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Original Paper

The Seismic Refraction Survey to Determine the Depth of Bedrock at the Damansara Area for Horizontal Directional Drilling Method Application

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Abstract

The seismic reflection survey conducted along the road at Damansara to determine the depth of bedrock in order to justify whether HDD method can be utilize to store the fiber optic cable. 10 line seismic survey performed along 1.2 km roadside. The result show that the subsurface profile represent by two layer of earth materials that is topsoil and bedrock granite. Determination between topsoil and granite based on the values of seismic velocity. The boundary between granite and soil interpreted by a velocity value 1,200 m/s. If the velocity values is less than 1,200 m/s, it interpreted as soil or highly weathered rock. Meanwhile the velocity value more than 1,200 m/s is refer as rock and hard to excavate especially using HDD method. The study shows that the general thickness of topsoil along the road in Damansara is around 2.0 to 4.0 m. The minimum thickness of topsoil is 1.0 m and maximum found around 6.0 m. The bedrock observed very shallow and not suitable for HDD method to implement.

Keywords

Seismic Refraction Survey, Damansara, Bedrock determination

1. Introduction

1.1 Background

This paper presents the result of the seismic refraction survey method along the road from SMK Bandar Sri Damansara 2 to SMK Bandar Sri Damansara 1 at Bandar Sri Damansara, Selangor, Malaysia. The study carried out with the ultimate objective to determine the depth of bedrock along the road from SMK Bandar Sri Damansara 2 until SMK Bandar Sri Damansara 1. It anticipated that this project would provide the information about the depth profile of bedrock in detail that is required to decide the suitable method for piping the fiber optic cable within the area.

Although the Horizontal Directional Drilling (HDD) is the best method of installing underground pipelines, cables and service conduit through trenchless methods but the limitation is this method cannot penetrate through the hard rock or bedrock such as granite. The area with shallow bedrock less than 7.0 m considered not suitable using HDD method. The seismic survey will show the profile and depth of bedrock along the pipeline proposed in the study area.

1.2 The Study Area

The study area is located at Bandar Sri Damansara Selangor. It located at the north of Kota Damansara nearby Kepong (Figure 1). The line survey follow the alignment of pipeline fiberoptic from SMK Bandar Sri Damansara 2 to SMK Bandar Sri Damansara. The line survey conducted along the road, which is about 1.2 km length. The length for each line seismic survey is 125 m. Therefore, to cover 1.2 km length of pipeline, we construct about 10 line of seismic surveys.

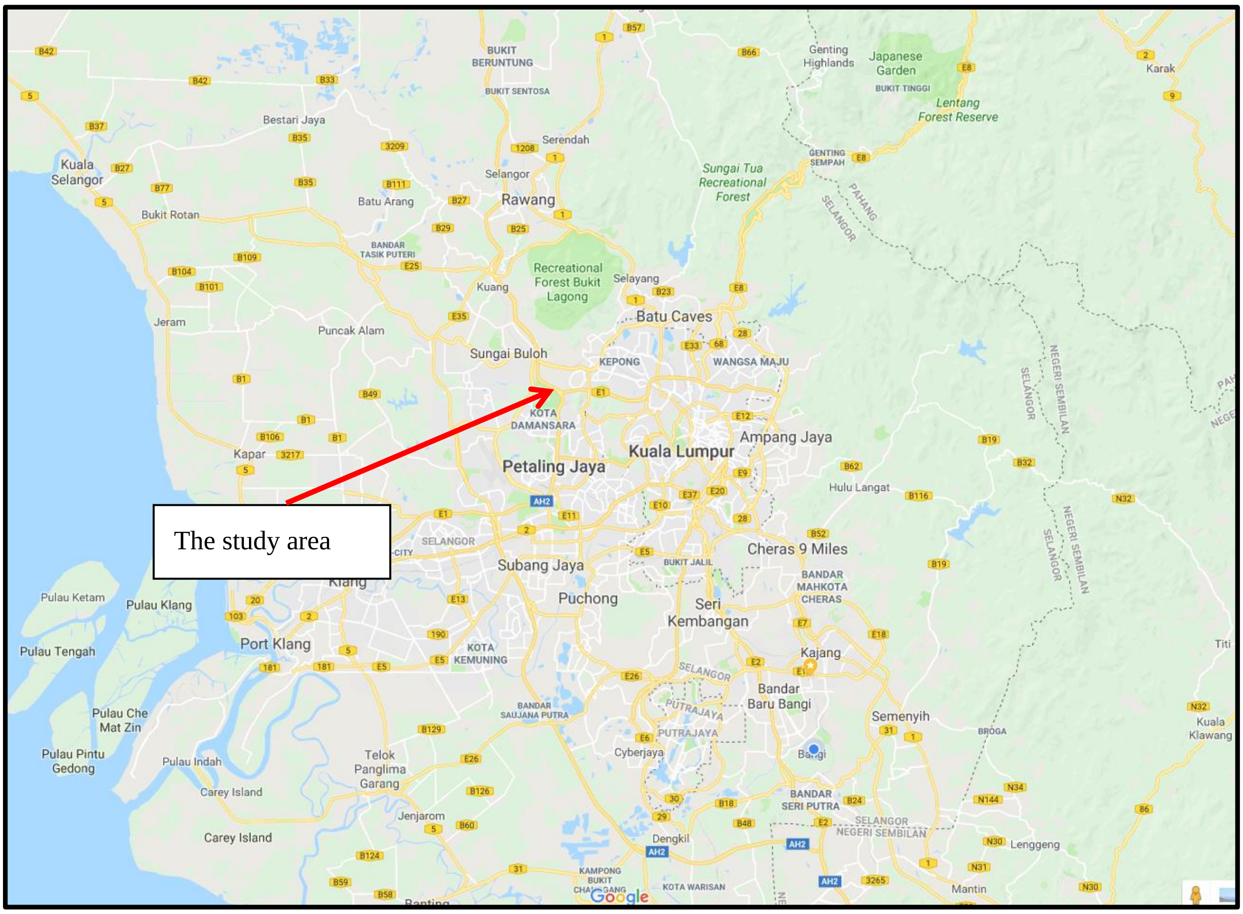

Figure 1. The Location of the Study Area at Bandar Sri Damansara. It Located at the North of Kota Damansara Nearby Kepong

1.3 The General Geology

Based on literature review, the study area considered as part of Main Range Granite Batholith (Figure 2). It assigned as Bukit Lanjan Granite and beside it the Kuala Lumpur Granite. The age of Main Range Granite is between 207-230 Ma. The main rock type is a coarse to very coarse grained megacrystic biotite granite that has typical S-type and ilmenite-series characteristics. Large K-feldspar phenocrysts up to 7 cm long are common and often give the rock a distinctly megacrystic appearance in hand specimen. Quartz vein, aplo-pegmatite complexes and sclieren are among common modification in the granite.

Based on our site visit, we discover the boulder during our fieldwork is consists of granite rock. It was white colour contain quartz as a major mineral with size more than 2 cm. The boulders found fresh and very hard (Figure 3).

Figure 2. The Geological Map of the Area around Kinta Valley Including the Study Area

Figure 3. The Boulder of Granite Observed Near Line S8

2. Methodology

2.1 Introduction

Seismic methods commonly used in shallow depth investigations. It was implement to discovering the potential groundwater area and subsurface profile in many area nowadays (Haeni, 1986; Umar & Abdul, 2006; Mohd et al., 2016). The method is based on recording the travel time of an elastic wave created by hitting a steel plate with a hammer (in this study) or gun, refracted from an interface at the subsurface, and received via geophones on the surface.

The seismic refraction method based on the measurement of the travel time of seismic waves refracted at the interfaces between subsurface layers of different velocity. Seismic energy provided by a source ("shot") located on the surface. For shallow applications, this normally comprises a hammer and plate, weight drop or small explosive charge (blank shotgun cartridge). Energy radiates out from the shot point, either travelling directly through the upper layer (direct arrivals), or travelling down to and then laterally along higher velocity layers (refracted arrivals) before returning to the surface. This energy is detected on surface using a linear array (or spread) of geophones spaced at regular intervals. Beyond a certain distance from the shot point, known as the crossover distance, the refracted signal observed as a first-arrival signal at the geophones (arriving before the direct arrival). Observation of the travel-times of the direct and refracted signals provides information on the depth profile of the refractor.

2.2 Line Distribution and Data Acquisition

In our study, we conduct 10 lines of seismic survey along the road from SMK Bandar Sri Damansara 2 to SMK Bandar Sri Damansara 1. The view of survey line S1 near SMK Bandar Sri Damansara 2 was show in Figure 4(a). The view of survey conducted for other lines shown in Figure 4(b). The example of seismic wave recorded on machine shown in Figure 4(c). ABEM Terraloc MK6 24-channel seismic recording equipment used in this survey. Geophone interval was set 5 m. During the survey, the P wave travel times considered. First arrivals to each geophone are marked and extracted from the data

2.3 The Processing Data

The seismic survey was conducted by create 7 individual shots at certain distance along the survey line. Seven shot locations were done at -5.0 m (offset), 3.0 m, 28.0 m, 58.0 m, 88.0 m, 113.0 m and 120.0 m. Each shot locations will produce graph of wiggle traces that is displaying travel time of wave against distance. It means for one seismic survey line, we have seven seismic time-distance graphs. In our study, we have 10 lines of seismic survey, which is give the total number of graph need to process is 70 graphs.

We used the software picked the first time-arrival from seven seismic time-distance graphs and tabulated it into excel. By combining seven time-distance graphs and first-arrival reading collected from each graphs, we established the whole view of segmentation of survey line to calculate the velocity for each layer and their thickness. The values of velocities and thickness of every electrode point inserted into software. It purposed is to generate the pattern of graph and layers of the soil profile**.**

3. The Result

3.1 The Line Distribution

The location of line survey is proposed by client followed exactly the alignment of their pipeline for fiber optic. The alignment is along the roadside. In our survey, we marked the line survey as S1 until S10 refers to Seismic survey. The survey line is continuous from line S1 until S10 as show in Figure 5.

3.2 The Interpretation of Velocity and Rip Ability Scale

The seismic velocity of a rock formation related to characteristics of the rock mass that include rock hardness and strength, degree of weathering and discontinuities. Usually the velocity is just one of several parameters used in the assessment of excavate ability (Bailey, 1975). Weaver (1975) presented a comprehensive rippability rating chart (Table 1) in which the p-wave velocity value and the relevant geological factors could be entered and assigned appropriate weightings. The total weighted index found to correlate very well with actual rippability.

In this study, we use directly the seismic velocity values to interpret their rippability of the rock because in many cases we conducted the seismic study, the result show the similarity and correlated directly in practice with rating chart proposed by Weaver (1975). Based on the rip ability-rating chart by Weaver (1975), we can divide the rock into rippable and non-rippable as shown in Table 2.

The boundary between rock and soil interpreted by a velocity value 1,200 m/s. If the velocity values is less than 1,200 m/s, it interpreted as soil or highly weathered rock. Meanwhile the velocity value more than 1,200 m/s is refer as rock and hard to excavate especially using HDD method

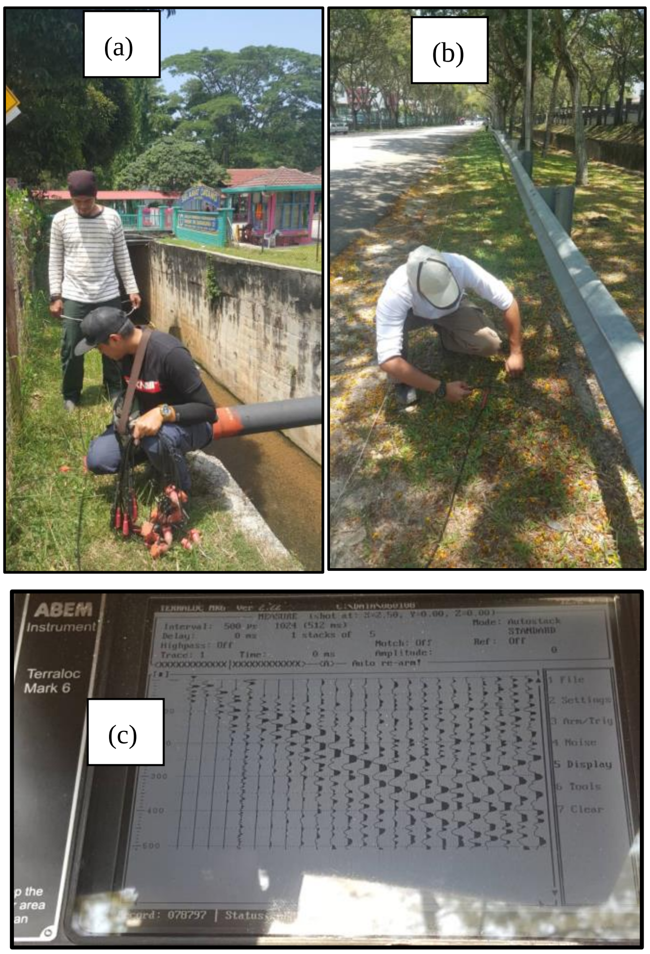

Figure 4. The Data Acquisition on Site (a) & (b) The View During Data Acquisition, (c) The Example of Seismic Wave Recorded on Machine

Figure 5. The Line Distribution along the Road in the Study Area

Table 1. The Rippability Rating Chart by Weaver (1975)

Rock class	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock
Seismic velocity (m/s)	>2150	2150-1850	1850-1500	1500-1200	1200-450
Rating	26	24	20	12	5
Rock hardness	Extremely hard rock	Very hard rock	Hard rock	Soft rock	Very soft rock
Rating	10	5	2	1	0
Rock weathering	Unweathered	Slightly weathered	Weathered	Highly weathered	Completely weathered
Rating	9	7	5	3	1
Joint spacing (mm)	>3000	3000-1000	1000-300	300-50	<50
Rating	30	25	20	10	5
Joint continuity	Non continuous	Slightly continuous	Continuous- no gougo	Continuous- some gougo	Continuous- with gougo
Rating	5	5	3	0	0
Joint gougo	No separation	Slightly separation	Separation< 1mm	Gouge <5mmm	Gouge >5mmm
Rating	5	5	4	3	1
Strike and dip orientation	Very unfavourable	Unfavourable	Slightly unfavourable	Favourable	Very favourable
Rating	15	13	10	5	3
Total rating	100-90	90-70*	70-50	50-25	<25
Rippability assessment	Blasting	Extremely hard ripping and blasting	Very hard ripping	Hard ripping	Easy ripping
Tractor horsepower		770/385	385/270	270/180	180
Tractor kilowatts		575/290	290/200	200/135	135

Table 2. The Interpretation of Rock Type Using Velocities Values

Class	Description	Seismic Velocity	Type of rock	Rippability
I	Very good Rock	> 2,150	Fresh bedrock	Non-rippable
II	Good Rock	2,150 - 1,850	Fresh Rock	Non-rippable
III	Fair Rock	1,850 - 1,500	Moderate fresh rock	Very hard Rippable
IV	Poor Rock	1,500 - 1,200	Weathered rock	Hard Rippable
V	Very poor Rock	< 1,200	Soil or highly weatehered rock	Rippable

3.3 The Result of Seismic Refraction Survey

Based on the seismic refraction survey, we interpreted the subsurface profile along the road consists two layers which is topsoil as the top layer and the second layer is granite bedrock. The topsoil velocity is range between 340.48 m/s until 507.96 m/s, while granite bedrock is range between 1,752.24 m/s until 3,446.45 m/s. The thickness of topsoil is in average about 3.0 m thick. The result show that HDD method cannot be perform along this line survey because the minimum thickness of soil needed is 5 to 6 m. The HDD method cannot penetrate through fresh rock. The summarize of the result was shown in Table 3.The subsurface profile for line seismic surveys conducted in the study area were shown in Figure 6. The top layer defined as the topsoil and the second layer is correspond to bedrock.

Table 3. The Summarizes of Result of Seismic Refraction Survey

Line Survey	Rock Layers	Seismic Velocity (m/s)	Thickness range (m)	HDD Method Application
S1	Topsoil	415.39	1.5 - 2.0	Not Suitable
	Bedrock	2,180.03		
S2	Topsoil	340.48	2.0 - 4.0	Not Suitable
	Bedrock	1,938.03		
S3	Topsoil	399.42	2.0 - 3.0	Not Suitable
	Bedrock	2,898.03		
S4	Topsoil	380.91	4.0 - 6.0	Not Suitable
	Bedrock	1,752.24		
S5	Topsoil	339.97	1.0 - 3.0	Not Suitable
	Bedrock	3,121.08		
S6	Topsoil	434.87	3.0 - 4.0	Not Suitable
	Bedrock	3,446.45		
S7	Topsoil	426.08	2.0 - 3.0	Not Suitable
	Bedrock	2,707.22		
S8	Topsoil	507.96	6.0 - 7.0	Not Suitable
	Bedrock	2,062.70		
S9	Topsoil	367.80	2.0 - 3.0	Not Suitable
	Bedrock	1,952.13		
S10	Topsoil	392.18	2.0 - 4.0	Not Suitable
	Bedrock	2,170.43		

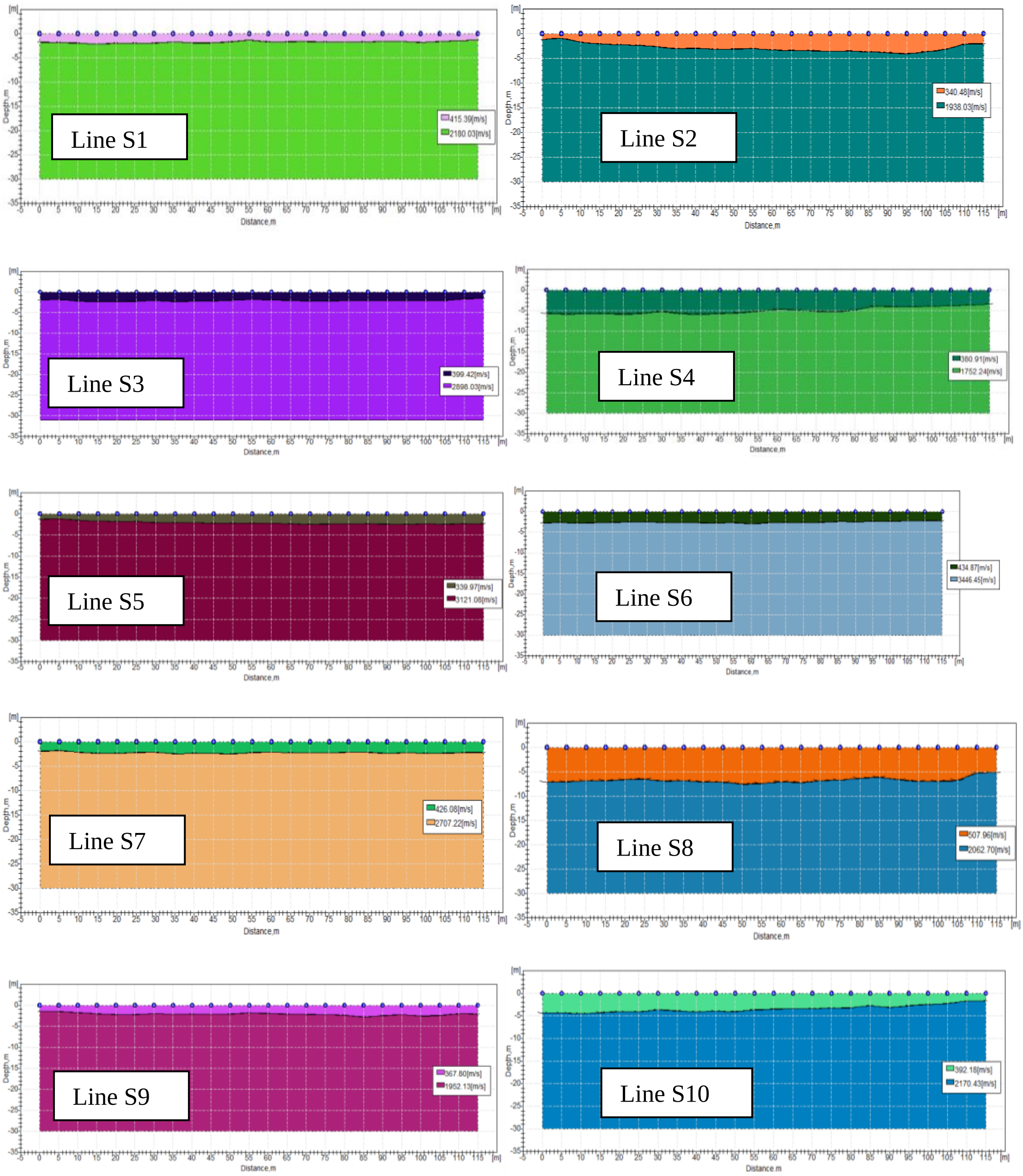

Figure 6. The Result of Subsurface Profile for Seismic Refraction Survey Conducted in the Study

4. Conclusion

The study shows that the general thickness of topsoil along the road from SMK Bandar Sri Damansara 2 to SMK Bandar Sri Damansara is around 2.0 to 4.0 m. The minimum thickness of topsoil is 1.0 m and maximum found around 6.0 m. The depth of bedrock observed is very shallow. The type of bedrock consists of granitic rock, which is in common very hard, compact and difficult to excavate, and at certain point need to blast to remove it.

In our case, the HDD method was propose to be implement for preparing the pipeline of fiber optic along this proposed road. The HDD method only suitable in the area with soil thickness more than 6.0

m. It cannot penetrate through the hard bedrock such as granite. The problem arises when during drilling using method HDD, they found the bedrock and work unsuccessful to go much further.

Based on the seismic survey finding, we concluded that the HDD method cannot be perform along the proposed line. This is because the bedrock is very shallow. The HDD method cannot penetrate the hard bedrock. In this situation, the very practical for preparing the fiber optic line is using open excavation on road surface. The proper step need to practice during the work for safety and cleanest

Acknowledgement

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