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To

The Chief Engineers dealing with National Highways, and other Centrally financed Road and Bridge works in States/Union Territories

Subject: Preliminary soil investigations for high embankments at approaches to bridges

It is sometimes required to assess the feasibility of high embankments approaches to bridges at an early stage of project preparation e.g. when the various important features of the bridge-cum-approach project might be still tentative. In such cases, soil investigations for the approaches should be carried out on a preliminary basis, but simultaneously with the soil investigations for the bridge foundations and preferably through a common investigation agency. On the basis of the soil data so available, it is to be assessed whether the layout and cross sections of the approach embankments can be decided on a final or tentative basis. If the latter be the case, further detailed soil investigations may be required for finalising the design of high embankments. Such necessity will generally arise in case of important projects and/or problematic ground conditions.

2. In the light of the considerations mentioned above, "guidelines for preliminary soil investigations for high embankments at approaches to bridges" have been evolved in this Ministry and the same are enclosed herewith. It is suggested that these guidelines may be made use of for ensuring that the soil investigations required for approaches to bridges are carried out expeditiously and at an early enough stage of project preparation.

3. Suggestions for additions and alterations to the enclosed guidelines will be welcome.

GUIDELINES FOR PRELIMINARY SOIL INVESTIGATIONS FOR HIGH EMBANKMENTS AT APPROACHES TO BRIDGES

1. Scope and purpose

The purpose of preliminary soil investigations for high embankments is to assess the feasibility of high embankments at a stage when the various features of the bridge-cum-approach project might be still tentative and also to bring out the need or scope for more detailed investigations, where appropriate. To serve this purpose, the preliminary soil investigations for approaches to bridges should be carried out simultaneously with the initial sub-soil investigations for the bridge proper and through a common investigations agency. On the basis of the soil data so available, it is to be assessed whether the layout and cross-sections of the approach enbankments can be decided on a final or tentative basis. If the latter be the case, further detailed soil investigations will be called for. Such necessity will generally arise in case of important projects and/or problematic ground conditions. (Where soil investigations are being carried out after the alignment plans, longitudianal sections and bridge abutment positions have been finalised, these are to be treated as detailed investigatios for which the present guidelines will not apply).

2. Location of boreholes

There will be minimum two boreholes for each approach i.e. a total of four boreholes covering both side approaches. The borehole positions may be located along the centre line of the proposed alignment and at distances of approximately 50 metres and 120 metres behind the abutment positions on both sides. If the subsoil conditions revealed from the four boreholes as above are indicated to be weak and/or highly variable, locating additional boreholes for clarifying the subsoil conditions may be given consideration.

3. Depths of boreholes

The depth of the boreholes below the ground level may ordinarily be 2½ times the maximum height of the embankment, subject to a minimum depth of 20 metres. However, the boreholes can be terminated a shallower depths if continuous hard strata yielding N value in excess of 50 are encountered. The continuity of the hard strata should be verified by extending the boreholes into the hard strata by 2 to 3 metres.

4. Collection of undisturbed samples

Thin-walled sampling tubes of 100 mm internal diametre and 450 mm minimum length conforming to IS 2132-1972 (in respect of area ratio, clearance ratio and other characteristics) should be used for collecting undisturbed samples from boreholes. One sample may be collected for each change of strata.

In thicker strata, more than one undisturbed sample should be collected and in such cases, the depth interval between successive sampling levels may be 2.5 to 3.5 metres. No undisturbed samples need be collected form purely cohesionless strata or from hard strata yielding N-value in excess of 50.

5. Carrying out Standard Penetration Tests (SPT)

This test should be done (according to IS : 2131-1981) immediately after the undisturbed samples have been collected in the manner described in para 4 above. In cohesionless or hard strata from which undisturbed samples are not be collected (vide para 4 above), SPT may be done at 1.5 to 2 m depth intervals. The soil entering the SPT spoon should be taken out and visually inspected for taking note of physical appearance, structure (e.g. fissures and inclusions), etc. and preserved as distrurbed sample in airtight containers.

6. Laboratory tests on boreholes samples

Undisturbed and disturbed samples collected from the boreholes may be subjected to laboratory tests along the lines indicated in Annexure I.

7. Laboratory tests on fill materials

Representative samples of fill materials intended to be used for forming the approach embankments should be collected and subjected to laboratory tests along the lines indicated in Annexure II.

8. Borings at abutment locations

The results of soil investigations for bridge foundations are also to be utilised for assessment of high embankment feasibility and for correlating bridge and embankment features in the vicinity of

the abutment positions. Keeping this in view, it is important for the boreholes at abutment locations in particular, that the portion of the soil profile lying above the scour level is not excluded from the scope of sample collection and testing. In all other respects, soil investigations at the abutment locations may be done as appropriate from the point of view of bridge foundation requirements.

9. Soil investigation report

The soil investigtion report may generally be organised into sections comprising(i) general report and conclusions including brief description of equipments and methods used for boring, sampling and testing (ii) borehole plan, borelogs, field test data and pictorial representations of soil profiles, (iii) laboratory data and plots for borehole samples, and (iv) laboratory data and plots for fill materials, including borrow-area plan and brief description of collection of fill material samples.

10. Miscellaneous

i) In carrying out boring and sampling and in compiling borelogs, the relevant provisions of IS : 1982-1979 (Standard Code of Practice for Site Investigation for Foundations) should be complied with.

ii) If there be the cases where attempts made to collect samples or carry out field tests are found to be unsuccessful, the same should be reported with reasons in the borelog.

iii) The locations of the boreholes can be marginally adjusted (by say upto about 10 metres or so in any direction), if this is felt necessary in the light of local site conditions.

iv) Boring, sampling, field tests and laboratory tests should be carried out under the supervision of a specialist geotechnical engineer. It will be desirable to finalise the programme of laboratory tests after evaluating borelogs and field test data.

ANNEXURE - I

LIST OF LABORATORY TESTS TO BE CONDUCTED ON BOREHOLE SAMPLES

1. Tests on undisturbed samples

Undisturbed samples are those collected in 100 mm dia thin-walled tubes conforming to IS : 2132-1972. These should be tested in the laboratory for the determination of the following soil properties :

(i) Grain size analysis (as per IS :2720 Part IV-1975)

(ii) Natural moisture content (as per IS : 2720 Part II-1973)

(iii) LL & PL (as per IS : 2720 Part V-1970)
(For soils suspected to be organic in nature, by virtue of colour, odour, texture, etc., LL on fresh as well as on oven-dry specimens may be separately found out.)

(iv) Cc, Cv and Pc (preconsolidation pressure) from consolidation test (according to IS : 2720 Part XV-1965).

(v) C and $\varnothing$ from unconsolidated, undrained (UU) triaxial test (according to IS : 2720 Part XI-1971). Bulk density, void ratio and moisture content before/after UU test should also be determined.

2. Tests on selected undisturbed samples

Where the method of stage construction of embankment based on the effective stress method of design requires to be kept in view, selected and representative undisturbed samples should be further tested in the laboratory for the determination of the following soil properties :-

C^1 |$\varnothing$ and A-factor from consolidated undrained triaxial tests with measurement of pore pressure i.e. $\overline{CU}$ tests (according to IS : 2720 Part XII-1981). Bulk density, void ratio and moisture content before/after $\overline{CU}$ test should also be determined.

3. Tests on disturbed samples

Samples recovered from the SPT spoon should be retained in glass jars sealed air-tight. These samples may be treated as disturbed samples and should be tested in the laboratory for the determination of following soil properties :-

(i) Grain size analysis (according to IS : 2720 Part-IV-1975)

(ii) Natural moisture content (as per IS : 2720 Part II-1973)

(iii) LL & PL (as per IS : 2720 Part V-1970
(For soils suspected to be organic in nature by virtue of colour, odour, texture, etc., LL on fresh as well as on oven-dry specimens may be separately found out).

4. Special remarks

(i) Laboratory tests should be carried out in accordance with the prescribed ISI Specifications/Codes and under the supervision of a specialist geo-technical Engineer.

(ii) Full laboratory records (e.g. measured values, particle size distribution curves, stress-strain curves, Mohr circle plots, e-log P curves, e-log t curves, etc.) should be included in the soil investigatioin report.

(iii) While carrying out UU or $\overline{CU}$ tests mentioned above, the test specimens should be got saturated in the triaxial cell by applying suitable back pressure before shearing, if the undisturbed samples have been collected above the water table, or if there be any doubt otherwise about the state of sample saturation.

(iv) It will be desirable to finalise the programme of laboratory tests after evaluating borelogs and field test data. In case of any

doubts regarding the type and quantum of laboratory tests to be carried out, clarfications may be sought before carrying out the tests.

(v) The left-overs of samples, after testing, should be preserved till the design of embankments have been finalised and preferably till the construction has been completed.

(vi) The years of IS Codes.Specifications cited in paras 1 to 3 above are as per information available. In case these have been revised in later years, the provisions of the later revisions will apply.

ANNEXURE - II

LIST OF LABORATORY TESTS TO BE CONDUCTED ON FILL MATERIALS TO BE USED FOR FORMING HIGH EMBANKMENTS

1. Obtaining samples of fill materials

For each type of soil encountered within the likely depth of excavation in the selected borrow areas, two representatives samples of weight 30 kg each should be collected in cloth bags or in polythene-lined gunny bags. The exact locations and depths of the samples should be noted and shown on a borrow area plan. Corresponding to each 30 kg sample, one small sample from the selected location (of one kg. weight or so) may be collected in air-tight glass jars for the determination of natural moisture content.

2. Laboratory tests to be done

(a) Test to be done on each sample

i) Grain size analysis (as per IS : 2720 Pt. IV-1975)

ii) Natural moisture content (as per IS : 2720 Pt. II-1973)

iii) LL and PL (as per IS : 2720 Pt. V-1970)
(For soils suspected to be organic in nature by virtue of colour, texture, odour, etc., LL on fresh as well as on even-dry specimensmay be separately found out).

iv) Moisture-density relationship using light compaction, commonly known as Proctor test (as per IS : 2720 Pt. VII-1980).

(b) Strength tests on selected samples :

On the basis of tests conducted as per (a) above, the samples may be categorised into types, each showing the same or closely similar soil characteristics. One or two samples out of each category may be judiciously selected so as to be representative and subjected to the following tests :-

(i) For cohesive fill material (e.g. clay or clay mixed with silt/sand), C & $\varnothing$ may be determined from unconsolidated undrained (UU) triaxial test (according to IS : 2720 Pt. XI-1972) on specimens remoulded to 95% Proctor density at O.M.C. plus 2%.

(ii) If the fill material is cohesionless, $\varnothing$ may be determined from direct shear test (according to IS : 2720 Pt. XIII-1972) on specimens remoulded to 95% Proctor density at OMC.

(iii) For cohesive fill materials which may be used for forming embankments likely to be subjected to submergence and drawdown, effective stress parameters C and $\varnothing$ as also A-factor, may be determiend from consolidated undrained test with measurement of pore pressure i.e. $\bar{C}U$ tests (according to IS : 2720 Pt. XII-1981) on specimens remoulded to 95% Proctor density at OMC pluc 2%.The test specimens in the triaxial cell may be saturated by applying back pressure before shearing. This test will be in addition to that mentioned in (b) (i) above and may be carried out for selected few representative samples only.

(iv) For any of the types of strength tests mentioned above, the actual bulk density, void ratio and moisture content of the specimen before/after the test should be found out and recorded.

3. Special Remarks

(i) Laboratory tests should be carried out in accordance with applicable ISI Specifications/Codes and under the supervision of a specialist geo-technical engineer.

(ii) Full laboratory records (measured values, particle size distribution curves, moisture density plots, stress-strain curves, Mohr circle plots, etc.) should be included in the soil investigation report.

(iii) In case of any doubts regarding the type and quantum of tests to be carried out, clarifications may be sought before carrying out the tests.

(iv) The left-overs of samples, after testing, should be preserved till the design of embankments has been finalised and preferably till the construction has been completed.

(v) The years of IS Codes/Specificationscited in paras 1-2 above are as per information available. In case these have been revised in later years, the provisions of the later revisions will apply.