circumstances should tracked vehicles be allowed to traffic over the laid, unprotected reinforcement.

m. The sequence of fill placement should be considered with care, particularly over very poor soft soil where bearing capacity is very low

7.4. Soil Stabilization using Cement/ Lime

Soil is modified with lower cement content to improve the material to get the required subbase properties. The specifications for materials and construction procedures are given under Clause 403 of MoRTH Specifications for Road and Bridge works (5th revision 2013)

The following points shall be kept in mind while executing the work.

a. The subgrade shall be checked for line, grade and its compaction must be ensured.

b. The surface shall be scarified and reshaped if required. In such cases, necessary density checks shall be followed and the layer got approved by the Engineer in charge.

c. Stabilization shall be carried out preferably by mechanical means.

d. Rotavators or agricultural machineries like ploughs or disc harrows shall be used for in-situ mixing the lime with soil.

e. It shall be ensured by trial runs that the plant used and method of processing shall be capable of pulverizing the soil to the required degree and achieving uniform mixing.
f. Wherever manual mixing is adopted, it shall be ensured that mixing of the ingredients is uniform to the full depth of the layer processed.
g. The degree of pulverisation shall be as specified (100% passing 26.5 mm sieve and 80% passing 5.6 mm sieve as per Clause 402.3.2 of MoRTH Specifications).
h. Mixing shall be uniform so that no streaks of free cement are visible.
i. After mixing, the cement content of the mix shall be determined.
j. Before compaction, the moisture content of the mixed material shall be brought to the desired level, normally optimum moisture content.
k. The time interval between mixing of cement with soil and compaction shall not exceed 3 hours.
l. Rolling shall commence from edge and progress towards the centre. In curves, the rolling shall proceed from the inner edge to the outer edge.
m. The surface after rolling shall be free from movement, compaction planes, ridges, cracks or loose materials.
n. After rolling, the compacted layer shall be checked for compaction control, levels and shape.
o. The layer shall be subjected to curing for 7 days and the subsequent pavement courses shall be laid immediately to prevent further drying out of the layer.
p. No traffic shall be allowed over the stabilized layer.

In this method, a pre-determined quality of lime is added to soil, mixed thoroughly and compacted at the required moisture content to get the desired subbase. The specifications for materials and construction procedures are given under Clause 402 of MoRTH Specifications for Road and Bridge works (5th revision 2013)

8. Drains

Drains are an integral part of road and must be provided for all roads. Moreover, these must be properly maintained, as otherwise, the entire road gets damaged. The main objective of drainage is to prevent early damage of the pavement due to entry of excess of water and preventing saturation up to a dept of 1 m below the top of the sub grade. This can be achieved by providing proper drainage. The two types are surface drains and subsurface drains. Details may be referred in IRC SP 42 and IRC SP 50, in case of urban drainage

In designing and constructing side drains, the following aspects shall be given due consideration:
a) The side drains are generally provided on both sides of the road. In hilly terrains, side drains on the hill side are made when road is built in a cut section.
b) Parabolic section is hydraulically the best and the most erosion resistant cross section for a side drain. However due to easiness in construction, trapezoidal sections are preferred. U-shaped drains are constructed when the discharge is high.
c) IRC: SP 42 - Guidelines on road drainage - may be referred for detailed hydraulic design of the drain.
d) The excavated bed and sides of the drains shall be dressed to bring them in close conformity with the specified dimensions, level and slopes.
e) As far as possible, the excavated earth from side drains shall be utilized in the construction of fill/subgrade, if found suitable.
In case of shoulder drain if material is impervious like clay or black cotton soil, one the following measures may be adopted:
a) Provide a continuous drainage layer 75 mm to 100 mm thick below the subbase extending to the full width of the embankment/cut.
b) Constructing a subbase/base layer with drainage material, extending to the full width of the cut/fill, and provided with a generous cross slope for rapid drainage.
c) A longitudinal filter drain at the edge of the pavement connecting the shoulder drains will be more effective in ensuring drainage.
d) Providing shoulder with hard materials like granular or stabilized soil for effective drainage.
For hilly terrain catch water drain methodology shall be adopted

9. Culverts

Culvert is a cross drainage structure having a total length of 6 m or less between the inner faces of the dirt walls or extreme vent way boundaries measured at right angles thereto. Construction of culverts shall conform to IRC: SP-13 and MoRTH Specifications or as directed by the Engineer in charge.

Following requirement shall satisfy in pipe culvert construction:

- Reinforced concrete pipes NP-4 type conforming to IS: 458 shall be used. The internal diameter shall not be less than 900 mm except in unavoidable situations.
- Provide concrete cradle bedding for pipes of internal dia. 1000 mm or more and when height of fill is more than 4 m above the pipe
- Provide first class bedding when height of filling is less than 4 m above the pipe.
- For expansive soils, provide a layer of approved granular material or non-expansive material of minimum 450 mm thickness under the bedding.
- Backfilling upto 300 mm above the top of the pipe shall be carefully done and the soil thoroughly rammed, tamped or vibrated in layers not exceeding 150 mm, particular care being taken to thoroughly consolidate the materials under the haunches of the pipe. Approved pneumatic or light mechanical tamping equipment can be used
- The cushion between the top of the pipe and the road level shall not be less than 600mm (IRC SP:13-2004)

Following requirement shall satisfy in culvert construction:

- Take the minimum depth of foundation up to the stratum having specified bearing capacity shown in the Drawing but not less than 2 m below the scour level where no bed protection is provided or 1.5 m below the protected bed level.
- In case of rocky bed, ensure embedment of foundation into the rock below, the minimum depth being 500 mm for hard rocks and 1200 mm for soft erodible rocks.
- Adopt coursed rubble/stone masonry or plain/reinforced cement concrete for piers, abutments and wing/return walls. For wings and return walls up to 3 m height, use random rubble masonry or plain cement concrete.
- Make provision for weep holes in solid abutments and provide filter media also.
- Provide vertical expansion gaps of 20 mm width between abutments and wing walls.
- Construction work shall be carried out in half lane of the pavement without hindering traffic in main roads.

10. Protection works

10.1. DR Retaining Wall

a) Solid retaining walls shall not be preferred where retaining heights exceeding 3 m
b) It shall be ensured by the Engineer in charge that masonry work is laid to line, level, curve and shapes as per working drawings
c) For masonry works over rock, a levelling course of 100 mm thickness M15 grade of concrete shall be laid and then stone masonry work shall be done
d) In case headers are not available, precast headers of M15 concrete shall be used. Cast in-situ headers are not permitted

10.2. RR Retaining Wall

a) Through bond stones shall be provided in masonry upto 600mm thickness, in case of thickness more than 600m a set of two or more bond stones overlapping each other at least by 150mm shall be provided in line from face to back

10.3. RCC Retaining Wall

a) The RCC cantilever wall type retaining structure shall be preferred for heights 4.5 m to 7.5 m.
b) Backfilling of retaining wall shall be applied on heel slab first and then toe side filling shall be carried out.
c) Inverted filter shall be provided behind retaining walls to drain off ground water table or rainwater seepage.
d) Special precautions shall be taken to prevent any wedging action against structures and the slopes bounding the excavation for the structure shall be stepped or strutted to prevent such wedging action.
e) Weep holes shall be provided in RR masonry walls at spacing of about 1.5 m centre-to-centre in either direction. The size of weep holes shall be 100 mm to 150 mm PVC (flexible) pipes and shall be sloped towards valley side to effectively drain the water from ground. The weep holes shall be provided above the low water level.

11. Pavement Layer construction

11.1. Granular Subbase

Granular subbase is made with well graded aggregates, spread and properly compacted on a previously prepared subgrade. Construction of GSB layer shall be as per MoRTH Cl: 401. When sub base is laid in two layers as upper and lower sub base, the thickness of each layer shall not be less than 150mm.

a. Materials

- The material for granular subbase shall be natural sand, crushed gravel or rock free from organic or other deleterious substances conforming to the grading as per MoRTH Table 400-1
- Water absorption for aggregate shall be checked as per IS:2386 Part 3
- If water absorption of aggregate is greater than 2% then the aggregate shall be tested for wet aggregate Impact value as per IS:5640
- Grading III and IV GSB shall be used for lower sub base and Grading V and VI shall be used for sub base cum drainage layer.

Table: 11.1- Physical Requirements for Material for Granular Sub Base (MoRTH Table 400-2)

Aggregate Impact Value (AIV)	IS:2386-Part 4	Max Value of 40 AIV
Liquid Limit	IS:2720-Part 5	Maximum Value of 25
Plasticity Index	IS:2720-Part 5	Maximum Value of 6
CBR at 98% Dry Density	IS:2720-Part 5	Minimum 30 unless otherwise specified in the contract

b. Laying Trials

Once the plant trials have been successfully completed and approved, the contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid and compacted in accordance with clause MoRTH Cl:501. The laying trial shall be carried out on a suitable area which is not to form part of the works. The area of the laying trials shall be a minimum of 100sq.m of construction like that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The contractor shall previously inform the Engineer in charge of the proposed method for laying and compacting the material. The plant trials then establish if the proposed laying plant, compaction plant, and methodology can produce satisfactory results.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project and no variation of either shall be acceptable, unless approved in the writing by the Engineer in charge, who may at his discretion require further laying trials.

c. Construction

The following points shall be given attention during execution of the work.

a) Engineer in charge shall check and certify that the subgrade is in line, grade and well compacted before laying GSB layer

b) Engineer in charge shall ensure the Moisture content of the mix in accordance with IS:2720(Part 2) and suitably adjusted so that at the time of compaction it is from 1% to 2% below optimum moisture content (OMC).

c) Spreading of GSB shall be done by using a motor grader

d) Immediately after spreading, the rolling shall be done with Engineer in charge shall ensure that roller used is as specified below

- 80 to 100 kN weight smooth wheel for compacted thickness <100mm
- 80 to 100 kN vibratory roller for a compacted single layer upto 200mm

e) Rolling shall commence from edge and progress towards the centre. In curves, the rolling shall proceed from the inner edge to the outer edge.

f) Rolling shall continue till the density achieved is at least 98% of the maximum dry density (MDD) determined as per IS: 2720 (Part 8).

g) It shall be ensured by the Engineer in charge that sufficient thickness of the layer is obtained after compaction and required density is achieved after final compaction

h) After compaction, Engineer in charge shall inspect the compacted surface and ensure that it is in required grade and camber.

i) If any surface irregularities are found during inspection, Engineer in charge shall immediately give instruction to contractor for rectification of defects immediately

11.2. Wet Mix Macadam

Wet mix Macadam (WMM) is constructed as a subbase or base and in accordance with IRC: 109. The detailed specification and construction procedures for the work are given under Clause 406 of MoRTH Specification for Road and Bridge works (5th revision 2013).

- Thickness of a single compacted Wet Mix Macadam layer shall not be less than 75mm. when vibrating or other approved types of compacting equipment are used compacted thickness of sub base course may be upto 200mm with approval of the Engineer in charge
- The aggregate used shall conform to the physical requirement set for as per MoRTH given in Table 11.2 below
- Aggregate should satisfy the grading requirement as per MoRTH table 400-13.

Wet mix macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced mixing arrangement like pugmill. The plant shall satisfy the features mentioned in MoRTH Cl: 406.3.3. Physical requirement of material for WMM shall satisfy the values given in table below

Table: 11.2- Physical Requirement of Coarse Aggregate for Wet Mix Macadam (MoRTH Table 400-12)		
Los Angeles Abrasion Value	IS:2386 Part 4	40% Maximum
Aggregate Impact Value	IS:2386 Part 4	30% Maximum
Combined Flakiness and Elongation Indices	IS:2386 Part 1	35% Maximum

a. Laying Trials

Laying trials shall follow the same procedure as mentioned under GSB layer construction

b. Construction

The following points shall be carefully observed while executing the work.

a) Engineer in charge shall check the subgrade/subbase for density requirement, line, grade and cross section. If required, Engineer in charge shall suggest surface scarification and reshaped followed by density check
b) Adequacy of the lateral confinement of the WMM mix shall be checked before the commencement of the work.
c) Spreading of mix shall be done using paver finisher. In exceptional cases where it is not possible to utilize mechanical means like motor grader
d) WMM shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pugmill or pan type mixer of concrete batching plant
e) For small quantity of wet mix preparation, mixing in a concrete mixer may be permitted.
f) The mixing shall be uniform and there should be no segregation of coarse and fine aggregates.
g) The optimum moisture content for WMM mix shall be determined in accordance with IS: 2720 (Part 8).
h) While adding water in the plant, due allowance shall be given for loss of moisture due to evaporation during transporting to site.
i) At the time of compaction, the moisture content shall not vary more than the agreed limit.
j) The wet mix shall be spread by the paver finisher or motor grader.
k) For portions where, mechanical means cannot be used, manual means as approved by the Engineer in charge shall be used only in restricted areas
l) After spreading, the surface of the aggregate shall be carefully checked with a template. Any high or low spots noticed shall be removed or filled up, as required.
m) The thickness of the layer shall be checked.
n) Rolling of the spread material shall begin immediately from edge to the centre.
o) In curve portions, rolling shall proceed from inner edge to the outer.

- If thickness of single compacted layer does not exceed 100mm, a smooth wheel roller of 80 to 100 kN weight may be used
- If compacted single layer thickness is upto 200mm, then compaction shall be done with help of vibratory roller of minimum weight 80 to 100 kN
- Speed of roller shall not exceed 5Km/h

p) Rolling shall continue till the required density is achieved as per IS:2720 Part-8. By site trials number of passes required by each roller to achieve the specified level of compaction shall be determined.

q) After final compaction, the layer can dry for 24 hours.

r) No traffic shall be allowed over the WMM layer

c. Rectification of surface irregularities

a) If the surface irregularity of the WMM layer exceeds the permissible tolerance, the same shall be rectified.

b) If the irregularities developed during rolling which exceed 12mm when tested with 3m straight edge. These surfaces shall be loosened, and premixed material shall be added or removed as required. And rolling again to achieve uniform surface conforming the desired grade and camber

c) Such areas shall be scarified to the full depth, excess material removed or fresh material added, as found necessary and recompacted to the required density.

d) In no case, the depression shall be filled up with unmixed or ungraded materials or fines

11.3. Prime Coat over Granular Base

Prime coat is the application of a single coat low viscosity bituminous material over a granular base or subbase. The specifications and procedure for applying prime coat is given under Clause 502 of MoRTH Specifications (5th revision).

a. Materials

a) The primer shall be cationic bitumen emulsion SS1 grade conforming to IS: 8887

b) For WMM, SS1 grade bitumen emulsion shall be used at the rate of 0.7 to 1.0 lit/m2.

c) The quantity of primer shall be selected based on site trials to achieve a penetration of 8 mm to 10 mm into the primed layer and there is no run-off of excessive primer.

b. Construction

a) Primer shall be applied by a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying the material shall not be allowed except in small areas

b) Granular surface shall be swept clean by power brooms or mechanical sweepers and free from dust

c) The primer shall be applied at a uniform rate using a bitumen pressure sprayer at the rate specified above

d) No heating or dilution of SS1 bitumen emulsion is permitted at site.

e) A primed surface shall be allowed to cure for at least 24 hours to allow for the moisture/volatiles to evaporate before the bituminous mix is placed.

f) Any excess primer shall be blotted with a light application of sand.

g) A primed surface shall not be allowed to traffic.

11.4. Tack Coat

A tack coat is a very light spray application of low viscosity liquid bituminous material to existing bituminous material, cement concrete or primed granular surface to create a bond between the new bituminous layer and the existing surface. Work shall be carried out in accordance with MoRTH Cl:503.

a. Materials

a) The binder for tack coat is either cationic bitumen emulsion (RS1) complying with IS: 8887 or suitable low viscosity paving bitumen VG 10 grade conforming to IS: 73.

b. Construction

a) Tack coat shall not be applied if the weather is rainy, windy or if the temperature in the shade is less than 10°C. If emulsion is used, the surface may be slightly damp. If cutback bitumen is used for tack coat, the surface shall be dry.

b) The tack coat shall be applied at a uniform rate using a bitumen pressure sprayer at the rate specified. Hand spraying may be permitted in small areas or narrow strips where the sprayer cannot be used.

c) The surface on which the tack coat is to be applied shall be clean, free of dust, dirt and any other extraneous matter.

d) Immediately before the tack coat is applied, the surface shall be swept clean with a mechanical broom and high-pressure air jet.

e) The granular or stabilized surfaces shall be primed before the application of tack coat.

f) No heating or dilution of RS1 bitumen emulsion is permitted at site.

g) The spraying temperature for bitumen emulsion is 20°C to 70°C

h) The tack coat shall be allowed to cure till all the volatiles are evaporated before any subsequent layer is placed. No plant or vehicles other than those required for the subsequent layer work shall be allowed over the tack coat.

Table 11.3 Rate of Application of Tack Coat (MoRTH Table 500.5)

Type of Surface	Rate of Spray of Binder in Kg/sq.m
Bituminous Surface	0.20-0.30
Granular Surface Treated with Primer	0.25-0.30
Cement Concrete Pavement	0.30-0.35

11.5. Dense Bituminous Macadam (DBM)

The specifications for the design and construction of Dense Bituminous Macadam are giver under Clause 505 of MoRTH Specifications (5th revision 2013).

a. Materials

a) The bitumen shall be viscosity graded paving bitumen complying with IS: 73 or as specified in the contract.

b) The coarse aggregate shall be crushed rock retaining on 2.36 mm sieve. Gradation of the aggregate shall be as per Table 11.4

Table 11.4 Composition of Dense Graded Bituminous Macadam (MoRTH Table 500-10)		
Grading	1	2
Nominal aggregate size*	37.5mm	26.5mm
Layer Thickness	75-100mm	50-75mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	
45	100	-
37.5	95-100	100
26.5	63-93	90-100
19	-	71-95
13.2	55-75	56-80
9.5	-	-
4.75	38-54	38-54
2.36	28-42	28-42
1.18	-	-
0.6	-	-
0.3	7-21	7-21
0.15	-	-
0.075	2-8	2-8
Bitumen content % by mass of total mix	Min 4.0**	Min 4.5**

*The nominal maximum particle size is the largest specified sieve size upon which any of the aggregate is retained

** Corresponds to specific gravity of aggregates being 2.7. in case aggregate have specific gravity more than 2.7, the minimum bitumen content can be reduced proportionately. Further the region where highest daily mean air temperature is 30^0C or lower and lowest daily air temperature is -10^0C or lower, the bitumen content may be increased by 0.5%

c) The physical properties of coarse aggregate shall be as per Table 500-8 of MoRTH Specifications

d) The filler shall be finely divided mineral matter such as rock dust, hydrated lime or cement. The grading limits of filler shall be as per Table 500-9 of MoRTH Specifications.

b. Job Mix Formula/Mix Design

The contractor shall submit the Mix design duly conducted and approved by a Govt. Engineering college/ Govt. Institution, to the Engineer in charge at least 21days before the start of work. The job mix formula proposed in the works, shall also include the following details:

a) Source and location of all materials;

b) Proportions of all materials expressed as follows:

- Binder type, and percentage by weight of total mix;
- Coarse aggregate/fine aggregate/mineral filler as percentage by weight of total aggregate including mineral filler;

c) A single definite percentage passing each sieve for the mixed aggregate;

d) The individual gradings of the individual aggregate fraction, and the proportion of each in the combined grading;

e) The results of mix design such as maximum specific gravity of loose mix, compacted specimen densities, Marshall stability, floe, air voids, VMA, VFB and related graphs and results of AASHTO T 283 moisture susceptibility test

f) Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch

g) Test results of physical characteristics of aggregate to be used

h) Temperature during transportation shall be around 140 to 150 degree Celsius

While establishing the job mix formula, the contractor shall ensure that it is based on correct and truly representative sample of the materials that will actually be used in the work and that the mix and its different ingredients satisfy the physical and strength requirements of these specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer in charge

c. Permissible Variation in Job Mix Formula

Once the laboratory job mix formula is approved, the contractor shall carry out plant trials to establish that the plant can produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix formula to be used shall be within the limits as specified in table 11.5 and shall remain within the gradation band. These variations are intended to apply to individual specimens taken for quality control tests in accordance with section 900 of MoRTH standards

Table 11.5. Permissible Variation in the Actual Mix from the Job Mix Formula	
Description	**Base/Binder Course**
Aggregate passing 19mm sieve or larger	+/-8%
Aggregate passing 13.2mm, 9.5mm	+/- 7%
Aggregate passing 4.75mm	+/- 6%
Aggregate passing 2.36mm, 1.18mm, 0.6mm	+/- 5%
Aggregate passing 0.3mm, 0.15mm	+/- 4%
Aggregate passing 0.075mm	+/-2%
Binder content	+/-0.3%
Mixing temperature	+/- 10^0C

d. Construction

a) The layer on which the DBM is to be placed shall be prepared in accordance with Clause 502 or 902 of MoRTH Specifications.
b) If any geosynthetic material is to be provided as per design, this shall be done in accordance with the Clause 703 of MoRTH Specifications.
c) If the design requires stress absorbing layer, it shall be provided in accordance with the requirements of Clause 517 of MoRTH Specifications.
d) Tack coat shall be provided on the cleaned surface as per Clause 503 of MoRTH Specifications.
e) If the surface on which the DBM is to be placed is not a bitumen bound surface, a prime coat shall be provided as per Clause 502 of MoRTH Specifications.
f) Transportation of the mix shall be carried out as prescribed in Clause 501.4 of MoRTH Specifications.
g) The Clause 501.5.1 of MoRTH Specifications shall be followed for weather and seasonal limitations.

e. Spreading and compaction

a) Laying trials shall be carried out as per MoRTH specification
b) Compaction of the mix spread shall be carried as per Clause 501.6 and 501.7 of MoRTH Specifications and based on the site trials.
c) The temperature of the mix at the time of laying and rolling shall be around 120 to 130 ^{0}C
d) Joints shall be prepared as per Clause 501.7 of MoRTH Specifications.
e) No traffic shall be allowed over the DBM layer till the mat cools down to the ambient temperature.

11.6. Bituminous Concrete (BC)

Bituminous concrete surfacing is done in accordance with requirement of IRC: 29- 1968. The construction of BC wearing, and profile corrective courses is given in Clause 507 of MoRTH

Specifications for Road and Bridge works (5th edition 2013). For grade 1 the thickness shall be 45 to 50mm

a. Laying Trials

Once the plant trials have been successfully completed and approved, the contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid and compacted all in accordance with clause MoRTH Cl:501. The laying trial shall be carried out on a suitable area which is not to form part of the works. The area of the laying trials shall be a minimum of 100sq.m of construction like that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The contractor shall previously inform the Engineer in charge of the proposed method for laying and compacting the material. The plant trials then establish if the proposed laying plant, compaction plant, and methodology can produce satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project and no variation of either shall be acceptable, unless approved in the writing by the Engineer in charge, who may at his discretion require further laying trials

b. Material

a. Paving bitumen complying with IS: 73 shall be used for designing BC mix.
b. Coarse aggregates shall be crushed rock retained on 2.36 mm sieve. The source of aggregate shall be approved only after testing for stripping. Aggregate shall satisfy the Requirement as per Table 11.5
c. Fine aggregates shall consist of crushed or naturally occurring mineral material or a combination of the two passing IS 2.36 mm sieve and retained on 75 micron. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious impurities.
d. The fine aggregate shall have a sand equivalent value of not less than 50 when tested as per IS: 2720 (Part 37). The plasticity index of the fraction passing 0.425 mm sieve shall not exceed 4, when tested in accordance with IS: 2720 (Part 5).
e. Filler shall be finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer in charge. When the aggregates fail to meet the water sensitivity test, then 2% hydrated lime by weight of aggregate shall be added without any additional payment.
f. The combined aggregate grading shall be tested and should confirm the limit given in table 11.6

Table 11.6 Physical Properties of Coarse Aggregate (MoRTH Table 500-16)		
Grain size analysis	Max 5% passing 0.075mm sieve	IS:2386 Part I
Combined Flakiness and elongation	Maximum 35%	IS: 2386 Part I
Los Angeles Abrasion Value	Maximum 30%	IS: 2386 Part IV
Aggregate Impact Value	Maximum 24%	IS: 2386 Part IV
Soundness • Sodium Sulphate • Magnesium Sulphate	5 Cycles Maximum 12% Maximum 18%	IS: 2386 Part V
Polished Stone Value	Min 55	BS: 812-114
Water absorption	Maximum 2%	IS: 2386 Part III
Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS:6241
Retained Tensile Strength	Minimum 80%	AASHTO 283

b. Construction

a. Laying shall be suspended during rain, fog and dust storms or if free standing water is present on the surface.

b. Bituminous work shall not be carried out if the temperature of the surface to be laid is below 10^0C.

c. The surface on which the mix to be placed shall be cleaned by means of a mechanical broom. Then a high-pressure air compressor shall be used to remove any dust or loose matters.

d. If a crack prevention layer is specified, it shall be provided in accordance with the requirement of Clause 522 of MoRTH Specification.

e. Tack coat shall be provided as specified. If the layer to receive the mix is a freshly laid bituminous layer not contaminated by dust, tack coat is not mandatory when overlay is done within two days.

f. All bituminous premixes shall be prepared in a properly calibrated hot mix plant of adequate capacity and capable of delivering a uniform mix with thoroughly coated aggregates.

g. The temperature requirement for bituminous mixes shall be as given in table 2300-36 (Table 500-2 of MoRTH Specifications).

h. The difference in temperature between the binder and the aggregate should at no time exceed 14^0C.

i. If the plant used is continuous type, the combined grading of the cold feed aggregate mix shall be within the grading limits approved for the mix.

j. The binder content shall be based on the combined grading including filler.

k. The mix from the hot mix plant shall be transported to the site in clean insulated trucks. The trucks shall be covered with water proof covers during transport and waiting for tipping.

c. Spreading and compaction

a. Spreading of the bituminous mix shall be carried out using a self-propelled sensor paver.
b. In restricted areas where mechanical paver cannot find access, manual spreading using experienced persons can be allowed.
c. Paving shall be stopped 300 mm before expansion joints of structures and resume 300 mm after the joint. The 600 mm left unpaved shall be kept clean free of any paving materials and other matters.
d. Bituminous mix with temperature more than 145°C shall not be placed over a bridge deck unless approved heat damage measures are taken.
e. The bituminous mix shall be kept clean and uncontaminated. If the mix gets contaminated due to some reason, the same shall be made good.
f. The base or binder course layer shall not be left uncovered for more than 3 days or as specified in the contract. If not covered in 3 days' time due to valid reasons, a tack coat shall be provided before placing the wearing course.
g. The compaction of the bituminous mix shall commence immediately after laying
h. The temperature of the mix at the time of laying and rolling shall be around 120 to 130 ^{0}C

The initial or breakdown rolling is done with 8-10 tonnes dead weight smooth wheeled rollers. The intermediate rolling shall be done with 8-10 tonnes vibrating rollers or Pneumatic Tyre Roller (PTR) of 12-15 tonnes weight with nine wheels with a minimum tyre pressure of 5.6 kg/cm2

12. Road Signs and Markings

12.1. Road signs

The purpose of traffic signs is to promote road safety and efficiency by providing for the orderly movement of all road users on all roads in both urban and non-urban areas. Traffic signs notify road users of regulations and provide warning and guidance needed for reasonably safe, uniform and efficient operation. Road signs shall be installed based on IRC 67-2012

12.2. Different traffic signs

Traffic Signs are broadly classified as mandatory, cautionary and informatory signs.

a. Mandatory/regulatory signs

It provide road users about certain laws and regulations to be followed, to provide safe and free movement of traffic.

b. Cautionary/warning signs

These signs warn the road users about any hazard on or adjacent to the roadway. These signs are in the shape of an equilateral triangle 60 cm or 90 cm, with apex pointing upwards. The sides have a red border 70 mm wide for 90 mm size boards and 45 mm for 60 cm size boards.

In non-urban areas, the warning signs should be located ahead of the hazard location. Is shown in table 12.1

Table 12.1 Recommended locations for installation of Cautionary signs (MoRTH Table 2800-1)

	Plain /rolling terrain	Hilly Terrain
NH/SH	120m	60m
MDR	90m	50m
ODR	60m	40m
Village roads	40m	30m

In urban areas, the warning signs should be located at about 50 m ahead of the hazard location.

c. Informatory/guide signs

These signs are used to guide road users about destination and distance, useful information etc to make the travel safe, easier and pleasant.

The informatory signs are classified under the following sub-heads:

- Direction and place identification signs.
- Facility information signs.
- Other useful information signs,
- Parking signs

The color, configuration, size and location of all the traffic signs for highways other than Express ways shall be in accordance with the code of practice for road signs, IRC:67 or as shown on the drawings. For expressways, the size of the signage, letters and their placement shall be as specified in the contract drawings and relevant specifications or as directed by the Engineer in charge.

12.3. Road Markings

Road markings are defined as lines, patterns, words or other devices, except signs applied or attached to the carriageway for controlling, warning and guiding and informing the users. Road markings perform an important function of guiding and controlling traffic on a highway. They can also be applied in other facilities used by vehicles to mark parking spaces or designate areas for other uses. Road markings shall be uniform in design, position and application so that they may be recognized and understood immediately.

The work shall consist of providing road marking of specified width, layout and design using paint of the required specifications as given in the contract and as per guidelines contained in from IRC:35-1997.

a) Materials

Road marking shall be of ordinary road marking paint hot applied thermoplastic compound, reflectorized paint or cold applied reflective paint as specified in the item and the material shall meet the requirements as specified in these specifications.

a. Ordinary Road Marking Paint

Ordinary paint used for road marking shall conform to Grade I as per IS:164. The road marking shall preferably be laid with appropriate road marking machinery.

b. Hot Applied Thermoplastic Road Marking

The thermoplastic material shall be homogenously composed of aggregate, pigment, resins and glass reflectorizing beads. The color of the compound shall be white or yellow as specified in the drawings or as directed by the Engineer in charge. The specification shall be as per MoRTH: Cl:803.4

c. Reflectorizing Glass Beads

Two types of glass beads are used to produce reflectorized pavement markings.

Type 1 beads are those which are a constituent of the basic thermoplastic compound.

Type 2 beads are those which are to be sprayed on the surface vide clause 803.6.4

The glass beads shall be transparent, colorless and free from milkiness, dark particles and excessive air inclusions. These shall conform to the requirements spelt out in MoRTH clause 803.4.2.3.

d. Reflectorized Paint

Reflectorized paint, if used, shall conform to the specification by the manufactures and approved by Engineer in charge. Reflectorizing glass beads for reflectorizing paints where used shall conform to the requirements of MoRTH Clause 803.4.2

Marking shall be done by machine. For locations where painting cannot be done by machine, approved manuals shall be used prior approval of the Engineer in charge. The contractor shall maintain control over traffic while painting operations are in progress to cause minimum inconvenience to traffic compatible with protecting the workmen.

The pavement temperature shall not be less than 10^0C during application. All surface shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the paint

The thermoplastic material shall be applied hot either by screeding or extraction process. After transfer to the laying apparatus, the material shall be laid at a temperature within the range specified by the manufacturer for the method of laying being used. The paint shall be applied using a screed or extraction machine.

Minimum thickness specified is exclusive of surface applied glass beads. The method of thickness measurement shall be in accordance with Appendices B and C of BS:3262 (Part 3).

e. Cold Applied Reflective Paint

The work shall consist of marking traffic stripes using a solvent based cold applied paint, which shall be applied on the asphalt/cement concrete road surface by brush or by road marker. Glass beads shall be subsequently spread pneumatically on to the paint when it is still wet so that the beads will be firmly held by the paint after drying. Color of the paint shall be white or yellow as specified in the drawings or as directed by the Engineer in charge. These shall meet the specification as per MoRTH: Cl:803.7

13. Mandatory Equipment to be Used in Each Stage of Work

In addition to the conditions included in the contract documents, the following conditions regarding use of equipment in work shall be satisfied:

- All equipment provided shall be of proven efficiency and shall be operated and maintained in a manner acceptable to the Engineer in charge.
- Plants, equipment and instruments provided shall have adequate sensitivity, facility for calibration to desired level and shall be robust
- Plant and equipment and instruments provided shall have adequate safety features and pollution control devices
- Plants, equipment and instruments provided shall be operated by skilled and qualified operators
- All the plant/equipment to be deployed on the works shall be got approved from the Engineer in charge
- Any material or equipment not meeting the approval of Engineer in charge shall be rejected and removed from the work site
- Contractor shall also make available stand by equipment and spare parts
- Contractor shall also make available equipment for site quality control work as directed by the Engineer in charge

The list of Machineries and their specification that to be used in each stage of work is provided in the Appendix IV

14. Quality Assurance and Quality Control

14.1. First Tier Quality Control Testing

First tier quality check shall be done by the quality team of the contactor in the presence of concerned Engineers in charge. The tests shall be done as per Section-900, Quality Control for Road Works, MoRTH 2013. The test shall be conducted as per the frequency given in Appendix I. The contractor shall arrange to provide fully furnished and adequately equipped field laboratory. The field laboratory shall preferably be located adjacent to the project site. The minimum floor space for the field laboratory shall be 150 m^2.

Lab shall include space for the storage of samples. The remaining space shall be provided for the installation of equipment, laboratory tables and cup boards, working spaces for carrying out various laboratory tests, a curing tank for the curing of samples around 4m x 2m x1m in size.

The testing instruments and their numbers as per Appendix II are indicative and shall be decided by the Engineer in charge as per the requirements of the project and modified accordingly (Ref; MoRTH Table 100-2, Cl: 120 Field Laboratory)

The frequency of quality control test for various items under road projects shall be based on the MoRTH Table 900-3, 900-4, Cl: 903.2.1 and IS: 2720-Part 8

The test results shall be verified and signed by the Engineers in charge and shall be submitted to SPV. If the quality does not meet the required standards, the same has to be rectified with contractors' own cost.

Note: For each project, if there is any change in scope of the work from the original BOQ, the Engineer in charge shall identify the test to be done and shall inform the PMU and get approval from TS authority and concurrence shall be obtained from KIIFB.

14.2. Second Tier Quality Control Testing

Second-tier Quality Control tests are to be done by the QC wing of SPV. The frequency of tests to be conducted as mentioned in Appendix III. The QC wing is authorized to inspect all road projects undertaken by KIIFB. After executing the agreement, the concerned Engineer in charge should forward the required details regarding the work to the QC wing before the commencement of the work and also forward a time programme schedule for execution of the work. There should be proper coordination between both QC wing and Execution wing for the arrangements of QC testing. Results of the tests shall be submitted in the prescribed format to the Engineer in charge with copy to SPV.

Note: If it is found difficult to conduct a specific test in QC Lab of SPV due to specific reasons, the same can be conducted in Govt. Engineering colleges or approved institutions. QC wing of SPV can engage the Govt Engineering colleges or approved institutions. SPV shall obtain a final approval of the list of Govt. Engineering colleges/approved institutions from KIIFB.

14.3. Third Party Technical Audit

Third Party Technical audit shall be done by an external agency/expert committee empanelled by SPV including Govt. agencies approved by KIIFB. Technical audit shall be applicable for all road projects of KIIFB. If there is a demand from technical audit committee, the test results and its analysis of first tier and second tier quality control tests are to be submitted through SPV. The frequency of audit shall be finalized by the TS authority and a minimum of three times audit shall be conducted based on the physical progress of the work ie; 30%, 60% and 100% of the work. All QC tests carried out in the first-tier and second-tier testing shall be reviewed by the technical audit committee. Non-destructive testing techniques shall be adopted if conventional testing techniques cannot be applied.

If the technical audit is found to be not satisfactory, the Engineer in charge can direct the contractor to take suitable rectification measures and the he should intimate SPV before next stage of payment.

Action Taken Report (ATR) shall be prepared by SPV and it should be submitted to KIIFB, if any defects noticed by the third-party technical audit.

14.4. Third Party Testing

Third party testing is carried out by an independent laboratory other than that of the Contractor or the SPV. This is required when the Contractor raise a dispute due to difference in the test results of first-tier and second-tier testing or existence of manipulated results are suspected.

The SPV can decide whether a third-party testing is required to settle the dispute. The expenses for the third-party testing shall be met by the contractor. However, the third-party testing will be the final regarding the quality test results. In this case the claim of the contractor will be finalized based on the third-party testing recommended by SPV.

During sampling for the first-tier and second-tier testing, sufficient number of additional samples shall be prepared and kept under safe custody for third-party testing, if warranted.

14.5. Release to Final Payment

Release of the final payment from KIIFB against final bill will be based on satisfactory conduct of First tier QC testing, Second tier QC testing, 3rd party technical audit and 3 tier QC testing (if needed).

15. Rectification of Defective Work and its Acceptance

The Contractor is bound to carry out the rectification works at his own cost, if results obtained during quality control tests either in the first-tier or second-tier do not comply with the requirement. He shall also carry out rectification works, if any, pointed out during technical audit done after completion of work. The Engineer in charge shall initiate action, if required based on the test results obtained from first-tier and second-tier testing and the technical audit. On receipt of the test reports, the Engineer in charge shall compare the results obtained in the tests with the values specified. If the result of any test falls outside the requirement, he shall issue notice to the Contractor forthwith, pointing out the nature and extend of defects and directing to rectify the defects by suitable methods. The Engineer in charge shall inspect site after rectification is completed and issue approval in writing based on the quality test conducted.

If a Contractor does not comply with the direction to carry out rectification work, Engineer in charge shall take suitable action based on the contractual agreement.

16. Health Safety and Environment

16.1. Health & Safety Assurance

The safety measures are to be followed by the contractor and SPV in all construction activities. The aim is to provide and maintain a working environment that is safe and effectively minimises risks to the health of its employees, contractor, equipments and members of the general public.

SPV shall ensure safety by

- Placing the health and safety of all people ahead of the provisions of service.
- Adequately training staff in the safe performance of jobs and in the basic areas of accident prevention.
- Taking corrective action for every incident with the potential to cause harm, whether such harm eventuates or not, and also in the case of every accident.
- Insisting on arrangements for the safe use, handling, storage and transport of equipment and substances.
- Insisting on adequate facilities and protective clothing & equipment to protect the health and safety of all employees

The practice of safety involves shared responsibilities and a team approach by all employees. Everyone associated with SPV shall be responsible for their own health and safety, and the safety of others affected by the actions of their work. Necessary provisions for safety shall be foreseen and incorporated in the estimates during project preparation stage itself.

The conditions of contract state that the contractor is responsible for the safety of all site operations and methods of construction, for the safety of persons on site and for the installation of such facilities as will protect the works, the public and the environment from injury or damage. The SPV should ensure the safety measures taken by the contractor.

16.2. Personal Protective Equipment (PPE)

a) Eye and Face Protection

- Safety glasses or face shields are worn anytime work operations can cause foreign objects getting into the eye such as during welding, cutting, grinding, nailing (or when working with concrete and/or harmful chemicals or when exposed to flying particles).
- Eye and face protectors are selected based on anticipated hazards.
- Safety glasses or face shields are worn when exposed to any electrical hazards including work on energized electrical systems.

b) Foot Protection

- Construction workers should wear work shoes or boots with slip-resistant and puncture-resistant soles.
- Safety-toed footwear is worn to prevent crushed toes when working around heavy equipment or falling objects.

c) Hand Protection

- Gloves should fit snugly.
- Workers wear the right gloves for the job (for example, heavy-duty rubber gloves for concrete work, welding gloves for welding, insulated gloves and sleeves when exposed to electrical hazards).

d) Head Protection

- Workers shall wear hard hats where there is a potential for objects falling from above, bumps to their heads from fixed objects, or of accidental head contact with electrical hazards.
- Hard hats are routinely inspected for dents, cracks or deterioration.
- Hard hats are replaced after a heavy blow or electrical shock.
- Hard hats are maintained in good condition.

e) Trenching

- Never enter an unprotected trench.
- Always use a protective system for trenches feet deep or greater.
- Employ a registered professional engineer to design a protective system for trenches 20 feet deep or greater.
- Protective Systems:
  - Sloping to protect workers by cutting back the trench wall at an angle inclined away from the excavation
  - Shoring to protect workers by installing supports to prevent soil movement for trenches that do not exceed 20 feet in depth.
  - Shielding to protect workers by using trench boxes or other types of supports to prevent soil cave-ins.

- Always provide a way to exit a trench--such as a ladder, stairway or ramp--no more than 25 feet of lateral travel for employees in the trench.
- Keep spoils at least two feet back from the edge of a trench.
- Make sure that trenches are inspected by a competent person prior to entry and after any hazard-increasing event such as a rain storm, vibrations and excessive surcharge loads.

16.3. Safe Guarding Environmental During Construction

The Contractor shall take all precautions for safeguarding the environment during the construction of the works. He shall abide by all laws, rules and regulations in force governing pollution and environmental protection that are applicable in the area where the works are situated.

a) Quarry Operations

The Contractor shall obtain materials from quarries only after the consent of the Mining and geology department and other concerned authorities is obtained. The quarry operations shall be undertaken within the preview of the rules and regulations in force.

b) Precautions for Installing Hot Mix Plants and Batching Plants

Clearance shall be obtained from Pollution Control Board/Local Body Authorities before installing the plant. Stone crushing and screening plants, bituminous hot-mix plants, concrete batching plants etc. shall be located sufficiently away from habitation, agricultural operations or industrial establishments. The Contractor shall take every precaution to reduce the levels of noise, vibration, dust and emissions from his plants and shall be fully responsible for any claims for damages caused to the owners of property, fields and residences in the vicinity and violation of pollution control norms, if any.

c) Control of Soil Erosion, Sedimentation and Water Pollution

The Contractor shall carry out the works in such a manner that soil erosion is fully controlled. Sedimentation and pollution of natural water sources, ponds, tanks and reservoirs shall be avoided.

d) Substances Hazardous to Health

The Contractor shall not use or generate any materials in the road construction works which are hazardous to the health of persons, animals or vegetation. Where it is necessary to use some substances, which can cause injury to the health of workers, the Contractor shall provide protective clothing or appliances to his workers.

e) Control of Dust Nuisance During Construction

The Contractor must take all reasonable steps to minimize dust nuisance during the construction of the works. All dust/mud or other extraneous materials from the works spreading on highways shall be immediately cleared by the Contractor. Clearance shall be effected immediately by sweeping and removal of debris, and all dust, mud and other debris shall be removed entirely from the road surface. Additionally, if so directed by the Engineer in charge, the road surface shall

be hosed or watered using suitable equipment. Compliance with the foregoing will not relieve the Contractor of any responsibility for complying with the requirements of any Highways Authority in respect of the roads used by him.

f) Noise

Noise is perhaps the most widespread hazard in any construction environment. Workers are exposed to noise levels which can cause permanent noise-induced hearing loss. For example, noise from trucks, machinery, tools in a workshop, batching plant and HMP site, Stone crusher unit and Compressor and Generators.

17. References

1. “MoRTH specification for Roads and Bridges Work” (Fifth Revision) April 2013, Ministry of Road Transport & Highways.
2. “Kerala Public Works Department Manual” (Revised Edition 2012)
3. “Quality Control Manual” (July 2015), Kerala Public Works Department (KPWD).
4. “Construction Supervision Manual” Kerala State Transport Project (KSTP Phase II)

Appendix- I: Frequency of Test for First Tier Quality Control Testing

(Ref: MoRTH Section-900, Table 900-4)

Test frequency for Borrow Material for Embankment Construction		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Sand content	2 test per 3000 cu.m
2	Plasticity test	Each type to be tested, 2 tests minimum
3	Density Test	Each soil type to be tested, 2 tests
4	Deleterious Content Test	As and when required by the engineer
5	Moisture Content Test	Two tests
6	CBR	1 Test (average of three specimen) or closer as and when required by engineer
Test frequency for Lime/ Cement Stabilized Soil Sub Base		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Quality of lime/cement	One test for each consignment subject to a minimum of one test per 5 tonnes
2	Lime / Cement content	Regularly
3	Degree of pulverization	Periodically as considered necessary
4	CBR/ UCCS test	As required
5	Moisture Content prior to compaction	One set of two test per 500 Sq.m
6	Density of compacted layer	One set of two test per 500 Sq.m
7	Deleterious Constituents	As Required
Test frequency for Granular Sub Base		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Gradation	1 test per 400cum
2	Atterberg Limit	1 test per 400cum
3	Moisture content prior to compaction	1 test per 400cum
4	Density of compacted layer	1 test per 1000sqm
5	Deleterious constituents	As required
6	California Bearing Ratio	As required
Test frequency for Wet Mix Macadam		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Aggregate impact value	1 test per 1000 cum
2	Gradation	1 test per 200 cum
3	Combined Flakiness & Elongation Indices	1 test per 500 cum
4	Atterberg limit of portion of aggregate passing 425micron sieve	1 test per 200 cum
5	Density of compacted layer	One set of three tests per 1000 Sq.m
6	Los Angeles Abrasion	1 test per 1000 Cum
Test frequency for Prime Coat/Tack Coat/Fog Spray		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Quality of Binder	Number of samples per lot and tests as per IS:73, IS:217 and IS: 8887 as applicable
2	Binder temperature for application	At regular close intervals

3	Rate of spread of binder	Three tests per day
Test frequency for Dense Bituminous Macadam/Bituminous Concrete		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Quality of Binder	Number of samples per lot and tests as per IS:73 or IRC SP: 53, IS :15462
2	Aggregate Impact Value/ Los Angeles abrasion value	1 test per 350 cu. m
3	Flakiness and Elongation Indices	1 test per 350 cu. M
4	Soundness Test	1 test for each source
5	Water absorption of aggregates	1 test for each source
6	Plasticity Index	1 test for each source
7	Mix Grading	One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant
8	Moisture susceptibility of Mix	1 test for each mix type
9	Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction	At regular intervals
10	Binder content	1 set for each 400 tonnes for mix subject to minimum of two tests per plant
11	Rate of spread of mix	After every 5th truck load
12	Density of compacted layer	One test per 700 sq.m area
Frequency of Test for Pipe Culvert		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Bedding Materials- length, width and thickness, Top and Bottom Levels, Preformation of cradle to lay pipes in bedding	Shall be checked while Laying
2	Laying and jointing of pipe- Invert level, longitudinal gradient, spacing when 2 or more pipes are laid in single or multiple rows, joining of pipes	Shall be checked before back filling
3	Back Fill- Filling of trench on both sides, tamping around pipe	Shall be checked during filling earth/granular material around pipe after laying
4	Thickness of Cushion over pipes	Shall be checked while filling
5	Side slopes on head wall	Before construction of guard stones
Frequency of Test for Cement		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Fineness	1 test for every 50 Tones
2	Soundness	1 test for every 50 Tones
3	Setting time	1 test for every 50 Tones
4	Compressive strength	3 specimens for each lot
Frequency of Test for Coarse aggregate		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Gradation	1 test per 40 m^3
2	Flakiness index	1 test per 40 m^3
3	Deleterious constituents	If in doubt, one test per source

4	Water absorption	Once for each source
5	Aggregate impact value	1 test per day work
6	Soundness	1 test per source
Frequency of Test for fine aggregate		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Gradation	1 test per 40 m^3
2	Deleterious constituents	If in doubt, one test per source
3	Silt content	1 test per 40 m^3
4	Bulking	1 test per 40 m^3
Frequency of Test for water		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Suspended matter	Water from each source before commencement of work and thereafter every three months till completion of work
2	Organic contents	
3	Inorganic contents	
4	Sulphates	
5	Chlorides	
6	pH value	
Frequency of test for reinforcing steel		
1	a. Tensile strength b. Proof stress c. Percentage elongation d. Elongation at maximum force	2 per cast (for casts/heats below 100 tonnes) 3 per cast (for casts/heats of 100 tonnes or more)
2	Bend test and rebend test	2 per cast (for casts/heats below 100 tonnes) 3 per cast (for casts/heats of 100 tonnes or more)

Appendix- II: List of Laboratory Equipment for Field Lab

(Ref: MoRTH Section-100, Table 100-2)

Sl. No.	Name	
A	**GENERAL**	
1	Weigh Balances	
	a) 5 kg-20 kg capacity Electronic type -Accuracy 1gm	1 No
	b) 500 gm capacity-Electronic Type Accuracy 0.01 gm	1 No
	c) Electronic 5 kg capacity Accuracy 0.5 gm	1 No
	d) Platform balance scale- 300 kg capacity	1 No
	e) Chemical balance 100 gm Capacity- accuracy 0.001gm	-
2	Oven-electrically operated, thermostatically controlled (including thermometer), stainless steel interior a) from 0^0C to 220^0C sensitivity 1^0C	1 No
3	Sieves: as per IS:460-1962	
	a) I.S sieves 450 mm internal dia of sieve sets as per BIS of required sieve sizes complete with lid and pan	1 set
	b) IS sieve 200 mm internal dia (brass frame and steel/or brass wire cloth mesh) consisting of sieve sets of required sieve sizes complete with lid	2 sets
4	Sieve shaker capable of taking 200 mm and 450 mm dia sieves-electrically operated with time switch	1 No
5	200 tonnes compression testing machine	1 No
6	Stop watches 1/5 sec. accuracy	1 No
7	Glassware compressing beakers, pipettes, dishes, measuring cylinders (100 to 1000 cc capacity) glass rods and funnels, glass thermometers range 0◦C to 100◦C and metallic thermometers range up to 300◦C	2 No. each
8	Hot plates 200 mm dia (1500 watt)	1 No
9	Enamel trays	
	a)600 mmX450 mmX50 mm	2 Nos
	b)450 mmX300 mmX40mm	2 Nos
	c)300mmX250mmX40mm	2 Nos
	d) Circular plates of 250 mm dia	2 Nos
10	Water testing kit	1 No
B	**FOR SOILS**	
1	Water still	-
2	Liquid limit device with ASTM grooving tools as per IS: 2720	1 No

3	Sampling pipettes fitted with pressure and suction inlets, 10 ml. Capacity	1 Set
4	Compaction apparatus (proctor) as per IS:2720(part 7) complete with collar, base plate and hammer and all other accessories	1 No
5	Modified AASHTO compaction apparatus as per IS:2720 (part 8) 1974 or heavy compaction apparatus as per IS complete with collar, base plate and hammer and all other accessories	1 No
6	Sand pouring cylinder with conical funnel and tap and complete as per IS:2720(part 28) 1974 including modern equipment	2 Nos
7	Ennore Standard Sand	As Required
8	Sampling tins with lids 100mm dia X 75mm ht.1⁄2 kg capacity and miscellaneous items like moisture tins with lid 50g etc.	4 Nos
9	Lab CBR testing equipment for conducting CBR testing, load frame with 5 tonne capacity, electrical operator with speed control as per IS:2720 (part 16) and consisting of following:	1 set
	a) CBR mould 150 mm dia- 175 mm ht.	6 Nos
	b) Tripod stand for holding dial gauge holder	4 Nos
	c) CBR plunger with settlement dial gauge holder	1 Nos
	d) Surcharge weight 147mm dia 2.5 kg wt.	6 Nos
	e) Spacers disc 148mm dia 47.7mm ht. with handle	2 Nos
	f) Perforated plate (Brass)	2 Nos
	g) Soaking tank for accommodating six CBR mould	2 Nos
	h) Providing rings of 1000 kg, 2500 kg capacity	1 No each
	i)Dial gauges 25mm travel 0.01mm per division	2 No
9	Standard penetration test equipment	1 No
10	Nuclear moisture density meter or equivalent	-
11	Speedy moisture meter complete with chemicals	1 No
12	Unconfined Compression Test Apparatus	1 No
C	**FOR BITUMEN & BITUMINOUS MIXES**	
1	Constant temperature bath for accommodating bitumen test specimen, electrically operated, and thermostatically controlled (To accommodate minimum six specimens)	1 No
2	Penetrometer automatic type, including adjustable weight arrangement and needles as per IS:1203- 1958	1 No
3	Soxhlet extraction or centrifuge type apparatus complete with extraction thimbles with solvent and filter paper	1 No

4	Bitumen laboratory mixer including required accessories (20 ltrs)	1 No
5	Marshall compaction apparatus automatically operated as per ASTM 1559-62 T complete with accessories	1 set
6	Furol viscometer	1 Nos
7	Ductility meter	1 Nos
8	Softening Point (Ring and Ball App)	1 Nos
9	Distant reading thermometer	-
10	Rifle box	1 Nos
11	Automatic asphalt content meter	1 Nos
12	Thin film over test apparatus for modified binder either with PMB or CRMB	-
13	Mastic asphalt hardness testing equipment	-
14	Sand equivalent test apparatus	1 set
15	Core cutting machine suitable for up to 150 mm dia core	1 set
16	Thermometers	4 Nos
D	**FOR CEMENT, CEMENT CONCRETE AND MATERIALS**	
1	Water Still	1 No
2	Vicat needle apparatus for setting time with plungers as per IS:269-1967	1 No
3	Moulds	
	a)150mm X 300mm ht. Cylinder with capping component along with the capping set and compound as per IS	As req
	b) Cube 150mm, and 100mm (each size)	As req
4	Concrete permeability apparatus	-
5	High frequency mortar cube vibrator for cement testing	-
6	Concrete mixer power driven, 1 cu.ft. capacity	-
7	Variable frequency and amplitude vibrating table size 1m X 1m as per the relevant British Standard	-
8	Flakiness index test apparatus	1 No
9	Aggregate impact test apparatus as per IS:2386 (Part4)1963	1 No
10	Los-Angeles abrasion test apparatus as per IS:2386 (Part4)1963	1 No
11	Flow table as per IS:712-1973	-
12	Equipment for slump test	1 No
13	Equipment for determination of specific gravity of fine and coarse aggregate as per IS:2386 (Part3)1963	1 No
14	Compression and flexural strength testing machine of 200T capacity with additional dial for flexural testing	1 No
15	Core cutting machine with 10 cm dia diamond cutting edge	1 No
16	Needle Vibrator	2 Nos

17	Air entrainment meter	-
18	0.5 Cft, 1Cft cylinder for checking bulk density of aggregate with tamping rod	As req
19	Soundness testing apparatus for cement (Le Chattlier)	1 set
FOR CONTROL OF PROFILE AND SURFACE EVENNESS		
1	Total station	1 No
2	Precision automatic level with micrometer attachment	1 set
3	Distomat or equivalent	1 set
4	Theodolite- Electronically operated with computerized output attachment	1 set
5	Precision Staff	2 set
6	3m straight edge and measuring wedge	1 set
7	Camber template two lane a) Crown type cross section	1 set
	b) Straight run cross section	2 set
8	Steel tape a) 5m long	2 Nos
	b) 10m long	2 Nos
	c)20m long	2 Nos
	d)30m long	2 Nos
	e)50m long	1 No
9	Roughometer (Bump Integrator)	1No (When Required)

Note: The items and their numbers listed above in this Section are indicative and shall be decided by the Engineer in charge as per requirements of the project and modified accordingly

Appendix- III: Frequency of Test for Second Tier Quality Control Testing

Test frequency for Borrow Material for Embankment Construction		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Sand content	2 test per 3000 cu.m
2	Plasticity test	Each type to be tested, 2 tests minimum
3	Density Test	Each soil type to be tested, 2 tests
4	Deleterious Content Test	As and when required by the engineer
5	Moisture Content Test	Two tests
6	CBR	1 Test (average of three specimen) or closer as and when required by engineer
Test frequency for Lime/ Cement Stabilized Soil Sub Base		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Quality of lime/cement	One test for each consignment subject to a minimum of one test per 10 tonnes
2	Lime / Cement content	Regularly
3	Degree of pulverization	Periodically as considered necessary
4	CBR/ UCCS test	As required
5	Moisture Content prior to compaction	One set of two test per 1000 Sq.m
6	Density of compacted layer	One set of two test per 1000 Sq.m
7	Deleterious Constituents	As Required
Test frequency for Granular Sub Base		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Gradation	1 test per 1000cum
2	Atterberg Limit	1 test per 1000cum
3	Moisture content prior to compaction	1 test per 1000cum
4	Density of compacted layer	1 test per 2000sqm
5	Deleterious constituents	As required
6	California Bearing Ratio	As required
Test frequency for Wet Mix Macadam		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Aggregate impact value	1 test per 2000 cum
2	Gradation	1 test per 400 cum
3	Combined Flakiness & Elongation Indices	1 test per 1000 cum
4	Atterberg limit of portion of aggregate passing 425micron sieve	1 test per 400 cum
5	Density of compacted layer	One set of three tests per 2000 Sq.m
6	Los Angeles Abrasion	1 test per 2000 Cum
Test frequency for Prime Coat/Tack Coat/Fog Spray		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Quality of Binder	Number of samples per lot and tests as per IS:73, IS:217 and IS: 8887 as applicable
2	Binder temperature for application	At regular close intervals
3	Rate of spread of binder	Three tests per day

Test frequency for Dense Bituminous Macadam/Bituminous Concrete		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Quality of Binder	Number of samples per lot and tests as per IS:73 or IRC SP: 53, IS :15462
2	Aggregate Impact Value/ Los Angeles abrasion value	1 test per 700 cu. m
3	Flakiness and Elongation Indices	1 test per 700 cu. M
4	Soundness Test	1 test for each source
5	Water absorption of aggregates	1 test for each source
6	Plasticity Index	1 test for each source
7	Mix Grading	One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant
8	Moisture susceptibility of Mix	1 test for each mix type
9	Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction	At regular intervals
10	Binder content	1 set for each 400 tonnes for mix subject to minimum of two tests per plant
11	Rate of spread of mix	After every 5th truck load
12	Density of compacted layer	One test per 1000 sq.m area
Frequency of Test for Pipe Culvert		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Bedding Materials- length, width and thickness, Top and Bottom Levels, Preformation of cradle to lay pipes in bedding	Shall be checked while Laying
2	Laying and jointing of pipe- Invert level, longitudinal gradient, spacing when 2 or more pipes are laid in single or multiple rows, joining of pipes	Shall be checked before back filling
3	Back Fill- Filling of trench on both sides, tamping around pipe	Shall be checked during filling earth/granular material around pipe after laying
4	Thickness of Cushion over pipes	Shall be checked while filling
5	Side slopes on head wall	Before construction of guard stones
Frequency of Test for Cement		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Fineness	1 test for every 100 Tones
2	Soundness	1 test for every 100 Tones
3	Setting time	1 test for every 100 Tones
4	Compressive strength	3 specimens for each lot
Frequency of Test for Coarse aggregate		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Gradation	1 test per 80 m^3
2	Flakiness index	1 test per 80 m^3
3	Deleterious constituents	If in doubt, one test per source
4	Water absorption	Once for each source

5	Aggregate impact value	1 test per source
6	Soundness	1 test per source
Frequency of Test for fine aggregate		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Gradation	1 test per 80 m^3
2	Deleterious constituents	If in doubt, one test per source
3	Silt content	1 test per 80 m^3
4	Bulking	1 test per 80 m^3
Frequency of Test for water		
Sl. No.	**Test**	**Minimum Frequency of test**
1	Suspended matter	Water from each source before commencement of work and thereafter every three months till completion of work
2	Organic contents	
3	Inorganic contents	
4	Sulphates	
5	Chlorides	
6	pH value	
Frequency of test for reinforcing steel		
1	a. Tensile strength b. Proof stress c. Percentage elongation d. Elongation at maximum force	2 per cast (for casts/heats below 100 tonnes) 3 per cast (for casts/heats of 100 tonnes or more)
2	Bend test and rebend test	2 per cast (for casts/heats below 100 tonnes) 3 per cast (for casts/heats of 100 tonnes or more)

Appendix- IV: List of Construction Equipment

Stages of Construction	Details of equipment	Minimum Capacity
For Embankment Construction	Dozer	200 Cum/hr
	Hydraulic Excavator	1.0 Cum Capacity
	Loader Backhoe	1.0 Cum capacity
	Water Tanker	6-10KL
	Tipper (Dumpers)	4-14 Cum Capacity
	Sheep Foot Soil Compactor	Drum width 2100mm, 100hp power, 11.6Tones Operating weight
	Single Drum Soil Compactor	Drum width 2134mm, 100hp power, 11.2 Tones Operating weight
	Scarifier	As per the requirement
For Granular sub base construction	Loader Backhoe	1.0 Cum capacity
	Dozer	200 Cum/hr
	Motor Grader	ENGINE OUTPUT ABOVE 150KW (BLADE 3.35 M) Spreading soil 200 Cum/hr
	Stone Crushing Plant (Cone Crusher with Primary and Secondary Crusher).	Minimum 200 TPH
	Water Tanker	4-10KL
	Tipper (Dumpers)	6-14 Cum Capacity
	Single Drum soil Compactor	Drum width 2134mm, 100hp power, 11.2 Tones Operating weight
For Wet Mix Macadam Construction	WMM Mixing Plant	Minimum 100 TPH
	Paver Finisher Mechanical for WMM work	100 TPH Size 5.5m
	Dozer	200 Cum/hr
	Motor Grader	ENGINE OUTPUT ABOVE 150KW (BLADE 3.35 M) Spreading soil 200 Cum/hr
	Loader Backhoe	1.0 Cum capacity
	Water Tanker	6-10KL
	Tipper (Dumpers)	4-14 Cum Capacity

For Prime and Tack coat application	Power Broom	1250 Sqm/hr
	Emulsion sprayer tanker	Minimum 4000L capacity
For Dense Bituminous Macadam/ Bituminous Concrete Construction	Hot Mix Plant (Batch Type) with electronic controls and vibratory screens with scrubber	Minimum 100 TPH
	Water Tanker	6-10KL
	Tipper (Dumpers)	4-14 Cum Capacity
	Paver Finisher Hydrostatic with sensor control	100 TPH Size 5.5m
	Tandem Roller	Maximum 8-10 Tonne
	Pneumatic Tyre Roller	Minimum 200-300KN
Concrete	Concrete Batching Plant	15 to 20 cu/hr
	Vibrators	As per requirement

Note: The Engineer in charge can make necessary changes in the Capacity of machinery according to site conditions

Appendix V: Check List - Safety

Check List **Category: Safety**				
Area or Location Inspected:				
Date:				
Inspected By:				
No.	**Item**	**Yes**	**No**	**Comments**
1	Do workers have a safe route to their place of work?			
2	Is the site fenced and secure so that the public cannot gain access?			
3	Are members of the public, such as people passing by the site, protected e.g. from falling materials, moving machines?			
4	Are traffic routes kept clear and are they well lit?			
5	Do vehicles have visual and reversing aids fitted where needed e.g. reversing camera, convex mirror?			
6	Is the site tidy and well laid out?			
7	Are appropriate safety signs in place e.g. traffic routes, authorised personnel			
8	Are First-Aid facilities in place and do workers know where they are?			
9	Have workers been instructed and trained on safe manual handling?			
10	Is appropriate lifting equipment provided for handling heavy loads; is it suitable for the job, certified and inspected regularly?			
11	Have existing services been identified and protect- ed e.g. overhead or buried electricity or gas lines?			
12	Are electrical systems and equipment maintained and frequently inspected by a competent person?			
13	Are collective measures in place to stop workers and objects from falling e.g. netting, scaffoldings?			
14	Are scaffoldings erected, altered and dismantled by competent CSCS scaffoldings?			
15	Are scaffoldings inspected at least weekly by a competent person and the results recorded?			
16	Are any remedial works identified during scaffoldings inspections complete?			

Appendix VI: Check List - Pavement Layer Construction

Check List **Category: Pavement Layer Construction**									
This check list can be used to inspect the pavement during construction stage and check the requirements.									
Area or Location Inspected:									
Date:									
Inspected By:									
No.	**Item**	**In Scope of work**		**Work Executed**		**Quality of Work**			**Comments**
		Y	**N**	**Y**	**N**	**Good**	**Fair**	**Not Satisfactory**	
1	Full depth reclamation								
2	Subgrade stabilization								
3	Sub grade compaction								
4	GSB layer thickness								
5	GSB layer Compaction								
6	GSB gradation								
7	WMM layer thickness								
8	WMM layer Compaction								
9	WMM gradation								
10	Prime Coat Application								
11	Tack Coat Application								
12	DBM Thickness								
13	DBM compaction								
14	BC thickness								
15	BC Compaction								

Appendix VII: Check List - Bituminous Layer Paving

Check List **Category: Bituminous Layer Paving**		
Area or Location Inspected:		
Date:		
Inspected By:		
Standard of Work	**Yes/No**	**Action Taken/Comments**
Has layer to be covered been approved?		
Is surface even and free of depressions?		
Is surface appearance acceptable?		
Has surface been cleaned?		
Was tack coat applied?		
When before paving was tack coat applied?		
Were density holes filled before paving?		
Was asphalt temp. from plant OK?		
Was joint prepared at start and end of run?		
Were trucks adequately covered?		
Were truckloads of asphalt consistent?		
Did paver operate without stopping?		
Was mat texture uniform from paver?		
Was rolling done in an organized pattern?		
Specify rolling pattern if possible		
Was whole area equally compacted?		
Was water used on rollers?		
Was supervision adequate?		
Were workers adequately skilled?		
Were adequate safety precautions used?		
Were sufficient signs and Barricades used?		
Did contractor's laboratory take samples?		