Application of microseismic methods for identification of ground movement potential in Cemara sub-village, Sukorejo village, Gunungpati Semarang

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Khumaedi*, Supriyadi, Sugiyanto and N A Pratiwi

Department of Physics, Faculty of Mathematics and Natural Science, Universitas Negeri Semarang, Indonesia

*Corresponding author: medisas@mail.unnes.ac.id

Abstract. Based on data of landslide from Regional Disaster Mitigation Board (BPBD), Sukorejo village is one of three urban villages in Gunungpati which has a high potential possibility for disaster, particularly landslide. One of the areas in Sukorejo Village that frequently sustains of land movement is Kampung Cemara. On April 23, 2018 in Kampung Cemara, a landslide occurred which caused detrimental damage to buildings. Several other accidents signified ground movement resulting cracks in the land surface. The high level of losses is not only induced by the magnitude of the disaster, but also due to inadequate information related to the potential for disasters and conditions in the area, that it decreases public awareness of the environment. That is the main reason for this micro seismic research. Micro seismic is a geophysical method which employ to determine the ground motion potency through the subsurface layer characteristics by calculating the value of Ground Shear Strain (GSS). The data processing is using the HVSR method. The value was ranged from 4.54 x 10^{-3} to 1.59 x 10^{-2}. The result represents that Kampung Cemara is considerably potential to undergo land movements with plastic-elastic soil properties and ground motion phenomena that can effect vibration and cracks in surface land and habitation.

1. Introduction

In topographically profile, Semarang consisted of hilly areas, lowlands and coastal areas. It indicates of various slopes and protrusions. According to Regional Disaster Mitigation Board (BPBD) data in 2020, there are nine out of sixteen sub-districts in Semarang that have landslide-prone points. The nine sub-districts are Banyumanik, Gunungpati, Gajahmungkur, Tembalang, Ngaliyan, Mijen, Tugu, Semarang Selatan and Semarang Barat. Most landslides occurs on the high hills with 15-45% of slide slope., Gunungpati sub-district is a landslide-prone area in Semarang. Topography condition in Gunungpati are corrugated soil and ravine/steep. BPBD Semarang city released that there are three villages in Gunungpati that have the potential for landslides, namely Sukorejo, Sadeng and Sekaran. However, it was not explained in detail where it was Based on the many research, Sukorejo Village has a high potential of landslides [1-3] . One of the areas in Sukorejo Village that frequently sustains of land movement is Kampung Cemara. Landslides occur when the slope goes to the processes that change its condition from stable to unstable condition. The landslide is triggered by a specific event (such as a heavy rainfall, an earthquake, a slope cut to build a road, and many others), although this is not always

identifiable. Microseismic is one of geophysical methods which employ to determine the ground motion potency through the subsurface layer characteristics by calculating the value of Ground Shear Strain (*GSS*). The Horizontal to Vertical Spectral Ratio (HVSR) metod was used on this research. The result of H/V curve contains frequency and amplification value. The basic assumptions of the HVSR and the amplitude discrepancy is primarily due to the vertical site response and the HVSR at the bedrock [4]. There is a consensus that HVSR resembles the empirical transfer function (ETF) in shape (alignment of peaks and troughs) and can thus be utilized to reliably reveal the (horizontal) fundamental frequency (f_0) of a site [5]. The mechanical and geometrical characteristics of the layers determine the fundamental frequency [6]. While the amplification effect of the vertical component are counterbalanced by the effect of refracting the ray path towards the vertical [4]. Ground Shear Strain can analyze the ground movement prone area such as landslides, liquefaction, fractures, vibrations, etc [8-10]. This research aimed to illustrates the characteristics of the sub-surface layer for identification ground movement potential in Kampung Cemara, Sukorejo Village and can be used as supporting data in mitigation of landslides.

2. Methods

Microsismic measurement is using the seismometer Vibralog MAE type-S3S while it is completed by data-logger, seismic sensor, data cables, GPS and compass. This research data is collecting in 20 points with spaces between points 50 meter. The duration of recording microseismic data at each point is 30 minutes. It based on intruction of mikroseismic book [11]. The seismometer vibralog records ambient seismic noise. Ambient seismic noise appear to be particularly suitable for planetary exploration, it's because they can involve ultra-light instrumentation, non-invasive, fast and easy to deploy, and applicable in reach areas or rough terrains [12]. The measurements were managed to be recorded in suitable conditions where there is no wind and rain by means of stable installation of seismometer on the ground and controlling the accuracy of level [13]. This data will be primary data in research. While secondary data is earthquake data of Wonosobo in 2013 and the V_{s30} value from the USGS website. Data analysis or data processing is using HVSR (Horizontal to Vertical Spectral Ratio) method. It has been analyzed by using *Geopsy* software. This software contains information of recording time of wave, amount of data, and another supporting data. Before analysis HVSR method, micro seismic data is in selection signal processing by windowing and cutting the noise or transien ambient signal. The Fourier amplitude spectral of each selected window are computed and smoothened after which the two horizontal components are merged applying the geometric mean [14]. The HVSR approach is a widespread tool for estimating the site resonance frequencies and the curve of H/V contain the frequency and amplification value. The peaks in HVSR correspond to the relative peaks of S and troughs of P waves [15]. The HVSR method has been widely used to estimate the resonance frequency or amplification of a site under the excitation of ambient noise or earthquake motion. The fundamental frequency is low for thick deposits or extremely soft materials and high for a very thin (shallow) layers [16]. The peak frequency (fpf/f_0) can be related to the average shear wave velocity(Vs) and thickness of the surface layer (*h*) [17]. To calculate the value of surface layer (*h*) needs Vs_{30} value from USGS Website. Determining the dynamic properties of a soil and that is widely used in site classification is the average shear wave velocity up to 30 m in depth. Then from frequency and amplification value can obtained the seismic vulnerability value (*Kg*) [18]. Then calculate the Peak Ground Acceleration (*PGA*) with magnitudo, hypocentre by earthquake data of Wonosobo on 2013 and periode dominan (T_0) by parameter of frequency. So the *Ground Shear Strain* (*GSS*) value can be found. The last step is microzonation process by Surfer and interpretation of the *GSS* value. Micro zonation of ground shear strain helps map areas to look out for and figure spots of highest potential ground movement probability. Then the phenomenon for *GSS* (γ) value is classified by the table that related to strain and the dynamic nature of the soil.

3. Results and Discussion

Research was done by Seismometer 3 component Vibralog MAE type- S3S. The 3D component is a seismic wave in time function with vertical**,** north-south component and east-west component. The time

function or time domain is converted by Fast Fourier Transform into a frequency function and then the spectrum ratio of the horizontal component to the vertical component (HVSR) and amplification are calculated using Geopsy software. H/V curve contain frequency and amplification value. This value is used to calculate the seismic vulnerability (*Kg*)**,** the Peak Ground Acceleration (*PGA*) and Ground Shear Strain (*GSS*). The GSS value is influenced by the seismic vulnerability index value, the Peak Ground Acceleration (PGA) value, and the seismic wave velocity in the base rock (C_b).

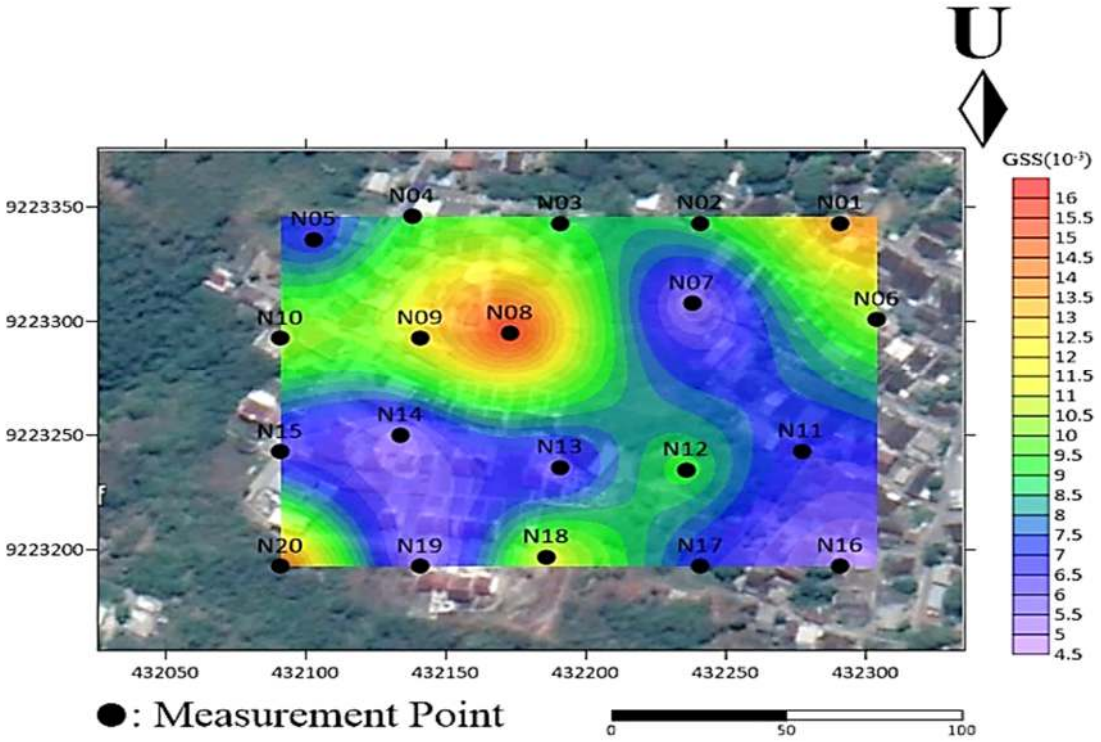

Figure 1. Ground Shear Strain (GSS) Contour Map of Kampung Cemara

The ground shear strain is an ability to stretch and shift upon receiving elastic wave propagation [19]. Maximun ground acceleration and seismic susceptibility parameter can determine the ground shear strain value. The maximum ground acceleration with earthquake data from Wonosobo is used to calculate the GSS value. Figure 1. shows that the GSS values in the Kampung Cemara area is having GSS values ranging in 4.54 x 10^{-3} to 1.59 x 10^{-2}. The lowest GSS value in the purple scale zone. While the largest value in the red zone. The value of the GSS are include on the order of 10^{-2}. The dynamics properties classification of this category is collapse soil due to repeated vibration and the phenomenon will probably occur are landslide, soil compaction, liquefaction [8**,** 20-22]. Based on the result and the phenomena, the research area has the high potential for landslide or disaster.

4. Conclusion

The value of the GSS in Kampung Cemara is range from 4.54 x 10^{-3} to 1.59 x 10^{-2}. The GSS value are include in the order category of 10^{-2}. The dynamics properties description of this category is collapse soil and the phenomenon of landslide will probably occur are landslide, soil compaction, liquefaction. So the research area has the high potential for landslide.

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