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CHARACTERIZATION OF SOIL PROFILE USING DISPERSION CURVE ANALYSIS

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Abstract

Research has been carried out on the seismic refraction exploration method by utilizing piles on the construction project of the Geomatics Campus II FTSP ITS Surabaya as a source of vibration. Rayleigh waves are one type of surface wave that is good for identifying layered structures near the earth's surface because 67% of the energy The total amount released by the seismic wave source is transmitted in the form of Rayleigh waves. In the layered medium, Rayleigh waves have dispersive properties, speed as a function of frequency. This property can be used to determine the structure of the earth's layers based on the shear wave velocity (Vs) with depth (h). The inversion process is carried out to match the measurement dispersion curve and the model. The result of the inversion process is the shear wave velocity (Vs) function of depth. This research is expected to identify and characterize the soil profile at the research site. On the track, there are three layers indicated as clay layers, in the first layer 0-6 meters with an average speed of 250 m/s, the second layer 6-19 meters with an average speed of 971 m/s, and the third layer 19-57 meters with an average speed of 1564 m/s.

Keywords: Soil profile; dispersion analysis; Rayleigh waves

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Introduction

In the seismic method, what is observed is the propagation time of sound waves, which are elastic and generated by specific wave sources (dynamite, hammer, or weight drop and piles). This study wants to take advantage of the momentum of installing pile foundations at the Geomatics Engineering campus of ITS Surabaya (Broto & Afifah, 2008).

This seismic refraction method is one of the most important and widely used methods in geophysical engineering. The seismic method has high accuracy and resolution in modeling the geological structure below the earth's surface. In determining geological structures, seismic methods can be divided into two

main categories, namely invasive tests and non-invasive tests. The invasive test method requires a drill hole (Cross-Hole, Downhole, P-S suspension logging), while the non-invasive method is carried out at ground level (Reflection, Refraction and SASW test) (Hudha et al., 2014).

Surface waves are divided into two, namely Rayleigh waves and Love waves. The surface waves used in this study are Rayleigh waves. The effect of Rayleigh waves is enormous. When the exciting force on the earth's surface and thick layers, Rayleigh waves account for 67% of the total energy, S waves by 26% and P waves by 7%. Rayleigh waves are very well used to identify soil profile problems because the energy reduction in their propagation is lower than other types of seismic waves. Therefore, the focus of this research is the analysis of Rayleigh waves (Fitriyani, 2016).

SASW (Spectral Analysis of Surface Wave) data has played a significant role in determining the soil profile. The processing is then carried out from this data to obtain a dispersion curve, namely the curve of the relationship between phase velocity or frequency to wavelength. After obtaining this dispersion curve, an inversion was then performed to obtain the profile character and the parameters of the elasticity of the soil (Joh, 1996). Problems encountered in conducting this research are:

How to know the characteristics of the structure of the subsurface of the earth

Method

A. Data Collection Stage

In this study, the distance on each track is 75 meters. Twelve geophones carry out the recording system straight with a vibrating source. Geophone pairs are placed with a predetermined spacing. Namely, the first point is 20 m from the vibration source, the second and third points are each 5 meters apart from eleven geophone points with eight trajectories.

B. Seismic Data Processing Stage

Two data signals in the time domain (y1(t) and y2(t) are first converted in the frequency domain using the Fourier transform so that Y1(f) and Y2(f) are obtained. Using spectrum analysis makes it possible to obtain information about data quality. And also the phase velocity as a function of frequency.

Signal quality is obtained using the "coherence function," which compares the results recorded by two geophones. A value close to one indicates a good level of correlation to be seen whether the data is affected by noise. This inversion process has required the value of the earth parameter as an initial guess which is then used to determine the theoretical wave speed. The final wave speed is obtained by iterating between the observed wave speed and the theoretical wave speed so that the error is smaller than the tolerance error (Hutahean, 2007). The phase velocity as a function of frequency is obtained from the phase Cross Power Spectrum, whose value is used to create the dispersion curve of the observation.

The inversion process is carried out to obtain a wave velocity profiling from the depth of the soil. After profiling, the shear wave velocity from the soil depth for each common midpoint is obtained. The shear wave velocity data to depth is processed using Surfer8 software to obtain a subsurface model based on shear wave velocity.

Results and Discussion

Data were obtained from each configuration of geophone pairs and impulse sources. The vibrations generated by the vibration source will be received by the geophone and recorded by the McSEIS-SX Model 1125 A in the time series format *.org (SEG-D). Furthermore, the data is filtered using an ombybandpass filter. Prior to filtering, analysis of the dominant frequency of a signal is first performed. This analysis is carried out with the Fourier transform. The results of the analysis of all signals show that the signal's dominant frequency is 16 Hz to 31 Hz. Next, filtering is carried out to pass a frequency signal of 16 Hz to 31 Hz. After that, the data is digitized into *.txt format. Filtering and digitizing data is done using Vista 7.0 Software.

This digitized data creates a dispersion curve using Rayleigh wave spectrum analysis. Spectrum analysis changes the time function data into a frequency function using the Fast Fourier Transform (FFT) algorithm. This algorithm can quickly change the time domain to the frequency domain by requiring the number of data to be 2n.

Spectrum analysis was conducted sequentially from equation (2.56) to (2.62). The distance used in the above formulation is the distance from the geophone pair. The results of this analysis are angular velocity as a function of frequency and coherence of the two signals analyzed. According to (Foti, 2000), coherence determines the signal quality to noise. The signal quality is good if the coherence value is close to one. Figure 1 shows that the coherence value is one, so it can be said that the quality of the data used in this study is free from noise.

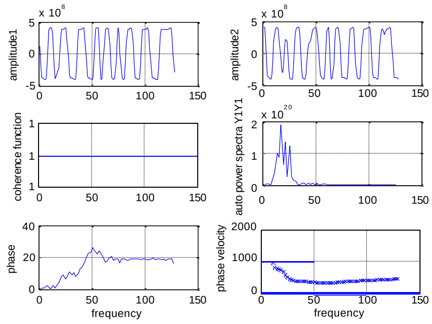


Figure 1
Rayleigh. wave dispersion curve results

The resulting dispersion curve is then inverted to obtain a shear wave velocity profile with depth. In this inversion process, initial parameters are needed in the form of shear wave velocity, density, layer thickness and Poison Ratio. These initial parameters are the initial values of the iterations performed. This parameter is determined based on the table of seismic wave velocity in various rock types attached in Appendix 2. Based on the local geological conditions at the research site, it is known that the soil type is clay, so the initial parameter used is the clay parameter.

The initial parameters are estimated using the Rayleigh wave equation to get the value of the phase velocity of the Rayleigh wave model as a function of frequency. The speed of the Rayleigh wave of this model is then compared with the speed of the Rayleigh wave of the research results so that an error is obtained. The error value will determine whether or not to iterate, and the inversion is complete. If the error value is greater than the desired one (error = 3.0), a new Rayleigh wave velocity is calculated to produce a lower error until the desired error is obtained. Figure 2 is an example of a Rayleigh wave inversion result.

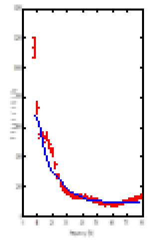


Figure 2
Inversion Results,

a) RMS Error relationship with iteration,
b) The phase velocity of theoretical and experimental results.
c) Shear wave velocity profile with depth

A. Data Interpretation

Detailed mapping of the subsurface structure is carried out by analyzing all adjacent geophone pairs in the measurement. Each pair of geophones produces a profile of shear velocity against depth. This velocity profile reflects the shear wave velocity between geophone one and geophone 2.

Estimation of shear velocity as a function of depth is done by inverting the dispersion curve of all closest geophone pairs. The results of all these shear wave velocity estimates reflect the subsurface structure between the two geophones. Next, two-dimensional modeling was carried out using the Surfer 8. software.

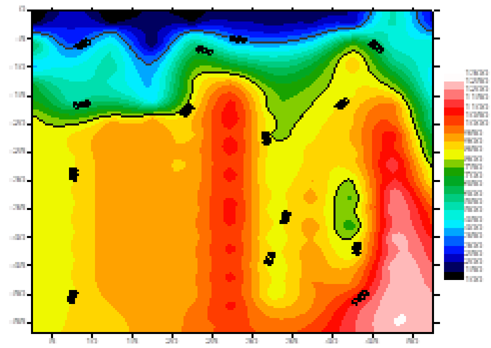
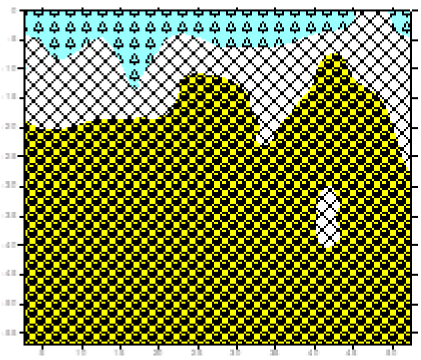


Figure 3
Two-dimensional modeling

The image of the shear wave velocity as a function of the position of the modeling results has a range between 109 m/s to 1252 m/s. According to (Sukardi, 1992), the geology of the research area consists of alluvium composed of clay, sand, gravel silt and gravel formed by coastal deposits. This geological information is compared with the sheer velocity values of various rocks in appendix 1, table



Description:

Sand loam saturated

Sand

Clay p Figure

Figure 4
Suspected subsurface structure

Besides being used for geological purposes, the shear wave velocity (Vs) can also be used for geotechnical purposes (Boominathan, 2006). Vs. is used as an indicator of rock hardness. Usually, this hardness is measured using the Standard Penetration Test (SPT). The harder it is, the higher the SPT value (>50). According to (Bang & Kim, 2007), (Boominathan, 2006) and (Chen, Evans, & Feldlaufer, 2006) that the value of the SPT is always positively correlated with Vs. An increase will always follow the increase in the value of the SPT in the value of Vs. It means the large Vs. Value of hard rock and small Vs. Value of soft rock.

The relationship between the SPT hardness values depends on the type of rock (Boominathan, 2006). Based on JRA (1980) in (Boominathan, 2006), the relationship between SPT (expressed in N) and Vs. Clay and sand areas in equations 1 and 2. Based on this equation, it is possible to estimate the SPT value of rock layers. In this study, SPT estimation was only carried out at a depth of 1 meter at Vs. for each geophone pair. Furthermore, the value of SPT and VS is used as an indicator of rock hardness as a geotechnical basement.

(for clay rock) (1)

(untuk batuan pasir) (2)

Based on the results of the geological interpretation above, the depth of 1 meter at the point of 2.5 meters to the point of 45 meters and at the point of 52.5 meters in the form of sandy clay rock and 47.5 meters in the form of sandstone. Thus, the SPT estimation is carried out using both equations (4.1 and 4.2), except for the 47.5-meter point, which only uses equation 4.2. The estimation results can be seen in Figure 4.5. The estimate is not appropriate because the SPT value exceeds 60 at the point 47.5 meters from the first geophone. This means that the rock is too hard, so SPT measurements cannot be carried out.

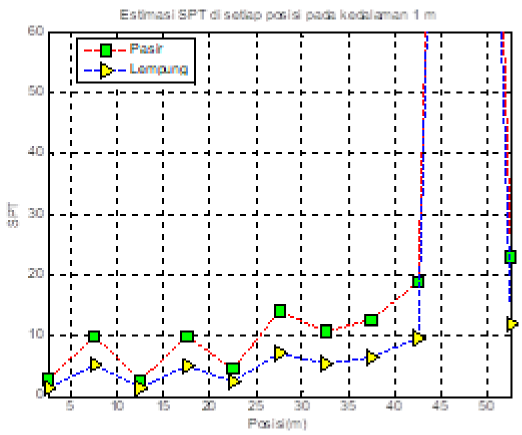


Figure 5
SPT graph at each position at a depth of 1 m

The estimated value of the SPT with the clay approach always has more minor results. This event is natural because, with the same hardness (clay and sand), the magnitude of Vs. in the sand is always smaller. This is caused by the porosity of the sandstone, which is greater than the porosity of the clay rock. The magnitude of the wave propagation velocity is always inversely proportional to the rock's porosity (Schoon, 1998). On the other hand, with the same Vs. Value: It is clear that clay rock's hardness value is smaller than that of sandstone.

SPT with the sand approach in Figure 5 and attachment 1 table L2 it is known that the soil layer located between the position of 2.5 meters to 37.5 meters from the first geophone is soft soil (SPT value <15) and the soil layer between position 37, 5 meters to 52.5 meters from the first geophone in the form of medium soil (SPT value 15-50) to hard soil (SPT value > 50). At the same time, the SPT with the clay approach is known that the soil layer at all points (except around point 47.5) is included in the soft soil. From these two estimates, it was found that the criteria were similar at points 2.5 to 37.5, namely rocks, including soft rocks. Furthermore, for geotechnical purposes in building construction, geotechnical engineering is required for the soft soil layer and the medium layer. Engineering is carried out to hard rock as a building base. Hardening the rock can be done by compacting the soil layer and mixed with limestone.

The initial parameters are estimated using the Rayleigh wave equation to get the value of the phase velocity of the Rayleigh wave model as a function of frequency. The image of the shear wave velocity as a function of the position of the modeling results has a range between 109 m/s to 1252 m/s. Next, two-dimensional modeling was carried out using the Surfer 8 software. The estimated value of the SPT with the clay approach always has more minor results. The SPT value exceeds 60 at a point of 47.5 meters from the first geophone, and the estimate is not appropriate. This means that the rock is too hard, so the SPT measurements cannot be carried out. SPT with clay approach is known that the soil layer (except around point 47.5) is included in soft soil. The soil layer, which is located between 2.5 meters to 37.5 meters from the first geophone, is soft soil (SPT value <15), and the soil layer between 37.5 meters to 52.5 meters from the first geophone is medium soil (value tax return 15-50)

Conclusion

After we studied it in-depth, research on soil profile characterization at the FTSP ITS geomatics campus using Rayleigh wave dispersion curve analysis can be concluded that:

Based on the local geological conditions at the research site, it is known that the type of characterization of the soil at the research site is clay, so the initial parameter used is the clay parameter.

The results of all these shear wave velocity estimates reflect the subsurface structure between the two geophones. The geological interpretation states that the depth of 1 meter at a point of 2.5 meters to the point of 45 meters and at a point of 52.5 meters in the form of sandy clay rocks and 47.5 meters in the form of sandstone. To hard soil (SPT value > 50). At the same time, the SPT with the clay approach is known that the soil layer at all points (except around the 47.5 m point) is included in the soft soil. From these two estimates, it was found that the criteria were similar at the point of 2.5 m to 37.5 m, namely rocks, including soft rocks.

Based on the results of this study in the context of building development, it is recommended:

1) For geotechnical purposes in the construction of buildings, geotechnical engineering is required for the soft soil and medium layers. Engineering is carried out to the hard rock as a building base.
2) Hardening the rock can be done by compacting the soil layer and mixed with limestone.
3) This research is used to determine government policies in implementing development.

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