The Application of the Seismic Method in Site Properties Assessment

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Abstract. Similar to the broad use of the seismic methods to identify the layers of soil and the distance strike the bedrock, initial site properties require geophysical techniques to assess them. This research was carried out to investigate the properties of the subsurface composition of a backyard area in Universiti Teknologi Malaysia, Johor campus, guided by the principles of this process. The Evaluation of seismic data analyzed using ZondST2D computer software by calculating the first arriving time of the propagated seismic wave throughout soil layers to obtain a subsurface prototype. The examined subsurface profile was composed of four layers displaying the weathering grade level of scales between 600 m/s to 4000 m/s depending on Malaysia's rock mass categorization. Weathering concentrations were observed to be declining at higher depth, with increased density of the material and reduced seismic velocity dampness. It was found that only for shallow subsurface compositions which is far from interference and noise, can the analysis of seismic refraction be conducted progressively.

Keywords: Site properties; Seismic method; Seismograph; Seismic refraction

1. Introduction
Throughout the surveys for petroleum-bearing structures, seismic refraction deemed the first geophysical tool to be stratified; however, its compliance in oil exploration has been diminished over the years due to the intervention of numerous modern studies [1]. Furthermore, this technique has been progressively used with a near-surface exploration, especially in construction management and engineering site investigations. [2]. If it is used in combination with explorative drilling, it offers high prospect inspections for shallow surveys. [3]. The refraction technique has already become a typical method for obtaining eligible high seismic portions in the
generated land seismic surveys. [4]. In the construction industry, several validated methods of analysis that describe each type of investigation have their advantages and disadvantages in the case of obtaining information about the condition of the subsurface. The process of seismic refraction is performed in this analysis without the use of laboratory or geological tests. Generally, it is intended to provide an initial impression of a project before preparing for an additional comprehensive program. The aim of this research is to assess the properties and geotechnical specifications of the site location and provide a sub-surface structure prospection.

The details derived from the implementation of the geophysical methods enable geotechnical teams to realize the essence of the proposed site for more details on the properties of the soil/rock and therefore assist experts to recommend a reliable design for the allocated layout to the foundation or earthworks. [5]. The methods to long-wavelength statistics are a form of delay-time, as per the seismic industries. [6]. The generalized linear inversion [7], Travel Period Tomography [8, 9], The first inverse of the waveform that has arrived [10–12]. The accuracy of the static refraction adjustment was usually based on the great importance of the first arrival time. Additionally, the far-offset transmission rate of refraction could not have been accurately chosen in certain locations, and it was also very challenging to do this with certain shots to ensure that the data acquired were reliable.

The refraction concept interferometry was implemented to enhance the signal-to-noise relation of head-wave arrivals to decide the selection of its first arrival time problem [11]. seismic, resistivity, or gravity techniques may be used to perform geophysical testing on a field. [13]. The seismic term could be further subdivided into two categories: reflection and refraction techniques [14]. The realistic consideration found in this research is in the process of seismic refraction. The seismic represent potentially force waves that arise by striking the rocks of the ground or an earthquake, it is the force that travels through the earth, which is registered using seismographs [15]: body waves, the primary and secondary waves. Also, surface wave, love, and Rayleigh wave are two basic types of seismic waves, as seen in Figure 1&2.

Regarding the transmission paths seen in Figure 2, each one of the waves travels separately. These variations are due to the basic property of seismic monitoring, which is based on the principle of stress-strain. Owing to its compressional uniaxial tension, the P-wave displacement is parallel to the propagating wave, whereas the S-wave becomes perpendicular because of its shear strain [17]. In comparison, the echo that can be detected after an earthquake or even human strides is called surface waves. [18]. Therefore, with the use of seismic refraction, the traditional way is to study the reactive P waves that the seismic instruments detect effectively. This also indicates that there is a far lower velocity relative to P-waves (Vs < Vp) for inaccurate ground motion induced by the disturbance of S-waves[19].
Figure 1. Seismic Waves [16]

Figure 2. Surface Wave [5]
1.1. Rocks Properties
Geophysical experiments are indications of physical properties (resistivity, frequency of movement of seismic waves, density, magnetism, permeability to water, etc.) to consider the composition and lithological properties of the masses of soil. Studies of refraction waves and seismic reflection are based on measuring the seismic wave intensity. There is a clear interaction between Vp and Vs and whether the rock masses locate the fractured regions.[20]. These same hydraulic characteristics relate to the velocity ratio between the conditions of broken and hard rock. Detecting precise relations between porosity and seismic activity in rock mechanics, velocities in permeable rocks have been a relevant subject for decades [21]. Permeation and pore volume of cracks are correlated with low-velocity ratios. [22]. Due to the contact between compressed and fractured rocks or stratigraphic changes, the poor reflection of the wave is most possibly shown on the layered reflection image [23].

2. Research Methods

2.1. Proposed Site and Geological Conditions
The subsequent investigation is in Universiti Teknologi Malaysia, Johor Bahru. The field suggested for the study is located near the backyard of M47 School of Civil Engineering and Water Stream (Figure 3). The research was done using a measurement device (seismograph), a 6.5 kg hammer and 24 geophones. Mostly on different ends, the interval distance between the geophones is 5 m, and also the offset shots are +10, -10. The study of seismic data obtained through ZondST2D tools by evaluating the first time of arrival before a block 2D form output is developed based on the initial transmission in soil layers of geophysical waves.

![Figure 3. Proposed site](image-url)
2.2. Data Collection

The collection of field data was conducted by using a survey spread labeled with 184 meters long, 48-channel seismograph. Besides, the vibration source, the 6.5 kilograms hammer was used. Shots were done at (0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 184) m. Using the ZondST2D program, source data collected by seismograph can be represented by choosing a range of 624 first arrival times. A velocity block segment model that will be addressed over the next chapter would be given by reversing these relevant data. The ABEM Terraloc MK8 seismograph, seismic cable, trigger cable, sludge hammer, battery, striker plates, geophones, and measurement tape all are used for this survey as shown in figure 4 below.

![Seismograph and survey instrument](image)

Figure 4. Seismograph and survey instrument

3. Research Findings and Discussion

Data obtained, analyzed, usually consists of a territory with a velocity of < 4000 meters / second. By using the high-frequency seismic technique, the highest point surveyed is 24 meters vertically and 186 meters horizontally. Either the first or second layers of the investigated near-surface characteristic were categorized as overburden, the variety of Vp from 600 meters / second to 4000 meters / second shows that the major rock probably originated from the unconsolidated alluvium sediments to the shale sedimentary rocks and we access granitic bedrock with a faster speed above 4000 m / s at a depth greater than 22 meters. According to [24], Regarding density and saturation of different forms, the primary soil velocity varied from 244 meters to 1219 meters/second. Besides, [25] revealed that the average velocity value ranged from 2400 to 6000 meters / second for intact and granitic rock. The overall pattern detected is that because components are more compact and thicker at great depth, for
less depreciation of seismic waves, the Vp tends to increase with depth. Seismic wave vibration dampening happens on components of high weathering degree that is usually on the relatively close ground surface. The viability of near-surface characterization will be affected by geomaterial lithology, permeability, and interstitial fluids decided to focus on P-wave seismic velocity comparative study[26].

Density, permeability, structural geology, compaction, friction, water saturation, and isotropic were measured by the seismic velocity factor. [27]. Figures 5 and 6 demonstrate the use of Zond applications. With increasing distance, the sub-surface materials change, with various blue color ranges reflecting close to the surface levels before Vp passes the orange bedrock to the pink hue. The result indicates four different velocity levels underneath the surveyed field. The first level reveals residual soil situated at a distance of 0-4 meters with a velocity value obtained of 300-600 meters/second. At the altitude of 4-12 meters, the second of the fully granitic weathered layer with a velocity of 600-1400 meters/second was detected. The third of the mildly granitic weathered layer was detected at depths of 12-19 meter with a velocity of 1400-2500 meter/seconds and the fourth of the strongly granitic weathered layer with a velocity of 2500-4000 meter/second was detected at depths of 19-23 meter. The new granite bedrock with the maximum velocity region of more than 4000 meters / second can be plotted at a depth of > 22 meters for further explanation.

Figure 5. Contour data collected employing Zond 2D Software
4. Conclusion
From the research review explored, it is inferred that the minimally - intrusive seismic refraction did not offer explicitly over a wide zone the quantifiable sub-surface information, it is restricted to support rapid decision-making on site selection and preparation. It is also regarded as the most important method for site investigation to analyze the bedrock composition and propagation of velocity, but somehow it declines to provide us with the understanding of actual sub-surface parts in regions of such rock types as limestone rocks. Throughout this scenario, the reflected wave analyzed during data acquisition, a sample area is overlapped by granitic soil, this could be described that even with an increase in depth, weathering levels reduced, compaction degree rises, density increases, permeability and fluid properties on seismic waves moving would influence the research, meaningful results. Eventually, only relatively shallow profiles are restricted to the scope of such a geophysical system. The construction management team can conduct a cross-hole seismic analysis or bore from SI activities if additional information is needed for the planning of engineering products on the site.

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