International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET2310141

3D Electrical Resistivity Imaging to Determine the Internal Causal factor for leaning of Minaret of Mosque in Baghdad

Hussein Abdelwahab Mossa
Physics Department, College of Education, Mustansiriyah University, Baghdad, Iraq

Article Info

Publication Issue :
Volume 10, Issue 1
January-February-2023
Page Number : 259-263

Article History
Accepted : 15 Jan 2023
Published: 04 Feb 2023

ABSTRACT

The cheapest, easiest, fastest and relatively accurate technique in geophysics exploration is the two-dimensional (2D) and the three-dimensional (3D) resistivity imaging method. 2D electrical resistivity image has been used to image the subsurface structure to discover the causal factor of leaning of the minaret of mosque in Baghdad- Iraq. Eight 2D images have been made to create 3D image for imaging subsurface structure of the study area. The length and width of the image are 80 m with a depth about 15 m. The results showed that there are four types of materials and weak and saturated area has been discovered in area of study. The conclusions have been qualified (confirmed) by using borehole data from the research region.

Keywords: Resistivity Imaging Method, Clay, Leaning Minaret

I. INTRODUCTION

Humans have explored the subsurface structure for a variety of reasons, including architecture, the environment, agriculture, archeology, etc. Boreholing is the most used form of subsurface exploration. Although the drilling approach is the most precise, it is not always appropriate for all desired goals since it is costly, has limited data, damages the research region, and requires a lengthy period of time (Ekinci, 2007). Therefore, the drawbacks of boreholes are avoided by using geophysical techniques. There are several geophysical techniques, and each technique has pros and cons that vary depending on the aim and the nature of the studied region (Metwaly, 2013). Imaging of electrical resistivity in two dimensions is a geophysical method. The 2D electrical resistivity approach has the following benefits: it is an excellent tool for examining intricate subsurface structure. It is proficient in finding pipes, cavities, and ground water. It is a somewhat inexpensive technique. Equipment that is convenient, portable, and has a long range (Xinjie Chen, 2022). The 2D electrical resistivity approach has the following drawbacks: it is less accurate than drilling results, and picking an incorrect array will decrease the accuracy of the measurements. The study area is located in Baghdad, Iraq; there is a leaning minaret of mosque in Baghdad, Iraq therefore to know the reason of this leaning, need to discover the subsurface structure under the minaret. So, the objectives of this study are mapping the subsurface structure, and detect the weakest parts under the minaret of mosque.

According to the borehole data on the site of investigation, the subsurface structure consist of clay, basement, and fill material at the surface.

II. Resistivity Imaging Technique

Obtaining accurate resistivity readings of subsurface structure is the main goal of the majority of contemporary electrical resistivity studies from apparent resistivity which are calculated from measured voltage after injection current to the earth by electrodes. The true resistivity is calculated by using numerical methods. Where the true resistivity has geological meaning for the subsurface structure (Dobrin, 1988). Ohm's law, which states that an electric current (I) in a material is proportional to the potential difference across it, is the basis of the resistivity imaging approach, n the equation:

$$V = I R \qquad (1)$$

wher stands for current, V for potential difference, and R for resistance. The linear connection between (V) and is the name given to the equation above (I). The resistance for a given material is related to the conductor's length (L) and inversely proportional to its cross-sectional area (A). The following equation represents these connections:

$$R = \rho L / A \qquad (2)$$

The conductor's resistivity is the proportionality constant (ρ). The capacity of a substance to resist the passage of charges is expressed by one of its physical properties, or the strength with which a material does so is measured (Mohd Hazreek Zainal Abidin, 2013).

Ohm's Law: "For many materials (including most metals), the ratio of the current density to the electric field is a constant σ that is independent of the electric field producing the current." (Loke, 2023)

$$J = \sigma E \qquad (3)$$

The constant of proportionality (σ) is called the conductivity of the material; (J) is current density, (E) electric field. The inverse of conductivity is resistivity (ρ)

$$E = \rho J \qquad (4)$$

The material's conductivity is denoted by the proportionality constant (σ); the other constants are (J) for current density and (E) for electric field. Resistivity is the opposite of conductivity (ρ):

$$E = \rho J \qquad (4)$$

The potential will divide radially outward from the current source for a homogenous region with a single electrode, where area (A) will be a half sphere ($2\pi r^2$) with radius (r). Equation 2 may now be expressed as follows:

$$\rho = R K \qquad (5)$$

where K=2πr for the half sphere. Equation 5 is divided into two parts. Resistance (R) is the first component, and geometric factor (K), which characterizes the electrode configuration's shape, is the second. Figure 1 depicts a homogenous region with two electrode pairings; Equation 5 geometrical factor will vary depending on the design of the electrodes.

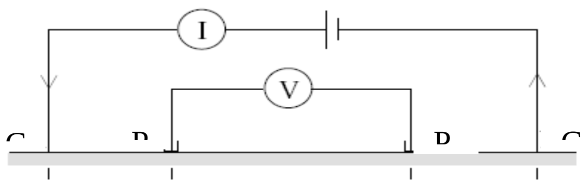

Figure 1: Resistivity measurements using four standard electrode configurations [taken from (Loke, 2023)

In actuality, the ground's geological features are uneven, and the measured resistivity is an apparent resistivity rather than the actual resistivity (Marianna Balasco, 2022). As a result, the resistivity (ρ) in Equation 5 will become an apparent resistivity (ρ_a) inside of a non - homogeneous region.

$$\rho_a = R K \qquad (6)$$

Equation 6 is the main equation to calculate the apparent resistivity depending on the type of the subsurface structure and the arrangement of electrodes of the current and voltage poles. The true resistivity can be calculated from apparent resistivity by using special commercial software, which is called RES2DINV. This software uses numerical methods to estimate the true resistivity and to plot 2D (Loke, 2023).

III. Methodology

Terrameter SAS 4000 is used in this study as shown in Figure 2. This system is Automatic electric imaging. The basics principal work of this system is injecting current into the surface by two electrodes that read the potential difference by another two electrodes. After that, the system will calculate the resistance R and apparent resistivity depending on the type of the array, which used in the survey. Electrode Selector ES10-64 is used with Terrameter SAS 4000 in electrical resistivity imaging (as shown in Figure 2). ES10-64 is a multichannel relay matrix switch, which connects to Terrameter SAS 4000. In additional, four spread cables, 61 stainless steel electrodes, and 62 jumpers are used with Terrameter SAS 4000.

Figure 2: Tools and equipment used in electrical resistivity imaging

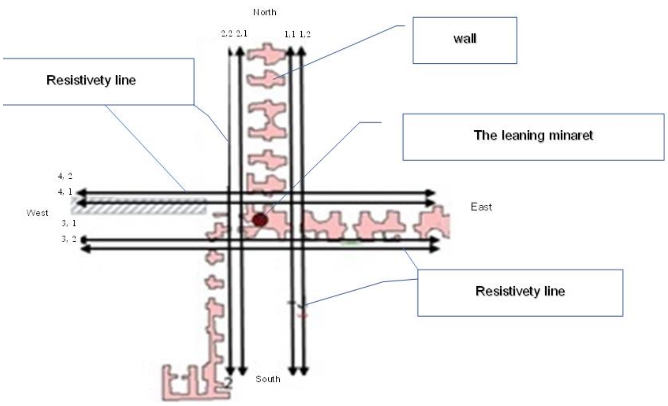

Figure 3: Electrical resistivity lines

The 2D resistivity image has been created for eight lines (four parallel pairs lines surround the minaret and the space between the pairs is 1 m) location and spacing have been chosen based on the reality of the situation of the building (as shown in figure 3). Each line is 2D resistivity image with length of 80 m and has 61 electrodes with one meter spacing by using four cables.

The borehole has been made in the study area. The borehole data shows the subsurface consist of fill material, clay and basement as shown in Figure 4.

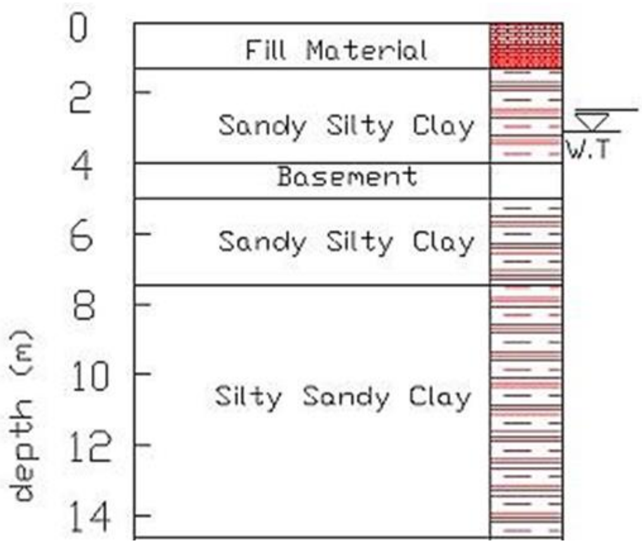

Figure 4: Borehole data in the study area

IV. Results and Discussion

The results in Figure 5 show eight resistivity pseudo-sections have been created by using Wenner array. Each pseudo-section is 2D resistivity image where the coordinate is length (x-axis) and depth (-z-axis). The color of each 2D image presents the resistivity values of the structure of the subsurface. The length of each line is 80m and the depth of the investigation of the lines is 14.5m, the distance between pair lines is about 1m.

The results show that resistivity values can be divided into four ranges. The ranges of resistivity values are between (1-10, 11-100, 150- 1000 and 101-above Ω.m). The results have been interpreted depending on borehole data and standard material resistivity values (Table 1) where the dark blue colour which has resistivity value about 1-10 Ω.m can be interpreted as a saturated zone of Clay. While light blue and green colours which have resistivity values about 11- 100 Ω.m have been interpreted as normal clay. In addition, green and yellow colours in the image with 150 -1000 Ω.m interprets as fill materials. Furthermore, the high resistivity values (101 and above Ω.m) are interpreted as a basement.

Figure 5 shows in line 2 the basement of building (the pair Western vertical lines from North to South). Moreover, it is clear to see the fill material on the surface of lines 1, 2 and 3. In addition, the most weak and saturaded areas placed on all lines.

Figure 6 shows the 3D image of the study is with depth 14.5m. The image shows the basement of the minaret until depth 4.5m and most of the subsurface consist of saturated clay. The most weak and saturated area has been noticed on North-East of the minaret.

Table 1: Resistivity (Ω.m) of common study area materials after Borehole data in figure (4) and (Reynolds, 1997)

Materials		Resistivity (Ω.m)
Basement		101-100,0000
Fill materials (alluvium and gravel)		150-1000
Clay	Normal clay	11-100
	Saturated clay	1-10

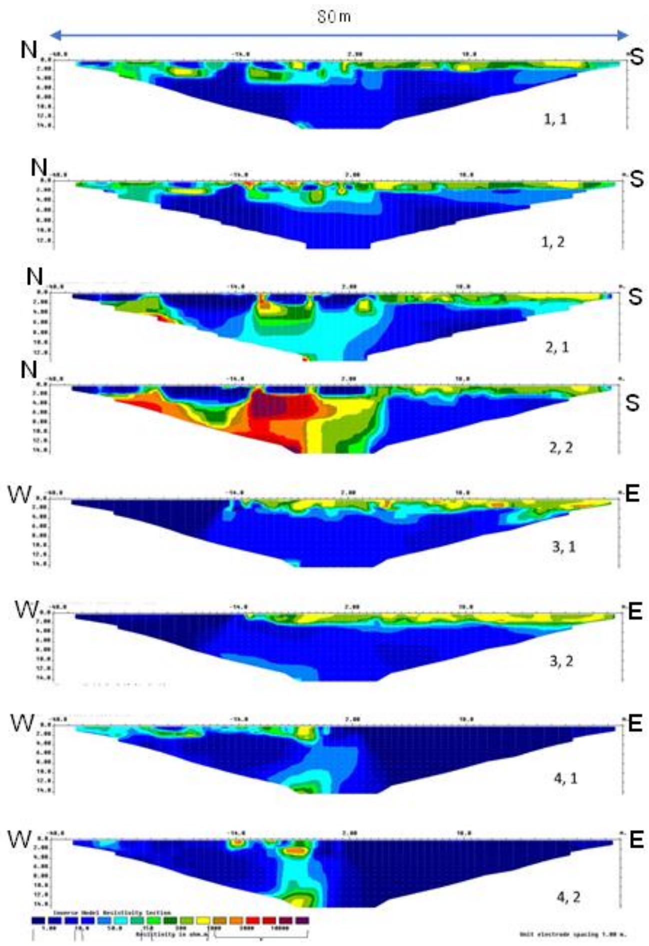

Figure 5: 2D electrical resistivity images for the study area

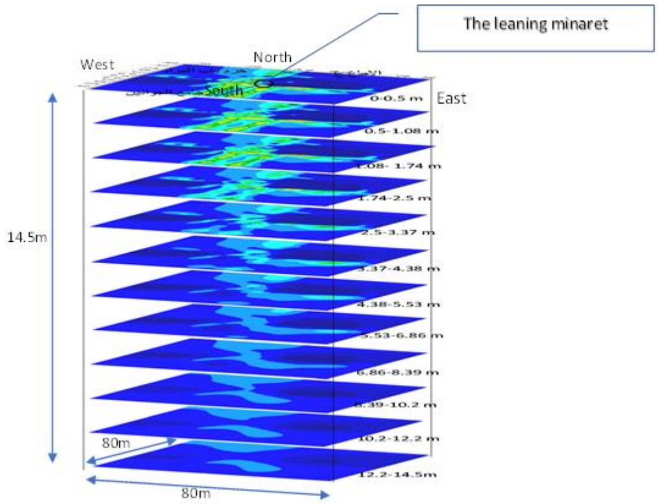

Figure 6: 3D electrical resistivity image for the study area

V. Conclusion

The 3D electrical resistivity method is a very effective method for detecting subsurface structure especially the groundwater. The subsurface structure of study area consists of three types, basement, clay and saturated clay. The weak part of the study area is located toward North-East of the minaret therefore, the minaret leaning toward North-East of the minaret.

VI. Acknowledgment

The author would like to express his gratitude to Mustansiriyah University, Baghdad, Iraq.

VII. REFERENCES

[1]. A. S. Bello, A. A. (2022). Electrical resistivity investigation for groundwater exploration of the basement complex of malumfashi, Nigeria. FUW Trends in Science & Technology Journal, 7(1), 100-113.

[2]. Dobrin, M. a. (1988). Introduction to geophysicsl prospecting. McGraw-Hill College.

[3]. Ekinci, Y. a. (2007). 3D resistivity imaging of buried tombs at the Parion necropolis. Jornal of the balkan geophysical society, 10(2), 1-8.

[4]. G.Bianchi Fasanib, F. .. (2013). G.Bianchi Fasanibc F. Bozzanobc E. Cardarelliac M. Cercato. Engineering Geology, 152(1), 109-121.

[5]. Haider M. Mekkiyah, H. M. (2018). The Tilting Problem of AL- Khulafa Mosque Minaret. Journal of Civil Engineering Research, 8(2), 33-39. doi:10.5923/j.jce.20180802.03

[6]. Loke, M. (2023). Lecture notes on 2D & 3D electrical imaging surveys. New Appendix J about a small inconsistency in the Dey and Morrison 2.5D finite-difference method. (16th ed.). Retrieved from www.geoelectrical.com

[7]. Lowrie, W. (2007). Fundamentals of Geophysics. Cambridge Unversity Press.

[8]. Marianna Balasco, V. L. (2022). Deep Electrical Resistivity Tomography for Geophysical Investigations: The State of the Art and Future Directions. Geosciences, 12(438), 1-19.

[9]. Metwaly, M. a. (2013). Application of 2-D geoelectrical resistivity tomography for subsurface cavity detection in the eastern part of Saudi Arabia. Geoscience Frontiers, 4(4), 469-476.

[10]. Mohd Hazreek Zainal Abidin, D. W. (2013). The Influence of Soil Moisture Content and Grain Size Characteristics on its Field Electrical Resistivity. The Electronic Journal of Geotechnical Engineering (EJGE), 18(D), 699-705.

[11]. P.Martínez-Pagán, D.-O. T.-C. (2013). The electrical resistivity tomography method in the detection of shallow mining cavities. A case study on the Victoria Cave, Cartagena (SE Spain). Engineering Geology, 156(1), 1-10.

[12]. Reynolds, J. (1997). An Introduction to Applied and Environmental Geophysics. John Wiley & Sons, Ltd.

[13]. Serway, R. a. (2007). Physics for Scientists and Engineers (2nd ed.). Thomson Brooks.

[14]. W. M. Telford, L. P. (1990). Applied Geophysics. Cambridge University Press.

[15]. Xinjie Chen, Z. G. (2022). Groundwater Detection Using the Pseudo-3D Resistivity Method: A History of Case Studies. Applied Science, 12(6788), 1-14.

Cite this article as :

Hussein Abdelwahab Mossa , "3D Electrical Resistivity Imaging to Determine the Internal Causal factor for leaning of Minaret of Mosque in Baghdad", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 10 Issue 1, pp. 259-263, January-February 2023. Available at doi : https://doi.org/10.32628/IJSRSET2310141
Journal URL : https://ijsrset.com/IJSRSET2310141