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

Version 1.0

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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?		