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4. METHODOLOGY

4.1 GENERAL APPROACH

Various engineering surveys and investigations have been carried out on the Project Road strictly following the relevant specifications mentioned in MoRTH/ IRC/ BIS Codes to generate adequate database for preparing the most appropriate proposal for the (i) Silchar ISBT (Start point of Silchar Bypass) to junction of NH-37 & NH-6 at Dhaleshwari, (ii) End of proposed Badarpur bypass to Churaibari (Assam-Tripura border), (iii) Spur from NH-8 near Karimganj to Sutarkandi.

Various engineering surveys and investigations carried out are listed below:

- Alignment Study
- Topographic Surveys
- Road Inventory and Condition survey
- Traffic Surveys
- Inventory and condition survey of bridges and culverts
- Hydraulic and Hydrological Investigations
- Pavement Investigations
- Soil and Material Investigations
- Sub-soil Investigations

4.2 RECONNAISSANCE AND ALIGNMENT STUDY

- In-depth study of the available land width (RoW), study of topographic maps of the project area was made and other available relevant information has been collected concerning the existing alignment and the vicinity of the project corridor.
- The detailed ground reconnaissance has been taken up immediately after the study of maps and other data. The primary tasks of reconnaissance survey include:
- Topographical features of the area.
- Typical physical features along the existing alignment within the RoW for understanding land use pattern along the project stretch.
- Possible alignment alternatives, vis-à-vis, scheme for the construction of additional lanes or paved shoulders parallel to the existing road to the left or right or central widening.
- Provision of the interchanges and underpasses for vehicle/pedestrian/animal crossing
- Traffic pattern and preliminary identification of traffic homogeneous sections.
- Identification of sections passing through congested areas.
- Critical areas requiring detailed investigations.
- Requirement for carrying out supplementary investigations.
- Soil (textural classifications) and drainage conditions.
- Type and extent of existing utility services along the alignment (within RoW).

- Identification of various agencies of the Govt. from whom the concerned project clearances for implementation are to be sought.
- General observations of the condition of existing pavement.

4.3 TOPOGRAPHICAL SURVEY

The basic objective of the topographic survey is to collect the essential ground features along the existing alignment and develop Digital Terrain Model (DTM). The equipment used for this purpose is the Mobile LIDAR. This data forms the basis for all the designs to be carried out, so as to take care of design requirements of new carriageway, possible improvements in highway geometrics, identifying areas of restriction and their remedies and relocation of utilities. The data collected will result in the final design and for the computation of earthwork and other quantities required. The detailed methodology including the various intermediate quality check procedures, control points and pillars, horizontal and vertical controls etc. have been described in detail, in the QAP, document submitted to NHIDCL.

4.3.1 Scope of Work

The detailed scope of services is enclosed in the contract agreement.

- Topographic Surveys along the Existing Right of Way (RoW):
 - Running a continuous open traverse along the existing road and realignments.
 - Fixation of Horizontal Intersection Points (HIP's), centre points, transit points etc.
 - Fixing reference pillars on either side of centre line at safe places within the RoW.
 - Establishment of Height Control by Auto Level.
- Detailed Topographical Survey to generate Digital Terrain Model of the defined corridor of the project road.
- Additional survey as required for geometric improvements like designing of Junctions and bypasses/realignment.

4.4 ROAD INVENTORY AND CONDITION SURVEY

4.4.1 Road Inventory

Road Inventory has been carried out for the Project stretch through dimensional measurements and visual inspection. The road inventory has been referenced to the existing kilometer & hectometer stones established along the roadside. The details of road inventory survey collected at every 100m, includes:

- Carriageway width
- Shoulder width
- Formation width
- Horizontal curve details and locations
- Height of fill and depth of cutting
- Cross road details

- Terrain
- Land use
- Details of drain condition
- Submergence, if any
- Existing drainage

4.4.2 Horizontal Curves

It is observed that the project highway has straight and curved alignments and traverse's majority of the stretch through plain and hilly terrain. Some horizontal curves are not confirming to acceptable geometric standards. The vertical gradients are gentle and the required sight distances are available as per the design standards.

4.4.3 Road Junctions

There are few major and minor junctions existing along the project road.

4.4.4 Road Condition

Road condition survey is conducted to evaluate the condition of pavement, shoulder and embankment.

4.4.5 Pavement Condition

- The criteria used for the pavement condition is, no cracking or rutting less than 10mm is classified as Good, rutting observed between 10mm to 20mm is classified as Fair and rutting more than 20mm or cracking exceeding 20% is treated as Poor. The major distresses are:
- Crack type (longitudinal, transverse, alligator and block), width (fine cracks <3mm and wide cracks >3mm) and as a percentage of total area.
- Raveling as percentage proportion per km.
- Pothole area as average Nos per km.
- Rut depth as average depth per km which is classified in three types-type I (<10mm), type II (10-20mm) and type III (>20mm)
- Edge fretting as average length per km.
- Material loss by checking the level difference between the paved surface and unpaved surface.
- Embankment condition and the material loss in the embankment.
- Drainage condition.
- The existing road condition varies from Good to fair.

4.5 TRAFFIC STUDIES AND ANALYSIS

The methodology and details of traffic studies and analysis are mentioned in detail, in Chapter-8, of this Volume-I.

4.6 INVENTORY AND CONDITION SURVEY OF STRUCTURES

Detailed inventory of the bridges has been carried out as per the guidelines stipulated in IRC SP: 35-1990 and the results of the inventory are presented in the format prescribed in IRC SP: 35-1990 in Annexures in Volume IIB.

4.6.1 Inspection of Bridges, Culverts and Causeways

- Preliminary inspection of the existing structures has been carried out by Sr. Bridge Engineer and data on the condition survey has been collected. Based on the condition survey of existing two-lane culverts, it has been decided whether they can be retained after carrying out repairs or not. In case any culvert is found to be beyond economical repair, it has been considered for reconstruction.
- Preliminary inspection of bridges has been carried out as per Appendix-4 of IRC SP: 35-1990 identifying the bridges which need attention for detailed inspection and further investigations. The bridges would be categorized as given below:
 - Those with minor defect, and
 - Those need further examination.
- Detailed Investigations can be done afterwards but Hammer test, inspection of bearings and other visual signs of distress are mentioned in separate report of each structure.
- All bridges showing signs of distress have been examined thoroughly as per Appendix-5 of IRC SP: 35-1990.
- The existing structures have been surveyed and data is collected on the following points:
 - Type of structure and details of span, vent height etc.
 - Existing width of structures.
 - Condition of sub-structure, super structure etc. and any deficiency required to be rectified.
 - Signs of silting and blockage of the vent way, need for change in invert levels if required after studying the present levels on both sides of culverts, over topping of the structure, observed scour level etc.
- Scouring below the pier locations and if sand is being excavated from the major bridge site had not been verified due to full flow of water. This will be verified during dry season while proposing sub-soil investigations.

4.6.2 Culverts

Various types of culverts found in the project road are:

Slab culverts / Box Culverts: Inventory data of existing Slab / Box culverts are examined to determine their present condition to assess the performance in future. These comprise of masonry / PCC abutments, wing walls, open foundations and RCC / Stone deck slabs. Structural Distress in deck slab, abutment and wing walls are examined. It is found that most of the slab culverts are in satisfactory condition and recommended for widening. Minor repairing

and strengthening works also suggested for the existing part of culverts. The list of Slab / Box / Pipe culverts and their improvement proposals are listed in structure inventory.

Pipe culverts: Detailed inventory of all the Pipe culverts was made and their condition survey was carried out to determine their present condition. Repair or replacement of culverts is called for when these are in distressed condition. Most of the pipe culverts are fair to good condition and are proposed for widening. Culverts having very poor condition are recommended for reconstruction with pipe diameter of 1200mm. The pipe culverts which have diameter less than 900mm are to be replaced with 1200mm diameter pipes keeping in view the constraints and inadvertences of maintenance. The list of Pipe culverts and their improvement proposals are listed in the condition survey report.

4.7 HYDRAULIC AND HYDROLOGICAL INVESTIGATIONS

4.7.1 Requirements for Hydraulic and Hydrological Investigation

The hydrological study aims at estimating the peak discharge of the flood generated by the run-off of rainfall within the catchment area. The hydrological study requires:

- Knowledge of the characteristics of peak rainfall in the regions
- Knowledge of the characteristics of the catchment areas
- Topographic data about the stream, upstream and downstream
- Survey of India topo sheets maps to a scale of 1:50,000 for identification of catchment area and its characteristics.

4.7.2 Data Collection

Topographic Survey Data: Topographic surveys will be done at all the major and minor river crossings with a view to obtain the cross section of the rivers at the centre line of the road and up to a reasonable distance at upstream and downstream. The High Flood Levels (HFL) will be obtained from existing flood marks/flood marks on Railway bridges or ascertained from enquiry with local knowledgeable persons.

Catchment Areas: The characteristics of the catchment areas will be ascertained from Survey of India topo sheets to a scale of 1:50,000 from which, catchment area at the proposed bridge site, length of the stream and fall in elevation from originating point to the point of crossing, could be determined. The slope of the stream will be determined from the contours on the topo sheets.

Rainfall Data: For rivers/streams having catchment area more than 25 sq. km, CWC Report No. C/16/1988 – Flood Estimation Report for Chambal sub zone 1(b), Flood Estimation Report for Upper Indo-Ganga Plains sub zone 1(e) in which the project site lies will be obtained. These Reports will be referred to determining the characteristics of peak rainfall regimes. These reports have been jointly prepared by CWC, MOST, Ministry of Railways and IMD and contain all the rainfall data required for estimation of design discharge of 25, 50 and 100 year returns periods by applying the Synthetic Unit Hydrograph approach, the parameters of which have

been indicated in the above report. For streams having a catchment area less than 25 sq km, IRC-SP-13 and RBF-16 have been referred to.

4.7.3 Hydrologic Design

The following methods will be used to estimate the peak discharge for bridge sites on major and minor streams:

- Rational Method
 - Synthetic Unit Hydrograph Method
 - Area-Velocity Method or Slope Area Method
- i. Discharge Estimation for the Catchment Areas Less than 25 Sq. Km (Rational Method) (Ref: IRC-SP-13 and BRIDGES AND FLOODS WING REPORT No. RBF- 16) This is a well-known method given in IRC: SP-13 and has been suitably improved as per report RBF-16 and is in use from many years.

Here, 50-year Peak Discharge is calculated by following formula

$$Q_{max} = 0.28fCIA$$

Where,

Q_{max} = design flood (m³/s) for 50-year return period

f = Areal Distribution Factor

C = runoff coefficient between 0 and 1.0

A = catchment area (sq.km)

I = mean intensity of rainfall in mm/h during the time of concentration (the time required for the most distant part of the catchment to Contribute to the outflow at bridge site)

Time of concentration has been taken from Bransby- Williams' formula as suggested in RBF-16:

$$t_c = 0.615 L / (A^{0.1} S^{0.2})$$

Where,

t_c = time of concentration (h)

L = mainstream length (km)

S = mean slope of mainstream (%)

A = catchment area (Km²)

Intensity of rainfall has been determined from formula $I = 2^*R / (t_c + 1)$

- ii. Synthetic Unit Hydrograph (SUH) Approach for Bridges having Catchment Area More than 25 Sq. Km

This method has been used for those bridges, which cater for more than 25 sq km of catchment area. In this method 1-hour Synthetic Unit Hydrograph is determined for an ungauged catchment. The following steps have been followed as suggested in CWC report for determination of discharge by this method.

- a) Physiographic parameters of the ungauged catchment viz. A, L and S will be determined from toposheets or field observations.
- b) SUH parameters will be computed using the equations set out in subzone manuals.
- c) The values calculated will be plotted to arrive at a unit hydrograph.
- d) The design storm duration is taken as equal to base period of unit graph.
- e) $(TB = 1.1 \times tp)$.
- f) Point rainfall is available in the given plate in CWC report for 50 year 24 hr rainfall.
- g) The areal rainfall of design storm duration is split into 1-hour rainfall increments
- h) Using time distribution coefficients.
- i) Estimation of effective rainfall excess unit will be done after taking design loss rate into account.
- j) Base flow will be estimated based upon the catchment area.
- k) Finally, for 50 year peak discharge, the effective rainfall excess after removing the losses from rainfall increments are arranged against unit hydrograph ordinates such that the maximum of effective rainfall is placed against the maximum UG ordinate, next lower value of effective rainfall against next lower value of UG ordinate and so on. Sum of the product of the above two added together with base flow gives peak discharge.

iii. Area Velocity Method/Slope Area Method

This method can be utilized to calculate the discharge from the stream cross-section and stream slope/bed slope at the proposed bridge sites, for both major and minor bridges. After plotting the cross section of the river, and marking the observed HFL, the cross-sectional area (A) and wetted perimeter (P) will be computed.

The velocity and Discharge are calculated using the Manning's formula:

$$V = 1/n R^{2/3} S^{1/2}$$

$$Q = A \times V$$

Where,

V = Velocity in m/sec

R = Hydraulic mean depth in m

S = Flood slope/bed slope

n = Co-efficient of rugosity

Q = Peak Discharge in cumecs

A = Area of cross section in sq.m

4.7.4 Fixing of Design Discharge

In general, the design discharge is taken as the highest of the discharges obtained from above methods. However, the general condition laid down in IRC SP-13 will be used to fix the design discharge, that is, if the discharge obtained by one method is greater than 1.5 times the discharge obtained from the other, the design discharge should be limited to 1.5 times of the smaller one. In the case where Average discharge obtained by Area Velocity method is higher

than 1.5 times the discharge obtained by the other method; design discharge has been taken as that of from previous method. Accordingly, the design discharge has been established for all the bridges. Also, in the case where area velocity method is governing case (i.e. discharge by catchment area method is lesser than the area velocity method) and the average discharge by area velocity method has been found lesser as compared to discharge by same at proposed bridge site, the discharge calculated at proposed bridge site has been considered as design discharge.

4.7.5 Afflux Calculation

Since some of the bridges in the alignment will have less clear waterway as compared to natural stream width and also velocities at bridge sites high due to steep bed slopes, this combined effect causes afflux at bridge sites during flood. Afflux for the bridges will be calculated using Weir and Orifice formulae as described in IRC SP-13.

4.7.6 Vertical Clearance

The vertical clearance for each structure will be calculated as per the standards set out in IRC SP-13.

4.8 MATERIAL AND GEO-TECHNICAL INVESTIGATIONS

4.8.1 Material Investigations

It has been ensured that all Geo-technical investigations confirm IRC, BIS codes and MoRT&H specifications. The Geo-technical investigation scheme has been prepared in accordance with the "Terms of reference". The Material investigations for road construction have been carried out to identify the potential source of construction materials and to assess their general availability, nature and quantum of materials available for the project. This is one of the most important factors for stable, economic and successful implementation of the project within the stipulated time frame. The investigation and testing of materials is carried out in accordance with MoRT&H, IS and IRC specifications.

Objectives:

The investigation into these material sources was carried out with the following basic objectives.

- Material investigation was carried out based on information collected from local PWD, Panchayat office, Zilla parishad office and from material suppliers along with public enquiry.
- Investigations have been carried out to identify and assess potential sources for bulk procurement of the following materials.
- Embankment fill material.
- Gravel for sub-grade
- Natural Gravel for GSB, if any
- Stone quarry for aggregate to be used for bituminous & non bituminous layers and GSB in case of non-availability of natural GSB

- Sand to be used for Cement Concrete
- Demarcating the location of source indicating place, kilometer stone and lead distance from the project road and the status whether it is in operation or new source.
- Identify the ownership of land/quarry, (Government or Private).
- Testing of materials to indicate the quality, classification and suitability of materials.
- To assess probable use of materials at various stages of construction activities, i.e. embankment fill, sub-grade, sub-base, wearing course and structures.
- During the process of investigation, due consideration has been given such that no material shall be selected from the right of way, at the same time locally available materials were selected for reducing the cost of construction.

4.8.2 Material Testing

The samples from various identified sources have been collected for laboratory testing as per IS & AASHTO standards.

(i) Interpretation of Test Results

The test results of soil samples have been presented as per IS:1498-1959. In addition to the tests already mentioned, soil samples to be used for sub-grade purpose shall be tested for soaked CBR in the laboratory on remoulded specimen compacted to 97 per cent Modified Proctor Density at Optimum Moisture Content. For this purpose, three individual specimens are subjected to different blows (10, 30 and 65) and CBR for each of the soaked specimen is determined. Actual CBR value corresponds to 97% of MDD is determined from a graph plotted between CBR and corresponding dry density.

The following tests have been performed on stone aggregate collected from various quarries:

Aggregate Impact Value

Specific Gravity

Water Absorption

Granular sub-base materials have been tested for its grading and Atterberg Limits. In addition, a soaked CBR test has been carried out following the standard procedure at 98% of modified Proctor Density. The sub-base material could be either natural granular material available in the quarries/borrow areas or shall be designed using crushed aggregates to meet the specific requirements of sub-base material as per MoRT&H specifications. The LL and PI of such material shall not be more than 25% and 6% respectively and soaked CBR value shall not be less than 30%.

For proper identification, index map and quarry charts, showing the following details will accompany the tables: Approximate Quantities and type of material available from each quarry source.

Location of each quarry and the distance up to the nearest link point of the Project Highway. The coarse aggregate for Wet Mix Macadam Sub-Base/Base shall be crushed stone

and confirm to MOSRT&H specification. Potential quarries have been identified in consultation with Forest dept/Mining dept. and shown in quarry charts. In case crushed gravel/shingle has to be used for advantage of availability and economy, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75mm sieve shall have at least two fractured faces.


4.8.3 Methodology for Conducting Sub-Soil Investigations

Geo-technical investigations are carried out with a view to furnish the Detailed Technical Information of the nature of sub-soil strata for foundation design and assessment of stability of high embankments.

4.8.4 Objectives and Scope of Work

The objectives of Geo-Technical Investigation are to evaluate the following:

1. To ascertain the sub-soil strata at structure locations.
2. To study standing Ground Water Level.
3. To study the physical and engineering properties of soil strata.
4. To evaluate allowable safe bearing capacity of soils to design foundations.
5. To recommend type and depth of foundation.
6. To recommend improvements to the weak soil strata if any.
7. To evaluate the stability of high embankment.
8. The Scope of Geo-technical Investigations includes the following field and Laboratory Tests.
 - a. Field Investigations
 - i. The scope of Field investigations is as follows:
 - ii. Boring of 150-mm dia holes in all kinds of soils up to refusal strata (N>100 Blows for 30 cms penetration) using Auger equipment.
 - iii. Boring of 150-mm dia Boreholes in all kinds of soils in Hard Rock whichever
 - iv. Encounter early using Calyx operated Rotary Boring Rig with Wash Boring Method.
 - v. Collecting Disturbed / Representative samples (DS / RS) during drilling and also
 - vi. During SPT Tests. Disturbed samples using the split spoon sampler and UDS samples using 100 mm thin-walled Shelby tubes shall be collected. The samples recovered will be packed in polythene bags, labelled and sent to the laboratory for testing.
 - vii. During field investigations, the standing Water Table levels will be studied and recorded in the Borehole log.
 - b. Laboratory Testing
 - i. The scope of Laboratory Testing is as follows:
 - ii. For Samples Obtained from SPT
 - iii. Grain Size Analysis as per IS 2720 part 4.
 - iv. For samples Obtained from UDS tube:
 - v. Specific Gravity as per IS 2720- part 3-Section 1 and IS 2720 – part 3
 - vi. Grain Size Analysis as per IS 2720 part 4

	Consultancy services for preparation of DPR and Pre-Construction services from (i) Silchar ISBT (Start point of Silchar Bypass) to junction of NH-37 & NH-6 at Dhaleshwari, (ii) End of proposed Badarpur bypass to Churaibari (Assam-Tripura border), (iii) Spur from NH-8 near Karimganj to Sutarkandi (Package-VII)	METHODOLOGY
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- vii. Atterberg Limits as per IS 2720 part 5, IS 2720 part 2.
- viii. Determination of natural moisture content as per IS 2720 part 2.
- ix. Determination of natural density as per IS 2720
- x. Determination of Tri-axial Shear Strength tests by UU and CU method as per IS 2720-part 10
- xi. For samples Obtained from Rock Cores:
- xii. Determination of Specific Gravity and Water Absorption of Rock Core Samples.
- xiii. Determination of Unit Weight and Classification of Rock Core Samples.
- xiv. Determination of Unconfined Compressive Strength of Rock Core Samples.

4.8.5 Contents of Geo-Technical Report

The report shall include in brief, the following contents:

1. The test procedure employed.
2. The sample calculation with reference to formula used to evaluate various parameters.
3. Summary of various soil parameters evaluated.
4. Type and character of soil.
5. Procedure of Investigation
6. Detailed bore logs, sub-soil strata, laboratory and field-test results.
7. Results obtained and their interpretation.
8. Recommendation for type and depth of formulation. Safe bearing capacity and settlement of the foundations adopted.
9. All recommendations shall be supported by a set of sample and back up calculations.
10. Any other information of special significance encountered during investigations shall be brought out in the Geo – Technical report.