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SEISMIC VULNERABILITY INDEX MICROZONATION IN MUARA AMAN CITY BASED ON HVSR METHOD

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Abstract

Muara Aman City has a high frequency of earthquakes. The research aims to map earthquake-prone areas using indicators such as natural/dominant frequency value parameter (f_0), amplification factor (A_0), and seismic vulnerability index (K_g). Measurements in this study were conducted using a PASI Mod Gemini 2 Sn-1405 seismometer for 30 minutes at 21 measurement points. The data processing results include natural frequency: 0.15-8.59 Hz, amplification factor: 0.97-6.009, and seismic vulnerability index: 0.2-56.3 After obtaining the values of these parameters, a distribution map is created by pairing each parameter value with the coordinates of the research point. Based on the values of these parameters, areas with high seismic vulnerability are found in zones T3, T4, T5, T6, T15, and T16. The research findings can offer valuable insights for both the community and government in implementing strategies to minimize the impact of earthquake damage and losses.

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INTRODUCTION

The Eurasian plate, the Indo-Australian plate, and the Pacific plate are the three active plate borders that cross Indonesia. The Indo-Australian plate and the Eurasian plate interact in the western region of Indonesia, extending south of Java Island and west of Sumatra Island to Nusa Tenggara (Isrona et al., 2022). As a result of these plate dynamics, faults on land begin to shift. Among these faults is the Great Sumatran Fault, commonly referred to as the Sumatra Fault (Fauziah, 2023). Sumatra Island is split in half by the Sumatra fault, which runs parallel to the subduction zone's alignment from Andaman Bay in the north to Semangko Bay in the south (Putri & Annisa, 2021). There are multiple sections to the Sumatra fault that splits the island (Julius & Marbun, 2014). On the island of Sumatra, this leads to numerous active faults, one of which is located in the province of Bengkulu. One of the active faults in Bengkulu Province is the Ketaun Segment. Bengkulu Province experiences tectonic earthquakes as a result of the existence of this fault (Supartoyo et al., 2018). Earthquakes classified as tectonic are caused by the shifting of the earth's crust as a result of energy released in the subduction zone. Strong earthquakes are caused by plate tectonics (Nisa Hanifah, 2021).

The Ketaun Fragment blame found in Lebong Rule extending from Ketahun to Muara Aman is regularly the most figure causing harm to the Lebong Rule region, particularly the region straightforwardly navigated such as Muara Aman which is one of the foremost vital regions in Lebong Rule when an seismic tremor happens due to Ketaun Section blame action. Earthquake damage depends on several factors including earthquake strength, earthquake depth, distance to the hypocentre, shock duration, soil condition, distance to the fault and building condition. According to the Lebong District RCPD data for 2019, the soil structure in Lebong District includes: fine-grained soil in an area of 105,454 hectares, medium-grained soil in an area of 76,837 hectares, and coarse-grained soil in an area of 10,633 hectares. Soil types in Lebong County include andosol, alluvial, hornwort, latosol, andosol latosol, lithosol latosol and padsolik latosol. Meanwhile, according to the geological map produced by the (Gafoer, s., T.C. Amin., 2007) Muara Aman is composed of the Hulusamping Formation, which is the oldest mountain unit in the Bengkulu Basin, formed in the Oligocene-Early Miocene. The main component of the formation is altered andesitic volcanic sediments that have undergone vitrification alteration and mineralisation.

According to previous studies (Natawidjaya, 2017), it can be predicted that an earthquake with a magnitude of over 7.0 SR will cause major damage in and around the Muara Aman area, and the conditions will be very different from those in 1943 and 1952, when there were more buildings and a growing number of residents. This means that the probability of damage and casualties is quite high if we do not have an adequate risk mitigation system in place. So far, no earthquake preparedness or risk mitigation studies have been conducted in Muara Aman City, although it is very important to reduce damage and casualties from earthquakes. One way to reduce the impact is to avoid buildings in earthquake-prone areas. This can be done by mapping earthquake-prone areas, one way being to micro-zone based on the seismic hazard index in Muara Aman City. Research on seismic vulnerability index using Microtremor method. Microtremor is used to estimate the soil vulnerability index. This method can be used to analyze soil characteristics, namely dominant frequency (f_0), and amplification factor (A_0). From these parameters, a seismic vulnerability index microzonation map can be created in Muara Aman City. The findings of this research are to provide greater insight into the anticipation of earthquake disaster mitigation and for sustainable development programs for the community and government.

Geoglogi Regional

The study area is located in the town of Muara Aman, which belongs to the district of North Lebong. The geological map shown in Figure 1 shows that Muara Aman consists of the Fursamping Formation, the oldest rock formation in the Bengkulu Basin, which was formed in the Oligocene to

Lower Miocene. The main component of this formation is altered andesitic volcanic sediments that have undergone vitrification, alteration and mineralisation.

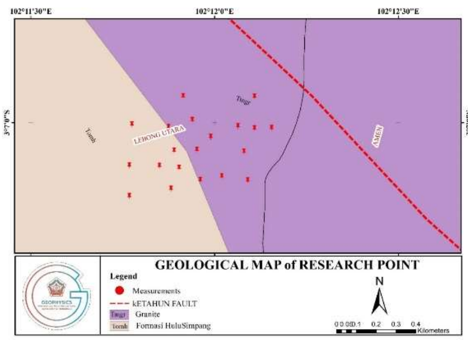

Figure 1. Geological map of the Muara Aman Township area (Gafoer, s., T.C. Amin., 2007)

METHOD

Microtremor measurements were conducted in Muara Aman City, Lebong Regency, Bengkulu Province. The data obtained is based on the measurement results at 21 points. The research survey design map can be seen in Figure 2.

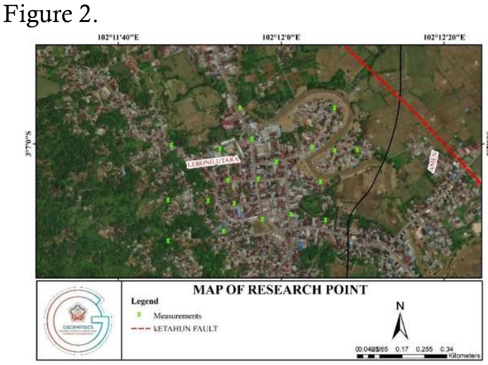

Figure 2. Survey design of the study area

At each data collection point, the acquisition process continued for 30 minutes and the sampling rate was 200 Hz (Bard et al., 2004). A PASI Mod Gemini 2 Sn1405 portable short-period seismometer was used during data collection to record ambient noise, and a laptop computer, connecting cable, GPS, compass, and camera were also used as equipment. During data collection, data were recorded as signalling data in *SAF format (Dal Moro & Panza, 2022).

Microtremor is a small, continuous vibration wave that is trapped in the surface layer of the sludge and bounces off the boundary device at a stable frequency, causing microvibrations in the subsurface and other external influences (Andre Rahmat Al Ansory et al., 2024).

The acquired data is processed using Geopsy software to obtain the natural frequency and maximum amplitude value using HVSR analysis process. In order to eliminate or reduce noise in the received signal, filtering was performed during data processing to obtain the expected main signal. The next step is manual window selection. Manual selection is performed to be able to select signals in specific time windows that have less noise and the most stationary signals are selected. After completing the windowing process, the three components of the signal consisting of North-South, East-West and Top-Bottom components will be analysed using HVSR where after HVSR analysis, the value of natural frequency (f0) and its amplification (A0) will be obtained. The value of seismic susceptibility (Kg) can be found by dividing the square of maximum amplitude by the value of natural frequency (Panjaitan et al., 2023).

From the result of the dominant frequency, the subsurface frequency can be inferred and the rock type and nature can be determined (Arifin et al., 2014). his dominant frequency is calculated using FFT (Fast Fourier Transform), where in the time domain the HVSR curve is converted to frequency domain (Lantu et al., 2018). Amplification (A_0) is the change in the magnitude of seismic waves caused by significant differences in material types between subsurface layers (Robiana, 2018). The character of horizontal signals with vertical signals will be proportional to the amplification of the waves as they pass through the medium (Tanjung et al., 2019).

The rock layer will be deformed by earthquake waves, this is because the ground surface is vulnerable, this is also interpreted as seismic vulnerability index (Panjaitan et al., 2023). A parameter that indicates the level of vulnerability to earthquakes based on the subsurface conditions in an area is called the seismic vulnerability value (K_g). This seismic vulnerability value is proportional to the induced exposure (Fatimah et al., 2019). The seismic vulnerability value is different in each region, so it is always necessary to compare with other points in the study area when determining the Kg value.

RESULT AND DISCUSSION

The research area has the Hulusimpang rock formation which is the oldest rock unit in the Bengkulu Basin which was formed in the Oligocene-Early Miocene. The main constituent of the formation is altered andesite volcanic deposits which have undergone vitrification, alteration and mineralization. The Bukit Barisan Mountains, located in the western part of mainland Sumatra, border the volcanic arc (Gafoer, s., T.C. Amin., 2007).

Table 1. Data Acquisition Point Coordinates

Point	Longitude	Latitude
Point 1	102.199	-3.115
Point 2	102.198	-3.117
Point 3	102.199	-3.117
Point 4	102.202	-3.115
Point 5	102.201	-3.117
Point 6	102.200	-3.117
Point 7	102.198	-3.118
Point 8	102.198	-3.119
Point 9	102.200	-3.117
Point 10	102.202	-3.117
Point 11	102.203	-3.117
Point 12	102.201	-3.118
Point 13	102.199	-3.119
Point 14	102.198	-3.120
Point 15	102.199	-3.118
Point 16	102.200	-3.119
Point 17	102.198	-3.119
Point 18	102.202	-3.119
Point 19	102.196	-3.117
Point 20	102.196	-3.119
Point 21	102.196	-3.120

Natural Frequency (f_0)

The value of the natural frequency describes the thickness of the weathered layer below the surface and the speed of the waves through the medium (Tanjung et al., 2019), the higher the value of a natural frequency, the lower the thickness of the weathered layer and vice versa. If the value of the natural frequency is high, an area tends to be at low risk (Rahma, 2022).

The characteristics of the subsurface rock can be learnt from the value of its natural frequency. According to the results of the study, the value of natural frequency distribution in Muara Aman Town, Lebong Regency, Bengkulu Province is shown in Figure 3.

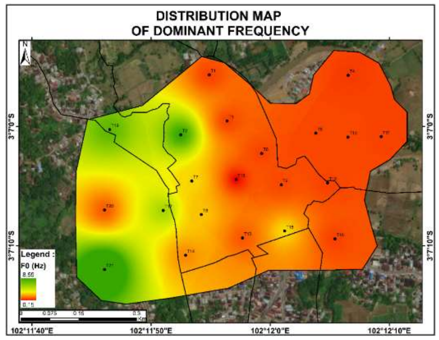

Figure 2. Dominant frequency distribution map (f_0)

The variation of the dominant frequency value (f0) varies from the value range of 0.97 Hz-8.59 Hz. Rock types have different dominant frequency values. The variation of the dominant frequency value around the research area is generally type 4 and 2. Based on the soil classification based on the dominant frequency value by Where describes the thickness of sediments whose surface is in the medium category of 5-10 metres which is composed of alluvial rocks (sedimentary rocks), which has a thickness of 5 metres. It consists of sandy gravel, sandy hard clay, and loam. In Figure 3 it can be seen that areas T2, T17, T19, and T21 have dominant frequency values in the range of 4.48-8.6 Hz which on the map are shown in green.

Dominant Amplication

According to the classification of amplification values (Hadi et al., 2021) the velocity of waves propagating in the medium is a factor that affects the magnitude of amplification, when the wave velocity is low, the amplification will be greater and vice versa. This explains that the density level of the rock is related to the amplification factor (Syahputri & Sismanto, 2020). Soft sedimentary rocks prolong the travelling time of waves in the area.

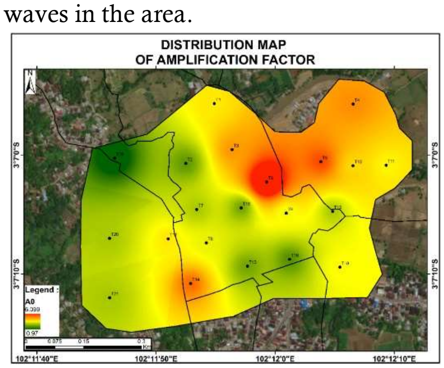

Figure 3. Map Distribution of amplification factor values (A_0)

The gain value in the study area has a value in the range of 0.97-6.009. The distribution map of gain values in the study area is shown in Figure 4. The distribution map of gain values shows that the study area has mostly small values of gain which can be seen in green colour with values of 0.97-2.87.

Yellow and red colours in the map indicate moderate to high amplification values with values ranging from 3 to 6.099 which are shown at sites T1, T3, T4, T5, T6, T10, T11, T14 and T17.

Seismic Vulnerability Index (K_g)

The distribution of seismic vulnerability index shows that there are several locations that have a high value of seismic vulnerability index with a value of 6.1-56.4 in zones T1, T3, T4, T5, T6, T9, T10, T11, T12, T14, T15, T16 and T18 shown in red and yellow colour. The results show that the soil types at locations with high values of the seismic vulnerability index are areas with soil types prone to earthquakes.

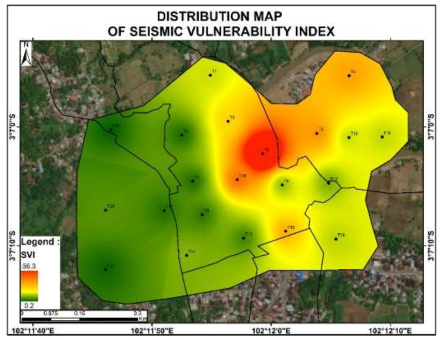

Figure 4. Map Distribution of amplification factor values (A_0)

CONCLUSION

The value of dominant frequency in Muara Aman city, Lebong regency has a value range of 0.15-8.59 Hz, the value of amplification factor has a value range of 0.97-6.009, and the value of seismic vulnerability index is 0.2-56.3. From the analysis of micro tremor data by the value of dominant frequency, amplification factor and seismic vulnerability index, it is found that the areas with high earthquake probability are located in T3, T4, T5, T6, T15 and T16 zones.

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