2-D Resistivity Assessment of Subsurface Characterization and its Engineering and Environmental Implications at SiLC

2-D Resistivity Assessment of Subsurface Characterization and its Engineering and Environmental Implications at SiLC

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Abstract. The role of geophysics in Environmental Earth Sciences and Engineering is considered. In the developing era, geophysics has mainly contributed in investigation of new constructions such as tunnels, road, dams and high-rise buildings. This study was carried out to assess the foundation depths around a construction site in the Southern Industrial & Logistics Clusters (SiLC), Nusajaya, Johor using 2-D resistivity method. The 2-D resistivity method was carried out with a view to characterize different subsurface geological and to provide the engineering and environmental geophysical characterization of the study area. Measurements of eight 2-D resistivity profile using Pole-dipole array with 2 m minimum electrode spacing was taken with the use of ABEM Terrameter SAS4000 and ES10-64C selector. The results are presented as inversion model resistivity with the outline of the survey line. The inversion model resistivity from L1-L8 obtained is characterized by resistivity range of 1-8000 ohm-m. This range indicates the occurrence of silt, clay, sandy clay and sand whose ranges are; 10-100 ohm-m, 1-100 ohm-m, 100-800 ohm-m and 100-3000 ohm-m respectively. However, there was a boulder with range of >5000 ohm-m and saturated zone (1-20 ohm-m) which may indicate the weak zones of the study area. The 2-D resistivity method is not intended to replace borings, except in specific cases where information gathered would be sufficient to address the intended engineering and environmental purpose.

1. Introduction

The Southern Industrial & Logistics Clusters (SiLC), Nusajaya, Johor is a new site that is intended to be developed for industrial development with world-class managed, clean and green industrial park designed and planned to meet the current demand for environmentally sustainable development. Though there are existing structures on the site, however, there is need for the development of new structures to meet the population changes. For this reason, 2-D resistivity investigation was carried out for evaluation of site condition as an aid to geotechnical engineers.

Environmental problems will be definitely one of major social problems in this century. Many academic and engineering societies have paid their attention to the environmental issues in recent years. Environmental problems include many problems relating to human life such as natural disasters due to earthquakes, volcanic activities, landslides and various accidents due to existing underground

constructions (collapse structures, karst void, cavity and sinkholes) as well as environmental pollutions.

Geophysical methods, particularly 2-D resistivity method have been extensively used for a wide variety of engineering and environmental problems [1,2,3]. This is due to the fact that, the 2-D resistivity survey is one of the simplest and less costly geophysical surveys employed. 2-D resistivity survey is relatively easy to perform and can be used to identify geological structures [4].

2. Site description

The area of investigation is located in the Southern Industrial & Logistics Clusters (SiLC), Nusajaya, Johor approximately at latitude 103° 35' 30" E and longitude 1° 28' 38" N (Figure 1 and 2). SiLC is a 1,372 acre (5.6 km^2) industrial park with close proximity to two international airports and cargo hubs as well as four seaports both in Johor and Singapore is a value-adding advantage. As an international gateway, this key logistical factor adds soaring value to the business activities of industry players.

Figure 1. Map of Nusajaya, Johor showing the study area.

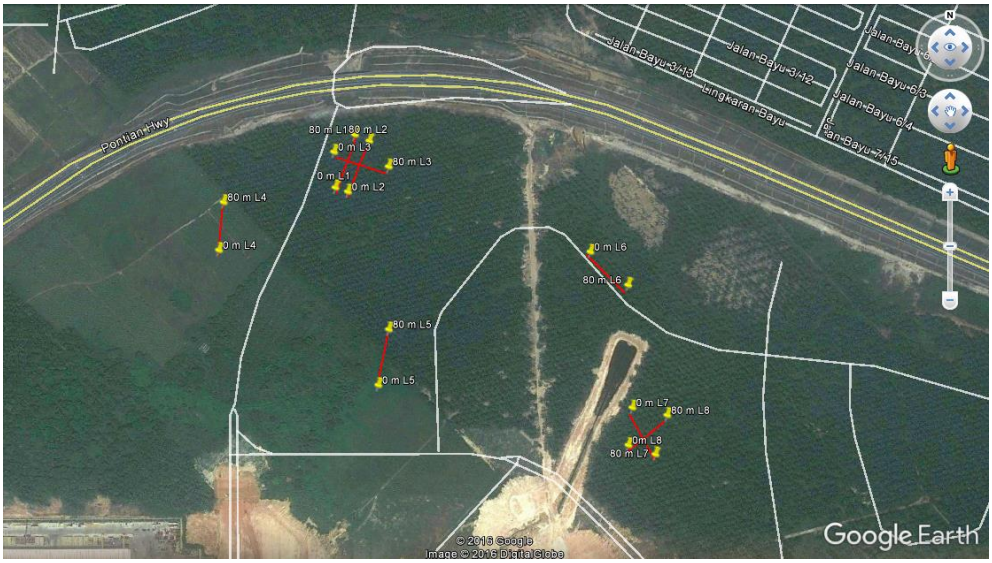

Figure 2. Map of survey line at SiLC, Nusajaya, Johor.

3. Geological area

Both [5] and [6] emphasized the variable lithology of the Older Alluvium. The most common variety is coarse feldspathic sand with occasional rounded phenoclasts, but gravelly clay, sandy gravel, sandy

clay, silty clay, clayey sand and clay are also all well represented. The Older alluvium contains phenoclasts of vein quartz, quartzite, sandstone, siltstone, shale, hornfels, granite, granite porphyry, alaskite, aplite, rhyodacite, andesite and tuff. Bedding in it is generally only moderately well-developed, but close interbedding of the various lithological types can be seen in a few places. Where the formation is exposed in outctrops its feldspar content has in many places been weathered to a kaolinitic clay, and thus in the case of the common feldspathic sand type its surface appearance is that of a sandy clay or clayey sand [7].

4. Methodology

The 2-D resistivity survey was conducted using ABEM SAS4000 Terrameter, ES10-64C as a selector, electrode cables with 5 m takeouts and stainless steel electrodes. Eight survey lines were occupied in this study area. The survey used Pole-dipole array with space between electrodes are 2 m. The data were processed using Res2Dinv software for gridding, contouring and final presentation. The image from 2-D inversion model resistivity (L7) will be present with correlation of resistivity values and N-values from the borehole record. The results of the 2-D inversion model were combined to produce 3-D image using Surfer software.

5. Results and discussion

The inversion model resistivity from L1-L8 obtained is characterized by resistivity range of 1-8000 ohm-m (Figure 3-5). This range indicates the occurrence of silt, clay, sandy clay and sand whose ranges are; 10-100 ohm-m, 1-100 ohm-m, 100-800 ohm-m and 100-3000 ohm-m respectively. Borehole log records from each line were used as a control for the interpretation of the entire profiles obtained in this survey (Figure 6). The results of the inversion model resistivity assumed that the first layer is characterized by relatively high resistivity value (3000-8000 ohm-m) and thin thicknesses (1-3 m). This layer was considered to be reclaimed area; however their wide ranges of resistivity values are due to dry nature and percentage of sand. Low resistivity values (1-50 ohm-m) were interpreted as saturated zone. Boulder was found at L1, L2, L7 and L8 with resistivity values of 3000-8000 ohm-m. The borehole information starts at depth of 3 m from inversion model resistivity. The results of the borehole information and inversion model resistivity assumed that the second layer is topsoil which contain of sandy silt. It was observed that the maximum depth of sandy clay (100-800 ohm-m) is reached at 15-20 m with N-values of 14-22. The third layer can be said to be sand formation with gravel. It is characterized by relatively high resistivity value and at maximum depth of 21 m with N values of 22-50. Figure 7 shows the sedimentary topography of the study area base from the inversion model resistivity profiles.

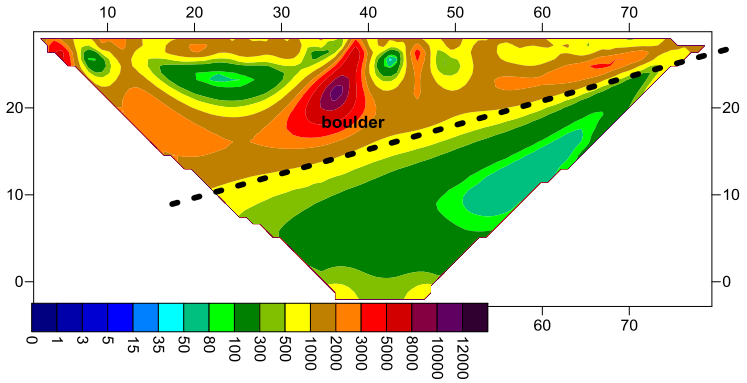

Figure 3. Inversion model resistivity of L1 at Nusajaya, Johor.

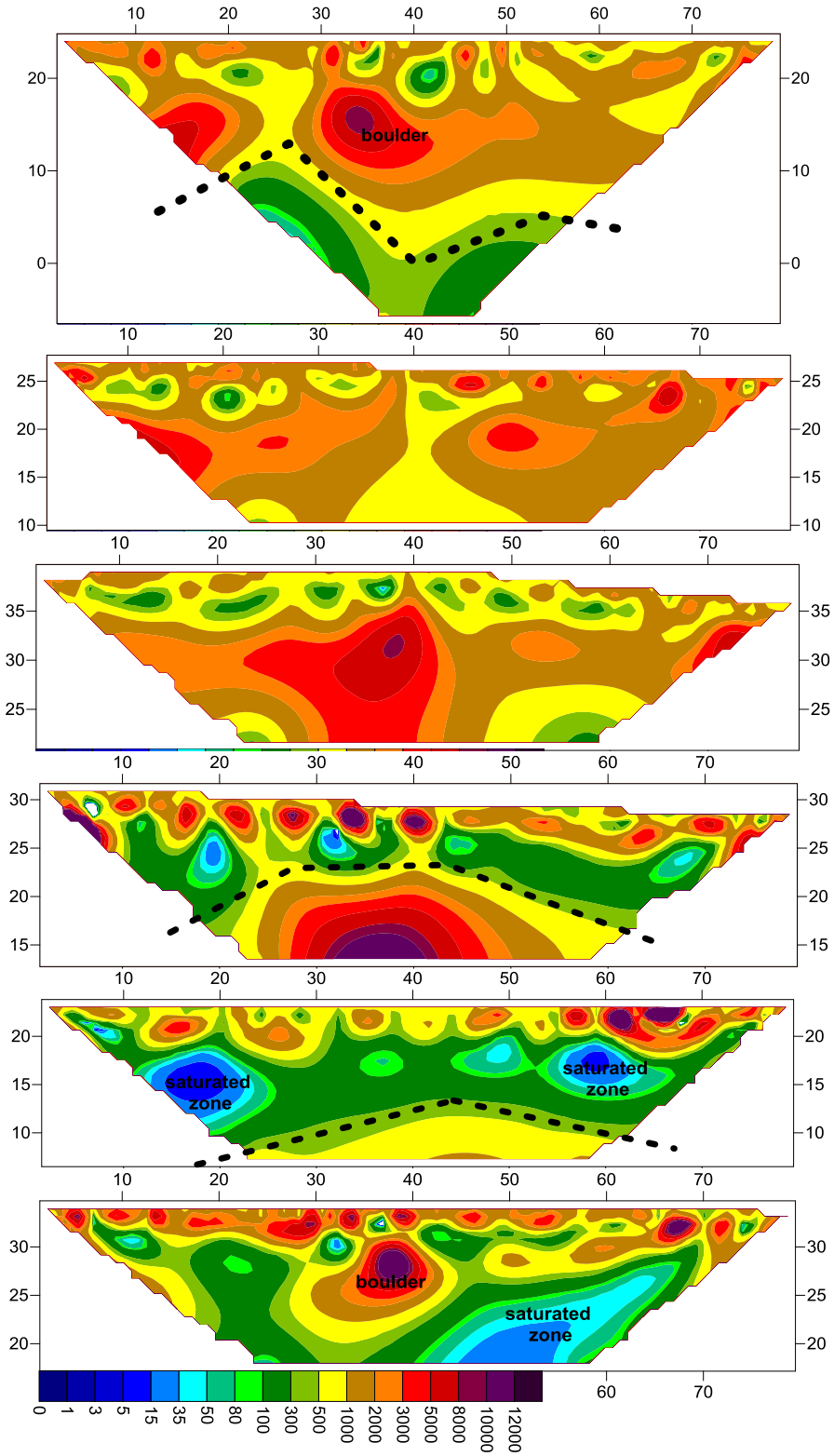

Figure 4. Inversion model resistivity of L2-L7 at Nusajaya, Johor.

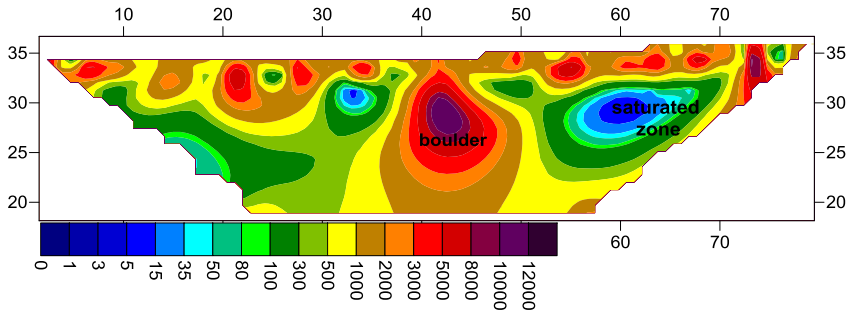

Figure 5. Inversion model resistivity of L8 at Nusajaya, Johor.

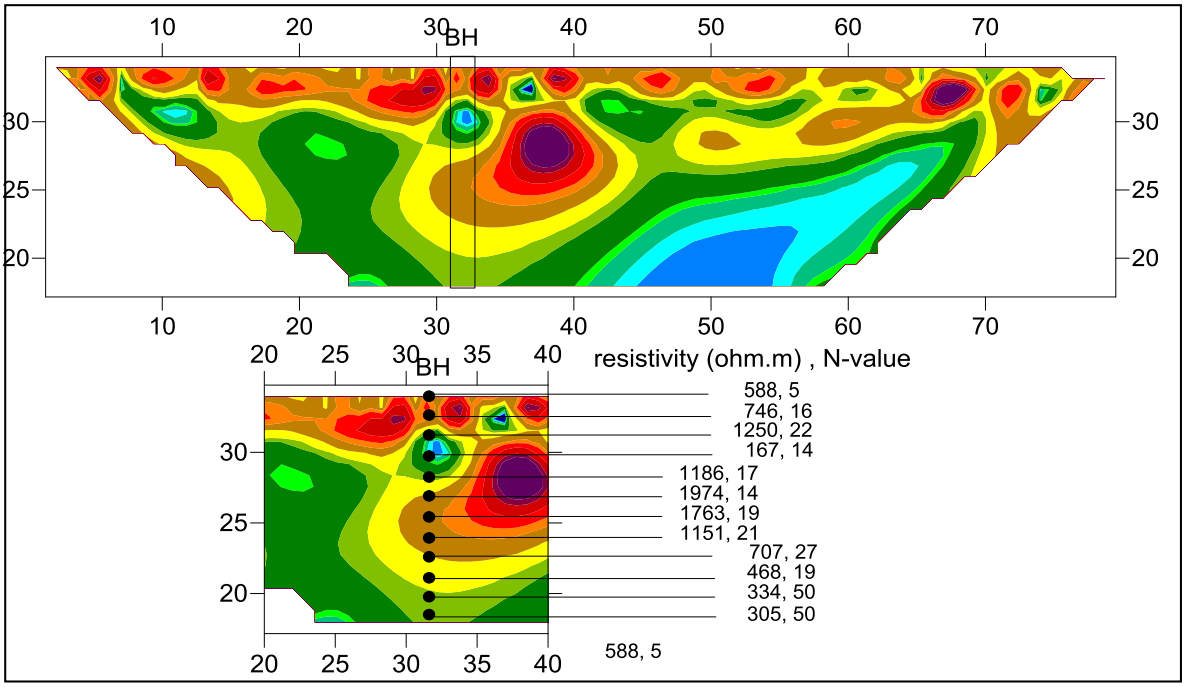

Figure 6. Inversion model resistivity of L7 with borehole at Nusajaya, Johor.

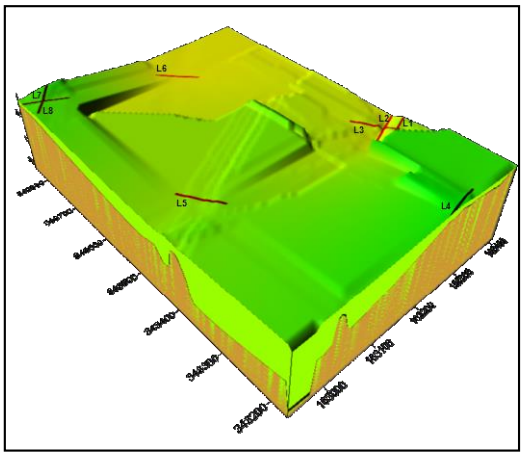

Figure 7. Sedimentary topography and survey lines of SiLC, Nusajaya, Johor.

6. Conclusion

A key to success in the development of a site is the understanding of the subsurface formation during the planning stages. Measurement of 2-D resistivity method is one of the most widely used geophysical survey methods in this respect. 2-D resistivity method can afford in determining inherent engineering and environmental effects of the subsurface variations. The inversion model resistivity from L1-L8 obtained is characterized by resistivity range of 1-8000 ohm-m. This range indicates the occurrence of silt, clay, sandy clay and sand whose ranges are; 10-100 ohm-m, 1-100 ohm-m, 100-800 ohm-m and 100-3000 ohm-m respectively. The investigation of the study area by using 2-D resistivity method was correlated with borehole log records and these show a sequence of topsoil, clay, sandy clay and sand. Therefore, the third layer to be the most competent for founding small to medium engineering structures due to the presence of sand thickness that varies from 10-25 m and resistivity values that range between 100-3000 ohm-m. The results of 2-D resistivity method could be used to detect subsurface problem and subsurface characterization supported by borehole records for engineering and environmental purpose.

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Acknowledgements

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