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GEOTECHNICAL PROPERTIES AND AERIAL DISTRIBUTION OF BEARING STRATA ALONG THE SHATT AL-ARAB RIVER BANK FROM QURNA TO FAO

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ABSTRACT

Geotechnical properties of many boreholes were collected and interpreted for identifying the bearing strata in Basrah region. Based on these geotechnical properties, the lithological succession along the Shatt Al-Arab River from Al-Qurna to Al-Fao in Basrah Region could be classified into eight layers. The bearing capacity of surface layer is 300-600 kN/m^2, which is suitable for small construction projects, whereas, the deepest eighth layer has N-value >50, this is suitable for large construction projects. The other sixth layers in between are very weak and of low plasticity, where the N-value is <15, which are not suitable for any construction projects. The lateral distribution of the layers explains the source and the geological history of the area.

INTODUCTION

The surface sediments of southern Mesopotamian plain derived from multi-sources sediments. The major part belongs to fluvial deposits of Tigris, Euphrates and Karun Rivers, and the alluvial deposits of Dibdibba Formation, and between is of marine origin in addition to minor part of aeolian deposits. The southern Mesopotamian plain characterized by a vertical and lateral variation in lithology. This variation could be related to interfingering of sedimentary environments and the numerous source of sediments as indicated above.

The geotechnical properties of this area have been a subject of many technical reports and scientific research papers. Saeedy and Mollah (1990) described the geotechnical properties of the three main layers between Basrah and Khor Al-Zubair. Khan *et al.* (1992) proposed a model of the main successive layers around Basrah region. Albadran and Albadran (1994) deals with the geotechnical properties of the navigation channel sediments. The bearing strata and their distribution around Basrah town have been well described by Albadran and Albadran (1997). The technical reports of National Centre of Construction Laboratories (NCCL) are disseminated reports of numerous locations in the southern part of Mesopotamian plain. Each report describes the succession and their geotechnical properties to an oriented project of construction in that location. Mahmood and Albadran (2002) classified the bearing strata in Basrah city into ten stratum according to the consistency of cohesive deposits and the compactness of cohesionless deposits.

The upper most part of the succession consists of silty clay resulted from the reworking processes of the river sediments, which are normally consolidated (Saeedy and Mollah, 1990 and Salman and Al-Mussaway, 1991). These upper most layers of recent sediments are underlay by Hammar Formation, consists of clayey silt with shell fragments, this latter formation is undulated by the underlain Dibdibba Formation of Upper Miocene (Buday, 1980).

The area extent from Qurna to Fao needs a regional sedimentological and geotechnical studies for the shallow recent sediments succession to correlate between them and finally construct an isopach map of each layer.

This study is an attempt to trace the lateral distribution of recent sediment succession in order to plot isopach maps for each layer with their geotechnical properties along the Shatt Al-Arab River bank from Qurna to Fao.

Stratigraphic description:

The loose sediments of the southern part of Mesopotamian plain are of different origin (Buday, 1980). The upper layers of about 8 meters in depth belong to recent period (Aqrawi, 1995). Below these layers, it is the Hammar Formation of Pleistocene (Bellen *et al*., 1959 and Aqrawi, 1994). This later formation composed of two parts, the upper part from 8 to 11 meter below the ground surface is silty clay with shell beds, and the depth internal from 11 to 17 meter is silty sandy clay (Bellen et al., 1959). Based on carbon dating, Aqrawi (1995) stated that the age of these layers is limited between Pleistocene to Recent. From 17 to 24 meters, the sediments are variable from clay to sand. Owing to Albadran and Albadran (1997), these sediments were reworked from Dibdibba Formation during the transgression period. These sediments are underlain unconformably by Dibdibba Formation, where the later composed of dense to very dense sand. This stratum is considered as a bearing stratum in Basrah region.

Data collection:

This work is based on the elaboration of technical data abstracted from many reports submitted to the National Centre of Construction Laboratories of Basrah branch. These reports represent a site investigation of many projects distributed along the Shatt Al-Arab River bank from Qurna to Fao to a depth about 30meters (Fig. 1). The reports are concerned by geotechnical properties and grain size distribution. Liquid and plastic limits were measured by using Casagrande cup and rolling threats method respectively. Moisture content was calculated by loses in weight after drying. Grain size analysis was obtained by sieving of coarse grains and hydrometer method for fine grains. All of these analyses were conducted according to the British Standard (BS 1377; 1975).

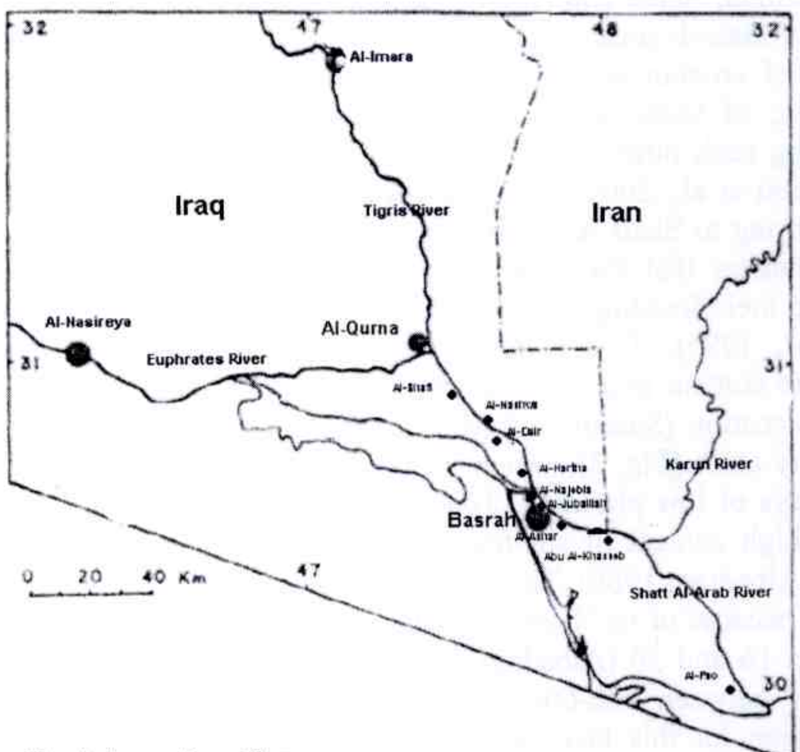

Fig.1- Location Map.

DISCUSSION

There is a huge vertical variation in sediment texture between successive layers and horizontally also in the same layer. So, the grain size distribution in few layers (Table 1) does not match with the nomenclature of this layer. This is due to the application of statistical method to deduce the mean for each parameter after many analyses. The variation in each parameter is high as you see in the standard deviation of each parameter (Table 1).

In this study, on the bases geotechnical properties, grain size distribution and visual description, eight layers have been identified and this is the difference of this study from the others. This could be related to the huge data and wide geographic distribution of the boreholes.

The first layer from the ground surface is very stiff brown silty clay (Fig. 2). Albadran and Albadran (1997), this layer was considered as surfacial alluvial deposits. It is situated parallel to the axis of Shatt Al-Arab River (Fig. 2). It becomes in a high thickness in few localities as in Al-Dair, Al-Jubaillah, Ashar and Abu Al-Khasseb but it is absent in Al-Hartha. The floor of Basrah area is characterized by the prevalence of the periodic cycles of erosion and deposition, therefore, no continuous stratigraphic sequence of Quaternary can be supposed and many lithological facies replacing each other both horizontally and vertically(Parson, 1957 in Al-Marsoumi et al., 2004). This variation in thickness could be related to the neighboring to Shatt Al-Arab River, consequently, this may conduct to get a conclusion that the layer represents the sediments of Shatt Al-Arab through their flooding periods which happened during the last 3000 years (Aqrawi, 1995). This layer is highly affected by the atmosphere; the moisture content is no more than 40%. It is normally, consolidated due to the desiccation (Saeedy and Mollah, 1990). This layer was placed in CL plasticity chart (Fig. 3), which means that the layer is inorganic clays and silty clays of low plasticity. This variation in plasticity could be attributed to the high content of silt fraction, where the later reduces the plasticity index (Albadran, 1986). This surface layer is suitable for small construction project because of its N-value of Standard Penetration Test (SPT), which is between 16 and 30 (Albadran and Albadran, 1997), it indicates a bearing capacity between 300-600 kN/m^2 (Mahmood and Albadran, 2002). The desiccation let this layer to be brown due to dryness and oxidation of naturally packed grains (Terzaghi and Peck, 1948).

Table 1- Some sedimentilogical and geotechnical analyses.

No.	Stratum	Analysis	Range	Mean	Standard deviation	Number of samples
1	Very stiff brown silty clay	M. C.	14-36	23.54	5.88	11
		L.L.	40-51	44.91	3.73	11
		P.I.	13-29	20.45	4.29	11
		Clay%	30-63	50.27	9.02	15
		Silt%	35-55	45.73	6.61	15
		Sand%	1-18	3.67	4.30	15
2	Stiff brown to gray silty clay and clayey silt	M.C.	21-37	28.33	4.60	12
		L.L.	37-49	43.67	3.77	12
		P.I.	18-26	20.17	2.33	12
		Clay%	32-72	48.40	12.52	15
		Silt%	28-68	46.93	11.20	15
		Sand%	0-19	4.60	6.03	15
3	Medium stiff gray silty clay laminated with silt	M.C.	22-51	31.65	6.33	17
		L.L.	25-48	39.29	6.34	24
		P.I.	8-26	18.56	4.77	24
		Clay%	21-59	38.92	12.11	25
		Silt%	42-72	58.04	9.78	25
		Sand%	0-17	3.84	4.36	25
4	Soft gray silty clay laminated with silt	M.C.	28-47	38.62	5.95	13
		L.L.	26-48	37.79	4.83	38
		P.I.	8-26	16.39	4.05	38
		Clay%	27-57	42.49	6.89	39
		Silt%	41-72	53.15	9.93	39
		Sand%	0-26	2.41	4.83	39
5	Medium stiff gray clayey silt	M.C.	33	--	--	--
		L.L.	32-50	39.64	5.97	11
		P.I.	10-26	17.36	5.62	11
		Clay%	26-59	38.44	11.26	18
		Silt%	37-61	50.72	7.09	18
		Sand%	0-25	9.67	8.45	18
6	Stiff gray clayey silt	M.C.	--	--	--	--
		L.L.	22-61	36.50	10.58	12
		P.I.	7-33	17.17	7.40	12
		Clay%	21-67	36.75	13.41	16
		Silt%	28-71	49.75	11.42	16
		Sand%	1-35	13.44	10.80	16
7	Very stiff clay-silt-sand mixture	M.C.	--	--	--	--
		L.L.	28-54	39.80	9.34	10
		P.I.	8-26	18.10	6.37	10
		Clay%	9-62	29.87	13.90	15
		Silt%	33-73	50.73	13.36	15
		Sand%	0-41	18.47	11.70	15
8	Dense and very dense gray silty sand					

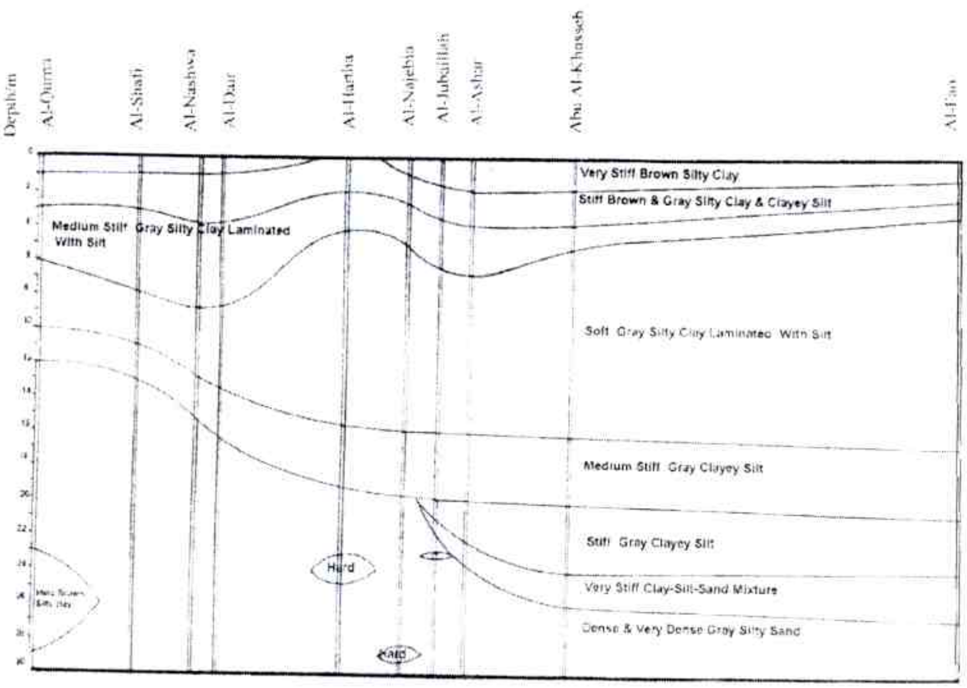

Fig. 2. Lithological soccession of the study area

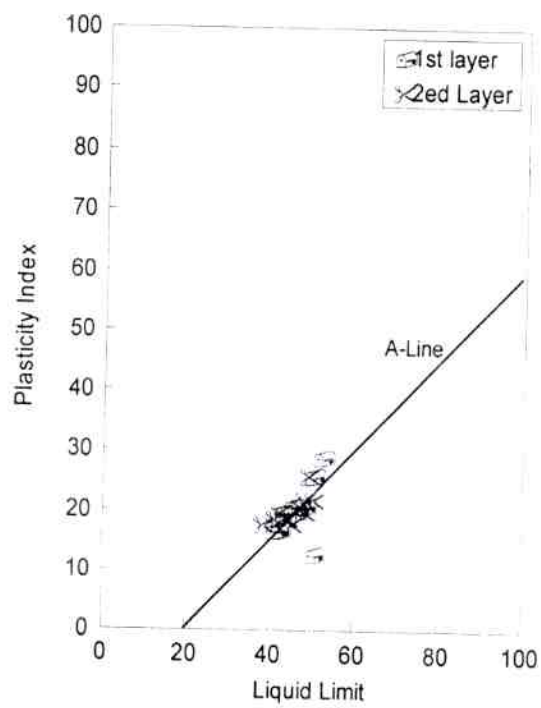

Fig. 3. Plasticity chart of first and second layers

The second layer (Fig. 2) is a stiff brown to gray silty clay and clayey silt. This layer is relatively moist (Table-1) because firstly it is close to the water table, where the later is shallow in this area and secondly it is protected by the surface layer from any desiccation. Albadran and Albadran (1997) stated that this layer is one of high compressibility and of medium bearing capacity (150-300 kN/m^2) due to the increase of void ratio and compression index (normally consolidated). So, the N-value of this layer (9-15) is less than the first layer. The geotechnical properties of this layer are highly affected by the ground water fluctuation and it's low permeability, which led to long period of grain-water interaction. This is clear by the little increasing in the moisture content, whereas, the texture resembles the texture of the first layer. The plasticity chart of this layer (Fig. 3) show a clay to silty clay of low plasticity CL, moreover, the points are concentrated in small area, this could be the influence of the high void ratio.

The third layer is medium stiff gray silty clay laminated with silt (Fig. 2), with N-value (5-8) and bearing capacity between 75-150 kN/m^2. The silt fraction (Table-1) increases in this layer, consequently the geotechnical properties will be affected. Liquid limit and plasticity index reduce, whereas the moisture content increases. The increasing in the moisture content could be attributed to the sort of the arrangement of clay sheets and silt grains. The plasticity chart (Fig. 5) shows that the points are distributed parallel to the A-Line. The lower plasticity index points belong to the sample of high percentage of silt fraction, where the later parameter reduces the plasticity index (Albadran, 1986). This layer is of low plasticity CL.

The fourth layer is soft gray silty clay laminated with silt (Fig. 2). The N-value ranges between (3 – 4) and the bearing capacity is < 75 kN/m^2. The difference in consistency between this layer and the previous layer could be attributed to the little increase in moisture content, and the relative increase in clay content. The plasticity chart shows the spatial distribution of samples (Fig. 4) of low plasticity CL, some samples located on the A-line and one sample is below this line. The influence of silt fraction on the geotechnical properties is uncontrolled, due to many reasons; the first is the type of arrangement between the clay mineral sheets and the silt grains, the second reason is the type of these sheets of clay minerals and third one is the exoscopic shape of silt grains. In nature, there are some grains of silt and fine sand of cylindrical or perforated shape, where these shapes keep a notable quantity of water in the cavities (Albadran, 1986).

The fifth layer is medium stiff gray clayey silt (Fig. 2). This layer resemble the third clay medium stiff gray silty clay laminated with silt, and the sixth layer stiff gray clayey silt. The resemblance includes the moisture

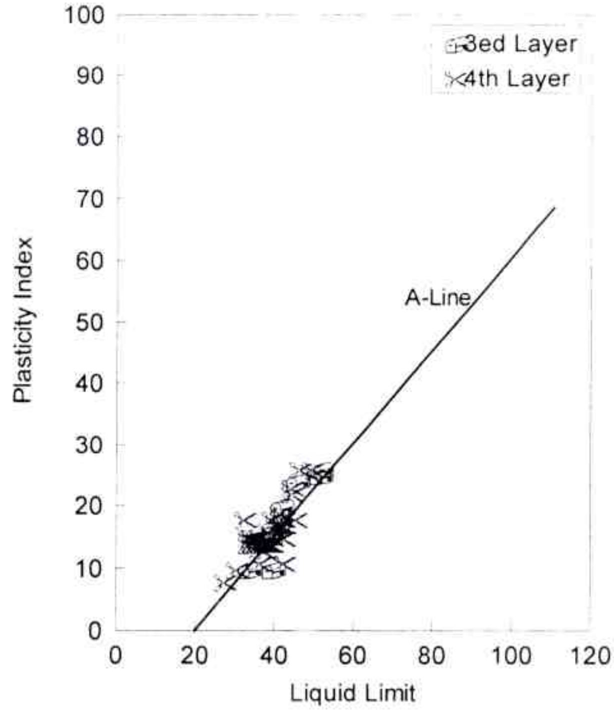

Fig. 4 - Plasticity chart of third and fourth layers.

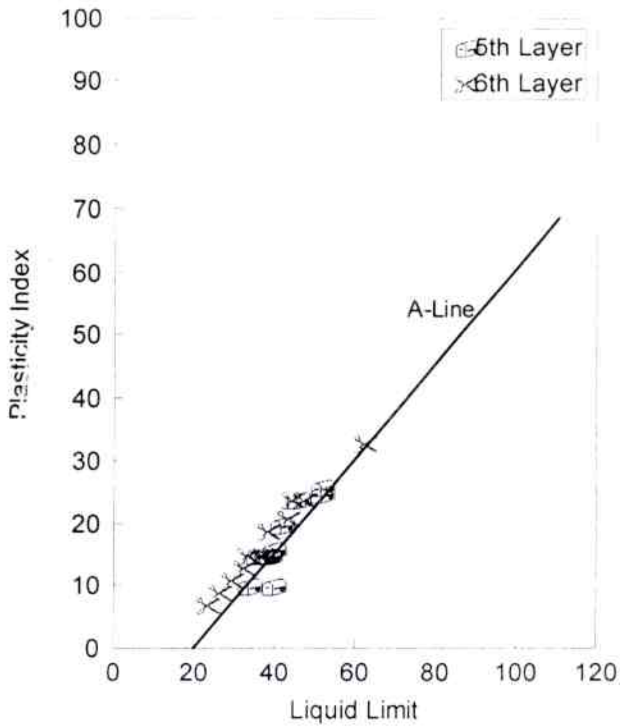

Fig. 5 - Plasticity char of fifth & sixth layers.

content, liquid and plastic limits (Fig. 5), and grain size distribution (Table 1). The difference is only in cohesion; this could belong to the clay mineral type and the porosity and permeability nature of each layer.

The sixth layer is stiff gray clayey silt (Fig. 2), It appears in Al-Jubaillah, Al-Ashar, Abu Al-Khasseb and Al-Fao, no record for moisture content. The percentage of sand increases in comparison with other previous layer. The stiffness could attribute to the natural consolidation and to the arrangement of clay, silt and sand in this layer, naturally, the sort of arrangement of silt and sand embedded between the clay mineral sheets influence on the moisture content (Albadran, 1986). The samples of this layer are located on a line upward and parallel to the A-line (Fig. 5). This means that the geotechnical properties of this layer are highly sensitive to any increasing in silt, as it is seen from the relationship between liquid limit and plasticity index is approximately linear. This phenomenon can not been seen in other layers. This layer is classified as CL of low plasticity.

The seventh layer is a very stiff clay–silt-sand mixture; its distribution resembles that of the sixth layer. The plasticity chart (Fig. 6) has the same a tendency of the previous layer, stiff gray clayey silt, where, the distribution of the points are located in approximately linear and parallel to A-Line. Two points are located below the A-Line, this could attribute firstly to the influence of silt fraction and secondly to the type of clay minerals, which play a grand role on the geotechnical properties (Botereau, 1971).

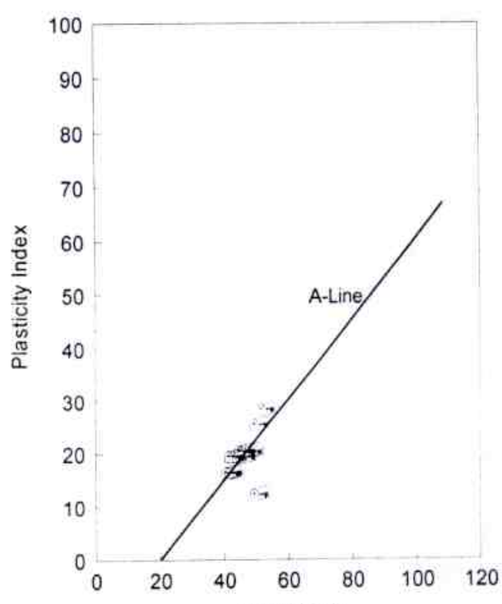

Fig. 6- Plasticity Chart of seventh layer.

The eighth layer is dense to very dense gray silty sand and the N-value is more than 50. For Albadran and Albadran (1997), this layer represents a transition layer between the overlain Hammar Formation and the underlain Dibdibba Formation. This layer is considered as a bearing stratum in Basrah Region.

Geographic Distribution of Layers:

The correlation in Figure (2) reveals the geographic distribution of these layers from Qurna to Fao. The three top layers vary in their thickness between the sites, which could be linked to the neighboring to the Shatt Al-Arab River. These layers may be representing the river bank deposits. The human activities change also the thickness of these layers due to the artificial compaction and damping of low area for civil constructions. The rest of layers show a gentle slope toward the south. This explains the topography of the basin of deposition which had the deepest part in the south, this indication is in agreement with the direction of the depositional basin during the quaternary period.

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الخواص الجيوتكنيكية والتوزيع الأفقي للطبقات التحملية على طول ضفاف شط العرب من القرنة إلى الفاو

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الخلاصة

جمعت نتائج الفحوصات الجيوتكنيكية من الآبار المحفورة في منطقة البصرة من أجل تفسير وتعيين الطبقات التحملية. قسمت التتابعات الليثولوجية، اعتمادا على المواصفات الجيوتكنيكية، للمنطقة وعلى طول نهر شط العرب من مدينة القرنة والى الفاو إلى ثمان طبقات. وكانت الطبقة السطحية مناسبة للإنشاءات الصغيرة حيث كانت سعتها التحملية 300 – 600 كيلو نيوتن/م^{2}، بينما كانت الطبقة الثامنة والعميقة مناسبة إلى الإنشاءات الكبيرة بسبب قابلية التحمل التي تملكها حيث أن فحص الاختراق القياسي تجاوز 50 في هذه الطبقة. أما الطبقات الست المتبقية والتي تقع بين الاثنتين السابقتين فأنها طبقات ضعيفة وغير ملائمة كطبقات تحملية وان فحص الاختراق القياسي لم يتجاوز أل 15 في هذه الطبقات. بين التوزيع الأفقي للطبقات أصلها والتأريخ الجيولوجي للمنطقة.