

# SCOPE OF WORK AND TECHNICAL SPECIFICATIONS

## 1. GENERAL

### BRIEF PROJECT DESCRIPTION

- 1.1. Area based development is taken up in Shillong smart city under smart city Mission of GoI initiated in yr. 2015. Under Shillong smart city project, infrastructure is proposed to be developed with underground storm water drains, underground ducting for electrical power supply, overhead electrical cables and related electrical infrastructure, HDPE DWC Pipe for communication cables, rainwater harvesting and groundwater recharge measures and LED street lighting. It is also proposed to reconstruct or retrofit open surface drains and augment, retrofit and reconstruct roads and junctions, after laying the said underground utility services. The roads are to be constructed as per the street design attached in this document following the street design guidelines prescribed by IRC, UTIPEC, MoUD, GoI.
- 1.2. About 6 km. of roads in Smart City area are proposed to be developed with all infrastructure facilities. Dedicated corridors will be provided with traffic services like, pedestrian track, bus bays, etc. as per the available ROW and approval of engineer in charge. The scope of project includes re-construction of the selected existing roads as per the latest guidelines, rules, and regulations. The roads construction should include construction of junction, pedestrian track, as per the design. The construction of roads must have to be considered for complete modification/up-gradation with utility ducts for underground electrification work and HDPE DWC pipes for telecommunication cables.
- 1.3. The details of different roads to be developed under this project are given in figure 1 below. Table 1 gives names of roads, available Right of Way (ROW) and respective road lengths that is proposed to be developed with the aforementioned infrastructure are tabulated. The drawings attached herewith this document's Annexures, gives Typical Cross-Sectional details of each of the roads proposed with their various project components. Figure 2 identifies the roads where undergrounding of electrical and telecommunication infrastructure is proposed.
- 1.4. Details and drawings given in document (attached in the Annexures) are for information purpose only and successful bidder shall undertake confirmatory surveys for accuracy and completeness of data. It is mandatory and is in scope of successful Bidder to undertake all Site Surveys, Geotechnical investigations/Engineering Surveys, hydrological investigations, underground Utility Survey of the roads for shifting and creating new infrastructure for electrification, fibre optic cable, storm water sewers etc. It shall be the responsibility of the contractor to obtain all required approvals from the relevant authorities, carry out Design and Drawings for all the components of the work as per Employers requirement and submit the same to client for review and approval and carry out construction work as per the approved drawings accordingly. The successful bidder shall have to prepare and submit both 'Good for Construction Drawings' before execution and 'As Built Drawings' after execution depicting the exact construction carried out on site, in soft and hard copy format. A maintenance manual is to be submitted to client for approval before start of the project for post construction period.



FIGURE 1-1: THE FIGURE SHOWING IDENTIFIED SMART ROAD NAMES

**Legend**

- Vehicular Roads
- Pedestrian Roads
- Wards Lake

Sl No	Road Name	Road Names as per the junction names in the proposal	Road Lengths (m)	Road widths as per survey	Proposed Section
1	Traverse Lane	RD 03 (A1-A9) RD 07 (A9-Botanical garden bridge)	143+340	6.50-10.00	7m ROW: TCS Type 2B; 9m ROW: TCS Type 2A;
2	Bivar Road	Botanical garden bridge-B3	550	8.00-10.00	10m ROW: TCS Type 1;
3	By lane connecting GS Road & Traverse Lane	B1-A9	95	6	6m ROW: TCS Type 5; Storm Water Drain on RHS
4	Vivekananda Road	RD 07 (B2-B3) RD 08 (B3-B5) RD 08 (B5-C4)	727	8.00-12.50	For 10m ROW: TCS Type 1; From B5-C4: Electrical trench on RHS and tel.com. spacer on LHS
5	Keating Road	C1-Keating junction	220	5.00-7.00	7m ROW: TCS Type 7;
6	By lane connecting Keating to SP office	Keating junction-C3	137	5.00-7.00	7m ROW: TCS Type 7; 5m ROW: TCS Type 4 (Larger SWD on RHS)
7	Old Jowai Road	B7-B4	165	8.90-14.00	For 10m ROW: TCS Type 1; Electrical trench on RHS and tel.com. spacer on LHS
8	By Lane Connecting Old Jowai Road and Temple Road	B8-B7	448	4.00-8.20	For 5m ROW: TCS Type 4;
9	PWD Secretariat Hill Road	Chief engineer office (DTO)-B7	240	6.00	For 6m ROW: TCS Type 2B; For 10m ROW: TCS Type 1; Electrical trench on RHS and tel.com. spacer on LHS
10	Temple Road	B9-B8-chief engineers office (DTO)	200 240	6.00-12.00	For 5-6m ROW (200m length): TCS Type 5; 7m ROW: TCS Type 2B; For 10m ROW: TCS Type 1; Electrical trench on RHS and tel.com. spacer on LHS
11	Umsohsun Road	A7-A6-A5	340	4.00-8.50	For 6m ROW: TCS Type 5;
12	Police Bazaar Road	A1-A8-A7	419	4.50-12.00	Only surface relaying, cleaning of storm water drains and trenches, provision of overhead cables.
13	Thana Road	A8-A5-A4	246	5.00-8.00	Cleaning of storm water drains and trenches, provision of overhead cables.
14	Quinton Hills Road	A1-A4-A3-central jail junction	628	5.00-10.00	6m ROW: TCS Type 3B; 9m ROW: TCS Type 3A;
15	Jail Road	A2- central jail junction	144	6.00	6m ROW: TCS Type 4;
16	Pulin Behari Road	RD 01 (A1-A2-A3)	413	5.5-12.00	9m ROW: TCS Type 6A; 11m ROW: TCS Type 6B;

**TABLE \_ : LIST OF IDENTIFIED SMART ROADS, RESPECTIVE LENGTHS AND PROPOSED TYPICAL CROSS SECTIONS.**

## 2. SCOPE OF THE PROJECT

Under this Agreement, the scope of the Project shall mean and include:

- 2.1. Investigation, survey, detailed design and construction work for Improvement of Roads consisting of Up gradation, Augmentation, Foot paths, Bus bays, Utility Ducts, Road Markings, underground storm water drainage, rainwater harvesting and groundwater recharge measures, shifting of electrical poles and overhead power supply lines, underground electrical cable laying with installation and commissioning of allied electrical infrastructure and other Miscellaneous works shall be done on the selected Road segments (total 6 Km length) of various road widths in ABD Area whereas retrofitting of existing open drains, shall be carried out with other Miscellaneous works. Under this tender Scope of work of contractor also include Maintenance of Tendered works for Period of Five years with Preparation of Working Drawings, Procurement and Construction Basis.
- 2.2. Maintenance of the Project in accordance with the provisions of this Agreement and in conformity with the requirements.
- 2.3. Performance and fulfilment of all other obligations of the Contractor in accordance with the provisions of this Agreement and matters incidental there to or necessary for the performance of any or all of the obligations of the Contractor under this Agreement.
- 2.4. If due to any unavoidable circumstances, it needs to shift the location of project partly or fully, the contractor shall carry out the work partly or fully at another alternative location without any extra claim. The expenditure towards preliminary activities if carried out by the contractor shall be reimbursed by SSCL. (Actual expenditure or payment shown in Schedule of Payment-preconstruction activities-as per stage of work carried out by the contractor whichever is less).
- 2.5. Scope of work contained in the paragraphs mentioned below is only indicative and not exhaustive. In addition, the contractor shall be responsible for executing all items required for completing the work as per direction of Engineer-in-charge. The price quoted shall include all the items and covers all details as may be required to meet the purpose and intents of the contract.
- 2.6. The proposal including design- drawing and estimates are for reference only, contractor is supposed to carry out all sorts of investigations like site surveys, topographical surveys, hydrological surveys, geo-technical investigations, scanning roads for assessment and identifications of services and utilities laid down previously (like CCTV Cables, OFC Cables, Telecom Cables, Electrical Cables, water supply lines, etc.). The contractor is responsible to take out aforesaid services, restore them and shift them in the corresponding infrastructure created for respective services. The scope of work includes dismantling old work and create new facilities after design and approval from the Engineer in charge.
- 2.7. The scope of work is not limited only as mentioned in above paras, but also include to address any exigency generated during tendered work execution and no extra cost shall be paid for the same.
- 2.8. No extra payment shall be paid for time overrun.

### A. DETAIL SCOPE OF WORK CIVIL COMPONENTS:

The works under Contract comprises the construction of proposed improvement of roads, junctions, storm water drainage works, rainwater harvesting and groundwater recharge measures, construction of new carriageway, construction of utility ducts, cross drains, culverts, foot path,

traffic signage, road markings and miscellaneous works and the maintenance of tendered works for period of five years. Details and drawings given in tender document is for information purpose only and successful bidder shall undertake confirmatory survey for accuracy and completeness of data. It is in scope of successful Bidder to undertake all Site surveys, Geotechnical investigations, Underground Utility Surveying and Scanning of the roads for utility shifting, obtaining all required approvals from the relevant authorities, Carry out Design and Drawings for all the components of the work as per Employers requirement and submit the same to client for review and approval, Prepare Good for Construction Drawings, submit maintenance manual to client for approval before start of Maintenance period. The successful bidder shall have to prepare and submit 'As Built Drawings' depicting the exact construction carried out on site, in editable soft and hard copy format. Statutory and other charges for getting various required approvals shall be in scope of Successful bidder

The scope of work also includes:

- a. Contractors are requested to visit the site prior to fill/submit the tender and check all the necessary attributes/matters related for completion of this project.
- b. Site clearance, demolition works, earthworks, temporary works, traffic diversion, barricading the construction site, utility shifting and all ancillary works deemed necessary for the carrying out of temporary & permanent construction works.
- c. Widening/ re-cambering/ raising/ milling down & overlaying of existing carriageways, flexible/ rigid pavement at grade road intersections & accesses to adjoining developments.
- d. Tree cutting (if any) as indicated in the drawings.
- e. Construction of Utility ducts, cross drains as per approved drawing.
- f. Retrofitting the existing roads as per the proposed road sections with respect to carriageways, provision of footpath, cycle track, services lanes.
- g. Installing RPM, making road markings along the road edge, road centre line & as per IRC guidelines, bus stop marking, construction of medians & speed breakers, & junction improvements as per the drawings & in accordance with the Employer's requirements and to the satisfaction of the Engineer in charge.
- h. Construction of footpaths, kerbs, railings, vehicular impact guardrails and other road related facilities as per the guidelines of IRC in accordance with the Employer's requirements and to the satisfaction of the Engineer in charge.
- i. Supply and installation of new traffic signage, directional signage, street name signs & re-sitting of such existing signs & other road signs to be retained, inclusive of support & foundation as per Employers Requirement.
- j. Supply and installation of new electric poles and light fittings as per approved Drawings;
- k. All other works and services ancillary or related to the full completion of the Works in accordance with the Employer's requirements.
- l. The Contractor shall ascertain, determine and verify the locations of all utility services by scanning the roads in the vicinity of the Works, and co-ordinate with utility agencies for the diversion of affected services and the laying of new services. The Contractor shall support and protect services that need not be diverted or pending diversion and remove all abandoned services.
- m. Contractor shall be responsible for relocation, reconstruction, reconfiguration of driveways, site accesses, temporary and permanent drains, pipe conduits and necessary connections for public lighting and traffic lighting, earth works, turfing, environmental assessments, necessary safety measures and protection works, sewer lines etc.

- n. The Contractor's responsibility for the design and build works includes the submissions to relevant government authorities / technical departments for obtaining all necessary clearances/approvals.
- o. The Contractor shall co-ordinate and interfaces his works with that of all other contractors, subcontractors, utility services, statutory authorities, etc. and achieve the completion of the Works to the satisfaction of the Engineer.
- p. The Contractor shall verify the proposed road reserve, cadastral boundary and contract boundary and all dimensions on Site prior to submission of Tender. The Contractor is responsible for clarifying any discrepancy between the Drawings and actual condition on Site.
- q. The Contractor shall make good all works including road surfaces, drains, concrete slabs, gratings, kerbs, pavements, turfing, railing, fence, boundary wall, etc. affected or damaged during the course of construction, to the satisfaction of the Engineer. The costs of making good all these defects shall be borne solely by the Contractor and deemed included in his Contract Sum.
- r. All works specified shall include the provision of all labour, tools, equipment, material, traffic control, transport and everything else necessary for the satisfactory completion of the Work by the Contractor to the satisfaction of the Engineer.
- s. Description of the Works involved in this Contract is given in the Specifications for the guidance of the Contractor. The Contractor shall be solely and fully responsible for investigating and Ensuring the actual extent and nature of the works comprised in the contract prior to submission of his tender.
- t. Construction management and the quality of the works shall comply with the drawings, specification and employer's requirement.
- u. All the activities required to be carried out for successful and timely completion of this project shall be carried out by the successful contractor.

## **B. UTILITIES - SCOPE OF INFRASTRUCTURE FOR CONTRACTOR**

The project of Smart Roads has been considered under smart city for showcasing the pilot development to the rest of the city, which makes the area liveable and better eco-friendly environment. The scope of work for infrastructure is explained in the following section.

- a. Development and Strengthening of Carriage way with uniform lane widths.
- b. Development of footpath and pedestrian friendly ways.
- c. Reserving the space for utilities in a specified corridor.
- d. Rehabilitation of tertiary storm water roadside drain for easing out of rainwater with proper shoulders etc. Development of junction across entire road.

## **C. UNDERGROUND STORM WATER DRAINAGE WORK - SCOPE OF WORK FOR CONTRACTOR**

- a. All 6000m of smart road proposed in the phase-1 has the provision of SWD system.
- b. The Storm water drainage works should be carried out in accordance with the drawing and specifications without any extra cost. The work shall conform to CPHEEO manual on storm water drainage system: 1999 and as per latest edition of Indian Standard Specifications.
- c. The drain section is varying from 0.40m to 0.90m in width and 0.45m to 1.2m in Depth including 300mm free board. Details of discharge capacity and slope considered for design of drain section for different roads are enclosed at DPR along with the Drainage plan.

- d. Drain depth includes a provision of 0.3m free board. This free space may be considered for keeping provision of fixing a separate header pipe (63mm HDPE) for house connection connected from existing / proposed distribution water pipe line.
- e. Storm water drain/Utility Tunnel will be of RCC with M25 Grade of Concrete as per IS 456:2000. The size and the shape will be as per the respective drawing for different section of roads as shown in drawing.
- f. Storm water from property area will collected through 160mm HDPE PE100, PN4 pipe which will be installed at an interval of 30m as shown in drawing.
- g. Contractor needs to propose Good for construction drawing for approval. They need to submit as built drawing once the work is over in a particular road.
- h. It is the responsible of the contractor to interconnect existing drain (inlet or outlet) with the new system as applicable.

#### **D. LANDSCAPE, HARDSCAPE AND CYCLE TRACK WORKS**

The various components included (but not limited to) in this are – wide footpaths, landscape corridor with trees, bus bays, on-street parking, road markings, universal accessible design by introduction of ramps, benches and planting beds, provision for future bus stops, etc.

- a. Design and Construction of bus stops, public toilets and ATMs is not part of the contractor scope of work. Although the contractor is required to ensure site coordination and construction activity alignments when these works are being undertaken by other contractors.
- b. General Arrangement Plans (Surface Finishes Layouts) including Materials, Site
  - a. Furniture, cycle tracks etc.
- c. Levels and Grading Layouts; Material/Lighting/Furniture Schedules; Hardscape
  - a. Details (including ramps, cycle tracks, bus bays, on-street parking and benches); pedestrian lighting details; planting schedule; planting and soil details
- d. Hard landscape specification including all details in employers bill of quantities (BoQ) and technical specs.
- e. Softscape Specifications including all details in Employers BoQ and Technical Specs
- f. Final Setting-Out Plan for hardscape, softscape; furniture, footpaths, etc.
- g. All detail construction drawings suitable for construction works to be undertaken by competent contractor
- h. All necessary coordinated services drawings (including but not limited to location of light fixtures, cycle tracks, footpaths, existing site services and any new added services etc.)
- i. Shop drawings for all proprietary items/vendor items
- j. The contractor must be aware of general and specific site conditions, topography and any existing landscape `prior to commencement of any landscape works on site.

### **3. PROGRAM OF WORK**

Prior to starting the works on site Appointed Contractor shall submit the following documentation for approvals:

**A. DETAILED PROGRAMME OF WORK FOR ALL WORKS:**

- a. Prepare a detailed programme showing the stages, sequence and timing of all parts of work in MS Project (including subcontractors involvement/items and itemised items from Outline Programme of Work); It should include the resources, men, material, equipment required with clear critical path to execute the work as per agreed implementation schedules by employer.
- b. Timelines should be clearly defined. They should include estimated completion date and number of working days.
- c. Programme should include detailed information on resources (manpower, equipment etc.), works by subcontractors etc.
- d. Schedules are to be coordinated with the main contractor's program and subject to Client's approval.
- e. Method statement for all works, including transport & delivery of materials, site works including earth works, hard works installation, plant protection, temporary storage etc. should be clearly defined.
- f. Potential risks to programme should be summarised and mitigation methods provided (alternative programme of work if applicable).
- g. Special coordination requirements to be defined.

**B. PROCUREMENT PLAN:**

- a. Submit a Procurement Plan based on Client Representative's comments regarding the Procurement Schedule (as submitted with the tender document). The submitted Procurement Plan shall provide clear information on the following.
- b. Procurement schedule for all materials.
- c. Information of Supplier's
- d. Existing and future availability of materials.
- e. Information of Supplier's and/or Contractor's Off- site.
- f. Existing and future availability of materials.

**C. MATERIAL/PRODUCT SAMPLES:**

- a. All samples for material are to be submitted as required in advance
- b. Product certificates for manufactured products should be submitted.
- c. Type and number of samples as specified in relevant sections of this document
- d. All samples need to be approved by Employer/ PMC prior to commencement of works on site.
- e. For material, re-submit list with source and quantity available for each representative material.
- f. Landscape species should indicate height, spread, calliper and root ball size, for final approval by Client's Representative/PMC. Any agreed substitutions to plants species or specifications should be included here.
- g. Contractor to arrange for visit by Client's Representative and PMC staff to supplier or manufactures site location for an eyewitness and material testing to approve selected materials prior to procurement at this own cost (including travel/perdiem/accommodation etc. to the employer's representative and PMC staff).



#### **D. SITE MANAGEMENT PLAN**

Measures to be taken before commencement of works as well as during the works and maintenance period,

- a. Site arrangement layout for temporary structures, storage, water and electricity supply etc.;
- b. **PHASING Plan** to be submitted for approval to Employer/PMC prior to commencement of site work. Contractor has to ensure that there is little or no disturbance to the traffic, while planning the implementation phasing. Commuters shall be provided with proper signages, warnings, alternative routing etc. after discussions and approvals of Employer/ Engineer. It is to be ensured that at no time during the construction phase, the functioning of each of the roads is to be disturbed or stopped. Consultation will be required with the relevant authorities for construction phasing.
- c. Contractor has to show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earthwork operations. Submit before earth work begins.

#### **E. HEALTH AND SAFETY PLAN**

- a. Prior to commencing site works the following will be provided to the Client's representative:
- b. Method statements on how risks from hazards will be addressed.
- c. Details of management structure and responsibilities.
- d. Arrangements for issuing health and safety directions.
- e. Procedures for informing other contractors and employees of health and safety hazards.
- f. Procedures for communications between the project team, other contractors and site operatives.
- g. Arrangements for coordination and cooperation between contractors.
- h. Procedures for carrying out risk assessments and for managing and controlling the risks.
- i. Emergency procedures including those for fire prevention and escape.
- j. Arrangements for ensuring that all accidents, illness and dangerous occurrences are recorded.
- k. Arrangements for welfare facilities.
- l. Procedures for ensuring that all persons on site have received relevant health and safety information and training.
- m. Arrangements for consulting and taking the views of people on site.
- n. Arrangements for preparing site rules and drawing them to the attention of those affected and ensuring their compliance.
- o. Monitoring procedures to ensure compliance with site rules, selection of management procedures, health and safety standards and statutory requirements.

## **4. TECHNICAL SPECIFICATIONS**

### **TECHNICAL SPECIFICATIONS/ WORK REQUIREMENTS**

- a) The works in General shall be carried out as per latest specifications/work requirements of Public Works Department (PWD) (for civil works) and Meghalaya Power Distribution Corporation Limited (MePDCL) (for electrical works) unless otherwise specified in the nomenclature of the individual item or in the particular specifications of concerned items of works.
- b) The road works shall be as per "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS" (FIFTH REVISION) 2013 along with other Addendum/Corrigendum issued up to 28 days before the final date of submission of the bid, issued by the Ministry of Road Transport and Highways (MoRT&H), Government of India and published by the Indian Roads Congress (IRC), with a cross reference to relevant Bureau of Indian Standards (BIS) for materials or other aspects not covered by the IRC. In the absence of any definite provisions on any particular issue in the aforesaid Specifications, reference may be made to the latest codes and specifications of IRC and BIS in that order. Where even these are silent, the construction and completion of the works shall conform to sound international engineering practice as approved by the Engineer.
- c) Electrical works: All equipment and materials shall be designed manufactured and tested in accordance with the latest applicable standards of the International Electrotechnical Commission (IEC) and equivalent standards of the Bureau of Indian Standards (BIS). In the absence of any definite provisions on any particular issue in the aforesaid Standards, the construction and completion of the works shall conform to sound international engineering practice as approved by the Engineer.
- d) The works of water supply, sewerage (if applicable) and drainage shall be carried out as per the work requirements of PHED, Govt. of Meghalaya and SMB. In the absence of any definite provisions on any particular issue in the aforesaid Specifications, reference may be made to the latest codes/specifications/guidelines/manual of BIS and CPHEEO and CPWD in that order. Where even these are silent, the construction and completion of the works shall conform to sound international engineering practice as approved by the Engineer.
- e) Technical Specifications for all other works shall be as per the latest Specifications as published by the Central Public Works Department (CPWD), Government of India and deemed to be bound into this document.
- f) The latest edition till 28 days before the final date of submission of the bid of all specifications / standards shall be applicable.

### **CIVIL WORKS**

The works in General shall be carried out as per latest Government of Meghalaya's PWD Specifications, (updated with up to last date of submission of tender) unless otherwise specified in the nomenclature of the individual item or in the particular specifications of concerned items of works. For items not covered under Meghalaya PWD Specifications with correction slips or those specifications that are not given in the technical specifications appended or not incorporated in the nomenclature of the individual item, all Civil work shall be done as per following specifications or as per approval of Engineer-in-charge:

1. Government of Meghalaya's PWD Specifications,
2. UTIPEC Road Design Specifications
3. CPWD Specifications
4. MoRTH Specifications.
5. IRC Specifications

## 1. ROAD WORK TERMINOLOGY

**Asphalt:** A natural or artificial mixture in which bitumen is associated with mineral matter. The word 'Asphalt' should always be qualified by indication of its origin or nature.

**Asphalt Mastic:** An intimate mixture of mineral fillers, well graded sand and/or stone chippings with a hard grade of bitumen, cooked and laid hot manually by means of wooden float. The mixture settles to a coherent, void less and impermeable solid or semi-solid mass under normal temperature condition.

**Binder:** The binder shall be an appropriate type of bituminous materials complying with the relevant Indian Standard (IS) as defined in the appropriate clauses of these specifications or as otherwise specified herein. The choice of binder shall be stipulated in the contract or by the Engineer-in-charge.

**Bitumen:** A black or dark brown non crystalline solid or viscous material, having adhesive properties derived from petroleum either by natural or refinery processes and substantially soluble in carbon di sulphide.

Bitumen shall be paving bitumen of viscosity grade complying with Indian Standard Specifications for "Paving bitumen" IS:73:2006 of grade appropriate for the traffic and climatic conditions of the Project Highway. The heavily trafficked roads in hot areas may find harder grade bitumen more appropriate while pavements in mountainous regions subject to sub-zero temperatures during winter months carrying relatively lower traffic loads subject to the phenomenon of "Frost Heave" may find less viscous bitumen resistant to fatigue and cold cracking more appropriate.

**Bitumen-Cutback:** Bitumen, the viscosity of which has been reduced by a volatile diluent when blended with kerosene or naphtha type diluent or fuel oil, is called, medium or rapid or slow curing cut backs respectively.

**Bitumen-Emulsion:** A liquid product in which a substantial amount of bitumen is suspended in a finely divided condition in an aqueous medium containing an emulsifier and stabiliser. The emulsion is termed 'Anionic' when the bitumen particles are negatively charged and the aqueous phase is alkaline. The emulsion is termed 'cationic' when the particles are positively charged and the aqueous phase is acidic.

**Bitumen Mastic Filler:** Inorganic mineral material all of which will pass through specified IS sieve used in admixture with solid or semi-solid bituminous material.

**Road tar:** A product obtained by treating at high temperature coal tar in such a manner that it conforms to a specification which defines its suitability for road construction.

**Tar:** A viscous material having adhesive properties and resulting from the distinctive distillation of certain type of organic material. The term Tar should be preceded by the name of the material from which it is produced e.g. coal, shale, peat, vegetable matter and its mode of production shall be indicated.

**Flash point:** The lowest temperature at which the vapor of a substance can be ignited in air by a flame under specified conditions of test. The substance itself does not continue to burn.

**Tack Coat:** It shall consist of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to further bituminous construction.

**Bitumen concrete (Asphaltic concrete):** A well graded mixture of high quality aggregates with designated proportion of bitumen, hot mixed, hot laid and hot rolled into a uniform dense mass with specified design criteria.

**Ductility :** The property by which a material can be drawn out without breaking, for bitumen it is measured by the distance in centimeters to which it will elongate before breaking, when two ends of a briquette specimen of the material of the specified form and cross- section are pulled apart under water at a specified speed and temperature.

**Viscosity:** The property of a liquid by which it resists flow due to internal friction and is measured by the ratio of the shearing stress to the rate of shear.

## 2. MATERIALS

### 2.1. Aggregate Coarse

Coarse aggregate as specified in the item shall be either crushed/broken stone, crushed slag, over burnt (Jhama) brick aggregate or one of the naturally occurring aggregates such as kanker or laterite of suitable quality as stated hereinafter and approved by the Engineer-in-Charge.

The stone aggregate shall conform to the physical requirements set forth in Table 1. The type and size range of the aggregate shall be specified in the contract.

If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part-5).

**TABLE 1**  
**Physical Requirements of Coarse Aggregate for Water Bound Macadam for Sub-Base / Base Courses**

S. No	Test	Test method	Requirements
1.***	Los Angeles Abrasion value or Aggregate impact value	IS 2386 (Part-4) IS 2386 (Part-4) or IS 5640*	40% (Max.) 30% (Max.)
2.	Combined flakiness and Elongation Indices (Total)**	IS 2386 (Part-1)	35% (Max.)

\* Aggregates which get softened in presence of water shall be tested for impact value under wet conditions in accordance with IS:5640.

\*\* The requirements of flakiness index and elongation index shall be enforced only in case of crushed/broken stone and crushed slag.

\*\*\* In case water bound macadam is used for sub-base, the requirements in respect of Los Angeles Value and Aggregate Impact Value shall be relaxed to 50 percent and 40 percent maximum respectively.

The coarse aggregate shall conform to one of the grading's given in Table 2 as specified. For crushable type of aggregates such as brick metal, kankar and laterite, grading shall not be regarded as very important, but the material should generally be within the specified range.

**TABLE 2**  
**Grading Requirements of Coarse Aggregate for W.B.M.**

Grading No.	Size Range	IS Sieve Designation	Percent by weight passing the sieve
1	90 mm to 45 mm	125 mm	100
		90 mm	90 – 100
		63 mm	25 – 60
		45 mm	0 – 15

		22.4 mm	0 – 5
2	63 mm to 45 mm	90 mm	100
		63 mm	90 – 100
		53 mm	25 - 75
		45 mm	0 – 15
		22.4 mm	0 – 5
3	53 mm to 22.4 mm	63 mm	100
		53 mm	95 – 100
		45 mm	65 – 90
		22.4 mm	0 – 10
		11.2 mm	0 - 5

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

- 1.1.1. Overburnt (Jhama) Brick Aggregates:** Brick aggregate shall be made from over-burnt bricks and dense brick bats. It shall be homogeneous in texture, roughly cubical in shape, clean and free from dust, dirt and other objectionable and deleterious materials.
- 1.1.2. Crushed or Broken Stone:** When crushed or broken stone is specified as the coarse aggregate, it shall be hard, durable and free from excess of flat, elongated, soft, disintegrated particles, dirt and other objectionable matter. The total quantity of such deleterious material including clay lumps, soft fragment, foreign material etc. shall not exceed 5% of the weight of the aggregate.
- 1.1.3. Crushed Slag:** Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other deleterious materials. The weight of the crushed slag shall not be less than 11.2 kN per cubic metre (1120 kg per cubic metre) and the percentage of glossy material shall not be more than 20. Water absorption of slag shall not exceed 10% (IS 2386 Pt.III).
- 1.1.4. Kankar:** Kankar shall be tough, having a blue almost opalescent fracture. It shall not contain any clay in the cavities between nodules.
- 1.1.5. Laterite:** Laterite shall be hard, compact, heavy and of dark colour. The light-coloured sandy laterite as well as those containing much ochreous clay shall be rejected.

## 2.2. Aggregate-Fine

The fine aggregate shall be the fraction passing 2.8 mm sieve and retained on 90-micron sieve. It shall consist of crusher run screenings, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from injurious, soft or flaky pieces and organic or deleterious substance.

The contents of organic and deleterious materials shall not exceed the limits specified *in Table 3.*

**TABLE 3**

	Uncrushed	Crushed

Coal and lignite	1%	1%
Clay lumps	1%	1%
Material passing through 75 microns (I.S.S.) Sieve	3%	3%
Shale	1%	1%

The sum of the percentages of all deleterious material shall not exceed 5%. Tests for estimation of deleterious materials and organic impurities shall be done as per IS 2386 (Pt. II).

### 2.3. G.I. Barbed Wire

The barbed wire shall be of galvanised steel as specified and it shall conform to IS 278. The sampling criteria is given in Table 4. The wire shall be manufactured from steel by any process and shall not contain sulphur and phosphorous exceeding 0.065 per cent. The galvanised steel barbed wires shall be of two types: Type A (Lowa Type) and Type B (Glidden Type).

**Type A (Lowa Type)** : The barbs shall have four points and shall be formed by twisting two point wires, each two turns, tightly around both line wires making altogether four complete turns.

**Type B (Glidden Type)** : The barbs shall have four points and shall be formed by twisting two point wires, each two turns, tightly around one line wire making altogether four complete turns.

#### Details of G.I. Barbed wire

The galvanised steel barbed wire shall be of the size designations given in Table 4.

**TABLE 4**

Size Designation	Nominal dia. of wire				Mass of completed Barbed Wire		Distance between two barbs	No. of lays between the two consecutive barbs
	Line Wire		Point Wire					
	Nom	Tol	Nom	Tol	Max	Min		
	(mm)	(mm)	(mm)	(mm)	(g/m)	(g/m)		
1.	2.50	± 0.08	2.50	± 0.08	155	136	75 ± 12	2 to 7
2.	2.50	± 0.08	2.50	± 0.08	120	108	150 ± 12	2 to 7
3.	2.50	± 0.08	2.00	± 0.08	125	108	75 ± 12	2 to 7
4.	2.50	± 0.08	2.00	± 0.08	103	89	150 ± 12	2 to 7
5.	2.24	± 0.08	2.00	± 0.08	106	97	75 ± 12	2 to 7
6.	2.24	± 0.08	2.00	± 0.08	85	78	150 ± 12	2 to 7

Note: The mass in g/m shall be obtained by dividing the total mass of the reel by the linear length in metres.

The number of lays between the two consecutive barbs shall vary between 2 to 7.

The barbed wire shall be formed by twisting together two-line wires, one or both containing the barbs. The size of the line and point wires and barb spacing shall be as specified. The permissible deviation from the nominal diameter of the line wire and the point wire shall not exceed  $\pm 0.08$  mm. The line and point wires shall be circular in section, free from scales and other defects and shall be uniformly galvanised. The line wire, shall be in continuous lengths, and shall not contain any welds other than those in the rod before it is drawn. The distance between two successive splices shall not be less than 15 metres. It shall have the tensile properties as specified in Table 5.

**TABLE 5**  
**Tensile Properties**

Size of Line Wire	Tensile Strength of line wire	Minimum Breaking Load of Completed Barbed Wire
mm	kgf/sq. mm	kgf
2.50	40 to 60	375
2.24	40 to 60	300

The number of reels to be selected at random for this purpose shall be in accordance with Table 6.

**TABLE 6**  
**Sampling Criteria**

No. of Reels in the Lot	No. of Reels to be selected
Up to 25	3
26 to 50	4
51 to 150	5
151 to 300	7
301 and above	10

## 2.4. Binding Material

Binding materials to prevent ravelling of water bound macadam construction shall consist of a fine grained material possessing plasticity index value of 4 to 9 when the water bound macadam is to be used as a wearing course, and 4 to 6 when W.B.M. is being adopted as a sub-base/base course with bituminous surfacing on top of it. The plasticity index shall be determined in accordance with IS 2720 (Pt. V). The quantity of binding material used in each layer shall be as per direction of Engineer-in-Charge. Application of binding material may be dispensed with the approval of Engineer-in-Charge, where screenings consisting of crushable type material like moorum or gravel are used. Where earth cut for sub-grade formation is used as binder with the approval of Engineer-in-Charge, no separate payment shall be made for collection of this binder material.

### a. Bitumen Straight Run

A range of grades, from a very soft to a very hard consistency, can be produced by varying the temperature and the rate of flow during distilling process. It shall conform to IS 73. Grades of bitumen for different uses is given in Table 7.

**TABLE 7**  
**Bitumen Grades**

Grade		Temperature to which it shall be heated
	FOR PAINTING (Surface Dressing)	
	1. Paving bitumen of grade VG- 10	177 deg. C to 190 deg. C
	2. Paving bitumen of grade VG- 30	177 deg C to 190 deg. C
	3. Bitumen emulsion min. 50% bitumen content:- RS grade IS 8837	(Cold application)
	4. Cut backs RC-3 (rapid curing) IS 217	—do—
	FOR PREMIX CARPETING	
	1. Paving asphalt 30/40 S-35 or 80/100 S-90	149 deg. C to 177 deg. C
	2. Bitumen Emulsion min. 60% bitumen contents RS grade IS 8837	(Cold application)
	3. Cut back MC (medium curing) IS 4545	(Cold application)
	FOR ASPHALTIC CONCRETE STRAIGHT RUN BITUMEN 60/70 (S-65) CONFORMING TO IS 73	150 deg. C to 177 deg. C

**Note:** For premix carpeting with paving asphalt, extra shall be paid if solvent is used.

## 2.5. Filler

The filler, where specified, shall be an inert material, the whole of which passes through a 710 micron sieve, atleast 90 per cent passing through a 180 micron sieve and not less than 70 per cent passing through a 90 micron sieve. The filler shall be cement, stone dust, hydrated lime, lime stone dust, flyash or any other non-plastic mineral matter approved by the Engineer-in-Charge.

**TABLE 8**  
**Aggregate Gradation including Filler**

Sieve designation	Percent by weight passing the sieve	
	For 25 mm thickness	For 20 mm thickness
20.0 mm	100	-
12.5 mm	75-100	100
10.0 mm	60-85	75 – 100
4.75 mm	35-55	35 – 55
2.36 mm	20-35	20 – 35
600 micron	10-22	10 – 22



300 micron	6-16	6 – 16
150 micron	4-12	4 – 12
75 micron	2- 8	2 - 8

## 2.6. Flyash

Flyash shall conform to IS 3812

## 2.7. Lime

Lime shall be of specifications as directed by Engineer-in-Charge.

## 2.8. Moorum

It shall be obtained from pits of weathered disintegrated rocks. It should preferably contain silicious material and natural mixture of clay of calcareous origin. The size of moorum shall not be more than 20 mm.

## 2.9. Posts and Struts—R.C.C.

All posts and struts shall be of standard size, the length of posts being 1.8 m or as specified and that of struts being minimum of 2.0 m. These shall be cast in cement concrete 1:1 ½ :3 (1 cement : 1 ½ coarse sand : 3 graded stone aggregate 12.5 mm nominal size) reinforced with 10 mm diameter tor steel bars as directed and finished smooth with cement mortar 1:2 (1 cement: 2 fine sand). The specifications for R.C.C. work shall apply. The posts and struts shall be free from cracks, twists and such other defects. G.I. staples on wooden plugs or 6 mm bar nibs will be provided as directed by Engineer-in-Charge while casting the posts. Quantity of RCC post, struts, Rails and Pales to be measured in cubic content.

## 2.10. Pre-moulded Joint Filler

It shall conform to IS 1838, the thickness shall be 20 mm or 25 mm as specified and shall be of the maximum available standard length. During the casting of the slab the premoulded joint filler shall be placed accurately in position against the finished end of concrete slab. The filler shall remain 20 mm below the top surface of the pavement and shall extend upto the subgrade.

## 2.11. Screenings

Screening to fill voids in the coarse aggregate shall generally consists of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than river borne rounded material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent.

As far as possible screenings shall conform to the grading's set-forth in Table 9. Screenings of type A shall be used with coarse aggregate of grade I of Table 2. Screenings of type A or B as specified shall be used with coarse aggregates of grading 2. Type B screenings shall be used with coarse aggregates of grading the use of screenings may be omitted in the case of soft aggregates such as brick metal, kankar and laterite. For screenings like moorum or gravel the grading's given in Table 9 shall not be binding.

**TABLE 9**  
**Grading for Screenings**

Grading Classification	Size of Screenings	IS Sieve Designation	Percent by Weight Passing Sieve
A	13.2 mm	13.2 mm	100
		11.2 mm	95 -100
		5.6 mm	15 - 35
		180 micron	0 – 10
B	11.2 mm	11.2 mm	100
		9.5 mm	80-100
		5.6 mm	50 - 70
		180 micron	05 - 25

### 2.12. Sealing Compound

After the curing period is over the joint portion above the filler board shall be cleaned thoroughly as directed by the Engineer-in-Charge. The joints shall be filled with hot applied sealing compound. Grade A (Normal) for concrete constructions other than those which are subjected to spillage of kerosene or other heavy petroleum oils and Grade B (Jet fuel resistant) for concrete constructions of runways for jet air crafts, conforming to IS 1834.

### 2.13. Soil

Soil having a plasticity index (PI) between 5 and 20 shall be suitable. Atleast one test for 200 cubic metre of soil for determining P.I. shall be conducted.

### 2.14. Stones

These shall be clean, hard, sound and durable stones, free from decay and weathering. They shall be in blocks and hammer dressed on all sides. The size of pitching stones shall be approximately 22.5 cm in depth and not less than 15 cm in any other direction.

### 2.15. Stone Chippings For Surface Dressing/Painting

The stone chipping shall consist of fairly cubical fragment of clean, hard, tough and durable rock of uniform quality throughout. These shall be obtained by crushing stone river gravel (shingle) or other approved materials. Rounded gravel shall be used only if specifically permitted by the Engineer-in-Charge. The chipping shall be free of elongated or falky pieces, soft or disintegrated stone, salt, alkali, vegetable matter, dust and adherant coatings. They shall conform to the quality requirements of **Table 10**.

However, the total quantity of such deleterious material including clay lumps, soft fragments, foreign material shall not exceed 5% of the weight of the aggregate.

The aggregate shall be got tested to ensure the requirements specified in **Table 10**.

**TABLE 10**  
**Physical Requirements of Aggregates for Surface Dressing**

Sl. No.	Test	Test method	Requirements

1.	Los Angles Abrasion Value	IS 2386 (Part-4)	40% (Max.)
2.	Aggregate Impact Value*	IS 2386 (Part-4)	30% (Max.)
3.	Flakiness Index	IS 2386 (Part-1)	25% (Max.)
4.	Stripping Value	IS 6241	25% (Max.)
5.	Water Absorption	IS 2386 (Part-3)	1% (Max.)

\*Aggregates may satisfy requirements of either of the two tests.

## 2.16. Stones for Kerb and Channels

Kerb and channel stones are provided on roads having raised berms for foot path etc. These shall be of selected hard stone, sound, durable free from laminations and other structural defects. The length of each kerb and channel stone shall be not less than 49.5 cm except that 29.5 cm long stones shall be permitted for closures and for curves. The other dimensions shall be 30 x 20 cm for kerb stones and 30 x 10 cm for channel stones, unless specified otherwise. Kerb and channel stones shall be chisel dressed on exposed surface and edges. The dimensions of the exposed faces of kerb and channel stones shall be of sizes as specified with a tolerance of 10 mm in width and depth. In the case of kerb stones a tolerance of 5 cm shall be allowed in the dimensions of unexposed back and bottom faces and in the case of channel stones a tolerance of 10 mm shall be allowed in thickness.

## 2.17. Boundary Stone

The boundary stones shall be of either hard stone or sound and durable quality or precast R.C.C. These shall be in blocks of size 15 × 15 × 90 cm unless directed otherwise by the Engineer-in-Charge. A tolerance of 12.5 mm shall be permitted in the specified size. In the case of boundary stones of hard stone, the upper 30 cm shall be chisel dressed on all the four sides and on the top.

The R.C.C. boundary stones shall be cast in cement concrete 1 : 1 ½ : 3 (1 cement : 1 ½ coarse sand : 3 graded stone aggregate 20 mm nominal size), reinforced with 10 mm diameter tor steel bars or as directed and finished smooth with cement mortar 1 : 3 (1 cement : 3 fine sand ). The specifications for R.C.C. work shall apply.

## 2.18. Kilometre stone

Standard designs of kilometre stones are given in Fig. Ordinary kilometre stone for National Highways, State highways and Major District shall be of the size 35 × 111 × 25 cm. One cm offset shall be provided around the stone slab in 10 cm height above the formation level to serve as the pedestal. The kilometre stones shall be fixed at right angle to the centre line of the carriage way. The kilometre stone shall indicate the name and distance of the next (intermediate) important town only. On the side of the kilometre stone facing the carriage way, the number of the kilometre stone shall be inscribed (without the name of any place) which shall be painted later on.

Kilometre stones for every fifth kilometre on National Highways, State highways and major district roads shall be of the size 50 x 152.5 x 25 cm. One cm offset shall be provided around the stone slab in 13 cm height above the formation level to serve as the pedestal. This kilometre stone shall be fixed at right angles to the centre line of carriage way. It shall show the name and distance of the terminal or the starting station also above those of intermediate towns. On the side facing the

carriage way, the number of the kilometre stone in continuity of ordinary kilometre stone shall be inscribed (without the name of any place) which shall be painted later on.

Kilometre stone for other district roads and village roads shall be of the size 35 × 93.5 × 18 cm. One cm offset shall be provided around the stone slab in 10 cm. height above the formation level to serve as the pedestal. It shall be fixed at right angles to the centre line of carriage way and shall indicate the name and the distance of the next important station. On the side facing the carriage way, the number of the kilometre stone shall be inscribed (without the name of any place).

The kilometre stones shall be fixed at the edge of the road way outside the shoulder on especially erected platforms, if necessary. In cutting these shall be fixed clear of the shoulder and the side drain as per Fig. On existing roads the stones shall be fixed on the side of the road other than that on which miles stones exist. On new roads, these shall be located on left hand side of the road as one proceeds from the station from which kilometre count starts.

Kilometre stones shall be of approved design of R.C.C. or stone slabs.

- a. **Kilometre Stones in R.C.C.:** It shall be cast in cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) with reinforcement as directed and finished smooth with cement mortar 1: 3 (1 cement: 3 fine sand) on exposed surfaces above the ground. The specifications for R.C.C. work shall apply.
- b. **Kilometre Stone Slabs:** The stone slabs shall be of red or white sand stone unless otherwise specified. The slab shall be hard, even, sound and durable. The stone slabs shall have been sawn or chiseled in a plane parallel to the natural bed of the stone. The slabs shall be chisel dressed on the exposed surfaces above ground facing road side, so that the dressed face shall not be more than 3 mm from a straight edge placed on it. The thickness of the slab shall be uniform and as specified in the item with a permissible tolerance of 1.5 mm. The thickness shall be measured correct to 3 mm.

### 3. SUB-GRADE: PREPARATION AND CONSOLIDATION

In sub-grade composed of clay, fine sand or other soils that may be forced up into the coarse aggregate during rolling operation, an insulation layer of suitable thickness of granular materials or over size brick aggregate not less than 10 cm thick shall be provided for blanketing the sub-grade, which shall be paid for separately, unless otherwise specified in the agreement.

In slushy soils or in areas that are water logged, special arrangements shall be made to improve the sub-grade and the total pavement thickness shall be designed after testing the properties of the sub-grade soil. Necessary provision for the special treatment required shall be made in the project and paid for separately.

#### 3.1. Preparation of Sub-Grade

The surface of the formation for a width of sub-base, which shall be 15 cm more on either side of base course, shall first be cut to a depth equal to the combined depth of sub-base and surface courses below the proposed finished level (due allowance being made for consolidation). It shall then be cleaned of all foreign substances. Any ruts or soft yielding patches that appear due to improper drainage conditions, traffic hauling or from any other cause, shall be corrected and the sub-grade dressed off parallel to the finished profile.

#### 3.2. Consolidation

The sub- grade shall be consolidated with a power road roller of 8 to 12 tonnes. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as elastic mass (the roller shall pass a minimum of 5 runs on the sub grade). All undulations in the surface that develop due to rolling shall be made good with material or quarry spoils as the cases may be and the sub-grade is rerolled.

#### 3.3. Surface Regularity

The finished surface shall be uniform and conform to the lines, grades and typical cross section shown in the drawings, when tested with the template and straight edge, the variation shall be within the tolerances specified in Table 11.

**TABLE 11**

**Permissible Tolerances of Surface Evenness of Sub Grade**

<i>Longitudinal profile maximum permissible undulation when measured with a 3 metre straight edge</i>	<i>Cross profile maximum permissible variation from specified profile when measured with a camber template</i>
24 mm	15 mm

Where the surface irregularity of the sub grade falls outside the specified tolerances, the contractor shall be liable to rectify these with fresh material or quarry spoils as the case may be, and the sub- grade rerolled to the satisfaction of Engineer-in-Charge.

#### 3.4. Measurements

The length and width shall be measured correct to a cm. The area shall be worked out in square metre, correct to two places of decimal.

### 3.5. Rate

The rate for preparation and consolidation of sub grade shall include the cost of materials and labour involved for all the operations mentioned in above unless otherwise specified.

## 4. EMBANKMENT CONSTRUCTION (UNDER OPTIMUM MOISTURE CONDITIONS)

In the case of earth work consolidated under optimum moisture conditions each layer of earth shall be carefully moistened to give field moisture content of about +1% to -2% of the optimum moisture content (OMC). The OMC shall be determined according to IS 2720 (Pt.VIII) Methods of Tests for Soils. Each layer shall then be compacted by rolling with 8 to 10 tonnes power road roller and a sheep foot roller if required. The required amount of water shall be added during consolidation to keep the moisture content of the soil at the optimum as per test. The density to be achieved for each layer of the material shall not be less than 95% of the density obtained in the laboratory (Proctor Method).

Each compacted layer shall be tested in the field for density and accepted before the operations for next layer are begun.

Control on compaction in the field shall be exercised through frequent moisture content and density determinations. A systematic record of these shall be maintained. At all times during construction the top of the embankment shall be maintained at such cross fall as will shed water and prevent ponding.

### 4.1. Density Measurement and Acceptance Criteria

- 4.1.1. One measurement of density shall be made for each 500 sqm of compacted area or for a smaller area as decided by the Engineer-in-Charge. Each measurement shall consist of atleast 5 density determinations tests and the average of these 5 determinations shall be treated as the field density achieved. The determination of density shall be as per IS 2720 (Pt. XXVIII).
- 4.1.2. In general the control at the top 40 cm thickness of the formation shall be more strict with density measurements being done at the rate of one measurement for 250 sqm of compacted area. Further for the determination of the mean density the number of tests in one measurement shall not be less than 10 and the work will be accepted if the mean dry density equals or exceeds the specified density.
- 4.1.3. When density measurements reveal any soft areas in the embankment, the Engineer-in-Charge shall direct that these be compacted further. If in-spite of that the specified compaction is not achieved the material in the soft areas shall be removed and replaced by approved materials and compacted to the satisfaction of the Engineer-in-Charge.
- 4.1.4. Control Tests on Borrow Material
- 4.1.5. Soil suitable for consolidation under O.M.C. conditions should preferably have the following characteristics :
  - (a) Minimum percentage of clay 10%
  - (b) Liquid limit 14
  - (c) Plasticity index 4
  - (d) Percentage of silt should not exceed 50%
  - (e) Peat, muck and organic soils are unsuitable.

- 4.1.6. The Engineer-in-Charge may, however, relax these requirements taking into account availability of materials, cost of transportation and other relevant factors.
- 4.1.7. Various test required to be conducted on the borrow material with their recommended frequency are indicated below. All the test need not be stipulated on every project. Depending upon site condition etc. only some may be found necessary at a particular project. The frequency of testing indicated refers generally to the minimum number of tests to be conducted. The rate of testing must be stepped up as found necessary depending upon the variability of the materials and compaction methods employed at a project.
- (a) *Gradation*: At least one test for each kind of soil. Usual rate of testing 1 to 2 tests per 8000 cum of soil.
  - (b) *Plasticity*: At least one test for each kind of soil. Usual rate of testing 1 to 2 tests per 8000 cum of soil.
  - (c) *Proctor Tests*: At the rate of 1 to 2 tests per 8000 cum of soil.
  - (d) *Deleterious Contents*: As required.
  - (e) *Moisture contents*: One test for every 250 cum of soil.

## **4.2. Measurements**

The filling shall be measured and quantity of earth work computed from cross sections of filling or the embankment. No deduction shall be made for voids.

## **4.3. Rate**

Rate shall include the cost of all operations described above including operation mentioned in Control Tests on Borrow Material to the extent applicable.

# **5. SUPPLYING AND STACKING OF MATERIALS**

## **5.1. Aggregates**

The item of work shall specify stone aggregate/brick aggregate/red bajri etc., as the case may be.

### **5.1.1. Stacking**

- 5.1.1.1. Ground where stacks are proposed to be made shall be cleared, levelled or dressed to a uniform slope and all lumps, depressions etc. shall be removed. The stacked material shall be free from vegetation and other foreign matter. Coarse aggregates stack shall be made at places as directed by the Engineer-in-Charge. All rejected stone material shall be removed from the site.
- 5.1.1.2. The aggregate shall be stacked in convenient units of one metre top width, 2.2 m bottom width, 60 cm height and of length in multiples of 3 m for new roads. Where berm width is limited or for repair works it shall be stacked in units of 40 cm top width 1.4 m bottom width, 50 cm height and length in multiples of 3 m. Template of steel shall be used for making the stacks and shall always be kept at site for check measurements. The Engineer-in-Charge may permit stacking in different sizes and height ranging between 45 to 75 cm for new roads and 40 to 60 cm for repair work, in case the site conditions so demand. In a particular reach of road as decided by the Engineer-in-Charge, the quantity of stacked material shall be comparable to the theoretical quantity required for W.B.M. to be laid in that reach.

5.1.1.3. The stacks shall be uniformly distributed along the road and shall be numbered serially. The number plate shall be planted on each stack, which shall remain in position until the stack is used in the work. A register showing daily consumption of stacks shall be maintained at site of work. The collection of stone metal shall be for completed length of one km (for each layer of W.B. Macadam) or as directed by the Engineer-in-Charge in writing.

#### **5.1.2. Measurements**

Length, breadth and height shall be measured correct to a cm. The total quantity so arrived shall be reduced by 7.5% to arrive at the net quantity for payment, in cases of aggregates. No such reduction shall be made in case of fine aggregate i.e. Bajri & screening etc.

### **5.2. Binder**

#### **5.2.1. Stacking:**

5.2.1.1. Specified binder shall be brought to the site of work in the sealed original containers. Binder brought in damaged containers shall not be allowed. The material shall be stacked in fenced enclosures, as directed by the Engineer-in-Charge, on one side of the roadway. The material shall be purchased from reputed firms or their authorised dealer. All the drums brought to site shall be serially numbered and used in the same order. The materials shall be brought in at a time in adequate quantities to suffice for the whole work or for at least a fortnight's work.

5.2.1.2. For major bituminous road works, supply of bitumen in bulk may be taken for economic reasons, or if the contingencies of the work so require. Sufficient storage arrangement shall be made at site for at least ten days requirement.

5.2.1.3. Materials shall be kept in the joint custody of the contractor and the representative of the Engineer-in-Charge. The empty containers shall not be removed from the site of work, till the relevant item of work has been completed and permission obtained from the Engineer-in-Charge. A few drums may be removed before completion of work for heating bitumen and mixing aggregates etc. with the permission to the Engineer-in-Charge.

Empty drums required to be returned to stores shall be in good condition. Recovery rate for non-return of the empty drums or for the damaged drums shall be as decided by the Engineer-in-Charge.

#### **5.2.2. Measurements:**

The materials shall be recorded as per standard weights of different type of container as intimated by manufacturers. The material shall be weighed where containers are found leaking.

#### **5.2.3. Rate:**

The rate shall include the cost of all labour and materials involved in all the operations described above.

### **5.3. Moorum/Stone Chippings/Good Earth**

The item of work shall specify moorum/stone chippings/Good Earth as the cases may be.

#### **5.3.1. Stacking:**

5.3.1.1. Ground where stacks are proposed to be made, shall be dressed to a uniform slope and all lumps, depressions etc. shall be removed. Sample of moorum shall be got approved from the Engineer-in-Charge, before the material in bulk is brought to site.

5.3.1.2. Moorum/Good Earth shall be stacked in convenient units of one cubic meter in between aggregate stacks in each length of 100 m as per requirement. The stacks shall be made with wooden boxes open at both ends and of 2 × 2 × 0.25 m dimensions. These shall always be kept at site for stacking and check measurement.



5.3.1.3. The stacks shall be uniformly distributed along the road. The supply of moorum shall be completed for the entire work or for a complete length of one km or as directed by the Engineer-in-Charge in writing.

**5.3.2. Measurements:**

Length and breadth of boxes shall be measured correct to a cm. Volume shall be calculated in cubic meters, correct to two places of decimal.

**5.3.3. Rate:**

The rate shall include the cost of all materials and labor involved in all the operations described above.

## **6. EARTHWORK IN ROAD CONSTRUCTION**

6.1. Earthwork connected with road construction fall broadly into three categories.

- (a) Earthwork in cutting including borrow pits.
- (b) Earthwork in fillings in embankments (without optimum moisture conditions).
- (c) Earthwork in fillings in embankments (under optimum moisture conditions).

6.2. Detailed specifications relating to Earthwork already described in subhead Earth Work, CPWD Specification Vol- I, 2019 so far as the various options in the earthwork for road construction as indicated below shall be applicable.

- Site clearance
- Setting out and making profile
- Blasting operations
- Excavation in all kinds of soils
- Excavation in ordinary/hard rock
- Earthwork in filling
- Measurements
- Rates
- Surface excavation
- Rough excavation and filling

6.3. In addition to the above, there are certain special requirements of earthwork for road constructions, especially in embankments and excavations from borrow pits. These shall broadly conform to.

- (a) IRC : 36 Recommended practice for construction of earth embankments for road works.
- (b) IRC : 10 Recommended practice for borrow pits for road embankments by manual operations.

6.4. Excavation from borrow pits shall conform to provisions in para 3 of IRC: 10 and the road embankment shall generally conform to section, slopes and location of borrow pits as per Fig. given in CPWD Specifications Vol. I, 2019.

## **7. EMBANKMENT CONSTRUCTION (WITHOUT OPTIMUM MOISTURE CONDITIONS)**

7.1. In addition to what is described in 5 above, the following shall apply: materials used in embankments shall be earth moorum, gravel, a mixture of these or any other material approved by the Engineer-in-Charge. Such materials shall be free of logs, stumps, roots,

rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment. The work shall be so planned and executed that the best available materials are saved for the top portion of the embankment.

Highly expansive clays exhibiting marked swell and shrinkage properties may be deposited only at the bottom of the embankment and no such material shall be placed nor permitted to remain in the top 500 mm portion of the embankment below the sub-grade.

## **7.2. Preparation of Foundations**

The foundations of the embankment shall be ploughed to a depth of 15 to 25 cm. All clods shall be broken into fine earth and the area roughly levelled. The surface shall then be well watered before the earth work is started.

## **7.3. Source of Supply**

**7.3.1.**The material used in embankment shall be obtained either from cutting high ground or from borrow pits as directed by the Engineer- in-Charge. In case of road embankments, the borrow pits may be excavated along the sides of the road so as to form road side drains with proper slopes and sections. The clear berm width between the toe of the bank and the inner edge of the borrow pits shall be specified by the Engineer-in- Charge but it shall not be less than 5 metres after making due allowance for future development.

**7.3.2.**Borrow pits shall be rectangular in shape with one side parallel to the centre line of the road. If on road land, these shall be dug as near the boundary as possible. Borrow pits shall not be dug continuously. Ridges of not less than 8 metres width should be left at intervals not exceeding 300 metres. Small drains should be cut through the ridges to facilitate drainage. Borrow pits shall be well drained. The bed level of the borrow pits, shall, as far as possible, slope down progressively towards the nearest cross drain, if any and shall not be lower than the bed of the cross drain. Borrow pits shall not be dug within 0.8 km of towns or villages. If unavoidable these shall not exceed 30 cm in depth and shall be drained.

**7.3.3.**Where it becomes necessary to borrow filling materials from temporarily acquired cultivable lands the depth of borrow pits shall not exceed 45 cm. The top soil to a depth of 15 cm shall be stripped and stacked aside. Thereafter soil shall be dug out to a further depth not exceeding 30 cm and used in forming the embankment. The top soil shall then be spread back on the land.

**7.3.4.**In case of flood and marginal banks, earth shall be obtained from borrow pits on the river side of the banks. No borrow pit shall be excavated on the land side of the bank, unless permitted by the Engineer -in- Charge in writing depending upon the depth of borrow pits and height of embankment. However the minimum berm width between the toe of the bank and the edge of the borrow pits on the river side shall be 15 metres and that between the toe of the bank and the edge of the borrow pits on the land side 25 metres.

**7.3.5.**Guide-banks shall be constructed from material obtained from excavation for laying stone aprons and further borrow pits excavated if necessary, according to the directions of the Engineer-in-Charge.

## **7.4. Earth Filling and Compactions**

**7.4.1.**Before commencement of filling the toe lines of the embankment shall be marked by pegs driven into the ground at 15 metres intervals and by continuous nicking (daf balings) to indicate the limits of the side slopes. Bamboo and string profiles shall be erected at every 60 metres interval in straight reaches and 15 metres apart in curved portions.

**7.4.2.**Embankment material shall be laid in 20 cm layers which shall be continuous and parallel to the finished grade. The placing of earth fill shall be done in the full width of embankment

including slopes, and the section of formation shall be kept slightly sloping away from the centre to avoid pools of water forming due to rain. The height of filling in different sections shall be uniform as far as possible. All clods shall be broken while the earth is being placed. Organic matter of any kind shall be removed and disposed off as directed by the Engineer-in-Charge.

**7.4.3.**Joining of old and new embankments shall be done by stepping in an overall slope of about 1 to 5.

**7.4.4.**Each layer of earth shall be adequately watered to aid compaction.

**7.4.5.**If the material delivered to the road bed is too wet it shall be dried by aeration and exposure to the sun, till the moisture content is acceptable for compaction. It shall then be rolled with roller of minimum 1/2 tonne weight, not less than 5 times, till it gets evenly and densely consolidated with wooden or steel rammers of 7 to 10 kg weight having a base of 20 cm square or 20 cm diameter. The labour for ramming shall be atleast one rammer to six diggers. Every third layer of earth and the top most layer shall be well consolidated with a power roller of minimum 8 tonnes weight, rolled not less than 5 times, till the soil behaves as an elastic material and gets compressed only elastically under the load of roller.

**7.4.6.Dressing:** The embankment shall be dressed neatly to the required level as per designed section and grade, after it has been completed and thoroughly consolidated. The top and slopes shall be protected from any damage and maintained, till the work is completed and handed over to the Engineer-in-Charge.

## **7.5. Embankment Around Structures**

**7.5.1.**To avoid interference with the construction of abutments, wing walls or return walls of culvert/bridge structure, the contractor shall at points to be determined by the Engineer-in-Charge suspend work on embankments forming approaches to such structures, until such time as the construction of the latter is sufficiently advanced to permit the completion of approaches without the risk of interference or damage to the bridge works.

**7.5.2.**Unless directed otherwise, the filling around culverts, bridges and other structures upto a distance of twice the height of the embankment shall not be done. The fill material shall not be placed against any abutment or wing wall unless permission has been given by the Engineer-in-Charge but in any case, not until the concrete or masonry has been in position for 14 days. The embankment shall be brought up simultaneously in equal layers on each side of the structure to avoid displacement and unequal pressure. The sequence of work in this regard shall be got approved from the Engineer-in-Charge.

**7.5.3.**Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter material shall conform to the requirements for filter medium as specified. Payment for providing filter material shall be made separately under relevant items.

**7.5.4.**Where it may be impracticable to use power roller or other heavy equipment, compaction shall be carried out by mechanical tampers or other methods approved by the Engineer-in-Charge. Care shall be taken to see that the compaction equipments does not hit or come too close to any structural member so as to cause any damage to it.

## **7.6. Earth Work for Widening Existing Road Embankment**

**7.6.1.**When an existing embankment is to be widened and its slope is steeper than 4:1 continuous horizontal bench each at least 0.3-metre-wide, shall be cut into the old slope for ensuring adequate bond with the fresh embankment material to be added. The material obtained from cutting of benches could be utilised in the widening of the embankment. However,

when the existing slope against which the fresh material is to be placed is flatter than 4:1 the slope surface may only be ploughed or scarified instead of resorting to benching.

**7.6.2.** Where the width of the widened portion is insufficient to permit the use of standard rollers compaction shall be carried out with the help of sheep's foot roller mechanical tampers or other approved equipment. End dumping of material from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other type of hauling equipment.

## 7.7. Cutting

Where the formation level of the road is lower than the ground level, cutting shall be done up to formation level. Side slopes except in rock cutting shall be evenly and truly dressed.

**7.7.1. Disposal of Surplus Earth:** Earth from cutting shall be utilized for filling in embankment as directed by the Engineer-in- Charge. Earth not required for embankment shall be disposed off as directed by the Engineer -in-Charge. The area where the surplus earth is disposed off shall be levelled and neatly dressed. When the surplus earth is disposed off at a distance of more than 50 metres the extra lead shall be paid for.

**7.7.2. Measurements :** The quantity of earth work shall be calculated by measuring the volume of earth excavated from the borrow pits and shall be done as specified where it is not possible or convenient to take measurements from cutting the filling shall be measured and the quantity of earth work computed from cross sections of the filling. The quantity of earth work so computed shall be reduced by 5% to arrive at the quantity for payment.

For the purpose of taking measurements of earth work in cutting or embankment, ground levels of the area shall be recorded as specified in 5.

**7.7.3. Rate:** It includes the cost of all the operations described above. The lead and lift for depositing the earth or disposal of unsuitable material shall be as described in the description of item.

## 8. WATER BOUND MACADAM WITH STONE AGGREGATE

### 8.1. Water Bound Macadam with Stone Aggregate

Stone aggregate of specified size is used. This is a standard sub base/base and is used where stone aggregate is available at reasonable rates. This consists of clean crushed coarse aggregate mechanically interlocked by rolling and voids thereof filled with screening and binding material with the assistance of water, laid on a prepared sub grade, sub-base, base or existing pavement as the case may be. Water bound macadam may be used as a sub base, base course or surfacing course.

### 8.2. Approximate Quantities of Materials

Quantities of coarse aggregate, screening and binding material required to be stacked for 100 mm approximate compacted thickness of W.B.M. for 10 sqm shall be as per table 12 for stone aggregate of the size 90 mm to 45 mm. For stone aggregate of other size, 63 mm to 45 mm and 53 mm to 22.4 mm quantity of coarse aggregate and stone screening for 75 mm approximate compacted thickness of WBM base for 10 sqm. shall be as per Table 13.

**TABLE 12**

Coarse Aggregate			Stone Screenings		Binding Material
Classification	Size Range	Loose Quantities	Grading/classification and size	Loose Quantity	Quantity
Grading 1	90 mm to 45 mm	1.21 cum to 1.28 cum	Type A 13.2 mm	0.27 cum to 0.30 cum	0.08 cum to 0.10 cum

Note: Net quantity = Loose quantity measured in stacks minus 7.5%.

**TABLE 13**

Coarse Aggregate				Stone Screenings		
Classification	Size Range	Compacted Thickness	Loose Quantity	Grading Classification & Size	For WBM Sub-base/Base Course (Loose Quantity)	For WBM surface course (Loose Quantity)
Grading 2	63-45 mm	75 mm	0.91 to 0.96 m <sup>3</sup>	Type A 13.2 mm	0.12 cum to 0.15 cum	0.10 cum to 0.12 cum
-Do-	-do-	-do-	-do-	Type B 11.2 mm	0.20 cum to 0.22 cum	0.16 cum to 0.18 cum
Grading 3	53-22.4 mm	75 mm	-do-	Type B 11.2 mm	0.18 cum to 0.21 cum	0.14 cum to 0.17 cum

Note: 1. The quantity of metal measured in stacks and reduced by 7.5% to calculate net quantity.

2. The above-mentioned quantities should be taken as a guide only for estimation of quantities for construction etc.

The quantity of binding material required for 75 mm (approximate) compacted thickness will be 0.09 cum/10 sqm in the case of W.B.M. base course and 0.13 cum/10 sqm when the W.B.M. is to function as a surface course.

### 8.3. Preparation of Foundation

In the case of an existing unsurfaced road, where new materials is to be laid, the surface shall be scarified and reshaped to the required grade, camber and shape as necessary. Weak places shall be strengthened, corrugations removed and depressions and pot holes made good with suitable materials, before spreading the aggregate for W.B.M. Where the existing surface over which the sub base of W.B.M. is to be laid is black topped, to ensure effective internal drainage, furrows 50 mm x 50 mm (depth of furrows increased to reach bottom of bituminous layer where necessary) at one metre intervals shall be cut in the existing bituminous surface at 45 degree C to the central line of the carriageway before the W.B.M. is laid.

### 8.4. Provision of Lateral Confinement of Aggregates

Before starting with W.B.M. construction, necessary arrangements shall be made for lateral confinement of aggregates. One method is to construct side shoulders in advance to a compacted layer of the W.B.M. coarse (Fig. 1). Inside edges may be trimmed vertical and the included area cleaned off all spilled materials thereby setting the stage for spreading the coarse aggregate. The practice of laying W.B.M. after excavating a trench section in the finished formation must be completely avoided.

## **8.5. Spreading Aggregate**

The coarse aggregate shall be spread uniformly and evenly upon the prepared base in required quantities with a twisting motion to avoid segregation. In no case shall these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed base be permitted. The aggregates shall be spread uniformly to proper profile by using templates placed across the road six metres apart. Where specified, approved mechanical devices may be used to spread the aggregates uniformly. The levels along the longitudinal direction upto which the metal shall be laid, shall be first obtained at site to the satisfaction of Engineer-in-Charge, and these shall be adhered to.

The surface of the aggregate spread shall be carefully trued up and all high or low spots remedied by removing or adding aggregate as may be required.

The W.B.M. sub-base shall be normally constructed in layer of 100 mm compacted thickness and W.B.M. base shall be normally constructed in layers of 75 mm compacted thickness. No segregation of large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The coarse aggregate shall normally not be spread in lengths exceeding three days average work ahead of the rolling and blending of the proceeding section.

## **8.6. Rolling**

Immediately following at spreading of the coarse aggregate, it shall be compacted to the full width by rolling with either the three- wheel- power -roller of 8 to 10 tonnes capacity or an equivalent vibratory roller. Initially, light rolling is to be done, which shall be discontinued when the aggregate is partially compacted with sufficient void space in them to permit application of screenings.

The rolling shall begin from the edges with the roller running forward and backward and adding the screenings simultaneously until the edges have been firmly compacted. The roller shall then progress gradually from the edges to the centre, parallel to the centre line of the road and overlapping uniformly each preceding rear wheel track by one half width and shall continue until the entire area of the course has been rolled by the rear wheel. Rolling shall continue until the road metal is thoroughly keyed with no creeping of metal ahead of the roller. Only slight sprinkling of water may be done during rolling, if required. On superelevated curves, the rolling shall proceed from the lower edge and progress gradually continuing towards the upper edge of the pavement.

Rolling of sub base shall not be done when the sub-grade is soft or yielding or when the rolling causes a wave like motion in the sub-base or sub-grade. When rolling develops irregularities that exceed 12 mm when tested with a three metre straight edge, the irregular surface shall be loosened and then aggregate added to or removed from it as required and the area rolled until it gives a uniform surface conforming to the desired cross-section and grade. The surface shall also be checked transversely by template for camber and any irregularities corrected in the manner described above. In no case shall the use of screenings to make up depressions be permitted

## **8.7. Application of Screenings**

After the coarse aggregate has been lightly rolled to the required true surface, screenings shall be applied gradually over the surface to completely fill the interstices. Dry rolling shall be continued while the screenings are being spread so that the jarring effect of the roller causes them to settle into the voids of the coarse aggregates. The screenings shall not be dumped in piles on the coarse

aggregate but shall be spread uniformly in successive thin layers either by the spreading motion of the hand, shovels or a mechanical spreader.

The screenings shall be applied at a slow rate (in three or more applications) so as to ensure filling of all voids. Rolling and brooming shall continue with the spreading of the screenings. Either mechanical brooms or hand brooms or both may be used. In no case shall the screenings be applied, so fast and thick as to form cakes, ridges on the surface making the filling of voids difficult, or to prevent the direct bearing of the roller on the coarse aggregates. The spreading, rolling and brooming of screenings shall be performed on sections which can be completed within one day's operation and shall continue until no more screenings can be forced into the voids of the coarse aggregate. Damp and wet screenings shall not be used under any circumstances.

### 8.8. Sprinkling and Grouting

After spreading the screening and rolling the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screening into the voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued and additional screenings applied where necessary until the coarse aggregates are well bonded and firmly set for the entire depth and until a grout has been formed of screenings and water that will fill all voids and form a wave of grout ahead of the wheels of the roller. The quantity of water to be used during the construction shall not be excessive so as to cause damage to the sub-base or sub-grade.

### 8.9. Application of Binding Material

After the application of screenings and rolling, a suitable binding material shall be applied at a uniform and slow rate in two or more successive thin layers. After each application of binding material, the surface shall be copiously sprinkled with water and the resulting slurry swept in with hand brooms or mechanical brooms or both so as to fill the voids properly. The surface shall then be rolled by a 8-10 tonne roller, water being applied to the wheels in order to wash down the binding material that may get stuck to the wheels. The spreading of binding material, sprinkling of water, sweeping with brooms and rolling shall continue until the slurry that is formed will, after filling the voids form a wave ahead of wheels of the moving roller.

### 8.10. Setting and Drying

After final compaction of the course, the road shall be allowed to cure overnight. Next morning defective spots shall be filled with screenings or binding material, lightly sprinkled with water, if necessary and rolled. No traffic shall be allowed till the macadam sets.

The surface evenness of completed W.B.M. sub -base in the longitudinal and transverse directions shall be as specified in Table 14 for sub base with stone aggregate of size 90-45 mm and above.

**TABLE 14**

Size of Coarse aggregates	Longitudinal profile measured with a 3 metre straight edge			Cross profile
	Maximum permissible undulation	Max. No. of Undulations permitted in any 300 m length exceeding		Max. permissible undulation when measured with a camber template
		15 mm	10 mm	
90-45 mm & above	15 mm	-	30	12 mm

The longitudinal profile shall be checked using a 3 meter long straight edge and graduated wedge at the middle of each traffic lane along a line parallel to the Centre line of the road. The transverse profile shall be checked with adjustable template at intervals of 10 meters. For base with stone aggregate of size 63 to 45 mm and 53 to 22.4 mm surface evenness to be as per Table 15.

**TABLE 15**

Size of aggregates	Coarse	Longitudinal profile measured with a 3 metre straight edge		Cross profile	
		Maximum permissible undulation	Max. No. of Undulations permitted in any 300 m length exceeding		Max. permissible undulation when measured with a camber template
			15 mm	10 mm	
63-45 mm and 53-22.4 mm	12 mm	-	30	8 mm	

The longitudinal profile shall be checked with a three-meter-long straight edge and graduated wedge at the middle of each traffic lane along a line parallel to the centre line of the road. The transverse profile shall be checked with adjustable templates at intervals of 10 metres.

### 8.11. Rectification of Defective Construction

Where the surface irregularity of the W.B.M. sub-base course exceeds the tolerances specified in Table 14 or where the course is otherwise defective due to sub grade soil mixing with the aggregates, the layer to its full thickness shall be scarified over the affected area, reshaped with added material or removal and replaced with fresh materials as applicable, and re-compacted. The area treated in the aforesaid manner shall not be less than 10 sqm. In no case shall depressions be filled up with screenings and binding materials.

### 8.12. Measurements

The length and breadth shall be measured to the nearest centimeter. The depth of consolidated layer shall be computed to nearest half centimeter by taking average of depths at the center and at 30 cm from the left and right edges at a cross section taken at 100 meter interval or less as decided by the Engineer-in-Charge by making small pits. The consolidated cubical contents shall be calculated in cubic meters correct to two places of decimal. The cubical contents shall be compared with net quantity of stone aggregates paid (that is stacked quantity – 7.5%). If the cubical contents are within ( $\pm$ ) 5% of the paid net stacked quantity of stone aggregates, the work shall be treated as acceptable. If the cubical contents are short of net stacked quantity by more than 5% then the payment shall be restricted to the quantities derived from cubical content.

### 8.13. Rate

The rate shall include the cost of all labor and materials involved in all the operations described above, except cost of stone aggregate, kankar moorum, screenings and bajri, for which separate payments shall be made. Where W.B.M. is to be laid over an existing road, scarifying and consolidation of the aggregate received from scarifying shall be paid for separately.



## **9. WATER BOUND MACADAM WITH BRICK AGGREGATE (OVERBURNT (JHAMA) BRICK AGGREGATE)**

9.1. Over burnt (jhama) brick aggregate of size 120 mm to 40 mm or 90 mm to 45 mm is used. This is used when stone aggregate is costly and over burnt brick aggregate is available at reasonable rates. This is also used over soft clayey sub grade with high moisture contents and low CBR values.

### **9.2. Quantities of Materials**

Approximate quantity of brick aggregate (to be paid for separately) required to be stacked for 100 mm average compacted thickness of W.B.M. sub-base shall be 1.60 cum (approximate). The quantity of binding material, if required shall be as specified by the Engineer-in-Charge. Brick aggregate shall be broken from overburnt or well burnt brick bats. It shall be homogeneous in texture, roughly cubical in shape, clean and free from dirt and other foreign matter.

9.3. Foundation shall be prepared as specified in 7.4.

9.4. For spreading aggregate clause 7.6 shall apply except that the quantities of materials shall be as given above.

9.5. The rolling shall be done as specified in 7.7 except that rolling shall be done with the light power roller. The use of screenings shall also be omitted. Rolling shall be done 3 to 5 times for each layer.

9.6. For rolling with Binding material clause 7.10 shall apply except that rolling shall be done with a light power roller instead of a heavy road roller and water shall not be used during rolling. Rolling shall be done 3 to 5 times for each layer.

9.7. Surface Evenness rectification of Defective construction, Measurements and Rate shall be as specified under 7.12 to 7.15.

## **10. BAJRI PATHS**

### **10.1. Preparation of Sub-Grade**

The formation for a width equal to that of the bajri path shall first be cut to a depth, below the proposed finished level, equal to the thickness of the course of brick aggregate (due allowance being made for consolidation) and dressed off in level to the finished profile.

In case of made up soil, adequate watering shall be done so that earth settles down as much as possible and the same rolled up with a minimum three tonnes or light power roller, as directed by the Engineer-in-Charge.

### **10.2. Laying and Packing Brick Aggregate :**

Shall be as specified in 7.6 except that brick aggregate shall be used instead of stone aggregate and laid to 7.5 cm depth unless specified otherwise.

**10.2.1. Consolidation :** Shall be as specified in 7.7 except that rolling shall be done by three tonnes or light power roller instead of by heavy road roller as directed by the Engineer-in-Charge.

**10.2.2. Rolling with Blinding Materials :** Shall be as specified in 7.10 except that rolling shall be done by three tonnes or light power roller instead of by heavy road roller as directed by the Engineer-in-Charge.

### **10.3. Measurements**

The finished work shall be measured between the kerb or channel stones or brick edging etc. as the case may be. Length and breadth shall be measured, correct to a cm. The area shall be calculated in square metres, correct to two places of decimal.

### **10.4. Rate**

The rate shall include the cost of materials and labour involved in all the operations described above.

## **11. BRICK EDGING**

### **11.1. Edging**

Trenches of specified width and depth shall first, be made along the edges of the wearing course of the road to receive the bricks. The bed of trenches shall be compacted to a firm and even surface and then the bricks shall be laid with its length at right angle or parallel to the side of the road depending upon the width of edging as specified in the item. The bricks shall be abutting against the wearing course, true to line, gradient and in camber with the finished road surface at the edge.

### **11.2. Finishing**

Berms and road edges shall be restored with excavated earth and consolidated by manually. All surplus earth including rubbish etc. shall be disposed off as directed by the Engineer-in-Charge.

### **11.3. Measurements**

Length of the finished work shall be measured in running metres along the edges of the road correct to a cm.

### **11.4. Rate**

The rate shall include the cost of materials and labour involved in all the operations described above.

## **12. SCARIFYING METALLED (WATER BOUND) SURFACE**

### **12.1. Scarifying**

All dirt, dust, cacked up mud, slush, animal droppings, vegetation and all other rubbish shall be removed from the water bound macadam surface.

The macadam surface shall be scarified to a depth of approximately 5 cm with such additional picking of high parts of the road as may be necessary to the required camber and gradient as directed by the Engineer- in-Charge. Any hollows that remain after picking shall be filled with new aggregate 50 mm nominal size and well consolidated to bring the surface to template.

### **12.2. Finishing**

The scarified aggregate shall be raked to bring smaller stones on the top and surface brought to the required camber and gradient with tolerance of 12 mm longitudinally as well as transversely.

All rubbish etc. shall be disposed off as directed by the Engineer-in-Charge. Scarifying operation will also include consolidation with road roller the aggregate received from scarifying, although this aggregate will be consolidated along with aggregate of new wearing course to be paid separately.

### **12.3. Measurements**

The finished work shall be measured between the kerb or channel stones or brick edging etc. as the case may be. Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres correct to two places of decimal.

### **12.4. Rate**

The rate shall include the cost of labour and materials involved in all the operations described above except the cost of stone aggregate which shall be paid for separately.

## **13. DRY STONE PITCHING**

### **13.1. Stones**

These shall be clean, hard stones, free from decay and weathering. They shall be in block and hammer dressed on all sides.

The size of the pitching stones shall be approximately 22.5 cm.in depth and not less than 15 cm. in any other direction.

### **13.2. Preparation of surface**

The sides and bottom of earth work to be pitched, shall be brought to the required slope and gradient and shall be compacted to a firm and even surface.

### **13.3. Pitching**

Pitching shall be of 22.5 depth unless specified otherwise. Profiles shall be put up by means of pegs and strings or by placing stones, at intervals of not more than 15 cm. Stones shall then be laid closely in position in between the profile and firmly embedded with joints staggered and with exposed faces true to line, gradient and in uniform slope throughout.

Cross bands of approximately 22.5 cm. width through bond stones equal to the full depth of pitching shall be provided at an interval of approximately 3 metres centre to centre both longitudinally and transversely.

The interstices between adjacent stones shall be filled in with stones of proper size, well driven in with crow bars to ensure tight packing and complete filling of all interstices. Such filling shall be carried on simultaneously with the placing in position of the large stones and shall in no case be permitted to fall behind. Final wedging shall be done with the largest sized chip practicable, each chip being well driven home with a hammer so that no chip is possible of being picked up or removed by hand.

### **13.4. Measurements**

The measurements shall be taken in sqm. The area of pitching for drains shall be calculated by multiplying the perimeter (bed width plus side slopes) by the length of the pitching. The length, width and side slope shall be measured correct to a cm.

### **13.5. Rate**

The rate shall include the cost of the materials and labour involved in all the operations described above, except pitching stone, if specified, shall be paid for separately.

## **14. BRICK PITCHING**

Bricks shall be all class designation 75 unless otherwise specified. The specification of bricks shall be as per SH 6.00 (Brick work) CPWD Specification – 2019.

### **14.1. Preparation of Surface**

The sides and bottom of earth work to be pitched, shall be brought to the required slope and gradients and shall be compacted to a firm and even surface.

### **14.2. Pitching**

Pitching shall be 10 cm. in depth or in multiples of 10 cm. as specified. Profiles shall first be put up by means of pegs and strings or by placing bricks at intervals not more than 15 cm. Bricks shall then be laid in parallel rows breaking bond or Herring –bone bond pattern as directed. In the case of drains, bricks shall be laid on bed width in parallel rows breaking bond and on sides in either of the above manner. At the top, the toe and at every 3 m. intervals, brick courses shall be laid with bricks on ends. All bricks shall be laid closely in position and firmly embedded, true to line, gradient and in uniform slope through out pitching work.

### **14.3. Measurements**

Para 12.4 shall apply, except that the measurements of the dry pitching 10 cm. deep for the drains shall be taken by adding 10 cm. on either side to the perimeter of the drain so as to allow for the top 20 cm. courses. In this case the perimeter of the drain (bed width plus sides slopes) plus 20 cm. multiplied with the length of the pitching shall give the area of the pitching in sqm.

### **14.4. Rate**

The rate shall include the cost of material and labour involved in all the operations described above.

## **15. CUTTING W.B.M. ROADS AND MAKING GOOD**

### **15.1. Cutting**

All road crossings shall be cut in half the width at a time and repaired, unless otherwise permitted by the Engineer-in-Charge. Cutting shall be straight and uniform in width. Soling stone and aggregate obtained from cutting macadam shall be stacked separately, clear of the road surface. Aggregate shall be screened. Stones of size below 20 mm and with rounded edges shall be discarded and disposed.

### **15.2. Making Good**

**15.2.1.** After the trenches have been filled in with excavated earth in layers of 15 cm thickness, watered, well consolidated with heavy iron rammers and brought to sub grade level, soling stone obtained from cutting shall be laid as per existing soling and consolidated with heavy iron rammers. Where the earth consolidation is well done, no settlement need occur subsequently, for this excess watering should be avoided.

**15.2.2.** New aggregate 50 mm nominal size or as required, shall be added to old aggregate and spread over to a depth of 7.5 cm as specified in 7.6. This shall then be consolidated with hand roller or heavy iron rammers, as directed, first with light sprinkling then with sufficient application of water till the aggregate has become adequately consolidated and does not get displaced. All undulations shall be loosened by hand picking, surplus aggregate removed from high spots and depressions filled with surplus and new aggregate and the surface compacted again. When thoroughly consolidated, kankar moorum and red bajri, freshly collected shall be spread over it in 12 mm layer and consolidated with hand roller or heavy iron rammers, with sufficient application of sufficient water till a uniform surface is obtained.

**15.2.3.** The finished surface shall be in camber and left a little higher than the adjoining road surface to allow for any settlement on drying.

**15.2.4. Measurement:** Length and width of cutting shall be measured correct to a cm. The area shall be calculated in square metre, correct to two places of decimal.

**15.2.5. Rate:** The rate shall include the cost of materials and labour involved in all the operations described above.

### **15.3. Cutting Bituminous Roads and Making Good**

**15.3.1.** Cutting, making good and measurements shall be as specified in 14.1 except the top bituminous surface shall be finished as per the existing surface or as directed by the Engineer-in-Charge. The item shall include cutting and restoration of W.B.M. portion as well as Bitumen portion.

**15.3.2. Rate:** The rate shall include the cost of materials and labour involved in all the operations described above.

## **16. CUTTING BAJRI PATHS AND MAKING GOOD**

### **16.1. Cutting**

Cutting shall be straight and uniform in width. Brick aggregate obtained from cutting shall be screened, aggregates of smaller size discarded and disposed off and rest stacked clear off pathway.

### **16.2. Making Good**

After the trench has been filled in with excavated earth, consolidated and brought to sub-grade level, brick aggregates obtained from cutting and mixed with new aggregates 50 mm nominal size, as required shall be spread to a depth of 7.5 cm as specified in 9.2. This shall then be consolidated with blinding materials and finished as specified in 14.1.2

### **16.3. Measurements**

Length and width of cutting shall be measured correct to a cm. The area shall be calculated in square metre correct to two places of decimal.

### **16.4. Rate**

The rate shall include the cost of materials and labour involved in all the operations described above.

## **17. GRANULAR SUB-BASE**

### **17.1. Scope**

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid in one

or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer-in-charge.

## 17.2. Materials

**17.2.1.** The material to be used for the work shall be natural sand, crushed gravel, crushed stone, crushed slag or combination thereof depending upon the grading required. Use of materials like brick metal, Kankar and crushed concrete shall be permitted in the lower sub-base. The material shall be free from organic or other deleterious constituents and shall conform to the grading given in Table 44 and physical requirement given in Table 45 Gradings III and IV shall preferably be used in lower sub-base. Grading V and VI shall be used as a sub-base-cum-drainage layer. The grading to be adopted for a project shall be as specified in the Contract. Where the sub-base is laid in two layers as upper sub-base and lower sub-base, the thickness of each layer shall not be less than 150 mm.

**17.2.2.** If the water absorption of the aggregate determined as per IS : 2386 (Part 3); if this value is greater than 2 per cent, the aggregate shall be tested for Wet Aggregate Impact Value (AIV) (IS: 5640). Soft aggregates like Kankar, Brick ballast and laterite shall also be tested for Wet AIV (IS: 5640).

**TABLE No. 44**  
**GRADING FOR GRANULAR SUB-BASE MATERIALS**

IS Sieve Designation	Percent by Weight Passing the IS Sieve					
	Grading I	Grading II	Grading III	Grading IV	Grading V	Grading VI
75.0 mm	100	--	--	--	100	--
53.0 mm	80-100	100	100	100	80-100	100
26.5 mm	55-90	70-100	55-75	50-80	55-90	75-100
9.50 mm	35-65	50-80	--	--	35-65	55-75
4.75 mm	25-55	40-65	10-30	15-35	25-50	30-55
2.36 mm	20-40	30-50	--	--	10-20	10-25
0.85 mm	--	--	--	--	2-10	--
0.425 mm	10-15	10-15	--	--	0-5	0-8
0.075 mm	<5	<5	<5	<5	--	0-3

**TABLE No. 45**  
**PHYSICAL REQUIREMENTS FOR MATERIALS FOR GRANULAR SUB-BASE**

Aggregate Impact Value (AIV)	IS:2386 (Part 4) or IS:5640	40 Maximum
Liquid Limit	IS:2720 (Part 5)	Maximum 25
Plasticity Index	IS:2720 (Part 5)	Maximum 6
CBR at 98% dry density (at	IS:2720 (Part 5)	Minimum 30 unless otherwise specified in the

IS:2720-Part 8)		Contract
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### 17.3. Construction Operations

#### ***17.3.1.Preparation of Sub-Grade:***

The surface of the sub grade to receive the Granular Sub-base shall be prepared to the specified lines and crossfall (Camber) as necessary and made free of dust and other extraneous materials. Any ruts or soft yielding places shall be corrected in an approved manner and rolled with 80 – 100 kN smooth wheeled roller until firm surface is obtained if necessary by sprinkling water. Weak places shall be strengthened, corrugations removed and depressions and pot holes made good with suitable materials, before spreading the aggregate for GSB.

Where the existing surface over which the sub base of GSB is to be laid is black topped, to ensure effective internal drainage, furrows 50 mm x 50 mm (depth of furrows increased to reach bottom of bituminous layer where necessary) at one metre intervals shall be cut in the existing bituminous surface at 45 degrees to the central line of the carriageway at one metre intervals in the existing road before the GSB is laid.

#### ***17.3.2.Spreading and compacting:***

The sub-base material of grading specified in the Contract and water shall be mixed mechanically by a suitable mixer equipped with provision for controlled addition of water and mechanical mixing. So as to ensure homogenous and uniform mix. The required water content shall be determined in accordance with IS:2720 (Part 8). The mix shall be spread on the prepared sub-grade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation, or other means as approved by the Engineer-in-charge.

Moisture content of the mix shall be checked in accordance with IS:2720 (Part 2) and suitably adjusted so that, at the time of compaction, it is from 1 to 2 per cent below the optimum moisture content (OMC).

Immediately after spreading the mix, rolling shall be done by an approved roller. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall or on super elevation. For carriageway having crossfall on both sides, rolling shall commence at the edges and progress towards the crown.

Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS : 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

## 17.4. Measurements

Granular sub-base shall be measured as finished work in position in cubic metres. The length and breadth shall be measured to the nearest centimetre. The depth of consolidated layer shall be computed to nearest half centimetre by taking average of depths at the centre and at 30 cm from the left and right edges at a cross section taken at 100 metre interval or less as decided by the Engineer-in-Charge by making small pits. The consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal. The protection of edges of granular sub-base extended over the full formation as shown in the drawing shall be considered incidental to the work of providing granular sub-base and as such no extra payment shall be made for the same.

## 17.5. Rate

The Contract unit rate for granular sub-base shall be payment in full for carrying out the required operations including all labour, tools, equipments, machinery and incidentals to complete the work to the specifications as described above.

## 18. WET MIX MACADAM (WMM) SUB-BASE/BASE

### 18.1. Scope

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared subgrade/sub-base/base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Engineer-in-charge.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub- base course may be increased to 200 mm upon approval of the Engineer-in-charge.

### 18.2. Materials

#### 18.2.1. Aggregates

##### 18.2.1.1. Physical requirements

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 46 below.

if the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS:2386(Part-5).

**TABLE 46**  
**PHYSICAL REQUIRMENTS OF COARSE AGGREGATES FOR SUB-BASE/BASE COURSES**

	Test	Test Method	Requirement
1.	Los Angeles Abrasion value or Aggregate impact value	IS:2386 (Part-4)	40 per cent (Max.)
2.	Combined Flakiness and	IS:2386 (Part-4) or IS:5640 IS:2386 (Part-1)	30 per cent (Max.) 35 per cent (Max.)*



	Elongation indices (Total)		
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*\*To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.*

**18.2.1.2. Grading requirements :**

The aggregates shall conform to the grading given in Table 47 below.

**TABLE 47  
GRADING REQUIREMENTS OF AGGREGATES FOR WET MIX MACADAM**

IS Sieve Designation		Per cent by weight passing the IS sieve
53.00	mm	100
45.00	mm	95-100
26.50	mm	---
22.40	mm	60-80
11.20	mm	40-60
4.75	mm	25-40
2.36	mm	15-30
600.00	micron	8-22
75.00	micron	0-5

*Materials finer than 425 micron shall have Plasticity Index (PI) not exceeding 6.*

*The final gradation approved within these limits shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.*

**18.3. Construction Operations**

**18.3.1. Preparation of base:**

The surface of the sub grade / sub base / base to receive the Wet Mix Macadam shall be prepared to the specified lines and crossfall (Camber) as necessary and made free of dust and other extraneous materials. Any ruts or soft yielding places shall be corrected in an approved manner and rolled with 80-100 kN smooth wheeled roller until firm surface is obtained if necessary by sprinkling water. Weak places shall be strengthened, corrugations removed and depressions and pot holes made good with suitable materials, before spreading the aggregate for WMM.

Where the existing surface over which the sub base of WMM is to be laid is black topped, to ensure effective internal drainage, furrows 50 mm x 50 mm (depth of furrows increased to reach bottom of bituminous layer where necessary) at one metre intervals shall be cut in the existing bituminous

surface at 45 degrees to the central line of the carriageway at one metre intervals in the existing road before the WMM is laid.

**18.3.2.Provision of lateral confinement of aggregates:**

While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer.

**18.3.3.Preparation of mix:**

Wet Mix Macadam 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. For small quantity of wet mix work, the Engineer may permit the mixing to be done in concrete mixers.

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

**18.3.4.Spreading of mix :**

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub- base/base in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix may be spread either by a paver finisher.

The paver finisher shall be self-propelled of adequate capacity with the following features:

- (i) Loading hoppers and suitable distribution system. So as to provide a smooth uninterrupted material flow for different layer thickness from the tipper to the screed.
- (ii) Hydraulically operated telescopic screed for paving width upto 8.5 metre and fixed screed beyond this. The screed shall have tamping and vibrating arrangement for initial compaction of the layer.
- (iii) Automatic leveling control system with electronic sensing device to maintain mat thickness and cross slope of mat during laying procedure. In exceptional cases where it is not possible for the paver to be utilized mechanical means like motor grader may be used with the prior approval of the Engineer-in-charge. The motor grader shall be capable of spreading the material uniformly all over the surface.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine panicles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

The Engineer-in-charge may permit manual mixing and / or laying of Wet Mix Macadam, where small quantity of WMM is to be executed. Manual mixing / laying in inaccessible / remote locations and in situations where use of machinery is not feasible can also be permitted. Were manual mixing / laying is intended to be used, the same shall be done with the approval of the Engineer-in-charge.

**18.3.5.Compaction:**

After the mix has been laid to the required thickness, grade and crossfall/camber the same shall be uniformly compacted, to the full depth with suitable roller. If the thickness of single compacted layer

does not exceed 100 mm, a smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN with an arrangement for adjusting the frequency and amplitude. An appropriate frequency and amplitude may be selected. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/superelevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one-third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the centre line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or subgrade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 metre straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case should the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part-8)

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

**Setting and drying:** After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

### ***18.3.6. Opening to Traffic***

No vehicular traffic of any kind should be allowed on the finished wet mix macadam surface till it has dried and the wearing course laid.

### ***18.3.7. Surface Evenness***

All work perform shall confirm to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Engineer-in-charge, subject to the permitted tolerances described herein after.

### **18.3.8. Horizontal Alignment**

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriage way as constructed shall be correct within a tolerance of  $\pm 10$  mm there from. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be  $\pm 25$  mm.

### **18.3.9. Surface Levels**

The levels of the Sub-base / base course as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Engineer-in-charge beyond the tolerances mentioned as below:

#### **TOLERANCES IN SURFACE LEVELS OF WMM**

Sub-base

- (a) Flexible pavement  $\pm 10$  mm
- (b) Concrete pavement  $\pm 06$  mm

Base course flexible pavement

- (a) Bituminous Base / Binder Course  $\pm 06$  mm
- (b) Granular
  - (i) Machine laid  $\pm 10$  mm
  - (ii) Manually laid  $\pm 15$  mm

For checking compliance with the above requirement for sub-base / base courses, measurements of the surface levels shall be taken on a grid of points placed at 6.25 m longitudinally and 3.5 m transversely.

The longitudinal profile shall be checked with a 3 metre long straight edge / moving straight-edge as desired by the Engineer-in-charge at the middle of each traffic lane along a line parallel to the centre line of the road.

## **18.4. Measurements**

Wet Mix Macadam shall be measured as finished work in position in cubic metres. The length and breadth shall be measured to the nearest centimetre. The depth of consolidated layer shall be computed to nearest half centimetre by taking average of depths at the centre and at 30 cm from the left and right edges at a cross section taken at 100 metre interval or less as decided by the Engineer- in-Charge by making small pits. The consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal.

## **18.5. Rates**

The contract unit rate for Wet Mix Macadam shall be payment in full for carrying out the required operations including all labour, tools, equipments machinery and incidentals to complete the work to the specification as described above.

## **19. SURFACE DRESSING ON NEW SURFACE WITH HOT BITUMEN OF GRADE VG- 10 ONE COAT**

- 19.1. This type of treatment shall consist of cleaning the existing water bound macadam kankar or gravel surfaces, and applying one coat of hot bitumen of grade VG- 10 of approved quality using 2.25 kg of bitumen per sqm with 1.65 cum of stone chippings 13.2 mm nominal size per 100 sqm of road surface on the prepared base, blinding it with stone chippings of 13.2 mm nominal size and consolidation with a road roller of 6 to 8 tonne

capacity. This type of treatment is normally done for a road with light density rubber tyred traffic and roads for temporary construction. This treatment is also done on existing water bound macadam before applying the final surface treatment. In the latter case, after applying a coat of painting the road is thrown open to traffic till the road is consolidated. The final treatment is then given after making good the undulations etc. in the road surface.

19.2. Preparation of surface (Repairs and Cleaning) shall be as specified under 24.2(a).

19.3. Applying binder, blinding, consolidation, surface finishing, measurements and rates shall be as specified under 24 except that binder shall be applied at the rate of 2.25 kg of bitumen per sqm and stone chippings of size 13.2 mm at 1.65 cum per 100 sqm unless otherwise specified.

## 20. SURFACE DRESSING ON NEW SURFACE USING HOT BITUMEN OF GRADE VG- 10 —TWO COATS

This consists of the application of two coats of surface dressing each coat consisting of a layer of bituminous binder sprayed on a base prepared previously, followed by a cover of stone chippings properly rolled to form a wearing course. The existing water-bound macadam, kankar or gravel surface shall be cleaned thoroughly before application of bituminous binder. The work shall be carried out only when the atmospheric temperature in shade is 16 deg C or above. No bituminous material shall normally be applied when the road surface or material is damp, when the weather is foggy or rainy, or during dust storms.

### 20.1. Materials

Binder i.e. bitumen of grade VG- 10 conforming to IS: 73 shall be as specified and shall conform to Table and stone chippings shall conform to grading as the Table. Unless otherwise specified or directed by the Engineer -in- Charge the quantities of materials shall be as specified in Table. A proper record will be kept to ensure that the daily out-turn of work is co-related with the quantity of bitumen used as per proforma given.

**TABLE 17**

Type of coat	Stone Chipping			Bitumen Quantity VG- 10
	Nominal Size	Specification	Quantity	
First Coat	13.2 mm	100 per cent passing through IS sieve 22.4 mm square mesh and retained on IS Sieve 11.2 mm square mesh	1.5 cum/100 sqm of road surface	1.8 kg per sqm of road surface
Second coat	11.2 mm	100 per cent passing through IS sieve 13.2 mm square mesh and retained on IS sieve 5.6 mm square mesh	1.0 cum/100 sqm of road surface	1.1 kg per sqm of road surface

### 20.2. First Coat

#### (a) Preparation of Surface

*Repairs* : Pot holes or patches and ruts in the water bound macadam base or surface course which is to be surface treated, shall be repaired by removal of all loose and defective material by cutting in rectangular patches and replacement with suitable material.

For the purpose of repairs the area of pot holes shall be taken upto 0.75 sqm and depth upto 5 cm. All pot holes, patches and ruts upto 2.5 cm deep shall be repaired and brought to level with premix and properly consolidated while those of depths greater than 2.5 cm shall be repaired with similar specifications as adopted originally.

*Cleaning* : Prior to the application of the binder, all dust, dirt, caked mud, animal dung, loose and foreign material etc. shall be removed 30 cm on either side, beyond the full width to be treated, by means of mechanical sweepers and blowers, if available or otherwise with wire brushes, small picks, brooms etc. The material so removed shall be disposed off as directed by the Engineer-in-Charge.

For a water bound macadam surface, the interstices between the road metal shall be exposed upto a depth of about 10 mm by means of wire brushes. The surface shall then be brushed with soft brooms to remove all loose aggregate. Finally the traces of fine dust which get accumulated while brushing shall be thoroughly removed from the surface by blowing with gunny bags.

The prepared surface shall be closed to traffic and maintained fully clean till the binder is applied.

**(b) Applying Binder (Hot Bitumen) VG- 10 (confirming to IS : 73)**

The binder shall be heated in a boiler to a temperature as specified under Table 7 for the grade used and maintained at the temperature, the use of a thermometer being essential.

The binder shall be applied evenly to the clean dry surface by means of a pressure sprayer at the rate specified. The binder shall be applied longitudinally along the length of the road and never across it. The edges of the binder surface shall be defined by wire or a rope stretched in position.

Heating in cut out drums and pouring from perforated tins, cans and such other methods shall not be permitted. Except in the case of petty works and repairs with the specific approval of the Engineer-in-Charge.

Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage or any other reason shall be suitably corrected before the stone chippings are spread.

**(c) Blinding or Spreading Stone Chippings**

Immediately after the binder is applied and while it is still hot, stone chippings free from dust and in a dry and clean state shall be spread evenly over the surface at the rate specified above. Spreading shall be done preferably by means of a mechanical gritter, otherwise manually with a twisting motion to avoid segregation which otherwise shall have to be removed by brushing the excess stone chippings over the surface into hungry spots to obtain a uniform surface, free from waviness, depressions and other irregularities. The surface shall be checked by means of a camber board laid across the road and a three metre straight edge laid parallel to the centre line of the road, and undulations if any shall be corrected by addition or removal of blindage till a surface free from undulation is obtained.

If a uniform surface is assured at this stage, the completed surface should be normally free from undulations and unevenness.

**(d) Consolidation of Blindage**

Immediately following the application of the stone chippings and light brooming, the road surface shall be compacted by a power roller of 6 to 8 tonnes, starting at edges and working towards the centre (or to the outside edge in case of super elevated curve). Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. The roller shall be worked or started and stopped without jerks and shall not be stopped or reversed each time at the same location to cause displacement of stone and other irregularities. Consolidation shall be considered complete when the stone chippings are firmly embedded.

Generally, five to six trips shall be made for thorough compaction of the surface or as may be specified by the Engineer-in-Charge.

Along kerbs, manholes and all places not accessible to the roller, compaction shall be secured by means of steel rammers or hand rollers.

### **20.3. Second Coat**

- (a) *Cleaning the Road Surface*** : The surface shall be examined and any loose material and foreign matter shall be removed by brooming or blowing off by fanning with gunny bags, care being taken not to loosen the blindage already set.
- (b) *Applying Binder (Hot Bitumen of Grade VG- 10)*** : The second coat of binder shall be applied immediately after the blinding has been set and the surface has been cleaned. The binder shall be applied at the specified rate in the manner specified for the first coat 17.2(b).
- (c) *Blinding or Spreading Stone Chippings*** : Immediately after the second application of binder, the stone chippings shall be spread at the rate specified as above in the manner described in 17.2(c).
- (d) *Consolidation of Blinding*** : The specifications described in 24.2(d) shall apply. Further the prepared finished surface shall be protected from traffic for 24 hours or such period as may be specified by the Engineer-in-Charge.

### **20.4. Surface Finishing**

The finished surface shall be uniform and conform to the lines, grades and typical cross-sections shown in the drawings.

The finished surface shall be thrown open to traffic on the following day. Controlling traffic shall be done by suitable methods like barricading posting of watchman etc.

### **20.5. Measurements**

The length and width of the finished work shall be measured correct to a cm along the finished surface of the road. The area shall be calculated in square metre, correct to two places of decimal.

For record purposes, the measurement for binder and stone chippings shall be taken as specified in 4.2 and 4.3 before they are actually used on the work. Premeasurements of materials taken for record purposes shall simply serve as a guide and shall not form the basis for payment.

### **20.6. Rate**

The rate shall include the cost of materials and labour involved in all the operations described above, except for repairs described under 17.2.

## **21. SURFACE DRESSING ON OLD SURFACE WITH HOT BITUMEN OF GRADE VG- 10 (CONFIRMING TO IS : 73) ONE COAT**

This treatment consists of cleaning old painted surfaces and applying a coat of hot bitumen of grade VG- 10 on the prepared base, blinding with stone chippings and consolidation with road roller of 6 to 8 tonne capacity

21.1. Binder shall be as specified and conform to Table 7 stone chipping shall conform to grading given Table 17 for 11.2 mm. Unless otherwise specified or directed by the Engineer-in-Charge stone Chippings of 11.2 mm nominal size shall be used @ 1.50 cum per 100 sqm area and bitumen @ 1.95 kg per square metre area. A proper record shall be kept to ensure that the daily turn out of work is correlated with the quantity of bitumen used as per proforma given in Appendix 'A'.

21.2. Preparation of Surface (Repairs and cleaning) shall be as specified under 17.2.

21.3. Applying binder, Blinding, Consolidation, Surface Finishing, Measurement and Rate shall be as specified under 24 except that the binder and chippings shall be applied at the rate specified above.

## **22. SURFACE DRESSING ON NEW SURFACE WITH BITUMEN EMULSION (MINIMUM 50% BITUMEN CONTENT RS GRADE CONFIRMING TO IS : 8887) ONE COAT**

This treatment consists of cleaning the existing water bound macadam, kankar gravel or stabilized base and other black top surfaces, applying a coat of bitumen emulsion at atmospheric temperature, blinding it with stone chippings including consolidation with a road roller.

This type of treatment is normally applied under damp conditions and for minor repair works during rainy season for roads with medium density, rubber tyred traffic such as service roads. This treatment is also done on existing water bound macadam before applying the final surface treatment. In the latter case, the road is consolidated. The final treatment is then given after making good the undulations depressions etc. in the road surface.

### **22.1. Materials**

Binder shall be as specified and shall conform to RS grade confirming to IS : 8887. Stone chipping of 13.2 mm size shall conform to Table 17. Unless otherwise specified or directed by the Engineer-in-Charge 13.2 mm stone chippings shall be used @ 1.5 cum per 100 sqm area and bitumen @ 1.95 kg/sqm area. A proper record shall be kept to ensure that the daily out turn of work is correlated with the quantity of bitumen used as per proforma given in Appendix 'A' .

### **22.2. Preparation of Surface**

The specification described in 17.2 (a) shall apply except that the binder used for patch repairs etc. shall be bitumen emulsion.

### **22.3. Applying Binder**

The specification described in 24.2 (b) shall apply except that bitumen emulsion is not heated in boilers but it shall be spread at atmospheric temperature at the specified rate. In case the road surface is very dry the surface shall be very lightly sprinkled with water just before applying the binder.



Blinding including consolidation, Measurements and Rate shall be as specified under 24 except that the stone chippings shall be spread at the specified rate immediately after the bitumen emulsion on application breaks i.e. changes colour from brown to black.

## **23. SURFACE DRESSING ON OLD SURFACE WITH BITUMEN EMULSION (MINIMUM 50% BITUMEN CONTENT RS GRADE CONFIRMING TO IS : 8887) ONE COAT**

This treatment consists of cleaning old painted surfaces and applying a coat of bitumen emulsion on the prepared base, blinding with stone chippings and consolidation with a road roller. This type of treatment is normally done under damp conditions.

### **23.1. Materials**

Binder shall be as specified and shall conform to RS grade confirming to IS : 8887. Unless otherwise specified or directed by the Engineer- in-Charge 11.2 mm the stone chippings shall be used @ 1.10 cum per 100 sqm area and bitumen @ 1.22 kg per sqm area. A proper record shall be kept to ensure that the daily out turn of work is correlated with the quantity of bitumen used as per proforma given in Appendix 'A'.

- 23.2. Preparation of surface shall be as specified in 24.2 (a) except that the binder used for patch repairs etc. shall be bitumen emulsion.
- 23.3. Applying binder, bitumen emulsion, blinding or Spreading to it including consolidation of blindage, measurement etc. shall be as specified under 24 except for preparation of surface and that the binder and stone chippings shall be used at the rates prescribed above.

## **24. PRIME COAT OVER GRANULAR BASE**

### **24.1. Scope**

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix.

### **24.2. Materials**

- Primer:- The primer shall be cationic bitumen emulsion SS1 grade conforming to IS:8887 or medium curing cutback bitumen conforming to IS:217 or as specified in the contract.
- Quantity of SS1 grade bitumen emulsion for various types of granular surface shall be as given in Table 49 or as specified in the item of contract.

**Table 49**

**Quantity of Bitumen Emulsion for various types of Granular Surfaces**

Type of Surface	Rate of Spray (kg/sqm)
WMM/WBM	0.7-1.0
Stabilized soil bases/Crusher Run Macadam	0.9-1.2

- Cutback for primer shall not be prepared at the site. Type and quantity of cutback bitumen for various types of granular surface shall be as given in Table 50.

**Table 50**

**Type and Quantity of Cutback Bitumen for various types of Granular Surface**

Type of Surface	Type of Cutback	Rate of Spray (kg/sq.m)
WMM/WBM	MC 30	0.6-0.9
Stabilized soil bases/Crusher Run Macadam	MC 70	0.9-1.2

- The correct quantity of primer shall be decided by the Engineer-in-Charge and shall be such that it can be absorbed by the surface without causing run-off of excessive primer and to achieve desired penetration of about 8-10mm.

### 24.3. Construction

#### ***24.3.1. Equipment***

The 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 shall not be allowed except in small areas, inaccessible to the distributor, or in narrow strips where primer shall be sprayed with a pressure hand sprayer, or as directed by the Engineer-in-Charge.

#### ***24.3.2. Preparation of Road Surface***

The granular surface to be primed shall be swept clean by power brooms or mechanical sweepers and made free from dust. All loose material and other foreign material shall be removed completely. If soil/moorum binder has been used in the WBM surface, part of this should be brushed and removed to a depth of about 2 mm so as to achieve good penetration.

#### ***24.3.3. Application of Bituminous Primer***

After preparation of the road surface the primer shall be sprayed uniformly at the specified rate as per item of contract. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

No heating or dilution of SS1 bitumen emulsion and shall be permitted at site. Temperature of cutback bitumen shall be high enough to permit the primer to be sprayed effectively through the jets of the spray and to cover the surface uniformly.

### 24.4. Curing of Primer and Opening to Traffic

A primed surface shall be allowed to cure for at least 24 hours or such other higher period as is found to be necessary to allow all the moisture/volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with a light application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course.

### 24.5. Measurement for Payment

Prime coat shall be measured in terms of surface area of application in square meters.

#### **24.6. Rate**

The contract unit rate for prime coat shall be payment in full for carrying out the required operations i/c all equipment's, labor and machinery as described above.

#### **25. TACK COAT OF HOT STRAIGHT RUN BITUMEN OF GRADE VG- 10**

The rate of application of binder which shall be as specified and which shall conform to 1.5 shall depend on the surface on which the premix carpet is to be laid.

- (a) 0.75 kg/sqm on W.B.M./ W.M.M. Surface
- (b) 0.50 kg/sqm on bitumen surface.

#### **25.1. Materials**

**Bitumen** : This shall be straight-run bitumen of grade VG- 10 conforming to IS 73 specifications.

#### **25.2. Preparation of Surface**

##### ***25.2.1. Cleaning***

Prior to the application of bitumen, all vegetation, loose sealing compound, caked mud, animal dung, dust, dirt and foreign material shall be removed from the entire surface of the pavement and from existing dummy, construction and expansion joints (wherever existing) by means of mechanical sweepers and blowers, otherwise with steel wire brushes, small picks, brooms or other implements as approved by the Engineer-in-Charge. The material so removed shall be disposed off as directed by the Engineer-in-Charge.

##### ***25.2.2. Weather and Seasonal Limitations***

The tack coat shall not be applied nor any bitumen work done during rainy weather or when the surface is damp or wet or when the atmospheric temperature in the shade is not more than 16° C.

#### **25.3. Application of Tack Coat**

**25.3.1. Heating** : Bitumen shall be heated in a boiler to a temperature of 165 deg. C to 175 deg. C and maintained at that temperature. Temperature shall be checked at regular intervals with the help of a thermometer.

**25.3.2. Application of Bitumen** : Hot bitumen shall be applied evenly to the clean, dry surface by means of a pressure sprayer at specified rate. Even and uniform distribution of bitumen shall be ensured. Bitumen shall be applied longitudinally along the length of the pavement and never across it. Excessive deposits of bitumen caused by stopping or starting of the sprayer or through leakage or any other reason shall be suitably rectified.

#### **25.4. Measurements**

Length and breadth shall be measured correct to a cm, along the surface of pavement. Area shall be worked out in sqm correct to two places of decimal.

#### **25.5. Rate**

Rate shall include the cost of all materials and labour involved in all the operations described above.

## 26. TACK COAT WITH BITUMEN - EMULSION/ HOT BITUMEN OF GRADE VG- 10

### 26.1. Scope

The work shall consist of the application of single coat of low viscosity liquid bituminous material to existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix, as specified in the contractor or as instructed by the Engineer-in-Charge and applied as specified in the nomenclature of item.

### 26.2. Materials

The binder used for tack coat shall be either cationic bitumen emulsion (RS1) complying with IS:8887 or suitable low viscosity paving bitumen of VG 10 grade conforming to IS:73. The use of cutback bitumen RC:70 as per IS:217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by the Engineer-in-Charge. The type and grade of binder for tack coat shall be as specified in the contract or as directed by the Engineer-in-Charge.

### 26.3. Construction

#### 26.3.1. Equipment

The tack shall be applied by a self propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at specified rate. Hand spraying shall not be permitted except in small areas, inaccessible to the distributor, or narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer-in-Charge.

#### 26.3.2. Preparation of Base

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt and any extraneous material, and be otherwise prepared in accordance with the requirements. The granular or stabilized surfaces shall be primed as per Para 65 clause (priming coat) immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high pressure air jet, or by other means as directed by the Engineer-in-Charge.

#### 26.3.3. Application of Tack Coat

The application of tack coat shall be at the rate specified in **Table 17 A** and it shall be applied uniformly. If rate of application of tack coat is not specified in the contract, then it shall be the rate specified in **Table 17 A**. No dilution or heating at site RS1 bitumen emulsion shall be permitted. Paving bitumen if use for tack coat shall be heated to appropriate temperature in bitumen boilers to achieve viscosity less than 2 poise. The normal range of spraying temperature for a bituminous emulsion shall be 20 C to 70 C and for cutback, 50 C to 80 C. The method of application of tack coat will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed or forward movement. The contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

**Table 17A**  
**Rate of application of tack coat**

Type of Surface	Rate of Spray of Binder in Kg per sq.m
Bituminous surfaces	0.20-0.30

Granular surfaces treated with primer	0.25-0.30
Cement concrete pavement	0.30-0.35

#### **26.3.4. Curing of Tack Coat**

The tack coat shall be left to cure until all the volatiles have evaporated before any subsequent construction is started. No plant or vehicles shall be allowed on the tack coat other than those essential for the construction.

#### **26.4. Measurement of Payment**

Tack coat shall be measured in terms of surface area of application in square metres.

#### **26.5. Rate**

The contract unit rate for tack coat shall be payment in full for carrying out the required operations including for all components i.e. labour, equipments and machinery as described above.

### **27. DENSE GRADED BITUMINOUS MACADAM (DBM)**

#### **27.1. Scope**

Dense Bituminous Macadam (DBM) for use mainly but not exclusively, for in base/binder and profile corrective courses. DBM is also used as road base material. This work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

#### **27.2. Material**

**27.2.1. Bitumen :** The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS:73, or as otherwise specified in the item. The type and grade of bitumen to be used shall be specified in the item of Contract. Where modified bitumen is specified, it shall conform to the requirements of IRC:SP:53 and IS:15462.

Section criteria for viscosity grade bitumen, based on highest and lowest daily mean temperatures at a particular site are given in **Table 40A**.

Selection criteria for modified bitumen shall be in accordance with IRC:SP53.

**27.2.2. Coarse Aggregates :** The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm IS Sieve. They shall be clean, hard, durable, or cubical shape, free from dust and soft or friable matter, organic or other deleterious substance. Before approval of the source, the aggregates shall be tested for stripping. The aggregates shall satisfy the physical requirements specified in **Table**, for dense bituminous macadam.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm IS Sieve shall have at least two fractured faces.

**27.2.3. Fine Aggregates :** Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36 mm IS Sieve and retained on the 75 micron sieve. These shall be clean, hard, durable, dry and free from dust and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder courses. However, natural sand upto 50 percent of the fine aggregate may be allowed in base courses.

The fine aggregate shall have a sand equivalent value of not less than 50 when tested in accordance with the requirements of IS 2720 (Part 37).

The plasticity index of the fraction passing the 0.425 mm IS Sieve shall not exceed 4, when tested in accordance with IS 2720 (Part 5).

**TABLE 35**  
**Physical Requirements for Coarse Aggregate for Dense Bituminous Macadam**

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis <sup>7</sup>	Max 5% passing 0.075mm sieve.	IS:2386 Part 1
Particle shape	Combined Flakiness and Elongation Indices*	Max 35%	IS:2386 Part 1
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 35% Max 27%	IS:2386 Part 4
Durability	Soundness either: Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	IS:2386 Part 5
Water Absorption	Water Absorption	Max 2%	IS:2386 Part 3
Stripping	Coating and stripping of Bitumen aggregate Mix	Minimum retained coating 95%	IS:6241
Water sensitivity	Retained Tensile Strength**	Min 80%	AASHTO 283

*\*To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The values of flakiness index and elongation index so found are added up.*

*\*\* If the minimum retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement.*

**27.2.4. Filler :** Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer-in-Charge. The filler shall be graded within the limits indicated in **Table 36**.

**TABLE 36**  
**Grading Requirements for Mineral Filler**

Is Sieve (mm)	Cumulative per cent passing by weight of total aggregate
0.6	100
0.3	95-100
0.075	85-100

The filler shall be free from organic impurities and have a plasticity index not greater than 4. The Plasticity Index requirements shall not apply if filler is cement or lime. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 35, then 2 percent by total weight of aggregate, of hydrated lime shall be used and percentage of fine aggregate reduced accordingly.

**27.2.5. Aggregate Grading and Binder Content :** When tested in accordance with IS 2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and added filler for the particular mixture shall fall within the limits shown in **Table 37**

for dense bituminous macadam. To avoid gap grading the combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

**TABLE 37**  
**Composition of Dense Graded Bituminous Macadam Pavement Layers**

Mix Designation	Grading 2
Nominal aggregate size*	26.5 mm
Layer Thickness	50-75 mm
IS Sieve <sup>1</sup> (mm)	Cumulative % by weight of total aggregate passing
37.5	100
26.5	90-100
19	71-95
13.2	56-80
4.75	38-54
2.36	28-42
0.3	7-21
0.075	2-8
Bitumen content percent by mass of total mix (Marshal method)	Min 4.5** or as specified in the item
Bitumen grade	As specified in item or directed otherwise.

\*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° C or lower and lowest daily air temperature is – 10 ° C or lower, the bitumen content may be increased by 0.5 percent.

**27.2.6.** Bitumen content indicated in **Table 37** is the minimum quantity. The quantity shall be determined in accordance with the Mix Design. Para 46.3

### 27.3. Mix Design

The bitumen content required shall be determined following the Marshall mix design procedure contained in Asphalt Institute Manual MS-2.

The Fines to Bitumen (F/B) ratio by weight of total mix shall range from 0.6 to 1.2.

**27.3.1. Requirement for the Mix:** The mix shall meet the requirements as given in **Table 38**.

**TABLE 38**  
**Requirements for Dense Bituminous Macadam**

Properties	Viscosity	Grade Modified bitumen		Test Method
	Paving Bitumen	Hot climate	Cold climate	
Compaction level	75 blows on each face of the specimen			
Minimum stability (kN at 60° C)	9.0	12.0	10.0	AASHTO T245
Marshall flow (mm)	2 – 4	2.5 - 4	3.5 - 5	AASHTO T245
Marshall Quotient } Stability } Flow }	2 – 5	2.5 - 5		MS-2 and ASTM D2041
% air voids				

% Voids Filled with Bitumen (VFB)	65 – 75	
Coating of aggregate particle	95% Min.	IS:6241
Tensile Strength ratio	80% Min.	AASHTO T283
% Voids in Mineral Aggregate (VMA)	Minimum percent voids in mineral aggregate (VMA) are set out in Table 40	

**TABLE 39**  
**Minimum Percent Voids in Mineral Aggregate (VMA)**

Nominal Maximum Particle size <sup>1</sup> (mm)	Minimum VMA, Percent Related to Design Percentage Air voids		
	3.0	4.0	5.0
26.5	11.0	12.0	13.0
37.5	10.0	11.0	12.0

**Note:** Interpolate minimum voids in the mineral aggregate (VMA) for designed percentage air voids values between those listed.

**27.3.2. Binder Content :** The binder content shall be optimized to achieve the requirements of the mix set out in Table 38. The binder content shall be selected to obtain 4 percent air voids in the mix design. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2.

Where maximum size of the aggregate is more than 26.5 mm, the modified Marshall method using 150 mm diameter specimen described in MS-2 and ASTM D 5581 shall be used. This method requires modified equipment and procedures. When the modified Marshall test is used, the specified equipment and procedures. When the modified Marshall test is used, the specified minimum stability values in Table 39 as above shall be multiplied by 2.25 and the minimum flow shall be 3 mm.

**27.3.3. Job Mix Formula :** The contractor shall inform the Engineer-in-Charge in writing, at least 21 days before the start of the work, of the job mix formula proposed for use in the works, and shall give the details of Source and location of all materials, their sizes, grading, 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 and Mixing temperature and compacting temperature and test results.

While establishing the job mix formula, the Contractor shall ensure that it is based on a 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 for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer-in-Charge.

Job mix formula shall be revised if there is a change in source of material and be got approved by Engineer-in-Charge.



**27.3.4. Plant Trials – Permissible Variation in Job Mix Formula:** Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials at the mixer to establish that the plant can be set up to 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 from the job mix formula to be used shall be within the limits as specified in Table 40.

**TABLE 40**  
**Permissible Variations in the Actual Mix from the Job Mix Formula**

<b>Description</b>	<b>Permissible Variation</b>	
	<b>Base/Binder Course</b>	<b>Wearing Course</b>
Aggregate passing 19 mm sieve or larger	± 8%	± 7%
Aggregate passing 13.2 mm, 9.5 mm	± 7%	± 6%
Aggregate passing 4.75 mm	± 6%	± 5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 5%	± 4%
Aggregate passing 0.3 mm, 0.15 mm	± 4%	± 3%
Aggregate passing 0.075 mm	± 2%	± 1.5%
Binder content	± 0.3%	± 0.3%
Mixing temperature	± 10°C	± 10°C

**27.3.5. 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.

## **27.4. Construction Operations**

**27.4.1. Preparation of Base :** The base on which DBM is to be laid shall be prepared, shaped and compacted to the required profile as appropriate or as directed by the Engineer-in-charge. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air, in locations where mechanical broom cannot get access, other approved methods shall be used as directed by the Engineer-in-charge.

**27.4.2. Tack Coat :** Where the material on which the dense bituminous macadam is to be laid is **either** bitumen bound layer or primed granular layer, tack coat shall be applied as specified, in accordance with the provisions of **para 29**, or as directed by the Engineer-in-Charge.

**27.4.3. Mixing and Transportation of the Mixture :** The provisions are as specified in the **para 30.3.3** shall apply. **Table 41A** gives the mixing laying and rolling temperature for dense mixes using viscosity grade bitumen. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with viscosity grade bitumen. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to have uniform quality, the plant shall be calibrated from time to time.

## **27.5. Spreading :**

The provisions are as specified in the **para 29.3.5** shall apply. The paver finisher shall be fitted with electronic sensor device.

**27.5.1. Rolling / Compaction & Joints :**

**27.5.2.** The provisions are as specified in the **para29.3.6 and 29.3.7** shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer-in-charge in writing.

**27.5.3. Opening to Traffic :** The newly laid surface shall not be open to traffic for at least 24 hours after laying the completion of compaction, without the approval of the Engineer-in-Charge in writing, on the surface until the DBM layer has cooled to the ambient temperature.

**27.5.4. Surface Finish and Quality Control of Work :** The surface finish of the completed construction shall conform to the requirements of section 900 of MORTH Specifications. For control of the quality of materials supplied and the works carried out the relevant provisions of Section 900 of MORTH Specifications.

**27.5.5. Arrangement for Traffic :** During the period of construction, arrangements for traffic shall be made in accordance with the provisions of specification and as per direction of the Engineer-in-charge.

## 27.6. Measurement

Dense Bituminous Macadam shall be measured as finished work in cubic meters, correct to two places of decimal.

## 27.7. Rate

The rate includes the cost of all material, labour, machineries and equipments in all the operations described above.

## 28. BITUMINOUS MACADAM

### 28.1. Scope

This work shall consist of construction in a single course having 60 mm to 100 mm thickness or in multiple courses of compacted crushed aggregates premixed with a bituminous binder on a previously prepared base to the requirements of these Specifications. Since the bituminous macadam is an open-graded mix, there is a potential that it may trap water or moisture vapour within the pavement system. Therefore, adjacent layer (shoulders) should have proper drainage quality to prevent moisture-induced damage to the BM.

### 28.2. Material

**28.2.1. Bitumen :** The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS:73, or as otherwise specified in the item. The type and grade of bitumen to be used shall be specified in the Contract. The type and grade of bitumen to be used would depend upon the climatic conditions and the traffic. Guidelines for selection of bitumen are given in **Table 40A**.

**Table 40A**

**Selection Criteria For Viscosity-Graded (VG) Paving Bitumen Based On Climatic Conditions**

Lowest Daily Mean Air Temperature °C	Highest Daily Mean Air Temperature, °C		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

**28.2.2. Coarse Aggregates** - same as 46.2.2 excepting strength which shall be max 40% for Los Angeles Abrasion Value and Aggregate Impact Value of max 30%.

**28.2.3. Fine Aggregates** : Same as 46.2.3.

**28.2.4. Proportioning of Material:**

The combined aggregate grading shall not vary from the lower limit on one sieve to the higher limit on the adjacent sieve to avoid gap grading. The aggregate may be proportioned and blended to produce a uniform mix complying with the requirements in Table 41. The bitumen content and appropriate thickness are as per Table 41.

**TABLE 41**  
**Composite of Bituminous Macadam**

Mix Designation	Grading 2
Nominal maximum aggregate size*	19 mm
Layer Thickness	50-75 mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing
26.5	100
19	90-100
13.2	56-88
4.75	16-36
2.36	4-19
0.3	2-10
0.075	0-8
Bitumen content** percent by mass to total mix	3.4** or as specified in the item
Bitumen grade	As specified in item or directed otherwise

\*Nominal maximum aggregate size is the largest specified sieve size upon which any of the aggregate material is retained.

\*\* Corresponds to specific gravity of the Aggregate being 2.7. In case aggregates have specific gravity more than 2.7, bitumen content can be reduced proportionately. Further, for regions where highest daily mean air temperature is 30° C or lower and lowest daily mean air temperature is – 10° C or lower, the bitumen content may be increased by 0.5 percent.

**28.2.5. Aggregate Grading and Binder Content** : When tested in accordance with IS 2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and added filler for the particular mixture shall fall within the limits shown in Table 41 for bituminous macadam.

### 28.3. Construction Operation

**28.3.1. Preparation of the Base:** The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile as appropriate, and a prime coat, shall be applied as specified, in accordance with the provisions or as directed by the Engineer-in-charge. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air, in locations where mechanical broom cannot get access, other approved methods shall be used as directed by the Engineer-in-charge.

**28.3.2. Tack Coat** : Where the material on which the bituminous macadam is to be placed is bitumen bound surface, a tack coat shall be applied as specified, in accordance with **Para 29**, or as directed by the Engineer-in-Charge.

**28.3.3. Mixing and Transportation of the Mixture :** Pre-mixed bituminous materials, shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. Appropriate mixing temperatures are given in **Table 41A** of these Specifications; the difference in temperature between the binder and aggregate should at no time exceed 14°C. In order to ensure uniform quality of the mix and better coating of aggregates, the hot mix plant shall be calibrated from time to time. The essential features of the hot mix plants are given in Annex. A of IRC:27.

If a continuous type mixing plant is used, the Contractor must demonstrate by laboratory analysis that the cold feed combined grading is within the grading limits specified for that bituminous bound material. In the case of a designed job mix, the bitumen and filler content shall be derived using this combined grading.

Bituminous materials shall be transported in clean insulated vehicles, and unless otherwise agreed by the Engineer, shall be covered while in transit or awaiting tipping. Subject to the approval of the Engineer, a thin coating of diesel or lubricating oil may be applied to the interior of the vehicle to prevent sticking and to facilitate discharge of the material.

**TABLE 41A**

**Mixing, Laying and Rolling Temperatures for Bituminous Mixes (Degree Celsius)**

Bitumen Viscosity Grade	Bitumen Temperature	Aggregate Temperature	Mixed Material Temperature	Laying Temperature	*Rolling Temperature
VG-40	160-170	160-175	160-170	150 Min.	100 Min.
VG-30	150-165	150-170	150-165	140 Min.	90 Min.
VG-20	145-165	145-170	145-165	135 Min.	85 Min.
VG-10	140-160	140-165	140-160	130 Min.	80 Min.

\*Rolling must be completed before the mat cools to these minimum temperatures.

**28.3.4. Cleaning of Surface :** The surface on which the bituminous work is to be laid shall be cleaned of all loose and extraneous matter by means of a mechanical broom and air jet. or any other approved equipment/ method as specified in the contract. The use of a high pressure air jet from a compressor to remove dust or loose matter shall be available full time on the site, unless otherwise specified in the Contract.

**28.3.5. Spreading :** Prior to spreading the mix, the base shall be prepared by carrying out the required operation. Except in areas where a mechanical paver cannot get access, bituminous materials shall be spread, leveled and tamped by an approved self-propelled paving machine equipped with an electronic sensing device. The essential features of the paver finisher shall conform to Annex A of IRC:27. As soon as possible after arrival at site, the materials shall be supplied continuously to the paver and laid without delay.

The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of the paver, and its method of operations, shall be adjusted to ensure an even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation of the material. In areas with restricted space where a mechanical paver cannot be used, the material shall be spread, raked and leveled with suitable hand tools by experienced staff, and compacted to the satisfaction of the Engineer-in-charge.

The minimum thickness of material laid in each paver pass shall be in accordance with the minimum values given in the relevant parts of these Specifications. When laying binder course or wearing course approaching an expansion joint of a structure, machine laying shall stop 300 mm short of the joint. The remainder of the pavement up to the joint, and the corresponding area beyond it, shall be laid by hand, and the joint or joint cavity shall be kept clear of surfacing material.

Bituminous material, with a temperature greater than 145°C, shall not be laid or deposited on bridge deck waterproofing systems, unless precautions against heat damage have been approved by the Engineer-in-charge.

**28.3.6. Rolling / Compaction :** Bituminous materials shall be laid and compacted in layers which enable the specified thickness, surface level, regularity requirements and compaction to be achieved.

Compaction of bituminous materials shall commence as soon as possible after laying. Compaction shall be substantially completed before the temperature falls below the minimum rolling temperatures stated in the relevant part of these Specifications. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, rolling shall commence at the edges and progress towards the center longitudinally except that on super elevated and unidirectionally cambered portions, it shall progress from the lower to the upper edge parallel to the center line of the pavement. Rolling shall continue until all roller marks have been removed from the surface. All deficiencies in the surface after laying shall be made good by the attendants behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with 8 – 10 tonnes dead weight smooth-wheeled rollers. The intermediate rolling shall be done with 8 – 10 tonnes dead weight or vibratory roller or with a pneumatic tyred roller of 12 to 15 tonnes weight having nine wheels, with a tyre pressure of at least 5.6 kg/sqcm or 0.56 MPa. The finish rolling shall be done with 6 to 8 tonnes smooth wheeled tandem rollers. Rolling shall be continued until the specified density is achieved, or where no density is specified, until there is no further movement under the roller.

Where compaction is to be determined by density of cores the requirements to prove the performance of rollers shall apply in order to demonstrate that the specified density can be achieved. In such cases the Contractor shall nominate the plant, and the method by which he intends to achieve the specified level of compaction and finish at temperatures above the minimum specified rolling temperature. Laying trials shall then demonstrate the acceptability of the plant and method used.

Bituminous materials shall be rolled in a longitudinal direction, with the driven rolls nearest the paver. The roller shall first compact material adjacent to joints and then work from the lower to the upper side of the layer, overlapping on successive passes by at least one-third of the width of the rear roll or, in the case of a pneumatic-tyred roller, at least the nominal width of 300 mm.

In portions with super elevated and unidirectional camber, after the edge has been rolled, the roller shall progress from the lower to the upper edge.

Rollers should move at a speed of not more than 5 km per hour. The roller shall not be permitted to stand on pavement which has not been fully compacted, and necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or standing. The wheels of rollers shall be kept moist with water, and the spray system provided with the machine shall be in good working order, to prevent the mixture from adhering to the wheels. Only sufficient moisture to prevent adhesion between the wheels of rollers and the mixture should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.

**28.3.7. Joints :** Where joints are made, the material shall be fully compacted and the joint made flush in one of the following ways:

- (a) All joints shall be cut vertical to the full thickness of the previously laid mix. All loosened material shall be discarded and the vertical face coated with a suitable viscosity grade hot bitumen, or cold applied emulsified bitumen. While spreading the material along the joint the material spread shall overlap 25 mm to 50 mm on the previously laid mix beyond the vertical face of the joint. The thickness of the loose overlap material should be approximately a quarter more than the final compacted thickness. The overlapped mix shall be dragged back to the hot lane so that the roller can press the small excess into the hot side of the joint to obtain a high joint density.
- (b) By using two or more pavers operating in echelon, where this is practicable, and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling

All longitudinal joints shall be offset at least 300 mm from parallel joints in the layer beneath or as directed, and in a layout approved by the Engineer-in-charge. Joints in the wearing course shall coincide with either the lane edge or the lane marking, whichever is appropriate. Longitudinal joints shall not be situated in wheel track zones.

**28.3.8. Opening to Traffic :** The newly laid surface shall not be open to traffic for at least 24 hours after laying the completion of compaction, without the approval of the Engineer-in-Charge in writing.

**28.3.9. Surface Finish and Quality Control of Work :** The surface finish of the completed construction shall conform to the requirements of section 900 of MORTH Specifications. For control of the quality of materials supplied and the works carried out the relevant provisions of Section 900 of MORTH Specifications.

**28.3.10. Arrangement for Traffic :** During the period of construction, arrangements for traffic shall be made in accordance with the provisions of specification and as per direction of the Engineer- in-charge.

## **28.4. Measurement :**

Bituminous Macadam shall be measured as finished work in cubic meters correct to two places of decimal.

## **28.5. Rate:**

The rate includes the cost of all material, labour, machineries and equipments in all the operations described above.

## **29. DENSE BITUMINOUS CONCRETE**

### **29.1. Scope**

Dense Bituminous Concrete (DBC), is used in wearing and profile corrective courses. This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer in a single layer shall be 30 mm / 40 mm / 50 mm thick.

### **29.2. Materials**

**29.2.1. Bitumen:** The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS:73, or as otherwise specified in the item. The type and grade of bitumen to be used shall be specified in the item of Contract. Where modified bitumen is specified, it shall conform to the requirements of IRC:SP:53 and IS:15462.

Section criteria for viscosity grade bitumen, based on highest and lowest daily mean temperatures at a particular site are given in **Table 40A**.

Selection criteria for modified bitumen shall be in accordance with IRC:SP53.

**29.2.2. Coarse Aggregates :** Same as specified in para 46.2.2 excepting strength which shall be max 30% for Los Angeles Abrasion Value and Aggregate Impact Value of max 24%. Where crushed gravel is proposed for use as aggregate, not less than 95 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

**29.2.3. Fine Aggregates:** The fine aggregates shall be all as specified in para 46.2.3.

**29.2.4. Filler:** Filler shall be generally as specified in para 46.2.4.

**29.2.5. Aggregate Grading and Binder Content :** When tested in accordance with IS 2386 part 1 (wet grading method), the combined grading of the coarse and fine aggregates and added filler shall fall within the limits shown in Table No. 42 for grading 1 or 2 specified in the contract.

**TABLE NO. 42**  
**Composition of Bituminous Concrete Pavement Layers**

<b>Grading</b>	<b>1</b>	<b>2</b>
Nominal aggregate size*	19 mm	13.2 mm
Layer Thickness	50 mm	30-40 mm
IS Sieve <sup>1</sup> (mm)	Cumulative % by weight of total aggregate passing	
45	-	-
37.5	-	-
26.5	100	-
19	90-100	100
13.2	59-79	90-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content % by mass of total mix	Min. 5.2* or as specified in the item	Min. 5.4** or as specified in the item
Bitumen grade	Specified in item or directed otherwise	Specified in item or directed otherwise

\*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° C or lower and lowest

daily air temperature is – 10 ° C or lower, the bitumen content may be increased by 0.5 percent.

### 29.3. Mix Design

The bitumen content required shall be determined following the Marshall mix design procedure contained in Asphalt Institute Manual MS-2.

The Fines to Bitumen (F/B) ratio by weight of total mix shall range from 0.6 to 1.2.

**29.3.1. Requirements for the Mix :** Same as specified in **Para 28.3.1** shall apply.

**29.3.2. Binder Content:** Same as specified in **para 28.3.2**.

**29.3.3. Job Mix Formula:** The procedure for formulating the job mix formula shall be generally as specified in **Para 30.3.3**.

**29.3.4. Plant Trials – Permissible Variation In Job Mix Formula :** The requirements for plant trials shall be as specified in **Para 30.3.4** and permissible limit for variation as given in **Table 43**.

**TABLE 43**  
**Permissible Variations in the Plant Mix from the Job Mix Formula**

<i>Description</i>	<i>Permissible Variation</i>
Aggregate passing 19 mm sieve or larger	± 7%
Aggregate passing 13.2 mm, 9.5 mm	± 6%
Aggregate passing 4.75 mm	± 5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 4%
Aggregate passing 0.3 mm, 0.15 mm	± 3%
Aggregate passing 0.075 mm	± 1.5%
Binder content	± 0.3%
Mixing temperature	± 10°C

**29.3.5. Laying Trials:** The requirements for laying trials be as specified in **Para 46.3.5**. The compacted layers of bituminous concrete (BC) shall have a minimum field density equal to or more than 92 percent of the average theoretical maximum specific gravity (Gmm) obtained on the day of compaction in accordance with ASTM D2041.

### 29.4. Construction Operations

**29.4.1. Preparation of Base :** The base on which DBC is to be laid shall be prepared, shaped and compacted to the required profile as appropriate or as directed by the Engineer-in-charge. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air, in locations where mechanical broom cannot get access, other approved methods shall be used as directed by the Engineer-in-charge.

**29.4.2. Tack Coat :** Where the material on which the bituminous macadam is to be placed is bitumen bound surface, a tack coat shall be applied as specified, in accordance with **Para 29**, or as directed by the Engineer-in-Charge..

**29.4.3. Mixing and Transportation of the Mixture:** The provisions are same as specified in **Para 31.3.3** shall apply.

**29.4.4. Spreading:** The provisions are same as specified in **Para 47.3.5** shall apply.

**29.4.5. Rolling / Compaction:** The provisions are same as specified in **Para 47.3.6** shall apply.



**29.4.6. Opening to Traffic :** The newly laid surface shall not be open to traffic for at least 24 hours after laying the completion of compaction, without the approval of the Engineer-in-Charge in writing.

**29.4.7. Surface Finish and Quality Control of Work :** The surface finish of the completed construction shall conform to the requirements of section 900 of MORTH Specifications. For control of the quality of materials supplied and the works carried out the relevant provisions of Section 900 of MORTH Specifications

**29.4.8. Arrangement for Traffic :** During the period of construction, arrangements for traffic shall be made in accordance with the provisions of specification and as per direction of the Engineer-in-charge.

## 29.5. Measurement

Dense Bituminous Concrete shall be measured as finished work in cubic meters, correct to two places of decimal.

## 29.6. Rate

The rate includes the cost of all material, labour, machineries and equipments in all the operations described above.

## 30. PREMIX CARPET WITH HOT BITUMEN OF PAVING ASPHALT GRADE VG- 10/ VG-30

This type of treatment is normally applied on roads where the motor traffic is of medium intensity, but bullock cart traffic is fairly heavy. This treatment is suitable for district roads and for internal and service road in colonies. The consolidated thickness of this type of treatment shall be 2 cm or 2.5 cm as specified.

This treatment consists of applying a tack coat on the prepared base followed immediately by spreading aggregates pre-coated with specified binder to camber and consolidated.

Premix carpet shall not be laid during rainy weather or when the base course is damp or wet or, when the atmospheric temperature in the shade is not more than 16oC.

### 30.1. Preparation of Surface

This shall be done as described in 22.

### 30.2. Materials

Grading of stone chipping shall be as per Table 17. Binder shall be as specified in nomenclature of item and shall conform to Table.7. Quantities of materials shall be as given in Table 18. A proper record shall be kept to ensure that the daily out turn of work is correlated with the quantity of bitumen used as per proforma given in Appendix 'A'.

**TABLE 18**

Consolidated thickness of premix carpet	Binder Hot Bitumen of grade VG- 10/ VG- 30 (kg/ cum of stone chipping)	Stone Chippings (in cum/ 100 sqm)	
		13.2 mm size	11.2 mm size
2.00 cm	(52 kg/cum of 13.2 mm size and 56 kg per cum of 11.2 mm	1.8	0.90

2.50 cm	-Do-	2.25	1.12
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### 30.3. Tack Coat

The rate of application of binder for tack coat shall be as specified in the nomenclature of item. The rate will be depending upon the surface on which the premix carpet is to be laid i.e. water bound macadam surface or existing black topped surface. Tack coat shall be applied as described in 28.

### 30.4. Preparation of Premix

The aggregate shall be dry and suitably heated to temperature as directed by Engineer-in-Charge before these are placed in the mixer to facilitate mixing with the binder.

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.

The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Engineer-in-Charge, in boilers of suitable design avoiding local overheating and ensuring a continuous supply.

The aggregates shall be dry and suitably heated to a temperature as directed by Engineer-in-Charge before these are placed in the mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified.

The mixing of binder with chippings shall be continued until the chippings are thoroughly coated with the binder. The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be cleaned and be covered over in transit if so directed.

### 30.5. Spreading and Rolling

The premixed material shall be spread on the road surface with rakes to the required thickness and camber or distributed evenly with the help of a drag spreader, without undue loss of time. The camber shall be checked by means of camber boards and inequalities evened out. As soon as sufficient length of bituminous material has been laid, rolling shall commence with 6 to 9 tonne power rollers, preferably of smooth wheel tandon type, or other approved power roller. Rolling shall begin at the edges and progress towards the centre longitudinally. Except on the super elevated portions rolling shall progress from the lower to upper edge, parallel to the centre line of the pavement. The consolidated thickness shall not at any place be less than the specified thickness by more than 25%. However, the average thickness shall not be less than that specified in the item.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roller marks eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose.

Rollers shall not stand on newly laid material as it may get deformed thereby.

The edges along and transverse of the carpet, laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

Further, the prepared finished surface shall be protected from traffic for 24 hours or such period as may be directed by the Engineer-in-Charge.

### 30.6. Surface Finishing

The surface regularity both in longitudinal and transverse directions shall be within the tolerances specified in Table 19.

**TABLE 19**

Longitudinal profile Max. permissible undulation when measured with 3 M straight edge	Cross profile Max. permissible variation from specified profile when measured with a camber template
10 mm	6 mm

The longitudinal profile shall be checked during rolling with a three meters long straight edge and graduated wedge at the middle of each traffic lane along the road. Similarly the transverse profile shall be checked with adjustable templates at intervals of 10 meters.

### 30.7. Rectification

Where the surface irregularity fall outside the specified tolerances limit the contractor shall be liable to rectify it to the satisfaction of Engineer-in-Charge by adding fresh material and recompacting to specifications where the surface is low. Where the surface is high the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications.

### 30.8. Measurements

The length and width of the finished work shall be measured correct to a cm along the finished surface of the road. The area shall be calculated in square metre, correct to two places of decimal.

For record purposes, the measurement for binder and stone chippings shall be taken as specified in 4.2.2 and 4.3.2 before they are actually used on the work. Premeasurements of the materials taken for record purposes shall simply serve as a guide and shall not form the basis for payment.

### 30.9. Rate

The rate shall include the cost of materials, machinery and labour involved in all the operations described above for the particular item, except for the cost of Repairs described under para 17.2(a).

## 31. PREMIX CARPET WITH BITUMEN EMULSION

This type of work is not ordinarily recommended but may be done in case of urgent repairs under damp conditions.

### 31.1. Materials

Binder shall be as specified and shall conform to RS grade as per IS 8837 grading of 11.2 mm stone chipping shall be as per Table 17. Quantities of bitumen emulsion and stone chippings shall be as specified in Table 20. A proper record shall be kept to ensure that the daily out turn of work is correlated with the quantity of bitumen used as per proforma given in Appendix 'A'.

**TABLE 20****Bitumen Emulsion**

Consolidated thickness of premix Carpet	Bitumen Emulsion (medium setting minimum 65% bitumen content)	Stone Chippings
	For Carpet in kg/cum of chippings	cum per 100 sqm
2 cm	96	2.4 (11.2 mm nominal size)
2.5 cm	96	3.0 (11.2 mm nominal size)

31.2. Preparation of surface and binder application shall be as specified under 26 except that the rate of application of bitumen for tack coat shall be 0.75 kg per sqm on water bound macadam surface and 0.5 kg per sqm on black topped surface.

31.3. Preparation, spreading, consolidating mix, surface finishing, measurements and rate shall be as specified under 30 except that the bitumen emulsion shall not be heated but it shall be poured over the aggregate at atmospheric temperature at the correct rate before spreading on the road surface. The rolling with road roller of 6 to 9 tone capacity shall commence 24 hours after spreading the mixture. The surface shall be protected by a suitable device such as barricading and posting of watchmen for closing the traffic.

## 32. BITUMINOUS PENETRATION MACADAM

### 32.1. Scope

The work shall consist of construction of one or more layers of compacted crushed coarse aggregates with alternate applications of bituminous binder and key aggregates in accordance with the requirements of these specifications to be used as a base course on roads, subject to the requirements of the overall pavement design, in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer-in-Charge. Thickness of an individual course shall be 50 mm or 75 mm or otherwise as specified.

### 32.2. Materials

**32.2.1. Bitumen :** The binder shall be paving bitumen of specified penetration grade conforming to IS 73 or approved cutback satisfying the requirement of IS 217 or 454 as specified in item. The actual grade of bitumen or cutback to be used shall be as specified in item or as directed by the Engineer-in-charge.

**32.2.2. Aggregates:** The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm IS sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter. Where the contractors selected source of aggregate have poor affinity for bitumen, as a condition for approval of the source, the bitumen shall be treated with approved anti-stripping agents, as per the manufacturers recommendations, without additional payment. Before approval of the source the aggregate shall be tested for stripping. The coarse aggregate shall conforming to Table 31. The coarse and key aggregates shall conform to the grading given in Table 21.

**32.2.3. Quantities of Material :** The quantities of materials used for this work shall be as specified in Table 21.

### 32.3. Construction Operations

**32.3.1. Weather and Seasonal Limitations:** Laying shall be suspended while free standing water is present on the surface to be covered, or during rains, fog and dust storm. After rain, the bituminous surface, tack coat shall be blown off with a high pressure of air jet to remove excess moisture, or the surface left to dry before laying shall start. Laying of bituminous mixture shall not be carried out when the air temperature at the surface on which it is to be laid is below 10°C.

**32.3.2. Equipment :** A mechanical broom, compressor, self propelled or trailed bitumen heater/ distributor, mechanical aggregate spreader and 8 to 10 tonne smooth steel wheel roller or vibrating roller are required for the preparation of Penetration Macadam.

**32.3.3. Preparation of the Base :** The base on which the Penetration Macadam Course is to be laid shall be prepaid, shaped and compacted to the specified lines, grades and sections as appropriate or directed by Engineer-in-Charge. A prime coat, where specified shall be applied over the base as directed by the Engineer-in-charge.

**32.3.4. Spreading Coarse Aggregate :** The coarse aggregate shall be dry and clean and free from dust, and shall be spread uniformly and evenly at the rate specified in Table 21. It shall be spread by a self-propelled or tripper tail mounted aggregate spreader capable of spreading aggregate uniformly at the specified rates over the required widths. The surface of the layer shall be carefully checked with camber templates to ensure correct line and level and cross fall. The spreading shall be carried out such that the rolling and penetrating operations can be completed on the same day. Segregated aggregates or aggregates contaminated with foreign material shall be removed and replaced.

**TABLE 21**  
**Composition of Penetration Macadam**

IS Sieve Designation (mm)	Cumulative percent by weight of total aggregate passing			
	For 50 mm compacted Thickness		For 75 compacted Thickness	
	Coarse Aggregate	Key Aggregate	Coarse Aggregate	Key Aggregate
(1)	(2)	(3)	(4)	(5)
63	-	-	100	-
45	100	-	58-82	-
26.5	37-72	-	-	100
22.4	-	100	5-27	50-75
13.2	2-20	50-75	-	-
11.2	-	-	-	5-25
5.6	-	5-25	-	-
2.8	0-5	0-5	0-5	0-5

Approx. Loose Aggregate quantities cm/m <sup>2</sup>	0-06	0.015	0.09	0.018
Binder Quantity (Penetration Grade) <sup>(1)</sup> (Kg./m <sup>2</sup> )	As specified in item		As specified in item	

**Note :** (1) If cutback bitumen is used, adjust binder quantity such that the residual bitumen is equal to the values in this table.

**32.3.5. Compaction :** After the spreading of course aggregates, dry rolling shall be carried out with an 8-10 tonne smooth steel wheel roller. After initial dry rolling the surface shall be checked with a crown and 3 metre straight edge. The surface shall not vary more than 10 mm from the template or straight edge. All surface irregularities exceeding the above limit shall be corrected by removing or adding aggregate as required the rolling shall continue until the compacted coarse aggregate has a firm surface, true to cross-section shown on the plans and has a texture that will allow free and uniform penetration of the bitumen material.

Compaction shall be done as per following procedure.

Bituminous materials shall be laid and compacted in layers which enable the specified thickness, surface level, regularity requirements and compaction to be achieved.

Compaction of bituminous materials shall commence as soon as possible after laying. Compaction shall be substantially completed before the temperature falls below the minimum rolling temperatures stated in the relevant part of these specifications. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, rolling shall commence at the edges and progress towards the centre longitudinally except that on super elevated and uni-directional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Rolling shall continue until all roller marks have been removed from the surface. All deficiencies in the surface after laying shall be made good by the attendants behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with 8-10 tonnes dead weight smooth- wheeled rollers. The intermediate rolling shall be done with 8-10 tonnes dead weight or vibratory roller or with a pneumatic tyred roller of 12 to 15 tonnes weight having nine wheels, with a type pressure of at least 5.6 kg/sqcm. The finish rolling shall be done with 6 to 8 tonnes smooth wheeled tandem rollers.

Where compaction is to be determined by density of cores the requirements to prove the performance of rollers shall apply in order to demonstrate that the specified density can be achieved. In such cases the Contractor shall nominate the plant, and the method by which he intends to achieve the specified level of compaction and finish at temperature above the minimum specified rolling temperature. Laying trials shall then demonstrate the acceptability of the plant and method used.

Bituminous materials shall be rolled in a longitudinal direction, with the driven rolls nearest the paver. The roller shall first compact material adjacent to joints and then work from the lower to the upper side of the layer, overlapping on successive passes by at least one-third

of the width of the rear roll or, in the case of a pneumatic-tyred roller, at least the nominal width of 300 mm.

In portions with super-elevated and uni-directional camber, after the edge has been rolled, the roller shall progress from the lower to the upper edge.

Rollers should move at a speed of not more than 5 km per hour. The roller shall not be permitted to stand on pavement which has not been fully compacted, and necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or standing. The wheels of rollers shall be kept moist with water and the spray system provided with the machined shall be in good working order, to prevent the mixture from adhering to the wheels. Only sufficient moisture to prevent adhesion between the wheels of rollers and the mixture should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.

After initial dry rolling, the surface shall be checked with a crown template and a 3 metre straight-edge. The surface shall not vary more than 10mm from the template or straight-edge. All surface irregularity exceeding the above limit shall be corrected by removing or adding aggregates as required.

The rolling shall continue until the compacted coarse aggregate has a firm surface true to the cross section shown on the plans and has a texture that will allow free and uniform penetration of the bitumen material.

**32.3.6. Application of Bituminous Material :** After the coarse aggregate has been rolled and checked, the bituminous binder shall be applied at the rate given in Table 21, at a temperature directed by Engineer-in-Charge.

At the time of applying the binder, the aggregates shall be surface dry for the full depth of the layer.

In certain circumstances, depending on the type and size of aggregate used, the Engineer-in-Charge may direct the placing of a bed of clean sand or quarry fines, not exceeding 10 mm in thickness, on the prepared foundation before placing the coarse aggregate. The sand or fine material shall be slightly wetted, just sufficient for it to slurry up during the compaction process. Where cut back is used, if flooding of the binder occurs it should be applied in two operations, or as directed by the Engineer-in-charge.

**32.3.7. Application of Key Aggregates :** Immediately after the first application of bitumen, the key aggregates, which shall be clean, dry and free from dust shall be spread uniformly over the surface by means of an approved mechanical spreader or by approved manual methods at the rate specified in Table 21.

Where directed by the Engineer-in-charge, the surface shall be swept and the quantity of key aggregate adjusted to ensure uniform application, with all the surface voids in the coarse aggregate being filled without excess. The entire surface shall then be rolled with a 8-10 tonnes smooth steel wheel roller (or vibrating roller operating in non-vibratory mode) in accordance with the procedure specified in above para 32.2.5.

#### **32.4. Surface Finish and Quality Control**

The surface finish of the completed construction shall conform to the requirements of section 900 of MORTH specifications. For control of the quality of materials supplied and the works carried out the relevant provisions of Section 900 of MORTH specifications.

#### **32.5. Surfacing**

The penetration Macadam shall be provided with a surfacing (binder/wearing course) within a maximum of forty-eight hours. If there is to be any delay, the penetration macadam shall

be covered by a seal coat as specified and directed by Engineer-in-charge. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

### 32.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of specification and as per direction of Engineer-in-Charge.

### 32.7. Measurement for Payment

Penetration Macadam base course shall be measured as finished work in square metres.

### 32.8. Rate

The rate includes the cost of all materials, labours and equipment involved in all the operations described above.

## 33. BITUMEN MASTIC WEARING COURSES

### 33.1. Definition

The bitumen mastic is an intimate homogeneous mixture of mineral fillers and well graded fine and coarse aggregates with a hard grade bitumen, cooked and laid hot, troweled and floated by means of a wooden float. The mixture settles to a coherent, void less and impermeable solid mass under normal temperature conditions.

The bitumen mastic is normally used as a wearing course. Over the mastic laid surface, hard stone chips pre-coated with bitumen are grafted or spread and rolled to provide a skid resistant surface.

Bitumen mastic is used as a wearing course in different situation of heavy duty road pavements. However, use of this material is not recommended in places where abundant fuel oil dripping is expected on the pavement surfaces like bus depots, fuel filling and service stations etc.

### 33.2. Materials

**33.2.1. The** bitumen shall be industrial bitumen conforming to IS 702 of grade 85 /25 or suitable consistency satisfying the requirements of physical properties as given in Table 22.

**TABLE 22**  
**Physical Properties of Bitumen**

S.No.	Characteristics	Requirements	Method of Test
1.	Penetration at 25 deg. C in 1/10 mm	15 ± 5	IS 1203
2.	Softening point (R&B)	65 ± 10	IS 1205
3.	Ductility at 27 deg.C (Minimum in cms.)	3	IS 1208
4.	Loss on heating, per cent (Maximum)	2	IS 1212
5.	Solubility in trichloroethylene per cent by mass (minimum)	95	IS 1216
6.	Ash (mineral matter) %age by mass	1.0	IS 1217

**33.2.2. Coarse Aggregates:** The coarse aggregates shall consist of clean, hard, durable, crushed rock free of disintegrated pieces, organic and other deleterious matter and adherent coatings. They shall be hydrophobic, of low porosity, and satisfy the physical requirements set forth in Table 23.



**TABLE 23**  
**Physical Requirements of Coarse Aggregates for Bitumen Mastic**

S.No	Test	Test Method	Acceptance Criteria
1.	Los Angeles Abrasion Value or Aggregate impact value	IS 2386 (Pt.4) -do-	40% (Max.) or 30% (Max.)
2.	Flakiness Index	IS 2386 (Pt.1)	30% (Max)
3.	Stripping Value	IS 6241	25% (Max)
4.	Soundness		
	(i) Loss with Sodium Sulphate 5 cycles	IS 2386 (Pt.5)	12% (Max)
	(ii) Loss with Magnesium Sulphate 5 cycles	-do-	18%(Max)
5.	Water Absorption	IS 2386 (Pt.3)	2% (Max)
6.	Retained tensile strength	-	80% (Min)

The percentage and grading of the coarse aggregates to be used in the bitumen mastic depending upon the thickness of the finished course shall be as in Table 24. The minimum and maximum thickness of the bitumen mastic for wearing course shall be 25 mm and 50 mm respectively except for footpaths of bridges where it shall be 20 mm and 25 mm respectively.

**TABLE 24**  
**Grading and Percentage of Coarse Aggregates for Bitumen Mastic in Wearing Course and Footpath**

S. No	Type of work	Grading of coarse aggregate		Thickness of finished mastic surface course	Percentage of coarse aggregates(mm)
		IS Sieve	%age passing IS sieve		
1.	Wearing course for road pavement and bridge decks	19 mm	100	(a) 25-40 or	(a) 30-40 or (b) 40-50
		13.2 mm	88-96		
		2.36 mm	0-5	(b) 41-50	
2.	Footpaths	6.7 mm	100	20-25	15-30
		600 micron	0.15		

**33.2.3. Fine Aggregates:** The fine aggregates shall consist of crushed hard rock or natural sand or a mixture of both. The grading of fine aggregates inclusive of filler material passing 75 micron shall be as given in Table 25.

**TABLE 25**  
**Grading of Fine Aggregate I/C Filler**

Passing IS Sieve	Retained on IS Sieve	% age by Weight
2.36 mm	600 micron	0-25
600 micron	212 micron	10-30
212 micron	75 micron	10-20
75 micron	—	30-50

**33.2.4. Filler :** The filler shall be limestone powder passing 75 micron and shall have a calcium carbonate content of not less than 80 per cent when determined in accordance with IS 1514.

### **33.3. Equipment for Bitumen Mastic**

**33.3.1.** There are two ways of preparing a mastic. The conventional method is by using a mastic cooker which is dealt with in this specification. The other method using fully mechanized units needed for large scale work, as is generally practiced in Germany (Gussasphalt), may form the subject of a separate document.

**33.3.2.** Mastic cooker are very similar to tar boilers. These are insulated tanks mounted on wheeled chassis. The heating of the bitumen and material is generally done by oil fired burners. Mastic cookers have compartments. The central and main compartment is used for heating bitumen and for preparing the mix. The side pockets or compartments are meant for pre-heating of the coarse and fine aggregates. Since heating is by oil fired burners, the temperature can be easily controlled by controlling the flames or supply of the fuel.

**33.3.3.** Mastic cookers of various capacities ranging from 1/2 tonne to 3 tonne are used depending on the amount of work involved. These are not being marketed commercially because it is not a common specification but can be easily got made from manufactures of tar boilers. Fig. 13 indicates the broad details of equipment and components of cooker presently in common use.

**33.3.4.** Apart from mastic cooker, the following equipments are required for transportation and laying.

- (1) Wheel barrows and flat mortar pans (for short distance haul) and small dumpers (for long distance haul).
- (2) Wooden trowels, heavy wooden floats, suitable hand tools gauge, straight edge and hand level.
- (3) Angle irons, required to contain the mastic in desired width and thickness.

### **33.4. Manufacture of Bitumen Mastic**

**33.4.1.** The manufacture of bitumen mastic involves different stages. Initially the filler alone shall be **heated** to a temperature of 175 deg. C to 210 deg. C in mechanically agitated mastic cooker and half the required quantity of bitumen heated at 175 deg. C to 180 deg. C added. They shall be mixed and cooked for one hour. After that the fine aggregates and the balance bitumen at 175 deg. C to 180 deg. C shall be added to that mixture in the cooker and heated upto 175 deg. C to 200 deg. C and further mixed for another one hour. In the final stage, the coarse aggregates shall be added and heating of mix shall continue for another one hour. Thus a total period of minimum three hours will be needed to prepare the mastic. During mixing and cooking, care shall be taken to ensure that the contents in the cooker are at no time heated to a temperature exceeding 210 deg. C.

**33.4.2.** In case the material is not required for immediate use, the bitumen mastic with filler, fine aggregates and bitumen shall be cast into blocks each weighing about 25 kg. The bitumen mastic blocks (without coarse aggregates) shall show on analysis a composition with the limits as given in Table 26. These blocks when intended to be used subsequently shall be transported to site, broken into pieces of size not exceeding 60 mm cube and remelted in the cooker at a temperature ranging from 175 deg. C. to 210 deg. C thoroughly incorporating the requisite quantity of coarse aggregates as indicated in Table 26 and mixed continuously for at least an hour. Mixing

shall be continued until the laying operations are completed so as to maintain the coarse aggregates in suspension. At any stage the temperature during the process of mixing shall not exceed 210 deg. C.

**TABLE 26**  
**Composition of Bitumen Mastic Blocks without Coarse Aggregates**

IS Sieve		% age by weight	
Passing	Retained	Minimum	Maximum
2.36 mm	600 micron	0	22
600 micron	212 micron	4	30
212 micron	75 micron	8	18
75 micron	-	25	45
Bitumen content		14	17

### 33.5. Hardness Number

The hardness number of bitumen mastic shall be determined at 25 deg. C in accordance with IS 5317 and with the method specified in Appendix D of IS 1195. It shall conform to the following requirements:

- (1) Without coarse aggregates at 25 deg. C      60-80
- (2) With coarse aggregates at 25 deg. C      10-20

### 33.6. Laying the Bitumen Mastic

**33.6.1. Preparation of the Base :** The base on which bitumen mastic is to be laid shall be prepared, shaped and conditioned to the specified levels, grade and camber as directed. If the existing surface is too irregular and wavy, it shall be made good by providing a corrective course of bituminous concrete mix as per IRC:29. The surface shall be thoroughly swept clean and made free of dust and other deleterious matter. Spots rich in binder shall be scrapped and repaired. Under no circumstances the bitumen mastic sheet be spread on a base containing a binder which will soften under high application of temperature. If any such spot exists, the same shall be cut out and repaired before the bitumen mastic is laid. To receive and contain the mastic, angle irons of sizes 25 or 50 mm are placed at required spacing till finish of the job.

**33.6.2. Transportation of Mix :** When the bitumen mastic, duly prepared including addition of coarse aggregates at the manufacturing point, is to be transported over a long distance and delivered to the laying site, arrangements for transport shall be made in a towed mixer transporter with adequate provision for heating and stirring so as to keep the aggregates and filler suspended in the mix till the time of laying. However for small works and where the laying site is near the manufacturing point, the mix can be transported in wheel barrows/flat mortar pans. To prevent the molten material from sticking to the wheel barrows/pans, the inside of the transport may be sprinkled with a minimum quantity of inorganic fine material like limestone dust. However, cement, ash or oil shall not be used.

### 34. Laying of Mix

**34.1.1.** The bitumen mastic shall be discharged into containers sprinkled with limestone dust or provided with lime-wash. The bitumen mastic shall be deposited directly on the

prepared base immediately in front of the spreader where it is spread uniformly by means of wooden floats to the required thickness. The mix shall be laid in one metre widths confined between standard angle irons of size 25 mm to 50 mm to receive and contain the mastic of required thickness. The temperature of the mix at the time of laying shall be 175 deg. C. In case blowing takes place while laying the bitumen mastic, the bubbles shall be punctured while the mastic is hot and the surface made good. Since mastic asphalt is an expansive material, extreme care shall be taken while fixing the angle irons and their level checked with instrument at suitable intervals.

**34.1.2. Laying Bitumen Mastic Surfacing over Old Existing Bridge Deck :** Before laying bitumen mastic over old existing bridge deck, the existing cross fall/camber, expansion joint members and water drainage spouts shall be carefully examined for their proper functioning in the bridge deck structure and any deficiency found shall first be removed. Loose elements in the expansion joint shall be firmly secured. The cracks in the concrete surface, if any, shall be repaired and filled up properly or replaced by new concrete of specified grade before laying the bitumen mastic over bridge deck.

**34.1.3. Laying over New Bridge Deck :** New concrete bridge deck which is not in camber/cross fall shall first be provided with required camber and cross fall by suitable concrete or bituminous treatment. In case of laying over concrete surface, following measures shall be taken:

- (1) For proper bond with new concrete deck, surface shall be roughened by means of stiff broom or wire brush and it shall be free from ridges and troughs.
- (2) A thin bituminous tack coat (with bitumen of grade 80/100) shall be applied on the concrete deck before pouring mastic. The quantity of bitumen for tack coat shall not exceed 5-6 kg per 10 sqm.
- (3) On surface in longitudinal slope, after applying tack coat, chicken-mesh reinforcement of 1.5 mm dia steel wire with hexagonal or rectangular openings of 20-25 mm shall be placed and held properly in position on the concrete surface before pouring mastic.

## 34.2. Joints

All construction joints shall be properly and truly made. These joints shall be made by warming the existing bitumen mastic by the application of an excess quantity of hot bitumen mastic which afterwards shall be trimmed off to make it flush with surface on the either side.

## 34.3. Surface Finish

The bitumen mastic surfacing has got a very fine texture which on initial laying provides very little resistance to skidding. Therefore, the bitumen mastic after spreading and while still hot and in plastic condition shall be spread over with bitumen pre-coated fine grained hard stone chips/aggregates of approved quality of 13.2 mm size complying with quality requirement as per Table 27 depending upon the thickness of mastic, using bitumen at the rate of 2 to 3 percent of S-65 or S-90 grades and aggregates at the rate of 0.005 cum (1/200 cum) per 10 sqm. and at a spacing of 10 cm c/c in both directions and pressed into the surface when the temperature of bitumen mastic is between 80 deg. C. and 100 deg. C. Such pre-coated aggregates when laid should protrude 2 to 4 mm over the mastic surface. Flakiness index of stone aggregates used for anti-skid measures shall be less than 25 per cent. The addition of 2% filler complying with Table 28/30 may be required to enable the quantity of bitumen to be held without draining.

**TABLE 27**

<b>Sl.No.</b>	<b>Name of Test</b>	<b>I.S.Code</b>	<b>Acceptance Criteria</b>
1.	Grain size analysis	IS 2386 Part 1	Max. 5% passing IS sieve 75 micron
2.	Flakiness or elongation Index	IS 2386 Part 4	Max. 30% *
3.	Los Angeles Abrasion Value	-do-	Max. 30%
4.	Polished Stone Value	B.S. 812 (Part 114)	Min. 55
5.	Soundness Sodium Sulphate Magnesium Sulphate	IS 2386 (Part 5)	Max. 12% Max. 18%
6.	Water absorption	IS 2386 Part 3	Max. 2%
7.	Coating and stripping of bitumen aggregate mixture	IS 6241	Min retained coating 95%
8.	Water sensitivity retained tensile strength	AASHTO T 283	Min. 80% **

\*The elongation test to be done only on non-flaky aggregate to the sample.

\*\* This test is only required if the maximum retained coating in the stripping test is less than 95%.

**TABLE 28**

Sl. No.	IS Sieve (MM)	Cummulative percent passing by weight of total aggregate
1.	0.6	100
2.	0.3	95-100
3.	0.075	85-100

the traffic may be allowed after completion of work when the bitumen mastic has cooled down to the ambient temperature.

### **34.4. Controls**

**34.4.1.** Sieve analysis of each type of the aggregate used shall be made at least once a day to see that the gradation of the aggregates follows the original gradation as approved. Additional tests shall be carried out in case of variation in grading or receipt of supply of material from new source. The number of samples to be tested per day would depend upon the bulk supply of aggregates made in a day at the plant site. Physical properties such as aggregate impact values, flakiness index, water absorption etc. shall be determined at the rate of one test for every 25-50 cum of aggregates or as directed by the Engineer at site.

**34.4.2.** Two sets of test shall be carried out on each lot of supply of bitumen for checking penetration and softening point as per IS 1203 and IS 1205.

**34.4.3.** For filler material calcium carbonate content and fineness shall be tested at the rate of one set of tests for each consignment subject to a minimum of one set of test per 5 tonne or part thereof.

**34.4.4.** It shall be ensured that the aggregates are not wet before heating, otherwise it would affect the output adversely. During heating the aggregate temperature shall be recorded periodically to see that it does not exceed the limits prescribed.

**34.4.5.** Material in block form shall be sampled by taking approximately equal amount in pieces, from not less than six blocks chosen at random. The total weight of specimen to be tested shall not be less than 5 kg. In case the preparation of the mix is at site, then at least one sample of every 10 tonne of bitumen mastic discharged from the

mastic cooker or at least one sample for each cooker per day shall be collected and following tests done:

- (1) Two specimens each of 10 cm dia or 10 cm square and 2.5 cm thick shall be prepared and tested for hardness number.
- (2) Bitumen shall be extracted from about 1000 gm of the mastic sample and bitumen content determined as specified in Appendix C of IS 1195.
- (3) A sieve analysis of the aggregates after the bitumen is extracted, shall be done and the gradation determined according to the procedure laid down in IS 2386 (Pt.I).

**34.4.6.** The temperature of the bitumen mastic at the time of laying shall not exceed 210 deg. C and shall not be less than 175 deg. C.

**34.4.7.** The longitudinal profile of the finished surface shall be tested with a straight edge 3 m long and transverse profile with a camber template while the mastic laid is still hot. Irregularities greater than 4 mm in the longitudinal and transverse profile shall be corrected by picking up the mastic in full depth and full area of the affected panel and relaying.

**34.4.8.** Bitumen mastic shall not be laid on a damp or wet surface or when the atmospheric temperature in the shade is 15 deg. C or less.

### **34.5. Measurements**

The length & breadth of the area where bitumen mastic wearing course of specified thickness has been provided shall be measured correct to a centimeter and the area shall be calculated in square metres correct to two decimal places.

### **34.6. Rate**

The rate per square metre shall include cost of all the operations described above including anti- skid treatment mentioned in para 26.1 above.

## **35. SEAL COAT**

### **35.1. Scope**

This work shall consist of the application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade and cross fall (camber).

**35.1.1.** Seal coat shall be of either of the two types specified below:

- (A) Liquid seal coat comprising of an application of all layer of bituminous binder followed by a cover of stone chips.
- (B) Premixed seal coat comprising of a thin application of the aggregate premixed with bituminous binder.

### **35.2. Materials**

**35.2.1. Binder :** The binder and its quantity shall be a penetration bitumen of a suitable grade as specified in the item or as directed by the Engineer-in-charge.

**35.2.2. Stone Chips for Seal Coat :** The stone chips shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They should be free of soft or disintegrated stone, organic or other deleterious matter. Stone chips shall be of 6.7 mm size defined as 100 per cent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic metre per 100 square metre area. The stone chips shall satisfy the quality requirements in Table 31 bituminous except that the upper limit for water absorption value shall be 1 per cent.

**TABLE 30**

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

**TABLE 30**

Sl. No.	Name of Test	I.S. Code	Acceptance Criteria
1.	Grain size analysis	IS 2386 Part 1	Max 5% passing IS sieve 75 micron
2.	Flakiness and elongation Index	IS 2386 (Part 4)	Max 30%
3.	Los Angeles Abrasion Value	IS 2386 (Part 4)	Max 30%
4.	Polished stone value	B.S. 812 (part 114)	Min 55%
5.	Soundness Sodium sulphate Magnesium sulphate	IS 2386 (Part 5)	Max 12% Max 18%
6.	Water absorption	IS 2386 (Part 3)	Max 2%
7.	Coating and stripping of Bitumen aggregate mixture	IS 6241	Min retained coating 95%
8.	Water sensitivity retained tensile strength	AASHTOT 283	Min 80%

\*The elongation test to be done only on non-flaky aggregate on the sample.

\*\* This test is only required if the minimum retained coating in the stripping test is less than 95%.

**35.2.3. Fine Aggregate :** The aggregate shall be sand or grit and shall consist of clean, hard durable, uncoated dry particles and shall be free from dust, soft or flaky/elongated material, organic matter or other deleterious substances. The aggregate shall pass 2.36 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cubic metres per 100 square metres area. Stones or fine aggregate shall be used as specified in item.

### 35.3. Construction Operations

**35.3.1. Weather and Seasonal Limitations :** Ref. Item No. 32.2.1.

**35.3.2. Preparation of Surface :** The seal coat shall be applied immediately after laying the bituminous course which is required to be sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other extraneous matter.

**35.3.3. Construction of Seal Coat with Stone Chips :** Bitumen shall be heated to 150oC - 163oC and sprayed at the rate specified on the dry surface in a uniform manner with a self-propelled mechanical sprayer Immediately after the application of binder, stone chips which shall be clean and dry, shall be spread uniformly at the rate specified on the surface preferably by means of a self –propelled or towed mechanical grit spreader so as to cover the surface completely. If necessary, the surface shall be brushed to ensure uniform spread of chips. Immediately after the application of the cover material, the entire surface shall be rolled with a 8-10 tonne smooth wheeled steel roller, 8-10 tonne static weight vibratory roller, or other equipment approved by the Engineer after laying trials if required. Rolling shall commence at the edges and progress towards the centre except in super elevated and unidirectional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass

of the roller shall uniformly overlap not less than one-third of the track made in the proceeding pass. While rolling is in progress, additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

**35.3.4. Construction of Seal Coat with Premixed Fine Aggregate :** A mixer of appropriate capacity and type approved by the Engineer-in-charge shall be used for preparation of the mixed material. The plan shall have separate dryer arrangements for heating aggregate.

The binder shall be heated in boilers of suitable design, approved by the Engineer-in-Charge to the temperature appropriate to the grade of bitumen or as directed by the Engineer-in -Charge. The aggregates shall be dry and suitably heated to a temperature between 150oC and 165oC or as directed by the Engineer-in-charge before these components are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued until the latter are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

As soon as a sufficient length has been covered with the premixed material, the surface shall be rolled with an 8-10 tonne smooth-wheeled roller. Rolling shall be continued until the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

#### **35.4. Opening to Traffic**

In the case of seal coat with premixed fine aggregate traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. In the case of seal coat with stone chips traffic shall not be permitted to run on any newly sealed area until the following day. In special circumstances, however, the Engineer-in-charge may open the road to traffic immediately after rolling, but in such case traffic speed shall be rigorously limited to 16 km. per hour until the following day

#### **35.5. Measurement for Payment**

Seal coat, for both items shall be measured as finished work over the area specified to be covered, in square metres at the thickness specified in the item.

#### **35.6. Rate**

The rate for seal coat shall be cost of all materials, labour and equipment involved in operation described above.

### **36. PAINTING ROAD/ RUNWAYS MARKINGS**

#### **36.1. Materials**

**36.1.1.** Special Road marking paint of approved brand and manufacture shall be used. The paint shall conform to IS 164. Ready mixed paint as received from the manufacturer shall be used without adding any admixture.

**36.1.2.** During work, if the consistency of the paint gets thick and thinning becomes necessary it shall be done by use of thinner of the approved brand of paint recommended by the manufacturer and with the approval of the Engineer-in-Charge.

**36.1.3.** *The* paint shall be brought to the site of work by the contractor in original sealed containers. The material shall be brought in one lot in adequate quantity to suffice for the entire work. The material shall be kept in the joint custody of the contractor and the Engineer-in-Charge.



The empty container shall not be removed from the site of work, till the work has been completed and permission obtained from the Engineer-in-Charge.

### **36.2. Preparation of Surface**

The surface shall be thoroughly cleaned and free from dust. All the dirt, scales, oil and grease shall be thoroughly removed before painting is started. The prepared surface shall be inspected and approved by the Engineer-in-Charge before painting is commenced.

### **36.3. Application**

**36.3.1.** Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its original container. The paint shall be continuously stirred in the smaller container while applying to runway surface so that its consistency is kept uniform.

**36.3.2.** The painting shall be applied evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternatively in opposite direction, two or three times and then finally brushing lightly in a direction at right angle to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

**36.3.3.** Each coat shall be allowed to dry out thoroughly before the next coat is applied.

**36.3.4.** Earlier applied coat shall be cleaned off dust before the next coat is laid.

**36.3.5.** No left over paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

**36.3.6.** No hair marks from the brush or clogging of paint puddles shall be left on the work.

**36.3.7.** The surface shall ordinarily not be painted until it has dried up completely. Trial patches of paint shall be laid at intervals to check if drying is satisfactory.

**36.3.8.** The runway marking shall be done in accordance with the drawing unless otherwise instructed by the Engineer-in-Charge.

### **36.4. Brushes and Containers**

**36.4.1.** After work, the brushes shall be completely cleaned of paint by rinsing with turpentine. A brush in which paint has dried up is spoiled and shall on no account be reused for painting work. On no account kerosene oil shall be used for washing the brush.

**36.4.2.** When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth so that they are clean, and can be used again.

### **36.5. Measurement**

Length and breadth shall be measured correct to a cm. Area shall be worked out in square metre, correct to two places of a decimal.

### **36.6. Rate**

Rate shall include cost of all materials, tools and labour involved in all the operations described above including all cartages and lifts.

## **37. PAINTING ROAD SURFACE (WITH READY MIXED ROAD MARKING PAINT)**

Specifications of item no. 36 to be followed except that road surface to be painted with ready mixed road marking paint of approved brand instead of paint of superior make.

## **38. RETRO REFLECTIVE SIGN BOARD**

### **38.1. General**

The colour, 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.

### **38.2. Materials**

#### **38.2.1. Concrete**

Concrete shall be of M-25 grade.

#### **38.2.2. Reinforcing steel**

Reinforcing steel shall confirm to the requirement of IS 1786 unless otherwise specified.

#### **38.2.3. Bolts Nuts and Washers**

High strength bolts shall confirm to IS 1367 whereas precision bolts, nuts etc. shall confirm to IS 1364.

#### **38.2.4. Plates and Supports**

Plates and support sections for the sign posts shall confirm to IS 226 and IS 2062 or any other stated IS specification.

#### **38.2.5. Substrata**

The substrate shall be either aluminium sheeting or aluminium composite material (ACM) confirming to following sub-sections.

#### **38.2.6. Aluminium**

Aluminium sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminium alloy confirming to IS 736 material designation 24345 or 1900.

#### **38.2.7. Aluminium composite materials**

- (i) The Aluminum Composite Material (ACM), used as the substrate for signage application shall have a thickness of at least 4.0mm (excluding coating thickness).
- (ii) The ACM shall be composed of thermoplastic core of ‘Low Density Polyethylene’ (LDPE) of 3.0mm thickness sandwiched between two thick sheets of aluminium, of 3003 grade and H-18 temper and minimum thickness of 0.5mm each. The retro reflection sheeting must be applied on the top surface with aluminium surface with recommended surface preparation from sheeting manufactures.
- (iii) A fluorocarbon coating may be applied over the exposed surface of aluminum to ensure corrosion resistance and weather proof and thus shall confirm to relevant ASTM.
- (iv) The ACM shall have a high-surface energy coating on the top surface, over which the retro reflective sheeting shall be applied.
- (v) When measured after 24 hrs after application, the 90 peel-adhesion strength of the top surface of ACM with the retro reflective sheeting applied on it using a 2kg roller as per ASTM D3330 shall be at least 1.5 kg-f.
- (vi) The front surface shall have no other coating other than the high-surface energy coating and shall be protected with a self-adhesive peel-off film. The retro reflective sheeting shall be applied only on the top surface with high-surface energy coating.
- (vii) On the back surface, it shall have a polyester based service coating preferably grey in color to protect against possible corrosion and to avoid undesired glare from the rear side of the sign.

- (viii) The mechanical properties of 4mm ACM and that of its aluminium skim shall confirm to the requirement given in table 44 below. When tested accordance with the test methods mentioned against each of them.

**Table 44**  
**Specification for Aluminium Composite Material (ACM)**

S. No.	Description	Specification for 4mm	
		Standard Test	Acceptable Value/Results
A	Physical Tests for ACM		
1	Over all thickness of ACM	Measurement	4mm (Tolerance + 0.2mm)
2	Aluminium Skin thickness (each side)	Measurement	0.5mm (Tolerance +/- 0.03mm)
	Panel weight (ACM)	Measurement	5.5 Kg/m <sup>2</sup> (+ 5%)
B	Mechanical Properties of ACM		
1	Peel off strength with retro reflective sheeting. (Drum Peel Test)	ASTM D903	Min. 4 N/mm
2	Tensile strength	ASTM E638	Min. 40 N/mm <sup>2</sup>
3	0.2% Proof Stress	ASTM E638	Min. 34 N/mm <sup>2</sup>
4	Elongation	ASTM E638	Min. 6%
5	Flexural strength	ASTM C393	Min. 130 N/mm <sup>2</sup>
5	Shear strength with punch shear test	ASSTM D732	Min. 18 N/mm <sup>2</sup>
C	Properties of Aluminium skin		
1	Tensile strength (Rm)	ASTM E8	Min. 150 N/mm <sup>2</sup>
2	Modules of elasticity	ASTM E8	Min 70000 N/mm <sup>2</sup>
3	Elongation	ASTM E8	Min. 2%
4	0.2% proof stress	ASTM E8	Min. 110 N/mm <sup>2</sup>
D	Properties of High surface energy coating		
1	(90 deg) Peel adhesion strength of Retroreflective sheeting on ACM surface with high-surface energy coating	ASTM D330	Min. of 1.5 kgf i.e. Equal to or more than that with surface prepared aluminium

### 38.2.8. Performance Certificate

Requisite performance certificate from the manufacturer of the ACM stating compliance with ACM technical specification as per Table 44 above shall be submitted by the contractor to the Engineer- in-Charge.

### 38.2.9. Retro- Reflective Sheeting (Type-XI Prismatic Grade sheeting):

**(AS per IRC 67-2012 Clause 6.7)**

The retro reflective sheeting used on the signs shall consist of white or coloured sheeting having a smooth outer surface which has the property of retro reflection over its entire surface. It shall be weather resistant and exhibit colour fastness. It shall be new and unused and show no evidence of cracking, scaling, and pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having the sheeting tested for coefficient of retro reflection, daytime colour and luminance, shrinkage, flexibility, liner removal, adhesion, impact resistance, specular gloss and fungus resistance, 3 years outdoor weathering and its having passed these tests shall be obtained from International / Government Laboratory / Institute by the manufacturer of the

sheeting and in case the certificate is obtained from international agency, it should also be obtained from Indian agency within 3 years of launching of product by the manufacture in abroad. Alternatively, a certificate conforming to ASTM Specification (D 4956-09) on artificial accelerated weathering requirements from a reputed laboratory in India can be accepted provisionally. In such a situation, the Employer/ Client, if so desires, could seek for a performance guarantee which would be released after receipt of certificate meeting the requirement of three years outdoor weathering of the sheeting.

Retro-reflective sheeting is typically manufactured as a cube corner. The reflective sheeting shall be retro-reflective sheeting made of micro prismatic retro-reflective material. The retro-reflecting surface after cleaning with soap and water and in dry condition shall have minimum co-efficient of retro reflection (determined in accordance with ASTM D4956-09) confirming to IRC:67 Table 6.9.

When totally wet, the sheeting shall not show less than 90 per cent of the values of retro-reflection. At the end of 10 years the sheeting shall return at least 80 per cent of its original retro-reflectance.

**38.2.10. Adhesives :** The sheeting shall have a pressure-sensitive adhesive of the aggressive-tack type requiring no heat, solvent or other preparation for adhesion to a smooth clean surface, in a manner recommended by the sheeting manufacturer and approved by Engineer-in-Charge. The adhesive shall be protected by an easily removable liner (removable by peeling without soaking in water or other solvent) and shall be suitable for the type of material of the base plate used for the sign. The Adhesive shall form a durable bond to smooth, corrosion and weather resistant surface of the base plate such that it shall not be possible to remove the sheeting from the sign base in one piece by use of sharp instrument. The sheeting shall be applied in accordance with the manufacturers specifications.

### **38.3. Installation**

**38.3.1.** Surface to be reflectorised shall be effectively prepared to receive the retro- reflective sheeting. The Aluminium / ACP sheeting shall be de-greased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth plain surface before the application of retro-reflective sheeting. Complete sheet of the material shall be used on the signs except where it is unavoidable. Sheeting with heat-activated adhesives may be spliced with an overlap not less than 5 mm or butted with a gap not exceeding 0.75 mm. The material shall cover the sign surface evenly and shall be free from twists, cracks and folds.

**38.3.2. Sign** posts, their foundations and sign mountings shall be so constructed as to hold these in a proper and permanent position against the normal storm wind load or displacement by vandalism. Normally, sign with an area upto 0.9 sq.m shall be mounted on a single post and for greater area two or more supports shall be provided. Sign supports shall be as specified in item or as per directions of Engineer-in-Charge. The work of foundation shall conform to relevant specification as specified.

**38.3.3. Backside** of aluminium sheet portion shall be painted with two coats of epoxy paint. Any part and support frame with two or more coats of synthetic enamel paint.

### **38.4. Performance Certificate**

Requisite performance certificate from the manufacturer of the ACM stating compliance with ACM technical specification as per Table 44 above shall be submitted by the contractor to the Engineer-in-Charge.

### **38.5. Warranty and Durability**

The Contractor shall obtain from the manufacturer a ten year warranty as per IRC:67 for satisfactory performance including stipulated retro-reflectance of the retro-reflective sheeting, the screen printed areas and cut out sheeting and cut out durable transparent overlay film and submit the same to the Engineer-in-Charge.

Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and following cleaning, shall show no appreciable discoloration, cracking, blistering or dimensional change and shall not have less than 50 percent of the specified minimum reflective intensity values when subjected to accelerated weathering of 1000 hours, using type E or EH Weather meter (AASHTO Designation M 268).

### **38.6. Measurement**

These shall be measured in square meters upto two place of decimal.

### **38.7. Rate**

The rate includes the cost of materials labour and equipments involved in all the operations described above except **49.1.1 to 49.1.4**.

## **39. ROAD MARKINGS STRIPS**

The colour width and layout of road markings shall be in accordance with the Code of Practice for Road Markings with paints, IRC : 35, and as specified in the drawings or as directed by the Engineer- in-Charge.

### **39.1. Materials**

Road markings shall be of ordinary road marking paint (retro-reflective), hot applied thermoplastic compound as specified in the item.

### **39.2. Hot Applied Thermoplastic Road Marking**

#### **General**

- (i) The thermoplastic material shall be homogenously composed of aggregate, pigment, resins and glass reflectorizing beads.
- (ii) The thermoplastic compound shall be screeded/extruded on to the pavement surface in a molten state by suitable machine capable of controlled preparation and laying with surface application of glass beads at a specific rate. Upon cooling to ambient pavement temperature, it shall produce an adherent pavement marking of specified thickness and width and capable of resisting deformation by traffic.
- (iii) The thermoplastic material shall conform to ASTM D36/BS-3262-(Part I).
- (iv) The material shall meet the requirements of these specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/supplier/Contractor.
- (v) **Marking** : Each container of the thermoplastic material shall be clearly and indelibly marked with the following information:
  1. The name, trade mark or other means of identification of manufacturer.
  2. Batch number

3. Date of manufacture
  4. Colour (White or yellow)
  5. Maximum application temperature and maximum safe heating temperature.
- (vi) **Sampling and Testing** : The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Engineer-in-Charge a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification.

### 39.3. Preparation

- (vii) The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material to avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material should be used as expeditiously as possible and for thermoplastic material which has natural binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.
- (viii) After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

### 39.4. Properties of Finished Road Marking

- (a) The stripe shall not be slippery when wet.
- (b) The marking shall not lift from the pavement in freezing weather.
- (c) After application and proper drying, the stripe shall show no appreciable deformation or discolouration under traffic and under road temperatures upto 60oC.
- (e) The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil drippings from traffic. The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.
- (f) The colour of yellow marking shall conform to IS Colour No. 356 as given in IS 164.

### 39.5. Application

Marking shall be done by fully /semi automatic paint applicator machine fitted with profile shoe, glass beads dispenser, propane tank heater and profile shoe heater, driven by experienced operator as specified in item. For locations where painting cannot be done by machine, approved manual methods shall be used with prior approval of the Engineer-in-charge. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

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

The pavement temperature shall not be less than 10oC during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the paint.

Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be hand-sprayed.

The minimum thickness specified is exclusive of surface applied glass beads.

The finished lines shall be free from ruggedness on sides and ends and be parallel to the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

### **39.6. Measurements for Payment**

The painted markings shall be measured in sq. metres of actual area marked (excluding the gaps, if any) correct upto the two places of decimal.

### **39.7. Rate**

The rate includes the cost of all materials, labour and equipments required in all the above operations.

## **40. KERB CHANNEL OF CEMENT CONCRETE**

**Base :** The base of the channel to be of the 75 mm compacted thick dry brick ballast 40 mm nominal size well rammed and consolidated and grouted with fine sand.

Kerb channel shall be provided in cement concrete of specified grade. These shall be cast in-situ of specified size as given in the item. Top surface of channel to be finished smooth.

**Measurements :** Cement concrete channel shall be measured in metre of length of the completed channel correct upto two places of decimal.

**Rate :** The rate includes the cost of all the materials, labours and tools required in all the operations described above.

## **41. POST DELINEATORS**

The role of delineators is to provide visual assistance to drivers about alignment of the road ahead, especially at night. Delineators are particularly effective in the case of complex locations involving changes in horizontal / vertical geometry and doing severe weather condition such as heavy rain, fog or snow. Normally reflectors are used on the delineators for better night time visibility. Road delineators may have a circular, rectangular or triangular cross-section, however the side facing the traffic should not be less than 10 cm wide.

In board sense, Delineators stands for any device or treatment whose aim is to outline the road way.

### **41.1. Material :**

The design, materials to be used and the location of the road delineators shall conform to recommended practice for road delineators, IRC:79, and to relevant drawings and as directed by the Engineer-in-charge.

The delineators are to be made of Acrylonitrile Butadiene Styrene (ABS) body fitted with 2 No. 100 mm dia of highly reflective reflectors are mounted on M.S. pipe of 65 mm dia or of size specified otherwise, duly powder coated of minimum 40 microns thickness anti-rust and anti-theft, installed as per direction of Engineer-in-charge. Road delineators may have a circular, rectangular or triangular cross-section, however the side facing the traffic should not be less than 10 cm wide.

#### **41.2. Dimensions :**

Height of the delineator should be not less than 800 mm above ground. Width not less than 100 mm. Not more than 300 mm below the ground while being installed.

#### **41.3. Placement and spacing :**

As a general rule, delineators posts should be erected at the edge of the usable shoulders, and in the case of kerbed sections at a distance of 0.6 to 1.5 m from the kerb face. On hill roads they may be placed either on the parapet or at the edge of the shoulders.

The delineator should be so positioned that the reflectorised face is perpendicular to the direction of travel.

#### **41.4. Warranty :**

The contractor shall obtain a two years warranty for satisfactory performance including stipulated retro-reflectance of the retro-reflective sheeting and submit the same to the Engineer-in-charge.

#### **41.5. Measurement**

The measurement shall be made in numbers of delineators fixed at site.

#### **41.6. Rate**

The rate include the cost of all the material, labour and equipments required in all the operations described above.

### **42. FACTORY MADE CEMENT CONCRETE INTERLOCKING PAVER BLOCK**

#### **42.1. Base**

Interlocking paver block to be fixed on the bed 50 mm or specified otherwise thick of coarse sand of approved specification and filling the joints with the sand of approved type and quality or as specified and as directed by Engineer-in-charge.

#### **42.2. Interlocking Paver Block**

Factory made precast paver block of M-30 or otherwise specified grade to be used. Paver blocks to be of approved brand and manufacturer and of approved quality. Minimum strength as prescribed by manufacturer and as per direction of Engineer-in-Charge for the grade specified to be tested as per method mentioned in specification of subhead cement concrete of CPWD Specification 2019 Vol. I.

#### **42.3. Measurement & Rates**

Area provided with paver block to be measured in sqm. correct upto two places of decimal. The rate include the cost of the material, labour, tools etc. required in all the operations described above.

### **43. KERB STONE (PRECAST)**

#### **43.1. Laying**

**43.1.1.** Trenches shall first be made along the edge of the wearing course of the road to receive the kerb stones of cement concrete of specified grade. The bed of the trenches shall be compacted



manually with steel rammers to a firm and even surface and then the stones shall be set in cement mortar of specified proportion.

**43.1.2.** The kerb stones with top 20 cm. wide shall be laid with their length running parallel to the road edge, true in line and gradient at a distance of 30 cm. from the road edge to allow for the channel and shall project about 12.5 cm. above the latter. The channel stones with top 30 cm. wide shall be laid in position in chamber with finished road surface and with sufficient slope towards the road gully chamber. The joints of kerb and channel stones shall be staggered and shall be not more than 10 mm. Wherever specified all joints shall be filled with mortar 1:3 (1 cement : 3 coarse sand) and pointed with mortar 1:2 (1 cement: 2 fine sand) which shall be cured for 7 days.

**43.1.3.** The necessary drainage openings of specified sizes shall be made through the kerb as per drawings or as directed by the Engineer-in-Charge for connecting to storm water drains.

#### **43.2. Finishing**

Berms and road edges shall be restored and all surplus earth including rubbish etc. disposed off as directed by the Engineer-in-charge. Nothing extra shall be paid for this.

#### **43.3. Measurements**

It shall be measured in cubic meters with Length of the finished work (for specified width and height of stone) shall be measured in running metre along the edge of the road correct to a cm.

#### **43.4. Rate**

The rate shall include the cost of all the materials and labour involved in all the operations described above.

### **44. REFLECTIVE PAVEMENT MARKERS (RPM) OR ROAD STUDS**

#### **44.1. Scope**

The work shall cover the providing and fixing of reflective pavement marker (RPM) or road stud, a device which is bonded to or anchored within the road surface, for lane marking and delineation for night-time visibility, as specified in the Contract.

#### **44.2. Material**

**44.2.1.** Plastic body of RPM/road stud shall be moulded from ASA (Acrylic Styrene Acrylonitrile) or HIPS (Hi-impact Polystyrene) or Acrylonitrile Butadiene Styrene (ABS) or any other suitable material approved by the Engineer. The markers shall support a **load of 13.635 kg tested in** accordance with ASTM D 4280.

**44.2.2.** Reflective panels shall consist of number of lenses containing single or dual prismatic cubes capable of providing total internal reflection of the light entering the lens face. Lenses shall be moulded of methyl methacrylate conforming to ASTM D 786 or equivalent.

#### **44.2.3. Design**

The slope or retro-reflecting surface shall preferably be  $35 \pm 5^\circ$  to base and the area of each retro- reflecting surface shall not be less than 13.0 sq.cm.

#### **44.2.4. Optical Performance**

#### **44.2.5. Unidirectional and Bi-directional Studs.**

Each reflector or combination of reflectors on each face of the stud shall have a Coefficient of Luminous Intensity (C.I.L.), as specified in **Table 48**

**TABLE NO 48**  
**Minimum C.I.L. values for Road Studs**

Entrance Angle	Observation Angle	C.I.L. in mcd/lx		
		White	Amber	Red
0° U 5° L&R	0.3°	220	110	44
0° U 5° L&R	0.5°	120	60	24

**44.2.6. Tests**

Co-efficient of luminance intensity can be measured by procedure described in ASTM E 809 “Practice for Measuring Photometric Characteristics” or as recommended in BS:873-Part 4 : 1973.

**44.3. Fixing of Reflective Markers or Road Studs or Cats Eyes.**

**44.3.1. Requirements**

The enveloping profile of the head of the stud shall be smooth and the studs shall not present any sharp edges to traffic. The reflecting portions of the studs shall be free from crevices or ledges where dirt might accumulate. Marker height shall not be less than 10 mm and shall not exceed 20 mm, and its width shall not exceed 130 mm. The base of the marker shall be flat within 1.3 mm. If the bottom of the marker is configured, the outermost faces of the configurations shall not deviate more than 1.3 mm from a flat surface. All road studs shall be legibly marked with the name, trade mark or other means of identification of the manufacturer.

**44.4. Placement**

The reflective marker shall be fixed to the road surface using the adhesives and the procedure recommended by the manufacturer. No nails shall be used to affix the marker so that they do not pose safety hazard on the roads. Regardless of the type of adhesive used, the markers shall not be fixed if the pavement is not surface dry and on new asphalt concrete surfacing until the surfacing has been opened to traffic for a period of not less than 14 hours. The portions of the highway surface, to which the marker is to be bonded by the adhesive, shall be free of dirt, curing compound, grease, oils, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive.

The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the of the marker in a quantity sufficient to result in complete coverage of the area of contract of the marker with no voids present and with a slight excess after the marker has been lightly pressed in place. For epoxy installations, excess adhesive around the edge of the marker, excess adhesive on the pavement and adhesive on the exposed surfaces of the markers shall be immediately removed.

**44.5. Warranty and Durability**

The contractor shall submit a two year warranty for satisfactory field performance including stipulated retro-reflectance of the reflecting panel, to the Engineer-in-charge. In addition, a two year warranty for satisfactory infield performance of the finished road marker shall also be given by the contractor who carries out the work of fixing of reflective road markers. In case the markers are displaced, damaged, get worn out or lose their reflectivity compared to stipulated standards, the contractor would be required to replace all such markers within 15 days of the intimation from the Engineer-in-charge, at his own cost.

**44.6. Measurement**

The measurement of reflective road markers or road studs shall be made in numbers supplied and fixed at site.

**44.7. Rates**

The rates include the cost of all the material, labour, tools and equipments required in all the operation described above.

**ELECTRICAL SPECIFICATIONS:****1. Technical Specification for Compact / Package Secondary Substation****1.1. APPLICABLE CODE & STANDARDS:**

All equipment and material shall be designed manufactured and tested in accordance with the latest applicable IEC standards.

The 12KV Package Substation Design must be as per IEC 61330/62271-202.

The Package Sub-station offered shall in general comply with the latest issues including amendments of the following standards.

Particulars	Standards
High Voltage Low Voltage Pre-Fabricated Substation	IEC:61330/ 62271-202
High Voltage Switches	IEC 60265
Metal Enclosed High Voltage Switchgear	IEC 60298/IEC62271-200
High Voltage Switchgear	IEC 60694
Low Voltage Switchgear and Control gear	IEC 60439
Power Transformers	IEC 60076

**1.2. Applicable Service Conditions:**

The Package substation shall be suitable for continuous operation under the basic service conditions indicated below

Ambient Temperature: 50 Deg C

Relative Humidity upto 95%

Altitude of Installation upto 1000m

The Enclosure of High Voltage switchgear-control gear, Low Voltage switchgear-control gear & Transformer of the package substation shall be designed to be used under **normal outdoor service condition** as mentioned. The enclosure should take minimum space for the installation including the space required for approaching various doors & equipment inside.

**1.3. General Design Criteria FOR PACKAGE SUB-STATION**

**1.3.1.** The required Package Sub-station should consist of the following electrical equipment:

- SF6 insulated VCB Ring Main Unit – Motorized & Non extensible type
- Transformer, Oil Type
- LV Switchgear
- FRTU
- HT Metering

**1.3.2.** The design of the compact substation should enclose the above-mentioned equipment in one single continuous enclosure. No equipment shall be placed outside the CSS enclosure.

**1.3.3.** The equipment mentioned above can be accessed after opening the enclosure lockable doors

**1.3.4.** The prefabricated-package substation shall be designed for

- a) Compactness,
- b) Fast installation,
- c) Maintenance free operation,
- d) Safety for worker/operator & public.

The Switchgear and components of Package Sub-station shall be capable of withstanding all type of Stresses whether mechanical or electrical or developed due to short circuits (listed in ratings and requirements clause) without any damage or deterioration of the materials.

For continues operation at specified ratings temperature rise of the various switchgear components shall be limited to permissible values stipulated in the relevant standard and / or this specification.

#### 1.4. TENDER Specific Required

The main components of a prefabricated- package substation are Transformer, High-voltage switchgear-control gear, Low-voltage switchgear-control gear and corresponding interconnections (cable, flexible, bus bars) & auxiliary equipment. The components shall be enclosed, by either common enclosure or by an assembly of enclosure. All the components shall comply with their relevant IEC standards.

##### *Ratings*

Description	Unit	Value
Rated Voltage / Operating Voltage	kV rms	11
<b>Rated frequency &amp; Number of phases</b>	Hz & nos.	50 & 3
<b>Rated maximum power of substation</b>	kVA	<b>630 KVA Oil Type Transformer</b>
<b>Rated Ingress protection class of Enclosure</b>	IP:	IP-23 for Transformer Compartment and IP:54 for LT & HT Switchgear Compartment.
<b>Rated temp Class of Transformer Compartment</b>		K10
HV Insulation Level		
Rated withstand voltage at power frequency of 50 Hz	kV rms	28
Rated Impulse withstand Voltage	kV peak	75
HV (RMU) & Bus bar		
Rated current on CB & Bus	Amp	630A
Rated short time withstand current	kA rms / 3 sec	21
Making capacity for switch-disconnector & earthing switches	kA peak	50KA
Breaking capacity of Isolators ( rated full load)	A	630A
LV Network		As per requirement in specs

## 1.5. SPECIFICATIONS FOR ENCLOSURE OF PACKAGE SUB-STATION

- 1.5.1. The outdoor enclosure shall be made of galvanized Sheet Steel suitable for local weather conditions
- 1.5.2. The enclosure shall be of partially modular design made of GI sheets fastened by riveting or bolting from the inside of the enclosure. The fastening shall not be visible on the outer surface of enclosure.
- 1.5.3. Excessive use of bolts for fastening on the front side of doors shall not be allowed. If bolting is employed for fastening it should be fastened from the inside of enclosure. This is to avoid corrosion.
- 1.5.4. The thickness of enclosure shall be 1.5 mm for non-load bearing members & 2mm for load bearing members.
- 1.5.5. The enclosure shall be powder coated or Wet Polyurethane paint as per manufactures standards.
- 1.5.6. The protection degree of the Enclosure shall be IP54 for LT & HT switchgear compartment & IP23 for Transformer compartment. Proper / adequate ventilation aperture shall be provided for natural ventilation by way of louvers.
- 1.5.7. The metal base shall ensure rigidity for easy transport & installation.
- 1.5.8. Substation will be used in outdoor application hence to prevent enclosure from rusting/corrosion, welding should be avoided. All equipment's to be fitted inside Enclosure only.
- 1.5.9. Considering the outdoor application of the substation the doors shall be provided with proper interlocking arrangement for safety of operator and to avoid corrosion door should have stainless steel hinges. Door should be provided with stoppers.
- 1.5.10. Interconnection between HT switchgear and transformer shall be using 1Cx3x95 sq.mm al. unarmoured XLPE cable and between transformer and LT switchgear shall be using Aluminium busbar.
- 1.5.11. **Internal Fault:** Failure within the package substation due either to a defect, an exceptional service condition or mal-operation may initiate an internal arc. Such an event may lead to the risk of injury, if persons are present. It is desirable that the highest practicable degree of protection to persons shall be provided. The Design shall be tested as per IEC61330/62271-202.
- 1.5.12. Type test report of arcing due to internal fault should submitted with offer .The Package substation shall be tested for internal arc test –AB for 20KA for 1 sec (A-operator , B-pedestrian). The manufacturer has to submit the internal arc 20KA / 1 sec type test report for customer verification, in event of order.
- 1.5.13. Covers & doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. Ventilation openings shall be so arranged or shielded that same degree of protection as specified for enclosure is obtained. Additional wire mesh may be used with proper Danger board for safety of the operator. All covers, doors or roof shall be provided with locking facility or it shall not be possible to open or remove them before doors used for normal operation have been opened. The doors shall open outward at an angle of at least 90° & be equipped with a device able to maintain them in an open position.
- 1.5.14. The locks employed for door locking or latch handle used for door locking should have an arrangement to cover them with metallic cover –to ensure that locks/latches do not rust due to exposed environment.

**1.5.15. Earthing :** All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation, by way of flexible jumpers/strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry. The components to be connected to the earth system shall include:

- a) The enclosure of Package substation,
- b) The enclosure of High voltage switchgear & control gear from the terminal provided for the purpose,
- c) The metal screen & the high voltage cable earth conductor,
- d) The transformer tank or metal frame of transformer,
- e) The frame &/or enclosure of low voltage switchgear

**1.5.16.** The earthing of the enclosure shall be done with copper of suitable thickness.

**1.5.17.** There shall be an arrangement for internal lighting activated by associated switch for HV, Transformer & LV compartments separately.

**1.5.18. Labels:** Labels for warning, manufacturer's operating instructions etc. shall be durable & clearly legible.

**1.5.19. Cleaning & Painting:** The paints shall be carefully selected to withstand tropical heat and rain. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling. **The enclosure shall be painted with wet polyurethane paint or Powder coated.**

## **2. TECHNICAL SPECIFICATION OF 11KV SF6 METAL ENCLOSED, INDOOR RING MAIN UNIT (VCB quenching)**

This RMU should be complete with all components necessary for its effective and trouble free operation along with associated equipment etc. such components should be deemed to be within the scope of supplier's supply.

**The RMU should be fixed type SF-6 insulated with Vacuum circuit breakers with O/C & E/F relay for the protection of the transformer. It should be maintenance free equipment, having stainless steel robotically welded IP67 enclosure. Vacuum Interrupter inside RMU should be of Own Make.**

### **2.1. STANDARDS AND REFERENCE DOCUMENTS**

#### **2.1.1. Codes and Standards**

The **RING MAIN UNIT (RMU)** should be designed, manufactured and tested to the latest version of:

- IEC 60694 Common specifications for high-voltage switchgear and control gear standards.
- IEC 62271-200 : A.C metal-enclosed switchgear and control gear for rated voltages above 1KV and up to and including 72KV and the IEC Codes herein referred.
- IEC 60129/ IEC 62271-102: Alternating current disconnections (isolators) and earthing switches
- IEC 60529 : Classification of degrees of protection provided by enclosures
- IEC 60265 High-voltage switches-Part 1: Switches for rated voltages above 1kV and less than 52 kV
- IEC 60056 : Circuit breakers
- IEC 60420 High-voltage alternating current switch-fuse combinations

- IEC 60185 Current transformers
- IEC 60186 Voltage transformers
- IEC 60255 Electrical relays

Any other codes recognized in the country of origin of equipment might be considered provided that they fully comply with **IEC standards**.

***The design of the switchgear should be based on safety to personnel and equipment during operation and maintenance, reliability of service, ease of maintenance, mechanical protection of equipment, as offered RMU shall be fixed and Non extensible type hence not applicable.***

## **2.2. RMU of the Package Sub-station should have following features:**

11KV SF6 INDOOR Ring Main Unit (RMU), comprising of 2 Nos. 630A Load break Switches, 1No. 630 A Vacuum Circuit Breaker with (3 O/C & 1E/F ) Relays. And 1 No. metering module.

The RMUs shall be motorized operator for LBS & VCB & can be connected to SCADA / DMS through F-RTU terminal

### **a) Load break switch (630A) - 3 Nos with Motorized operation**

Load break switch should have the following

- Manually operated 12 KV, 630A Load Break switch and Earthing Switch with making capacity
- "Live Cable" LED Indicators through Capacitor Voltage Dividers mounted on the bushings.
- Mechanical ON/OFF/EARTH Indication
- Anti-reflex operating handle
- Cable testing possible without disconnection of cables.
- Cable boxes suitable for 1 X 3C x 300 sq mm XLPE Cable with right angle Cable terminal Protectors.
- Cable boxes should be Arc Proof and interlocked with respective Earthing Switches. For safety of operator it should not be possible to open the cable box unless the earth switch is ON.

The ON-OFF operation of the load break switch shall be manually/motorized at local & operated through SCADA from remote

### **b) Circuit Breaker (630 A) – 1 Nos with motorized operation**

Circuit Breaker should have the following:

- Manually operated 630 A Vacuum circuit breaker and Earthing Switch with making capacity
- Mechanical tripped on fault indicator
- Auxiliary contacts 1NO and 1NC
- Anti-reflex operating handle
- "Live Cable" LED Indicators thru Capacitor Voltage Dividers mounted on the bushings.
- 3O/C + 1E/F self-powered relay with Low and High set for Over current and Earth Fault. Relay should have facility to display the maximum loaded phase current also. Relay should have facility to trip the breaker from remote commands without shunt trip coil.
- Mechanical ON/OFF/EARTH Indication
- The ON-OFF operation of the VCB shall be manual/motorized at local & operated through SCADA from remote.

### **c) Metering Module – 1 No**

Metering Module should have the following:



- Air insulated metering module 11kV, 630A.
- Potential Transformer with HT fuse on primary side and MCB on secondary side for protection.
- Primary voltage: 11000 : V3 V, Secondary voltage: 110:V3 V.
- Burden winding 1: 25 VA, Class winding 1: 1.0.
- Digital MFM
- Space heater with thermostat.

**IO list details required for F-RTU communication –**

Following is the list of I/O requirements for RMU Modules. Please note that all DI – DO should be potential free contacts.

- A. List of potential free contacts for Isolator (terminals shall be provided):
- a. Digital Indications:
    - i. Isolator ON – 2 NO and 2 NC
    - ii. Isolator OFF – 2 NO and 2 NC
    - iii. Isolator Earth Switch Status (ON/OFF)
    - iv. FPI Operated
    - v. Local Remote Switch Position
  - b. List of Commands:
    - i. Isolator Close
    - ii. Isolator Open
    - iii. FPI Reset
- B. List of potential free contacts for Circuit Breaker / Bus coupler (terminals shall be provided):
- a. Digital Indications:
    - i. Circuit Breaker ON
    - ii. Circuit Breaker OFF
    - iii. Auto Trip
    - iv. Local/Remote Switch position
  - b. List of Commands:
    - i. Circuit Breaker Close
    - ii. Circuit Breaker Open

## **2.3. TECHNICAL REQUIREMENTS OF FRTU**

### ***2.3.1. General***

The Feeder Remote Terminal Unit (FRTU) shall be installed for Ring Main Units (RMUs). FRTU shall be used for control of switching devices such as breaker, isolator inside RMU. FRTU & RMU should be of same make to have better integration.

### ***2.3.2. Design Standards***

The FRTUs shall be designed in accordance with applicable International Electro-technical Commission (IEC), Institute of Electrical and Electronics Engineer (IEEE), American National Standards Institute (ANSI), and National Equipment Manufacturers association (NEMA) standards, unless otherwise specified in this Technical specification. In all cases the provisions of the latest edition or revision of the applicable standards in effect shall apply.

### **2.3.3. FRTU Functions**

As a minimum, the FRTU shall be capable of performing the following functions:

- a) FRTU should be modular and DIN rail mountable with separate head unit and IO module. Head unit shall communicate upstream with control centre and downstream to IO modules. (IO module shall acquire hard wired digital input, digital output and analog Input). IO Module can be placed in RMU/LT Panel Unit supporting distributed architecture and can be connected on Ethernet Port with main FRTU panel so as to avoid or reduce the inter-panel control cable. These IO Module should be of DIN-Rail mounted only for convenience of mounting and maintenance in future.
- b) Receiving and processing digital commands from the master station(s)
- c) Data transmission rates 300 to 19200 bps for Serial ports for MODBUS. and 10/100 mbps for TCP/IP Ethernet ports
- d) Use of IEC 60870-5-101/104 protocol to communicate with the Master station(s)
- e) Use of MODBUS and IEC 61850 protocol over RS485 interface to communicate with MFTs / Protection Relays.
- f) Have required number of communication ports for simultaneous communication with Master station(s), MFTs and FRTU configuration & maintenance tool.
- g) FRTU shall have the capability of automatic start-up and initialisation following restoration of power after an outage without need of manual intervention. All restarts shall be reported to the connected master stations.
- h) Remote database downloading of FRTU from master station from SCADA/DMS control centre.
- i) As the SCADA/DMS system will use public domain such GPRS/CDMA etc, therefore it mandatory to guard FRTU data/ equipment from intrusion/damage/breach of security & hence FRTU shall have adequate cyber security features as per IEEE P1686, IEC62351.
- j) The FRTU shall support IEC 61131-3 PLC programming for for future automation design as incorporation of peer to peer communication & achieve Self Healing Grid (SHG) automation logic.
- k) The FRTU head unit shall have in-built web server facility for commissioning and maintenance with local and remote access compatibility with PC.
- l) One PT100 sensor input shall be directly taken in FRTU without any external transducer to measure temperatures, such as (ambient air or transformer oil).
- m) FRTU should be fitted in the factory & RMU/PSS operations shall be demonstrated during FAT.
- n) RTU shall support archiving of Status Events, Measurements, System Logs.

### **2.3.4. Communication ports**

The FRTUs shall have following communication ports to communicate with master station MFTs and configuration & maintenance terminal.

- The FRTU shall have one Ethernet port for upstream communication with Master station(s) using IEC 60870-5-104 protocol.
- The FRTU shall have one more TCP/IP Ethernet port for communication with third party field devices.
- FRTU shall have one Serial RS485 port for communication with MFT's to be connected in daisy chain using MODBUS protocol.
- FRTU shall have one port (Ethernet/USB) for connecting the portable configuration and maintenance tool for FRTU.

#### **a) Master Station Communication Protocol**

FRTU shall be able to communicate with SCADA on 2 channels. In case of redundancy the SCADA will activate the backup communication channel. The RTU shall accept communication with at least 4 SCADA simultaneously.

FRTU shall use IEC 60870-5-104/101, DNP3 as a communication protocol for communicating to master station. The FRTU shall support Secure Authentication according to IEC 62351-5.

**b) Communication Protocol between FRTU & MFTs / Protection Relays**

The FRTU shall acquire data from the MFTs using the MODBUS protocol.

The FRTU shall also be capable to communicate with IEC 61850 protocol either in server mode for the Scada or in client mode for devices like Protection Relays. The FRTU shall be capable to provide the data base as an IEC 61850 data model.

**c) Wifi Connectivity for local access**

An inbuilt wifi communication modem shall be offered in FRTU for local access via hand held devices (Tablet / smart phone / etc..). It shall be secured by means of

- Activation/deactivation from the Scada
- SSID visibility configurable
- Passphrase
- Automatic disconnection by timeout

**Cyber Security**

In order to secure all controls and data acquisition, the FRTU shall be designed to be compliant with NERC and IEC62351 requirements. The FRTU shall support secure access based on RBAC, with the possibility to configure the roles.

Local and Remote access connection shall be secured for maintenance through HTTPS, SFTP and SSH Protocols.

The FRTU should allow managing user authentication through a Radius server.

**a) Future proof design**

Remote firmware update

- The FRTU shall support remote firmware updates
  - o Centralised RBAC management
- The FRTU shall be evaluative in order to be compatible with a full centralised RBAC management in compliance with IEC 62351-8

**b) Hardening**

Device hardening

- Disabled or unused functionality shall not compromise security.
- Unnecessary services and programs shall be removed. If removal is not possible, the unnecessary services and programs shall be disabled.
  - Interface minimization
- Each interface shall support only the data types and protocols needed to meet the functional requirements.

- Unused interfaces and ports shall be removed. If removal is not possible, the unused interfaces and ports shall be disabled.
- A complete list of supported data types and supported communication protocols per interface shall be provided.
- All hardware interfaces that are used for programming or debugging shall be completely removed after production.

#### Account hardening

- The FRTU shall not contain active default, guest and anonymous accounts.
- All remote access to root accounts on the FRTU shall be disabled.
- All Vendor-owned accounts where feasible shall be removed.
- The list of all accounts on the FRTU shall be provided.

#### c) **Communication**

##### Compliance to security standards

The FRTU shall follow the IEC 62351 standards and at least:

- IEC 62351-5: 2013
- IEC 62351-3

#### d) **Configuration**

- Remote access connection shall be secured for maintenance shall be on web browser through HTTPS and SSH for Console and Configuration Tool.

#### e) **Access control**

- The FRTU shall support the implementation of Role-based Access Control in compliance with IEC 62351-8.
- It must be possible to configure the privileges of individual roles. It must be possible to carry out changes by configuration files through a secure way.
- It must be possible to define more roles for future applications.
- It shall be possible to assign each role individual security credentials.
- It shall be possible to bind roles to individual user accounts on the FRTU.

The minimum following function and data shall be controlled through RBAC:

- Configuration files
- Software update
- User management
- Executing program or shell command
- I/O on local maintenance access

A specific tool shall permit to configure the security policy, role and password.

#### **Management of Security passwords**

- The FRTU service application shall support individual user passwords.
- Passwords shall be stored together with a salt using an allowed cryptographic hash function.
- The FRTU service application shall enforce a high complexity of passwords.
- The FRTU shall lock the access after several password errors.

#### **User Authentication**

- The FRTU shall authenticate the communication parties on the WAN interface using a challenge-response protocol based on message authentication codes The FRTU shall terminate the connection if the user authentication fails.

- The FRTU shall authenticate the communication parties on the Local Maintenance interface.
- It shall be possible to configure the FRTU so that it blocks authentication requests, either temporarily or permanently, from an account after a number of failed login attempts. The number of failed login attempts and the time the account is blocked shall be configurable.

#### **Central management of user account**

- The FRTU should allow managing user authentication through a Radius server.

#### **f) Security Log**

- The FRTU shall provide a local audit trail for all security events that occur.
- Log files shall be produced in Syslog format.
- Security events shall be logged locally in a dedicated security log or/and on a SYSLOG server.

#### **g) Documentation**

##### **Secured Versioning**

- All released versions (hardware, firmware, software) of a device or product shall be uniquely identifiable.
- Exchangeable hardware modules shall be versioned separately.

##### **Design Documentation**

- The Protocol Implementation Conformance Statement as in IEC 62351 and IEC 60870-5-7 shall be provided on request.

#### **IO Acquisition module details:**

##### **Status input (32 DI capability in IO module)**

FRTU shall be capable of accepting isolated dry (potential free) contact status inputs. The FRTU shall provide necessary sensing voltage, current, optical isolation and de-bounce filtering independently for each status input. The sensing voltage shall not exceed 24Vdc.

##### **Sequence of Events (SOE) feature**

To analyse the chronology or sequence of events occurring in the power system, time tagging of data is required which shall be achieved through SOE feature of FRTU. The FRTU shall have an internal clock with the stability of 100ppm or better. The FRTU time shall be set from time synchronization messages received from master station using IEC 60870-5-104 protocol. SOE time resolution shall be 10 ms or better.

##### **Control Outputs (16 DO capabilities in IO module)**

The FRTU shall provide the capability for a master station to select and change the state of digital output points. These control outputs shall be used to control power system devices such as Circuit breakers, isolator, reset, relay disable/enable and other two-state devices, which shall be supported by the FRTU. A set of control outputs shall be provided for each controllable device. On receipt of command from a master station using the select check-before-execute operate (SCBO) sequence, the appropriate control output shall be operated for a preset time period which is adjustable for each point from 0.1 to 2 seconds. Each control output shall consist of one set of potential free NO contact. The output contacts shall be rated for atleast 0.2 Amp. at 24Vdc / 48 Vdc. These output contact shall be used to drive interposing relays. In case Control output module of FRTU does not provide potential free control output contact of this rating, then separate control output relays shall be provided by the contractor. These relay coils shall be shunted with diodes to suppress inductive

transients associated with energizing and de-energizing of the relay coils & shall conform to the relevant IEC requirements.

**a) Interposing control output relays**

The control output contact from the FRTU shall be used for initiating Interposing relays for trip/close of switching devices. The contractor shall provide Interposing relays. Each control output relays shall consist of atleast 2 NO contacts. The output contacts shall be rated for at least 8 Amps Continuous at 24Vdc and shall provide arc suppression to permit interruptions of an inductive load. Relay coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils. The relays shall conform to the IEC255-1-00 and IEC 255-5 requirements.

**b) Control Security and Safety Requirements**

The FRTU shall include the following security and safety features as a minimum for control outputs:

- (a) Select- check-before-operate operate (SCBO) sequence for control output.
- (b) No more than one control point shall be selected/executed at any given time.
- (c) The control selection shall be automatically cancelled if after receiving the "control selection" message, the "control execute" command is not received within the set time period.
- (d) No control command shall be generated during power up or power down of FRTU.

**c) Dummy breaker latching relay**

The Contractor shall provide a latching relay to be used to simulate and test supervisory control from the Master station. The latching relay shall accept the control signals from the FRTU to open and close, and shall provide the correct indication response through a single point status input.

**Analog Inputs (4AI capability in IO module)**

The real time values like, Active power, Reactive Power, Apparent power three phase Current & Voltage and frequency, power factor & accumulated values of import /export energy values will be acquired FRTU from the following in the given manner:

1. MFTs installed in RMU/DTs
2. FRTU shall also take 4-20 mA, 0-20mA, 0- -10mA, 0-+10mA, 0-5V etc as analog inputs to acquire DC power supply voltage etc.

FRTU should have capability to transmit Analog Data to SCADA in Cyclic mode as well as based on Event.

The measurement shall be spontaneously sent to SCADA according to configuration of :

- Threshold
- Dead band

**Contact Multiplying Relays (CMRs)**

Contact Multiplying Relays (CMRs) are required to multiply the contacts of breaker, isolators and protection relays etc. wherever potential free contacts shall not be available. The contacts of these relays shall be used to provide status inputs to the FRTUs. The relays shall be DC operated, self-reset type. The rated voltage for relay operation shall be on 24/48/110/220V DC depending on the station DC supply. The relay shall be able to operate for +/-20% variation from nominal voltage. The relay shall have a minimum of two change over contacts, out of which one shall be used for telemetry purposes. The contacts shall be rated to carry minimum current capacity of 5A. The relay shall conform to following requirement.

- a) Power Frequency withstand voltage—2KV for 1 minute as per IEC 255-5.
- b) Insulation Resistance of 100M ohms measured using 500V DC megger.
- c) 5KV Impulse test as per IEC 255-5

The relays coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils. The relays shall conform to the IEC 255-1-00 and IEC 255-5 requirements. The relays must be protected against the effects of humidity, corrosion & provide with a dust tight cover. The connecting terminals shall be screw type & legibly marked. The relays may optionally have a visual operation indicator. The relays are to be mounted in junction /termination box and therefore shall be equipped with suitable mounting arrangements. In case suitable space is not available in junction /termination box the same shall be mounted in FRTU panel.

#### **Time facility**

The internal FRTU time base shall have a stability of 100 ppm. The FRTU shall be synchronised through synchronisation message from master station at every 5 minutes (configurable from 5 minutes to 60 minutes) over IEC 60870-5-104/101/NTP/SNTP.

#### **Diagnostic Software**

Diagnostic Software shall be provided to continuously monitor operation of the FRTU and report FRTU hardware errors to the connected master stations. The soft-ware shall check for memory, processor, and input/output ports errors and fail-ures of other functional areas defined in the specification of the FRTU.

#### **Power Supply**

The FRTU and RMU shall include a common power supply unit which integrates a 24Vdc battery charger.

##### **a) Power supply input**

Input voltage: 230V AC  $\pm$  20%

The power supply shall be protected for Input Overvoltage. It should cut off if voltage goes above range of 295-300VAC. It should restart after normal voltage resumption.

The power supply shall also be protected for Input Surge Voltage at 6kV for both differential and common mode.

##### **b) Battery (if not a part of RMU)**

The battery capacity shall maintain a backup time of 4 hours for all the voltage outputs and shall permit 10 Open/Close cycles of the switchgear.

##### **c) Monitoring**

The power supply shall deliver the following status to the SCADA

- Battery disconnected / Charger Fail
- Absence of power input / AC Fail
- DC Fail

Also, DC Voltage and DC Current of entire equipment with Switchgear should be monitored continuously by FRTU as Measurement/Analog value using DC Transducer with 4-20mA Output and transmitted to SCADA.

#### **Environmental Requirements**

The FRTU will be installed in inside RMU Panel or in open environment with no temperature or humidity control. The FRTUs shall be capable of operating in ambient temperature from 0 to +55 degree C with rate of temperature change of 20 degree C/hour and relative humidity less than 95%, non-condensing. FRTUs to be installed in the hilly region with the history of snowfall, the same the lower ambient temperature limit shall be -5 degree C.

#### **FRTU Size and Expandability**

FRTU shall be equipped for minimum (Basic + 20%) 32 Digital Inputs, 16 Digital Outputs & 4 Analog Inputs Hardwired point counts. It shall be possible to expand the FRTU capability for additional 20 % of the basic point counts by way of addition of hardware such as modules, racks, panels, , however, FRTU software and database shall be sized to accommodate such growth without requiring software or database regeneration.

#### **Archives**

FRTU Events shall be archived in logs.

FRTU Events shall be stored in the archive logs with a time resolution of 1ms, and a discrimination of 10ms.

The capacity of the logs shall be up to 200,000 events and measurement

All the logs shall be available from a maintenance tool connected to the FRTU or sent on request to the SCADA. The contain of the logs shall be configurable and the name of the logs sent to the SCADA shall be configurable. It shall be formatted as a .csv file.

#### **Type Test Reports for FRTU**

The following type test reports from NABL/Central Govt./Internationally recognized laboratory as per IEC or relevant standards with latest amendments not more than 10 years as on the date of opening of the bid shall be furnished.

##### EMC/EMI Immunity Test

- i. IEC 61000-4-2 Electrostatic discharge
- Level 3 : Passing Criteria A
  - i. IEC 61000-4-3 Radiated Field
- Level 3 : Passing Criteria A
  - i. IEC 61000-4-4 Electrical Fast transients
- Level 3 : Passing Criteria A
  - i. IEC 61000-4-5 Surge Immunity
- Level 3 : Passing Criteria A
  - i. IEC 61000-4-8 Power Frequency Magnetic Field
- Level 3 : Passing Criteria A

##### Environment Test

- i. IEC 60068-2-2 Dry Heat
- Continuous Operation at 55 Deg C for 16 hours: No Flashover or Breakdown.
  - i. IEC 60068-2-78 Damp Heat
- At 95% RH and 40 Deg C : No Flashover or Breakdown.

##### Insulation Test

- i. Power Frequency Voltage Withstand
- 1kVrms for 1 minute



- i. 1.2/50  $\mu$ s Impulse voltage withstand
- 2kVp
  - i. Insulation resistance

Measure Insulation resistance using 500 VDC Megger before and after Power Freq & Impulse Voltage withstand tests.

#### **2.4. Indoor RMU**

- Modular design, panel type with front cable access
- RMU must be made of robotically/TIG/MIG welded stainless steel with thickness of minimum 2 mm with all live parts inside stainless steel tank
- Maximum Modules can be accommodated in a single Stainless steel Tank so as to make it more compact and reliable.
- Cable covers must be interlocked with Earth switch to have complete safety of operating person. The cable bushings shall be Bolted / Pushfit type design as per manufacturer's standard practice.
- The HT RMU shall be completely housed inside the enclosure of IP54 rating. The operation of the RMU shall be only possible after opening the CSS enclosure door.
- **Vacuum Interrupter inside RMU should be of Own Make.**

#### **2.5. DIELECTRIC MEDIUM**

**SF6 GAS shall be used for the dielectric medium. Arc quenching should take place in vacuum** for 11KV RMU's in accordance with IEC376. It is preferable to fit an absorption material in the tank to absorb the moisture from the SF6 gas and to regenerate the SF6 gas following arc interruption. The SF6 insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering a simple go, no-go indication.

#### **2.6. GENERAL TECHNICAL REQUIREMENTS**

- 2.6.1.** Fixed type Vacuum breakers insulated in SF6 gas. It should be maintenance free, having stainless steel robotically welded enclosure for INDOOR RMU application.
- 2.6.2.** Low gas pressure devices- less than 1.4 Bar pressure. RMU should have full rating with Bar gas pressure.
- 2.6.3.** Live cable indicators- High operator safety.
- 2.6.4.** Fully Rated integral earthing switch for Switches and Breakers.
- 2.6.5.** Self powered Microprocessor Based 3O/C + 1E/F self powered relay with Low and High set for Over current and Earth Fault - Does not require any external source of power.
- 2.6.6.** Units fully SCADA Compatible. Retrofitting at site possible at a later date. Line switches (Load break switches) as well as T- OFF circuit Breaker can be operated by remote.
- 2.6.7.** Cable boxes should be front access and interlocked with earth switch. No rear access required.
- 2.6.8.** Cable testing possible without disconnection of cables.
- 2.6.9.** Compact in dimension / Dimension to be submitted with offer Low pressure, sealed for life equipment,
- 2.6.10.** Cable earthing switch on all switching device-standard, for operator safety.
- 2.6.11.** All live parts should be inside a hermetically sealed Stainless Steel

## **ENCLOSURE FOR INDOOR RMU.**

**2.6.12.** Indoor unit should be classified as sealed pressure system with gas leak rate of less than 0.1% per year requiring no gas filling for 30+ years of functional life.

### **Technical Parameters to be monitored from SCADA (Remote)**

- Ring switch/T Switch off status & operation
- Line status live/dead/earth
- Protection data (setting / events / fault-history)
- Equipment healthiness: Gas pressure, Trip Ckt healthy ,Number of operations

These inputs shall be hooked up to FRTU Terminal for further SCADA interface

## **TECHNICAL AND GUARANTEED PARTICULARS.**

The bidders shall furnish all guaranteed technical particulars as called for this specification.

## **2.7. DESIGN CRITERIA**

### ***2.7.1. Service conditions***

The offered switchgear and control gear should be suitable for continuous operation under the basic service conditions indicated below. Installation should be in normal indoor conditions in accordance with IEC 60694.

- Ambient temperature -10C to +40 deg C
- Relative humidity up to 95%
- Altitude of installation up to 1000m, IEC 60120

### ***2.7.2. General structural and mechanical construction***

The offered RMU should be of the fully arc proof metal enclosed, free standing, floor mounting, flush fronted type, consisting of modules assembled into one or more units. Each unit is made of a cubicle sealed-for life with SF6 and contains all high voltage components sealed off from the environment. The overall design of the switchgear should be such that front access only is required. It should be possible to erect the switchboard against a substation wall, with HV and LV cables being terminated and accessible from the front.

The manufacturer should submit the certificate of grade of stainless steel used during stage inspection / engineering

The cubicle should have a pressure relief device. In the rare case of an internal arc, the high pressure caused by the arc will release it, and the hot gases are allowed to be exhausted out at the bottom of the cubicle. A controlled direction of flow of the hot gas should be achieved.

The switchgear should have the minimum degree of protection (in accordance with IEC 60529)

- IP 67 for the tank with high voltage components
- IP 2X for the front covers of the mechanism
- IP 3X for the cable connection covers

**The RMU shall be internally arc tested for 20kA for 1 sec for the gas tank & Cable box chamber. Relevant type test reports should be submitted by the manufacturer.**

## 2.8. TECHNICAL DATA

### 2.8.1. Ring Main Unit, Electrical data

#### 2.8.1.1. Electrical data and service conditions

<b>No Rated voltage</b>	KV	<b>12KV</b>
1 Power frequency withstand voltage	KV	28
2 Impuls withstand voltage	KV	75
3 Rated frequency	Hz	50
4 Rated current busbars	A	630
5 Rated current (cable switch)	A	630
6 Rated current (T-off)	A	630

#### **Breaking capacities:**

7 active load	A	630
8 closed loop (cable switch)	A	630
9 off load cable charging (cable Switch)	A	10
10 earth fault (cable switch)	A	200
11 earth fault cable charging (cable switch)	A	115
12 Short circuit breaking current (T-off circuit breaker) kA		21
13 Rated making capacity	kA	50
14 Rated short time current 3 sec.	kA	21

#### **Ambient temperature:**

15 Maximum value	°C + 40
16 Maximum value of 24 hour mean	°C + 35
17 Minimum value	°C 0
18 Altitude for erection above sea level	4m ...1000
19 Relative humidity	Max 95%

### 2.8.2. Ring Main Unit Technical data(11KV) INDOOR

#### **General data, enclosure and dimensions**

1 Standard to which Switchgear complies	IEC
2 Type of Ring Main Unit	Metal Enclosed, Panel type, Compact Module.
3 Number of phases	3
4 Whether RMU is type tested	Yes
5 Whether facility is provided with pressure relief	Yes
6 Insulating gas	SF6
7 Nominal operating gas pressure	< 1.4 bar abs. 20° C
8 Gas leakage rate / annum %	0.1% per annum
9 Expected operating lifetime	30 years
10 Whether facilities provided for gas monitoring can be delivered	Yes, temperature compensated manometer
11 Material used in tank construction	Stainless steel sheet

#### **No Operations, degree of protection and colours**

1 Means of switch operation	separate handle
-----------------------------	-----------------

2 Means circuit breaker operation	separate handle and push buttons
3 Rated operating sequence of Circuit Breaker	O –3min-CO-3min-CO
4 Total opening time of Circuit Breaker	approx. . 40-50ms
5 Closing time of Circuit Breaker	approx. . 40-60ms
6 Mechanical operations of switch	CO 1000
7 Mechanical operations of CO earthing switch	1000
8 Mechanical operations of circuit breaker	CO 2000
9 Principle switch / earth switch	3 position combined switch
<b>Degree of protection:</b>	
10 High Voltage live parts,	<u>SF6 tank IP 67</u>
11 Front cover mechanisms	IP 2X for Indoor
12 Cable covers	IP 3X for Indoor
<b>Colours:</b>	
14 Front cover	RAL 7035
15 cables cover	RAL 7035

## 2.9. CIRCUIT BREAKERS

Vacuum bottles should be use as interrupters of the currents. **Vacuum Interrupter inside RMU should be of Own Make.** The circuit breaker main circuit should be connected in series with a three-position disconnect–earthing switch. The operation between circuit breaker and disconnect earthing must be interlocked.

Vacuum circuit breaker must self tripping and have self powered relay.

## 2.10. OTHER MAIN FEATURES

### 2.10.1. Bus bars

Comprising the 3 single phases copper bus bars and the connections to the switch or circuit breaker. The bus bar should be integrated in the cubicle Bus bars should be rated to withstand all dynamic and thermal stresses for the full length of the switchgear.

### 2.10.2. Earthing Switch

Earthing switches should be rated equal to the switchgear rating.

Earthing switches should be quick make type capable of making Rated Fault Current. Ear thing switch should be operated from the front of the cubicle by means of a removable handle.

### 2.10.3. The mechanisms

All mechanisms should be situated in the mechanism compartment behind the front covers outside the SF6-tank. The mechanism for the switch and the earthing switch is operating both switches via one common shaft. The mechanism provide independent manual operation for closing and opening of the switch, independent closing of the earthing switch and dependent opening of the earthing switch.

The mechanism for the T-off switch and earthing switch is operating both switches via one common shaft. The mechanism has stored spring energy and provide independent manual operation for closing and opening of the switch, independent closing of the ear thing switch and dependent opening of the ear thing switch. The mechanism for the vacuum circuit breaker (VCB) and disconnect- earthing switch is operating the VCB and the disconnect earthing switch via to separate shafts. The mechanism for the VCB has stored spring energy and provides independent

manual operation for closing and opening of the VCB. The mechanism has a relay with related CT's and/or remote tripping device. The mechanism for the disconnecter earthing switch provide independent manual operation for closing and opening of the disconnecter, independent closing of the earthing switch and dependent opening of the earthing switch.

#### **2.10.4. Front covers**

The front cover contains the mimic diagram of the main circuit with the position indicators for the switching devices. The voltage indicators are situated on the front panels. Access to the cable bushings is in the lower part of each module.

#### **2.10.5. Position indicators**

The position indicators are visible through the front cover and are directly linked to the operating shaft of the switching devices.

#### **2.10.6. Voltage indicator**

The voltage indicators are situated on the front cover, one for each module, and indicate the voltage condition of each incoming cable. Identification of the phases is achieved with labels L1, L2 and L3 on the front of the voltage indicators. The voltage indicator satisfies the requirements of IEC61243.

#### **2.10.7. Cable compartment**

The Cables access in the RMU shall be from the front.

The cable bushings shall be either bolted type or plug-in type or any other manufacturer design that can enable facility for site removal of bushings. The bushings shall be standardized type C interface for 630A current carrying suitability.

The detailed drawing of type C 630A rated bushing should be submitted during detailed engineering for verification, in event of order.

#### **2.10.8. Power connection.**

The cables are installed in the dedicated compartment below the mimic front cover. At the bottom of the cable compartment, an earthing bar system made of copper/GI with a minimum cross section of 120 mm<sup>2</sup> should be fitted. In each compartment the earthing bar should be fitted with 4 screws M10. The earthing system is connected to the tank by a copper/GI bar, which rises up to the connecting point of the tank behind the rear partition wall on the middle of the switchgear.

#### **2.10.9. INTERLOCKING**

The mechanism for the cable switch should be provide a built in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position.

The mechanism for the T-off switch should be provide a built in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position. The mechanism for the VCB and the disconnecter-earthing switch should be has a built in interlocking system to prevent operation of the disconnecter-earthing switch when the VCB is in the closed position.

Further is should not be possible to Open the Cable doors unless the Earthing Switch is Turned ON. In case the Cable door is accidentally left open a positive interlock shall prevent operation of Load Break Switch and Isolators / Breaker from any operation.

#### **2.10.10. Current Transformers**

All current transformers should be complying with IEC 60185.

Current transformers should be of dry type, with ratings and ratios as required.

Cable current transformers used in circuit breaker modules should be maximum 100mm wide. Current transformers used in metering cubicles should be having dimensions according to DIN 42600, Narrow type. Current transformer shall be placed in the cable covers so that it can be easily replaced at site without removing the bushings.

#### **2.10.11. Fault Passage Indicators.**

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU to avoid thefts. The FPI shall have clear display, automatic reset facility and shall be SCADA compatible.

### **2.11. TESTING AND CERTIFICATION.**

#### **2.11.1. TYPE TESTS.**

Units should be type tested in accordance with IEC standards 60056, 60129, 60265, 60298, 60420, 60529 and 60694. The following type tests should perform on the HT Switchgear and report should submit with offer.

- Short time and peak withstand current test
- Temperature rise tests
- Dielectric tests
- Test of apparatus i.e. circuit breaker and earthing switch
- Arc fault test
- Measurement of resistance of main circuit.
- Mechanical endurance test.
- Duty cycle test.
- Internal arc test for HT chamber.

Type test reports for above type shall be submitted with the offer.

#### **2.11.2. ROUTINE TESTS**

Routine tests should be carried out in accordance with IEC 60298 standards. These tests should be ensure the reliability of the unit.

**Stage Inspection of Vacuum bottle will be done during manufacturing stage.**

**Below listed test should be performed as routine tests before the delivery of units;**

- Withstand voltage at power frequency
- Measurement of the resistance of the main circuit
- Withstand voltage on the auxiliary circuits
- Operation of functional locks, interlocks, signalling devices and auxiliary devices
- Suitability and correct operation of protections, control instruments and electrical connections of the circuit breaker operating mechanism
- Verification of wiring
- Visual inspection
- Time travel characteristics measurement facility for Breaker should be available with the manufacturer to assess the quality of RMU.

### **10.0 Oil Type Transformer**

11KV/ 433 volt Volts distribution transformer shall be a part of packaged substation which will be housed in the enclosure.

The transformers shall be installed in hot, humid tropical atmosphere. All equipment accessories and wiring shall be provided with tropical finish to prevent fungus growth.

The transformers shall be capable of continuous operation of rated output under the operating conditions of voltage and frequency variations as per statutory limits governed by relevant Indian Standard and Indian Electricity Rules, 1956 / IEC with latest amendments in force.

Use of Prime Grade core, directly from reputed Manufacturers like Nippon / Posco/ AK steels, ensures high endurance of core. Fully automated core cutting line, that ensures uniform cutting of core resulting in low burr level and hence low core degradation ensures lower maintenance cost. Boltless, Step lap core design carried out automatically on Hydraulic Platform that avoids Multiple Handling thus ensuring low losses. Automated Foil Winding for LV coils that Make coil capable of withstanding higher thermal & mechanical stresses.

The two winding Power transformer shall be Mineral oil immersed transformers shall conform to IS 1180 (Efficiency Level) and shall have following specifications:

This specification covers design, engineering, manufacture; shop testing, inspection, painting, packing, and supply of Distribution Transformers complete with all accessories for efficient and trouble-free operation of the proposed Substation.

The design, manufacture and performance of equipment shall comply with all currently applicable statues, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility. The Quality of Raw material , Manufacturing process & design parameters should meet the requirement so as to ensure quality of transformers.

The equipment shall conform to the latest edition of applicable standards as follows. In case of conflict between applicable standards and this specification, this specification shall govern.

- IS 1180, for Tests & tolerance on Guaranteed Particulars
- IS:3639 for Fittings and Accessories
- IS:2099 for Bushings > 1000 V
- IS:7421 for Bushings < 1000 V
- IS:1271 for Electrical Insulation classified by Thermal stability

**Requirement:** 11000/433 Volt ONAN Transformer double wound, Dyn11, core type with Copper conductor. Oil immersed ONAN suitable for packaged substation housed in an enclosure with corrugated tank arrangement hermetically sealed.

**Voltage Ratio:** No load voltage 11000/433 volts within tolerance as stipulated in IS: 1180.

Insulating material shall be of proven design. The insulating materials shall be **class "A" for ONAN**

**Rating:** The transformer shall have a continuous rating as specified at any of the specified tapping position and with the maximum temperature rise specified. The rated KVA shall be the product of the rated voltage in kV, the corresponding rated current and the phase factor 1.73. When the transformer is operated with the rated primary voltage applied to the terminals of the primary winding, the apparent power (kVA) at the terminals of the secondary winding, when carrying the rated secondary current differs from rated kVA by an amount corresponding to the regulation of the transformer and is the product of the actual secondary voltage, the rated secondary current and phase factor 1.73.

**WINDINGS: -**

- i. Winding shall be made with 99.9% pure electrolytic grade copper, insulated with **thermally upgraded paper (Insulation Class A / Conductor Interturn insulation Class E)**. The HV & LV winding should be able withstand thermal and mechanical stress in the event of short circuit.
- b) Winding shall be carried in dust free area.
- c) The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture within the insulation.

**Temperature Indicator**

One set of winding temperature indicators with necessary current transformer, heating coil and a detector element and one set of oil temperature indicator with maximum reading pointer shall be mounted locally so as to be readable at a standing height from ground level. Each of the above indicators shall be provided with necessary contacts for alarm and trip.

**Connections:** H.V. Delta and L.V Star connected with neutral brought out on the secondary side for connection to earth; Vector group DYn11 of IS: 1180.

## **STREET-SCAPING WORKS**

### **PAVER BLOCKS FOR PAVEMENTS, CYCLE TRACKS AND PARKING AREAS**

For pavements and cycle lanes, providing and laying 60mm thick grey or coloured reflective rubber moulded M-35 Paver blocks over a bed of sand (min. 75mm thick). For car parking areas, providing and laying 80mm thick grey or coloured reflective rubber moulded M-30 Paver blocks over a bed of sand (min. 75mm thick). For bus bay area's areas, providing and laying 100mm thick grey or coloured reflective rubber moulded M-40 Paver blocks over a bed of sand (min. 75mm thick). Job includes spreading sand on excavated and compacted sub base / PCC bed, compacting sand by ramming and interlocking them with the use of a suitable plate vibrator, job includes all incidental works like cleaning the site of debris, etc.

The paver blocks supplied should adhere to the following requirements: Material – 60 mm (M-35)/ 80mm (M30)/ 100mm (M-40) thick (respectively, as stated above) Rubber Moulded Reflective Paver blocks rough finished conforming to IS-15658:2006 compressive strength and grade. Manufacturer Sirex or equivalent.

Where specified in plan, cycleways are also proposed in 100 mm thick M-20 RCC with minimum reinforcement.

***Scope of Work:***

Excavation and compaction up to 300mm depth for the whole area of pavements/ parking / cycle lanes as per drawing in all sorts of soil including removal and stacking / preserving of top 200mm of 'Top Soil' as per GRIHA standards for top soil preservation. Other loose soil / debris shall be removed / carted from site of excavation up to 5 km. The scope of work shall include supplying and laying of precast paver blocks, at site. Since the site is a public place, care should be taken to ensure that the routine activities shall not be disturbed. The job of laying may need to be carried out during night also for no extra cost. The work shall be executed to perfect line and level as per instructions of



Engineer in charge. Coloured concrete paver tiles shall be manufactured and shall adhere to clause 4.4 of IS 15658:2006.

The contractor shall guarantee that all materials and components designed, fabricated and supplied and laid by him shall be free of any type of defects due to faulty material / workmanship / laying / erection for a period of three years from the date of completion of work, which shall be considered defect liability period. Within this defect liability period, the contractor shall render free maintenance failing which the same shall be deducted for the retention cost as per contract. All modes of measurements shall be in Square meters.

### **GARDEN / GRASS PAVER BLOCKS FOR FOOTPATH AREA**

Providing and laying 60mm thick grey or coloured reflective rubber moulded M-30 Grass Paver blocks of 300 x 300 x 60mm or 600 x 400 x 60mm over a bed of Stabilized soil with mulch as per Landscape architects specifications (min. 50mm thick). Job includes spreading sand on excavated and compacted stabilized soil base over compacted sand / PCC bed as specified by Landscape Architect, compacting sand by ramming and interlocking them with the use of a suitable plate vibrator, job includes all incidental works like cleaning the site of debris, etc. Edge protection of paved area using concrete retaining curbs as per Engineers instructions. The paver blocks supplied should adhere to the following requirements:

Material – 60mm thick Rubber Moulded Reflective Paver blocks rough finished of M-30 conforming to IS15658:2006 compressive strength and grade of M-30 meant for light traffic as per Table 1 IS 15658:2006. Manufacturer Sirex or equivalent. Size 600 x 400 x 60mm or 300 x 300 x 60mm as selected by Architect / employer.

#### ***Scope of Work:***

- Excavation and compaction up to 300mm depth for the whole area of Footpath in all sorts of soil including removal and stacking / preserving of top 200mm of 'Top Soil' as per GRIHA standards for top soil preservation. Other loose soil / debris shall be removed / carted from site of excavation up to Municipal dumping yard or as specified by Engineer. The scope of work shall include
- Laying of stabilized soil using conserved top soil mixed with mulch as per specification and compacted using plate compactors to achieve minimum 95 percent Standard Proctor Density per ASTM D 698 for pedestrian areas. Verify subsoils have a permeability between 0.5 and 3.0 inches per hour.
- Verify that geotextiles, if applicable, have been placed in accordance to specifications and instructions of Engineer / Architect.
- Install edge restraints per the drawings and manufacturer's recommendations.
- Supplying and laying of precast Grass paver blocks, at site. Since the site is a public place, care should be taken to ensure that the routine activities shall not be disturbed. The job of laying may need to be carried out during night also for no extra cost. The work shall be executed to perfect line and level as per instructions of Engineer in charge. Coloured concrete paver tiles shall be manufactured and shall adhere to clause 4.4 of IS 15658:2006.
- The contractor shall guarantee that all materials and components designed, fabricated and supplied and laid by him shall be free of any type of defects due to faulty material / workmanship / laying / erection for a period of three years from the date of completion of work, which shall be considered defect liability period. Within this defect liability period, the

contractor shall render free maintenance failing which the same shall be deducted for the retention cost as per contract. All modes of measurements shall be in Square meters.

### **Concrete/ Wall Bench**

Concrete Bench Shall as per Approved Drawings. Sitting platform size - 1800 mm length X 450mm width X 50 mm Leg size - 400mm Height X 450mm Width X 150mm .Sitting height is 450 mm (overall) It has to accommodate 3-4 persons comfortably It shall be placed on footpath in a way that the pedestrians pass-by without disturbing the user Materials All components are manufactured using M-30 grade of Concrete using vibro compaction process. All parts shall be joined together with galvanized nuts & bolts of suitable size and all bolts are sealed after assembly.

### **Bollards**

Bollards shall be installed at pedestrian crossing. The bollards are of concrete/cast iron / steel etc & shall serve the purpose of defining the edge of the road and guide pedestrians. Concrete Bollards of M-30 grade, by vibro compaction method using FRP/steel. The Foundation slab shall be made in min. M25 concrete. The bollards shall not be fragile and safely secured to its foundation. All bollards shall be of uniform shape, size, colour on the same width of the road. Overall Dimensions: 918 mm Height X 300 mm Dia. Suitable reinforced to promote long life and to prevent damage during handling, transportation, & erection moulds, so as to achieve shuttering finish.

### **Tree Grate**

The Overall dimensions 1800mm x1800mm x 40/100mm thickness. Suitably reinforced for long use and to prevent damage during transportation & handling. Manufactured with M-30 grade of concrete using vibrocompaction process using joint less FRP moulds so as to achieve shuttering finish on five faces and gurmala finish on the top surface. A choice of standard colours and unlimited custom colours will match any natural stone finish or interlock pavers in the surrounding. The top surface of the tree grates shall be polished.

## **PLANTING AND LANDSCAPING**

### **Planting of Shrubs, Creepers, Ground Covers**

Plant material shall be well formed and shaped true to type and free from disease, insect and defect such as knots, windburn, sun-cold, injuries, abrasion or disfigurement. All plant materials shall be healthy, sound, vigorous with good foliage, and free from plant diseases, insect pests, or their eggs, and shall have healthy well-developed root systems. Plants supplied shall be conforming to the names listed on the plant list. No plant materials will be accepted if branches are damaged or broken. All material must be protected from the sun and weather until planted.

Preparation of soil for grass, ground cover, edges, shrubs and flower beds: Then prepare the same soil with 23" thick layer of well decomposed, weed free farm yard manure or vermicomposting. Treat the soil with chlorophyriphos / Lindane / Neemcake depends upon the infestation of soil borne pests. Treat the soil with proper herbicide to control the weeds only on need basis. Finally level the soil as per the drawing or planting details.

Preparation of pits for shrubs, creepers and hedges : The bed shall be prepared with good earth mixed with 1/3rd quantity of decomposed farmyard manure along with a sampling of shrubs, ground

covers, lilies, suckering plants etc. as per design plant spacing – 30-60 cm. maintaining( application of liquid manures/ growth regulators/ pesticides as per need, weeding regularly so as to keep the plant healthy all the time) it for a period of 12 Months from the date of virtual completion of development work

Planting shrub/ground cover- Planting of shrub in the bed prepared earlier by filling garden soil and manure (67:33 ratio). Planting the shrub with root ball in the pit (tin grown / poly bag grown) after removing carefully and without disturbing the root. Pressing the soil firmly around the tree / shrub planted. Preparing the bed around the shrub and watering after staking and tying. Maintenance of shrub/ground cover up to 12(Twelve)months by regular watering and attending the inter-cultivation practices such as weeding, racking, watering gap filling, free of weeds by regular hoeing etc. The plant should be well maintained, disease free, well-trimmed at the time of handing over. In case of death of the plant the contractor needs to replace the same with equally well grown healthy plant. Nurture the shrubs/ground cover with organic solid manures and liquid manures, spray bio-insecticides, parasites, predators to protect the trees from pest and disease. Amend the soil on regular basis with proper soil amendments to keep the pH level between 7 - 7.5.

Planting hedges / edges - Planting of hedge / edge in the ground prepared earlier by filling garden soil and manure. Preparing a pit of require size (for accommodating the root ball of plant) Planting the plants in 2/3 rows (as per instructions) at root ball removed carefully and without disturbing the root ball from poly bag. Pressing the soil firmly around the plant. Preparing the basin for watering. Maintain hedge / edge up to twelve months by regular watering and attending the inter-cultivation practices such as weeding, raking, gap filling, trimming and pruning etc. The hedge / edge should be well maintained, disease free, well-trimmed at the time of handing over. In case of death of the plant the contractor needs to replace the same with equally well grown healthy plant.

Planting Ground cover - Planting of ground cover plants in the ground prepared earlier by filling garden soil and manure preparing a pit of require size in the ground. Planting the ground cover plant root ball at nine inches apart in the pit after removing carefully and without disturbing the root ball. Pressing the soil firmly around the plant preparing the basin around the plant watering. Maintenance of ground cover up to two months by regular watering and attending the inter-cultivation practices such as weeding, raking, gap filling, trimming and pruning etc. The ground maintained; disease free, well-trimmed at the time of handing over. In case of death of the plant the contractor needs to replace the same with equally well grown healthy plant.

## **Maintenance Schedule of Planting & Landscaping Works**

### ***General Obligations***

- a. The Contractor shall maintain the works for the maintenance period of twelve months from the date of completion.
- b. The extend of the landscape to be maintained by the Contractor shall be deemed to cover and include all softscape landscape areas within the overall project boundaries as shown on the drawings including any existing soft landscape not affected by the Sub-Contract works and retained intact or nearly so through the end of the Sub-Contract period as well as all the landscape works covered in the Sub-Contract scope of works. No additional charges will be allowed unless specifically agreed to by the Landscape Architect in writing.
- c. The Contractor's Horticulturist or Landscape Architect shall inspect the site every day and shall submit report to the Contractor on their actions and closure of the pending works. Also on weekly

basis, the Contractor's Horticulturist and Landscape Architect shall prepare a brief schedule of operations planned for the week with target dates.

d. The daily report and the weekly schedule shall be running record of proposed operations which would be checked at the maintenance inspections every month. If in the opinion of the Landscape Architect/Site- In Charge, the maintenance works have not been satisfactorily carried out according to site conditions and the specifications, the payment will be withheld until the works have been satisfactorily carried out besides the penalty as in the penalty clause.

i. The Contractor shall take all necessary measures to ensure that all pot plants, trees and shrubs and other plants shall thrive and become established within this period. All landscape areas will be inspected and list of remedial works issued after each inspection. All items on the remedial lists are to be carried out by the time of the next inspection.

ii. The Contractor shall keep the landscape areas clean and tidy at all times and dispose of all waste materials arising from the cleaning.

iii. If the Contractor's works are found to be unsatisfactory, payment shall be withheld and the maintenance period extended for the period of time that the landscape maintenance has not been satisfactory. All cost associated with the extension of time shall be borne by the contractor.

### **Maintenance of Planted Areas: Trees, Shrubs, Climbers, Herbaceous Plants and Groundcovers Including Lawn**

a. The Contractor shall water all trees, palms, shrubs, groundcover, herbaceous plants and other planting areas as often as necessary to keep the ground moist all around and to the full depth of the roots.

b. All planting beds are to be kept in a weed free condition with a weeding operation as per maintenance schedule or more regularly as required. All weeds, stones and rubbish collected from this operation shall be removed from the site by the Landscape Contractor.

c. Firming up and adjusting of stakes/ties shall be carried out monthly to ensure that the trees and shrubs are firmly held in ground. If required, guy ropes or tree ties shall be adjusted, tightened or loosened. If tree ties or ropes are rubbing the bark of the trees, the ties are to be taken off and retied. Any damaged branches are to be carefully pruned and the wounds sealed.

d. All protective fencing is to be maintained and kept in good condition as long as required on site.

e. All shrubs and groundcovers are to be reviewed monthly and pruned as and when required during the Maintenance Period to promote bushy growth and good flowering characteristics. The shrubs shall be checked and all dead wood, broken, damaged or crossed branches shall be cut back, depending on species.

f. The Contractor shall on continual basis supervise and attend to fertilizer needs/disease control/termite or fungus control as maintenance operations during the entire period of contract an approved fertilizer/insecticides/pesticide shall be applied to each plant.

g. The Contractor shall make regular weekly checks to ensure that the plant material is insect and pest and free.

## Maintenance of Lawn Areas

The lawn shall be trimmed and maintained properly without any weeds.

### *Details of Periodic Maintenance Activities*

SL. NO	OPERATION	FREQUENCY (TIMES)	PERIOD/DURATION AFTER HANDING OVER
1	Irrigation		As per Demand or as specified under
(a)	In Summer	15	Month- Every Alternate day
(b)	In Rainy Season	5 to 7	Monthly or as per climatic condition
(c)	In Winter	10	Monthly

### *Staking & Supports*

Stakes shall always be used when planting instant trees, standards and single stem palms and for tall shrubs as indicated in the drawings and the Stakes shall be mangrove poles, bamboo or equal and shall be appropriate to the size of the plant to be supported.

### *Protection Of Planted Areas*

The Landscape Contractor shall take all necessary precautions to prevent or eradicate any outbreak of disease or insect attack, The Contractor shall be responsible for protecting all planted areas. If it is necessary for the Contractor to erect temporary protective fencing, the Contractor shall be responsible for keeping the fencing in position and in good repair until the end of the maintenance period. Fencing proposals shall be submitted to the Landscape Architect for approval.

### *Maintenance Prior To Completion*

- i. After planting and prior to the onset of the maintenance period, the Landscape Contractor shall be responsible for carrying out all necessary measures to ensure that the plant material thrives and becomes established and that the landscape areas are kept in a clean and tidy condition.
- ii. The Contractor shall allow for carrying out the following maintenance operations when necessary prior to the onset of the maintenance period, all as specified in section 7 of this specification
  - Replacement of dead/missing plants
  - Grass cutting
  - Watering
  - Cultivation and loosening of soil
  - Weeding
  - Pruning and clipping
  - Firming up and adjustment stakes and ties
  - Eradication of pest or insect attack
  - Top drawing and mulching
  - Fertilizing
- iii. The Contractor shall be responsible for replacing any plants which fail to survive as a result of inadequate maintenance operations, poor workmanship or poor quality of plant material prior to completion
- iv. The Certificate of completion will not be issued until all plans scheduled on the Drawings and Schedule of Works are installed in a healthy condition in the manner specified.