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REDISTRIBUTION OF AL-ADHAMIYAH LAND USE BY ASSESSMENT OF THE GEOTECHNICAL PROPERTIES USING GIS TECHNIQUE

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Abstract

The growth of Al-Adhamiyah city in Baghdad, Iraq was limited in the early stages around the shrine of Imam Abu Hanifa until the establishment of the Aal Bayt University in 1924. The design idea of Al-Adhamiyah city was extrapolated based on the principle of congruence in the optical and motor access. This assist to facilitate mobility and movement between several parts of the urban infrastructure. According to the literature reviews and a field survey conducted between July 2016 and August 2016, the city of Al-Adhamiyah was divided into five separated zones. This study aims to redistribute the zones and proposed appropriate types of buildings according to the geotechnical properties. Around 100 geotechnical investigation reports were adopted. Geographic Information System (GIS) was used to deduce the geotechnical and engineering properties of the soil under each zone and to suggest the proper type of building for construction. For a durable design, a specific table is proposed to reflect the bearing capacity of each zone with the appropriate type of building. It was observed that the GIS approach could be helpful for building type assessment and assists in land use distribution.

Keywords: Architecture geotechnique, GIS technique, Land use.

1. Introduction

1.1. Historical view

Al-Adhamiyah is one of the main cities in Baghdad, Iraq. The growth of Al-Adhamiyah was limited in the early stages around the shrine of Imam Abu Hanifa and spread over the ruins of the Quraysh cemetery. Al-Adhamiyah located in the north of Baghdad, which was a peninsula surrounded by river's water from three sides. In the year 459 AH (1067 AD), the old city became the origin of the city's growth and expansion [1].

The district has many famous places such as Imam Azm Mosque, Adhamiya Hour, Royal Cemetery, Antar Ibn Shaddad square, royal court, Adhamiya Cornish, and Imams Bridge, which established in 1957 instead of the old bridge. Moreover there are many scientific schools, universities, houses of literature has spread boards and forums dealing with literature, thought, sociology, politics, history and economy [2].

After the establishment of the Aal Bayt University in 1924. The growth of the city was started to increase. The main access to the university and the central university campus was proposed to be the tomb of King Faisal First. The basic design of Aal-Bayt University was designed by the English Engineer Major Wilson and his assistants [1]. He separated the university site from the royal cemetery and connected it with the rest of the urban structure visually.

The design idea of Al-Adhamiyah city was extrapolated based on the principle of congruence in the optical and motor access to facilitate mobility and movement between the different parts of the urban infrastructure. The construction of Al-Adhamiyah Bridge (1925-1930) assists to strengthen the link between the royal cemetery and the Karkh side. An attempting was partially adopted to transform the center of the urban structure from the shrine of Imam Abu Hanifa to the royal cemetery. This made the city as a nucleus for the growth of the southern parts of the urban structure [3].

The construction of the Imams Bridge in 1957 eases to re-structure the city of Al-Adhamiyah in a comprehensive manner by high lighting the features of the Imam Abu Hanifa scene and linking it with the Kadimia landscape [1].

Meanwhile, the city of Al-Adhamiyah is considered one of the strategic cities since it is located in an essential area in the Baghdad (the capital of Iraq). Al-Adhamiyah connects the two sides of Baghdad (Rusafa and Karkh). The main border of the city is Tigris River. For this reason, the city has beautiful scenes, which assist to establish several entertainment activities. In this study, the regions of Al-Adhamiyah were identified in terms of the land use [2].

1.2. GIS techniques

Geographical Information Systems (GIS) and Global Position Systems (GPS) ease the growth of thematic geotechnical maps [4]. Thematic maps provide a powerful database and strong visual presentation of data using the Digital Elevation Model and the satellite imageries [5]. This helps to identify the proposed type of building and the foundation design of each structure.

Several studies used GIS to design and plan the urban areas according to the geotechnical properties [6]. GIS is also used to determine the safety features of soil underneath every building [7]. Alnedawi [5] produced several thematic maps for Baghdad city based on California Bearing Ratio (CBR) and Resilient Modulus (MR) values. The study depended on soil properties obtained from soil investigation reports. In general, the study showed that there is an upper fill layer in some municipalities followed by a layer of cohesive materials consists of brown silty clay or brown clayey silt. The authors recommended the data presented in study should be updated continuously to represent every town in Baghdad.

As the current land use of the city was describe in section 1.1, there is need to characterize the city according to the geotechnical properties. Therefore, this study aims to develop a new zoning for the city.

Based on literature reviews, field survey, and GIS thematic maps, the city of Al-Adhamiyah was divided into 5 zones. In order to develop the above-mentioned zones and to propose the appropriate type of buildings, 100 geotechnical investigation reports were adopted. GIS technique was used for the purpose of mapping the geotechnical and engineering properties of the soil. These engineering maps could be used as a reference for future land use.

1.3. Brief study of urban design

Due to the growth of urban trends application worldwide, changes have been noticed in conceptual with the growth in urban problems of modern cities. New concepts started in the second half of the twentieth century in the composition of the residential environment were initiated, such as convergence and aggregation instead of abstract concepts of previous trends and organic characteristics of growth. The confirmation of more complex relationships between the old fabric and the new function, which Curist and William in1982 defined as the search for a new language of urban design [8]. Curist also rejected the principles of garden cities and rational models of the 1930s, and opposition to the principle of free buildings that ignore the traditional street pattern in the urban environment [8].

Urban design deals with the study and design of a part or a group of parts of the city like a group of buildings or integrated fabric, and focuses on physical elements such as building blocks and spaces [9].

2. Study Area Location

The studied area is located in the north-west of Baghdad and to its east is a tangent with the Tigris River. The whole area is approximately about (25 km^2) embraced by the coordinates (from 442111.15 to 442045.88) easting and (from 332355, 25 to 332355.25) northing in the zone (33 N-44E) according to UTM Projection system.

GIS techniques (ArcMap 9.2) was used in order to draw the boundaries of Al-Adhamiyah city as shown in Fig. 1, depending on a digital map of Baghdad of scale (1:14000) which is used to define the boundaries of the municipality. It was developed in 2003 by National Imagery and Mapping Agency, USA.

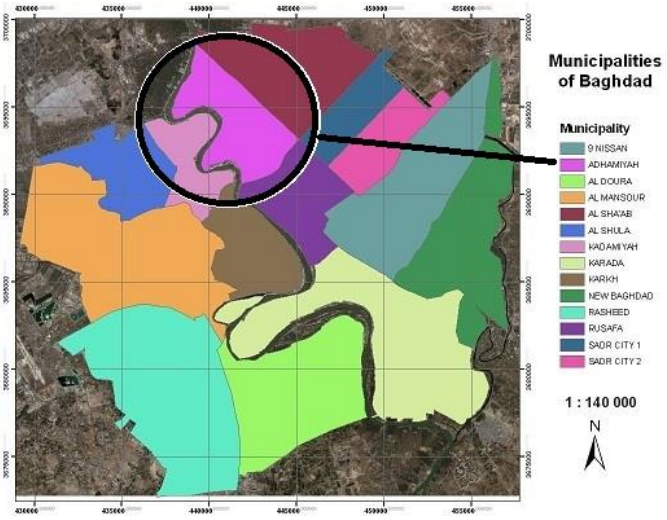

Fig. 1. Municipalities of Baghdad [8].

3. Methodology

The current study is based on a field survey conducted on the period from 1/7/2016 to 15/8/2016, which included a questionnaire about the available and desired function of the users in the studied area. The city of Al-Adhamiyah was divided into five zones accordingly. The experimental results were taken from soil investigation reports carried out by Andrea Engineering Testing Laboratory. The reports included soil investigations for several projects, such as buildings, bridges, and interchanges, commercial buildings, college, service stations, health center sand roads. The total number of locations in the study area is 13 for each zone, which covered all Al-Adhamiyah city zone. The essential information was gathered from these reports such as the name, objective of the job, location, depth of borehole and soil properties. A GIS based landscape design approach is adopted to develop thematic maps form the soil properties of each zone then to specify design criteria for a required location. GIS can map the data available to be in electronic form, therefore it will be easily stored, managed, edited, and transmitted. Data were interpolated to introduce a continuous surface as a visual display using spatial interpolation i.e. the process of using points with known values to estimate values at other unknown points

3.1. Zoning of Al-Adhamiyah City

Based on the current land use and a field survey conducted for the period from 1/7/2016 to 15/8/2016, the city of Al-Adhamiyah was divided into 5 new zones as shown in Fig. 2.

1. Green Use Zone (GUZ).
2. Mixed Use Zone (MUZ) commercial and residential use Area.
3. Accommodation Use Zone (AUZ).
4. Education Use Zone (EUZ).
5. Religion Use Zone (RUZ).

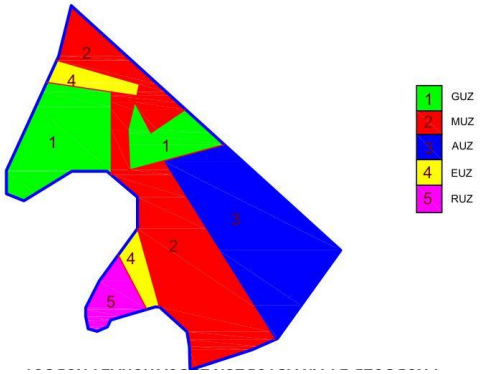

Fig. 2. Zones of Al-Adhamiyah.

3.2. Data base preparation in Excel files

The database is prepared in Microsoft Office EXCEL. The database is stored to recognize each location linked with X, Y (Easting, Northing) coordinates of each borehole.

3.3. Data linkage to GIS

Boreholes were linked to their geographic locations through their coordinates using ArcMap 9.2 software as a GIS platform as shown in Fig. 3.

Fig. 3. The study area.

4. Results and Discussion

Data were interpolated to introduce a continuous surface as a visual display using spatial interpolation. The following sections describe the thematic maps of different soil properties.

Thematic maps

4.1. Plasticity index

Plasticity Index (PI) is a measure of the plasticity behavior of a soil. Commonly, it is the difference between the liquid limit (LL) and the plastic limit (LL). Generally, a high PI is attributed to the high montmorillonite in clay. Contrary, soils with a lower PI are characterized by silt. Some types of soils have PI of 0, which means the materials are not plastic such as soil with a little amount of silt as coarse particle (sand). Figures 4 and 5 show the variation of the plasticity index values across the studied area at depths 0-2 m and 2-4 m respectively. The upper 2.0 m layer has a range of PI value between 15 and 31. Most of the evaluated area has a range of PI between 15 and 20. As a result, the soil plasticity is medium to high according to unified Soil Classification System.

The second layer with a depth of 2-4 m as shown in Fig. 5. A range of PI values between 15 and 34 was observed. PI value changes from high to low and vice versa indicating change of the consistency limits.

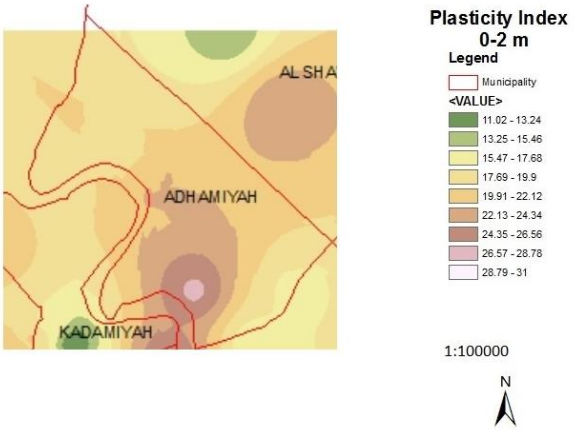

Fig. 4. Variation of Plasticity Index at depth 0– 2 m across the study area.

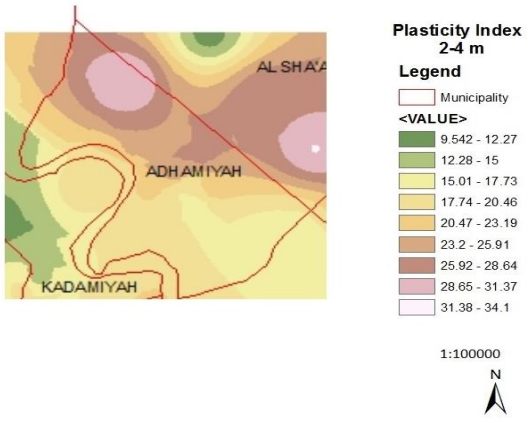

Fig. 5. Variation of Plasticity Index at depth 2– 4 m across the study area.

4.2. Bearing capacity

Generally, the foundation is the base of the structure. The main role is to transfer the load of the structure uniformly to the soil. A proper designed foundation could transfer the static building loads to the soil with minimum distresses the soil.

The outcome of overloading the soil could outcome in either extreme settlement or shear failure of the soil, which causes failure to the structure. Thus, the designer of the foundations must assess the bearing capacity of soils underneath the structure [10].

The produced GIS maps showed that the values of bearing capacity of subgrade for the shallow foundation in the study area vary between 4 and 20 T/m^2, as shown in Fig. 6. Most of the area has values of bearing capacity around (8 -12) T/m^2. The values drop into a range between 4.5 and 8 T/m^2 in the north and the north-west of the studied area. It is worth to mention that the bearing capacity was measured at a depth of 2.0 – 4.0 m as reported in the investigation reports.

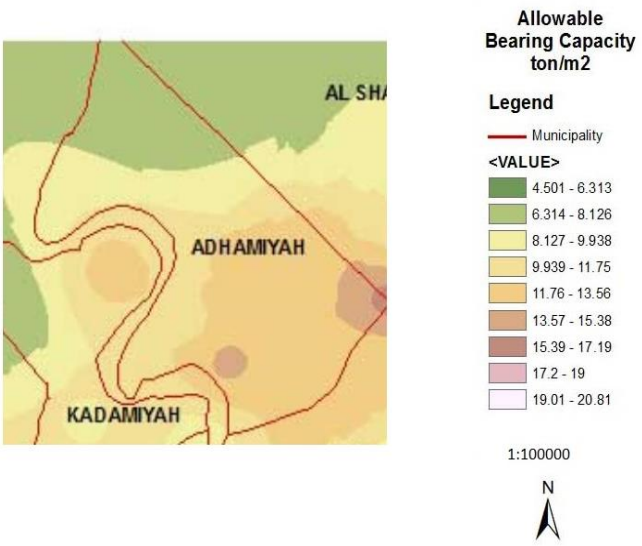

Fig. 6. Bearing Capacity distribution 2– 4 m across the study area.

4.3. Depth of fill

The upper layer of the study area is filled with natural soil and the main type of soil is brown silty clay or clayey silty Sand. Also, it may be found as clayey Silt, broken brick, gravel, ceramics, pieces of masses, and percent of organic materials. Figure 7 illustrates the distribution of the fill thickness across the study area. The range of depth of fill is between 1.0 and 2.5 m below the natural ground level. A high depth of fill between 8.3 and 9.9 m below ground level is located at the middle of the study area. This fill layer explains a high compression tendency and a low bearing capacity, and it is preferable that foundations of important and sensitive structures avoid this layer as much as possible [11].

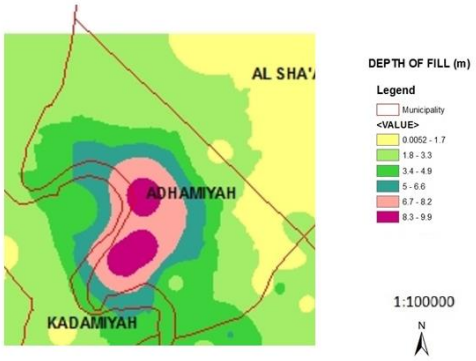

Fig. 7. The depth of fill across the study area.

4.4. California bearing ratio (CBR)

The values of CBR at depths from 0.0 to 4.0 m are ranged from 2.9 to 15.9 % as shown in Figures 8 and 9. This means that the soil could be characterized as weak to firm according to Iraqi Specification for Roads and Bridges [12, 13].

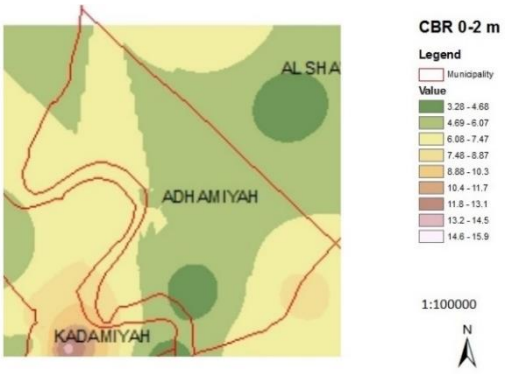

Fig. 8. CBR at 0-2 m across the study area.

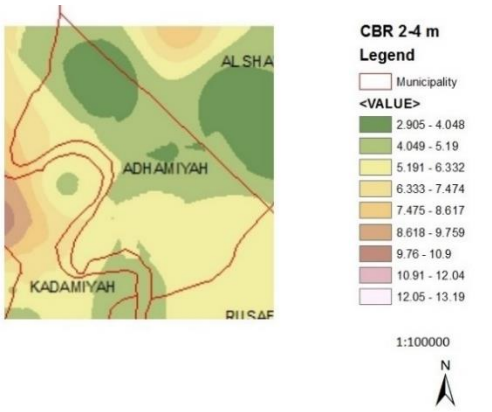

Fig. 9. CBR at 2-4 m across the study area.

4.5. Bearing capacity analysis

Since all type of building which will be selected according to geotechnical properties of soil underneath each zone depending on evaluating bearing capacity and settlement. The following criteria should be taken into consideration [14]:

i. The adequate factor of safety against failure in shear.
ii. The adequate margin against the excessive settlement.

The bearing capacity could be evaluated from one of the following methods.

i. The bearing capacity is calculated according to Terzaghi equation with modification suggested by Meyerhof (1963) [15]

$q_{ult} = CN_c + q\,N_q + 0.5\,B_\gamma\,N_\gamma$ Continuous footing (1)

$q_{ult} = 1.3\,CN_c + q\,N_q + 0.4\,\gamma\,B\,N_\gamma$ Square footing (2)

$q_{ult} = 1.3\,CN_c + q\,N_q + 0.3\,\gamma\,B\,N_\gamma$ Circular footing (3)

$q_{ult} = CN_c\,S_c\,d_c + q\,N_q\,S_q\,d_q + 0.5\,\gamma\,B\,N_\gamma\,S_\gamma\,d_\gamma$ Meyerhof (4)

where N_c, N_q, N_γ are bearing capacity factors, S_c, S_q, S_γ are shape factors, and d_c, d_q, d_γ are depth factors.

These are defined as:

$$S_c = 1 + \frac{N_q}{N_c}\frac{B}{L} \quad (5)$$

$$S_q = 1 + \frac{B}{L}\tan\phi \quad (6)$$

$$S_\gamma = 1 - 0.4\frac{B}{L} \quad (7)$$

$$d_c = 1 + 0.4\frac{D_f}{B} \quad (8)$$

$$d_q = 1 + 2\tan\phi(1-\sin\phi)^2\frac{D}{B} \quad (9)$$

$$d\gamma = 1 \quad (10)$$

ii. Bearing capacity for the foundation on undrained saturated clay for ϕ =0, so the general expression will be:

$q_{ult} = CN_c + \gamma\,D_f$ (i.e., N_q =1, $N\gamma$ =0) (11)

$$(N_c)_{rectangular} = \left(1 + 0.2\frac{B}{L}\right)(N_c)_{Strip} \quad \text{(Skempton)} \quad (12)$$

iii. The net allowable bearing capacity of clay or plastic silt is approximately equal to the unconfined compressive strength, where

$q_{ult} = CN_c + \gamma\,D_f$ for Φ=0 (13)

Thus, the allowable bearing capacity of clay or plastic silt approximately equal to the unconfined compression strength.

iv. 5. The ultimate bearing capacity of the pile (Q_u) is made up of adhesion (Q_s) and end bearing (Q_b); (adhesion often called skin friction) is usually much greater than end bearing in clay

$$Q_u = Q_s + Q_b \tag{14}$$

$$Q_u = \alpha C_u A_s + N_c\, C_{ub}\, A_b \tag{15}$$

where Q_u is the ultimate bearing capacity (T), C_u is the shear strength of soil adjacent to the shaft, α is the shaft adhesion factor taken as 2/3 =0.67, A_s is the surface area of pile shaft, N_c is the bearing capacity factor (usually taken as = 9), C_{ub} is the shear strength of soil (2/3)d below base where d= base diameter, and A_b is the area of pile base.

5. Final Assessment and Findings

As a professional distribution of zones has been adopted in this study, and according to the expected land use and human activities. Therefore, there is a need to link the geotechnical properties with the type of urban structure to help minimize risk exposures. The distribution of structures and building for each zone has been more successful in reducing risk exposures if depending on geotechnical engineering.

Land use of each zone is selected depending on equations and formulas mentioned in 4.5 above, which explained the recommended design to prevent or reduce the risk exposure, which is due to the bad use in each area selected.

Based on the geotechnical data from the investigation reports and the GIS maps, each zone of the study area has been evaluated against the bearing capacity values. As a result, Table 1 was produced which shows the proper foundation width with respect to the bearing capacity value for a settlement of not more than 25 mm. This table assists to the safe selecting type of structure or construction for each zone. Table 2 shows suggested the type of building and foundation for each zone.

Table 1. Bearing capacity of each zone from GIS techniques.

Zone No.	Bearing Capacity (T/m^2) Foundation Width (m)			
	1 m	2 m	3 m	raft
Green Use Zone (GUZ).	4	5	6	4.5
Mixed Use Zone (MUZ)	6	7	8	6.5
Accommodation Use Zone (AUZ).	7.5	8.5	10	8
Education Use Zone (EUZ).	7	7.5	8.5	7.3
Religion Use Zone (RUZ).	5	5.5	6.5	5.5

Table 2. Type of Building vs, type of foundation.

Zone No.	Building Type Foundation Width (m)				
	1 m	2 m	3 m	raft	Pile
Green Use Zone (GUZ).	A*	A	-	A	B**
Mixed Use Zone (MUZ)	A	B	B	A&B	A&B
Accommodation Use Zone (AUZ).	C***	C	C	C	C
Education Use Zone (EUZ).	A	B	B	B	-
Religion Use Zone (RUZ).	A	A&B	-	-	-

*A one-story Building, ** B two-story building, and *** C multi-story building

6. Summary and Conclusion

Redistribute the zones and proposed appropriate types of buildings of Al-Adhamiyah city according to the geotechnical properties using GIS Techniques were well studied and the following conclusions were drawn:

- The context of urban structure, in addition to the renewal projects within a spatial model has a great influence in redistribution of Al-Adhamiyah city.
- Using GIS techniques gives very reasonable results and assistance in land use distribution of Al-Adhamiyah city.
- The GIS-based approach is used to reanalysis and redistributed of types of building and structures all around the city by dividing it into five zones.
- Two tables were developed to reflect the bearing capacity of each zone and presents a guide for the users to select the type and depth of footing with respect to the number of stories.
- Most of the study area has a range of Bearing capacity of 4 to 12 T/m^2 while the settlement from each zone profile shows a critical condition in some zones especially near the river
- The variable activities in Al-Adhamiyah area lead to distribute the building according to land use.
- The digital architecture maps with the aid of GIS techniques are representative, easy to use, and save time and cost.
- Urban planning emphasizes land uses and policies to the public. Urban design must also combine physical design with political decision-making powers to form the interconnected urban structure between public and private property and control their growth and change.
- The research recommends linking the theoretical and applied approach in the preparation of the proposed designs for the development of urban structures or in the construction of new urban structures.

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