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# Deformation Analysis of Jangli Road Section, Diponegoro University, Semarang Using Microtremor Method

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## ABSTRACT

The new road in Tembalang was built to reduce traffic congestion in the Gombel area. Jalan Jangli is an alternative road to Undip or vice versa. There is a deformed road on Jalan Jangli therefore by identifying the characteristics of the soil based on the analysis of the HVSR spectrum (Horizontal to Vertical Spectral Ratio) is used to assess the soil response to vibrations or earthquakes and identify the causes of deformation of Jalan Jangli. The study was conducted with microtremor with 48 measurement station, this study aims to determine the value of soil amplification $(\mathbf{A_0})$, seismic vulnerability index value $(\mathbf{K_g})$, and Ground Shear Strain (GSS) value on Jalan Jangli Baru Tembalang. Based on the results of the study, the distribution value of soil amplification $(\mathbf{A_0})$ on the road of Jangli Tembalang, the amplification value in the research area is 1.0008-6.61. The lowest value is at point 31 and the highest value is at point 36. The value of the seismic vulnerability index $(\mathbf{K_g})$ on the road of Jangli Tembalang is in the range of 0.07-22.76. The highest Ground Shear Strain (GSS) value on the road of Jangli Tembalang is at point 18 with a value of $\mathbf{5,6 \times 10^{-3}}$. Analysis of deformation of the Jangli Road Section based on field conditions at point 36 has a high classification $(\mathbf{A_0})$ and $(\mathbf{K_g})$, the GSS value is 0.003 based on the table of relationships between strain and dynamic soil properties (Ishihara, 1996) including the phenomenon of cracking and land subsidence, this is in accordance with field conditions.

***Keywords:*** *soil amplification, seismic susceptibility index and Ground Shear Strain.*

## INTRODUCTION

Landslides can be triggered by high rainfall or earthquakes. Indonesia's earthquake-prone areas have resulted in several areas also being prone to landslides. The danger of landslides increases with the greater the slope, rock weathering, rock layer structure, and soil texture indicating a higher level of landslide danger [1].

Road damage in the Jangli area, Semarang due to deformation not only disrupts community mobility, but can also endanger the safety of road users and increase maintenance costs.

Deformation is a change in the road surface from its original profile after construction in the form of waves, grooves, collapses, and sungkur [2]. The research location is shown in Figure 1 with a road that has experienced deformation.

**a**

**b**

**c**

**Figure 1. Research area a) road conditions on google earth b) Damaged road conditions c) road conditions after repair**

Landslides are the displacement of slope-forming materials in the form of soil, rocks, embankments or mixed materials that move down or out of the slope [3]. According to the Ministry of Energy and Mineral Resources Indonesian Geological Agency (2015), landslides can be categorized as one of the geological disasters that can be predicted with several parameters that can be used to monitor the possibility of landslides.

Microtremor are natural vibrations of the ground that have an amplitude displacement of around 0.1–1 microns and a speed of 0.001–0.01 cm/s that can be detected by certain seismographs [4]. Microtremor can also be said to be natural harmonic vibrations under the ground surface that occur continuously so that they are trapped in the sediment layer and reflected due to the existence of a layer boundary plane with a fixed frequency [5]. The HVSR (Horizontal to Vertical Spectral Ratio) method to estimate the frequency and amplification values of local geological conditions by comparing the amplification factor from the horizontal direction with the amplification factor from the vertical direction to obtain the dominant frequency value in an area [6].

The dominant frequency is the frequency value that often appears so that it is recognized as the frequency value of the rock layer in the area so that it can indicate the type and characteristics of the rock. In the same geological formation, different dominant frequencies will be obtained, this is due to differences in sedimentation thickness in the area [7]. The amplification factor is the magnification of seismic waves that occurs due to significant differences between layers [8].

The amplification factor value can be grouped into four zones, namely low, medium, high and very high. This classification is explained by [9].

In microseismic measurements, the parameters used are amplification and index $K_g$. Amplification describes the magnitude of wave amplification at a certain medium, with soil amplification being the surface layer to waves (soil layer response). Nakamura's seismic vulnerability index (1998) and Huang & Tseng (2002) to identify the vulnerability of a layer that experiences deformation.

The ability of soil layer material to shift during an earthquake is called Ground Shear Strain (GSS). An area with a high risk of landslides, cracked soil, land subsidence and liquefaction has a high Ground Shear Strain (GSS) value. To determine the Ground Shear Strain (GSS) value, HVSR (Horizontal Vercital Spectral Ratio) analysis is used with the following illustration Dynamic characteristics of soil in the form of dominant frequencies ($f_0$) and amplification factor ($A_0$). The relationship between dynamic properties in soil [10].

## METHODS

This study uses the microtremor method measurement carried out in July 2024 on Jalan Jangli Undip with coordinates Latitude -7.0425, Longitude 110.438 which is located in Tembalang District, Semarang City. Data acquisition was carried out at 48 stations.


**Figure 2. Measurement Station**

The microtremor signals obtained in the acquisition are stored on the GL-240, GL-840 midilogger device and stored in the format*.txt* so that it can be input into the geopsy software. In the geopsy software, the data will be processed into an HV curve that produces a frequency value. ($f_0$), period and amplitude at each acquisition point, From the H/V curve the predominant frequency value is generated ($f_0$) and amplification factor ($A_0$). The results of microtremor signal processing using the HVSR method are then saved in. hv format. Then inversion is carried out using the dinver software in the geopsy software. Shear wave velocity value data ($V_s$) and the depth obtained from the inversion results is used to create a 2D subsurface profile using Surfer 13 software. Next, calculate the Ground Shear Strain (GSS) value using Excel and then create a profile in Surfer 13.

## RESULT AND DISCUSSION

Amplification is the magnification of seismic waves that occurs due to significant differences between layers, in other words, seismic waves will experience amplification when propagating from one medium to another medium that is softer than the initial medium it passes through. Therefore, it can be seen that a high amplification factor in an area will cause the earthquake wave shocks to be greater and of course will cause more severe damage. Amplification is influenced by wave speed. The larger the wave, the greater the amplification [11]. This shows that amplification will also be related to layer density. The distribution of amplification values in the research area can be seen in Figure 3. Based on the results obtained, the amplification value in the research area is 1.0008-6.61. A high amplification value indicates the presence of a soft and thick sediment layer underneath. A large amplification value is very prone to multiple reflections of body waves or trapping of earthquake waves in sediments which will cause great potential damage [12].

**Figure 3. Research location**

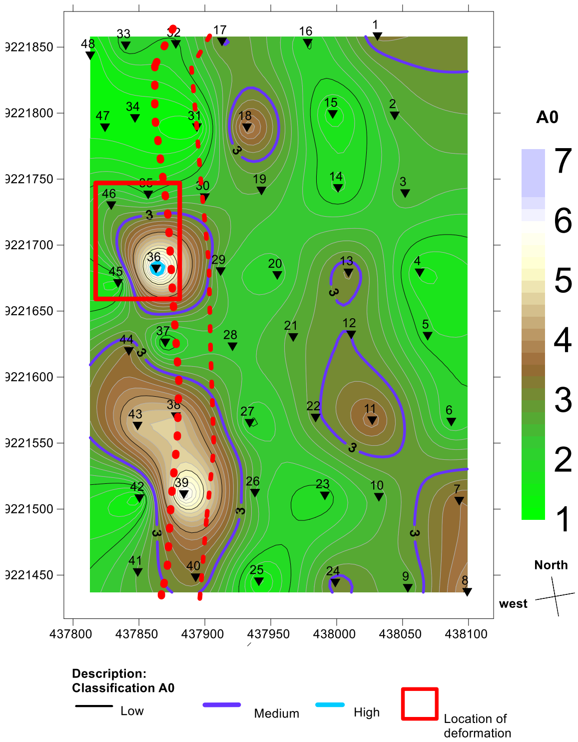


**Figure 4. $A_0$ Contour**

The seismic vulnerability index value (kg) is a parameter to identify the level of vulnerability of an area to strong landslides (Nakamura, 1989). If an area has a large seismic vulnerability index, the level of risk caused by earthquakes will be high. The seismic vulnerability index value is directly proportional to the amplification, the greater the amplification value, the greater the seismic vulnerability value. The distribution of seismic vulnerability index values can be seen in Figure 5. Based on the calculation results, the seismic vulnerability index value in the research area is in the range of 0.07-22.76. Based on the classification [13], a Kg value greater than 20 is included in the high seismic vulnerability classification. In the research area, there are several points that have a kg value of more than 20, including points 18 and 36. Based on field conditions, point 18 indicates soil deformation. Overall, the average kg value in the research area is at 2.96. This value is included in the low classification.

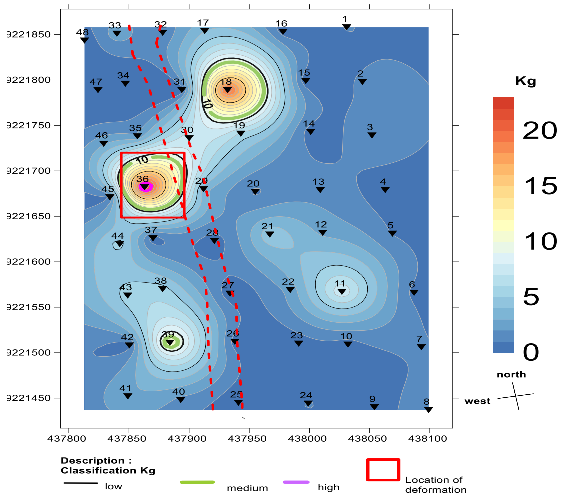


**Figure 5. $K_g$ Contour**

The measured strain value in the research area shows the magnitude of the strain level in the constituent material when an earthquake occurs. Identification caused by the GSS value is obtained after the GSS value from the calculation results is correlated with the identification table and its dynamic properties. The GSS value that occurs is around $10^{-1}$ to $10^{-6}$.

According to Ishihara (1996) and Nakamura (1997) the soil layer will experience a plastic condition if the shear strain value ranges from $10.000 \times 10^{-6}$ and for the shear strain value $>10.000 \times 10^{-6}$ the soil condition will be susceptible to landslide cracks and liquefaction if an earthquake occurs. The distribution of the GSS values of the study can be seen in Figure 6. In the research area, the range $8,6 \times 10^{-5}$ of GSS values is up to $5,6 \times 10^{-3}$. The highest GSS value is at point 18 with a value of $5,6 \times 10^{-3}$.

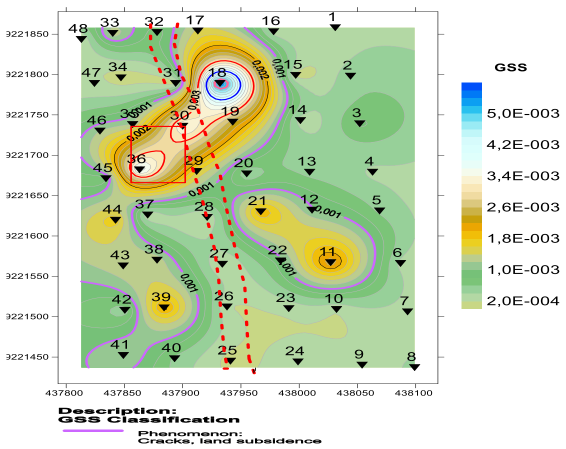


**Figure 6. GSS Contour**

## CONCLUSION

The distribution value of soil amplification $(\mathbf{A_0})$ on the road of Jangli Tembalang, the amplification value in the research area is 1.0008-6.61. The lowest value is at point 31 and the highest value is at point 36. The seismic vulnerability index value on the road of Jangli Tembalang is at a range of 0.07-22.76. The highest Ground Shear Strain (GSS) value on Jalan Jangli Baru Tembalang is at point 18 with a value of $\mathbf{5,6 \times 10^{-3}}$. Analysis of deformation of the Jangli Section based on field conditions at point 36 has a high classification $(\mathbf{A_0})$ dan $(\mathbf{K_g})$ the GSS value of 0.003 based on the table of strain relationships with dynamic soil properties (Ishihara, 1996) is included in the phenomenon of cracking, land subsidence, this is in accordance with field conditions.

## *Declaration by Authors*

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