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كلية الهندسة - جامعة بغداد

جمعية كليات الهندسة اعضاء اتحاد الجامعات العربية

Developing digital geotechnical maps using GIS Techniques (Review)

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Abstract— Geographic Information Systems (GIS) consist of software that is used to collect and display data, analyze, process and produce maps. This software is a computer-based system that works to collect, maintain, store, analyse, output and distribute spatial data and information. For specific goals and descriptions, this software helps in planning and decision-making concerning agriculture, city planning, and housing expansion, in addition to reading the infrastructure of any city. This system enables to enter geographical information (maps, aerial photographs, satellite visuals) and descriptive information (names, tables) and process them. (Correcting them from errors), storing them, retrieving them, inquiring about them, analyzing them spatially and statistically, and displaying them on a computer screen or on paper in the form of maps, reports, and graphs. This research aims to review previous studies according to which researchers produced different maps of all soil properties using geographic information systems.

.Keywords— Thematic maps; GIS; SPT; bearing capacity; shallow foundation.

1. Introduction

Nowadays it has become possible to communicate all different geometric properties more easily, thanks to the use of GIS mapping tools. A researcher can use GIS to produce graphs based on data [30]. After reviewing the various references between the years 2000 and 2023, the relevant research papers were collected (evidence, tests on the soil, its physical and geotechnical properties) .The remaining evidence that was not related to the subject of the study was deleted, can obtain data for different geometric properties, data with spatial value, and descriptive data. The most important soil properties data, such as soil bearing capacity data, standard penetration test, cone test data, specific gravity tests, density, salt percentage, groundwater level, and other spatial data.[18],[29]. Geographic information systems consist of basic elements: spatial and descriptive information, computers, application programs, human power (lapour), and methods used for spatial analysis. The focus here will be on some of these elements [27]. It is possible to obtain spatial information in many ways. One of these methods is called primary information, which can be collected by ground surveying, aerial photography, remote sensing, and GIS. It is also possible to use secondary information collected by a scanner, or automatic line tracer. The thematic map is provided with additional information called descriptive information to define the names of the regions and add more details to the maps. [6]

The superior ability of Geographic Information Systems in the process of searching databases and conducting various inquiries, then showing these results in a simplified form to the decision maker has benefited in many fields, including: crisis management, urban planning, environmental protection, producing maps for land uses and natural resources. Conclusion The shape of the Earth's surface, making appropriate decisions, and building maps.

2. Previous studies for Geotechnical Properties Using GIS.

2.1 *Local previous studies*

The literature is expected to present a wide range of different data and software approaches, limitations and application areas. It is possible to obtain different results using spatial value data such as soil bearing capacity, foundation bearing capacity, geotechnical soil specifications, groundwater level, and other types of spatial value data.[19],[21]. 12% of previous studies

focused on creating positional maps to classify soil using Geographic Information Systems. Figure 1 shows the percentages of different soil properties. A soil classification system can provide additional details about different soil types.

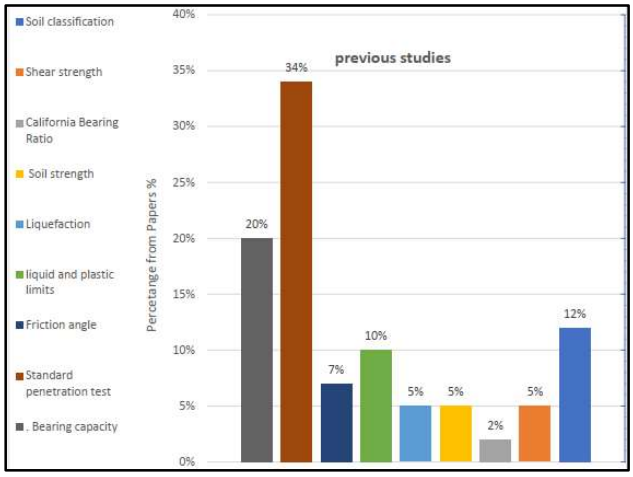

Figure 1: Percentages of standards used by previous studies. [32]

[24] Worked on implementing a major project in developing thematic geotechnical maps for a specific area in the city of Baghdad (Al-Rusafa) using geographic information systems (GIS) and remote sensing techniques. In a very exact and easy-to-use way, these maps produced by the program were then used to illustrate the dispersion of the various geotechnical characteristics. The researcher studied all the satellite images he obtained of the study area and linked them to some geotechnical properties such as soil bearing capacity, depth of boreholes, swell pressure, liquidity limits, and unit weight using ArcGIS, then he created digital geotechnical maps showing.

[22] Studies the geotechnical Characteristics of the soil were studied in the city of Nasiriyah (southern Iraq) using geographic information systems, where geotechnical tests revealed the type and classification of the soil, the limits of liquids and plastics at depth, and the possibility of soil swelling. .

[16] Explained the construction of maps of geotechnical for the soil using the GIS program for Najaf city in Iraq, in addition to determining the type of soil (gypseous soil) and soil layers. This study was completed in more than one stage to produce a map of the study area showing the administrative boundaries of the city after entering the necessary data. Using GPS and entering this data into a geographic information system program, the researcher complete 28 boreholes up to a depth of 6 meters. The study produced useful results, as the researcher classified the soil of the city of Najaf and created gypseous geotechnical maps in Najaf. For urban planning, [1] prepared geotechnical soil maps for residential purposes in Hilla city using geographic information systems. The researcher used all the information he obtained to draw these maps, and then collected data and engineering characteristics for the future study. The results were based on 77 geotechnical maps at a depth of 10.5 m. According to preliminary soil investigation reports, these maps were created using the results of 115 holes. Geotechnical soil maps show some of the physical properties of soil such as “Plasticity Limit” (PL) and “Liquid Limit” (LL), dry unit weight, saturated unit weight, carrying load capacity, and angle of internal friction as shown in Figure 2. [7] Studied the physical and geotechnical properties of soil in different cities of Iraq, such as Baghdad, Diyala, Wasit, and Babil, where he conducted a comparative study and analyzed the obtained data from the laboratory results of soil tests. Based on the results of the analysis, geotechnical maps were drawn at different depths, where the depths were as follows (1, 3, 5, 7.15 m). Some important tests were chosen, such as the limits of fluidity and plasticity, dry and wet densities, soil cohesion strength, angle of internal friction, the number of blows in the standard penetration test and the hydrometer test, plus some chemical tests such as the gypsum content, the content of organic materials, sulfates, and dissolved salts.

[5] Focused their research on producing geotechnical maps using GIS software that can be used in the initial design stage. They surveyed and drilled 164 wells in Wasit Governorate, southern Iraq. They obtained large amounts of data then analyzed classified it, and used them to construct geotechnical soil maps. The most important extacted data was shear strength, pressure factors, uniformity coefficient, carrying load capacity of soil, and groundwater levels. The results showed that GIS techniques are an excessive way to imagine geotechnical variables which can be directly used in assessing soil investigation reports (site) and soil geotechnical investigations.

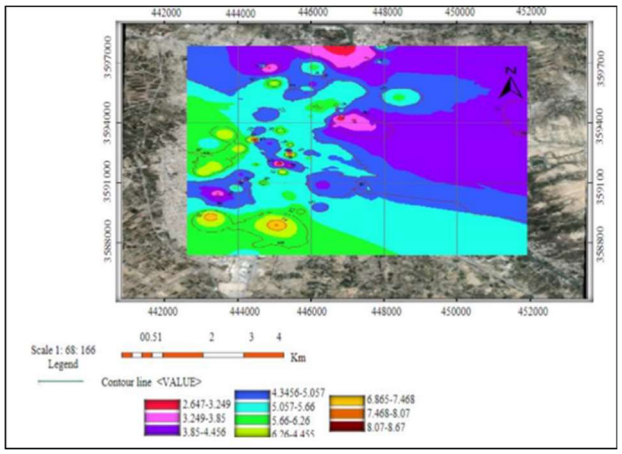

Figure 2: Bearing Capacity map (1 m) depth in Hilla. [16]

Using GIS and remote sensing techniques [25] generated a digital geotechnical map of the Saladin city in Iraq. These maps can provide with an accurate and easy-to-use representation of the distribution of various geotechnical variables and characteristics. The research concluded by creating geotechnical maps of the permissible carrying capacity of the foundation, the Atterberg limits, the percentage of organic materials, the percentage of gypsum,

and the groundwater level. The geotechnical properties of the soil of Basra city were examined by [4]. The geotechnical variables that were examined included three areas of the city, such as the standard penetration test, the results of sieve analysis, the limits of liquidity and plasticity, and some chemical properties, at a depth ranging from the ground level to depths from 16-26 meters. Geotechnical properties of Dhi Qar soil were mapped by digging 423 holes using geographic information systems for data visualization and the IDW and Kriging tools [23]. To produce maps of soil classification and various soil engineering properties such as dry and wet unit weight, liquidity limits, ultimate carrying capacity, and standard of soil, penetration testing. The permissible soil carrying capacity (the weight that the soil can bear) is one of the most important properties of soil.

2.2 *Global previous studies*

[31] Studied the classification of soil based on its susceptibility to landslides. Among the factors that had been considered were the soil type, depth, permeability, fluidity and plasticity limits, geological properties such as soil erosion and shrinkage, and the internal texture of the soil.in addition to geological properties such as soil erosion and shrinkage, and the internal texture of the soil. Maps of all relevant variables were taken from various references and analyzed using geographic information systems.

[28] Used ArcGIS software and remote sensing data landslide referencing were conducted in Cameron to achieve a range of topographic and geotechnical properties. In addition to collection of satellite photographs for this assignment was obtained over and done with evaluation of above ground photographs and daily ground studies. Geographic Information Systems software, processing image data and converting it into a spatial database for reference when needed in the future, then identifying dangerous places that could collapse and creating maps for them called landslide maps.

[15] Described the land condition and attitude of a Sata (Japanese city) using GIS software to produce contour maps of soil. The geotechnical properties of the soil are known through standard tests of boreholes sites, and physical properties are known from sieve analysis tests, density, direct shear, unconfined pressure tests, and others. Assessing risks, preparing for disasters, reducing their effects, avoiding them, and making future plans will be done using these useful maps.

GIS interpolation was used by [2] for geotechnical data analysis and planning. The research area consists of the campus of Hassan Osman Katsina Polytechnic University, Nigeria, and ArcGIS 10.2.1 were used for investigations and analysis. Soil samples were collected from ten experimental pits located around the research area and submitted for various laboratory tests for this investigation. This study calculated evidence of models and engineering properties in the GIS environment. A database of maps was created. The laboratory tests were recorded, analyzed, and presented using GIS technology. The results of the study included maps of different soil properties, shown in Figure 3.

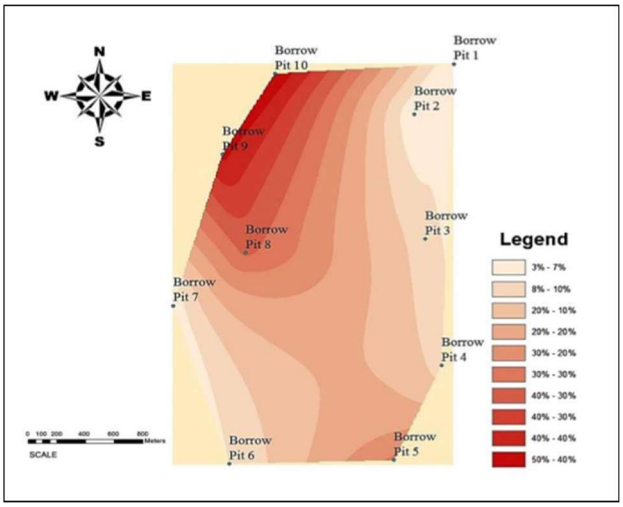

Figure 3: GIS-based CBR maps in India

[12] Used a Gaza city in Palestine as a study case to create a GIS study. The data was collected from 92 holes distributed in most of Gaza's neighborhoods. After that, Geographic Information Systems were used to create maps containing information such as the water ratio in the area, soil carrying load capacity, excavating depth, and soil type.

The data was uploaded into a geographic information system program that provides a framework for easily storing, retrieving and updating this data to assist in making decisions for different designs. Then, the soil properties in the Esenler area in Istanbul, Turkey were reviewed by [13] on maps founded on geographic information systems. To obtain the geotechnical engineering properties of the soil in the region, drilling, seismic refraction, and laboratory studies were used. In addition to increased depth, changes in SPT values, the velocities of earthquake, and classifications of soils are measured and displayed in the form of area maps for easy reading and understanding.

[20] A GIS system was used to display and store data and variables, then process and display them in the form of geotechnical maps. Maps showing shear resistance, angle of soil internal friction, standard penetration values and effective force were generated based on the results of the study.

[3] The capabilities of GIS and remote sensing used in soil research were analyzed by studying the variation and spatial change of surface soil parameters. About 170 soil samples (0-30 cm) were examined from, Punjab city in Pakistan. The surface soil factors were usefully interconnected with one to another. According to the results obtained using remote sensing technology and geographic information systems, can draw geotechnical maps using standard soil penetration tests data for a large area with high accuracy.

[17] Observed the construction of geotechnical sites in Faisalabad and tested these sites with the amount of weight each site could support. Based on how the land was created, the area was divided into three zones using GIS (Allowable bearing capacity of the soil, shear strength, and flatness coefficients, with number of blows N value). On this basis, engineers will learn about the bearing capacity of achievability studies, preliminary design tables, and the time required to complete them. This will allow engineers to design a large group of engineering projects with high accuracy.

[14] Observed the changes that have occurred in the geography and groundwater levels of India's national capital, Delhi. He distributed the variables of the study into groups. The ArcGIS software, was used to produce spatial difference maps. Then use the basic variables in the program to create geotechnical maps or maps of other variables. Geotechnical researchers and engineers have observed at in what way physical and chemical properties influence groundwater distance. Three-dimensional spreading maps display that groundwater depth is wrongly iIt's all about everything else.

[26] chosed India as a study area based on paper maps and various soil tests using a geographic information system. Geotechnical maps of cities were produced after testing the SPT, the permissible carrying capacity of the soil, and classifying the soil to determine its properties. Using geographic information systems can control the SPT values at different depths. The study depended on geographic information systems applications that were used to recognize and map phenomena that were problematic to study, not only in terms of accuracy, but also in terms of time using traditional methods.

[11] studied the carrying capacity and durability of soil in many cities and areas surrounding the Metro Manila Railway in the Philippines. For design purposes, many theories and research were used, including geotechnical variables and parameters such as unit weight, relative densities, cohesion forces, internal friction angles….. etc. Using standard penetration tests (SPT), these geotechnical parameters were estimated to calculate the carrying load capacity of the soil.

[8] Characterize the geotechnical properties of Multan area in Pakistan using ArcGIS by including documents from soil investigation reports of several building projects. The subsurface conditions of the study area were classified as a soil type, and standard penetration test was observed by using GIS.

[10] They carried out several studies to permit them to determine soil characteristics and measure its range throughout the area (Gujarat state).The samples of Soil were collected from different locations and the samples of soil were analyzed in the laboratory. It is important to assess the Ukai watershed in Gujarat, on the Indian in terms of soil class and gradient. Topography and configuration guides were evaluated by means of data from the GIS system, while soil property calculations were achieved using satellite data.

[9] analyzed the parameters of soil in the Turkish city of Kahramanmaras, he proposed an application using geographic information systems. Geotechnical tests were performed in the field and in the laboratory. To prepare 287 holes were dug in the city. To determine the physical properties of the soil, standard penetration tests (SPT) were used, and the effects of tests were used to designate the natural properties of soil boreholes. For this study, maps of SPT-N, soil bearing capacity, potential of liquefaction, and groundwater depth were complete.

3. Conclusion

The useful purpose of this study is to refer to the methods used in the procedure of Maps of geotechnical variables. There is a well understanding of the many different areas in which GIS is used and the applications to which it has been provided in the field of geotechnical engineering.

1-To better manage the passage of together parameters and certify data we must develop a geotechnical information system to manage the system and improve the information.

2-Geographic Information Systems give us the capability to extract and analyzing too much geotechnical data and provide suitable optical and digital data by taking out soil properties and information from maps.

3-Creating a thematic map using GIS programs that shows the variation in the permissible carrying load of shallow foundations by way of a purpose of earthly coordinates is one of the modern techniques.

4-For geotechnical engineers, their use of these thematic maps produced using geographic information systems will save them time and cost, especially for small projects that do not require soil investigations.

5-Local authorities can use these maps to directly extract the allowable bearing capacity of soil information.

6-To evaluate the foundations of existing and irregular buildings, one can benefit from these maps, as well as evaluate all risks such as failure and collapse.

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تطوير الخرائط الجيوتقنية الرقمية باستخدام تقنيات نظم المعلومات الجغرافية (مراجعة)

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الخلاصة: من البرامج الحديثة التي تستخدم لجمع وعرض البيانات وتحليل ومعالجة الخرائط وانتاجها والذي يستخدم بشكل شائع هو برنامج نظم المعلومات الجغرافية هو نظام قائم على الحاسوب يعمل على جمع وصيانة وتخزين وتحليل وإخراج وتوزيع البيانات والمعلومات المكانية.وهذه أنظمة تعمل على جمع وادخال ومعالجة وتحليل وعرض وإخراج المعلومات المكانية والوصفية، لأهداف محددة، وتساعد على التخطيط واتخاذ القرار فيما يتعلق بالزراعة وتخطيط المدن والتوسع في السكن، بالإضافة إلى قراءة البنية التحتية لأي مدينة يمكننا هذا النظام من إدخال المعلومات الجغرافية (خرائط، صور جوية، مرئيات فضائية) والوصفية (أسماء، جداول)، معالجتها (تنقيحها من الخطأ)، تخزينها، استرجاعها، استفسارها، تحليلها تحليل مكاني وإحصائي، وعرضها على شاشة الحاسوب أو على ورق في شكل خرائط، تقارير، ورسومات بيانية . يهدف هذا البحث إلى مراجعة الدراسات السابقة التي قام الباحثون بموجبها بإنتاج خرائط مختلفة لجميع خواص التربة باستخدام نظم المعلومات الجغرافية .

الكلمات الرئيسية – الخرائط التموضعية ,نظم المعلومات الجغرافية ,فحص الاختراق القياسي ,قابلية التحمل , الاسس الضحلة .