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GROUND INVESTIGATION USING 2D RESISTIVITY IMAGING FOR ROAD CONSTRUCTION

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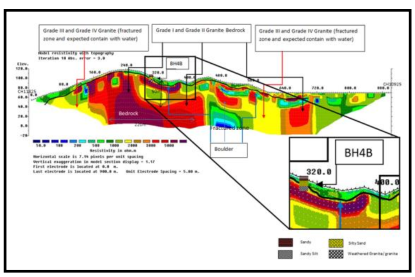
Graphical abstract



Abstract

This paper présents finding on the ground exploration using 2D resistivity imaging. The study was conducted to verify the borehole result, which shows a conflict between the actual site conditions. The proposed study is to investigate of high topography area for road construction. Electrical resistivity imaging method was used for estimating bedrock at Bandar Sri Sendayan, Negeri Sembilan. The site consist of acid intrusive igneous, which is dominantly covered by granite. Two lines of resistivity survey were conducted to identify ground material of this area. The survey was conducted using ABEM Terrameter equipment, where a two-dimensional resistivity profile has been identified for ground exploration and subsurface profiling. The resistivity images showed the existence of boulders and bedrock in multiple weathering grades with resistivity values ranges from 50 to 10 000 ohm-m along the proposed road alignment. The presence of these boulders and weathered bedrock probably not suitable to be used as domestic supply for road material such as crushed aggregate especially at depth less than 30m from surface. Soil or overburden was discovered 12m from the surface. The finding shows the mismatched between the borehole result and resistivity profile, where the borehole data was interpreted as bedrock however the resistivity result proved that it is a boulder.

Keywords: Electrical resistivity; boulders; granite; road construction

1.0 INTRODUCTION

Site investigation for a new road construction is aimed gathering information on the proposed location of the road. The most important reason for this site investigation is to ascertain the ground conditions. As the principle objective of the site investigation is to obtain all design parameters necessary for works, the information gathered must be truly shows the condition of the subsurface material. Besides that, the availability of material that could be used also become as one of the objective to be achieved.

In order to investigate the subsurface material of the area, ground investigation is normally carried out using boreholes drilling method. In some hilly area of granitic rock, the availability of the construction material such as for aggregates production requires a thorough and wise site investigation. Therefore ground investigation should be carried out very carefully to provide accurate information of the subsurface. This study is about ground investigation of a proposed site for new road construction using a geophysical method of 2D resistivity imaging technic and conventional method by boreholes drilling. The main objective of this study is to validate the ground condition and sub-surface profiles resulted from borehole logs.

The uncertainty regarding depths to bedrocks and occurrence of boulders in the shallow depth sub-surface can make the planning of a major road construction more difficult [1]. In ground exploration program where a structure is to be founded on rock it must be verified that bedrock and not boulders have been countered, and it is advisable to extent one or more borings of 3m into sound rock in order to determine the extent and character of the weathered zone of the bedrock [2]. In Malaysia, for road construction the deep boring should be carried out at a spacing of 60m to 600m. However to get a better ground information, geophysical survey method is suggested to supplement the borehole results.

Normally seismic refraction is used to determine the approximate bedrock profiles and geologic features with reasonable accuracy should be quite uniform and no boulders in the overburden soils [3]. In new development of geophysics technology, electrical resistivity imaging has become more popular in investigating the sub-surface. Many researches were conducted in determining the depth to bedrock ([4], [5], [6]), however very little involved in differentiating between boulders and bedrocks features in the ground. Furthermore, most of the previous studies emphasized on hydrological issues related to river bed and groundwater. This study is to differentiate between the layer of bedrock and boulder in road construction project where electrical resistivity imaging survey was carried out to verify the borehole results.

2.0 METHODOLOGY

Field measurement of resistivity traverse was conducted in April 2015. The resistivity survey was conducted using electrical resistivity survey equipment of ABEM Terrameter SAS 4000, combined with ES 10-64 electrode selector. Schlumberger array was chosen in this survey work as it gives a dense near-surface cover of resistivity data. Also, the array provides a good vertical resolution and can give a clear image of bedrock boundaries as horizontal and vertical structures [7]. ABEM Terrameter SAS 4000 and a switcher unit were used to control the induction of current and potential readings from electrodes connected by multicore-cable along the survey line. A resistivity survey line with length 900 meters was setup by using Schlumberger protocol, where spacing between each electrode was 5.0 meter. Five times roll-up (added 100m length per roll-up) setting has been carried out for the Line 1 to make a 900m total length of the survey.

Resistivity data were interpreted and analysed by using software namely RES2DINV. Blocky constraint was used in data interpretation as it is the most suitable inversion method when subsurface internal resistivity values are separated by sharp boundaries [8]. The resistivity of these rocks was greatly dependent on the degree of fracturing, and the percentage of the fractures filled with groundwater. Sedimentary rocks, which usually are more porous and have higher water content, normally have lower resistivity values. Wet soils and fresh groundwater have even lower resistivity values. Clayey soil normally has lower resistivity value than sandy soil. However, in the overlap in the resistivity values of the different classes of rocks and soils is occurred. This is because the resistivity of a particular rock and soil sample depends on a number of factors such as the porosity, the degree of water saturation and the concentration of dissolved salts.

3.0 LOCATION AND GEOLOGICAL SETTING

The study area is located at the proposed site of new road connecting Bandar Sri Sendayan, Seremban and Bandar Einstek, Sepang, Selangor. The resistivity survey (Figure 1) was conducted at Bandar Sri Sendayan in Negeri Sembilan state. From observation, the topography of the area is mountainous with undulating surface.

According to the geological map Department of Mineral and Geosciences Malaysia (DMGM, 1985), the study area is mainly founded by intrusive igneous rock. Topography of this area is undulating with hill and gully covered by vegetation. By observation this area consists of boulders in various sizes covered by residual soil. In general, the present of boulders and soil formation exhibit the occurrence of weathering process that breakdown the rocks to be classified the granitic body into various weathering grades.

The alignments of the resistivity lines were set according to the surveyor pack proposed by client where the Line 1 started from CH 11825 (0 m) to CH 10925 (900 m). The alignments of resistivity line were shown in Figure 2.

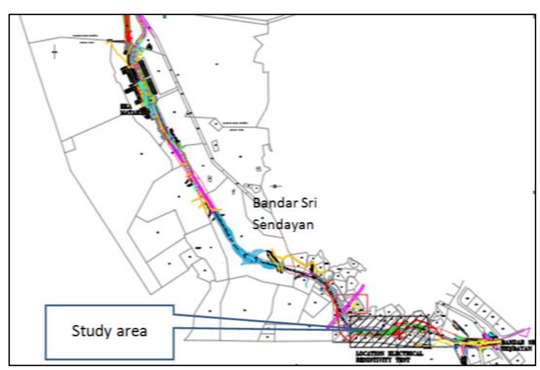


Figure 1 Location of study area at Bandar Sri Sendayan, Negeri Sembilan

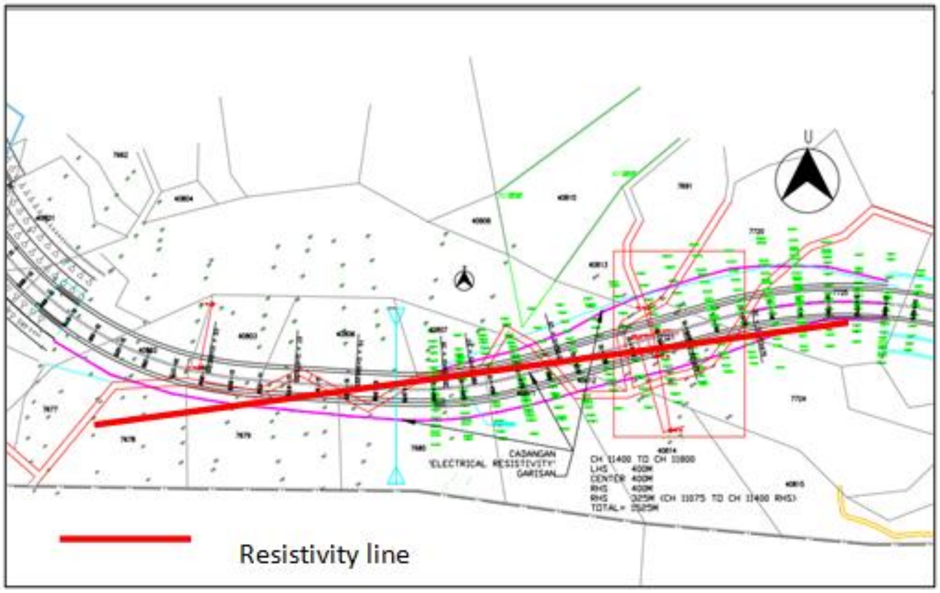


Figure 2 Alignment of resistivity line along study area at Bandar Sri Sendayan

4.0 RESULTS AND DISCUSSION

Results of the resistivity survey along the proposed road alignment are presented in images as shown in Figure 6. Two-dimensional (2-D) electrical imaging resistivity profiles were obtained from the resistivity survey conducted in this area. The resistivity distribution profile showed the length of the survey line and depth of penetration about 400 m with the depth encountered to 60m. The fresh granite has a resistivity value higher and could be reaching up to 10x 106Ωm. Nevertheless, in Malaysia which has an equatorial weather condition, the process of changing the physical properties of the granite to be more electrical conductive actively occur especially when it goes to a higher weathered grade granite. In this study area, some of the weathered granite exposed on the surface and give an advantage to know further information regarding the weathering grade of granite.

The resistivity image of Line 1 shows a subsurface profile of 900m long of resistivity survey line of the proposed road alignment. The resistivity value exhibits a huge range between 50 Ωm - 10000 Ωm. The resistivity value of more than 5000 Ωm which is represented by dark red colour in the resistivity profile is interpreted as fresh to slightly weathered (Grade I and Grade II) of the granite body that is found dominantly between the distances of 120m – 400m of the line. The fresh granite is estimated in 220 m long but varies in depth. It is also found that the granite body was detected near to surface, which estimated about 10m below ground surface. This finding matched to the borehole profile (BH4B) at distance of 300m where the granite bedrock was determined at 11 m depth from ground level. However, this granite body is suspected as BOULDER due to the no continuity of the resistivity image as the lower part of the boulder shows low resistivity value (<500 Ωm), which is interpreted as residual soil.

The resistivity value of 1000 Ωm to 5000 Ωm represented by dark green and yellow colour are interpreted as Grade III and Grade IV granite that is found dominantly between the distance of 400m – 720m of the line and partly has associated with the wet fractured granite. The very low resistivity value almost at the bottom middle of the profile is occurred probably d due to the presence of the fractured zone with the groundwater.

The resistivity value of less than 1000 Ωm, which is represented by greenish colour, is interpreted as Grade V and Grade VI granite where it makes a layer of residual soil at the upper part of the resistivity profile. This type of material is dominant and a bit thick at the distance of 0m to 100m from 720 m to 900 m of the profile. Granite boulders probably presence in this layer due to increasing of the resistivity value obtained.

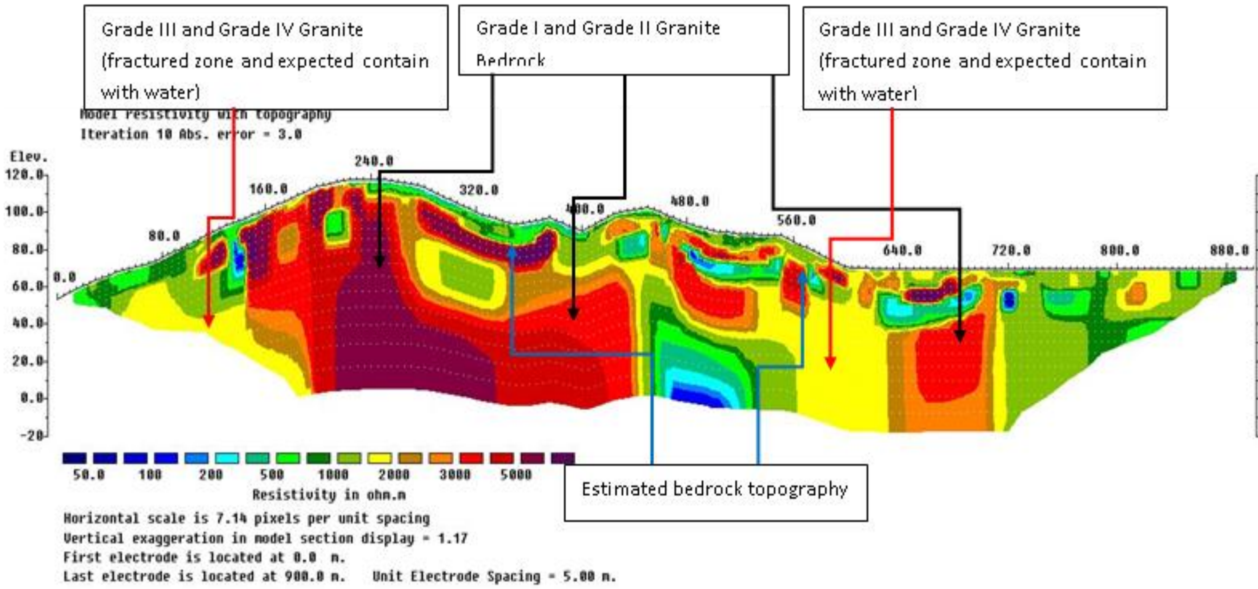


Figure 3 Resistivity image of study area and comparison between depth of BH4 to bedrock and resistivity image

5.0 CONCLUSION

In summary the resistivity profiles obtained from the survey have a range of resistivity value between 50 – 10,000Ωm. In this study there are three (3) types of significant resistivity value was found and was divided into three ranges as shown in Table 1.

It can be concluded that the ground material of this area shows a various weathering grade of granitic body, however the fresh rock of Grade 1 and Grade II is estimated can be found at 10m to 50m from ground level around the high topography area. The findings of resistivity image on the depth of granite Grade 1 and Grade II have a good correlation with the depth of fresh granite found in bore log. However, some of the fresh granites are boulders form which is often wrongly interpreted as bedrock in borehole profile.

Table 1 Summary of resistivity value of weathered material for the study area

Resistivity Value (Ωm)	**Material**	**Grade**	**Mark**
< 1000	Residual soil, highly weathered granite or fractured rock contained with water	(Grade V –VI)	blue – green colour
1000 - 5000	Medium weathered granite	(Grade III – Grade IV)	yellow – orange colour
> 5000	Low weathered to fresh granite	Grade I – Grade II	red – purple colour

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