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Research Paper

Identification of Structure and Lithology of Rocks in the Landslide Area of Kalongan Village, East Ungaran District, Semarang Regency, Central Java Using the HVSR Method.

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***Abstract**: Bandungan Hamlet is administratively located in Kalongan Village, East Ungaran Subdistrict, Semarang Regency, Central Java. The main access road connecting the village to the primary road network has experienced landslides. This study aims to determine the subsurface layering and the depth of the weak zone using the microtremor method, based on the shear wave velocity.The landslide occurred because the soil in the area is soft and loose, situated on the edge of a cliff. During rainfall, the soil becomes saturated with water, and internal water flow (piping) develops within the soil mass. This process leads to soil movement directed toward the river.*

***Key words :**Kalongan, Lanslide,Vp , microtremor*

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I. INTRODUCTION

Bandungan Hamlet is administratively located in Kalongan Village, East Ungaran Subdistrict, Semarang Regency, Central Java. The main access road connecting the hamlet to the primary road network has experienced a landslide, rendering the road impassable. This situation is highly concerning for residents as it disrupts their ability to access the main road, forcing them to take alternative, longer routes.The affected road is strategically significant as it is located near the Sriwedari Terrace, a popular local tourist attraction and an iconic feature of the hamlet. The landslide's impact on this key route not only hampers daily commuting but also affects the tourism potential of the area.

Based on the Geological Map of the Semarang-Magelang Sheet [1], the study area is composed of volcanic and sedimentary rocks from the Kaligetas Formation and the Kerek Formation (Figure 4). The volcanic rocks are predominantly volcanic breccia (Kaligetas Formation), while the sedimentary rocks are mainly sandstone and claystone (Kerek Formation).

The sandstone unit found around the landslide area is characterized by a grayish-brown color with medium to coarse sand-sized grains. This sandstone unit shows significant weathering, with some portions of the rock having disintegrated or degraded into soil [2].

The claystone unit in the study area exhibits a grayish-brown color. It consists of very fine grains and becomes slippery when exposed to water. This claystone unit also shows signs of substantial weathering [2].

Landslides or soil movements occur due to the displacement of soil material to a lower position. Factors contributing to reduced soil bearing capacity include fragile soil structures caused by weathering, increased water content in soil layers due to heavy rainfall, and high-energy vibrations. These are common causes of soil movement.Soil bearing capacity is closely related to dynamic soil parameters such as shear modulus and the ratio of compression wave velocity to shear wave velocity (Vp/Vs). The Vp/Vs ratio can help determine rock lithology as it is associated with the rock's porosity.

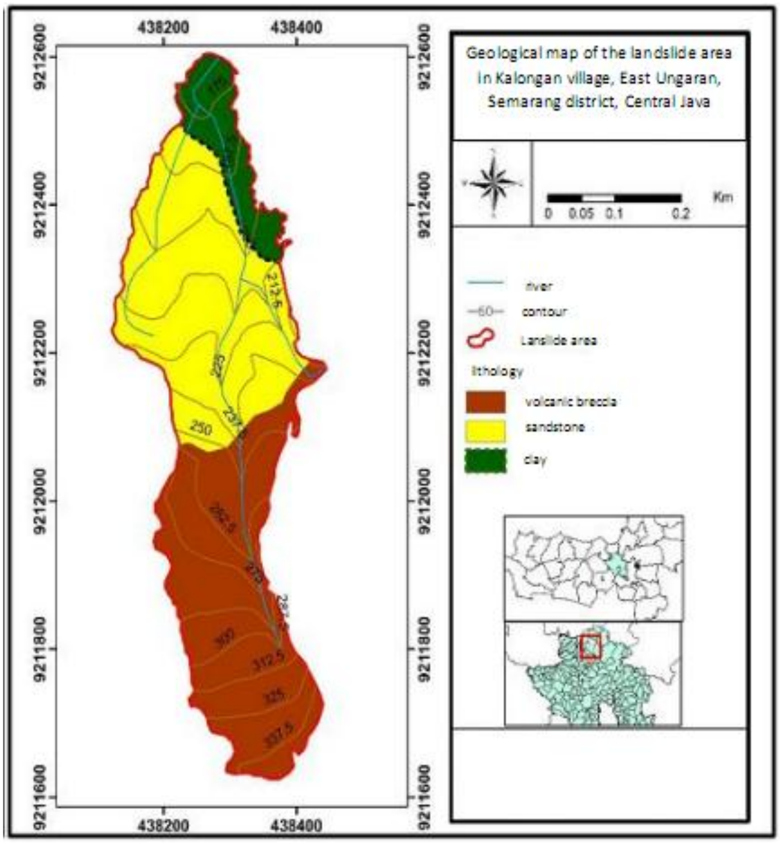


Figure 1:Geological Map of the Study Area [1]

The principle of the HVSR method is to compare the spectrum of the horizontal component with the vertical component of the spectrum of microwaves by assuming that most of the microwaves consist of shear waves and ignore surface waves (Rayleigh and Love waves). This method is almost the same as the transfer function between wave vibrations in sediment and bedrock. According to Nakamura [3] this method is an analytical method based on observations of shear wave propagation due to earthquake events for various geological conditions which can be estimated from the peak period of the microtremor H/V ratio [4]. In general, the HVSR method is a passive seismic method that uses three components in its measurement, namely 2 horizontal components East-West (East-West) and North-South (North-South), and 1 vertical component. Based on Herak [5], natural frequency and amplification are important parameters resulting from the HVSR method and can be used to determine local geological characterization. Ambient noise data can be used for HVSR and array analysis, which is important for obtaining the fundamental frequency of the location and the ellipticity of the fundamental mode of the Rayleigh wave at the location being measured. Array analysis is useful for obtaining dispersion curves, which are needed to estimate the shear wave velocity profile [6].

This study was conducted to identify the causes of soil movement. Determining the characteristics of the landslide is necessary to devise appropriate mitigation measures. The final recommendations are not definitive, as they need to be aligned with insights from other multidisciplinary studies.

II. Method

Data processing using the HVSR method was carried out with Geopsy software. The results of processing data using geopsy software are H/V curves and obtaining frequency (f_0), period, and amplitude values at each data collection point [7]. Subsequent processing is carried out in the dinver software. Dinver software is an inversion application that functions to get density, vp, vs, and depth [8]. The values of density, vp, vs, and depth can be calculated via Ms. Excel to obtain other parameters [9].

The subsurface structural analysis of this area was conducted using P-wave and S-wave velocity approaches. To represent the subsurface structure, 2D velocity profiles were generated for both the North-South and East-West directions.

Field measurements were divided into two track directions: the west-east tracks, denoted by numerical codes (1, 2, ... , 7) (Figure 3), and the south-north tracks, denoted by alphabetical codes (A, B, ... , K) (Figure 4).

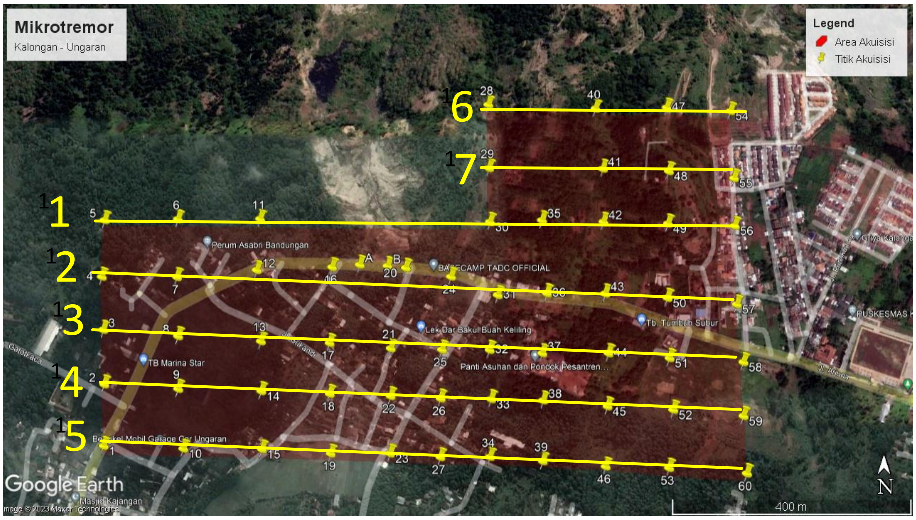


Figure 3. West-East Oriented Traverses

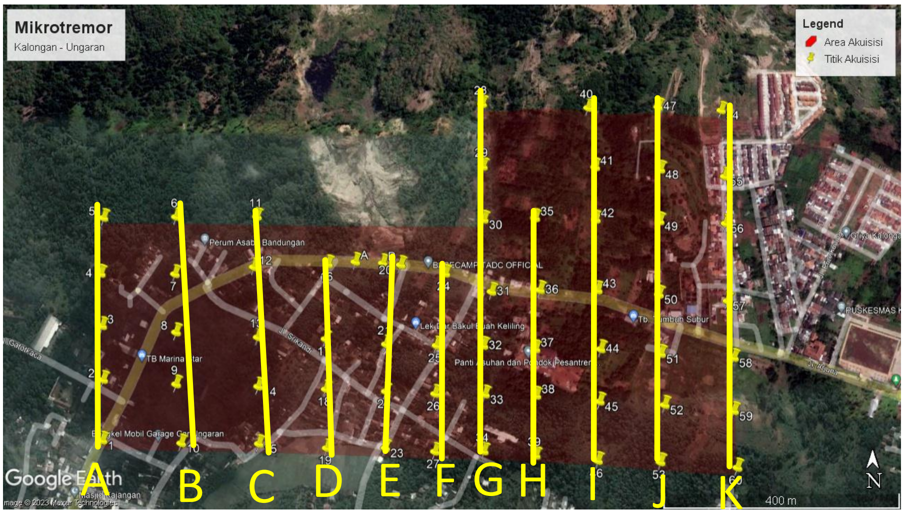
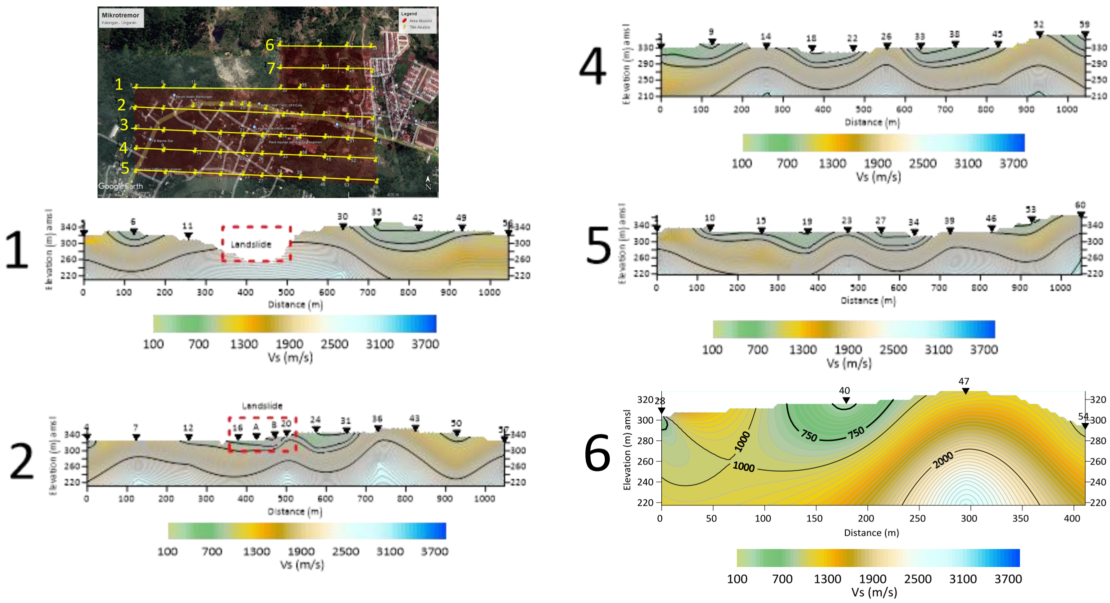


Figure 4. South-North Oriented Traverses

III. Result and Discussion



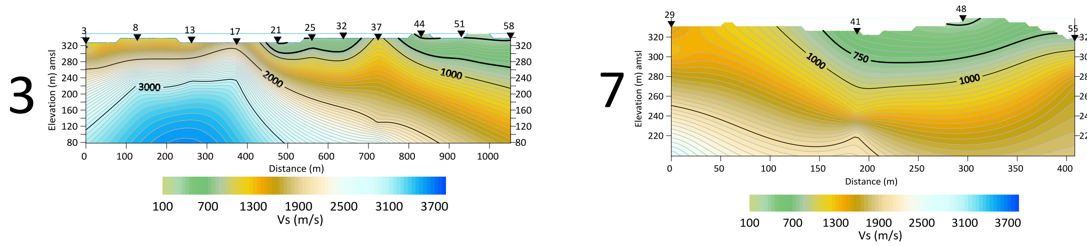
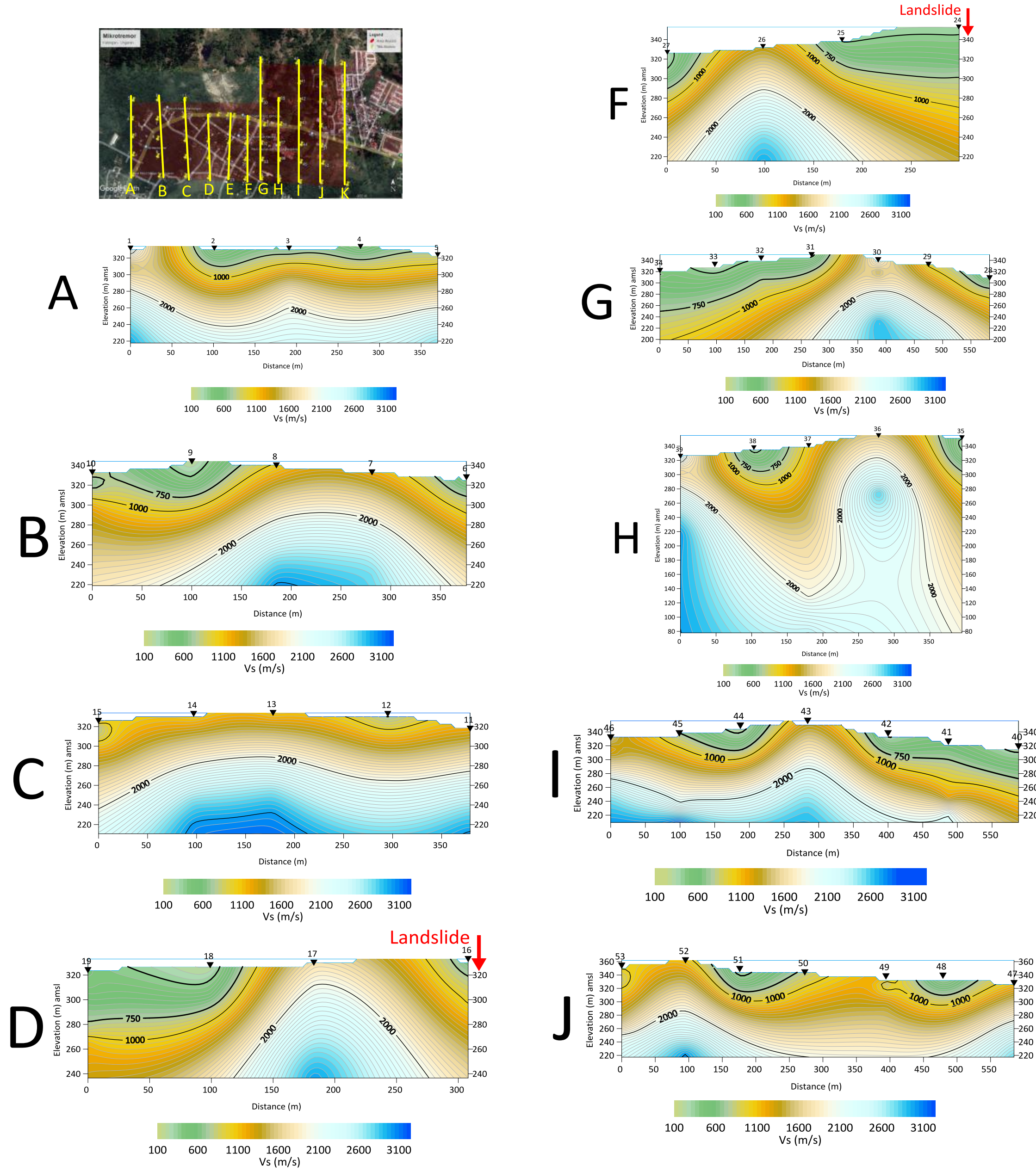


Figure 5. Shear Wave Velocity (Vs) Profile of the West-East Oriented Traverses

Based on Figure 5, in the landslide zone represented by Traverse 1 and Traverse 2, there are differences in the hardness properties of the soil or rock layers, indicated by the shear wave velocity values in the subsurface layers. In Traverse 1, the layers have a shear wave velocity greater than 750 m/s [10], but they are disrupted by soil movement due to gravity towards the north.



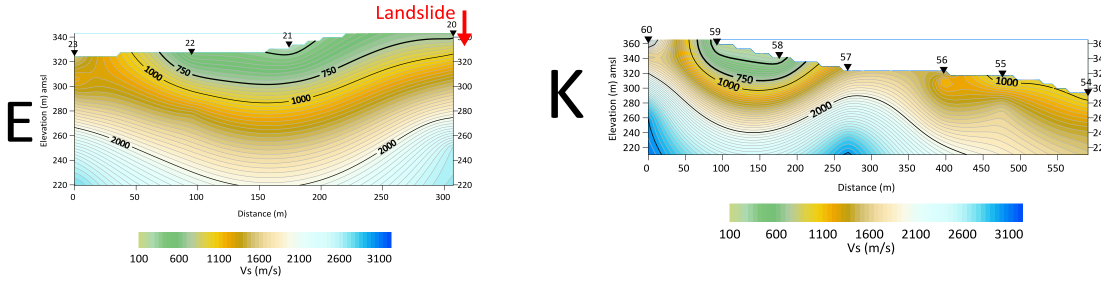


Figure 6. Shear Wave Velocity (Vs) Profile of the South-North Oriented Traverses**.**

Based on the Vs profiles in Figures 4 and 5, a slipping surface is visible in the northern part, specifically along Traverses B, D, F, G, H, and I. The landslide location on the south-north oriented Vs profile is found at Traverse D, Traverse E, and Traverse F. In Traverse E, the direction of the slipping surface is to the north (or the direction of the landslide), while in Traverses D and F, the slipping surface is interpreted to be oriented westward. The bedrock depth below point 16 (Traverse D) is 35 meters, below point 20 (Traverse E) is 20 meters, and below point 24 (Traverse F) is 80 meters.

Based on Figure 4, in the landslide zone represented by Traverse 1 and Traverse 2, there are differences in the hardness of the soil or rock layers based on the shear wave velocity values in the subsurface layers. In Traverse 1, the layers have a shear wave velocity greater than 750 m/s but are disrupted by soil movement due to gravity toward the north. What remains is a layer of hard soil. However, there are missing or insufficient data at around three locations on this traverse, as data acquisition could not be performed due to safety considerations.In Traverse 2, located just south of the section of road that was interrupted, there is a sediment layer (near point B in Figure 4) with a thickness of 15 meters and a length of about 30 meters, resting above hard soil for 120 meters. Based on the Vs profile, the slipping surface is oriented relatively westward. The bedrock depth in this traverse is about 40 meters. Outside of this traverse, other slipping surfaces are found, such as in Traverse 3, below points 44-51-58, and in Traverse 4, between points 52 and 59.

IV. CONCLUSION

Based on shear wave velocity, soil movement in the study area occurs because the soil is soft/loose and located at the edge of a cliff. During rainfall, the soil becomes saturated with water, and even internal water flow within the soil mass (known as piping) occurs, leading to soil movement directed towards the river

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