ABSTRACT

In the recent past, our country India has witnessed rapid growth in urbanization. Due to this rapid urbanization, an inclination towards in situ testing is observed in the geotechnical field. In this study, focus is given to the geotechnical parameters obtained directly from the in-situ tests and compare with the results obtained from the most widely used in-situ test (i.e., standard penetration tests, SPT) and laboratory tests (conducted on collected undisturbed samples from conventional boreholes). Based on the comparison, also an effort has been made to establish a relationship among them, so that one can predict the sub-soil profile along with the required geotechnical parameters (for design purpose) by carrying out only the in-situ tests instead of conventional laboratory and in-situ tests.

In this context, three numbers of in-situ tests, which are rarely used for the geotechnical investigation work in India, are chosen for this study. These tests are Marchetti Flat Dilatometer Test (DMT), Cone Penetration Test (CPT) and Pressuremeter Test (PMT). The DMT, CPT and PMT tests are carried out adjacent to the conventional bore-hole (BH) accompanied with SPT test, at various project sites located in the states of West Bengal (WB) and Odisha (OR).

Based on the laboratory test results (conducted on collected samples from the adjacent conventional boreholes), the site wise sub-soil profile has been predicted. Also, the site wise variation of SPT N values (estimated from the adjacent boreholes) and shear strength parameters of sub-soil have been plotted along depth.

In each site, for DMT tests, the variation of shear strength parameters (undrained cohesion, C_u and angle of internal friction ϕ), vertical drained constrained modulus (M_{DMT}), Dilatometer Modulus (E_D) and Material Index (I_D) have been plotted along depth. Also the sub-soil profile has been predicted based on the value of I_D.

Besides, for the CPT test, site- wise variation of shear strength parameters (C_u and ϕ), vertical drained constrained modulus (M_{CPT}), Cone penetration resistance (q_c), Sleeve friction (f_s) and Soil behavior type index (I_C) estimated from CPT tests, have been plotted along depth. Also, the sub-soil profile has been predicted based on the value of I_C. Apart from this, for the PMT tests, the variation of limit pressure (P_L) and pressuremeter modulus (E_{PMT}) have been plotted along depth and sub-soil profile has been predicted based on the adjacent boreholes and by visual inspection during the progress of PMT test in the borehole.

The first objective of this study is to compare the sub-soil profile obtained from the conventional boreholes, with the predicted profile from DMT and CPT tests by virtue of material index (I_D) and (I_C) respectively.

The shear parameters i.e., undrained cohesion (C_u) and angle of internal friction (ϕ) obtained from the laboratory tests (conducted on collected undisturbed samples) has been compared with the values empirically estimated from the DMT and CPT tests.

Another attempt has been made to predict the range of E_D, M_{DMT} for the cohesive sub-soil (silty clay/ clayey silt) with different consistency (SPT based consistency) by establishing a relationship between E_D and M_{DMT} with the SPT N values. In this regard, a chart has been suggested to predict the SPT based consistency from DMT test. Besides, probable value of the plastic limit (W_P) and plasticity index (PI) have been suggested from the estimated values of E_D and M_{DMT} by establishing relations between E_D/PI and E_D/W_P with the M_{DMT}.

In addition to this, in CPT test, an attempt has been made to predict the range of q_c, f_s and M_{CPT} for the cohesive sub-soil (silty clay/ clayey silt) with different SPT based consistency by establishing a relation between q_c, f_s and M_{CPT} with the SPT N values. In this regard, a chart has been prepared to predict probable value of the plastic limit

(W_P) and plasticity index (PI) from the estimated values of q_c and M_{CPT} by establishing relations between q_c/PI and q_c/W_P with the M_{CPT}.

In PMT test, a typical range of E_{PMT} and P_L, have been suggested for the cohesive sub-soil (silty clay/ clayey silt) with different SPT based consistency by establishing a relation between P_L and E_{PMT} with the SPT N. Simultaneously, another relation (relation between E_{PMT}/P_L with liquidity index, I_L) has been made to predict liquidity index (I_L) from the ratio of E_{PMT}/P_L.

In addition to the above, another study has been carried out on to predict the settlement of shallow foundation (placed on cohesive silty clay/ clayey silt soil) by CPT tests. In this context, it is worth mentioning that the settlement analysis has been calculated by using empirical equation based average cone resistance, C_{KD}. Then these values have been compared with the DMT based settlement along with the output of numerical model, (done on PLAXIS 2D software; based on Mohr Coulomb model).

It has also been observed that the undrained cohesion (C_u) estimated from DMT tests are more compatible with the laboratory triaxial (UU) test results than the CPT tests. However, it has been observed that the angle of internal friction (ϕ), estimated from both CPT and DMT tests, are well comparable with the laboratory direct shear test (DS) results. Besides, it has been observed that the vertical drained constrained modulus (M) of sub-soil, estimated from DMT and CPT tests are well tallying with each other.

It is concluded that the SPT based consistency of sub-soil (cohesive silty clay/ clayey silt) may be predicted from the DMT tests based on the value of E_D and M_{DMT}. The Liquid Limit (W_L), Plastic Limit (W_P) and plasticity index (PI) may also be predicted from the E_D and M_{DMT} values. Besides, SPT based consistency of silty clay/ clayey silt sub-soil may be predicted from the value of CPT based parameters i.e., q_c, f_s and M_{CPT}.

Also, the value of Liquid Limit (W_L), Plastic Limit (W_P) and plasticity index (PI) may be predicted from the value of q_c and M_{CPT}.

In PMT test, it is found that the nature of the variation of P_L along depth is similar with the SPT N values than the variation of E_{PMT} along depth. However, both the values of E_{PMT} and P_L depend on the consistency of soils. Therefore, a typical range of E_{PMT}, P_L alongwith the ratio of E_{PMT}/P_L for cohesive (silty clay/ clayey silt) sub-soil with different SPT based consistency has been suggested. Also, it is concluded that the liquidity index (I_L) may be predicted from the ratio of E_{PMT}/P_L.

On the study, for the prediction of settlement of shallow foundations (placed on cohesive soils) by CPT test, it is found that the predicted settlement based on C_{KD}, are well comparable with the other method. Lastly, it is concluded that the method to estimate settlement of shallow foundation based on the C_{KD}, may also be adopted for the shallow foundation placed on cohesive soil.