The Suitability of Soils for Constructor in selected sites at Nasiriya City, South of Iraq

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Abstract

Expansive soils are defined as those soils whose volume changes under the effect of wetting and drying cycles are these soils associated with the problems and failures that have been observed in construction field as reported from many parts of the world. In this paper various geotechnical properties have been studied .The purpose of this study is to evaluate soils for suitable construction. Four different sites were selected to evaluate some of geotechnical properties in some regions of Nasiriya city. By studying grain size distribution, chemical tests, Atterbreg limits, Consistency index swelling potential, and consolidation parameters. The present study provides typical ranges of some soil parameters.

The soil in the city of Nasiriya has a variation of engineering properties with depth. The sites were selected from different areas to compare between the engineering properties. The soil has low plasticity (LL < 50), and high swelling potential. Some of the study areas contain a percent of sulphate, which has a negative effect on concrete structures.

Keywords: Geotechnical properties, Consolidation, Swelling potential, Plasticity index

Introduction

This work discusses the soil condition in the city of Nasiriya, which is located in south of Iraq (Figure 1). Many engineering projects have been executed in this study area. The evaluation of some geotechnical properties of the soil is necessary in order to ensure safety and avoid engineering risks. The sub-soil ofNasiriya is generally alluvial, and the ground surface is generally a flat area at the unfolded zone (Buday, 1987). Sediments and landforms provide important clues to changes that occurred as a result of the last shift from the glacial to the non-glacial climatic mode. Nasiriya is located within the Mesopotamia plain, which is up to 200 km wide. It is underlain by fine grained alluvium of the Euphrates and Tigris Rivers. The modern flood plain includes active channels, natural levee, crevasse splays, and flood basins, as well as areas now removed from active fluvial deposition by avulsion or channel migration, which are overlying with sand and poorly graded silt (Aqrawi, 1995). The alluvial silty deposits overlying the marine Hammar Formation can be interpreted as resulting from a deltaic procreation to the southeast (Baltzer, 1990: Sanvlaville, 2001).

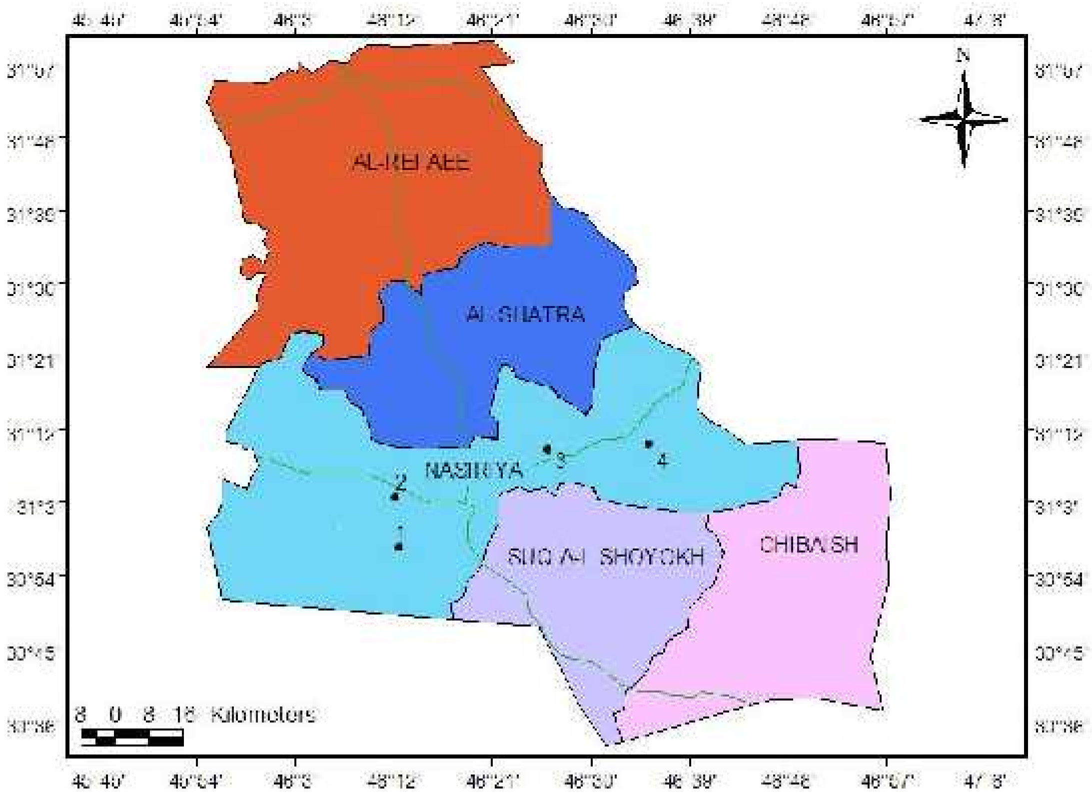

Figure 1: Location map

Field Work

Four sites have been taken to evaluate the soil in Nasiriyacity (Figure 1). The method of drilling was carried out according to the standards of the American Society for Testing and Materials (ASTM), which has a number of D5783. The field work consisted of drilling and sampling to the exploratory boreholes, with a maximum depth of 12m. The samples of soil were collected at each change of lithology strata in boreholes

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Laboratory Tests

A laboratory testing program was carried out for classification and evaluation of some geotechnical properties of the sub-soils. The location of the boreholes was set-up by the Basra Civil Engineering (BCE) laboratory recommendations. All tests achieved in BCE laboratory. The program includes the determination of liquid and plastic limits, particle size distribution, and consolidation tests. These tests were achieved according to the ASTM in 1995 as following:

1- ASTM D423 and D424 to identify the liquid limit, plastic limit and plasticity index.
2- ASTM D854 to identify the specific gravity.
3- ASTM D422 to identify the grain size distribution.
4- ASTM-2435-80 to identify the consolidation test.

Results and Discussion

Classification of soil:

A typical profile soil in the region has been determined according to the unified soil classification system (USCS). The sub-soil strata are shown in Table 1. All layers of the study area in Nasiriya consists of clayey silt. The percent of clay increases toward BH4 by about 65% with a decrease in silt.

The liquid and plastic limits are tested. Table 2 shows the results of the liquid and plastic limits which range from (36%-48%) and (25%-38%) respectively at different depths. These values have great importance in the soil classification and definition, in addition to identifying some of the soil characteristics, such as compression index and knowledge of the volumetric change of the soil (Cernic, 2006). It can be seen that the values of liquidity and plasticity indices almost close with a few differences with depth. It appears the liquidity values are less than

50%, and this means that the soil of the study area are generally of low plasticity. Also, the values of moisture content in general are closer to the values of plastic limit rather than to the liquid limit (Das, 2004)

Table 1: Grain sizes distribution Nasiriya city.

B.H.	Depth (m)	Particle size distribution				U.C.	Description of soil according USCS
		Clay %	Silt %	Sand %	Gravel %		
1	1.0	21	74	5	0	ML	Clayey silt with a little of sand
	5.5	24	70	6	0	ML	Clayey silt with a little of sand
	10.0	45	50	5	0	ML	Clayey silt with a little of sand
	12.0	44	50	6	0	ML	Clayey silt with a little of sand
2	1.0	22	75	3	0	ML	Clayey silt with trace of sand, low plasticity
	5.5	31	64	5	0	ML	Clayey silt with trace of sand, low plasticity
	10.0	27	64	9	0	ML	Clayey silt with a little of sand, low plasticity
	12.0	28	68	4	0	ML	Clayey silt with trace of sand, low plasticity
3	1.0	55	42	3	0	ML	Clay silt with trace of sand
	5.5	51	45	4	0	ML	Clay silt with trace of sand
	10.0	52	45	3	0	ML	Clay silt with trace of sand
	12.0	44	51	5	0	ML	Clayey silt with a little of sand
4	1.0	65	32	3	0	ML	Clay silt with trace of sand, low plasticity
	5.5	56	38	6	0	ML	Clay silt with a little of sand, low plasticity
	10.0	54	40	6	0	ML	Clay silt with a little of sand, low plasticity
	12.0	42	52	6	0	ML	Clayey silt with a little of sand, low plasticity

Consistency index (IC) could be calculated by the following equation: IC=L.L-mc\P.I ……….(1)

Where :L.L : liquid limit , mc: water contact, P.I : plasticity index

According to this equation, classification of the clay layer in investigated areas is stiff to hard soil (Kezdi, 1974). This index can be used in clay soils depending on water content, which obtained an index of unconfined compressive strength (qu) according (Kezdi, 1974 and Lambe, 1951) table below indicate to relationship between compressive strength and consistency index

qu((kN/m^2)	**Consistency**	**Consistency index Ic**
25-0	Very soft	0.25-0
50-25	Soft	0.5-0.25
100-50	Medium	0.75-0.5
200-100	Stiff	1-0.75
400-200	Very stiff	>1
> 400	Hard	>1

The compressive strength in the study area is (25-400) kN\m² (Kezdi, 1974 and Lambe, 1951).

Also, the viability of swelling of the soil was evaluated by the relationship between liquidity and degree of swelling that calculated in equation:S=3.75×10-4×L.L……..(2) (seed, et al, 1962 in Al-Zubaydi, 2006)

Where:

S = potential swelling

Table 2: Values of plasticity index and degree of swelling according of values of liquid limits and plasticity index.

B.H.	Depth (m)	Plasticity index					Type of soil	Swelling potential and degree of expansion based on liquid method	
		L.L	P.L	P.I	WC	Ic		Degree of expansion	Swell potension
1	1.0	44	31	13	25	1.5	Semi solid	High	8.75
	5.5	47	35	12	27	1.6	Semi solid	High	10.43
	10.0	48	38	10	23	2.5	Semi solid	High	11.03
	12.0	47	36	11	27	1.8	Semi solid	High	10.43
2	1.0	48	35	13	19.4	2.2	Semi solid	High	11.03
	5.5	42	33	9	22	0.18	Plastic	High	7.73
	10.0	49	37	12	35	1.1	Semi solid	High	11.65
	12.0	45	31	14	31	1.0	Semi solid to plastic	High	9.29
3	1.0	45	33	12	42	0.19	Plastic	High	9.29
	5.5	41	32	9	38	0.03	Plastic	High	7.25
	10.0	39	27	12	27	1.0	Semi solid to plastic	High	6.35
	12.0	36	25	11	35	0.02	Plastic	High	5.13
4	1.0	47	34	13	32.5	1.1	Semi solid	High	10.43
	5.5	41	32	9		0.6	Plastic	High	7.25
	10.0	37	27	10	27	1	Semi Solid to plastic	High	5.52
	12.0	39	28	11	31	0.7	Plastic	High	6.35

Depending on way of activity method related of liquid limit values, the values of swelling free (S) has a range of efficiency between 5.1 to 11.65 with different depth, table (2) shows the high swelling values in the study sites according to this method.

The swelling potential that relates with the plasticity index (PI) and the soil swell could be expanded and increased in size due to the increase of moisture content, which occurs normally in the clay soil. The swelling soil cases are serious problems facing the engineering projects, when unfertilized soil pressure uploaded to the foundation cause swelling which produces cracks in the buildings, especially in buildings with light loads.

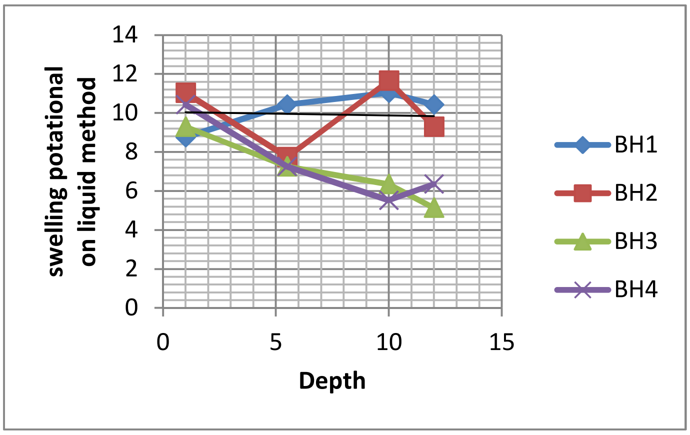

Figure 2: Illustrates the values of swelling potential with depth.

Consolidation test:

The results of the consolidation test are presented in preconsolidation pressure (Pc), initial void ratio (e_o), compression index (Cc), and swelling index (Cs). The compression index (Cc) ranged from 0.018 to 0.25, while the initial void ratio ranged from (0.65-1.08) Table (3).The different value of consolidation test related with percentage of soluble salt (Lee, *et al*,1974). The consolidation settlement can be estimated using the following equations:-

1- For normally consolidated clays (N.C.C.):

$$S_c = \frac{C_c \, . H}{1 + e_o} \log \frac{P_o + \Delta P}{P_o}$$

2- For overconsolidated clays (O.C.C.):

i- if $P_o + \Delta P < P_c$:

$$S_c = \frac{C_r \, . H}{1 + e_o} \log \frac{P_o + \Delta P}{P_o}$$

ii- if $P_o + \Delta P > P_c$:

$$S_c = \frac{C_r \, . H}{1 + e_o} \log \frac{P_c}{P_o} + \frac{C_c \, . H}{1 + e_o} \log \frac{P_o + \Delta P}{P_c}$$

Where;

S_c: consolidation settlement (final).

C_c: compression index.

C_r: recompression index.

H: thickness of clay layer.

e_o: initial voids ratio.

P_o: effective overburden pressure at the center of clay layer.

P_c: preconsolidation pressure.

ΔP: increase in pressure induced at the center of clay layer

In general, the results indicates that the cohesive soil layer is normally consolidated (PC=PO). The clay layer over consolidation have a high of resistance,that related of strong bond between molecular (Terzaghi & Peck,1995).

Porosity value (n), which relates to the parameter of void ratio, can be expressed by equation (4),

$n\% = e/(e+1)$ …….(4) (Bowles,1984)

Where:

n: porosity , e : void of ration

The values are controlling the movement of water and also the efficiency of shape and direction of grains around. Table (3)shows the results of porosity, where the highest values indicate the soil is dis assemble and has more void content that need engineering treated .

Table 3: Results of consolidation test and porosity.

B.H	**Depth (m)**	**P_c (kN/m^2)**	**C_c**	**C_s**	**e_o**	**n%**
1	1	41.9	0.026	0.006	1.080	51
	5.5	37.7	0.031	0.008	0.973	49
2	1	65.7	0.018	0.005	0.873	46
	5.5	69.2	0.033	0.008	1.024	50.5
3	1	65.4	0.25	0.063	0.71	41.5
	5.5	71.2	0.20	0.048	1.00	50
4	1	45.3	0.18	0.045	0.82	45
	5.5	51.7	0.21	0.053	0.65	39.3

To determine compression index (Cc) and swelling index (Cs), calculate compression ratio (CR) and rebound compression ration (RR) with the following equations:

$CR=Cc/1+e_o$ …… (5) (Al-Zubudy, 2006: Craig, 1983)

$RR=Cs/1+e_o$ ……. (6)

The rebound ratio (RR) range from 0.002 to 0.04. These values indicate that soil has high compression or consolidation settlement. It is commonly found in clay soil. Reducing the movement of water through the void because of less permeability (Alany, 1998). The result as shown in Table 4 and Figure 3 indicate the relationship of CR with L.L and PI is almost positive, while between L.L, PI and R.R is almost inverse.

Table.4 Value of liquid limits and plasticity index with RR and CR at different depths and soil types.

B.H	Depth (m)	Type of soil	L.L	P.I	CR	RR
Station1	2	ML	44	13	0.0125	0.002
	4	ML	47	12	0.030	0.004
Station 2	2	ML	48	13	0.096	0.002
	4	ML	42	9	0.016	0.003
Station 3	2	CL	45	12	0.146	0.036
	4	CL	41	9	0.1	0.043
Station 4	2	CL	47	13	0.098	0.024
	4	CL	41	9	0.027	0.047

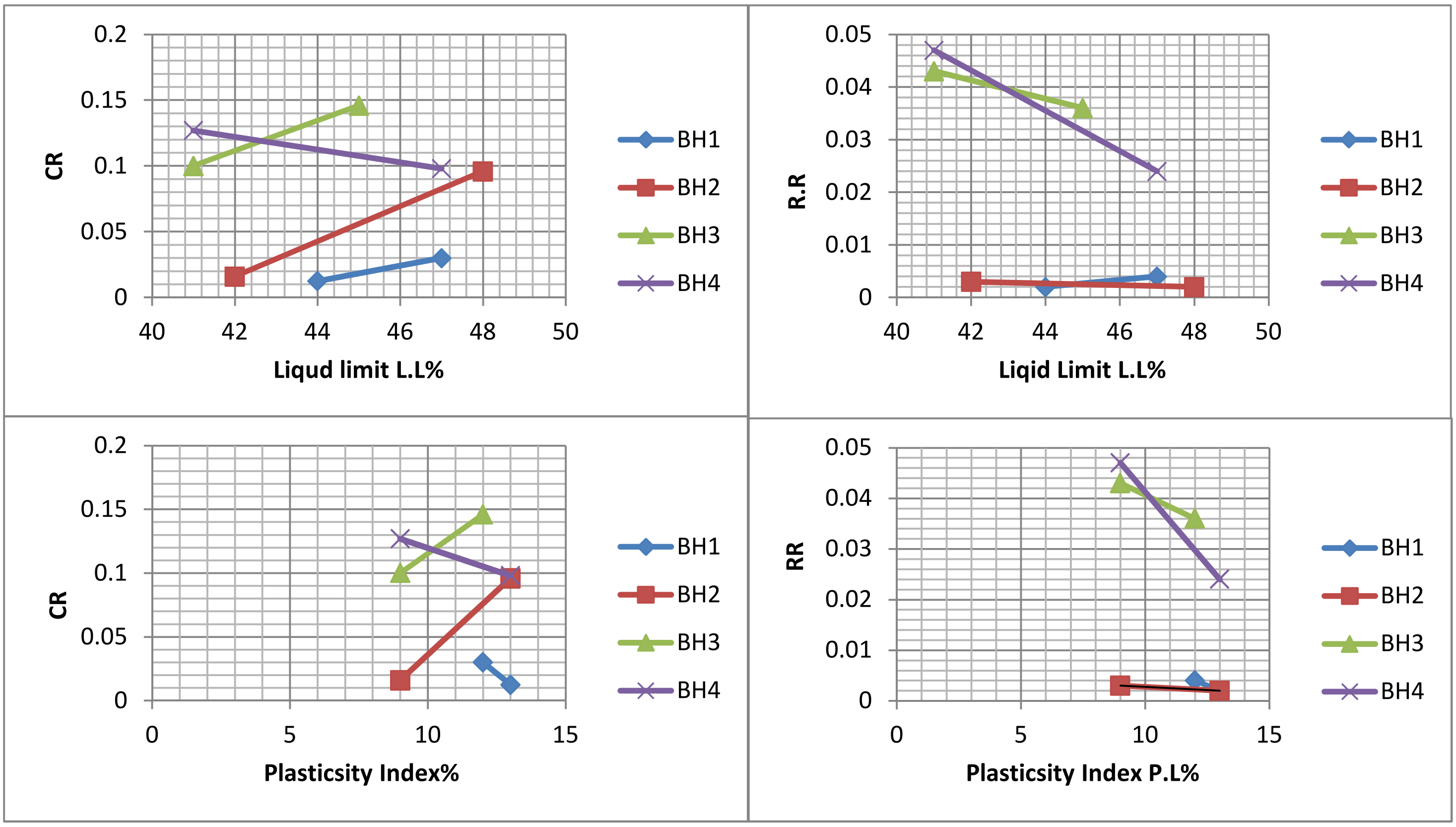

Fig.3 Relationship between liquid limits and plasticity index with RR and CR at different depth

Chemical analysis:

The chemical analysis included Sulphates as SO3%, Chloride, Cl, Organic Matter, O.R., Total Soluble Salt, T.S.S, Gypsum, CaSO4.2H2O, and pH values. Chemical analyses revealed the presence of concentrations of soluble sulphates in soil, occasionally reaching 0.35. These soluble sulphates might react with compounds of hydrated cement. Table. 5 shows that the highest percent of sulphate at BH3 is 0.35 and the lowest percent at BH4 is 0.13%. In some stations, the percentage of Gypsum content is reaches 7.16, which has a negative effect on foundation (Arutyunyan and Manukyan,1982). Therefore, the protection to these structures, which lie below and within ground surface, is necessary

(British standard institution, 1975). The chlorides content is high in station BH4 (0.83%). It also has a negative effect on the concrete structure. Putting a shield around the foundation about 5-15cm deep is recommended.

Tables 5: Results of chemical analyses.

B. H.	GWL	Depth (m)	SO_3 %	T.S.S. %	ORG %	Gyp %	Cl %	pH
1	1.5	1.5	0.35	8.15	0.08	6.80	0.07	7.1
		2	0.27	8.00	0.03	6.73	0.05	7.0
2	2.00	1.5	0.31	7.16	0.12	7.12	0.05	6.9
		2	0.22	7.92	0.06	6.19	0.04	6.8
3	0.83	1.5	0.33	8.10	0.05	7.16	0.08	7.0
		2	0.29	8.34	0.04	6.22	0.04	7.2
4	0.4	1.5	0.136	7.85	0.02	3.62	0.836	7.3
		2	0.148	8.35	0.03	2.18	0.721	7.4

The determined percentage of total soluble salt were estimated the proportion of salts that cause corrosion in the concrete foundation, as well as depended on the proportion of iron. Also determine the salts quality gives the possibility for exchange between the ionic solutions concerning mud on the viability of bloating and swelling effect (Salman, 1996).

The study area contains a high percentage of salt, which should be taken into consideration for holding any design in this region. The organic material is considered high in the soil if its percentage is more than 1%. Table 5 shows low content of organic material in the study area, except BH2 at a depth of 1.5m is 0.12, which is considered effect in the soil compression.

Conclusions:

According to the obtained results from this study the following pointes can be concluded:

1- All results from the investigated areas indicate uniform soil strata consisting mainly of Clayey Silt with increasing clay percentage east ward.

2- The cohesive soil is low plasticity soil (LL < 50), with high swelling potential.

3- Some of the stations in the study areas contain a high percent of Gypsum that has a negative effect on the foundation. Sulphate resisting cement should be used in construction works. Sulphate resisting Portland cement with a minimum cement content of 400 kg/m³ and maximum free water cement ratio of 0.40 by

4- Cohesive layer in the city of Nasiriya is normally consolidated.

5- Weight should be used.

6- The high level of ground water in some regions, which change the soil volume depending on water content, will cause a serious problem in constructions, such as swelling.

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تقيم صلاحية التربة للأعمال الإنشائية لمناطق مختارة في مدية الناصرية جنوب العراق

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الخلاصة

يمكن تعريف الترب الانتفاخية بأنها التربة التي يتغير حجمها بتغير محتواها الرطوبي . في هذا البحث اختيرت أربع مناطق في مدينة الناصرية الواقعة في الجزء الجنوبي من العراق تم دراسة بعض الخواص الجيوتكنيكية لغرض تقيمها هندسيا وملائمتها لبناء المنشاة ، وقد تم دراسة خواص التحليل ألحجمي وحدود اتربرغ والتحليل الكيميائي للترب وفحص القوام والانضمام ،,وحساب جهد الانتفاخ اعتمادا على حد السيول ودليل اللدونة.

أظهرت النتائج اختلاف في الخواص الجيوتكنيكية مع العمق من منطقه إلى أخرى، وقد بينت نتائج حدود اتربرغ أن تربة مناطق الدراسة كافه واطئه اللدانة (L.L<50%) ، ذات انتفاخية عالية اعتمادا على طريقة الفعالية .فحص الانضمام اظهر أن الترب ذات انضمام اعتيادي . Normally Consolidation