

# Microtremor Survey In Landslide Zone Of Ngroto Girimulyo Kulonprogo Yogyakarta

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**Abstract.** Research had been conducted to identify thickness of layers of sediment that could potentially lead to landslides. This study used 33 microtremor data analyzed using HVSR, seismic HV, and ellipticity curve. Results showed that value of predominant frequency  $f_0$  ranged from 1.9 Hz to 9.9 Hz and the amplification factor  $A_0$  ranged from 2.8 to 9.6. Microzonation of  $A_0$  indicated a pattern associated with fracture plane. There is a pattern of increasing value of amplification factor around the fracture lines. H/V seismic path of North-South showed that  $A_0 = 9.36$ , associated with sediment layers thickness of 8.80 meters on the fracture lines. H/V seismic path of West-East showed that  $A_0 = 9.8$ , associated with sediment layers thickness of 19.65 meters on the fracture lines.

## INTRODUCTION

Kulonprogo Regency is one of the districts that ranked first in the category of the number of landslide disaster events. This is because Kulonprogo Regency has geographical condition with height between 500 and 1,000 meters above sea level coupled with average rainfall per month of 161 mm and rainy day of 10 mm per day which can trigger the occurrence of landslide in certain area [1]. The occurrence of landslides per year reached 16 events and had damaged 4 houses and closed road segment [2]. From several hamlets located in Purwosari Village, Ngroto is one of the hamlets with very high landslide alertness level. Ngroto Hamlet is inhabited by 118 residents and has a history of fractures in one of the resident building with length of 8-meter which at any time can be a threat.

Movement of land or landslides that occurred can be caused by high rainfall factors, slope, land use and can also be triggered by earthquake. Earthquake can trigger landslide in a lower stability of soil structure in an area. One of the approach used to identify ground motion based on seismic wave propagation or earthquake is microtremor approach. The microtremor approach can describe local geological conditions from predominant frequency parameters and amplification factors. In addition, the identification of ground motion or landslide can be approached using seismic cross section of the H/V curve to determine the magnitude of the amplification factor associated with thickness of sediment layer. The purpose of this study is to get the predominant frequency microzonation and amplification factor and sediment layer thickness based on the seismic cross section of the H/V curve in the region which has high risk level of landslide.

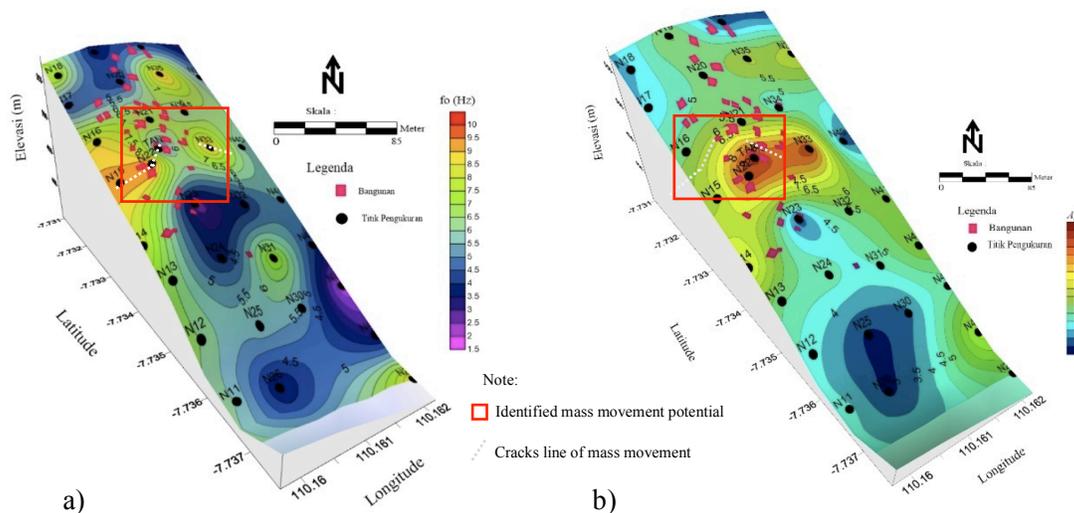
## METHOD

This study used microtremor data from 33 measurement points. Research location was in Ngroto area of Purwosari Village, Girimulyo Subdistrict of Kulonprogo Regency. The site was located at 7° 43 '52.314' S - 7° 44' 13.984 " S and 110° 9 '35.418' E - 110° 9' 43.830 " E. Research points were distributed on Kebobutak formation with composite rock material such as sand, dacite, brecciated andesite, clay, lapilli tuff, agglomerate rock, lava melt and andesite. The research was started by measuring microtremor signals and analyzing them using HVSR (*Horizontal to Vertical Spectra Ratio*) method to produce H/V spectrums[3]. The HV-generated H/V spectrum was then used to determine soil and subsurface rock characteristics as a function of predominant frequency values and amplification factor values.

## RESULTS AND DISCUSSION

### Microzonation of Predominant Frequency and Amplification Factor

The microzonation of predominant frequency values ( $f_0$ ) in Ngroto hamlet is shown in Figure 1. The distribution of predominant frequency values is categorized into three categories based on the class interval method i.e. low, medium, and high. A low  $f_0$  value ranged from 1.5 to 4.5 Hz is distributed in the southern part of the research area representing the conditions of thick sediment layers composed of sand material, clays, agglomerates and tili lapillas due to the accumulation of material from the north of the study area and the topography factor. The  $f_0$  values ranged from 4.5 to 7.5 Hz distributed in the northern part and southern part of the study area and have a thick sedimentary layer with material composed of rocky material. The  $f_0$  value with high category ranged from 7.5 to 9.1 Hz which is distributed in the western part of the research area and representing area with sediment layer that is shallower than the surrounding area where the characteristics of the material is composed by hard rock.



**FIGURE 1.** Maps of microzonation values: a) predominant frequency and b) amplification factor value in the study area.

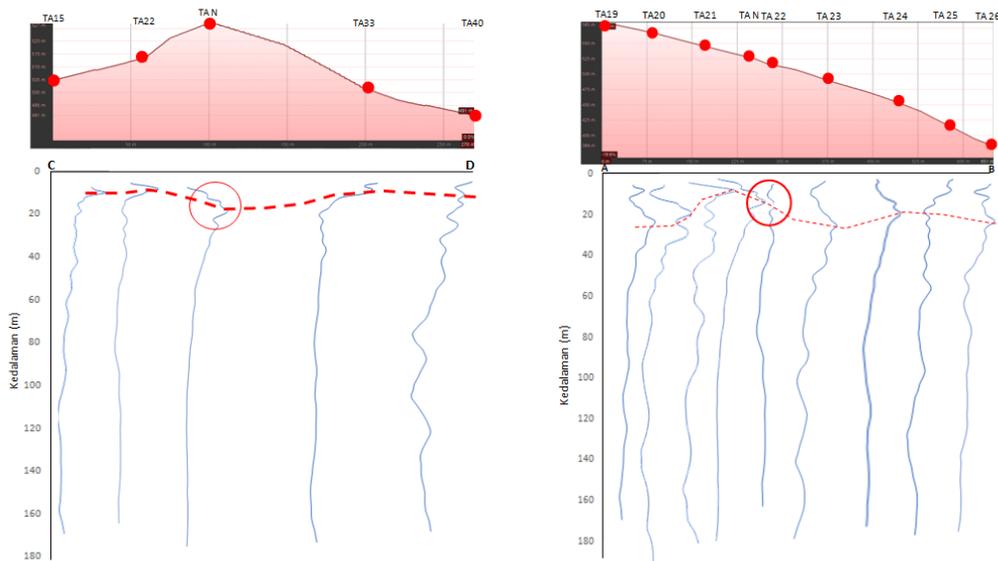
The soil amplification factor is a description of the change (enlargement) of ground vibration acceleration from the bedrock layer to the sediment layer. The greater the amplification factor is, the greater the acceleration of ground vibration on the surface<sup>[4]</sup>. When the amplification factor of an area is high, the risk of damage to the building experienced by an area is higher and vice versa. Ngroto area has amplification factor ( $A_0$ ) of 2.8 to 9.6.

In Figure 1(b), areas with high amplification factor with values of 7.5 - 9.6 are located in the upper middle of the study area shown at points N22, TAN, and N33. This indicates that all three points with high amplification factor

( $A_0$ ) have high acceleration of ground vibration and will affect the stability and balance of the building, thus lead to a risk to the building. Areas with medium amplification factor which has values of 5 - 7.4 are distributed in the middle and southeastern part of the study area. Then for regions with low amplification factor with values of 2.8 - 4.9 are distributed in the southern part of the study area. Based on the distribution of amplification values, the upper middle part of the research area has a high risk of damage to the buildings.

### Seismic Cross-section Analysis of The H/V Curve

Identification of sediment layer thickness in the study area can use 2 seismic cross sections with orientation of north-south and west-east direction. The seismic cross-sectional model represents the depth and amplification factors.



**FIGURE 2.** Seismic cross section on line a) C-D (East-West orientation) and b) A-B (North-South orientation)

Based on the cross section of the H/V curve of the C-D orientation (the east-west orientation) in Figure 2(a), there is a variation in the thickness of the sediment layer from 10.89 to 75.84 meters. The amplification factor values in this line ranged from 3.1 to 9.5. In the A-B line as shown in Figure 2(b) (north-south orientation), it has a sediment layer thickness of 8.83 - 75.09 meters and has variations in the amplification factor ranging from 3.1 to 9.6. Areas with high amplification potential are in the upper middle region with amplification value of 9.6. This condition is also correlated with the phenomenon of mass movement and 8 meters land fracture in the residents houses.

Based on the cross-sectional pattern of the east-west and north-south line, the region with a potential for ground motion distributed in the center of the study area, where it has a characteristic of increasing amplification factor along with the increase in the thickness of the sediment layer. This condition identifies the enlargement of seismic waves in the area so that it can lead to mass movement.

The 3D model shown in Figure 3 illustrates the distribution of amplification factor values and the thickness of the sediment layer. It shows that the deeper the sediment layer in an area is, the smaller the amplification factor. This shows that the depth of rock layers represents rocks with a lower seismic vibration response. The highest amplification factor values is located in the middle part of the study area and correlates with mass movement events.

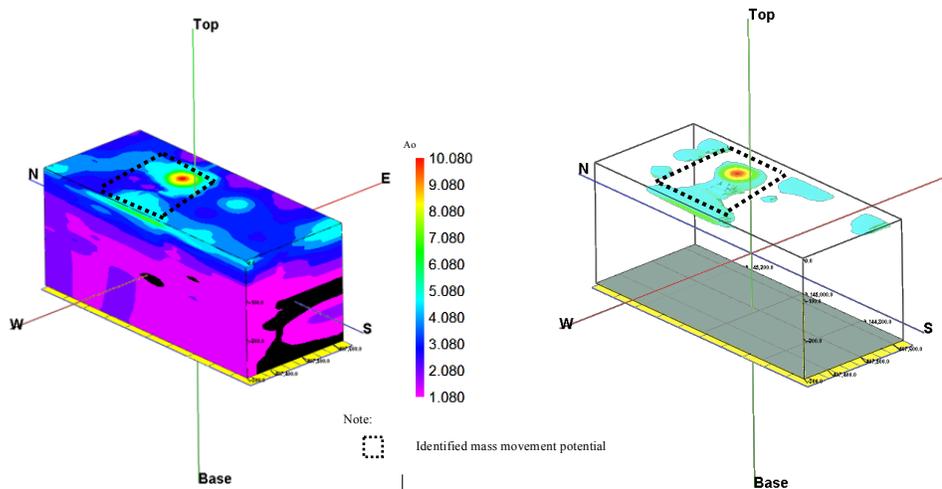


FIGURE 3. 3D Models of Sediment Layers and Amplification Factors in Ngroto Hamlet

## CONCLUSION

1. In the study area, the predominant frequency variation ranged from 1.5 to 9.1 Hz and amplification factors ranged from 2.8 to 9.6. The highest amplification factor is located in the middle part of the study area that correlates with mass movement phenomenon.
2. Seismic cross section of the H/V curve shows an increase in the amplification factor along with an increase in the sediment layer thickness.

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