

# **IMPLEMENTATION OF HIGHWAY PROJECTS : GEOTECHNICAL ASPECTS**

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## **INTRODUCTION**

The metropolitan cities are facing problems of traffic and transportation (Gopal Ranjan 1996). Site investigation is the first crucial step in the design and construction of highways. A carefully planned and properly executed investigation can result in a greater degree of confidence in the design and realistic evaluation of highway performance in addition to cost effectiveness.

## **GEOTECHNICAL INVESTIGATION – THE NEED**

A thorough geotechnical investigation with proper interpretation of data is the basis for safe and stable structures (Sanjay Gupta, 1993). With the current trend for BOT/BOLT type contracts, the thrust is on superior, maintenance free performance, stringent design criteria and tight time schedules for completion.

It is becoming increasingly important, especially on highway projects, to relate engineering solutions not only based upon overall stability, but also have acceptance criterion based upon its anticipated performance for least maintenance. With the developments in the infrastructure sector, new areas are being linked with roads / highways catering to faster and heavier traffic passing through areas / lands which were considered as "*not build-able*" in the past.

For adequate performance of such highways, geotechnical aspects play a vital role. In many cases, the sub-base/subgrade is often more critical/important than bridges and flyovers. Hence, each section of the road should be carefully evaluated to identify potential problems so as to ensure long term performance.

## **CURRENT TRENDS ON HIGHWAY PROJECTS**

At present, geotechnical investigations are carried out as a part of the feasibility report, especially for bridges/flyovers, to provide preliminary input for foundation design as per MOST specifications. The foundation system in most of the cases are pre-determined prior to finalization of contract.

The detailed investigations are carried out subsequently. At that stage, it sometimes becomes difficult to modify the designs. Similarly, for roads embankments very little consideration is given to the soils supporting such structures.

However, now the trend is changing. At the time of feasibility surveys/reports itself, somewhat more detailed geotechnical investigations are performed especially for bridges / flyovers – but by the conventional methods of boreholes only.

## INVESTIGATIONS FOR BRIDGES

On fast track projects in the highways sector, there is a greater responsibility on the geotechnical engineer to ensure a greater reliability in the foundation design (Ravi Sundaram & Sanjay Gupta, 2000). In-situ tests add the extra push that is required to enhance the level of reliability of geotechnical prediction. They provide a better insight into soil behaviour and should be relied upon to a greater extent.

Some of the in-situ tests that can improve the quality of prediction of foundation behaviour are discussed below.

**Pressuremeter Tests:** This is an advanced state-of-the-art test. A probe with a rubber membrane is lowered into the borehole and expanded under pressure. The pressure- volume relationship is correlated to various engineering properties of the soils. The prediction of soil bearing capacity and settlement from pressuremeter data is more realistic than other available methods. Fig.1 presents the control panel and probe of a Menard's pressuremeter. Fig.2 presents typical results of a pressuremeter test.

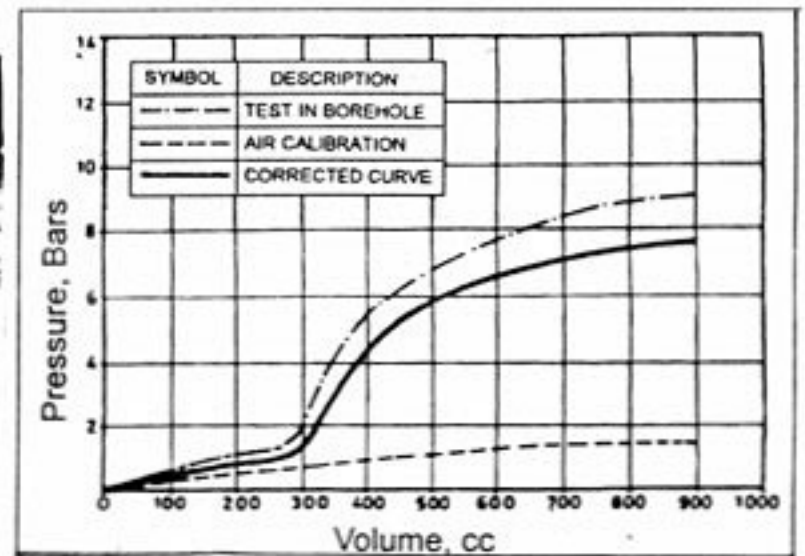
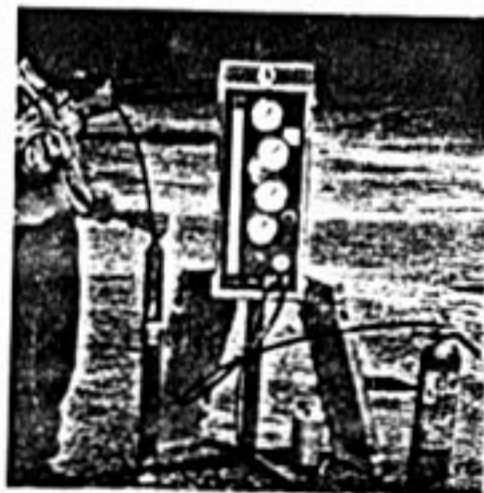
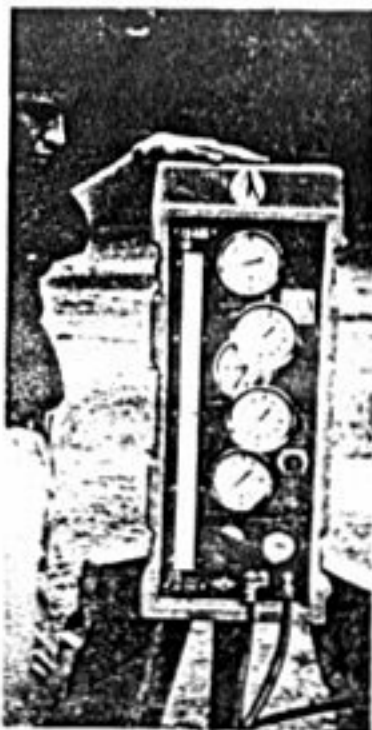


Fig.1 : The Pressuremeter Test Equipment

Fig.2 : Typical Results of Pressuremeter Test

**Static Cone Penetration Tests :** This test gives a continuous record of penetration resistance with depth and is useful to identify presence of soft layers, local variations etc. The cone tip resistance can be correlated to undrained shear strength of clays and density condition of sands. It can provide better assessment of bearing capacity

and settlement, pile capacities etc. Fig. 3 presents a static cone penetration test in progress.

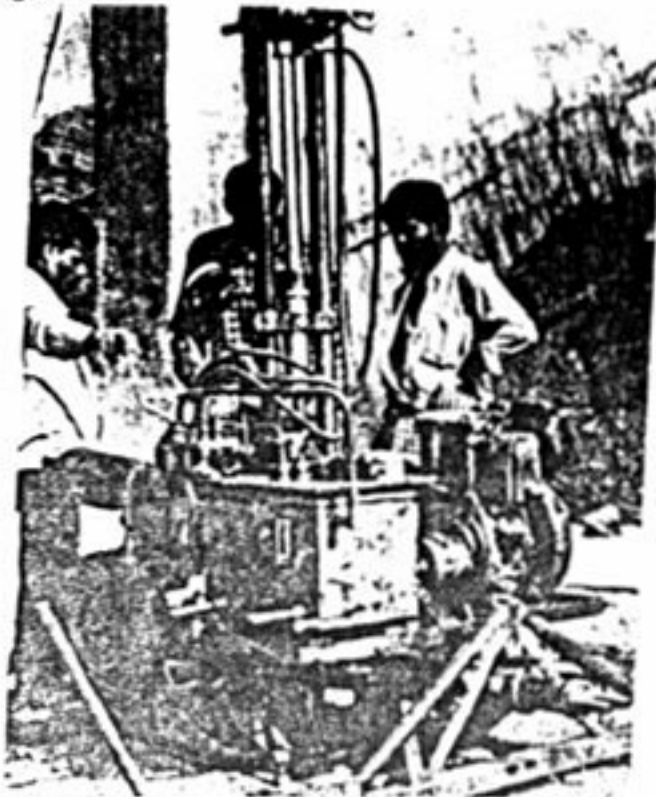


Fig. 3 : Static Cone Penetration Test in Progress



Fig.4 : Pile Load Test Using 700 Tonne Load Frame

**Vane Shear Tests** : This test is used to determine the in-situ shear strength of the soft clays. It is very important especially for sensitive clays. In such soils, undisturbed soils are difficult to collect or are of poor quality with the result that laboratory testing does not give realistic shear strength values.

**Load Tests:** Plate load tests and pile load tests are used to evaluate in-situ load-settlement behaviour. The plate load test is a scaled down model test on prototype footings. Although its usefulness is restricted by problems of scale effects and stratification, the results may be used as an indicator of foundation performance. Pile load tests (on individual pile and pile groups) can be effectively be used to assess the load settlement behaviour of the foundation system and thus ensure reliability of foundation performance. Fig.4 presents a 800 mm diameter bored pile for a flyover in Jaipur being tested using a specially designed load frame.

## INVESTIGATION FOR PAVEMENTS

**Field CBR Tests** : Field CBR tests provide the basic information for design of the road section. The CBR test by the modified DCP method (TRL, UK) offers a quick and easy measure of the in-situ CBR value. In this method, the penetration resistance of a 20 mm diameter cone driven into the subgrade using a 8 kg hammer is correlated to the CBR value.

**Laboratory Testing** : The field CBR tests should be backed up by a comprehensive laboratory testing programme. This should include routine classification tests (soil gradation, Atterberg limits, specific gravity), standard/modified Proctor compaction

tests and laboratory CBR tests. Tests should also be conducted on the base course material, soling stones etc. to ensure proper long term performance.

Where the highway passes through areas with loose soils, marshy lands, expansive/black cotton soils, saline zones etc., the in-situ and laboratory testing should be planned accordingly. The road section should be designed carefully to ensure all-weather performance.

## **INVESTIGATIONS FOR HIGH EMBANKMENTS**

Where high embankments are planned, the short term performance as well as the long term performance has to be carefully evaluated. This requires that the shear strength of the soils be assessed for undrained as well as the drained condition. The elastic and consolidation settlement of the underlying soils should also be determined.

It is essential to ensure an adequate safety factor is assured for the soil bearing capacity under undrained conditions since it is likely to be the governing criterion. Also the long term settlement (including consolidation settlement) should be within tolerable limits. In case shear failure is likely or excessive settlement may occur, ground improvement by provision of rammed stone columns or gravel piles (Sanjay Gupta & Ravi Sundaram, 1996) may be considered.

In-situ instrumentation, installing pore pressure probes as well as inclinometers (to measure long term settlement) are also gaining a lot of importance in monitoring the performance of high embankments. These can provide valuable data for design and ensuring corrective measures in case failure is likely.

## **SPECIFICATIONS**

The MOST and IRC specifications are fairly exhaustive and clearly spell out the technical requirements for a proper investigation. However, no specification can hope to cover all possible situations. It should be realized that such standard specifications are to be used as guideline and not a bible. The project specifications should allow for the necessary changes / modifications / corrections based on actual site conditions. In situ testing should be made a part of the project requirements for a better evaluation of the geotechnical behaviour.

## **CONCLUDING REMARKS**

In the new millenium, the thrust is on the use of better equipments and mechanization for higher production and performance. On fast track projects for better infrastructure facilities, of course, one requires superior technologies for effective implementation.

In such a scenario, it is equally important to have engineering parameters also based upon advanced technologies rather than using decades-old methods and analysis. If the input parameters are more realistic/ accurate, one can design structures with lower factor of safety, yet with higher level of reliability in the prediction of its performance.

Therefore, there is a need to incorporate in-situ testing and other modern testing technologies into the specifications of highways projects. The authors emphasize here that the quantum of investigation required is as important as the quality of data generated. Enough redundancy should be incorporated in the investigation, design and construction so as to make maintenance free highways a reality.

## REFERENCES

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