A STUDY TO CORRELATE FIELD AND LABORATOTRY TEST RESULTS OF c-ϕ SOILS

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ABSTRACT

Assessment of properties of soils from laboratory and field testing are essential for geotechnical applications. Sometimes it is very difficult to obtain undisturbed samples from field for laboratory testing, then field test data has to be relied upon for the assessment of properties and in some cases extensive field testing becomes very costly and properties have to be obtained from few field tests. In purely cohesive and cohesion less soils correlating tables are available, connecting field test data such as SPT with laboratory test data such as relative density , Angle of internal friction, unit weights for cohesionless (granular soils) and similarly for cohesive(clayey soils) SPT values are correlated with unconfined compressive strength or undrained cohesion of soil. However no such correlations are available for c-ϕ soils. Hence a study is carried out c-ϕ soils by conducting field and laboratory tests under different moisture contents.

Soils with percentage of fines varying between 15 to 45 are taken, SPT tests in the field and direct shear tests on undisturbed soil samples collected from the field were carried out. The effect of %fines, moisture content and Atterberg limits are studied for obtaining the correlations.

Keywords: Standard penetration test, LL, PI, Correlations.

INTRODUCTION

Due to limited budgets, tight schedules, or lack of concern, sometimes projects do not receive proper laboratory recommendations. However, in many cases, soil type, depth of water table, and standard penetration test blow counts are available to judge the subsurface soil conditions. The shear parameters, max dry density, OMC of soil are known and if it is difficult to conduct SPT test at field then the average SPT blows can be estimate by using correlation tables.

METHODOLOGIES:

For obtaining the above mentioned objectives of the thesis Laboratory tests are performed on four different types of soils with % fines varying from 15 to 45.Standard penetration tests were conducted in the field. Undisturbed soil samples were collected for determining moisture content (m) and in-situ dry density (γ_d).Shear parameters were obtained by conducting direct shear tests at in-situ moisture contents. To study the effect of moisture content on the strength/shear parameters of soil, disturbed soil samples were collected and standard proctor tests were conducted to obtain the values of OMC and γ_{dmax}. Direct shear tests were conducted at OMC and SMC. Field and laboratory tests were carried out with two moisture contents on dry of optimum and two on wet side for soils 1 and 2, and one on each side of optimum for soils 3 and 4.The direct shear results at OMC and SMC are used to make the necessary comparisons in field and laboratory studies.

LITERATURE REVIEW

Many Geotechnical engineering professionals and researchers conducted various tests for obtaining correlations with SPT results. Mustafa Abdou et al. (2013) studied the reliability of using SPT in predicting properties such as Atterberg limits and shear strength parameters of silty clay with sand soil. Frazad nasaji (2011) established method for predicting undrained shear strength (s_u) of fine grained soils using SPT results in southern and eastern of Tehran (Iran) by analysis from SPSS software used for the study. Timothy Brown et al. (2009) Studied estimation of shear strength properties of soils using SPT and equations were derived one for the estimation of ‘ϕ’ value of sand and other for ‘c’ value of clay. Bagherieh and Farsijani (2014) studied the effect of moisture content on shear strength parameters of plastic fines. CfaAkayuli et al. (2013) studied the influence of clay content on shear strength and compressibility of residual sandy soils. Kamal Mohamed (2015) studied the effect of percentage of low plastic fines on the unsaturated shear strength of compacted gravel soils.

Laboratory test results of four c-ϕ soils:

Grain size distribution, Atterberg limits, standard proctor tests and direct shear tests were carried out on disturbed soil samples collected from the field and the results are shown in Tables 1 through 4.

Table 1 Grain size distribution and PI values

Grain size distribution	Soil 1 %	Soil 2 %	Soil 3 %	Soil 4 %
Gravel	8	11	5	1
Coarse Sand	20	10	9	3
Medium Sand	32	36	30	28
Fine Sand	21	15	22	24
Silt & Clay	19	28	34	44
PI	14	17	8	9

Table 1 gives the grain size distribution and PI values. The plasticity index values indirectly show the presence of plastic fines (clay) in the soil. Though for soils 3 and 4 the % fines are more the clay content is less.

Standard proctor test results (Table 2), show that soils containing clay tend to conglomerate more and achieve higher densities. In all the four soils the OMC values are almost same. In soils 1 and 2 it may be due to the presence of plastic fines and in soils 3 and 4 due to more % of fines.

Table 2 Standard proctors compaction test results

γ_{dmax} in kN/m^3	19.6	19.2	18.8	19.38
OMC in %	12.5	13	12.5	13

Direct shear test results (Tables 3 and 4) at OMC and SMC show that the dry shear strength in general for c-ϕ soil is more than saturated strength (Dafalla, M. A., 2013). This is due to matric suction contribution of fines contributing to shear strength. Dry strength increases with increase in % fines and also in plasticity of soil. In soils 1 and 2 the dry strength increase can be attributed to increase in plasticity and in soils 3 and 4 due to increased % fines. In all the four soils the increase in friction angle (ϕ) is of the order of 4° to 6°.

Table 3 Direct shear test results of all c-ϕ soils at OMC

Soil Type	1	2	3	4
Cohesion (c) in kN/m^2	20	28	4	12
ϕin degrees	37°	35°	38°	34°

Table 4 Direct shear test results of all c-ϕ soils at SMC

Soil Type	1	2	3	4
Cohesion (c) in kN/m^2	18	22	4	12
Angle of internal friction(ϕ) in degrees	33°	29°	33°	30°

Fig. 1 shows the variation of SPT for soils 1 and 2 with moisture content (9-14.7%). The SPT values on the dry side of OMC are of the order of 15-18, and even with slight increase in moisture content to the wet side of optimum reduced the values to less than 5 i.e almost less than 1/3(SPT value on dry side).

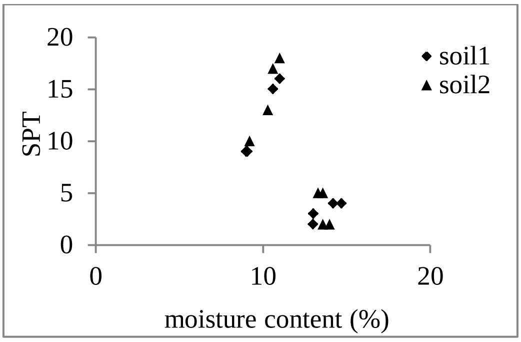

Fig. 1 Variation of SPT with Moisture Content for soils 1 and 2

Variation of SPT with moisture content (10-14.8%) for soils 3 and 4 is shown in Fig. 2. For these soils, though the variation of moisture content is similar to soil1 and 2, the peak SPT values are in the range of 11-12 on the dry side of optimum, and with increase in moisture to the wet side, the decrease in SPT ranges from 1/3to 1/2 on the dry side. The SPT values on the dry side of optimum in soils with more plastic fines are higher than those with less plastic fines. The penetration resistance in soils 1 and 2 can be attributed to matric suction and also the cohesive bonds developed between the particles with matric suction playing a dominant role (Nishimura, T. and Fredlund, D. G, 2000).

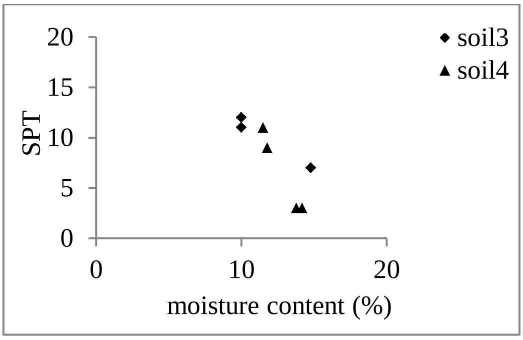

Fig. 2 Variation of SPT with Moisture Content for soils 3 and 4

However on the wet side of optimum the matric suction contribution has been considerably reduced though there is not much change in the cohesion forming the bonds. This is resulting in the drastic reduction in the SPT values on the wet side of optimum. In soils 3 and 4, matric suction is not as predominant as in soils 1 and 2 due to silt sized particles, shape of the particles and the size of the voids. On increasing the moisture content, the SPT value decreases due to decrease in matric suction but due to the rearrangement of the particles for the initial blows, the penetration resistance slightly increases in soils with less plastic fines and the reduction in SPT is not as much as observed in soils with more plastic fines.

Tables 5 through 7 shows the variation of shear parameters of the undisturbed soil samples collected from the field with moisture content. Shear parameters of these UD samples were compared with the shear parameters obtained at OMC. In all the four soils there is a slight variation in cohesion when compared with that at OMC. The decrease in the cohesion may be attributed to the decreased densities on the dry and wet side of optimum. However in soils 1 and 2, when the moisture content is on the dry side of optimum, the reduction in ϕ values are 1° to 2° and on the wet side 4 to 6°. In soils 3 and 4, the variation of ϕ on the dry side is 3 to 4° and on the wet side of optimum 8 to 9°.

Table 5 Results of Undisturbed samples of soil 1

m (%)	9	11	13	14.2
γ_d (kN/m^3)	16.9	19.2	18.3	18.8
c (kN/m^2)	22	22	19	19.5
ϕ (^{o})	35	35.5	33.6	31
Void ratio e	0.58	0.39	0.46	0.43

Table **6** Results of Undisturbed samples of soil 2

m (%)	9.2	11	13.6	14
γ_d (kN/m^3)	17.12	17.4	17.5	18.1
c (kN/m^2)	24	23	23	21
ϕ(Degree)	32.7^o	34.7^o	30.25^o	28.6^o
Void ratio e	0.566	0.54	0.595	0.472

Table 7 Results of Undisturbed samples of soil **3 and 4**

Description	Soil 3		Soil 4	
m (%)	10	14.8	11.5	14.3
γ_d (kN/m^3)	17.4	16	19	17.8
c (kN/m^2)	4	5	12	11
ϕ (^{o})	35	29	30.54	26
Void ratio e	0.567	0.388	0.352	0.32

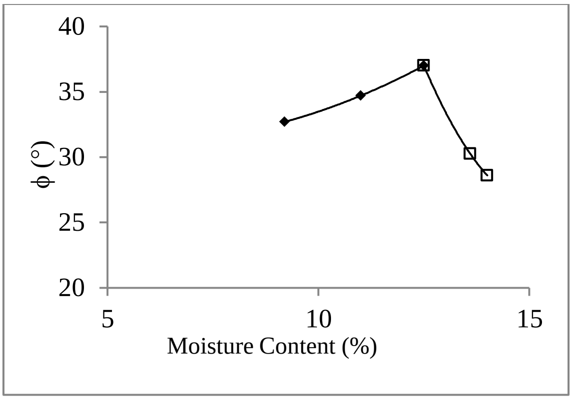

Fig. 3 Variation of ϕ with Moisture Content for soils 1

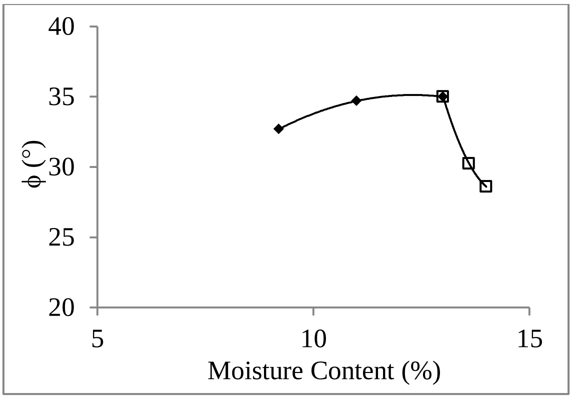

Fig. 4 Variation of ϕ with Moisture Content for soils 2

Fig. 3 and 4 shows the variation of angle of internal friction (ϕ) with moisture content for soils 1 and 2. Both on dry side and wet side, the variation is polynomial in nature. On the wet side of optimum, there is a steep reduction in ϕ values, whereas on dry side it is flat.

Fig. 5 shows the variation of ϕ with moisture content for soils 3 and 4 with less plasticity or plastic fines. However on the wet side reduction in ϕ is occurring over larger range of moisture content making the curve slightly flat on wet side and steep on dry side.

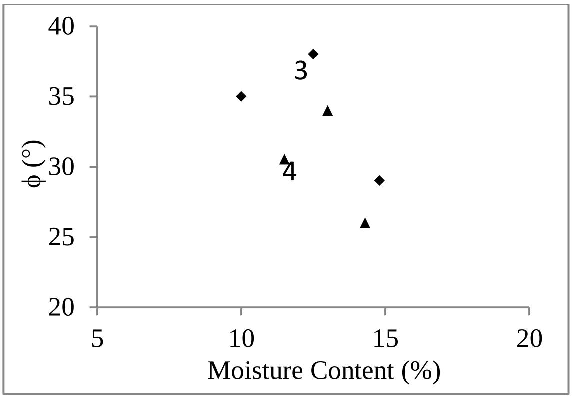

Fig. 5 Variation of ϕ with Moisture Content for soils 3 and 4

The observations made above are consolidated in table 8. The observations are made with reference to c and PI values as they are indirect indicators of presence of plastic fines in soil.

Table 8 Correlations for c-ϕ soils

Cohesion (kN/m^2)	ϕ(°)	PI	SPT (N value)	m.c (%)
<15	34-38	8-9	9-12	m<OMC
15-25	32-36	14-17	9-18	m<OMC
<15	26-29	8-9	3-7	m>OMC
15-25	28-34	14-17	2-5	m>OMC

CONCLUSIONS

1. The proposed correlations are a useful aid to obtain shear parameters from SPT values. However the basic parameters like grain size distribution, in-situ moisture content, PI etc. will help in fixing the shear parameters.
2. In-situ moisture contents on dry side of optimum considerably increases the shear parameters. The corresponding SPT values are also high in soils with more % of plastic fines. On wet side of optimum there is considerable decrease in SPT values.
3. In soils with less percentage of plastic fines, the decrease in SPT values with inundation is comparatively less than in soils with more plastic fines. However the shear strength on dry side is more for soils with more % plastic fines than for less % plastic fines.

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