Determination of Civil Engineering Problems Using Resistivity Methods in Ramadi, Western Iraq

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Abstract

Many civil engineering problems resulting from the presence of gypsum soil near the surface and the water table in shallow depth led to the solubility of the soil and creates a subsurface weak area in Ramadi city. 2D and 3D electrical resistivity imaging were applied using a Dipole-dipole array with an n-factor of 6 and a spacing values of 2 m. Imaging data sets have been acquired along five traverses with a line distance of 4 meters. The inversion model is generated by the robust inversion model constraint method, which clearly shows that the boundary of the weak area is sharper and straighter. The results show the presence of two main zones, the first represents the topsoil layer which extends to a depth of 2.5 m with a resistivity ranging from 28 to 312 Ωm. The second zone is located at 2.5 m depth and extends to 10 m with a resistivity value ranging from 0.267 to 28 Ωm. The variation of the water table, inhomogeneity of the sediment, weak areas, and sedimentation lenses are the main reasons for the failure of civil engineering. These failures may cause many problems such as wall cracks, foundation damage, and building collapses.

Keywords: Dipole-dipole array; Weakness zones; Resistivity imaging; Engineering problems; Ramadi City

1. Introduction

The main engineering risks are often related to construction in areas underlain by gypsum and carbonate rock. Generally, the water level in the General Company Warehouses for Construction Materials is relatively shallow, which is conducive to the dissolution of gypsum soil, leaving weak areas. The existence of weak area leads to restrictions land use causes serious civil engineering and environmental hazards, such as ground subsidence, ground structural collapse, cracks and fissures in ground structures (Elawadi, 2003). Roads subsidence, and dam leakage are also some of the risks associated with weak areas. In the past few decades, the use of geophysical methods to detect underground cavities and shallow weathered zones has aroused widespread interest (Abu-Shariah, 2009; Vachiratiengchai et al., 2010; Abed et al., 2021). Electrical resistivity techniques consider commonly method for investigation underground weak areas, because it provides semi-real images of underground structures, and quickly calculates and determines of subsurface resistivity (Metwaly and Al-Fouzan, 2013; Elawadi, 2003; Dutta and Saikia; 1970; Claerbout and Muir; 1973; Abed et al., 2020).

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Many studies in Iraq apply resistivity technique to engineering studies, especially the delineation of underground weak areas that may lead to risks in civil projects and buildings. For example, Al Saadi et al., 2021 performed a two-dimensional resistivity technique using a Wenner array with an electrode spacing of 2 m to study a specific industrial area near the Erbil-Kirkuk Borders. The resistivity imaging inversion sections of blocks A, B, C, and D did not show any signs of cavitation or weakening zones larger than 2.0 meters, and generally no signs of gypsum were found in these areas. Al Hetty et al. (2021) used the geoelectric method to expand the karst phenomenon at two locations in the western part of Al Anbar. The first site is the Um El-Githoaa cavity located in the Hit area. The second location is Haditha in the village of Barwana. It is carried out on the south side of the cave to verify whether the sewers distributed in the area are connected to the underground cave. The results of the dipole array show that there are three caves below the surface. This shows that these phenomena are spreading in the area. Othman et al. (2019) used the 2D resistivity method to determine whether the Mirakan site is suitable for Erbil dam construction. The Pseudo sections cross section shows that no faults were found at this location, there is no evidence of voids, and no sources of danger.

The General Company Warehouses for Construction Materials lie within Ramadi city, western Iraq (Fig.1). The surface soil represent Quaternary deposits consists of gypseferous soil, and gypcrete with thickness about 1.5 m, above the Injana Formation which consists of pale brown claystone, pinkish pale claystone, siltstone, and fine sandstone with secondary gypsum (Hussein, 2012). The main objective of the study is to identify the areas of weakness that cause risks to engineering sites in the city of Ramadi using resistivity imaging techniques.

2. Materials and Methods

The field work been acquired through the five 2D lines (Fig.2) using Terrameter SAS 4000 instrument. 2D and 3D survey was carried out by the dipole-dipole array with 42 electrodes, the a-spacing (2m), and the n-factor equal to 6. In order to build a 3D model, the measured values of five 2D lines are used, and the line spacing is 4 meters. All the 2D data input in one file to generate 3D imaging model by using the RES3DINV program (Geotomo, 2016).
3. Results and Discussion

3.1. 2D Resistivity Inversion of Dipole-Dipole Data

RES2DINV software, was used to generated 2D resistivity invers model (Geotomo, 2018; Loke, 2020). First stage including remove bad data through two methods to; The first is to manually select bad data by constructing configuration files for data points (Fig. 3a). The second stage is to use an automatic static method by removing data points using the RMS error option and improving the total RMS errors (Fig.3b). The 2D inverse model produced using the Robust Inversion Model Constraints, that shows that the boundary of the weak area is sharper and straighter.

Figs. 4 shows a 2D resistivity through lines 1, 2, 3, 4, and 5, respectively. It shows that there are two main zones, the first representative of the soil layer and extend to depth of 2.5 m with the resistivity range of 28 to 312 Ωm. This difference in resistivity value is usually caused by the high inhomogeneities in the deposits. However, the second zone located at 2.5 m depth and extent to 10 m with resistivity value extend from 0.267 to 28 Ωm. It represents sedimentary lenses and weak areas. This model shows present water table near the surface with low resistivity value 0.267 Ωm due to seepage from sewage water. The depth water in study area equals to 1.5 m in BH-CDS-1 well which cause weak zone due to dissolved gypsum soil.
Fig. 4. 2D resistivity inverse models for the Traverses 1, 2, 3, 4 and 5
3.2. 3D Resistivity Inversion of Dipole-Dipole Data

For created a 3D resistivity model of the underground the data files for five 2D lines (1, 2, 3, 4 and 5) were input in one file for the processing and interpretation in RES3DINV program. 3D imaging technique is the best to view underground weak zone because it can show the results in 3 dimensions, so it can define the problem in civil engineering application and environment situation clear image than 2D imaging. Fig. 5 shows the 3D resistivity inversion model for the study area by the robust constraint option. First and second slice display the highest resistivity value from the surface to 1.72 depth, reflect the inhomogeneity of topsoil that represents gypsum soil. The third and sixth slices from 1.72 to 7 m depth show variation in resistivity value due to present water table led to dissolved soil and created weak zone and void. Low resistivity area appears with a depth range of 7 to 23.2 m. This low resistivity zone representing a clay layer or saline water from seepage water.

Fig.5. 3D resistivity models

4. Conclusions

- The 3D resistivity technique is most suitable for engineering site investigation due to the results are presented in 3D dimensions, so it can define problems with a clear picture than the 2D imaging technique.
- Two main zones of electrical resistivity were recognized, the first represents the gypsum soil layer and extends to a depth of 2.5 m with the resistivity range of 28 to 312 Ωm. This difference in resistivity value is usually caused by the high inhomogeneities in the deposits. However, the second zone appears after 2.5 m depth and the extent to 10 m with resistivity value extending from 0.267 to 28 Ωm. It may be representing sedimentary lenses and weak areas.
- The Water table was defined as a low resistivity zone located near the surface.
- The variation of the water table, inhomogeneity of the sediment, weak areas, and sedimentation lenses are the main reasons for the failure of civil engineering projects.

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