POTENTIAL RISK MAPPING OF EARTHQUAKE DISASTER BASED ON SEISMIC VULNERABILITY INDEX IN PRAMBANAN AREA OF SLEMAN – KLATEN

Hesti [1], Akroma Hidayatika [2], Rahmi Mulyasari [3]
[1] Geophysical Engineering, Faculty of Engineering, University of Lampung
* E- mail correspondence: hesti.9201@eng.unila.ac.id

Abstract: Prambanan is an area that suffered severe damage in the earthquake in Yogyakarta in 2006 was marked by damage of houses and Prambanan buildings. The purpose of this study is to map the level of vulnerability earthquake events to minimize the risk of loss . This research was conducted using a single station microtremor data at 124 measurement points. Microtremor data were analyzed by the HVSR method to obtain the dominance frequency (fo) and amplification (Ao) values . Furthermore, the seismic vulnerability index value obtained at each point based on the value dominant frequency (fo) and amplification (Ao) . Seismic vulnerability index values in this study ranged from 0.16-179.38. The factors are then mapped by dividing the 4 zones of vulnerability to the herd that is very high, high, medium, and low .

Keywords : Microtremor, HVSR, Dominant Period , Dominant Frequency, Seismic Vulnerability Index

I. INTRODUCTION

Prambanan District is located on the border between Yogyakarta and Klaten. Yogyakarta and Klaten areas are part of the route earthquake that stretches from the islands of Sumatra, Java, Bali to Nusa Tenggara. As an area located in the earthquake lane, the physiographic conditions of the Regions of Yogyakarta and Klaten are greatly influenced by the Indo-Australian plate collision activity with the Eurasian plate. This condition makes the Yogyakarta and Klaten Regions one areas with high levels of seismic activity in Indonesia. Besides being prone to earthquake due to plate collision activity, the Region Yogyakarta is also a prone to earthquake due to the activity of several local faults on the mainland[2].

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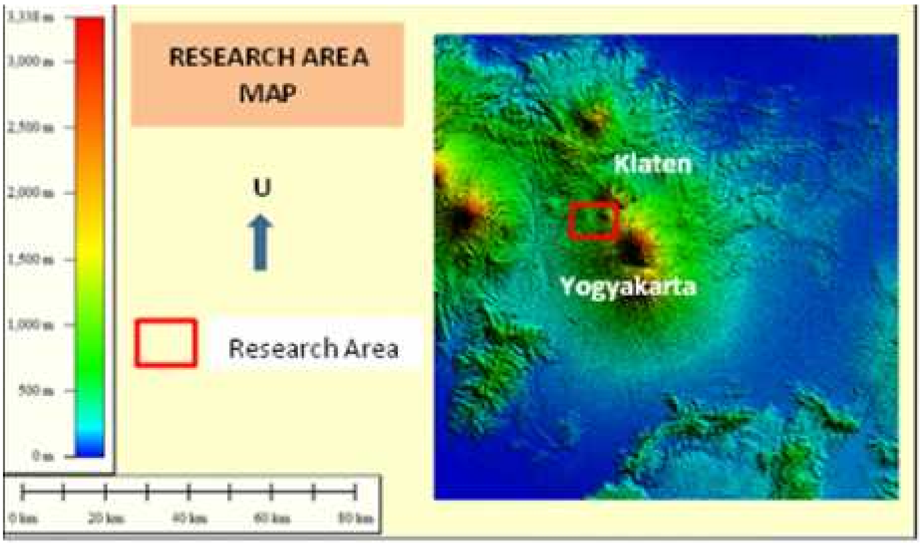

Figure 1 Research area map

In the 2006 Yogyakarta earthquake the Prambanan area get enough damage is marked by damage Prambanan temple buildings especially the Brahmana temple which was damaged on the stupa and fall in a radial pattern around them (Figure 2)

Figure 2 Damage of Prambanan Temple due to the 2006 Yogyakarta earthquake[3]

Research in the Prambanan temple complex has been carried out by Djumarma et al (2010). The results of this study indicate that in the area it is covered by sufficiently young Merapi Volcano deposits which is around 30-40 meters thick and has not been consolidated strong so that it makes the complex area of Prambanan Temple become quite risky when shaken by an earthquake. Research area is the Merapi Muda volcanic deposit which is in the Quaternary age[7].

This study conducted by analyzing the microtremor data to get seismic vulnerability index parameters, where this parameter can be used to see a vulnerability region by looking at the value of its seismic activity. Then zone the area to see areas with very high levels and high to low of vulnerability indeks on earthquake events.

II. MATERIALS AND METHODS

2.1 Tools and Materials

This study use a single station mictrotremor data, software Matlab to change CSV data format to SAF, Geopsy software to get the value of fo and Ao., and ArcGis 10.2 software to create a vulnerability map.

2.2 Research Methods)

The method in this study contains several stages performed, namely analysis of the horizontal to vertical spectral ratio (HVSR) curve, calculation of the value of seismic vulnerability index (Kg), and creat a map vulnerability zone. In simple terms this research method is in Figure 3.

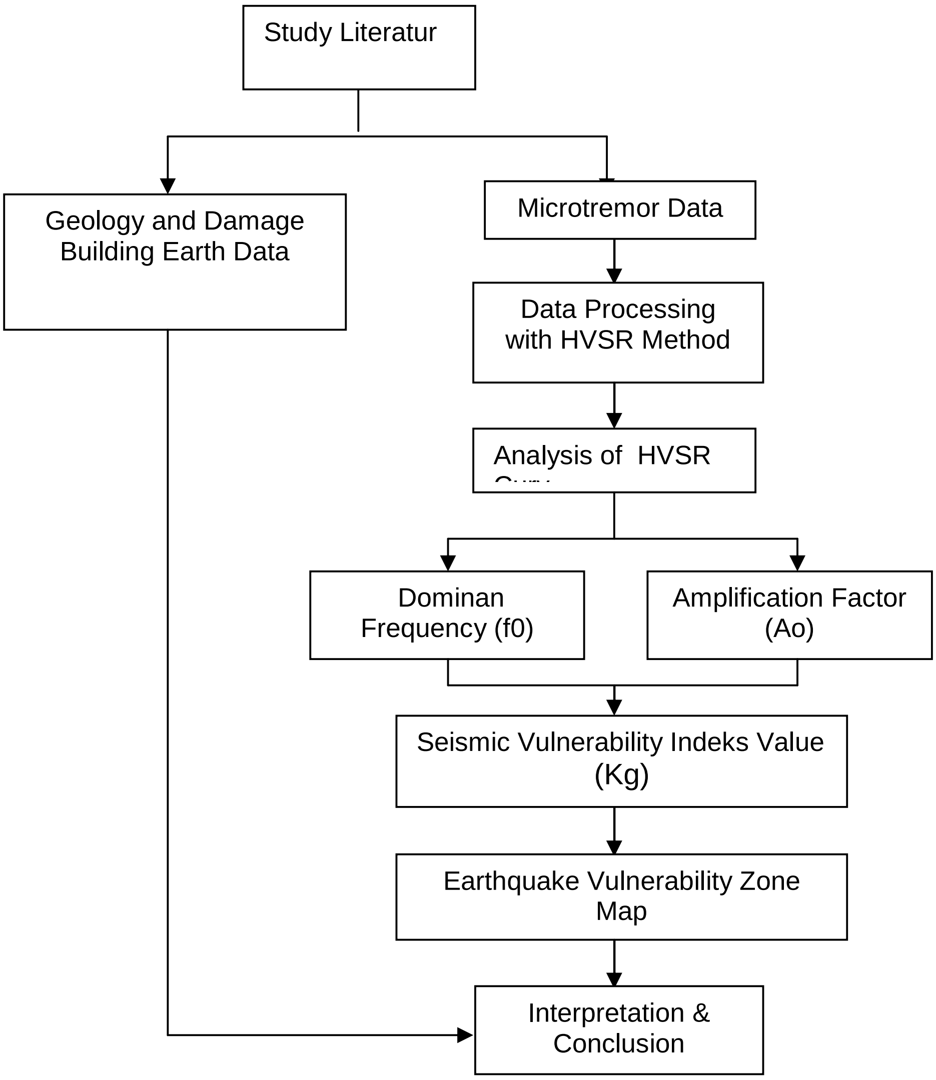

Figure 3 Flowchart of research methods

2.2.1 Horizontal to Vertical Spectral Ratio (HVSR) Analysis

Microtremor data analysis can be done using Horizontal to Vertical Spectrum Ratio (HVSR) method. HVSR method, or often called the Nakamura method, is an empirical technique to estimate the resonance characteristics of the sedimentary layers below surface[4].

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HVSR analysis is done by analyzing the HVSR curve from microtremor data processing using GEOPSY software. Analysis HVSR is needed to get the value of the dominant frequency factor (fo), dominant period factor (To) and amplification factor (Ao). Vertical component of HVSR curve shows the magnitude of the amplification value (Ao) and horizontal component shows the magnitude of the dominant frequency value (fo). The dominant period value (To) is obtained from its relationship with the frequency value dominant (fo) which has a reverse relationship.

Processing on the Geopsy software begins with opening 3 component microtremor data which is data in the time domain. This data is displayed in raw data as shown in Figure 4.

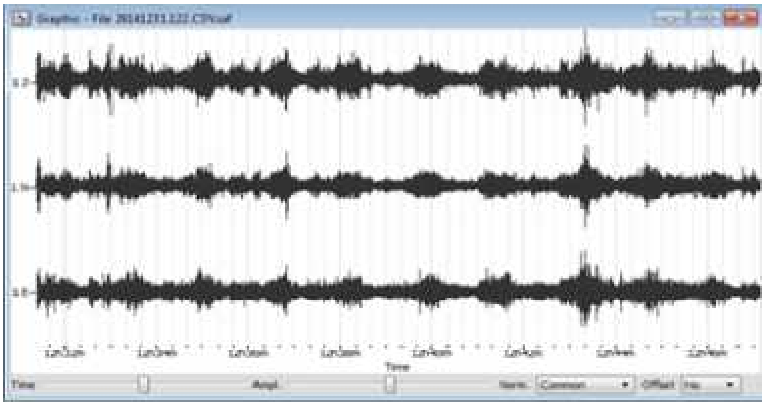
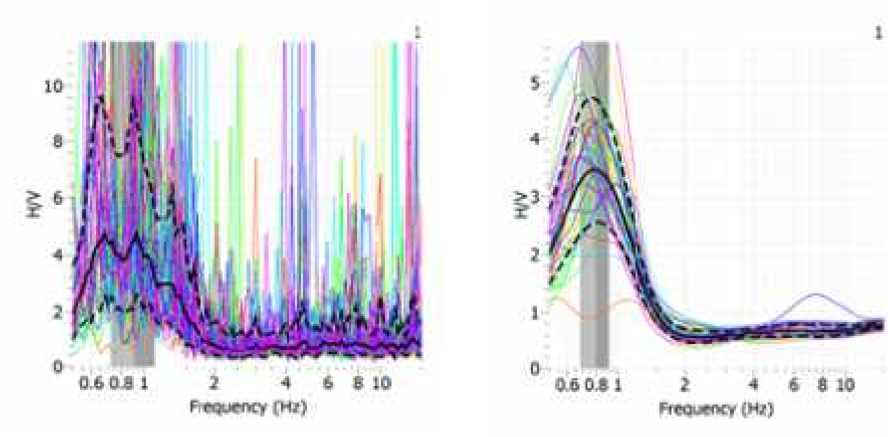


Figure 4. Raw 3 component microtremor data for point 4 signal recording

By carrying out several stages of data processing using the HVSR method the HVSR curve is obtained. The result of HVSR curve will look rough so it is necessary smoothing process (smoothing) in order to obtain a curve smooth one. The difference in the HVSR curve that is experienced refinement of data and no, can be seen in Figure 5. This research using a bandwidth value of 10 in order to obtain the HVSR curve with small standard deviation.



(a) b)

Figure 5 . Signal spectrum measured by point 4 (a) Display of the previous signal smoothing is done, (b) Display the signal after smoothing is done

The value of dominant frequency (fo) and amplification factor (Ao) in the area measurements can be determined based on the HVSR curve produced as in Figure 5.

2.2.2 Determination of the value of Seismic Vulnerability Index (Kg)

Nakamura introduces seismic vulnerability index parameters (Kg) which can describe the level of vulnerability of the soil layer which the surface against deformation when an earthquake occurs[5] . Wave seismic originating from earthquake including mechanical waves. Seismic vulnerability index values at each measurement point are calculated use the following equation:

$$\frac{A^2}{f_0} = K_g \qquad (1.1)$$

Where Kg = seismic vulnerability index
fo = dominant frequency (Hz)
Ao = Amplification factor

2.2.2 Making a Vulnerability Map

The final stage of this research is to create a vulnerability earthquakes level zoning map based on the distribution of vulnerability seismic index values in Prambanan District. Map of vulnerability is shared into 4 zoning namely very high, high, medium, and low. Vulnerability map zone is create using ArcGis software version 10.2

III. RESULTS AND DISCUSSION

The first results in this study are HVSR curves which has the amplification value Ao and dominant frequency fo. HVSR curve obtained from data processing with a single station microtremor using the HVSR method. The HVSR curve display is exemplified in Figure 6.

3.

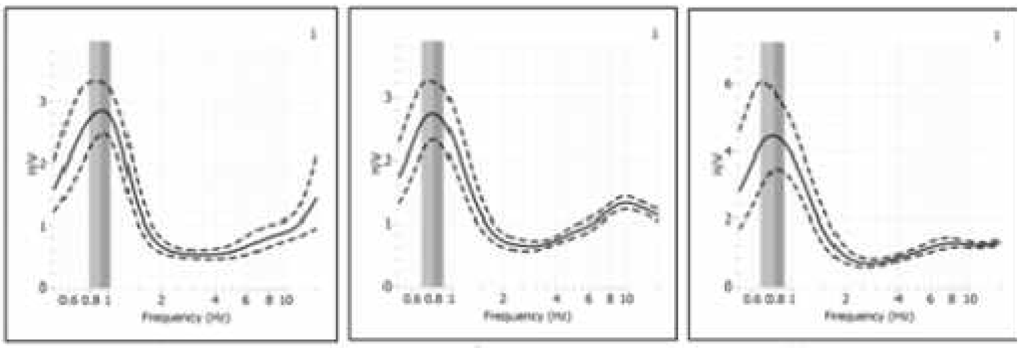


Figure 6 Example of the HVSR curve spectrum at 3 measurement points

The vertical component of the HVSR curve shows the value amplification (Ao) and horizontal components indicate the magnitude of the value dominant frequency (fo). The dominant period value (To) is obtained from relation to the dominant frequency value (fo) that has a relationship the opposite.

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The dominant frequency values obtained in this study range between 0.63 - 6.78 Hz, while the dominant period values are the results of this study 0.15 s - 1.57 s and the amplification value is between 0.75 - 12.81 times. From the dominant frequency value (fo) and Amplification (Ao), the value is obtained Seismic Vulnerability Index (Kg) using equation (1.1).

Seismic vulnerability index values in the study area ranged 0.16-179.38. Map of the distribution of seismic vulnerability index values in Prambanan area is divided into 4 zones, namely the red zone, yellow, blue and green. The lowest seismic vulnerability index is shown in green with a value of less than 4. Seismic vulnerability index medium is shown in blue with values ranging from 4- 8. A high seismic vulnerability index is shown in yellow with values ranging from 8-12. The seismic vulnerability index is very high indicated in red with a value of more than 12.

Areas that have a very high vulnerability index include a fairly large area in the research area, namely in the village of Bokoharjo, Kebondalem Kidul, Taji, Sanggrahan, Kemudo, Kebondalem Lord and Tologo. Areas that have a partially high seismic vulnerability index .The big one is located in the villages of Tlogo, Bugisan, and Kebondalem Lor, an area which is has a medium vulnerability index mostly located in villages Tlogo, Bugisan, Kokosan and Kebondalem Lor. Area that has Low seismic vulnerability index covers a narrow area and scattered in the villages of Tlogo and Kokosan. Detail can be seen in (Figure 6).

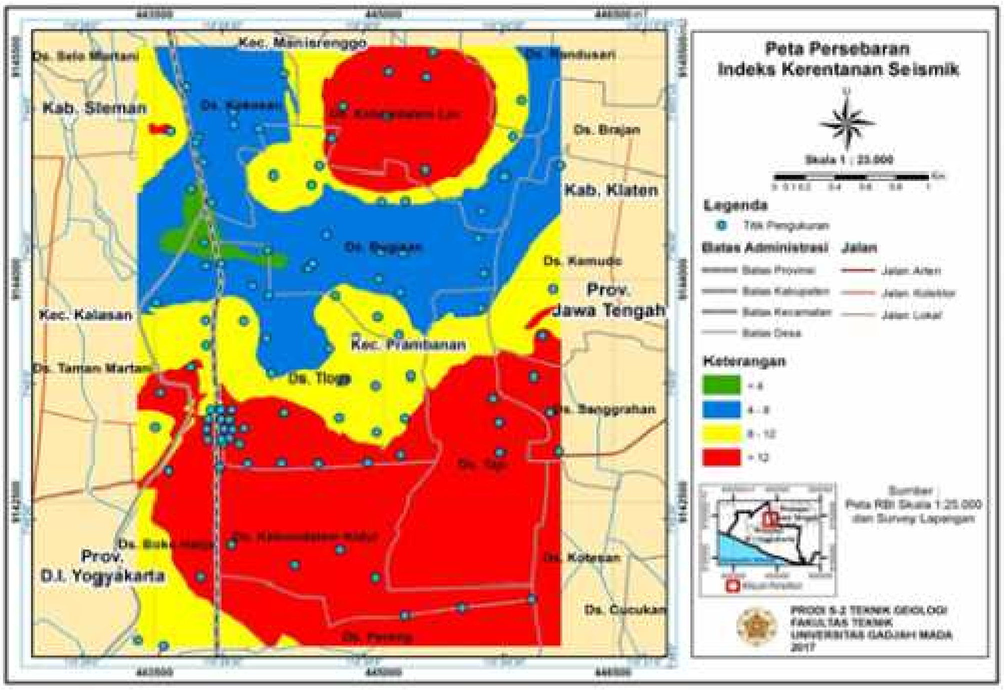

Figure 6 Map of the distribution of seismic vulnerability index values in the Prambanan area

The magnitude of variations in the seismic vulnerability index is strongly influenced by the type of lithology an area. Silt and thin sand material have a low seismic susceptibility index while sand and material thick clay has a very high seismic vulnerability index and vulnerable to seismic waves[8] . Research area is a thick sedimentary layer in the form of sandstone with a thickness of 50 m so it has a high seismic vulnerability index value. Seismic vulnerability index value of the study area is high in the middle then continue to the south area.

The value of seismic vulnerability index (Kg) indicates ability a sedimentary layer is deformed. The greater the seismic vulnerability index value will make it easier for rocks to deformation. Thus an area that has a high seismic vulnerability index value will be more vulnerable to risk damage caused by an earthquake.

We can see in Figure 6 where Taji village, Kebondalem Kidul, and Kebondalem Lor have the highest seismic vulnerability index value compared to other regions. This is in line with damage data that occurred in this location where some of these villages suffered severe damage due to the Yogyakarta earthquake May 27 2006.

Table 1 Data on Damage to Houses in Prambanan in Yogyakarta Yogyakarta May 27 2006[6]

Village Name	Total Damage	Damaged Heavy	Damaged Lightly
Kokosan	9	122	380
Kebondalem Kidul	412	419	111
Kebondalem Lor	42	90	193
Taji	691	314	87
Bugisan	196	416	207

Seismic vulnerability index values describe the level of damage land and buildings when experiencing an earthquake whose value will be higher in areas with thick soft sedimentary layers[5] . The distribution of seismic vulnerability index values is high corresponding with areas that experienced land fractures when an earthquake occurred [1].

IV. CONCLUSION

The results of this study indicate that the District area Prambanan is vulnerable to earthquakes due in large part the study area has a high seismic vulnerability index value with the highest vulnerability values are mostly in the southern area of the study.

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