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Identification of Potential Fissure Zone in the Hospitality Area, Yogyakarta, Indonesia Using Microtremor Data

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Abstract. In order to increase employment, community income, regional income, state income, and foreign exchange profits, efforts to develop and utilize various tourism potentials are one of the core industries that can drive economic activity, including other connected sector activities. Yogyakarta's various tourism potentials are linked to other tourism accommodations, such as hotel buildings. In December 2019, the number of tourists to Yogyakarta who stayed in hotels reached 9.01 million. Of course, tourists' water requirements are numerous, causing the groundwater level to drop. The reduction of groundwater levels is coupled with sloping topography, which increases the risk of soil fissures in the Yogyakarta city region. Because it is located in the ring of fire, Yogyakarta is vulnerable to earthquakes. Based on microtremor data, the goal of this study was to identify regions prone to earthquake-induced soil fissures caused by excessive groundwater extraction. Geological investigations and microtremor measurements are used in the research. The findings suggest that most of the study region has the potential for soil fracture due to earthquakes, with ground share strain values on the order of 10-4. However, no liquefaction potential because the most significant value of ground share strain is 0.000141.

1. Introduction

In Yogyakarta, there are 580 hotels, 90 of which are star hotels and 490 of which are non-star hotels and other accommodations [1]. In the last three months of 2018, tourists staying at Hotel Yogyakarta reached 1.460.284 people [2]. In December 2018, hotel visitors used a total of 78,006,240 liters per visitor. The city of Yogyakarta has groundwater reserves of 228,165,256 m3 / 228. 165,256,000 liters for the top aquifer system, and about 313,605,356 m3 / 313,605,356,000 liters for the bottom aquifer system [3]. As a result of the increasing number of hotel visitors and usage by the local population, the potential for groundwater level fall in Yogyakarta is very high. A drop in groundwater level causes ground cracks. Soil fractures can result from a drop in groundwater level. Soil fractures are cracks in the soil that can be created by a drop in groundwater level or other geological events. The main cause of soil fissures in big cities like Jakarta, Semarang [4][5], Arizona[6], and Mexico[7] is a reduction in groundwater level due to continual groundwater extraction. Microtremor readings can be used to map locations prone to soil fracture to lessen the risk of soil fracture. Human actions and natural phenomena are both sources

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of microtremor. Microtremor observations can be used to identify geological conditions and the thickness of the surface sediment layer, which describes the state of the bedrock surface (the layer beneath the surface sediment layer) in a given area [7].The goal of this study was to use microtremor data to identify locations prone to earthquakes caused by soil fissures. Furthermore, the findings of microtremor and maximum ground vibration acceleration (PGA) readings can be utilized to calculate ground shear strain, which describes the level of strain in the surface sediment layer and its influence due to earthquakes. If the ground shear strain in the area is 10-4-10-2[7], soil fracture will occur. This study will serve as a guide for planning groundwater use. It will provide an overview of the adverse effects of soil cracks that can occur due to excessive groundwater extraction in Yogyakarta.

2. Geological Setting

The formations in the study area are Alluvium (Qa), Merapi Volcanic Formation (Qvm), Young Merapi Volcanic Deposits (Qmi), Old Merapi Volcanic Deposits (Qmo), Kepek Formation (Tmpk), Wonosari - Punung Formation (Tmwl), Sentolo Formation (Tmps), Oyo Formation (Tmo), Wuni Formation (Tmw), Sambipitu Formation (Tms), Semilir Formation (Tms), Nglanggran Formation (Tmng), Kebo-Butak Formation (Tomk), and Mandalika Formation (Towm)[8].

3. Method

The Mark L4-3D seismometer is used for microseismic measurements and is equipped with a data logger, seismic sensor, data cables, GPS, and compass. The data for this investigation were gathered in 24 locations separated by approximately 2000 meters. The seismometer was stabilized on the ground and the level precision was controlled to ensure that the readings were taken in ideal conditions with no wind or rain. Due to the locations of the measurement points being in urban areas, the measurements were conducted at night to minimize noise. The first steps in processing microtremor data with geopsy software were signal filtering, windowing, and data analysis. The HVSR technique was applied to data that had been collected, selected, processed in accordance with Sesame European Project criteria, and computed using free geopsy software. [9][10][11][12]. Before computing the spectra, the window length for each data point was adjusted to 15 seconds to capture the low frequency of the H/V peak curve at a sampling rate of 100 samples per second and a 5% cosine taper value. The mean and linear trends of all windows were calculated using Geopsy software, then converted to Fourier spectra and smoothed using Konno and Ohmachi's b=15 method.

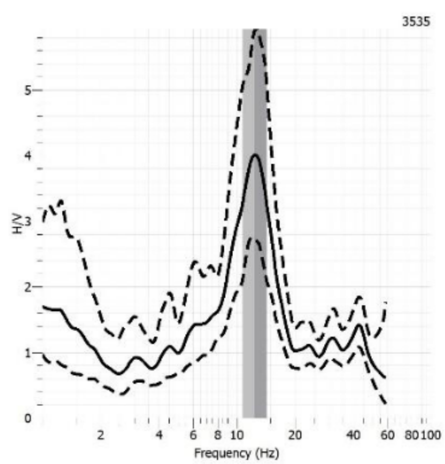

Figure 1. H/V curve of point MS07

The bulk of H/V curve observations indicate the presence of a single significant peak (Figure 1) with amplitudes consistent with an amplification value of around 4.008. This amplification value may be a result of a large impedance gap between the bedrock and the sedimentary layer above. A prominent peak with a dominating frequency of approximately 12.281 Hz appears in the research region. Then, using data from the Yogyakarta earthquake's magnitude, hypocenter, and dominant period (T0), calculate the Peak Ground Acceleration (PGA). As a result, the Ground Shear Strain (GSS) value can be determined. Surfer's microzonation and interpretation of the GSS value is the final phase. Microzonation of ground shear strains assists in identifying areas to monitor and highlighting areas with the greatest potential for ground movement. Table 1 then characterizes the GSS (γ) value phenomenon as being related to strain and the dynamic nature of the soil.

Table 1. GSS values derived from the sediment layer's dynamic characteristics [14]

Size of Strain γ	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}
Phenomena	Wave, Vibration		Crack, Settlement		Landslide, Soil Compaction, Liquefaction	
Dynamic Properties	Elasticity		Elasto-Plasticity		Collapse	
			Repeat-Effect, Speed-Effect of Loading			

4. Results and Discussion

The distribution value of the ground shear strain is depicted in Figure 2. In PGA calculations, the hypocenter and magnitude of an earthquake greater than 5 Mw are used as parameters. The PGA computation returned a value of 27.186-32.89 gal in this research region. Almost all places, according to Ishihara's classification [14], have a high fissure susceptibility, with a ground shear strain value of roughly 10-4-10-2. The Depok District (blue color) has a low ground shear strain value as a result of low amplification (low contrast between the sedimentary layer and the bedrock) and a high dominant frequency value, indicating a thin sedimentary layer. While the red zone is most valuable, it is mostly a hospitality zone. The GSS is estimated to be worth tens of thousands of dollars. The dynamical characteristics of this category are fissure, soil compaction, and liquefaction, while the most likely occurrences are fissure, soil compaction, and liquefaction. [5][15][16]. According to the research findings and phenomena, the research region has a high risk of fissure or tragedy.

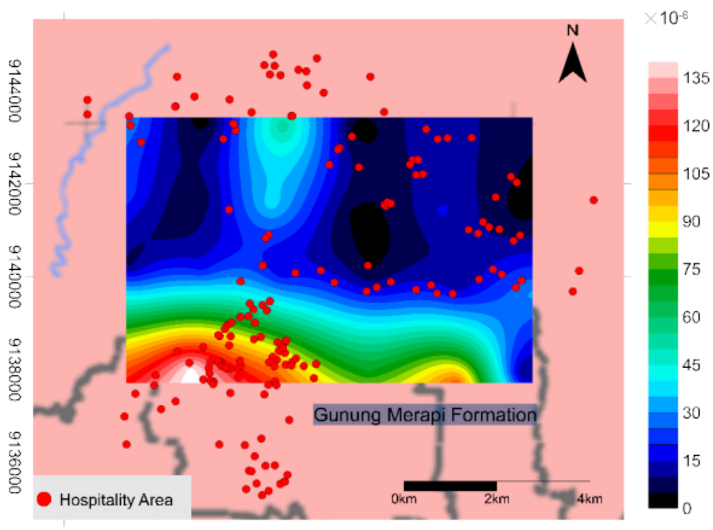

Figure 2. Ground shear strain distribution map with Geology base map

5. Acknowledgement

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