

**Term of Reference for the Subsoil Investigation of Bridge Site
in Digboi-Pengri-Bordumsa Road under NEC****Introduction:**

The Digboi Pengri Bordumsa Namchik Mahadevpur Road connects Lohit District with Changlang, besides catering the interstate connectivity between Assam and Arunachal Pradesh. Hence this road forms the socio economic lifeline of the people of Arunachal Pradesh residing in the two districts. The total length of the road is 70.831 km of which 40.831 km is in Arunachal Pradesh. The up-gradation proposal of the road includes works of improvement of formation of the road, Pavement, cross drainage and bridge in the road. The scope of this works shall be limited to the subsoil investigation of the bridge site on the road portion in the Changlang District which is within the jurisdiction of the Executive Engineer Jairampur Division. There are 8 numbers of sites identified for construction of small to medium span bridge for which the subsoil investigation is intended for safety design of foundation.

A. Brief scope of work for Sub-Soil Investigation of Bridge Site:

- 1) Selection of Bridge site
- 2) Preparation of Index Plan
- 3) Preparation of Site Plan.
- 4) Preparation of Cross Section and Longitudinal Section of river bed.
- 5) Collection of hydraulic data.
- 6) Calculation of design discharge and Linear Waterway.
- 7) Fixation of approximate span of bridge.
- 8) Sub-soil exploration and determination of engineering properties of soil.
- 9) Determination of bearing capacity of soil.
- 10) Submission of Report.

B. Detailed scope of work

The detailed descriptions of the scope of works to be undertaken by the consultants in carrying of the works are as given below:

1. Selection of Site for the Bridge

The selection for the site of the bridge shall follow the guidelines given the IRC: 5-1998 Clause 102.2. Formal approval of the bridge alignment shall be obtained from the Superintending Engineer in charge of the works before starting of the subsoil investigations.

2. Preparation of Index Plan

The index plan shall locate the project area with the Capital city of the State and nearly major towns. It should give bird's eye view of the project area and the overall road network in the State. Small size road map of the State can be used for preparation of the index plan.

3. Preparation of Site Plan

Site Plan shall be drawn to Scale showing the details of the site extending not less than 100 meters on upstream and downstream from the center of crossing. It should cover approaches to sufficient distant. In case the river is meandering near the site of bridge, the site plan should cover at least two loops on either side. The site plan should also contain direction of flow of water, existing approach, angle of skew if any, location and value of permanent bench mark, location of cross sections and longitudinal sections taken and location of trial pit of boring.

4. Preparation of Cross Sections and Longitudinal Sections of river bed

At least three cross sections should be taken for small bridge namely one at selected bridge site, one at upstream and another at downstream of the site, all to horizontal scale of not less than 1 cm to 10 m and exaggerated vertical scale of not less than 1 cm to 1 m. However, more numbers of cross sections in upstream and downstream of the site is preferable. Normally the approximate distance in upstream and downstream of the bridge site upto which the plotting of cross sections shall extend shall as below (IRC: SP: 13:2004):

1. Catchment area upto 3.00 sq km – 100m
2. Catchment area 3.00 sq.km to 15.00 sq km – 300 m
3. Catchment area over 15.00 sq km – 500 m

Similarly, the longitudinal cross section of the river should also extend upstream and downstream of the proposed site of bridge as shown above.

5. Collection of Hydraulic Data

The collection of hydraulic data shall include collection of history of flood discharge, maximum HFL, maximum velocity of flood flow, river flow characteristics, rainfall intensity and catchments area and characteristics of catchments area. The general guidelines provided in IRC:5-1998 Clause 102.3 shall be followed in the collection of the hydraulic data.

6. Calculation of Design Discharge and Linear Waterway

The design discharge shall be calculated using minimum three methods as per the guidelines given in IRC: 5-1998 Clause 103. Similarly, linear water way shall be calculated based on the methods and the formula given in IRC: 5:1998 clauses 104.

7. Determination of span of bridge

The span of the bridge shall be fixed based on the provisions of IRC 5-1998 based on the linear waterway or based on the type of river bed and banks. The span arrangement shall be determined considering the suitable type of bridge in the locations in consultations with the Executive Engineer and Superintending Engineer of the Department who are the in charge of the work.

8. Determination of borehole locations

With the tentative arrangement of span as approved by the Executive Engineer and Superintending Engineer in charge of the works the borehole location for collection of sub-soil sample shall be decided. One boring at each proposed location of abutment and pier shall be done and the engineering properties of the sub-soil at the location shall be worked out as detailed in the next pages.

9. Sub-Soil Exploration and Determination of Engineering Properties of Soil

The boring for collection of sample shall be done at the proposed location of abutment and pier as per approximate span arrangement fixed.

The sub-soil investigation shall broadly consist of two stages, preliminary Investigation and Detailed investigation. In general the investigation procedure and collection of data shall follow the guidelines provided in IRC-78-2000. The scope of sub-soil investigation in brief are as below:-

(A) Preliminary Investigation

- (i) Preliminary investigation shall include the study of existing geological information, previous site reports, geological maps etc., and surface geological examination. These will help to narrow down the number of sites under consideration and also to locate the most desirable location for detailed sub-surface investigation.

(B) Detailed Investigation

- (i) Based on data obtained after preliminary investigations, the bridge site, the type of structure with span arrangement and the location and type of foundations, programme of detailed investigations, etc., shall be tentatively decided. Thereafter the scope of detailed investigation including the extent of exploration, number of bore holes, type of tests, number of tests etc., shall be decided in close liaison with the design engineer and the exploration team, so that adequate data considered necessary for detailed design and execution are obtained.
- (ii) The exploration shall cover the entire length of the bridge and also at either end a distance of zone of influence i.e. about twice the depth below bed of the last main foundation to assess the effect of the approach embankment on the end foundations. Generally the sub-surface investigations should extend to a depth below the anticipated foundation level equal to about one and a half times the width of the foundation. However, where such investigations end in any unsuitable or questionable foundation material, the exploration shall be extended to a sufficient depth into firm and stable soils or to rock.
- (iii) The scope of the detailed sub-surface exploration shall be fixed as mentioned in B(i) and B(ii). However, as a general guide it shall be comprehensive enough to enable the designer to estimate or determine the following:-
 - (a) Engineering properties of the soil / rock
 - (b) Location and extent of weak layers and cavities, if any, below hard founding strata
 - (c) The sub-surface geological condition, such as, type of rock, structure of rock i.e. folds faults, fissures, shears, fractures, joints, dykes and subsidence due to mining or presence of cavities
 - (d) Ground water level
 - (e) Artesian conditions, if any;
 - (f) Quality of water in contact with the foundation
 - (g) Depth and extent of scour
 - (h) Suitable foundation level
 - (i) Safe bearing capacity of foundation
 - (j) Probable settlement and probable differential settlement of the foundations
 - (k) Likely sinking or driving effort; and
 - (l) Likely construction difficulties.

(C) Method of taking soil sample

The size of the bores shall be predetermined so that undisturbed samples as required for the various types of tests are obtained. The method of taking samples shall be as given in IS:1892 and IS:2132. The tests on soil samples shall be conducted as per relevant part of IS:2720.

(D) Foundations Requiring Shallow depth exploration (Open Foundation)

These shall cover cases where the depth of exploration is not deep and it is possible to take samples from shallow pits or conduct direct tests like plate load tests etc. This will also cover generally the foundation soil for approach embankments, protective works etc.

- (i) Tests shall be conducted on undisturbed representative samples, which may be obtained from open pits. The use of plate load test (IS:1888-Method of Load Test on soils) is considered desirable for ascertaining the safe bearing pressure and settlement characteristics. A few exploratory bore holes or soundings shall be made to safeguard against presence of weak strata underlying the foundation. This shall extend to a depth of about 1½ times the proposed width of foundation.
- (ii) The tests to be conducted at various locations for properties of soil etc., are different for cohesive and cohesionless soils. **These are indicated below and shall be carried out wherever required according to soil type.**

Cohesionless Soils.**(a) Laboratory Tests.**

- (i) Classification test, index tests, density determination etc.
- (ii) Shear strengths by triaxial / direct shear etc.

(b) Field Tests.

- (i) Plate Load Test.
- (ii) Standard penetration Tests (as per IS:213)

Cohesive Soils.**(a) Laboratory Tests.**

- (i) Classification test, index tests, density determination etc.
- (ii) Shear strengths by triaxial / direct shear etc.
- (iii) Unconfined compression test (IS:2720 Part X)
- (iv) Consolidation test (IS:2720 Part V)

(b) Field Tests.

- (i) Plate Load Test
- (ii) Vane Shear Test (IS:4434)
- (iii) Static Cone Penetration Test (IS:4968 Part III)

Note: Where dewatering is expected, the samples may be tested for permeability (IS:2720 Part-XVII).

(E) Foundation Requiring Large Depth of Exploration

In this group are covered cases of deep wells, pile foundations. Where the use of boring equipment, special techniques of sampling, in-situ testing etc., become essential. In addition to the problems of soil and foundation interaction an important consideration can be the soil data required from constructions. Often in the case of cohesionless soils, undisturbed samples cannot be taken and recourse has to be made to in-situ field tests.

- (i) The sub-surface exploration can be divided into three zones:-
 - (a) Between bed level and upto anticipated maximum scour depth (below H.F.L.)
 - (b) From the maximum scour depth to the foundation level and
 - (c) From foundation level to about 1½ times the width of foundation below it.

- (iii) Sampling and testing (in-situ and laboratory) requirement will vary in each case and hence are required to be assessed and decided from case to case. The sub-soil water shall be tested for chemical properties to evaluate the hazard of deterioration to foundations where dewatering is expected to be required, permeability characteristics should be determined.
- (ii) For the different zones categorized in para-E(ii), the data required, method of sampling, testing etc., are given in **Table-1**. Samples of soils in all cases shall be collected at every 1 to 1½ metre or at change of strata.

Table-1.

Zones	Data Required	Sampling and Testing	Remarks including limitations.
Bed level to anticipated maximum scour depth	(i) Soil classification (ii) Particles size distribution	Sampling for (i) and (ii) disturbed samples may be collected. For (iii) and (iv) undisturbed samples shall be collected. Cohesionless soils – Dynamic Penetration Tests as per details in para-D. Cohesive Soils – (i) Static penetration Test-cone and skin resistance to be obtained. (ii) Field vane shear may be done. Laboratory Test (i) Classification Tests including particle size distribution. (ii) Shearing strength Triaxial tests to be done on undisturbed samples. Unconfined compression tests to be done on undisturbed and remoulded samples.	(i) Laboratory tests to be conducted according to the relevant parts of IS:2720. (ii) Undisturbed sampling cohesionless solids are a difficult and expensive process. In general, in such cases, in-situ tests may be adopted. (iii) Boring and sampling tends to cause remoulding of sensitized clays. Disturbance and stress changes for fissured or layered clays may also make the sample not truly representative of the in-situ condition. In such cases use of in-situ tests may give results more representative of the actual soil characteristics.
Maximum anticipated scour level to the foundation level	(i) Soil classification (ii) Shearing strength characteristics (iii) Compressibility (iv) Permeability where dewatering is expected. (v) Moisture content, density, void ratio	Same as above	Same as above

Foundation level to about 1½ times of the width of foundation below it.	i) Soil classification (ii) Shearing strength (iii) Compressibility	Same as above and consolidation test to be done on undisturbed samples.	Same as above
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9. **Determination of bearing capacity-**

Based on the field test and laboratory test, the consultant shall suggest a tentative type of foundation to be adopted and calculate the bearing capacity of the soil at various founding level.

10. **Submission of report-**

The report of the sub-soil investigation results shall be submitted in two stages viz Preliminary Report and Final Report.

Preliminary Report : The preliminary report shall consist of the broad background of the soil strata of the area, observation results of preliminary investigations and detailed sub-soil investigations. Site plan of the bridge site, proposed location of bridge axis and locations of each boreholes shall be indicated in the report. The overall presentation of the report shall conform to guidelines / specification provided in IRC-78-2000. The bore log chart and sub-soil profile shall be presented as per the guidelines in **Sheet-1 and Sheet-2 (enclosed) of IRC-78-2000** respectively. The relevant soil properties for design of foundation shall be listed distinctly supported by calculations wherever required.

Final Report : On approval of the preliminary report by the competent authority of the department, the final report shall be submitted covering all the information as required in preliminary report with the modifications or additional data suggested by the department.