Correlation between flat dilatometer (DMT) index with insitu bearing strength for subgrade material

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ABSTRACT

In situ investigation of the soil characteristics offers significant promise for providing a reliable and economical method for obtaining strength and stiffness characteristics associated with pavement design. The investigation of the compressibility and compaction properties of a layer of soil below subgrade of an internal road was carried out in Salt lake campus of Jadavpur University. A cut section of 990 mm depth below existing ground level (EGL) was prepared for subgrade of that internal road construction. The characteristics of top subgrade soil are silty sand and foundation soil below subgrade is silty clay to clayey silt in nature upto a substantial depth. Field tests reported in this paper were carried out by flat dilatometer, field CBR using loaded reaction truck and truss both. Dynamic cone penetrometer(DCP) test was also done for a preliminary research program for evaluation of newly compacted subgrade support characteristics. Flat dilatometer (DMT) was used to determine the different properties and moduli of foundation soil below the subgrade and also field CBR, DCP and field compaction tests were carried out to determine the bearing strength and compaction properties. After completion of numerous dilatometer investigations the box was excavated in the field allowing for conducting field CBR test at different depth below the subgrade. Field and DCP CBR versus dilatometer index are plotted for moisture and density variations at different depth.

Keywords: dilatometer, cone penetrometer, CBR, DCP, compaction.

1 INTRODUCTION

The road was selected inside Jadavpur University,Salt Lake Campus for field study. It was an internal road of width 7.5 m and length 400 m. Road was constructed by cutting the earth at 990 mm depth below existing ground level(EGL).The characteristics of the soil was predominantly normal Calcutta deposit. Different hard crust and also blanket layers are overlain above the finished subgrade.The Flat dilatometer (DMT) is an in situ testing tool developed some 30 years ago. The DMT is currently used in practically all industrialized countries. It is standardized in the ASTM and the Euro code. It has been object of a detailed monograph by the ISSMGE Technical Committee TC 16.The DMT equipment is robust, easy to use and remarkably operator-independent and repeatable. The equipment provides information on stress history which is dominant criteria of soil behaviour. Being a penetration test, it has additional advantage of not requiring borehole. The various methods for determination of in-situ CBR are quite laborious and time consuming compared to laboratory CBR. But insitu tests always avoid the boundary effect compared to laboratory tests. Therefore after construction field CBR determination is always preferable .

2 OBJECTIVE AND SCOPE OF WORK

The primary objective of this study is to identify the potential for predicting in place subgrade and below the subgrade soil characteristics with the help of dilatometer modulus and bearing strength. The field compaction nature and variation of field moisture content at different depth were also studied. It was deemed important to evaluate the significance of soil type on the functional relationship.

3 TEST METHODOLOGY

3.1 Flat dilatometer test

The Flat dilatometer consisted of a steel blade (dimensions 95x200x15mm) having a thin, expandable, circular steel membrane mounted on one face. When at rest, the membrane was flush with the surrounding flat surface of the blade. The blade is connected by an electro pneumatic tube running through the insertion rods, to a control unit of the surface. The control unit is equipped with pressure gauges, an audio visual signal, and a valve for regulating gas pressure (provided by a gas cylinder) and vent valves. The blade was advanced into the soil by pushing vertically on a series of rods using cone penetrometer equipment by statical push.

The blade was pushed at different depths with a 20 ton cone penetrometer equipment(Photo.2). When the blade was advanced to the desired test depth, the penetration was stopped. At fixed depth intervals (0.20m) the penetration was stopped. The operator inflated the membrane and had taken about 30 sec, to take two readings(Photo.1): the A pressure, required to just begin to move the membrane (lift off pressure) and the B pressure, required to expand the membrane centre of 1.1 mm against the soil. Third reading C (closing pressure) can also optionally be taken by slowly deflating the membrane soon after B was reached. The blade was then advanced to the next test depth, with a depth increment of typically 20 cm.

Photo.1.Operators during field pressure acquisitions using the control box.

3.2 Field CBR, DCP CBR and Field Compaction Test

Field CBR tests were conducted using the loaded reaction truck and truss system both method as per IS:2720-Part31,1990 shown in Photo 3&4 which were jacked off. Similarly DCP CBR tests were carried out(Photo.5) as per ASTM D6951 nearest to same locations where field CBR tests were executed. Field compaction was checked by sand replacement method as per IS:2720-Part28,1974 and field moisture content was also determined as per IS:2720-Part2,1973 by using Rapid moisture meter. All the tests were conducted upto 2.6 m depth below finished subgrade level at 0.2 m interval. Field CBR, DCP CBR and Field compaction tests for each of lower layers were performed after carefully removing the soils on the top of them.

3.3 Laboratoratory compaction test

Laboratory Proctor compaction tests were carried out as per IS:2720-Part 7,1990 . Samples were collected from different depth at 0.2 m interval upto 2.6 m.

4 RESULTS AND DISCUSSION

Dilatometer modulus(E_D) characterized the stress-strain curve during the membrane's expansion of 1.1 mm. Dilatometer modulus was obtained by loading the soil distored by the blade insertion. From Table.1 and Figure.1,2 & 3, it is observed that dilatometer modulus, Field CBR by different methods and field compaction decrease with depth. From Table.1 and Figure.4, it is also observed that field moisture content increases with depth. It is indicated from Table.1 and Figure.5&6,that dilatometer modulus directly varies with field CBR and field compaction. Due to moisture increase in bottom layer, soil strata will be softer and field compaction decreases. When the dilatometer blade

Photo.2. Pushing the dilatometer blade using cone penetrometer equipment.

is inserted into bottom layers,bearing capacity and stiffness decrease and a local heaving of the sorrounding surface of layers is happened. Table.1 indicates that field DCP CBR values are higher compared to field CBR by truck and truss.

Table1. Different test results from field tests

Depth (m)	Bulk Density (kN/m^3)	Effective Overburden Stress ,σ_{vo} (kPa)	Dilatometer Modulus E_D (MPa)	Field CBR by Truck (%)	Field CBR by Truss (%)	Field DCP CBR (%)	Laboratory Proctor Density (kN/m^3)	Optimum Moisture Content (%)	Field Degree of Compaction (%)	Field Moisture Content (%)
0	16.7	24	5.1	9.0	8.0	10.0	15.9	15.0	98.0	9.0
1.4	18.6	27	18.1	14.0	12.0	14.0	16.1	14.0	97.0	7.0
1.6	17.7	31	17.2	12.0	12.0	15.0	16.1	15.0	95.0	9.0
1.8	17.7	34	16.5	12.0	13.0	14.0	16.2	14.0	94.0	10.0
2.0	16.7	38	9.5	8.0	9.0	11.0	15.2	18.0	93.0	16.0
2.2	17.3	41	1.1	3.0	3.0	5.0	15.7	18.0	92.0	17.0
2.4	17.9	44	1.7	4.0	4.0	7.0	15.1	20.0	94.0	17.0
2.6	18.1	48	1.2	4.0	3.0	6.0	15.1	19.0	91.0	15.0

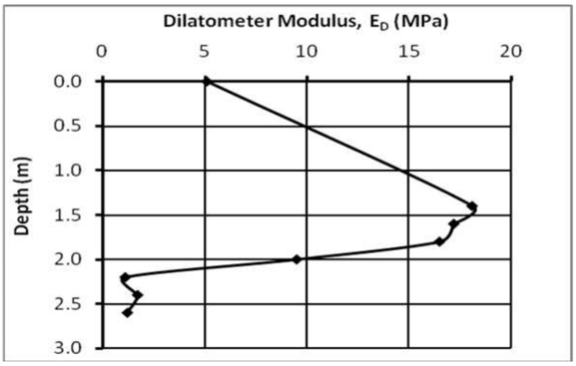


Fig. 1. depth vs dilatometer modulus

This variations might have occurred due to different procedures. Field CBR by truss or truck is based on gradual penetration of a plunger into the layer at the time of testing but DCP method is followed by free falling of a cone from a particular height.

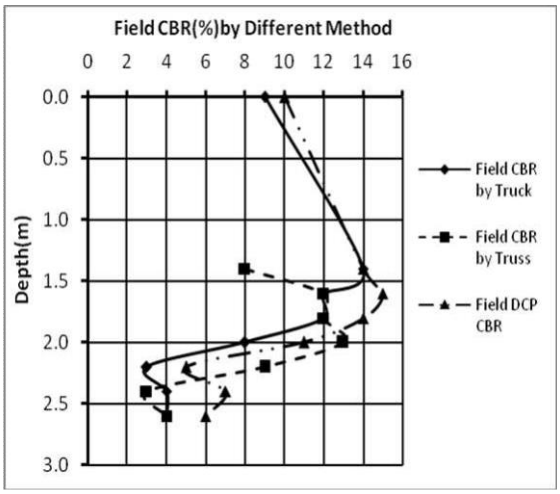
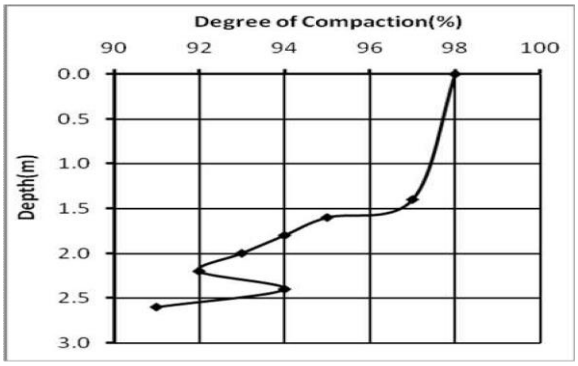


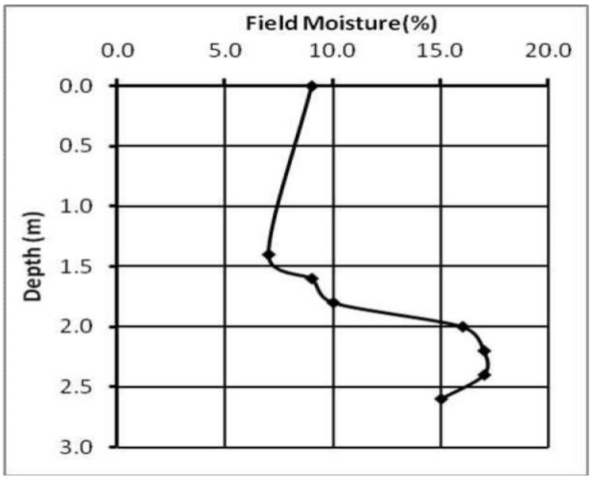
Fig. 2. depth vs field CBR by different methods

Fig. 3. depth vs degree of compaction



In field CBR by truck and truss, plunger is penetrated into the soil.Therefore undrained shear strength is measured but in case of DCP, the resistance of material is obtained through falling of 8 kg weight.DCP is the indirect measure of stiffness of layered material.

Fig. 4. depth vs field moisture



Therefore undrained strength versus stiffness is compared from field CBR by truck and truss.

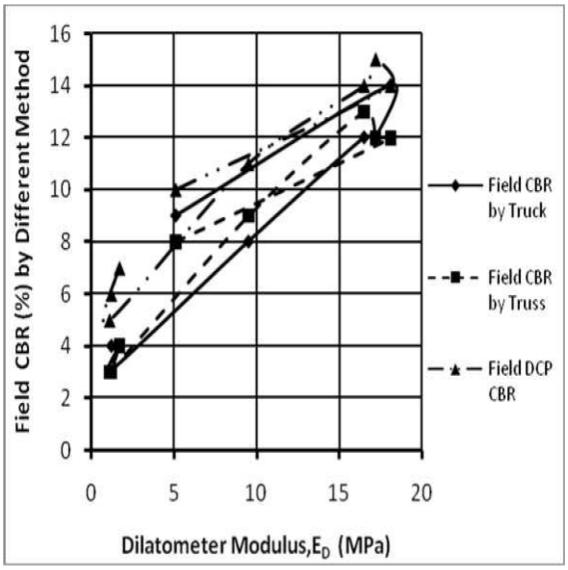


Fig. 5. dilatometer modulus vs field CBR by different methods.

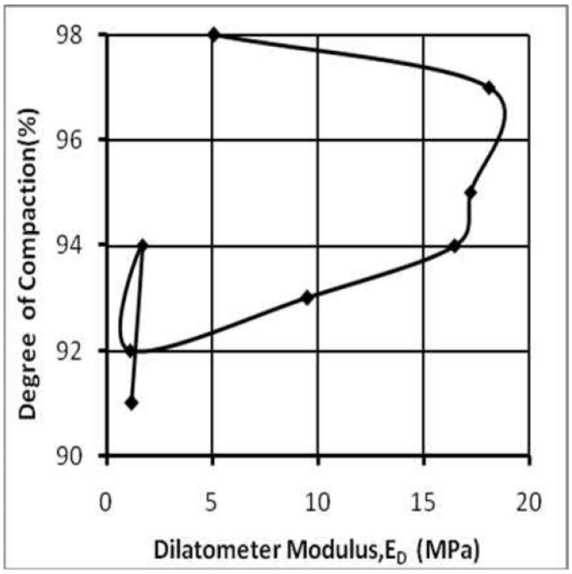


Fig. 6. dilatometer modulus vs degree of compaction.

7 CONCLUSION

In the present investigation an attempt had been made to correlate the flat dilatometer index with insitu bearing strength of the subgrade material. It has been observed that the different parameters relating to the strength and stiffness of the soil tally very well between the two methods.It may be concluded that flat dilatometer(DMT) may be used for determination of these properties where field CBR or DCP can not be carried out.

Photo. 3. Field CBR by loaded reaction truck.

Photo. 4. Field CBR by truss.

Photo.5 Field CBR by DCP method

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