Al-Khwarizmi Engineering Journal

Al-Khwarizmi Engineering Journal, Vol. 11, No. 2, P.P. 74- 85 (2015)

Profiles and Geotechnical Properties for some Basra Soils

Abbas J. Al-Taie

Ministry of Higher Education and Scientific Research/ Baghdad

Email: abbasjaltaie@yahoo.com

(Received 1 September 2014; accepted 4 January 2015)

Abstract

Basra province is known for its logistic location for trading activity and oil industry. By geological point of view, Basra areas are believed to consist mainly of alternation of (clay, silty clay, clayey silt, silt and sand) type of soil. Any development of industry in this area should be affected by the occurrence of the clay soil. That is why the investigation to the soil is more than necessary. In this case, a vast testing program was carried out by the author to evaluate the various formations constituting the of some Basra soils. An attempt to characterize and discuss the nature, minerals, engineering behavior and field properties of soil samples extracted from more than one thousand and one hundred boring liner meters of three sites was performed. The average values of various geotechnical design properties are calculated and plotted with depth. A preview of climate, geology, seismicity and earthquakes of the study area was conducted. Finally, the typical soil profiles were prepared.

Keywords: *Basra soil, soft clay, lean clay, Atterberg limits, moisture content, shear strength, standard penetration,*

1. Introduction

Although Basra province has logistic location for trading activity and oil industry, little attention has been given to geotechnical properties of the Basra soil (Hanzawa, 1977). Based on laboratory and field tests carried out during the geotechnical investigation for three large water projects (Site1, Site2 and Site3), characterization and discussion of the various formations constituting the soil of Basra province were given. The selected samples extracted from more than 1100 boring liner meters used to achieve the required purposes. Totally, 39 boreholes were drilled from natural ground and extended into a depth of 30 m. The number of boreholes for Site1, Site2 and Site3 are 24, 9 and 6 boreholes respectively. Many of the samples were obtained from Site1 which located about 18 km to the north of Al-Zubair district. Also, samples collected from Site2 (located about 11 km south-east of Al-Zubair district) and Site3. The boreholes in Site3 are distributed along a line of 17 km length between Al-Zubair and Abu Al-Khaseeb districts as shown in Fig. 1. In addition to the field tests, a vast laboratory testing program was carried out. The natural water content, Atterberg limits, sieve analysis and hydrometer, specific gravity, and consolidation test were included in this program.

2. Description, Climate, Geology, Seismicity and Earthquakes of the Study Area

2.1. Sites Description and Climate

Topographically, the sites are located within a flat plain called "Mesopotamian Plain" that slopes gently between Baghdad and Basra provinces and is also located between the rivers Tigris and Euphrates. This plain was historically lush but is now generally arid; palm trees and bushes densely cover narrow belts of natural levees rimming the Euphrates and Tigris rivers courses and artificially irrigated areas. The climate of Mesopotamian is semi-arid with maximum temperature up to

+53°C in July-August and a minimum temperature of -7°C in January. Average annual precipitation is 150 mm/year (mostly occurring from November to March) and can reach 250 mm/year and it falls to <100 mm/year towards the desert causing generally semi-desert to desert climatic conditions, Aqrawi, 2001.

Fig. 1. Sites Location.

2.2. Geology of the Area

Lake/marsh complex in south Iraq comprising the ancient Tigris-Euphrates-Karun Delta, and modern tidal flats and Shatt Al-Arab/Karun estuary/delta. Most of the lower Mesopotamian Plain is flat broad area (sometimes below sea-level).The Mesopotamian Zone was represents by the Quaternary Sediments that range in age from Pleistocene to Holocene, and in thickness from few meters up to 250 m, which were deposited by the interacting Tigris and Euphrates rivers, on the alluvial fans from the surrounding elevated areas. The Quarter]; nary Sediments are composed mainly of alternation of clay, silty clay, clayey silt, silt, sand and gravel. Plasticity of these soil sediments varied from low to high. These sediments often have a greyish tint due to increased contents of organic matter and traces of biological activity; also it is marked by the presence of well-preserved recent fossils (bivalves and gastropods), see Fig. 2, (Philip, 1969; Kukal and Sa'adalla, 1973; Raji and Salman, 1983).

2.3. Structural Geology

According to the tectonic map of Iraq (Fig. 3), Iraq can be divided into three tectonically different areas: The stable shelf with major buried arches and anti-forms but no surface anticlines, the unstable shelf with surface anticlines and Zagros Suture which comprises thrust sheets of radiolarian chert, igneous and metamorphic rocks. The investigated sites in this paper are located within the Zubair Subzone in the south of Mesopotamian Zone at the Stable Shelf area. The Zubair Subzone is bounded in the north by the Takhadid-Qurna Transversal Fault. The southern boundary of the subzone is either located at the Al Batin Fault or long a transversal fault in Kuwait. The northern dome of the Zubair anticline is associated with a negative gravity anomaly. However the southern dome of this anticline and the structures to the south in Kuwait are not. These structures and the southern Zubair dome could be included in another subzone. This subzone forms the southernmost unit the Mesopotamian Zone and has a uniform structural style controlled by the underlying basement. It contains prominent N-S trending structures which continue hundreds of kilometer southwards into Kuwait and eastwards Saudi Arabia, Jassim and Goff, 2006.

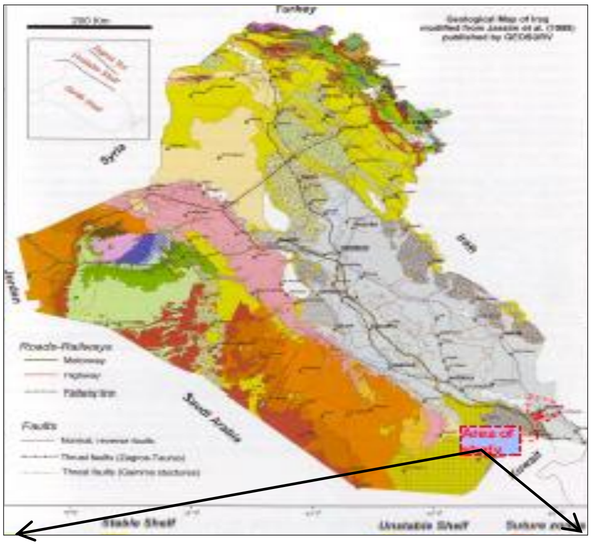

Fig. 2. Geological Map of Iraq (Jassim & Goff, 2006)

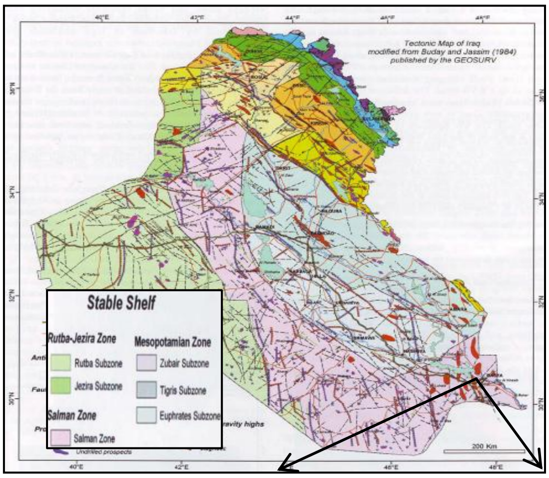

Fig. 3. Tectonic Map of Iraq (after Jassim & Goff, 2006).

2.4. Seismicity and Earthquakes

The seismicity of Iraq is of intermediate character and the focal depth is shallow. The seismicity of the stable shelf is due to located deformation but the seismicity of folded area is due to forces resulting from the movements of the Arabian plate towards the north and north east. According to the seismic zoning map, (isointensity map, Fig. 4), the investigated sites lie within the no damage zone (zone III).

Although Iraq is seemingly secure from seismic hazards, seismic observations indicate otherwise. Earthquakes are likely to happen and may cause substantial damage, especially in north east of Iraq and in the Mesopotamian Plain due to liquefaction of Quaternary Sediments. It is therefore important to take into consideration seismic parameters in future design of large building, Jassim and Goff, 2006.

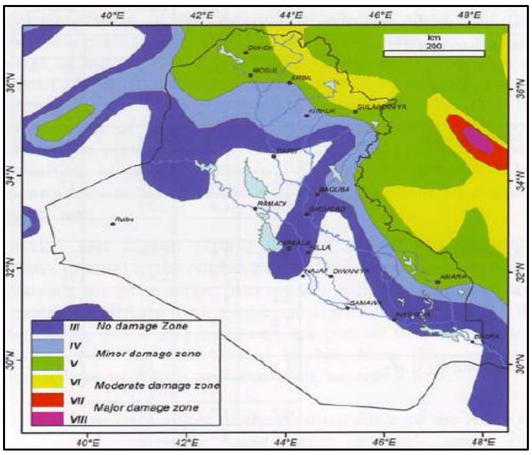

Fig. 4. Isointensity Map of Iraq (after (Jassim & Goff, 2006).

3. Results and discussion of basic and engineering properties

3.1. Moisture Content, Specific Gravity and Unit Weight

The distribution of moisture content and (Total and Dry) unit weight with depth for all sites is shown in Fig. 5, and average values of all the data points are summarized in Table 1.

Overall, moisture content, specific gravity and unit weight values are uniform with depth. A detailed assessment of the data reveals that average moisture content in the Site3 is somewhat larger than for the other sites, with a corresponding slightly smaller unit weight. The site1 has the lowest moisture content and highest unit weight. Values for the Site2 and the Site3 are very similar. The average specific gravity of Basra soil is typically 2.735. However, there is no clear difference in the results from the various formations.

3.2. Atterberg Limits of Basra Soil

Atterberg limits tests were conducted on 115 samples of soil fractions passing sieve No. 40 according to ASTM D 4318. The variation of values of liquid limit (L.L), plastic limit (P.L), and plasticity index (P.I) with different depth is summarized in Fig. 6 and the average values listed in Table 1. Except for the presence of some sandy lenses in the Site 1, the values are remarkably uniform, and 88% of data for all three sites fall in the classification 'clay of low plasticity' while 12% of data indicates high plasticity on the plasticity chart. Reexamination of the data in Table 1 confirms that the average values of index properties for all sites are very similar. The soil in Site 2 appears to have a slightly higher average plastic limit with a correspondingly lower average plasticity index than the other sites. Overall, natural moisture content values fall close to the liquid limit. Fig. 6 shows the distribution of PL/LL ratio of Basra soil with depth. This ratio varies from 0.76 to 0.37 with an average value of 0.56. From the scattering of experimental points of Basra soil shown in Fig. 6, it is reasonable to consider that PL/LL ratio remains same. Sridharan et. al. 2004, brought out that PL/LL ratio depends upon the type of clay minerals or mixtures of clay minerals and associated cations and its concentrations. For any particular region, the PL/LL ratio varies marginally or remains same.

Thus soils from the same region can be expected to have same ratios of PL/LL since they possibly have same type of clay mineral mixtures and same type of exchangeable ions and ion concentration. Accordingly, one can expected that the soil from all investigated sites in Basra may have same type of clay mineral mixtures and same type of exchangeable ions and ion concentration. This finding is compatible with section 3.4 of this paper.

An approximate determination of the shrinkage limit (SL) of Basra soil was performed in this paper using Casagrande method, Das 2010. By using the A-line and the U-line on plasticity chart, the plasticity index and liquid limit of Basra soil with different depths used to determine SL and the results are shown in Fig. 6. It can be seen that SL values range from 10 to 23 with an average value of 17. The typical values of SL for different clay minerals indicate that SL of Illite ranges from 15 to 17. Kaolinite has SL values varies from 25 to 29, Mitchell, 1976.

To identify the state of Basra soil in the field, liquidity index was calculated and the results are shown in Fig. 6. On average, 44% of liquidity index values range from 0.5 and 0.94. According to Terzighi et. al. 1996, the expected unconfined compressive strength of this soil ranges between (30 and 100) kPa.

Table 1,
Values of the Physical Properties of Basra soil.

	Site1			Site2			Site3		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Gs	2.92	2.52	2.73	2.81	2.68	2.74	2.78	2.50	2.74
Mc, %	49.4	10.0	30.2	40.8	26.4	34.2	44.8	27.4	35.9
γ_t, kN/m^3	23.78	15.33	19.48	23.06	17.71	20.29	21.87	17.70	19.35
γ_d kN/m^3	22.00	11.05	15.10	17.78	12.58	15.21	17.17	12.72	14.25
LL, %	59	21	40	46	34	40	49	31	40
PL, %	32	14	22	28	22	24	25	21	23
PI, %	31	5	19	23	11	16	26	10	17
Clay,%	79	3	48	70	38	63	71	49	63
Silt,%	49	4	32	42	19	34	44	15	32
Sand,%	89	0	19	43	1	3	66	1	8
Gravel,	0	0	0	0	0	0	0	0	0

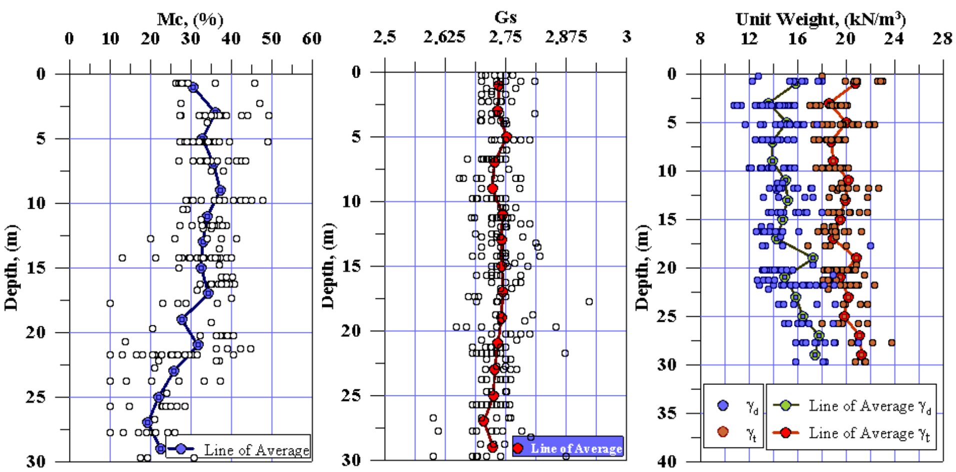

Fig. 5. Variation of Moisture Content, Specific Gravity and Bulk Unit Weight of Basra Soil.

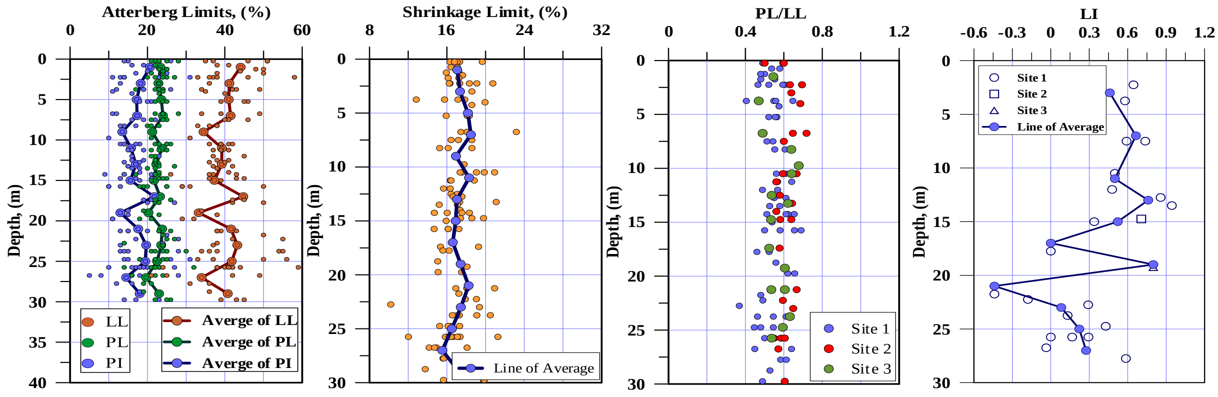

Fig. 6. Atterberg Limits and Liquidity Index of Basra Soil

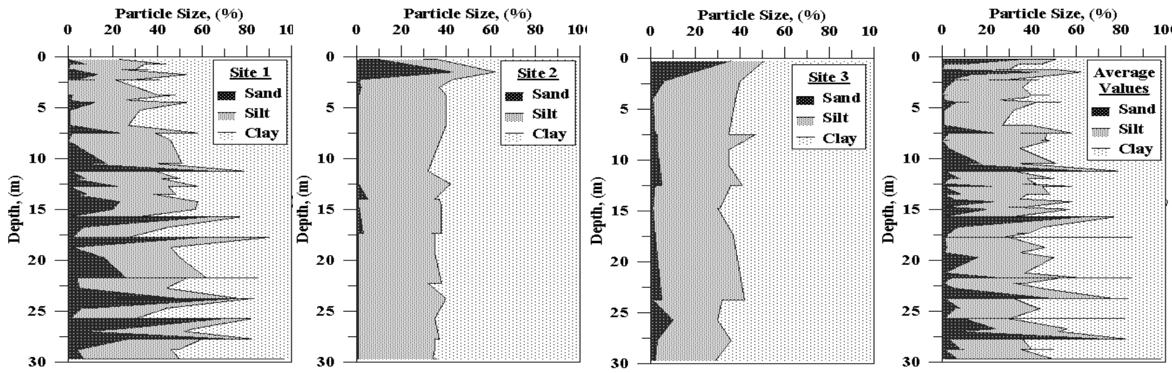

Fig. 7. Particle Size Percentages of Basra Soil.

The liquidity index of 30% of the investigated soil is less than 0.5 and greater than zero, while 26% of liquidity index values are less than or equal to zero. When the liquidity index is near zero, the expected compressive strength generally lies between (100 and 500) kPa, Terzighi, 1996.

3.3. Particle Size Percentage and Texture of Basra Soil

Grain size analysis tests were performed according to ASTM D 422. The percentages of gravel, sand, silt and clay particles of 126 soil samples are plotted against depth in Fig. 7. Note that Basra soil is predominantly silt and clay with trace of sand and no gravel. In general, the quantities of the various constituents in Sites 2 and 3 are relatively constant with depth. Based on the average values quoted in Table 1, it can be seen that there is some tendency for the quantity of sand in Site 1 to increase with depth. However, the average data reveals that sand content in the Site1 is greater than for the other sites, with corresponding smaller clay content. The Site2 has the lowest sand content and highest silt content. It can be seen that the average values for sites 2 and 3 remain almost the same.

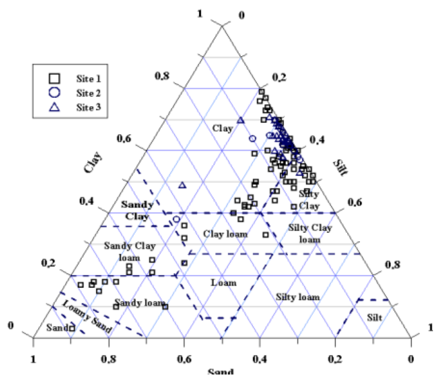

Fig. 8. Textural Soil Classification (TSC).

The Unified Soil Classification System (USCS) and Textural Soil Classification (TSC) were used to classify the soil of Basra. It was found that the soil is lean clay (CL) according to (USCS) and clay to silty clay according to (TSC), see Figs. (8 and 9).

3.4. Mineralogy of Basra soil

The identification of clay minerals is of the most important since they greatly influence the engineering behavior and properties of the soil, Day, 2006. The amount of attracted water, which is influenced by clay minerals, effects on the plasticity of a clay soil which is influenced by the amount of its clay fraction and the type of clay minerals present, Kempfert and Gebreselassie, 2006. One of a more common approach to identify clay minerals present in a soil is to use the location of clay particles as they plot on the plasticity chart (Fig. 9). It should be keep in mind that the estimation of clay minerals by this method is approximate because soil can contain more than one type of clay mineral, Day, 2006; Eden and Crawford, 1957.

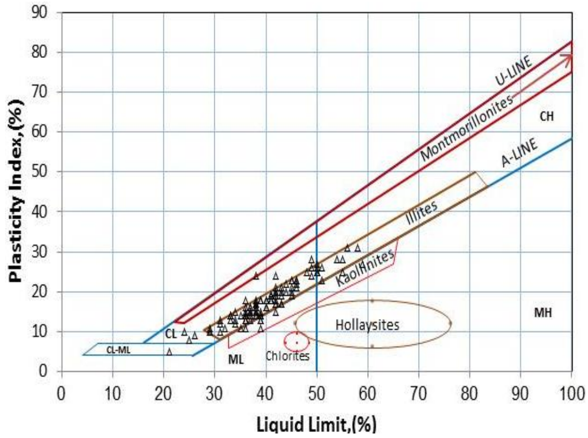

Fig. 9. Plasticity Characteristics of Common Clay Minerals.

Table 2,
The average values of the consolidation parameters of Basra soil.

	Site1			Site2			Site3		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
eo	1.390	0.412	0.856	1.187	0.6586	0.934	1.131	0.685	0.977
Cc	0.43	0.10	0.198	0.36	0.17	0.245	0.43	0.18	0.292
Cs	0.056	0.010	0.027	0.057	0.012	0.030	0.038	0.020	0.030
CR	0.18	0.04	0.10	0.18	0.10	0.13	0.25	0.11	0.15
RR	0.027	0.003	0.014	0.028	0.006	0.015	0.018	0.010	0.015

Examination of Fig. 9 indicates that the soil of Basra is composed mainly of illite with a tendency toward kaolinite. Very small amounts of montmorillonite can be seen in Fig. 9. As primary conclusion, Basra soil is mainly composed of illite with kaolinite as clay minerals. This result has much significance but final conclusion can be drawn by x-ray diffraction to identify the actual clay minerals. Therefore further work on the compositional analysis of the Basra soil is planned. Illite is the most common clay mineral in stiff clays and shales as well as in postglacial marine and lacustrine soft clay and silt deposit, while Kaolinite is one of the most common clay minerals in sedimentary and residual soils, Terzaghi et. al. 1996. Most soft clay deposits of marine and lacustrine origin are composed of a mixture of minerals that are likely to include illite and chlorite, substantial amounts of quartz and feldspar, and some montmorillonite, micas, and carbonates.

3.5. Compressibility of Basra Soil

A series of consolidation tests (119 tests) were carried out on selected specimens, as a part of this study, to determine their compressibility characteristics. The results used to calculate the consolidation parameters of Basra soil. Fig. 10 shows the variations of compression and swelling indices (Cc and Cs), and compression and recompression ratios (CR=(Cc/(1+eo) and RR=Cs/(1+eo)) with depth below the ground surface. As can be readily seen from this figure, values of (Cc, Cs, CR and RR) vary widely for a given depth below ground. The average values of these parameters vary with a narrow range for depth up to 15 m, and then values decrease slightly with depth. The average values listed in Table 2 suggest that Basra soil has a compression index, Cc, in the range of 0.10 and 0.43 with an average value of 0.22. This range is more or less identical to that suggested by Holtz and Kovacs 1981 for Chicago silty clay, CL, where Cc ranged from 0.15 to 0.30. Furthermore, about 36% of Cc calculated in the present work is less than 0.20, while 65% of the values ranges from 0.20 to 0.40. Therefore, the degree of compressibility of Basra soil, according to Kulhawy and Mayne 1990, can be classified as intermediate. Regarding to Cs of Basra soil, it ranges from 0.010 to 0.056 with an average value of 0.029. Typical values of Cs given in literatures are ranged from 0.015 to 0.035, where the lower values are for clays of lower plasticity and low OCR, Leonards 1976. Values of Cs outside the range of 0.005 to 0.05 should be considered questionable as stated by Holtz and Kovacs 1981.

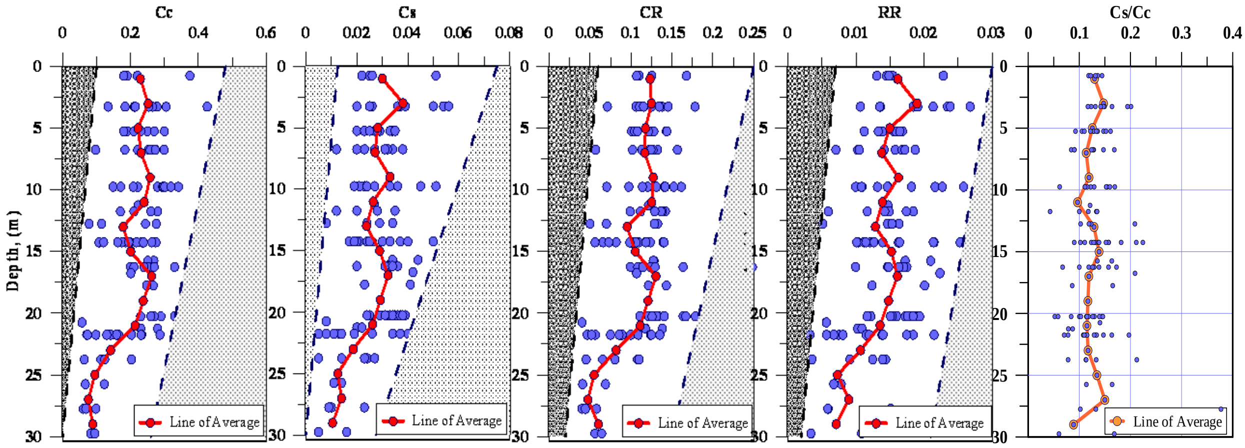

Fig. 10. Consolidation Parameters of Basra Soil.

The ratio of Cs/Cc for Basra soil varies from 0.043 to 0.377 (Fig. 10) with an average value of 0.12. Terzaghi et. al., 1996, demonstrated that most values of Cs/Cc are in the range of 0.02 to 0.20. Kempfert and Gebreselassie 2006, mentioned that Cs/Cc is a constant value and varies between 0.2 and 0.4. For the lacustrine soft clays in southern Germany, Scherzinger 1991, found that Cs/Cc is on average 0.2. According to Das 2008, the range of Cs /Cc is approximately from 0.1 to 0.2. Nevertheless, very low values of Cs/Cc, even lower than 0.02, correspond to highly structured and bonded soft clay and silt deposits, while high values correspond to micaceous silts and fissured stiff clays and shales, Terzaghi et. al.,1996.

3.6. Swelling Potential of Basra Soil

In this paper, an evaluation for swelling potential of Basra soil was carried out based on the average values of Atterberg limits and percent of clay fraction (<0.002mm). The classification system developed by Abduljauwad and Al-Sulaimani 1993, is adopted to achieve the above mentioned purpose as shown in Fig. 11. An examination to Fig. 11 reveals that the swelling potential of more than 70% of Basra soil can be classified as low, while less than (30%) of this soil may undergo medium swell under saturation condition. The values of activity presented in Fig. 11 reveal that Basra soil is inactive and this soil has an activity less than 0.75. This result, however, is expected for Basra soil which consists mainly of Illite with Kaolinite as clay minerals. Illite has an activity of 0.5 to 1.0, while the activity of Kaolinite is 0.5, Das, 2011.

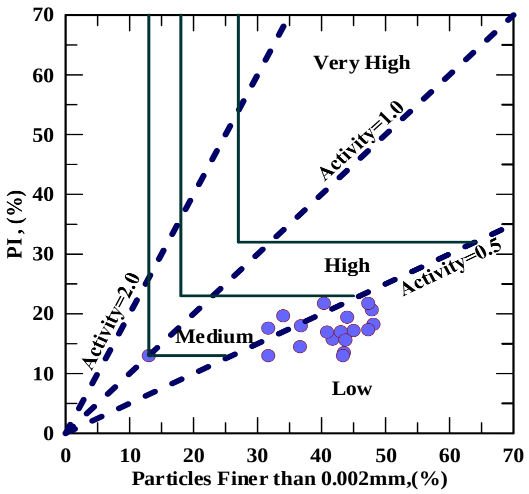

Fig. 11. Swelling Potential of Basra Soil.

3.7. Direct Shear Test of Basra Soil

A series of direct shear test have been carried out on selected soil samples at different depths of each borehole. Totally, 120 tests were conducted according to ASTM D 3080 – 98. All tested soil samples were carried out under soaking during the test. The variation of shear strength parameters (i.e cohesion (c) and angle of internal friction (ϕ)), with depth is shown in Fig. 12 and summarized in Table 3. An increasing in values of internal friction with depth can be seen at Site 1. This is mainly due to increasing coarse grains (sand content) as shown in Fig. 7. Except some values in Site 1, low cohesion values appear for soil samples with depth. However, the average shear strength parameters values in Sites 2 and 3 remain almost the same. These exhibit low shear strength parameters values which may be attributed to particle size of the soil at which the clay with water content closes to liquid limit than to plastic limit is predominated.

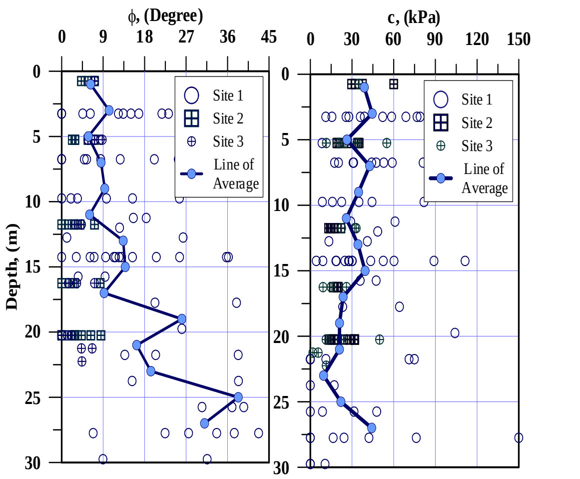

Fig. 12. Variation of Direct Shear Test Results of Basra Soil

Table 3,
Shear Strength and N-Values of Basra soil.

VALUES	SITES	c,kPa	ϕ	N	N60
Maximum		150	43	>50	>50
Minimum	SITE1	0	0	2	2
Average		36	19	30	30
Maximum		60	8	29	16
Minimum	SITE1	13	0	5	3
Average		24	4	10	7
Maximum		55	9	28	16
Minimum	SITE1	2	0	5	3
Average		23	5	10	7

3.8. Standard Penetration

The standard penetration test is performed routinely in ground investigations in Iraq. Five hundred and fifty seven tests were conducted at different depths to achieve the purpose of this study. The N values were corrected (N60) and presented in as shown in Figs. 13 to 15 and summarized in Table 3. The observed scatter in the data is considerable. Except Site 1, the values are remarkably uniform, and data fall in the classification 'soft to stiff' of the consistency of cohesive soil. The N values for the Site 1 are often considerably higher. The reasons for this may be attributed formation of soil in Site 1 which seems to have higher sand content than that encountered elsewhere.

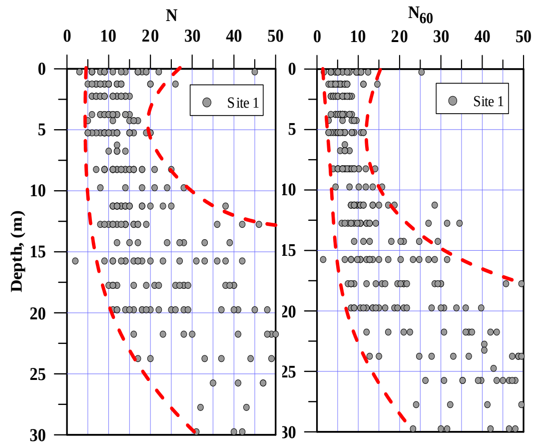

Fig. 13. Standard Penetration Test Results for Site 1.

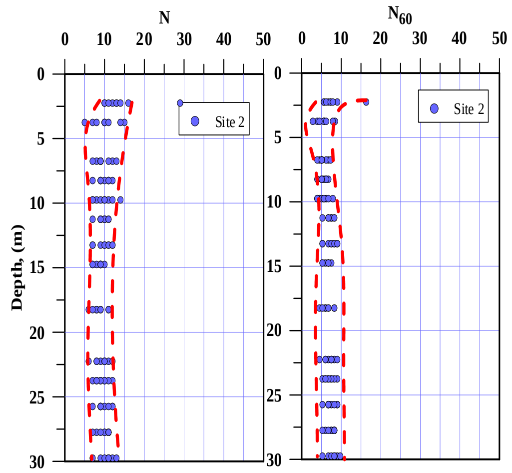

Fig. 14. Standard Penetration Test Results for Site 2.

3.9. Typical Profiles and Ground Water Table of Basra Soil

In this paper, with reference to boring results, typical soil profiles were prepared and showed mainly cohesive soil grading into clay and silt

(Fig. 13). The upper part of the soil is often medium stiff to stiff CLAY to depths of (2.5 to 4.5) m or more, but the deeper soil is identified by CLAY with soft consistency to depths of (12.0 to 18.0) m or more. Below this depth, and down to a depth of 30m, the soil is practically stiffer with the present of cohesionless layers of silty sand.

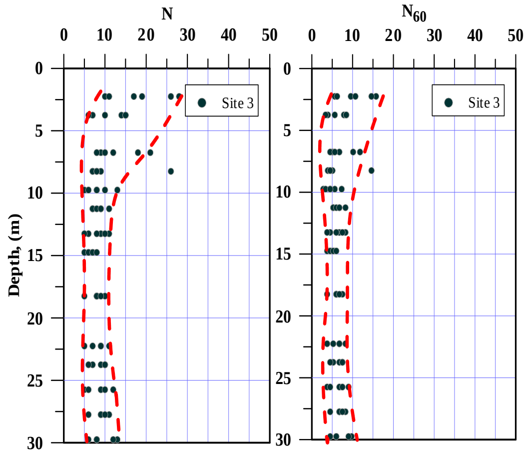

Fig. 15. Standard Penetration Test Results for Site 3.

Basra soil usually show non pronounced stratification and sometimes organic matter, shell and well-preserved recent fossils (bivalves and gastropods) are present in this deposits as shown in Figs. 16 to 18. Also, it is marked by the presence of lenses of clay and sand. This soil has a color of brown to grayish brown, gray to dark gray and brownish gray. Jassim and Goff 2006, attributed the grayish tint of this soil to the increasing the content of organic matter and traces of biological activity.

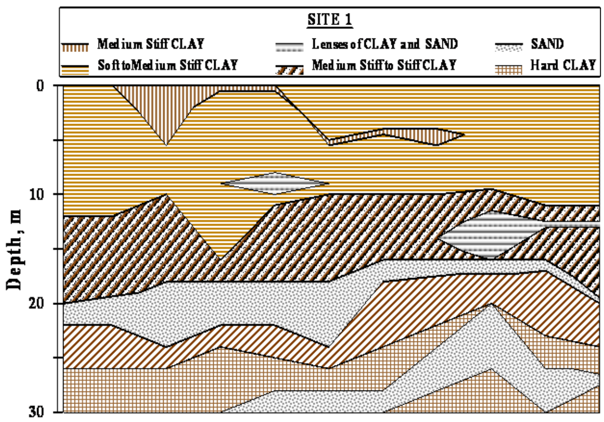

Fig. 16. Typical profiles for Site 1.

Basra soil usually show non pronounced stratification and sometimes organic matter, shell and well-preserved recent fossils (bivalves and gastropods) are present in this deposits as shown in Fig. 19. Also, it is marked by the presence of lenses of clay and sand. This soil has a color of brown to grayish brown, gray to dark gray and brownish gray. Jassim and Goff 2006, attributed the grayish tint of this soil to the increasing the content of organic matter and traces of biological activity.

The underground water table in Basra was encou- ntered at depths varied from (0.55 to 3.0)m below the natural ground level.

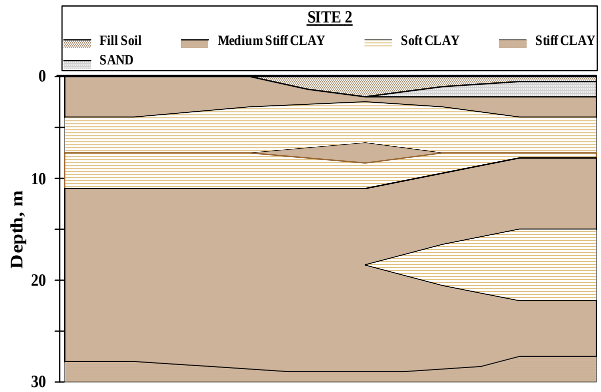

Fig. 17. Typical profiles for Site 2.

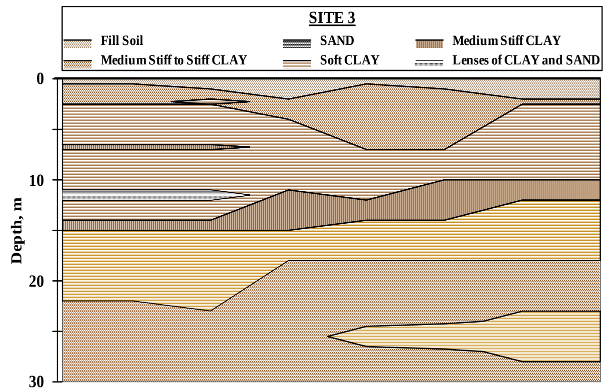

Fig. 18. Typical profiles for Site 3.

Fig. 19. Shell and Well-Preserved Recent Fossils (bivalves and gastropods).

4. Conclusion

A vast laboratory and field testing program was carried out to characterize and discuss the various formations constituting the soil of Basra province. A preview of climate, geology, seismicity and earthquakes of the study area was conducted. Accordingly, the following conclusions are obtained:

1. Topographically, the investigated sites are located within a flat plain called Mesopotamian Plain with semi-arid climate.
2. Geologically, the Quaternary Sediments that range in age from Pleistocene to Holocene, and in thickness from few meters up to 250 m, which were deposited by the interacting Tigris and Euphrates rivers, that represent the investigated sites.
3. According to the tectonic map of Iraq, the investigated sites are located within the Zubair Subzone in the south of Mesopotamian Zone at the Stable Shelf area.
4. According to the seismic zoning map, the investigated sites lie within the no damage zone. Although Iraq is seemingly secure from seismic hazards, seismic observations indicate otherwise. Earthquakes are likely to happen and may cause substantial damage; therefore important to take into consideration seismic parameters in future design of large building.
5. Basra soil composes mainly of alternation of clay, silty clay, clayey silt, silt and sand. The predominated plasticity of this soil is low. This soil often has a greyish tint and marked by the presence of well-preserved recent fossils (bivalves and gastropods
6. Mineralogy, Basra soil composes mainly of illite with a tendency toward kaolinite with very small amounts of montmorillonite.
7. The degree of compressibility of Basra soil classified as intermediate. The ratio of Cs/Cc for this soil varies from 0.043 to 0.377 with an average value of 0.12, while the Cs ranges from 0.010 to 0.056 with an average value of 0.029.
8. The swelling potential of Basra soil classified as low with a tendency toward medium, This soil is inactive and has an activity less than 0.75.
9. According to liquidity index values, the expected unconfined compressive strength of about 50% this soil ranges from (30 to 100) kPa.
10. In general, Basra soil is predominantly silt and clay with trace of sand and no gravel, thus, it's classified as lean clay. The water content of tis soil closes to liquid limit leading to intermediate Compressibility, low shear strength and hence low bearing capacity

Notation

c	cohesion
Cc	compression index
CR	compression ratio
Cs	swelling index
eo	initial void ratio
Gs	specific gravity
LI	liquidity index
LL	liquid limit
Mc	natural moisture content
N	number of b ows in SPT
N60	corrected N value for field condition
PI	plasticity index
PL	plastic limit
RR	recompression ratios
SL	shrinkage limit
SPT	standard penetration test

Greek letters

ϕ	angle of internal friction
γ_d	total unit weight
γ_t	dry unit weight

5. References

[1] Abduljauwad, S. N., and Al Sulaimani, G. J., 1993, "Determination of Swelling Potential of Al Qatif Clay", Geotechnical Testing J., ASCE, Vol.16, No.4, pp 469-484.

[2] Aqrawi, A. A. M., 2001, "Stratigraphic Signatures of Climatic Change During the Holocene Evolution of the Tigris-Euphrates Delta, Lower Mesopotamia", In Fard, A. M., (Editor of Special Issue), "Recognition of abrupt climate changes in elastic sedimentary environments, In Cloetingh et. al. (Editors), Global and Planetary Change, 25:pp.267-283. Das, B. M., 2008, "Advanced Soil Mechanics' 3rd Edition, Taylor & Francis, New York, NY 10016, USA.

[3] Day, R. W., 2006,"Foundation Engineering Handbook: Design and Construction with the

2006 International Building Code", McGraw-Hill Companies, Inc.

[4] Eden, W. J., and Crawford, C. B., 1957, "Geotechnical Properties of Leda Clay in the Ottawa Area", Soil Mechanics Section, Division of Building Research, Ottawa, Canada.

[5] Hanzawa, H. (1977b) “Geotechnical properties of normally consolidated Fao clay.” Soils and Foundations, 17(4), 1−15.

[6] Holtz, R. D., and Kovacs, W. D., 1981, "An Introduction to Geotechnical Engineering", Prentice Hall Inc., New Jersey.Pp341.

[7] Jassim, S. Z. and Goff, J. C., 2006, "Geology of Iraq", Dolin, Prague and Morravian Museum, Brno.

[8] Kempfert, H. G., and Gebreselassie, B., 2006, "Excavations and Foundations in Soft Soils", Springer-Verlag Berlin Heidelberg.

[9] Kukal, Z., and Sa'adalla, A., 1973, "Aeolian Admixtures in the Sediments of the North Persian Gulf". In: B. H. Purser (ed.), The Persian Gulf, Springer-Verlag, Berlin, pp. 115-121.

[10] Kulhawy, F. H., and Mayne, P. W., 1990, "Manuel on Estimating Soil Properties for Foundation Design",. Electric Power Research Institute, EPRI.

[11] Leonards, G. A., 1976, "Estimating Consolidation Settlements of of Shallow Foundations on Overconsolidated Clays", Special Report 163, Transportation Research Board, pp 13-16.

[12] Mitchell, J. K., 1976. “Fundamentals of Soil Behavior”, Wiley, New York

[13] Philip, G., 1969, "Mineralogy of recent sediments and some detrital deposits". Bull. Col. Sci., Baghdad University; 9, Baghdad.

[14] Raji, W., and Salman, B., 1983, "Palaeontological and Environmental Study of the Mesopotamian Plain in Samawa-Nasirriya Area", survey of Iraq, Baghdad, Unpublished Report.

[15] Scherzinger, T., 1991, "Material verhalten von Seetonen-Ergebnisse von Laboruntersuchungen und ihreBedeutungfür das Bauen in weichemBaugrund", P.hD. thesis, InstitutfürBodenmechanik und Felsmechanik der UniversittFridericiana in Karlsruhe, Heft 122.

[16] Sridharan, A., Rao, P. R. and Miura, N., 2004. “Characterisation of Ariake and other Marine Clays”, International Symposium on Lowland Technology ISLT 2004, Bangkok. pp. 53-58.

[17] Terzaghi, K., Peck, R. B., and Mesri, G. 1996, "Soil Mechanics in Engineering Practice", John Wiley & Sons, Inc., 3rd. Edition, New York.

المقاطع والخصائص الجيوتقنية لبعض ترب البصرة

عباس جواد الطائي
وزارة التعليم اللعالي والبحث العلمي/ بغداد
البريد الالكتروني : abbasjaltaie@yahoo.com

الخلاصة

تمتاز محافظة البصرة بموقع لوجستي للنشاط التجاري وصناعة النفط. من وجهة نظر جيولوجية، يعتقد أن مناطق البصرة تتألف أساسا من تبادل الانواع الاتية من التربة (الطين، والطين الغريني، والغرين الطيني، والغرين والرمل). ان اي عملية تطوير للصناعة ضمن هذه المنطقة يجب أن تتأثر بوجود التربة الطينية. ولهذا السبب فان اجراء تحريات موقعية للتربة ضمن هذه المنطقة ضروري جدا . في هذه الدراسة، تم تنفيذ برنامج مختبر ي وحقلي واسع لتقويم التكوينات المختلفة التي تشكل تربة البصرة . فقد تم إجراء محاولة لتوصيف ومناقشة طبيعة التربة والمعادن المكونة لها ، فضلا عن السلوك الهندسي والخصائص الحقلية لنماذج التربة المستخرجة من أكثر من ألف ومائة متر اخذت من ثلاثة مواقع في محافظة البصرة . تم حساب متوسط القيم لمختلف خصائص التصميم الجيوتقنية وعلى أعماق مختلفة وتم رسمها مع العمق. كما تم استعراض المناخ والجيولوجيا والزلزالية والزلازل لمنطقة الدراسة. وأخيرا، تم تقويم قابلية الانتفاخ لتربة البصرة كما تم اعداد مقاطع نموذجية لتسلسل طبقات التربة فيها.