Geotechnical analysis for types of surficial fine-grained Soils at eastern side of Basra region, Southern Iraq.

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ABSTRACT:

This research focused on analysis of consolidations settlement factors and XRD analysis of types from surficial fine-grained soils at eastern side from Basra region in southern Iraq. Four sites have been taken for sampling of disturbed and undisturbed samples. These samples refer to tidal flat deposits of Khor Abdullah coast (site-1) ,south and north of Khor Al Zubair channel (site 2 and Site-3), and the fourth is a site of Qarmatt Ali city locating north of Basrah city. The ASTM specifications are based on to carry out the classification of soil and consolidation tests. The Odometer test is carried out in two statws (natural and wet) for two sites St-1 and St-4. The values of void ratio ranged (0.61- 1.16), where up to highest value (1.16) at St-2 sites and lowest values (0.61) at St-4.Swelling rate index (Cs) values were extended between (0.036 – 0.047) in wet state. The values of compression index (Cc) show slightly variation between (0.41-0.4) in wet state for all sites, while there is observed variation in natural state was (0.02 & 1.156) at (St-4 & St-1) sites respectively. The Coefficient of consolidation (Cv) values ranged between (0.0178 – 4.07). The high values of Cvs were being in St-2 & St-3 sites (gray clays of Hammar formation deposits).

For XRD-analysis, Clay minerals percentages are Kaolinite mineral (6.0-18) %, Illite mineral (6.0 -20) %, Montmorillonite mineral (17 -36) %. And also, the mixed layers of Montmorillonite and chloride appeared with the range (10 -36%).

The investigated soils are silty clay with high plasticity and clay content exceeds 58%, in exceptional flood plain deposits (St-4 site) has low plasticity that % clay reached to 50%. And mineralogically, clays minerals percentages are reflected low activity of fine-grained soils, where the activity range between (0.28 -0.4). Also, according to consolidation parameters, Basra soil is not classified as collapsible soil at St-1 and St-4, but St-2 & St-3 may be risky and slightly classified as collapsible soil.

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المستخلص

تركز هذا البحث على تحليل خصائص هبوط الانضمام ، وكذلك تحليل الاشعة السينية الحائدة (XRD) لانواع من الرواسب السطحية الناعمة الحبيبات في الجانب الشرقي من منطقة البصرة في جنوب العراق. اخذت اربع نماذج مخلخلة واخرى غير مخلخلة من مواقع مختارة من منطقة الدراسة والمتمثلة برواسب المسطحات المدية لساحل خور عبدالله ، وفي جنوب وشمال قناة خور الزبير،والاخير يمثل شمال مدينة البصرة في قضاء كرمة علي ويمثل الموقع رواسب فيضية نهرية. نفذت الفحوصات المختبرية طبقا للمواصفة الامريكية ASTM. خضعت النماذج الغير مخلخلة الى فحص الانضمام، وقد اخذت حالتين الحالة الطبيعية للنموذج وحالة التشبع اثناء القياس بالنسبة للموقعين St-1 و St-4. تراوحت قيم نسبة الفراغات بين (0.61-1.16)، حيث ان القيمة الاعلى (1.16) كانت عند الموقع (St-2) والقيمة الاوطئ (0.61) عند (St-4). بالنسبة لدليل الانتفاخ للتربة (Cs) فأن القيم امتدت بين (0.036-0.047) في الحالة الرطبة. اما قيم دليل الانضغاط (Cc) فكان مدى التغير بين (0.4-0.41) في الحالة الرطبة في جميع المواقع، وقد كان هناك تغير ملحوظ في الحالة الطبيعية (0.02) و (1.156) عند المواقع (St-4) و (St-1) على التعاقب. اما بالنسبة لقيم معامل الانظمام (Cv) فقد تراوحت بين (0.017-4.07). بالنسبة لنتائج تحليل الاشعة السينية فأن نسب المعادن الطينية كانت: (الكاؤلينات (٦-١٨)%، الالايت (٦-٢٠)%، المونتموريلونايت (١٧-٣٦)%، والطبقات المختلطة من الكلورايت-مونتموريلونايت كانت (١٠-٣٦)%. ان ترب منطقة الدراسة في المواقع المختارة هي ترب طينية غرينية ذات لدونة عالية ومحتوى طيني عالي يتجاوز ٥٨% بأستثناء الرواسب الفيضية عند الموقع ٤ التي تكون واطئة اللدونة وذات محتوى طيني يصل الى ٥٠%. ومعدنيا فأن نسب المعادن الطينية في المواقع المدروسة تعكس ترب ناعمة ذات فعالية واطئة حيث يكون مدى الفعالية بين (٠,٢٨ – ٠,٤). وبحسب خصائص الانضمام فأن ترب البصرة في المواقع المختارة لا تصنف على انها ترب قابلة للانهيار خطرة عند المواقع ١ & ٤، ولكنها قد تكون نوعا ما قابلة للانهيار بالنسبة للمواقع ٢ &٣ .

INTRODUCTION

GEOLOGICAL SETTING & SEDIMENTATION CONDITIONS

Basrah region is a part of the lower Mesopotamian basin, this region can be classified into two sides; eastern side is neighbored with Iran borders that constituents of surficial fine-grained sediments (tidal flat, Marshes and flood plain deposits). Surficial fine-grained deposits are the relatively younger age materials overlying bedrock, which occur as two major classes: (1) transported deposits generally derived from bedrock materials by water, wind, ice, gravity, and man's intervention and (2) residual deposits formed in place as a result of weathering processes (Thorner, 2001). These sediments

covered the eastern side of basrah and it amounts 14m thickness, while the western side represents by the coarse-grained sediments. The western side is covered the neighbored part to Saudi Arabia and Kuwait borders from Basrah in which sediments are made up alluvial fan and Sandy Dibdiba deposits. The deltaic and fluvial sediments during the Pleistocene and Holocene ages covered the Mesopotamian plain representing Sandy Dibdiba and Hammar formations, and also by brackish Lacustrine sediments. The Dibdiba formation (Pliocene age) consists of sands and gravels with Igneous rocks origin, the sediments of formation gradually changed from marine sediments to river sediments. The upper layers of this formation are represented by hard Clays and alternating with very dense Sand layers having significant bearing capacity (Al-Tai, 2005). The fine-grained sediments of Hammar formation are covered by sandy Dibdiba formation. It is constituted of recent (Holocene) marine sediments. This formation was formed as a result of sudden changes in the marine conditions affecting the southern part of the Mesopotamian plain. Aqrawi (1995) divides this formation to several main parts; the top layers are composed of gray Clays.

Geographically, the surficial fine-grained soil occupies about (50%) of Basrah area. Most cities of Basrah Governorate are located on this type of soil. These soils have a range of depth (7-15) m of depth in the area. the present study area is bounded between two longitude lines ($48^0 45^-$) and ($47^0 30^-$)E, and two latitude circles (29^0 45^-) and (31^0 0^-)N.

Figure (2) shows sedimentological units of Basrah region. Basra region is considered a complex transitional environment in which types of those interacting units and which reflect many of different environments conditions. It consists of tidal flats sediments environment, flood plain deposits of Shatt Al Arab delta, Lacustrine sediments, marsh deposits, and coarse-grained deposits of (Alluvial fan & Sandy Dibdiba) sediments.

The present study focuses to analyze types of common surficial fine-grained deposits of Basrah region by testing of the geotechnical parameters relating with consolidation parameters, index properties, minorological properties, and then their comparison with a range some of types of international countries soils.

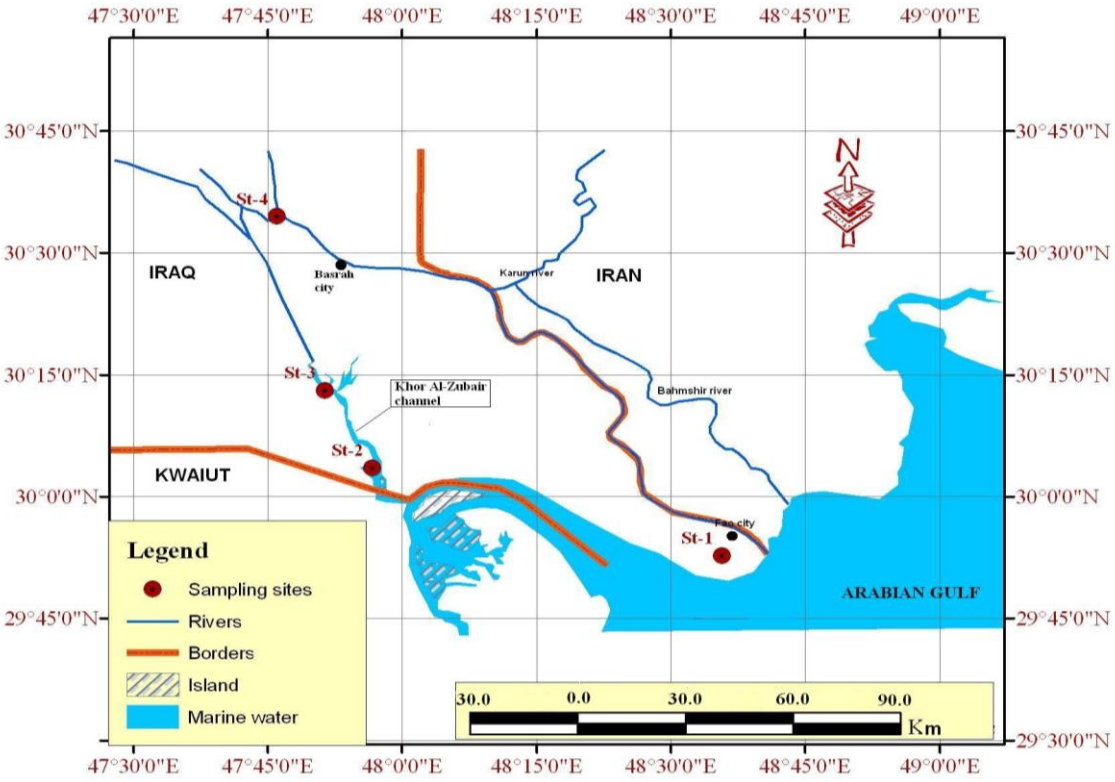

Figure (1) Location map of investigated area, modified by researcher, after processing of the TM Satellite image by GIS program.

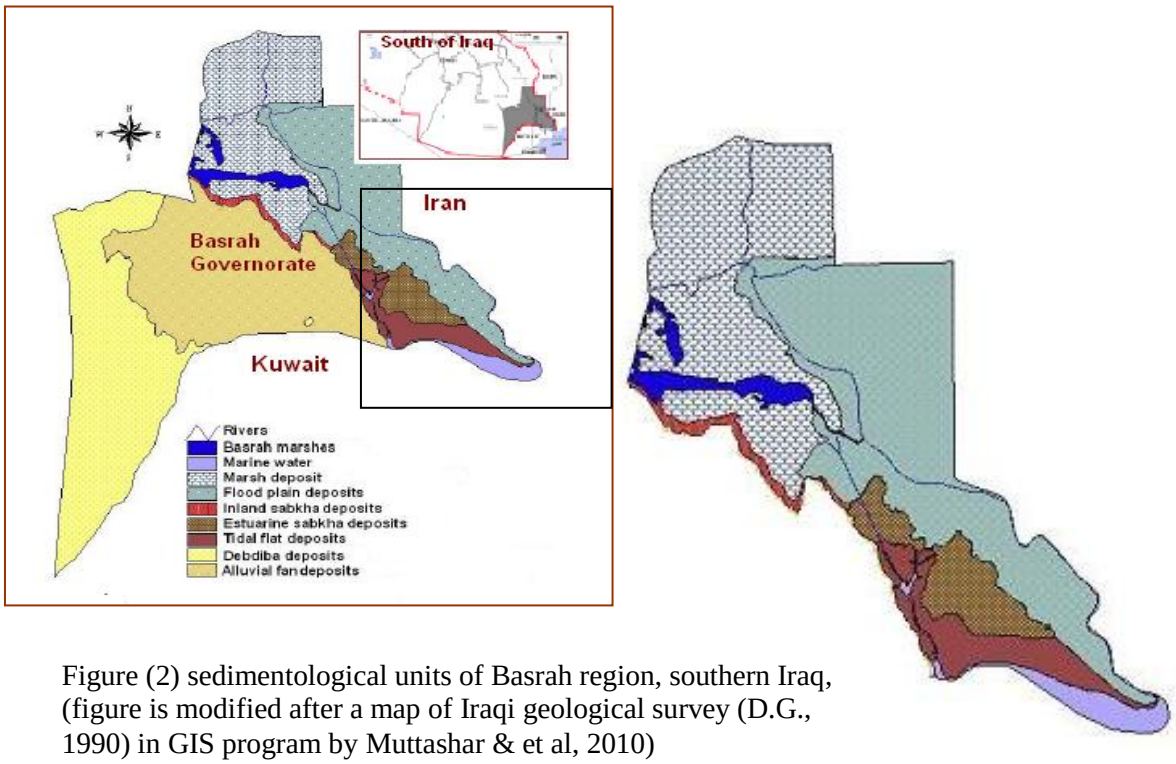

Figure (2) sedimentological units of Basrah region, southern Iraq, (figure is modified after a map of Iraqi geological survey (D.G., 1990) in GIS program by Muttashar & et al, 2010)

MATERIAL & METHOD

Four samples were taken from different locations in southern Basra region as shown in figure (1), and as described in table (1). The sites and methods of sampling could be described as following:

1- **St-1 site refers to tidal flat deposits. These sediments are influenced by Shatt Al Arab river sediments and slightly Aeolian deposits. St-2 site represents the soil of southern zone of Khor Al Zubair channel; it is mostly marine clays sediments belong to Hammar formation deposits. Whereas St-3 site is also marine clay sediments from northern zone of Khor Alzubair deposits at 4m of depth. St-4 site is north of Basrah city at Qarmatt Ali city. Its fine-grained soils were resulted from flood plain deposits of rivers.**
2- **Sampling method, Shelby tube of 4" diameter has been used to recover the undisturbed samples with length of 25 cm. whereas in St-2 and St-3 sites used the same diameter was used but with 50 cm of length.**

Table (1) contents on GPS locations of samples and their depths from Natural Ground Surface.

Sample No.	Easting	Northing	Depth of sampling (m)	Location Name
St-1	39R 265285	3310690	1.5	Khor Abdulla coast (south of Fao city).
St-2	38R 783667	3329637	1.5	South of Khor Al-Al Zubair Channel bank.
St-3	38R 774692	3346518	3.0	North of Khor Al-Al Zubair Channal bank.
St-4	38R 763530	3384562	2.0	Qarmatt Ali (north Basrah City)

According to ASTM specifications, the classification initial tests of samples were carried out which included moisture content, Grain size analysis and Atterberg limits.
Also, the consolidation parameters undisturbed samples were estimated using conventional Odometer device as described in (Bowles, 1970). The dimension of tested sample into consolidation cell was 75 mm diameter and 19.0 mm thickness.
The Odometer test carried out in two cases (natural and wet) for St-1 and St-4 samples because these samples have more different characteristics among the four samples table (1).
The elapsed time of tests samples was (0.0, .25, 0.5, 1, 1.5, 2, 3, 4, 5, 7, 9, 11, 15, 20, 25, 30, 35, 40, 50, 60, 90, 120, 180 min, and 24 hr.).

X-Ray Diffraction analysis (XRD): X-Ray Diffraction analysis has been carried out to analyze fourth sites samples for diagnosing of characteristics of clay minerals and their percentages. That Oriented slides of grain size (> 2μ) were used. The samples have been treated with Heating up to 500C^0, in addition to treat them with Ethylene Glycol solution. The purpose of these treatments for recognizing some of clay minerals

which interaction with the others in normal case, where identification is between two minerals Kaolinite and Illite at Heating treatment, and Montmorillonite and Illite at Ethylene solution treatment . ASTM Card has been depended on to diagnosis the clay minerals. Also, the test conditions of XRD analysis were:

Scan Axis	**Gonio**
Start Position [°2Th]	**2.0100**
End Position [°2Th]	**39.9900**
Step Size [°2Th]	**0.0200**
Scan Step Time [s]	**0.4000**
Scan Type	**Continuous**
Offset [°2Th].	**0.0000**
Divergence Slit Type	**Fixed**
Divergence Slit Size [°]	**1.0000**
Specimen Length [mm]	**10.00**
Receiving Slit Size [mm]	**0.1000**
Measurement Temperature [°C]	**25.00**
Anode Material	**Cu**
K-Alpha1 [Å]	**1.54060**
K-Alpha2 [Å]	**1.54443**
K-Beta [Å]	**1.39225**
K-A2 /K-A1 Ratio	**0.50000**
Generator Settings	**30 mA, 40 kV**
Diffractometer Type	**0000000011058177**
Diffractometer Number	**0**
Goniometer Radius [mm]	**240.00**
Dist .Focus-Diverg .Slit [mm]	**91.00**
Incident Beam Monochromator	**No**
Spinning	**Yes**

RESULTS & DISCUSSIONS

Table (2) shows classification results of the soils samples. The sites of St-2 & St-3 have high plasticity silty clay soil, in which the clay content exceeds 55%. Also, the sites St-1 and St-4 are Silty Clay soil but have low plasticity.

Table (3) shows the consolidation parameters of soils samples. Values of void ratio (e_o) is ranged (0.61- 1.16), where the highest value (1.16) is at St-2 site and the lowest value (0.61) is at St-4. Regarding to swelling rate index (Cs) values are changed between (0.036 – 0.047) in the wet state, whereas ranged between (0.01 – 0.289) in natural (dry) state at St-1 and St-4 sites. The values of compression index (Cc) slightly show variation between (0.41-0.4) in wet state for all sites, while there is observed variation in natural state was (0.02 & 1.156) at (St-4 & St-1) sites respectively.

Figure (3) shows the relation curves of void ratio (e_o) versus pressure (kN/m^2) of the studied samples. The curves explain the behavior of soil samples at some of different cases.

Comparison of the rate of consolidation results (Cv m^2/y.) of each samples with consolidation coefficients of soils in other countries in the world have been conducted

(table, 4). The table gives typical values of the coefficient of consolidation (Cv) in the world, and the Cvs of studied sites of basrah soils are added to it.

The Cvs values ranged between (0.0178 – 4.07). High values of Cvs have been found out in St-2 & St-3 sites, which are gray clays from Hammar formation deposits. Their classification is closer to Boston blue clay (CL), and slightly to Chicago silty clay (CL), whereas Cv value of St-1 site (Clays of Khor Abdulla coast) is like Swedish medium sensitive clays (CL – CH). Silty clay soil of Qarmatt Ali site (Flood plain soils) have a value closer to San Francisco Mud (CL) in natural state.

Also, some of measurements the present study have been compared with the collapsible silty clay soils which found in the State of Mato Grosso, in Central Brazil. Table (5) looms a comparison with the fourth investigated soils. According to Futai & et al, (2002) who explained theoretical and experimental study of the collapsible soils and gave the characteristics of these soils. The comparison of the soils properties of the present study with the collapsible soil properties in Futai s study has been carried out. It appears that some of the sites could slightly be close to characteristics of collapsible soils, table (5).

Table (2) classification tests results of soil samples

samples	Wn%	Atterberg Limits		Grain Size analysis			USCS	Description of soil sample
		LL%	PI%	Clay%	Silt%	Sand%		
St-1	35	46	21	68	32	0		
St-2	15	52	24	59	40	1	CL	Low plasticity gray Silty Clay
St-3	24	52	23	59	39	2	CH	High plasticity gray Silty Clay
St-4	22	43	14	50	45	5	CH	High plasticity gray Silty Clay

Table (3) Consolidation parameters of soil samples.

Sample	Test case	eo	Cc	Pc kN/m$_2$	Cs	Cv m^2/ye.
St-1	Natural	0.853	1.156	42	0.289	0.13 – 0.263
	Wet	0.888	0.146	30	0.036	0.0178 – 0.263
St-2	Wet	1.16	0.33	95	0.047	4.07
St-3	Wet	0.98	0.17	80	0.040	4.0
St-4	Natural	0.599	0.02	125	0.01	0.55 – 1.23
	wet	0.613	0.40	63	0.038	0.163 – 1.23

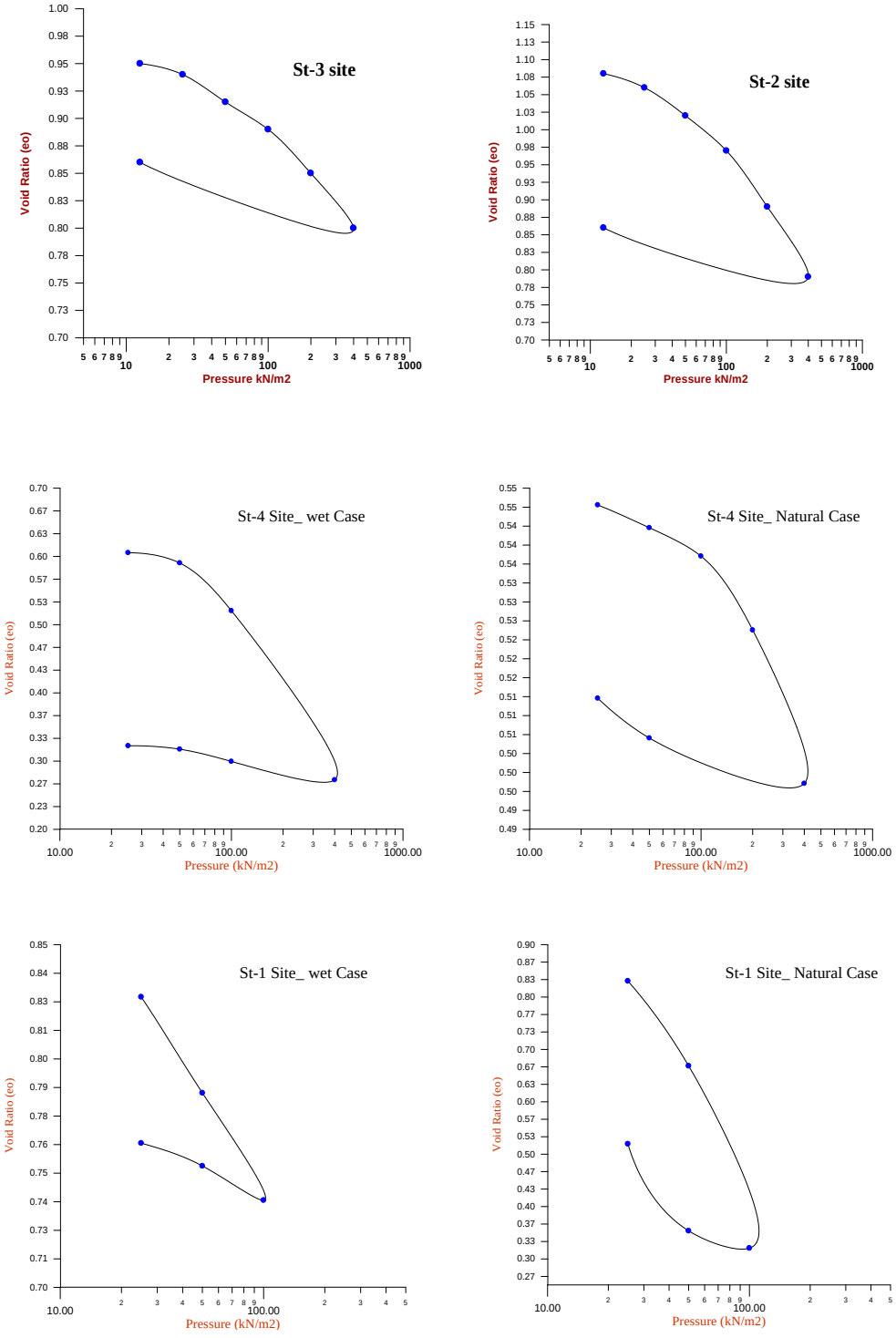

Figure (3) e Log P relation curves of studied samples

Table (4) Typical Values of the Coefficient of Consolidation (Cv) in the world.

Soil Type		c_v (m^2/year)
Boston blue clay (CL) (Load, and Luscher;1965)		12 ± 6
Organic silt (OH) (Lowe, Zacheo, and Feldman;1964)		0.6 - 3
Glacial lake clays (CL) (Wallace, and Otto, 1964)		2 - 2.7
Chicago silty clay (CL) (Terzagi, and Peck; 1967)		2.7
Swedish medium sensitive clays (CL-CH) (Holts, and Broms; 1972)		0.1 - 0.2
San Francisco Bay Mud (CL) (Leonards, and Girault; 1961)		0.6 - 1.2
Mexico City clay (MH) (Leonards, and Girault, 1961)		0.3 - 0.5
Jordan (Amman city) clay (CH)		0.1 – 0.4
St-1: Khor Abdulla coast (south of Fao city)	Wet case	0.017 – 0.26
	Natural case	0.13 – 0.26
St-2: South of Khor Al-Al Zubair Channel bank		4.07
St-3: North of Khor Al-Al Zubair Channal bank		4.0
St-4: Qarmatt Ali (north Basrah City)	Wet case	0.16 – 1.23
	Natural case	0.55 – 1.23

Table (5) Comparative table between porous silty clay found in the State of Mato Grosso, in Central Brazil with Basra clays

Property	St-1	St-2	St-3	St-4	Basra soils (present study)	Brazil Soils (Futai, 2002)
	values	values	values	values	values	values
Natural water content, w	35	15	24	22	15 -35	25 - 40%
in situ suction, s	Non	Non	Non	Non	Non	10 - 45 kPa
Average voids ratio, e	0.88	1.16	0.98	0.613	Lessthan 1.16	1.9
Plasticity index, I_p	21	24	23	14	14 -24	22.6%
Clay content	68	59	59	50	50-68	74%
Silt content	32	40	39	45	32 -45	16%
Sand content	0	1	2	5	0 -5	10%

Regarding to the results of X-Ray analysis, Figure (4) presents the curves of X-Ray diffraction of the four studied sites in which the percentages of clay minerals have been calculated, as shown in table (6). There are many clay minerals which loomed in investigated sites as in the following:

Kaolinite mineral (6.0-18) %; it's ranged between (6.0%) in north of Khor Al Zubair site, and (18) % in south of Khor Al Zubair site, while it reached to (13%) in Qarmatt Ali and (8.0%) in Khor Abdulla coast site.

Illite mineral (6.0 -20) %: it's ranged between (6.0 %) in north of KAZ and (20%) in South of KAZ and Khor Abdulla site, while in Qarmatt Ali is reached to (18%).

Regarding to Montmorillonite mineral (17 -36) %: it's ranged between (17%) in south of KAZ and (36%) in North of KAZ site, while it reached to (26%) in Khor Abdullah and (28%) in Qarmatt Ali.

Also, the mixed layers of Clay mineral that are interacting between Montmorillonite and chloride) appeared with the range (10 -36%).

table (7) shows classification of Clay activity ranges of the investigated soils sites according to the equation of (Skempton, 1953 in Al-Ashuo, 1991 and Waltham (2007), where is (plasticity Index/clay friction, <2μ). They have appeared non-active soils of all sites.

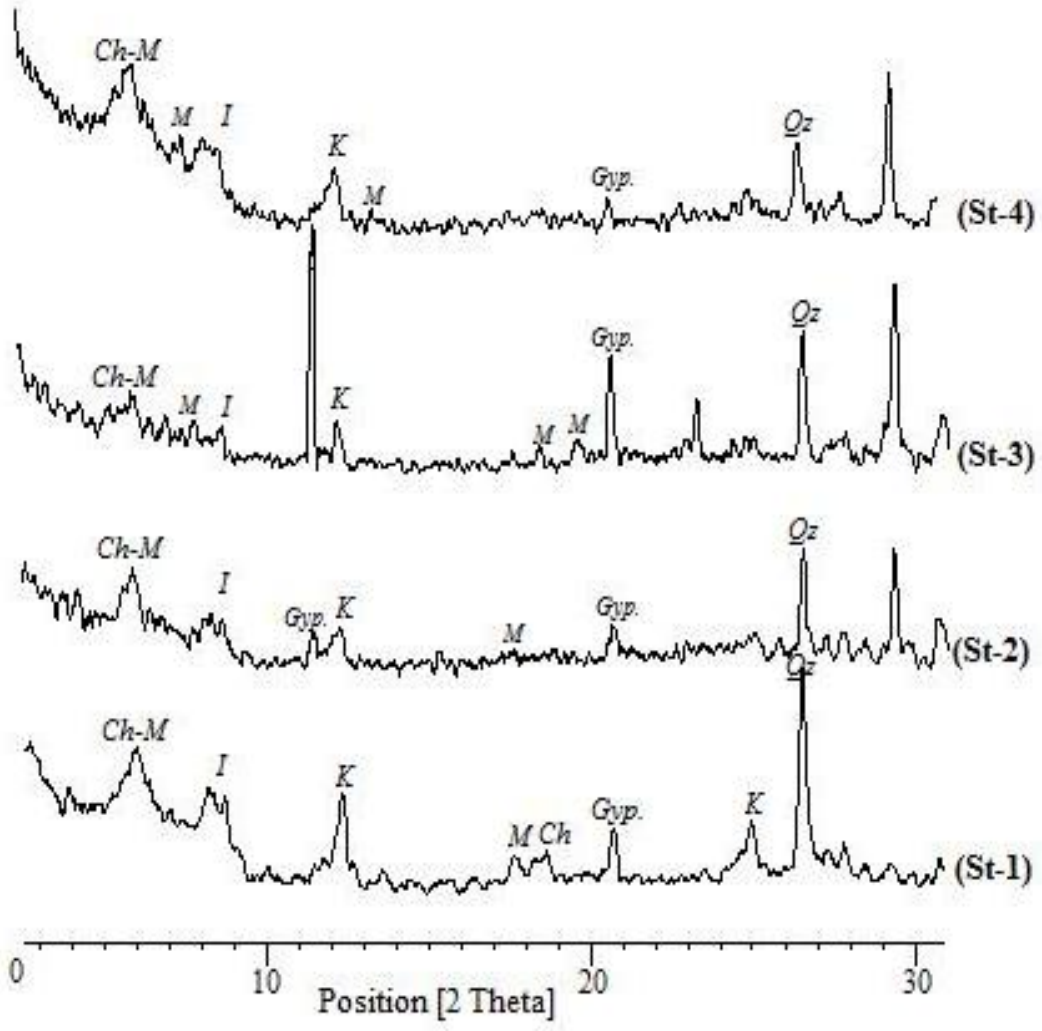

Figure (4) X-Ray Diffractions of the samples of the studied sites.

Table (6) classification of activity ranges of the investigated sites

Site	Khor Abdulla site (St-1)	South of Khor Al Zubair site (St-2)	North of Khor Al zubair site (St-3)	Qarmat Ali Site (St-4)
Montmorillonite (M)	26	17	36	28
Kaolinite (K)	8.0	18	6.0	13
Illite (I)	20	20	6.0	18
Chloride (Ch)	18	-	-	5.0
Mixed layer (M-Ch)	28	30	10	36

Table (7) clay minerals and their percentages which loom in studies sites.

site	The activity value	Classification according to (Al Ashuo, 1991)
St-1	0.30	Non-active soil
St-2	0.40	Non-active soil
St-3	0.38	Non-active soil
St-4	0.28	Non-active soil

CONCLUSIONS:

The investigated soils generally are silty clay with high plasticity and clay content exceeds 55%, in exceptional flood plain deposits (St-4 site) which has low plasticity and clay content reaches to 50%. The clay minerals compose from non- active clays reflecting low activity of fine-grained soils (0.28 -0.4). And also, according to Consolidation parameters, the eastern side soils of Basra are not classified collapsible soil (St-1 and St-4), but it may be risky and slightly classified as collapsible soil (St-2 & St-3).

REFRENCES

Al-Ashou, A. (1991) "Principles of Soil Mechanics", Ministry of Higher Education and Scientific Research, Musal University, Iraq.

Al-Tai, M. A. (2005) " Improvement of selected parts of basrah Governorate soil using polymer resins", Ph.D. thesis, Science college/ Basrah university, Iraq.

American Society for Testing And Material (1975) " Soil Rock Building Stone.

Aqrawi, A. A. (1995) " Correlation of Holocene Sedimentation Rate for mechanical compaction, the tigris Euphrates Delta, low Mesopotamia, Marine & petroleum geology, Vol.12, No.6, pp. 406-416.

Bowles, J. E. (1970); "Engineering properties of soils and their measurement", McGraw-Hill Book company. P. 103.

D .G .of geological Survey & mineral investigation(1990); "Tectonic map of Iraq ", Baghdad-Iraq

Futai M. M., Marcia D. &Soares D. (2002)" Collapsible Soil: A Theoretical and Experimental Study", EJGE digital Journal, www.EJGE.com

Lambe, T. W. & Whitman R. V. (1969), " soil Mechanics" S2 version, Massachusetts Institue of Technology, publisher John Wiley & Sons, N. Y.

Muttashar, Wisam R. et al, (2009)" Preparation Geodatabase of Sedimentological and Geological Properties by Using GIS Technology: A case Study Basrah Province, Southern Part of Iraq" the first conference of remote sensing & Geographic information system". College of Arts/Thi Qar University, Iraq.

Thorner R. H. (2001); "Engineering Geology Field Manual" S2, U.S. Department of the Interior Bureau of Reclamation,

Waltham T. (2007);" Foundation of Engineering Geology" Nottingham TrentUniversity , second edition, Tayor & Francis group, SPON PRESS, London and New york, p 52.