

## **SCHEDULE-D**

**(See Clause 2.1)**

### **SPECIFICATION AND STANDARD**

#### **1. Construction**

The Concessionaire/Contractor shall comply with the Specifications and Standards set forth in Annex-I of this Schedule-D for construction of the Project Highway.

#### **2. Design Standards**

The Project Highway including Project Facilities shall conform to design requirements set out in the following documents:

Manual of Specifications and Standards for six Laning of Highways (IRC: SP: 87:2019), referred to herein as the Manual.

## Annex- I

### (Schedule-D)

#### SPECIFICATIONS AND STANDARDS FOR HIGHWAYS

##### 1. Manual of Specifications and Standards to apply

Four Laning of the Project Highway shall conform to the 'Manual of Specifications and Standards for **Highway**' published as IRC: SP: 87-2019 and with all amendments and additions *up to Bid date* (Referred to as "Manual" in this Schedule) and MORTH Specifications for Road and Bridge Works (5<sup>th</sup> revision). Where the specification for a work is not given, Good Industry Practice shall be adopted to the satisfaction of the Authority Engineer/ Independent Engineer.

As regards, the work of utility shifting, the relevant specifications, relevant rules, regulations and acts of Utility Owning Department/Agencies shall be applicable

##### 2. Deviations from the Manual

The terms "Concessionaire", "Independent Engineer" and "Concession Agreement" used in the Manual shall be deemed to be substituted by "Contractor", "Authority's Engineer" and "Agreement" respectively.

Not with standing anything to the contrary contained in the aforesaid Manual, the Specifications and Standards shall apply to the Project Highway, and for purposes of this Agreement, the aforesaid Manual shall be deemed to be amended to the extent set forth below:

Sl. No.	Description	Clause Referred in Manual	Deviations
1	Sight Distance (clause 2.1 & 2.10 (vii) of Schedule-B)	2.9.5	The Vertical design, at grade change viaduct shall be done using Safe Stopping Sight Distance to be followed for Km 366+095 to 366+397 & Km 367+504 to 367+714
2	Typical Cross Section (TCS) of the Project Highway (clause 2.10 of Schedule-B)	2.11	TCS-1,2,3,4,5,6,6A,7,8 to be followed
3	Width of service road (clause 2.8 of Schedule-B)	2.12.2	The width of service road is variable as per site, provision of clause 2.8 of Schedule-B to be followed.
4	Pile foundations	7.9.3	In addition to provision, 'Cross Hole Sonic Logging Test' for testing of piles as per ASTM D6760 and RDSP BS-41 R1 is to be carried out for Integrity Testing
5	Design Speed	2.2	Speed 80 kmph at Km 368+100 to 368+275 due to Overhead utility bridge pier protection.
6	Separator Width	2.17	Separator width has been limited to 0.75m.

2.1 MoRTH RW/NH- 35083 /09/2024-S&R (P&B) (Computer No.-241094) dated 03.10.2024 shall be followed.

### **3. Adoption of Automated & Intelligent Machine-Aided Construction (AI-MC)**

#### **3.1 Definition of Automated & Intelligent Machine-Aided Construction (AI-MC)**

Automated & Intelligent Machine-aided Construction (AI-MC) has been adopted to Highway Construction Projects to achieve better Construction Quality with respect to compaction in confirmation with IRC:SP:97-2013, in a Safer Environment. Construction Efficiencies of Construction Machineries are being enhanced through Location referencing. Automated & Intelligent Machine-aided Construction (AI-MC) involves using Construction Equipment mounted with on-board Computers, using a combination of 3D Modelling Data along with Global Navigation Satellite System (GNSS) / Universal Robotic Total Station (URTS) Technology and Intelligent Guidance to control the manoeuvring of Construction Equipment. AI-MC provides Horizontal and Vertical Guidance in real time to Construction Equipment Operators. AI-MC Equipment has the potential to achieve designed Grades on the First Pass, without assistance of traditional staking.

#### **3.2 Obligations of the Concessionaire**

The concessionaire/contractor shall deploy at its own Cost and Expenses, the Grading/Paving/Compaction Equipment fitted with System of Automated & Intelligent Machine-aided Construction (AI-MC) for finishing of all Grades including Embankment, Subgrade, GSB, WMM, DLC, PQC. The System of Automated & Intelligent Machine-aided Construction (AI-MC) used by the Concessionaire/Contractor shall be capable of delivering accuracy as per the applicable IRC specifications. During the Construction Period, the Concessionaire/Contractor shall furnish all the Physical Progress Data (All desired type of Surface Grading Data, Compaction and Temperature Data etc.) obtained through System of Automated & Intelligent Machine-aided Construction (AI-MC)/CMS to Authority for monitoring of Construction on Daily Basis. These Digital Data and desired output shall be made available at the Location Server/(Cloud) finalised by Authority. Detailed specifications of this Technology is elaborated in subsequent Paras.

#### **3.3 Construction of the Project (detailed specification)**

Contractor/Concessionaire shall use 3D Digital Models and Automated & Intelligent Machine-aided Construction (AI-MC) for Motor Graders, Paver, Compactors and Dozers to ensure Quality Standards as per IRC Specifications and Productivity improvement. The Contractor shall generate measurable Digital Records that can be shared on a Digital Drive or Server. It shall be ensured that the Hardware and Software used by the Contractor shall have following Features and Specifications:

##### **1. Centralized Monitoring Software (CMS) for Preparing Design Data for Field Systems and Processing Results:**

A contractor/Concessionaire shall use appropriate (Design/Working) Software 3D Constructible Model from the approved Design Data, which can be carried in "Construction grade survey instruments and 3D machine control tools for construction purpose. The software shall be able to generate Triangulated Surface Models, 3D Line Works, and shall have the ability to Guide Machine, based on Design Data and also generate the Reports. There shall be provision to feed tolerance limits or desired passes for comparing with Final Results. The cloud-based Software shall be capable of Record Creation, Compilation, Exporting, Presenting in Graphical Format with Colour Coding showing different activity and Generate Report showing Location/Stretches where the work done is not conforming to limits/tolerances prescribed in Specification. The Non-conformity Report should be generatable for any selected Stretch in Tabular Format. Some of the Non-conformity/Conformity to be displayed includes:

- Location where the thickness of each layer (Embankment/Subgrade) is more than specified limit from prevailing finalised layer width with its clear location, to meet the requirements as per clause 305.3.5.1 of MoRTH Specification.
- Number of Passes Made with respect to Target Number of Passes for the compactors to achieve the compaction requirement of respective layers as per section 305 & 903.2 of MoRTH (Table 300-1 and 300-2).
- Weak spot w.r.t. Intelligent Compaction Measurement Value (ICMV), in conformity with clause 4.3.3.2 of IRC: SP:97-2013 (page 23), to bring the conformity as per section 305 & 903.2 of MoRTH (Table 300-1 & 300-2).
- Granular/Bituminous layer beyond the tolerance limits, as specified in clause 902 (Table 900-1) of MoRTH Specification.
- Laying and Rolling Temperature achieved by Asphalt Paver/Compactor/Pneumatic Rollers, with respect to specified minimum Target Temperatures as per IRC guidelines (clause 507 of MoRTH Specification; clause 4.4.3 of IRC 27-2009 for BM; clause 5.2.1 of IRC:SP:97-2013).

#### **ii. Automated & Intelligent Machine-aided Construction (AI-MC) System for Motor Grader for Accurate Grading to Design**

A contractor/concessionaire shall utilize Motor Grader controlled with GNSS Machine Control System in the Construction of Embankment, Subgrade & GSB Surface Grades. The requirement includes the finishing of Final Surface level of Embankment, Subgrade & GSB as per Clause 902 of MoRTH Specification.

In respect of Embankment layers, the Motor Grader shall be equipped with requisite instrumentation to set the desired level and inclination of blade automatically as per the design profile.

The contractor may use any type of GNSS/GPS/Universal Robotic Total Station type Machine Control System that results in achieving the Finished Design Profile for each earthwork layer. The 3D Machine Guidance and Control System shall be able to guide and assist the operation of the Motor Grader to follow the 3D Model output derived from the design.

The 3D Machine Control Systems shall have requisite instrumentation to execute Earthworks as Driven from Design Data. Machine Guidance & Control System shall have features to show and overlay required Field Design Data on Display Panel installed in Equipment with On-board Intelligent Monitoring Software. Data shall have at least the following information:, Date & Time Stamp, Location, Work Performed, Pass Count, Roller Speed, Temperature, Moisture, Elevation, Moisture Grade/GSB Name, Motor Grader Pass Number, Author/Manual.

#### **iii. Automated & Intelligent Machine-aided Construction (AI-MC) System for Pavers**

A Contractor/Concessionaire shall utilize Paving equipment controlled by Universal Robotic Total Station and Machine Control System in the Construction of Roadway Pavement for Automatic Control of Elevation and Slope. The requirement includes the finishing of Final Pavement surface as per the MoRTH Specification Clause 902.

Machine Guidance & Control System shall have provision to Show and Send required Fields Coverage Data for each Data Point in Dashboard/Office Monitoring Software. Data shall have at-least like this information: Date & Time Stamp, Easting, Northing and Elevation.

#### **iv. Automated & Intelligent Machine-aided Construction (AI-MC) System for Compactors**

The Automated & Intelligent Machine Guidance System on Compactor shall allow Operator to monitor the Number of Passes completed in real time for every layer of Embankment, Subgrade,

GSB or asphalt-based Items against a Target Pass Count. It should have provision to send required Fields Coverage Data for each Data Point for all Passes and Provision to show in Dashboard and Send the Data to CMS. Data shall have at least following information:

Date & Time Stamp, Longitude/Latitude, Easting/Northing, Local Easting/Local Northing, Height on the Ground above WGS84 Geoid/ Elevation/Local Elevation, GNSS Mode, Compactor Pass Numbers, Compactor Direction (Forward/Reverse), Compactor Speed, Vibration ON (YES/No, On/Off), Frequency, Amplitude, ICMV (Required for roller instrumented with Accelerometer).

**v. Automated & Intelligent Machine-aided Construction (AI-MC) System for Capturing of Temperature (T)**

There shall be an equipment to capture the temperature of the asphalt-based items during the Laying and Rolling process. The same should be reflected and captured in Machine Guidance System of the Paver and Rollers and shall be sent to Monitoring Software for further reporting and analysis in the following information:

Date & Time Stamp, Longitude/Latitude, Easting/Northing, Local Easting/Local Northing, Surface Temperature (Required for Tandem Roller instrument with Temperature Sensor).

**vi. Data/File transfer from CMS from Automated & Intelligent Machine-aided Construction (AI-MC) System.**

CMS should have the ability to send Design updates to all the equipment's in the Field ensuring that same Design Data is used by all equipment's. It should accept Field Data for Validation and Demonstration Process. It shall be capable for exporting the data to the any Highway Modelling Platform for demonstrating the Progress of Construction on real time basis by exposing the requested Data through API for further use like Scheduling, Billing, and Progress etc.