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Geotechnical Evaluation of Soils in Ammarah/Central Missan, Iraq

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Abstract

Before any system of urban development is adopted, soil stratigraphy should be studied and geotechnical information should be determined. In the current study, fundamental geotechnical data for Ammarah city were collected and the inherent properties of soils and the manner of soil layers distribution were studied. Furthermore, problems involved in the soil of the study area were reviewed. Site investigations and laboratory testing showed that the area of interest is characterised by silt of different percentages distributed over the depth. Standard penetration and Vane shear test results revealed a horizontal discontinuity of soil layers. Investigating and reviewing soil problems showed that Ammarah soils are free of problems associated with sand dunes and high gypsum content. On the other hand, sabkha soil is widely distributed over the area due to salts and the shallow depth of water table.

Keywords:- Ammarah soil, Geotechnical properties, Boreholes

Introduction

Ammarah is located in Missan, the southern Iraqi governorate, 320 km south-east Baghdad (Fig. 1). The importance of the governorate comes from two main sources; the trading activities due to its strategic geographic location as a border area with Iran, and the expansion of oil industries corresponding to establishing Missan Oil Company. As a result, job opportunities increased, making Missan an attractive city for living after it has been one of the main source of immigrants. This has cast a shadow over the construction industries and associated activities. Soil testing and determination of its geotechnical and physical features depending on a reliable soil investigation program are the first steps in any urban development. Preliminary assessment of soil condition based on information and recommendations provided by such investigations and their impact on the cost of projects are very necessary to both designers and clients.

Several studies have been conducted to describe the geotechnical properties of the soil of southern region of Iraq which includes Basrah, Missan and Thi-qar. The majority of these studies was focused on Basrah soil, e.g., [1] – [5]. A little amount of literature has been published on the geotechnical characteristics of Missan soil. Previous research on this soil was mainly sought to study the region from a geological point of view, for example, [6] – [10].

One of the earliest attempts to describe Missan soil for construction purposes was made by Gelson and Plank in 1960 [11]. The aim of soil investigation program was mainly to design a highway bridge across Tigris. The survey of boreholes driven at the proposed site revealed that soil layers were not continuous in the horizontal direction. Up to a depth of 30 m, the main soil strata were silts, clays and sands mixed with different quantities of sea shells, organic clay and Gypsum. In 2010, Al-kahadaar and Al-amery [12] investigated the relationships among a number of soil measurements of Ammarah. The authors presented some useful equations connect mechanical and physical features of the studied area. Mahmood (2014) [13] evaluated the bearing capacity of different types of foundations depending on Standard Penetration Test (SPT) data collected from seven locations in Missan. It is found that piles should be extended to a minimum depth of 17 m, which represents the depth of dense silty sand layer. In 2019, Al-Saedi [14] studied seepage effects on Teeb weir which located nearby Iraq-Iran border. Soil investigation showed two main strata. The first layer is shallow in depth (1 – 1.5 m) which consists mainly of stiff sandy silt/clay. The next layer extends up to a depth of 25 m contains dense sand and gravel with a little amount of silt.

The aim of the current study is to clarify the main geotechnical aspects of Ammarah soil by considering data collected from different locations over the city.

Fig. 1. Iraq map showing the region of study.

Geology of Ammarah/Missan

Missan is situated within the southern part of Mesopotamian plain. Its location on a net of rivers, lakes and marshes (locally known as Ahwar) resulted in a continuity in sedimentation processes due to the subsequent flooding and drying of these water bodies. Another source of sedimentation contributed to form the city caused by wind action which transmits fine sand from Southren desert as a result of irresistible desertification process. Geologists classify these sediments into Fluvial (cohesive layers), Dibdibba Formation sediments (non cohesive layers) and Aeolian deposits [13]. All of these sediments are of Quaternary deposits type from Holocene age. The city can be described as a relatively flat area except the north-east part (Iraqi-Iranian border) which contains Hemrin hills with an elevation of 230 m [15].

Used data

In the current study, data collected from 26 boreholes distributed randomly over the considered area of depths 12 to 30 m are used. Fig 2 illustrates locations of the boreholes. Geotechnical data are taken from soil investigation reports performed by the Engineering Consulting Bureau of College of Engineering, University of Basrah. The reports were performed in accordance with the request of clients. The authors contributed to site investigation, laboratory testing and preparation of final reports. In presenting results, selected boreholes were considered taking into account the most common features of soil layers. The data discussed in the current study intend to present major differences of Ammarah soil. Two cross-sectional soil profiles were plotted showing soil strata in the longitudinal and transverse directions of the city. At the time of investigation (from May, 2012 to February, 2013), the groundwater table is at relatively shallow depths and typically ranged between 1–2.5 m below natural ground. It should be kept in mind that the geotechnical data reported in the current study are not intended to discuss minor soil differences in the study area, but to record major soil properties.

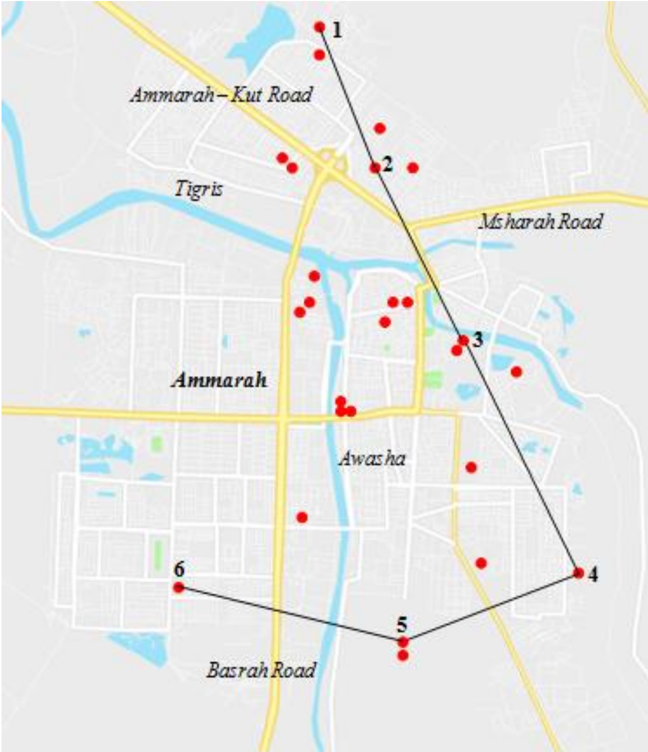


Fig. 2. Boreholes locations within the study area.

Results and discussion

The first cross-sectional profile passes through boreholes 1,2,3 and 4 respectively (see Fig. 2). The subsurface soil conditions of this cross-section are shown in Fig 3. Field tests including standard penetration test and Vane shear test were used to determine the consistency of soil. Moreover, shear strength parameters were determined in the laboratory by unconfined and triaxial tests. The first soil layer can be described as brown to gray silt of medium consistency. The depth of this layer ranges from 3 to 7 m. The silt becomes stiff and, sometimes, very stiff in the second layer which extends up to 8 m in boreholes 1 and 2. This layer did not appear in borehole 3, while borehole 4 showed only 1 m of this soil. From a depth of 7 to 12 m under the soil surface, all boreholes shared the same layer of soft brown to gray silt with low plasticity. After that depth, the silt showed stiffer behaviour ranges from stiff to very stiff. A layer of hard silt has appeared in the last 2 m of borehole 2 which extended up to 30 m.

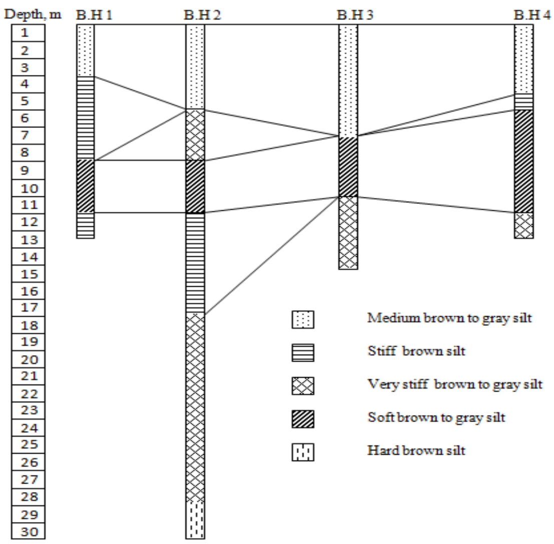


Fig. 3. Subsurface soil conditions through boreholes 1, 2, 3 and 4.

The second cross-sectional soil profile consists of boreholes 6, 5 and 4 drilled up to a depth of 12.5 m. Fig 4 shows the main features of this profile. In spite of the fact that silt is the main source of soil strata, it can be seen that the order of the layers with respect to their strength is not the same in the three boreholes. The discontinuity of horizontal soil layers over a small area is one of the main problems may face geotechnical engineers. However, boreholes 5 and 6 shared the same medium silt of low plasticity with varying depths. Soft silt was found in boreholes 4 and 6, while borehole 5 did not show soft behaviour. Soil strength in borehole 5 showed a tendency to increase with depth throughout the entire depth drilled. The bottom of boreholes 4 and 5 showed a layer of very stiff silt. Comparing the two cross sections shows that soil layers are distributed more randomly in the transverse cross section (6-5-4) than those observed in the longitudinal cross section (1-2-3-4).

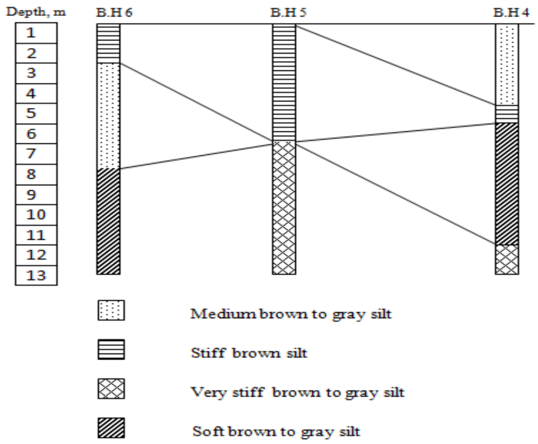
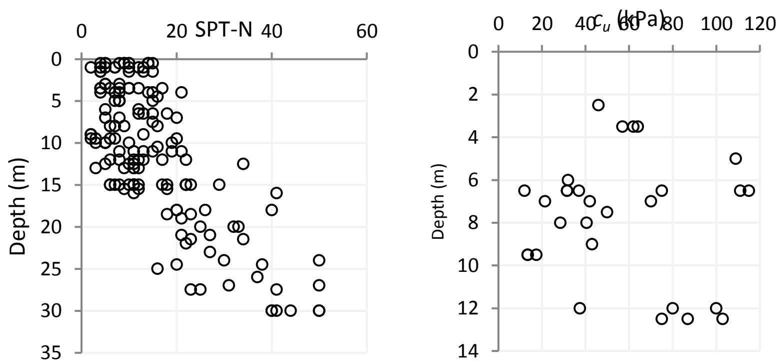


Fig. 4. Subsurface soil conditions through boreholes 6, 5 and 4.

Three types of soils were recognized by particle size analysis namely silt, sandy silt and silty sand. The percentages of these materials are randomly varied within the study area. However, the majority of soils of Ammarah city is silty soil which consists of 75% silt. Sand and clay share the remaining percentage equally. Sandy silt soils consist of 60, 30 and 10% of silt, sand and clay particles, respectively. Conversely, silty sand soil generally consists of 30% silt grains and 60% sand particles.

Values of standard penetration test (SPT) measured against depth at different locations in Ammarah are illustrated in Fig. 5(a). It can be seen that from the ground surface up to a depth of about 15 m, SPT-N values were in the range of 2 – 20 blows/feet with no or a very slight tendency to increase with depth. After that, a significant increase of SPT-N values with increasing depth can be observed.

Fig. 5(b) shows the variation of undrained shear strength values (cu) obtained by in-situ Vane shear test with depth. It can be noticed that cu values are randomly varied between 12 and 117 kPa, with no clear tendency of increase or decrease with depth. This is mainly due to the differences in soil consistency especially with the existence of soft soil layers located at varying depths.



(a) SPT-N values **(b) c_u values**

Fig. 5. Variation of soil strength with depth.

Plasticity properties of Ammarah soil are presented in Fig 6. The following ranges of plasticity characteristics can be noticed:

Liquid limit (%): 31–51;

Plastic limit (%): 21–39;

Plasticity Index (%): 7–16.

Plasticity chart illustrated in Fig 7 shows that the plasticity indices of the majority of Ammarah soil were located just below A-line with corresponding liquid limits of less than 50% (low plasticity). Other physical and chemical properties of the study area are listed in Table 1.

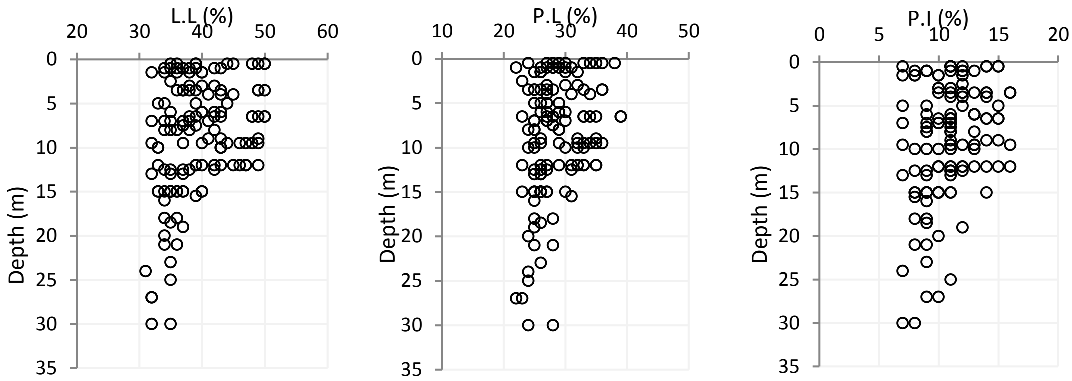


Fig. 6. Variation of Liquid limit, Plastic limit and Plasticity index with depth.

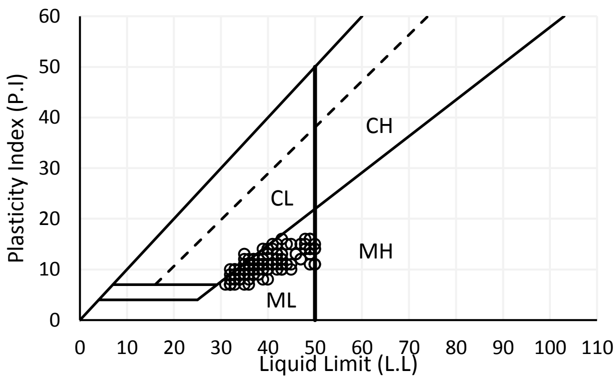


Fig. 7. Plasticity chart for Ammarah soil.

Table 1. Properties of Ammarah soil.

Description	Maximum	Minimum
Physical properties		
Bulk density (kN/m^3)	20.7	18.3
Dry density (kN/m^3)	16.6	14.5
Water content (%)	32.1	15.5
Consolidation properties		
Compression index, C_c	0.32	0.15
Recompression index, C_r	0.054	0.022
Natural void ratio, e_o	1.129	0.77
Chemical properties		
ORG (%)	2.45	1.08
SO_4 (%)	0.68	0.22
$CaCO_3$ (%)	7.92	5.51
Gyp (%)	7.83	5.02
Cl (%)	0.65	0.12

Geotechnical problems of Ammarah soils

Soils may be problematic for civil engineering projects due to several factors. Examples of problems in soil include gypseous soils, sabkha deposits, sand dunes, expansive soils and others. Based on the current investigation and available literature, the following features can be identified for the study area:

1. Investigations conducted by [16] and [17] showed that Ammarah and most nearby cities can be classified as slightly gypseous soils.
2. Although Missan Province is known for its sand dunes which distributed near Iraq-Iran boarder, such as Chailat and Al-Manziliyah [6], the study area is free of sand dunes.
3. Following some classifications and recommendations available in the literature, e.g. [18] and [19], liquid limit and plasticity indices results showed that Ammarah soil having medium degree of expansion.
4. The values of shear wave velocities of Ammarah range between 111 m/s just below the ground surface to 211 m/s at a depth of 20 m, as reported by [20].
5. The sabkha deposits occupy wide parts of southern region of Iraq. Sabkha soil can be recognised visually by its dark brown colour and chemically by its high content of salts [21]. The upper soil layer of Ammarah is ranged between brown to gray in colour with high percentages of salts. Another factor contributes to form sabkha soil in the study area which is the shallow depth of groundwater table.

Conclusions

In this paper, a description of some of geotechnical aspects of Ammarah city soil is presented. The first 30 m of the city is mainly silt with few percentages of clay and sand. Across two cross-sectional profiles within the study area, the investigated soil layers appeared to be erratically distributed with depths. A problematic soft soil layer is located in the range of 6 – 12 m under the soil surface. No such soft layer has been observed in borehole 5. This horizontal discontinuity in soil nature reflected the random varying in shear strength values obtained by Vane shear test. However, after a depth of 15 m onwards, a significant increase in SPT-N values with depth was observed. Investigating and reviewing soil problems showed that Ammarah soils are free of problems associated with sand dunes and high gypsum content. On the other hand, sabkha soil is widely distributed over the area due to salts and the shallow depth of water table.

Conflicts of Interest

The author declares that they have no conflicts of interest.

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التقييم الجيوتقني للترب في العمارة / مركز ميسان، العراق

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الخلاصة

قبل اعتماد أي نظام للتنمية الحضرية، ينبغي دراسة طبقات التربة وتحديد المعلومات الجيوتقنية. في الدراسة الحالية، تم جمع البيانات الجيوتقنية الأساسية لمدينة العمارة ودراسة الخواص المتأصلة للتربة وطريقة توزيع طبقات التربة. علاوة على ذلك، تم استعراض المشاكل التي تنطوي عليها تربة منطقة الدراسة. أظهرت فحوصات الموقع والاختبارات المعملية أن المنطقة مجال الاهتمام تتميز بطمي بنسب مئوية مختلفة موزعة على العمق. كشفت نتائج الاختبار القياسية للاختراق والقص عن عدم الانتظام الافقي لطبقات التربة. أظهر فحص ومراجعة مشاكل التربة أن تربة العمارة خالية من المشاكل المرتبطة بالكثبان الرملية ومحتوى الجبس العالي. من ناحية أخرى، توزع التربة السبخة على نطاق واسع على المنطقة بسبب الأملاح والعمق الضحل لمستوى المياه.

الكلمات الدالة: – تربة العمارة، الخصائص الجيوتقنية، الحفر الاختبارية.