DETERMINATION OF ESSENTIAL STRUCTURAL ENGINEERING PROPERTIES OF NAWABSHAH CAMPUS SOIL

Ghulam Shabir Solangi*, Kanya L. Khatri*, , Zeenat M.Ali**[1], M.M Tunio***, Sadiq A. Shah****

ABSTRACT

This study was conducted for finding essential soil properties from structural engineering point of view in order to determine its suitability to receive the loads of super structure and transfer them to the underlying strata safely. For this purpose the site was selected between "B" and "C" sectors of Quaid-e-Awam University of Engineering, Science and Technology, Nawabshah, Sindh, Pakistan. Soil and water samples were collected at every 5-foot up to 80-feet depth from ground surface by using auger boring. Various laboratory as well as field tests were conducted to find out soil parameters. Also some field in situ tests were performed at site to know the bearing capacity of soil. The results show that a thin layer of cohesive soil with substantial "c-value" and shear strengths prevails the soil beneath it is sandy, the water table is high, but at a depth of about 10-feet below the surface of the soil may be termed as suitable to receive structural loads with a bearing capacity of about 0.5 kg/cm^2 or 5 tones/m^2.

Keywords*: *Properties of soil, QUEST, Nawabshah, bearing capacity of soil.

1. INTRODUCTION

Soil exploration means technical investigation before any preliminary design is drawn or final plans prepared, by which the necessary information is obtained about geological, hydrological and soil conditions, geotechnical properties of soil at the prospective building site and the performance of the various soil types encountered when acted upon by structural and applied loads. This information is necessary as background upon which to base the design of a structure and to decide upon construction methods to be applied.

An engineering structures, however carefully designed is no better, than its foundation, supporting soil. In sufficient or inadequate information with respect to the character and bearing capacity of the underlying soil may result in serious structural damage or even collapse of the structure.

Soil exploration at the proposed building site is to be considered similar in purpose to the material survey, because soils are constructional materials in or on which or by means of which civil engineers build structure.

Soils are formed by the process of weathering of the parent rock. The properties of the soil materials depend upon the properties of the rock from which they are derived (Murthy, (1990). Soil is also a living natural body, formed by the interaction of environmental factors such as climate, parent materials, topography and living organisms. Nevertheless, this said soil which served as a sink to every matter on earth can be used for different purposes, but engineering purpose without proper evaluation of its present status it may result in soil degradation, rupture, structures collapse and alteration of the soil physical and chemical properties (Shepherd et al. 2002). The variety of soil materials encountered in engineering problems is almost limitless, at any given site, a number of different soil types may be present, and the composition may change over intervals of a little as a few inches (James, 1976). Similar combinations of soil-forming processes in different parts of the world have been found to lead materials of similar index properties and similar engineering characteristics (Taylor, 1990).

The bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in the soil. The the need for sort bearing capacity is based on the fact

*Department of Civil Engineering, MUET, SZAB Campus, Khairpur Mir's
**[1]Department of Chemical Engineering MUET Jamshoro
*** Energy & Environmental Engineering Department QUEST Nawabshah
**** Department of Mechanical Engineering, MUET, SZAB Campus, Khairpur Mir's

that foundations for different types of structure rest on soils. According to Bronick and Lai 2005, soil aggregation and its stability are dynamic processes because both are affected by many factors such as soil management practices, soil properties and soil environment such as soil moisture content. .In 1988, Salter said the performance of a highway pavement is influenced to a very considerable extent by the sub grade soil material. Furthermore, whereas, Oglesby and Hicks (1992) said that before 1920, attention was focused largely on the pavement surface, and little notice was given to the sub grade and base materials or to the manner in which they were placed or compacted. Later, increased vehicle speeds brought demands for higher design that resulted in deeper cuts and higher fills. In many instances, subsidence or even total failure of the roadway resulted. Study of these failures indicated that faults lay in the sub grade soil and not the pavement. This led to investigation of the properties of sub grade materials.

This would seem to be apparent that there would be no extra need to emphasize the importance of soil exploration. However, practice demonstrates that adequate soil exploration is frequently disregarded and even omitted. Lack of time in-sufficient to improper economy or to an attempt to save funds or time, the final cost of the structure exceeded every reasonable limit. The result may even be the failure of the structure itself, thus causing great troubles both to the builder and to the owner. This emphasizes the fact that it is the task of every civil engineer designing any construction work always to give first preference to the safety factor. In the light of safety, economic consideration should be regarded as secondary matter. This rule, however does not exclude the postulate of economical and safe structures. Besides timely and intelligently made soil explorations are relatively cheap as compared with the total cost of the structure or even as compared with the expenditure required only for the revision of the project and redesigning of the structure to fit the real soil conditions in order to avoid serious problems. Efficient, safe, economical design and construction can be achieved only through thorough evaluation of soil conditions under and adjacent to a proposed structure. This in turn, requires that adequate soil exploration at the proposed site should be made before any design of the foundations of a structure is started. It is best to pay proper attention to the bearing capacity and other geotechnical properties of the soil prior to the start of the construction activities or purchasing the land for construction purpose.

2. MATERIALS AND METHODS

For this study, soil as well as water samples at every 5-feet depth up to 80-feet below ground surface were collected by using auger boring. In order to determine the structural engineering properties of the studied soil, some laboratory as well as field in situ tests such as: water content, liquid limit, plastic limit, specific gravity, proctor's compaction test, sieve analysis, direct shear test, field bearing capacity by Proctor's needle method and vane shear tests were performed and their results are described in article 3.

3. RESULTS AND DISCUSSION

TABLE 3.1: Soil profile of study area up to 80- feet depth from ground surface

Depth (ft)	Type of soil	P.H value of water	Total Suspended Solids (ppm)
0-5	Silty-clay	---	---
5-10	Sandy	---	---
10-15	Sandy	---	---
15-20	Sandy	---	---
20-25	Sandy	---	---
25-30	Sandy	8.4	1477
30-35	Sandy	8.3	1372
35-40	Sandy	8.4	1423
40-45	Sandy	8.3	1344
45-50	Sandy	8.4	1456
50-55	Sandy	8.5	1680
55-60	Sandy	8.6	1897
60-65	Sandy	8.7	2136
65-70	Sandy	8.7	2380
70-75	Sandy	8.8	2464
75-80	Sandy	8.9	2828

TEST.3.1. Data and observation sheet for water content determination of 1st 5-ft depth soil by oven drying method

S.No.	Container No.	1	2	3	4
1	Wt.of empty container W_1 (g)	28.7	32.6	26	44.4
2	Wt.of container + wet soil W_2(g)	166.5	151.1	148.7	182.7
3	Wt.of container + oven dried soil W_3 (g)	143.8	131.9	128.7	160.3
4	Wt.of water (W_2-W_3) g	22.7	19.2	20	22.4
5	Wt.of dry soil (W_3-W_1) g	115.1	99.3	102.7	115.9
6	Water content (%) = $\frac{W_2-W_3}{W_3-W_1}$ x 100	19.72	19.33	19.47	19.58
7	Average water content = 19.52%				

TEST.3.2. Data and observation sheet for specific gravity determination of 1st 5-ft depth soil by Density bottle method

S.No.	Container No.	1	2	3
1	Wt.of empty density bottle W_1 (g)	250	260	265
2	Wt.of bottle + oven dried soil W_2(g)	449.6	460	464.7
3	Wt.of bottle + soil + water W_3(g)	1390.4	1400.4	1405.5
4	Wt.of bottle + water W_4 (g)	1260.5	1270.5	1275.5
5	Specific gravity (G) = $\frac{W_2-W_1}{(W_2-W_1)-(W_3-W_4)}$	2.86	2.85	2.87
6	Average specific gravity (G) = 2.86			

TEST.3.3. Data and observation sheet for specific gravity determination of 15-ft depth soil by Density bottle method

S.No.	Container No.	1	2	3
1	Wt.of empty density bottle W_1 (g)	250.6	260	265
2	Wt.of bottle + oven dried soil W_2(g)	450.6	460	465
3	Wt.of bottle + soil + water W_3(g)	1371.8	1381.2	1386.2
4	Wt.of bottle + water W_4 (g)	1245.9	1255.9	1260.9
5	Specific gravity (G) = $\frac{W_2-W_1}{(W_2-W_1)-(W_3-W_4)}$	2.699	2.677	2.678
6	Average specific gravity (G) at 27^0C = 2.684			

TEST3.4. Determination of shear parameters by Direct shear test.

Specimen No.	1	2	3	4
Shear force divisions	50	70	90	110
Normal load (kg)	4	8	12	16
Shear force (kg)	4.5	6	7.5	9
c = 32.9Kg/cm^2 = 2.9/36 = 0.08 kg/cm^2 = 80 g/cm^2				
ϕ = 20^0				
Area of specimen = 6 x 6 cm^2	Moisture content = 16%		Dry density = 1.81 g/cm^3	

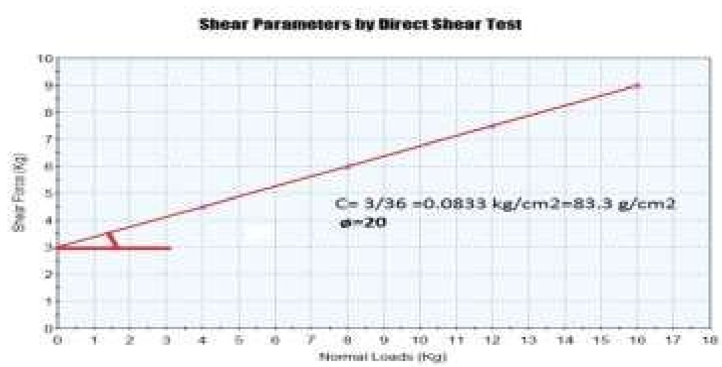
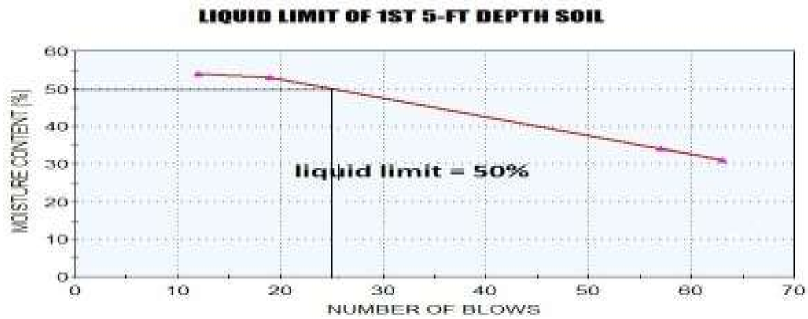


Fig.3.1 Graph between normal load and shear load

Test.3.5. Determination of liquid limit of 1st 5-ft depth soil

S.No.	Determination No.	1	2	3	4
1	No. of blows	57	63	12	19
2	Container No.	R	G	S	S
3	Wt.of container W_1(g)	53.1	36.0	26.1	28.8
4	Wt.of container + wet soil W_2 (g)	60.6	53.8	39.2	43.9
5	Wt.of container + dry soil W_2 (g)	58.7	49.5	34.6	38.7
6	Water content (%)	34	31	54	53



From graph, liquid limit at 25 blows = 50%

TEST.3.6. Determination of plastic limit and plasticity index of 1st 5-ft depth soil

S.No.	Determination No.	1	2	3
1	Wt.of container W_1 (g)	30	32.5	36
2	Wt.of container + wet soil W_2 (g)	31	34.4	38.6
3	Wt.of container + dry soil W_2 (g)	30.8	34	38.0
4	Water content (%)	25	26.66	30

Results:

(a) Average plastic limit = 27%
(b) Plasticity index = L.L – P.L = 50-27 = 23%

Test.3.7. Determination of compaction properties (bulk density, dry density and O.M.C) of first 5 feet depth soil by standard proctor's compaction test

(a) Density						
Determination No.	1	2	3	4	5	6
Wt.of mould W_1 (g)	4150	4150	4150	4150	4150	4150
Wt.of mould + compacted soil W_2 (g)	5950	6050	6100	6125	6110	6100
Wt.of compacted soil W = ($W_2 - W_2$) g	1800	1900	1950	1975	1960	1950
Bulk density (γ)	1.9	2.01	2.06	2.09	2.01	2.06
Dry density (γ/1+m)	1.7	1.76	1.8	1.7	1.65	1.7
(b) Water content						
Container No.	S	H	A	B	I	R
Wt.of container (g)	30	28.8	37.9	35.6	32.6	26.1
Wt.of container + wet soil (g)	80.5	100	96.4	121.7	93.9	115.8
Wt.of container + oven dried soil (g)	74.6	91	88.6	108.6	84.2	101.3
Water content (m) % =	13.2	14.5	15.4	17.8	18.8	19.3
O.M.C = 15.61 % ≈16% (from graph), Dry density = 1.80 g/cm³						

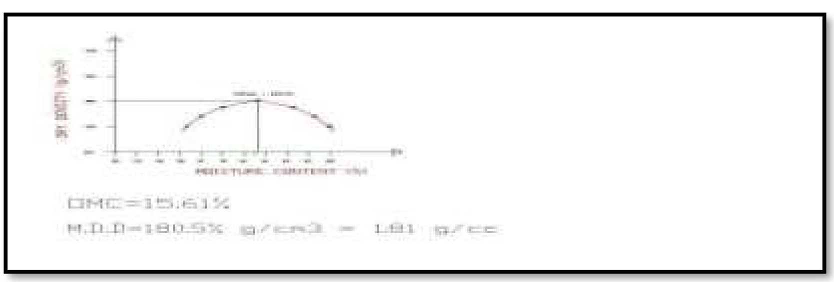


Fig.3.3 Graph between water content and dry density

Test.3.8. Determination of grain size distribution of 10-15 feet depth soil by sieve analysis

.

S.No.	Sieve size	Sieve opening	Wt. retained (g)	% retained	Cumulative % retained	Cumulative % finer
1	No.20	600 micron	10.1	1.01	1.01	98.99
2	No.30	485 micron	8.72	0.872	1.882	98.118
3	No.40	425 micron	6.00	0.60	2.482	97.518
4	No.50	300 micron	5.70	0.57	3.052	96.948
5	No.100	150 micron	5.00	0.60	3.652	96.348
6	No.170	90 micron	4.00	0.40	4.052	95.948
Total weight of soil sample = 1000 grams						

Result = Fine sand

TEST3.9. Determination of field bearing capacity of soil by Proctor's needle method

Observation No.	**1**	**2**	**3**	**4**	**5**
Ring readings	25	30	35	40	55
Load (kg)	12	14	16	18	55
Penetration resistance (kg/cm^2)	1.9	2.2	2.5	2.8	3.9
qu (average)	2.66 kg/cm^2 =	20.66 tones/m^2 = 37 lbs/in^2			
Diameter of needle head = 2.85 cm					
Area of bearing face = $\frac{\pi}{4}d^2 = \frac{\pi}{4}(2.85)^2$ **= 6.4 cm^2**					

TEST 3.10. Determination of cohesion apparent (c) of soil by Vane shear test

Determination No.	**1**	**2**	**3**	**4**	**5**
Height of vane (H) cm	10	10	10	10	10
Diameter of vane (d) cm	5	5	5	5	5
Torque (T) = Load x distance (kg x cm)	5x38=190	5x38=190	6x38=228	6x38=228	6.5x38=247
Value of "c"	0.4	0.4	0.5	0.5	0.54
Average cohesion apparent "c"	0.468 kg/cm^2 = 4.6 tones/m^2				
T $= \pi d^2 c\left(\frac{H}{2}+\frac{d}{6}\right)$ **c**	$= \frac{T}{158}$				

TABLE 3.2 Summary of results of Silty- clay (1st -5 feet) soil of the study area

S.No.	Description	Data
1	**Natural water content**	19.525%
2	**Liquid limit**	50%
3	**Plastic limit**	27%
4	**Plasticity index**	23%
5	**Specific gravity**	2.86
6	**Maximum dry density**	1.81 g/cm^3
7	**Optimum moisture content (O.M.C)**	16%
8	**Angle of internal fraction "Φ"**	20^0
9	**Cohesion apparent "c" by vane shear test**	0.468 kg/cm^2
10	**Field bearing capacity by Proctor's needle method**	2.66 kg/cm^2 or 37 lbs/in^2

3. CONCLUSIONS

The soil investigation details of which presented in this study were aimed at finding the essential soil properties from structural engineering point of view in order to determine its suitability to receive the loads of super structure and transfer them to the strata safely. The properties show that a thin layer of cohesive soil with substantial "c-value" and shear strengths prevails the soil beneath it is sandy, the water table is high, but at a depth of about 10-feet below the surface of the soil may be termed as suitable to receive structural loads with a bearing capacity of about 0.5 kg/cm^2 or 5 tones/m^2.

Results obtained from this study will be helpful to analyze and predict the bearing capacity of soils with considerable reliability and will let the engineers make relatively accurate estimate of safe bearing capacity of soil under different ground conditions.

Acknowledgement

The authors are grateful to the Quaid-e-Awam University of Engineering, Science and Technology, (QUEST) Nawabshah for providing the research facilities.

5. REFERENCES

[1] Bowles, J. E., Foundation Analysis and Design, 5th edition.

[2] Bronick C, Lai R (2005), Soil structure and management. A review, Geaderma

[3] BS 1377 (1990), Methods of test for soils for civil engineering purposes, General requirements and sample preparation

[4] Dangnachew. D., (2011), Investigation Engineering characteristics of soil in Adama Town, Ethiopia

[5] Das, B.M. (1998), Principles of Geotechnical Engineering, 4th edition, PWS Publishing Company.

[6] Eni, et al., (2013), Evaluation of soil bearing capacity and its implication for foundation compatibility in Calabar, Nigeria, Journal of Social Science, Vol. 2(2), pp 34-37

[7] Head, K. H. (1992), Manual of Soil Laboratory Testing, Volume 1: Soil Classification and Compaction Test, 2nd edition, John Wiley and Sons.

[8] James K.M., (1976), Fundamentals of soil behaviour, University of California, Berkeley, John Wily and sons, Incl.

[9] Murthy, V.N.S., (1990), Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering, Marcel Dekker, Incl., New York

[10] Oglesby, C.H and Hicks, R.G (1992), Highway Engineering, John Wiley and Sons, New York, 4th edition, 847 pp.

[11] Ola, S.A. (1978), Geotechnical properties and Behavior of some stabilized Nigerian Laterite Soil, Q.T.J. Engr. Geo. London Vol.III pp.144-160

[12] Quadri, et al., (2012), Investigation of the Geotechnical Engineering Properties of laterite as a Sub grade and Base Material for Road Constructions in Nigeria

.[13] Salter, R.J (1988), Highway Design and construction, Macmillan education limited, London, pp 341

[14] Soil Mechanics and Foundations Hand Book, Edited by Dr. B. C. Punmia

[15] Taylor R.M., (1990), Tropical Residual soils, The Quaternary Journal of Engineering Geology, London