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LOCATING CONTAMINATED GROUND LAYER USING WAVE PROPAGATION METHOD

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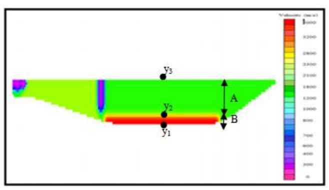
Haryati Awang*, Dayang Affrileawatty Yusof

Institute of Infrastructure Engineering and Sustainability Management, Faculty of Civil Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Malaysia

*Corresponding author
harya406@salam.uitm.edu.my

Graphical abstract



Abstract

Seismic wave refraction method is a field test that normally uses to determine ground or subsurface profile particularly the depth of bedrock under the ground surface. However, due to rapid development in ground exploration the function of this test increased rapidly with the growth of urbanisation development especially for environmental sustainability purposes. In Malaysia the need of this test is in high demand due to rapid development especially in urban area as it is a cost and time effective method. The increase in demand for this kind of ground exploration is because it is a non-destructive method where no drilling is required in order to obtain the unseen underground profile and information. One of the most significant uses of seismic wave test is for detecting the unseen underground contamination layer. This paper presents result of a study that was carried out to detect the ground layer contaminated with leachate. Contaminated ground with leachate sometimes solidifies to form solid plum. These hazardous substances may seep through loose soil spreading to the lower gradient downwards until it reaches impermeable stratum or bedrock. In order to achieve the objective, this study was carried out using seismic refraction method to locate the contamination layer under the ground surface. A physical model by a wooden tank was constructed and filled in with contaminated ground layers as a simulation to real condition on field. The two layers of different types of ground material; sand and concrete are the main medium where the time of travelling wave was measured. Findings of this study shows that it is reliable to use wave propagation technique in detecting layer of contamination underground as the actual profile and seismic wave profile matched to each other.

Keywords: Seismic wave, ground contamination, leachate, physical model, landfills

1.0 INTRODUCTION

Emissions from landfills can be divided into three different physical phases; particles, gases and contaminated waters (leachate). The most common way of waste disposal in developing countries is open dumping [1],[2]. When a landfill of open dumping is sufficent with waste materials, compaction is used as a way to reduce the size of the waste disposal pile. Lechate is a result of waste compaction that squeeze out and flow into subsurface. Locating the movement and flow of leachate or dense waste is a problem to be dealt with. There are many reasons why it is important to know to what extent the leachate is spreading. One of the reason is that the flow of leachate may spread out into the soil and groundwater in which situation it can seep into the river [3]. Another reason to detect the contaminated layer because it can dense and dissolve when ever react with suitable chemical element and this will lead to ground subsidence [4]. The contamination of ground layer may also contain harmful substances when realesed into the environment that can cause hazards to human health, and harm to living resourses and ecosystem.These are examples on why it is a need to locate the contaminated layers.

In Malaysia, depositing solid waste in open dumping is the most common practice for solid waste disposal. This practice may contribute to the ground contamination problems due to the flowing of leachate in the ground that may affect the the quality of surface water and groundwater. The contamination problems are expected to be serious due to the high rainfall pouring this tropical region annually. As the bedrock in Malaysia is located at shallow depth, it is suspected that the spreading of contaminated liquid will be trapped at the permeable statum which is the bedrock layer. Due to the problems, this research was carried out to locate the contaminated underground layer of landfill area. To solve this problem, a seismic wave propagation approach was employed to locate the thickness of contaminated layers. For this purpose a seismic refraction method was used to measure propagation of seismic through different ground material. This method is commonly used in the field where it is conducted by placing seismometers along a straight line and then detonating an explosive or sledge hammer close to one end and produced paths waves that travel from a boundary into another and bend into a different direction before arriving receivers. [5]. Seismic refraction surveying method had its beginnings when the first measurements were made of the speed of seismic waves where it changes as the wave moves from one kind of soil properties into another, depending on the physical properties of these materials. Seismic wave speeds cover a large range of values in different kind of rock and loose sediment. These values are most commonly given in the Systèm International (SI) units of meters per second (m/s).

2.0 EXPERIMENTAL

In order to locate the contamination layer in the ground, experimental works of this study were carried out using a physical model in the laboratory to simulate field condition.The model comprised of four walls where three of the walls were made by plywood and another by perspex. The actual soil model consisted of two layers of medium which are; sand and concrete. Sand represented the soil layers that poured with some leachate while concrete represented the bedrock where the bottom of the sand (top of concrete layer) is a contaminated layer. It is assumed that the leachate flow towards the bottom of the sand and pounding on the concrete layer. The thickness of the sand layer is 0.4 m. As for the concrete layer, the thickness is set to have 0.1 m as illustrated in Figure 1. Three points of shots (S) were defined to generate seismic wave using 500g hammer hit on steel plate. Data of wave travelling time at particular distance was collected by receiver of the seismograph before converting the digital data into image form using software called SeisOpt.

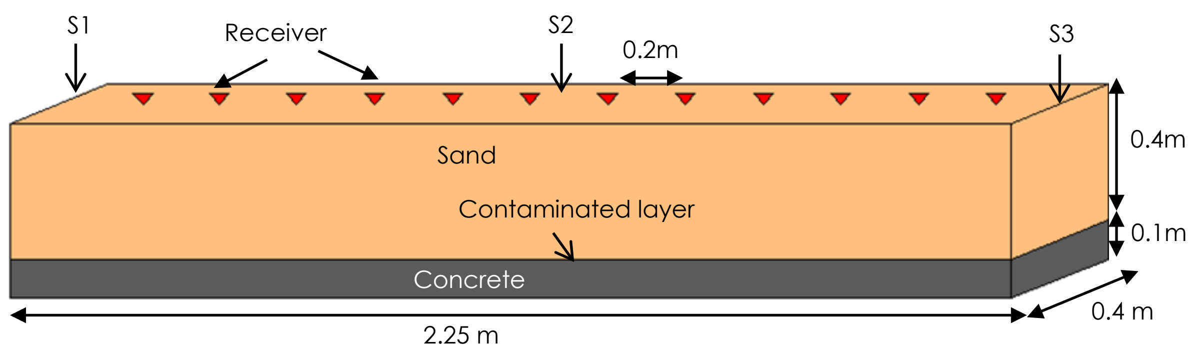


Figure 1 Physical model of seismic wave test

3.0 RESULTS AND DISCUSSION

3.1 Seismic Wave Profiling

The collected data of measured travelling time and defined distance produced a seismic wave velocity for different kinds of ground medium (sand and concrete). The result of seismic profile is shown in Figure 2 where the image was produced after data processing using SeisOpt 2D software. A different colour of image represents different types of ground medium referring to the velocity scale at the right side of the image. There are two main interpretations made from the image which are the depth or thickness and also the velocity of each type of the mediums. The depth of the medium was calculated by the y-values that appear on the image.

The y-value was referred to the point on the image where y_1 =-0.6698m, y2 =-0.4427m and y_3 = 0.00 m respectively. Hence, the thickness of the medium was represented as A and B in the seismic image for sand and concrete is 0.4427m and 0.2271m respectively. It was found that as the contamination layer pounding on the top of concrete layer, the depth to the concrete layer is the depth of the contaminated layer.

The velocity of the medium is automatically defined when the image is generated. Using the SeisOpt software, if the cursor is moved on each colour on the image, the value of the velocity automatically appears. The velocity for the lowest layer which is red in colour (concrete/contaminated boundary on the top) is 3152 m/s. For the upper layer which has the green colour, the velocity value is 1277 m/s.

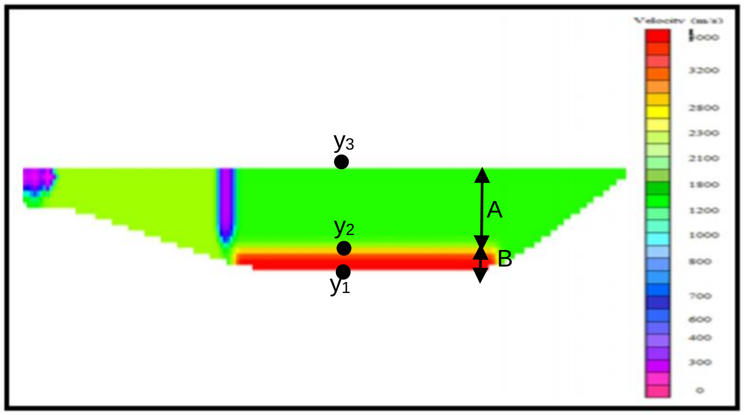


Figure 2 Result of seismic image

3.2 Comparison Between Physical and Seismic Profiles

The result of seismic wave test was compared with the actual ground profiles from the physical model in the laboratory as shown in Table 1. The comparison shows that the thickness of sand layer obtained from seismic image has only 10.68% differences to the actual thickness of the physical model. However the concrete layer shows ± 50% differences to the actual thickness. This is may be due to the thickness of concrete layer is too small compared to the total horizontal length of the test and cannot be easily resolved when the wave travelled through the layer. Even though the result shows significant difference on the concrete layer thickness, the depth to the concrete layer (top of concrete or sand layer thickness) still has a good agreement with the actual depth.

Table 1 Comparison between physical and seismic profiles thickness

Ground Material	Seismic Velocity (m/s)	
	This study	Kohnen, (1974)
Sand (loose)	1277	200-2000
Concrete	3152	3000-3500

3.3 Comparison Between Previous Study on Seismic Velocity

The result of seismic velocity was compared with the velocity of same material from previous study as in Table 2. The findings on seismic wave velocity of sand and concrete in this study are in range with [6]. This showed seismic wave propagation is reliable in determining the sub surface profiles.

4.0 CONCLUSION

It can be said that the ground profile produced by the seismic test has good agreement with the actual physical model in terms of depth to the concrete layer. The wave velocity of the materials used which are 1277 m/s for sand and 3152 m/s for concrete layer matched to the established value. Therefore, it can be concluded that the seismic wave propagation is a reliable method to be used in locating the ground contaminated layer.

Table 2 Comparison of seismic velocity with previous study

Ground Material	Profile Thickness (m)		Difference (%)
	Physical Model	Seismic	
Sand	0.4	0.4427	10.68
Concrete	0.1	0.2271	55.68

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