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Integration of Electrical Imaging Methods in Detecting Engineering Problems

A.H.A. Teh Saufia [+], Rosli Saad and M.M. Nordiana

[1] Geophysics Section, School of Physics, Universiti Sains Malaysia, 11800 USM, Penang

Abstract. Geophysical prospecting is commonly used in solving engineering problems because of time saving, low cost and nondestructive. However, among the other geophysical methods, the correlation between 2-D electrical imaging method and self potential method is rarely seen. The main objective of this study is to investigate the presence of saturated zone which causes several engineering problems in the area and leads to some damages such as soil settlements, piping effect and erosion. Four resistivity survey lines and two sites for self potential method were carefully chosen to cover the entire study area. The resistivity results show the subsurface consist of saturated zones with depth of 5 to 20 m, and SP results shows water flowing towards different directions. In conclusion, correlation of two electrical imaging methods (active and passive) can be used in solving engineering problems as well.

Keywords: Engineering problems, geophysical prospecting, self potential, 2-D electrical resistivity

1. Introduction

Power Plant Sdn. Bhd. (PPSB) Prai, was commissioned since June 2003 and had been operated for more than 3 years. During the years, several locations of the plant are found to have soil settlement leading to defects such as sinkholes, inclined piping and cracks. Geophysical surveys help in detecting the problems occurred in the area without drilling or digging, as is common, industrial compounds are filled with underground cables or pipes. According to K Subramanya, saturated zone also known as groundwater zone is a space between all pores which is filled with water [1]. In this case, existence of saturated zone underneath, leads to the water escapes slowly from the pores or voids which can loosen the soil, hence unstable foundations occurred. These problems happen in a matter of time as consolidation can be said as a process which requires change in volume of soil mass proportional to time.

2. Study Area

PPSB, owned by Malakoff Corporation Berhad is situated in Prai, Penang which is a narrow hinterland opposite Penang Island. This site occupies 4.3 acres and consists of a 350MW combined cycle gas turbine plant. It has over twenty separate buildings that house various processes for power generations. This area is situated at the flat, low-lying area near the coast. Based on Quaternary Geological Map of Peninsular Malaysia, the area with bearing N5˚ 22’ 33.6” E100˚ 22’ 23.4” is a locality of Gula Formation. The lithology is made up of clay, silt, and locally very clayey or silty sand. The fossil content and lithology of the Gula Formation presented shows that the sediment has been deposited in the littoral zone and estuarine to shallow marine environment during Holocene [2]. However, during this study, no further lithology study (boreholes) was carried out at this area.

[+] Corresponding author. Tel.: + (6013) 597 0895; fax: + (604) 657 9150
E-mail address: teh.saufia@gmail.com.

3. Methodology

The main purpose of this study is to investigate the geological problems which results in a catastrophe if rapid action is not taken. Therefore, early detection of problems is very important to avoid continuous problems in this area. Suitable geophysical method and a good survey line need to be chosen properly. In this study, 2-D electrical imaging and self potential methods were chosen. Fig. 1 shows the resistivity lines (RES1-RES4) and self potential grids (A1, A8, G1, G8 and X1, X23, Y1, Y23) conducted in the study area.

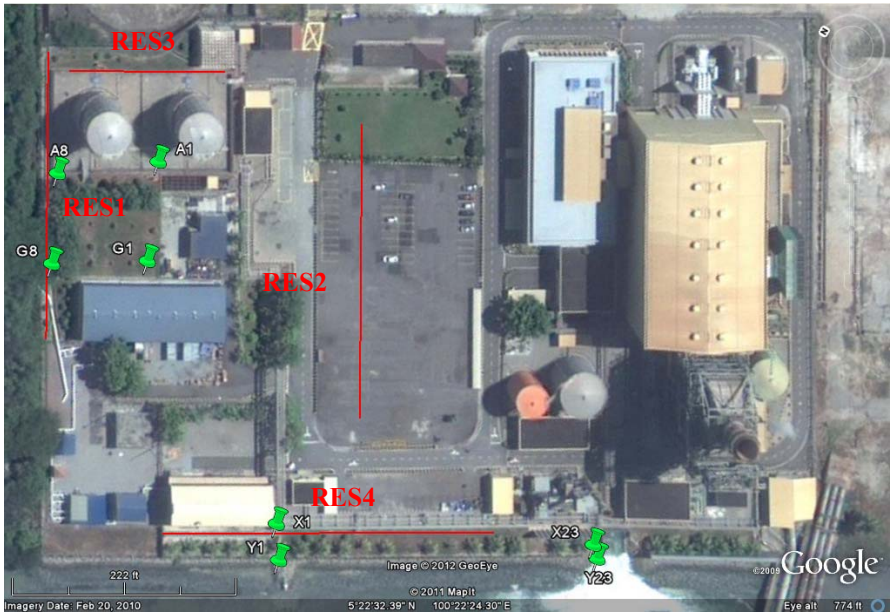

Fig. 1: The survey lines performed at PPSB, Prai

3.1 2D Resistivity imaging

Electrical prospecting uses a large variety of techniques based on some different electrical property or characteristic of Earth materials. Resistivity method is designed to yield information on formations or bodies having anomalous electric conductivity [3]. Fig. 2 shows a normal setup for 2-D survey with a number of electrodes along a straight line attached to multi core cable [4]. The purpose of resistivity surveys is to map the subsurface resistivity distribution by taking apparent resistivity measurements on the ground surface. Apparent resistivity measurements are made by injecting current into the ground through two current electrodes and measuring the resulting voltage difference between two potential electrodes. There are 4 survey lines conducted with different lengths because of site limitation. The survey used Pole-dipole array as it is relevant to the objective of this study which requires good horizontal and vertical resolution.

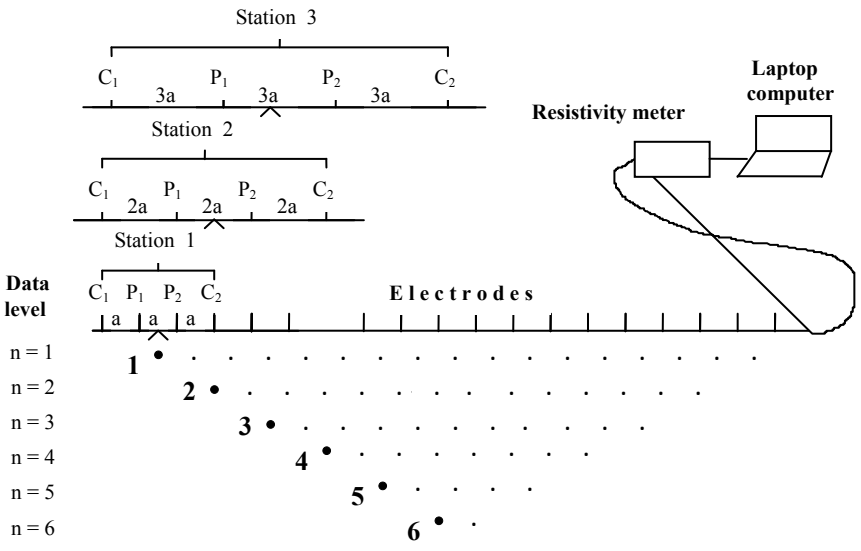

Fig. 2: The resistivity sequence measurement to build up a pseudoesection (Loke, 2004)

3.2 Self potential

Self potential method is a passive geophysical method which relies upon natural direct currents flowing in the ground. SP method usually use for detecting and monitoring groundwater flow [5][6]. Using any several types of high impedance dc voltmeters, one porous pot is place at infinity to establish a zero potential level. The potential (relative to the remote porous pot) over the entire area of interest is then established using a long wire, a second porous pot and the voltmeter.

There are 2 sites of SP survey area which the first site (site 1) used as profiles along lines while in second site (site2) used as contours of plan data from several lines. Every porous pot was placed at 4m spacing between each other.

4. Results & Discussions

Resistivity result shows that the area has two major resistivity zones (Fig. 3a). The first zone with resistivity value of <30Ωm is a saturated zone. It was identified beyond mean sea level and interpreted as stream or underground stream with intrusion of sea water. The second zone with resistivity value >100 Ωm was identified as a dry and compact zone, depth 4-8m and >20m. SP result shows flow of water towards several points which is believed to be the accumulation area for saturated zone (Fig. 3b). Site 1 shows water flows inwards the site area while for Site 2, the accumulation zone is at the centre. The potential range between -55 to 20 volt shows that the area is highly discharging and charging.

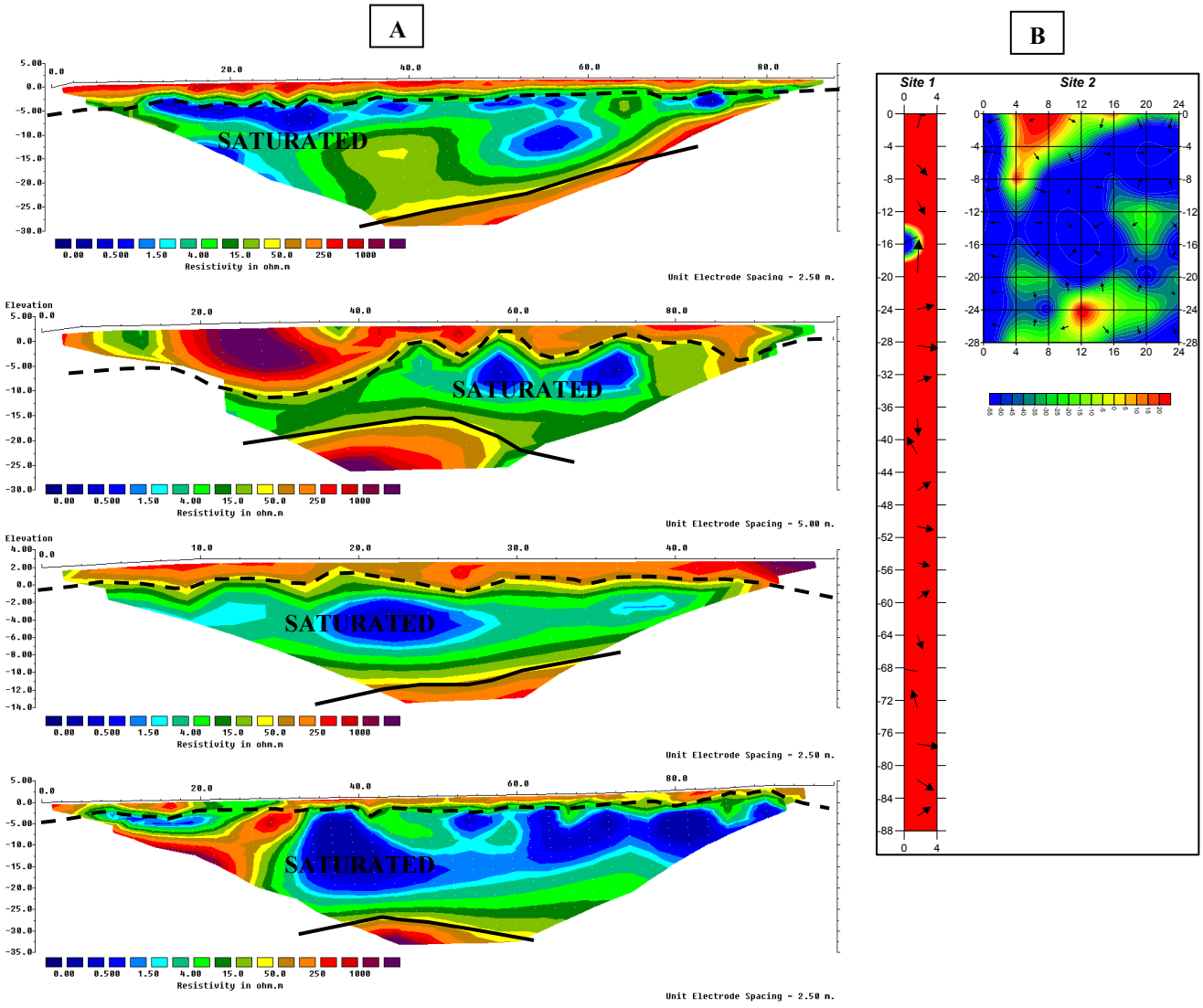

Fig. 3: a) 2-D resistivity inversion pseudosection results b) SP contour result

5. Conclusion

The objective of the survey to determine the saturated zones caused by underground streams with sea water intrusion that cause sinking was successful. In summary, water tends to move to the weaker space to reach the pressure equilibrium especially the area with high porosity which the water could fill up. Plus, the presence of saturated zone acts as a promoter which encourages the water flow underground; actively weakening the soil stability.

6. Acknowledgement

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