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LANDSLIDE POTENTIAL ANALYSIS ON NEW ROAD OF UNDIP-JANGLI CAMPUS, SEMARANG USING MICROTREMOR METHOD

Roy Jun Marselan Pasaribu[1]; Gatot Yuliyanto[1]; Tony Yulianto[1]
[1]*Departement of Physics, Faculty of Science and Mathematics, Diponegoro University, Semarang, Indonesia*
[1] royjun222@gmail.com

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Abstract- ***Tembalang is one of the sub-districts in the Tembalang District where landslides or landslides often occur (BPS Kota Semarang, 2021). The New Undip-Jangli Semarang Campus Road is a research area which is one of the areas with a medium level of vulnerability to ground motion (PVMBG, 2022). The study was conducted using the HVSR microtremor method with a total distribution of 40 measurement points. This study aims to identify areas prone to ground movement or landslides based on subsurface characteristics from the distribution of seismic susceptibility index (Kg) values, ground shear strain (GSS) values, identify profiles of subsurface characteristics laterally based on the distribution of shear wave velocity values (Vs). , around Jalan Baru Campus Undip-Jangli Semarang. Based on the research results, the distribution value of the seismic vulnerability index (Kg) around Jalan Baru Campus Undip-Jangli is between 0.27-17.27. The distribution value of Ground Shear Strain (GSS) in the study area is between 2.46x10^{-4}-1,39x10^{-3}. The value of the shear wave velocity distribution (Vs) around Jalan Baru Campus Undip-Jangli Semarang is between 179-2,981 m/s. Earth movement vulnerability analysis based on the parameters above indicates several zones of vulnerability to ground movement, namely at points 3, 4, 5, 6, and 7. Points 9, 10, 13, 14 and 16 and between points 16, 24 and 32. Points 22, 30 and 38 are to the east of the New Undip-Jangli Campus Road. The zone between points 3, 4, 5, 6 and 7 is to the south of the New Undip-Jangli Campus Road. At points 9, 10, 13, 14, and 16 the possible ground motions are rotational avalanches moving south.***

Keywords- ***HVSR, Seismic Susceptibility Index, GSS, Shear Wave Velocity, Undip-Jangli New Road Semarang***

I. Introduction

Ground movement is a consequence of natural dynamic phenomena for new conditions due to slope balance disturbances that occur, both naturally and as a result of human behavior [1]. The most obvious consequence of a landslide disaster is the accumulation of settlements or groups of people living above or below a slope whose condition is unstable. Therefore, this natural disaster not only causes damage to the environment and infrastructure, but can also cause casualties.

Based on the soil movement vulnerability zone map made by the Center for Volcanology and Geological Hazard Mitigation (2022), the area around the New Undip-Jangli Campus Road is in an intermediate soil movement vulnerability area. In areas of moderate soil movement susceptibility, soil movement can occur, especially in areas bordering river valleys, escarpments, road cliffs or if the slopes are disturbed. Old soil movements can be active again due to high rainfall and strong erosion. Slopes range from gentle (5-15%) to steep to nearly upright (>70%), depending on the physical and engineering conditions of the rock and weathering soil forming the slope. Cover conditions are generally less to very rare [2]. The New Undip-Jangli Campus Road is an area located in the upper part of Semarang, which has compacted sedimentary rock lithology, so it is relatively unaffected by liquefaction in the event of an earthquake but its hilly morphology and thick soil layers can potentially experience landslides. If landslides occur on river slopes and form natural dams, this can potentially trigger flash floods if the time of occurrence coincides with the rainy season [3].

Method *Horizontal to Vertical Spectral Ratio (*HVSR) is one of the passive geophysical methods introduced by Nakamura (1998), which aims to identify the response of rock layers that can describe the subsurface. The parameters of the HVSR method are needed to determine subsurface conditions that affect natural frequencies and amplification aims to interpret microzonation with HVSR correctly [4]. In this study, the microtremor data was then interpreted and correlated with the geological data of the study area which included geomorphology, slope, lithology and structures found in the study area.

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A. Dominant Frequency (f_0)

The dominant frequency value from HVSR processing represents the natural frequency found in the area. This states that if an earthquake or disturbance occurs in the form of vibrations that have the same frequency as the natural frequency, then a resonance will occur resulting in amplification of seismic waves in the area. The frequency observation limit for microtremor is generally between 0.5-20 Hz and for small frequency microtremor it can reach 0.2 Hz. The natural frequency value of an area is influenced by the thickness of the weathered layer and the average subsurface velocity [5].

$$f = \frac{Vs}{4H} f = \frac{Vs}{4H}$$

B. Amplification (A_0)

The amplification of a wave can occur when an object that has its own frequency is disturbed by another wave with the same frequency. Earthquake wave amplification can occur when waves propagate to the ground surface while the natural frequency of the ground has the same or nearly the same value as the earthquake frequency [6].

C. Seismic Susceptibility Index Value (K_g)

Seismic Susceptibility Index (K_g), Nakamura [7] and Huang and Tseng [8] stated that the Soil Susceptibility Index (K_g) identify the level of vulnerability of a layer of soil that is deformed by an earthquake with the following equation:

$$K_g = \frac{Am^2}{f}$$

With Am and f is the amplitude (amplification factor) and frequency HVSR. Mark K_g Generally found in soils with soft sedimentary rock lithology. This high value illustrates that the area is prone to earthquakes and if an earthquake occurs it can experience strong shaking. Instead, valueK_g small ones are generally found in soils with solid lithology of constituent rocks so that when an earthquake occurs they do not experience much shaking.

D. *Ground Shear Strain* (GSS)

Strain is a parameter that compares the change in shape of an object with its initial form.*Strain* divided into two viz*normal strain* and*shear strain*. *Shear strain* is the change in angle from the angle formed by the intersection of two straight lines. The basic concept of shear strain can be used in analyzing the deformation of a soil surface layer [7]. By using the parameters of the dominant frequency and amplification, theoretically the value*shear strain* can be determined.

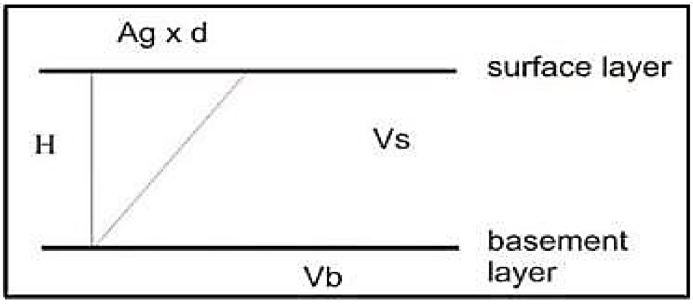

Figure 1. Illustration of shear strain on the deformation of the soil surface layer

II. METHODOLOGY

The measurement of the microtremor method will be carried out November-December 2022 on the new road of the Undip-Jangli campus which is in Banyumanik District, Semarang City. The location for collecting research data can be seen in Figure 2. Data acquisition was carried out in 40 points spread from the start of the construction of the Undip-Jangli New Road.

Figure 2. Research Locations

The research instrument consists of software and hardware. Software is a device related to the use of applications on a computer. The software used is*Google Earth, Geopsy, Surfer 13, Microsoft Excel 2013 dan ArcGIS*. As for the hardware used is*Graphthec midi LOGGER* GL-240, Compass, Seismometer,*Global Positioning System* (GPS) and Laptop.

Retrieval of primary data using the GL 240 begins with checking the tool first and attaching the cable to the data logger. After that, place the seismometer at the point that was made in the survey design by directing the y-axis to the north and adjusting the tool so that the bubble on the seismometer is right in the middle. After everything has been prepared, then press the on button to the right of the data logger then a boot screen will appear on the device then wait for a graph to appear on the data logger screen. After the graphic image appears on the screen, press the start button then enter. Data collection was carried out for each point for 10 minutes and 40 points were carried out according to the survey design.

Microtremor data processing is done by opening microtremor data in*Microsoft Excel 2013* change*file* data to form*.txt* use*notepad++*. On*software geopsy* the data will be processed into an H/V curve, where the results obtained are the frequency values (f_0), period and amplitude at each acquisition point, then the curve is stored in .hv format. In the process of determining the frequency and amplification, it is necessary to pay close attention*Smoothing type*. Incorrect selection will result in unexpected frequency output.*Smoothing type* recommended is*Smoothing* Kohno & Ohmaci which will produce the right output for low frequencies. From processing on*Geopsy* data will be obtained in the form of an HV curve which is then used to look for the spectrum. Spectrum searches were performed on*software Dinver* to get*spectrum* based on Inversion of the form*Fast Fourier Transfrom* (FFT). The results obtained from the processor through*Dinver* These are density, Vp, Vs, and depth. From processing results*Dinver* in the form of Vp and Vs, the next calculation is carried out on*software Microsoft Excel* to get the value of soil vulnerability index (Kg), value*peak ground acceleration* (PGA), and*ground shear strain* (GSS). Then, the frequency value (f_0), periode (T_0), and amplification (A_0) is calculated along with the value of Vp and Vp to obtain the value of the soil vulnerability index and peak ground acceleration (PGA). After that, the value of the ground shear strain results from the value of Kg andα. The value of ground shear strain is identified by connecting in the table between the strain and the dynamic properties of the soil [7].

The results of the data obtained will then be interpreted and identified values*ground shear strain* classified based on the table of the relationship between strain and dynamic properties according to Nakamura (1997) after which it will be linked to the geological map of the study area to analyze the impact that will occur in the area if an earthquake occurs for some time to come.

III.RESULT AND DISCUSSION

A. Dominant Frequency (f_0)

The distribution of the Dominant Frequency Values in the study area can be seen in Figure 3. The lowest frequency value in the study area is 0.603 Hz. Based on Kanai's classification (1983), this value is included in the Type IV classification (<2.5 Hz). This classification shows that the area is composed of alluvial rocks formed from deltaic sedimentation, top soil, silt, soft soil, humus, deltaic deposits or silt deposits which are classified as soft soils. The thickness of the sediment layer in this area is very thick, reaching 30 meters. The highest frequency value in the research area is 8.139 Hz Based on Kanai's classification (1983), the highest frequency value in the study area is included in the type I classification with a value range of 6.67-20 Hz. This classification indicates that the area is composed of tertiary or older rocks and consists of hard sandy gravel. The thickness of the sediment layer in this area is very thin because it is dominated by hard rock.

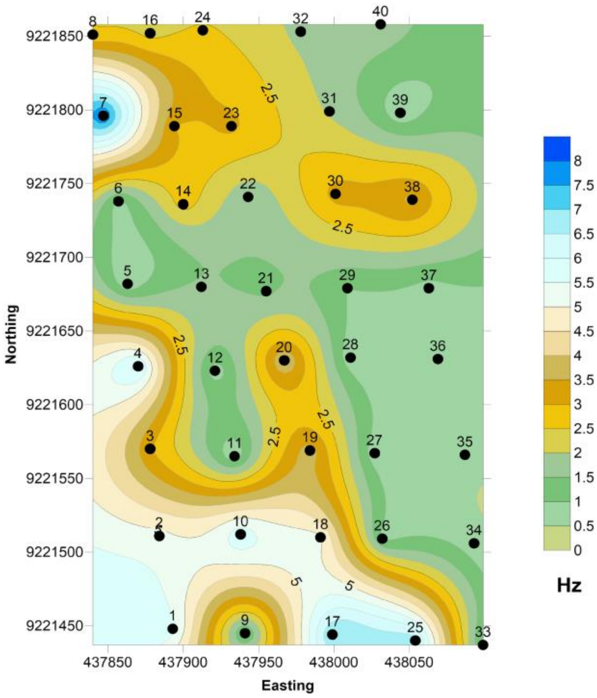

Figure 3. Distribution of Dominant Frequency Values in Study Areas

B. Amplification (A_0)

The distribution of amplification values in the study areas can be seen in Figure 4. Based on the results obtained, the amplification values in the study areas are in the range 1.120-4.62. A high amplification value indicates the presence of a soft and thick layer of sediment underneath. Large amplification values are very prone to multiple reflections of body waves or seismic waves being trapped in sediments which will cause great potential damage (Nakamura, 2000).

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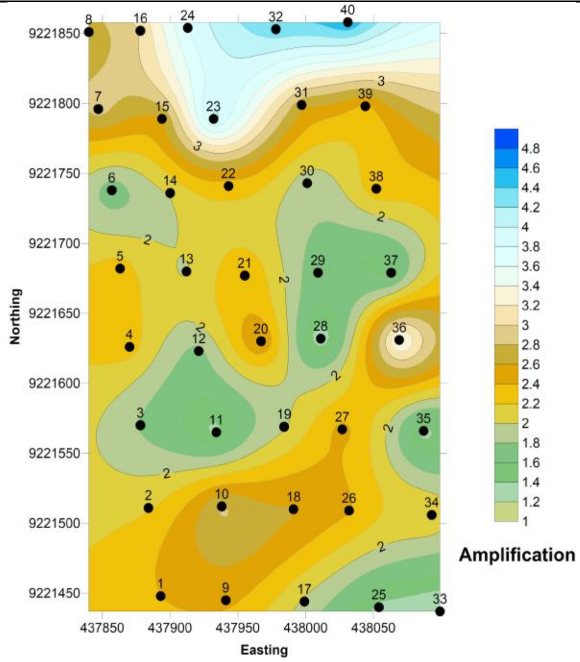

Figure 4. Distribution of Amplification Values in Study Areas

C. Seismic Susceptibility Index Value *(K_g)*

The distribution of seismic vulnerability index values in the study area can be seen in Figure 5. Based on the calculation results, the seismic vulnerability index values in the study area are in the range of 0.27 to 17.27. Based on the seismic vulnerability classification according to Daryono (2009), a Kg value greater than 20 is included in the high seismic vulnerability classification. In the research area, the research location points have a Kg value of less than 20. Based on field documentation, the points above do not indicate that the field conditions have a vulnerability to ground movement. These points are in fairly stable field conditions. Overall, the average Kg value in the study area was at 3.93. This value is included in the classification of low seismic vulnerability.

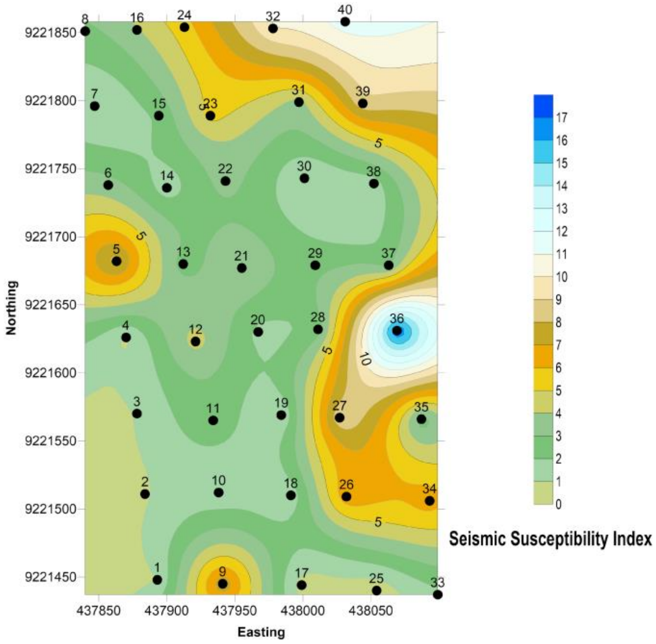

Figure 5. Distribution of Seismic Susceptibility Index Values in Study Areas

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D. *Ground Shear Strain* (GSS)

Value Distribution*Ground Shear Strain* the research area can be seen in Figure 6**.** In the research area, the range of GSS values is between 2.46×10^{-4} - $1{,}39 \times 10^{-3}$. Mark*GSS* the highest value is 1.39×10^{-3} is at point 36. Another point that has value*GSS* above 10^{-3} namely points 33, 37 and 41. Based on the strain relationship table with the dynamic properties of the soil proposed by Nakamura (1997), these values indicate that the soil is elastic and plastic and has the greatest potential to experience fractures and soil subsidence. However, based on field documentation, the points above do not indicate that the field conditions have a vulnerability to ground movement. These points are in fairly stable field conditions.

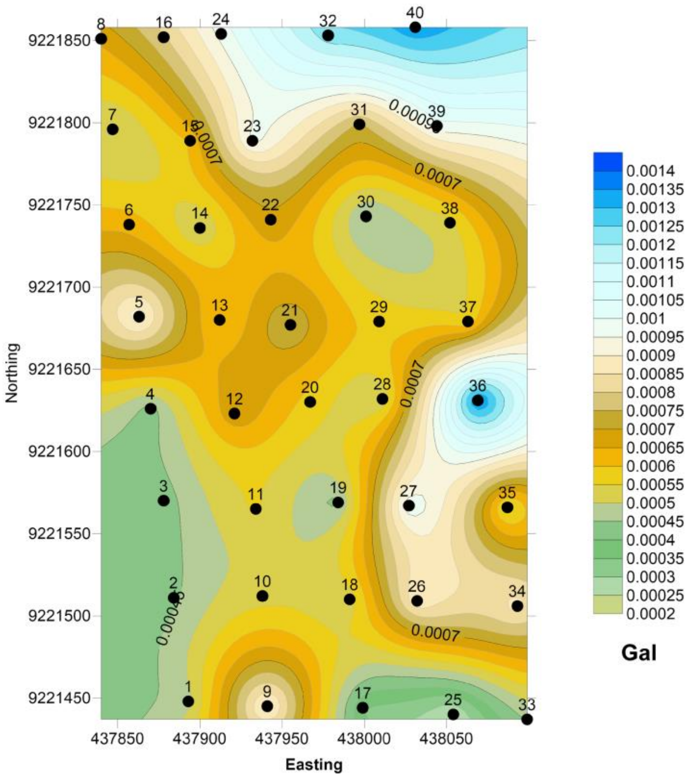
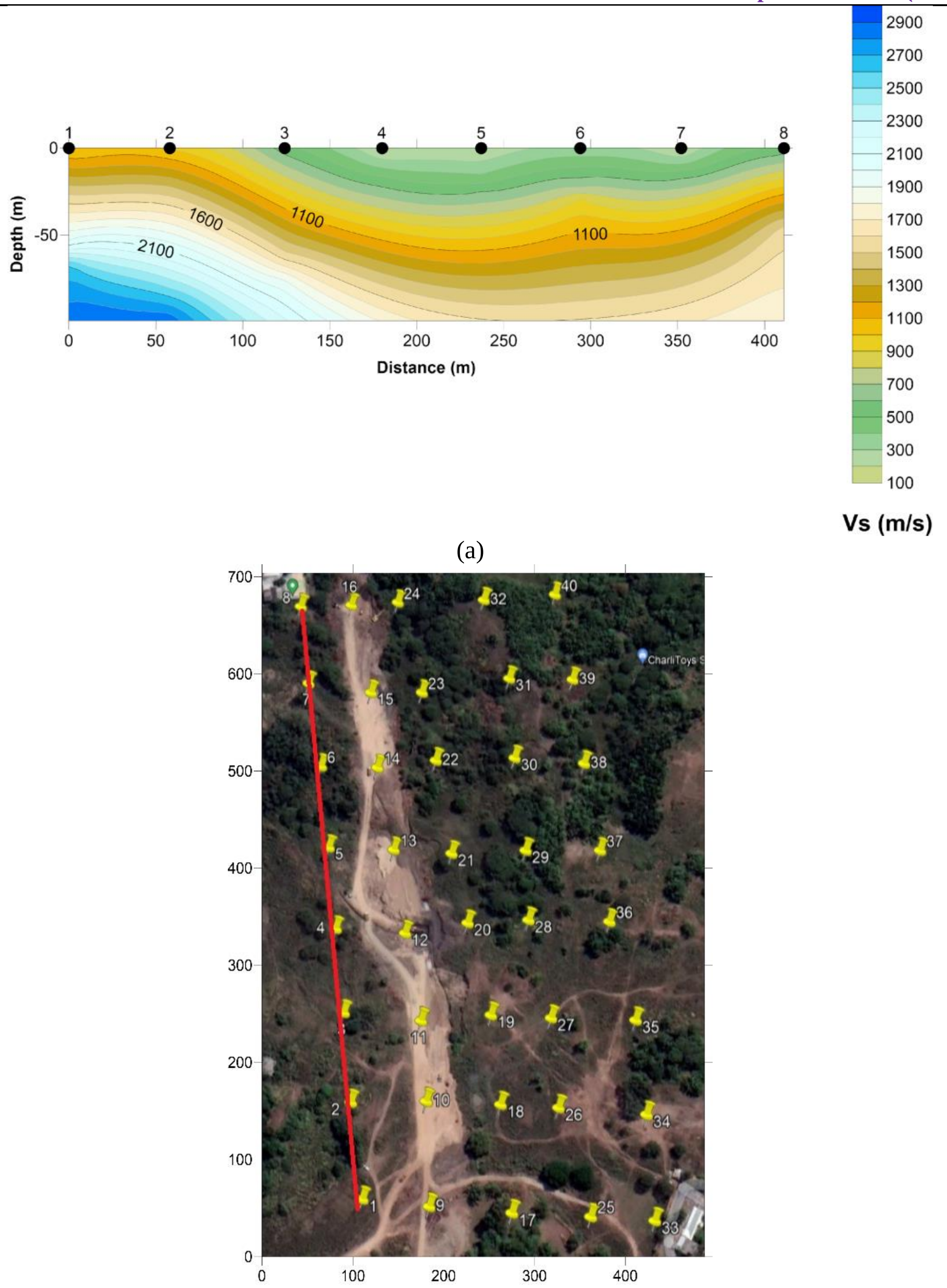


Figure 6. Distribution of Values*Ground Shear Strain* Research Area

E. Analysis of the Shear Wave Velocity Profile (*Vs*)

Profile of Line 1 Shear Wave Velocity Values can be seen in Figure 7. Line 1 consists of 8 measurement points with a track length of 411 m. The depth of measurement obtained is 100 m. shear wave speed (*Vs*) has the lowest value of 179 m/s while the highest is 2,878 m/s. The thickest sediment layer is at point 4 with a thickness of up to 5 meters. At points 1 and 2 indicate the presence of layers of hard rock on the surface. Based on the classification of SNI 1726 (2019), the overall soil layer has a site classification of SD (Medium Soil), SC (Hard soil, very dense and soft rock), SB (Rock) and SA (Hard Rock). Based on the geological conditions of the field, it is suspected that in Line 1 there is a zone prone to ground movement.



(a)

(b)

Figure 7. (a) Shear Wave Velocity Profile (*Vs*) on Line 1
(b) Location of Line 1 in the research area

Profile of Line 2 Shear Wave Velocity Values can be seen in Figure 8. Line 2 consists of 8 measurement points with a track length of 414 m. The depth of measurement obtained is 100 m. shear wave speed (*Vs*) has the lowest value of 194 m/s while the highest is 2,981 m/s. The thickest sediment layer is at point 10 with a thickness of up to 5 meters. At points 11, 12 and 15 indicate the presence of layers of hard rock on the surface. Based on the SNI 1726 (2019) classification, the soil layer as a whole has a site classification of Medium Soil (SD), Hard, very dense soil and soft rock (SC), Rock (SB) and Hard Rock (SA). Based on the geological conditions of the field, it is suspected that in Line 2 there is a zone prone to ground movement.

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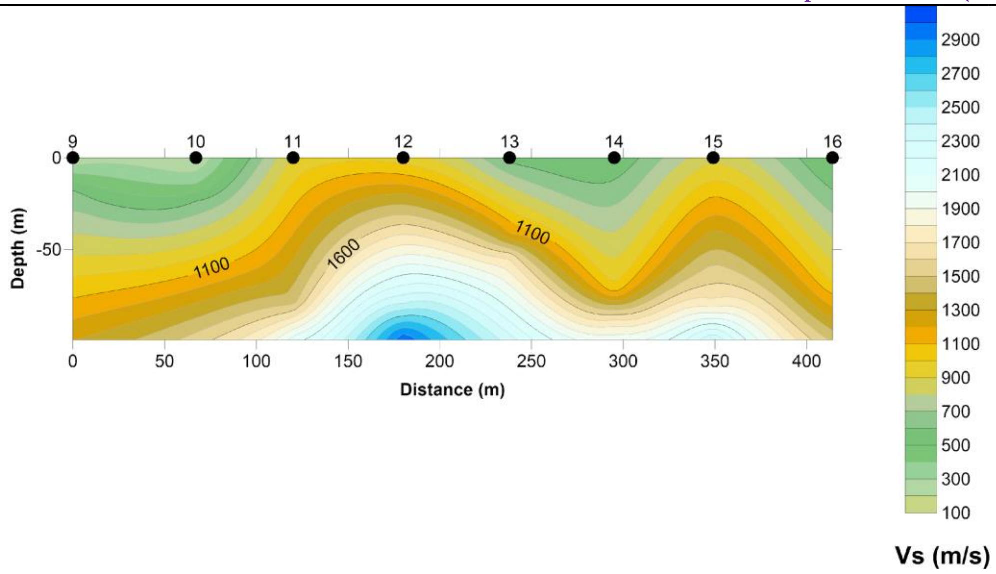
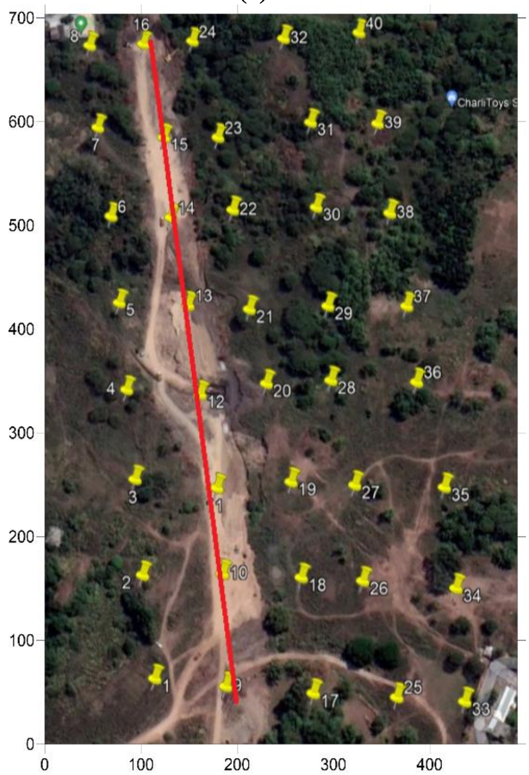


(a)



(b)

Figure 8. (a) Shear Wave Velocity Profile (*Vs*) on Line 2

(b) Location of Line 2 in the study area

IV. Conclusions

Seismic vulnerability index distribution value (*Kg*) around the Undip-Jangli Semarang New Campus Road is worth between 0.27 - 17.27 where the study area is included in the moderately dangerous zone classification on the ground surface (Kanai, 1983). Spread value*Ground Shear Strain* (GSS) in the study area is between 2.46 $x10^{-4}$-$1,39x10^{-3}$, where this value indicates the nature of the soil which is plastic elastic and has the greatest potential to experience fractures and soil subsidence. The shear wave velocity distribution value (*Vs*) profiles of each parameter have been made laterally for each measurement path. The shear wave velocity distribution value

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(*Vs*) around the New Undip-Jangli Semarang Campus Road is worth between 179 - 2,981 m/s which is a classification of SD (Medium Soil), SC (Hard soil, very dense and soft rock), SB (Rock) and SA (Hard Rock) (SNI 1726, 2019). Earth movement vulnerability analysis based on the parameters above indicates several zones of vulnerability to ground movement, namely at points 3, 4, 5, 6, and 7. Points 9, 10, 13, 14 and 16 and between points 16, 24 and 32.

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