Proceeding International Conference on Religion, Science and Education (2022) **1**, 633-637

Microtremor Data Processing and Interpretation: A Case Studi on Area Damaged by Yogyakarta 2006 Earthquake

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Abstract: The MATLAB was applied for processing microtremor data in the Yogyakarta area damaged by the 2006 earthquake. This study aimed to process and interpret microtremor data using Matlab software. A total of 7 microtremor data were processed using the HVSR (Horizontal-to-Vertical Spectral Ratio) method. Measurements were made directly at points damaged by the 2006 Yogyakarta earthquake, namely the ISI, STIE Kerjasama, BPKP DIY, Lippo Plaza, Amongrogo, Purawisata, and Mount Ireng for comparison. This paper has succeeded in processing microtremor data using the Matlab programming language. The results of processing microtremor data between Geopsy software and MatLab are not much different. According to the research result, a lot of damage occurred in the sediment area of Yogyakarta compared to the Wonosari hills that had a more solid layer. The amplification factor indicates building damages due to the Yogyakarta earthquake.

Keywords: Matlab, Microtremor, Yogyakarta.

Introduction

Indonesia is located at the confluence of three major tectonic plates i.e the Indo-Australian plate in the south, the Eurasian plate in the north, and the Pacific plate in the east. This causes Indonesia to have a high level of seismicity, indicated by the many occurrences of tectonic and volcanic earthquakes. One of the areas in Indonesia that were hit by an earthquake with severe damage is Yogyakarta. In 2006 a devastating earthquake with a magnitude of 6.3 on the Richter Scale took place in the city (Sunarjo et al, 2012). The earthquake killed more than 5000 people and destroyed thousands of houses (Lutfinur I et al, 2015). This shows that Yogyakarta has a high potential for damage due to earthquakes.

The areas which are close to the earthquake epicenter did not appear to be damaged (Perdhana R, 2019). Damage due to earthquakes is strongly influenced by local site effects (Nakamura, 2000). One of the geophysical methods, namely microtremor, can be used to study local site effects. Measurement of microtremor data is easy to do in urban areas, inexpensive, and suitable for micro zonation (Soehaimi A, 2009). This study uses Matlab software for microtremor data processing in the Yogyakarta areas.

Matlab is one of the software that is widely used especially for programming. Studies on the application of Matlab software for data processing have been carried out, one of them is by Yuliawati W.S., et al (2019). Her study reveals that microtremor data processing can be done with Matlab software. However, in this study, there was no comparison data as a control variable for microtremor data. In his research, Herak M. (2008) also explains that the Matlab program can be used for micro zonation or similar studies.

This study employed the HVSR (Horizontal to vertical spectral ratio) method. This method compares the spectra of the horizontal component

ISSN 2829-3355 | EISSN 2828-8467

microtremor data against the vertical component (Nakamura, 1989). The gained data were soil dominant frequency (f_0) and amplification factor (A_0). A similar method has been carried out by several researchers such as Susilanto P. et al (2015) who applied the HVSR to determine the response to seismic dynamics in Padang City. His study proposed that areas that have a vulnerability to earthquake disasters can be indicated by the dominant frequency values (f_0) and (A_0). Based on the above description, this study aims to process and interpret the results of microtremor data processing using Matlab software by looking at the frequency and amplification parameters.

Method

The research was conducted in Yogyakarta. A total of 7 microtremor data were processed using the HVSR (Horizontal-to-Vertical Spectral Ratio) method. The measurement data was then processed using Matlab and Geopsy software to produce the HVSR curve. The reliability criteria on the HVSR curve refer to the standards made by the SESAME European Research Project. Measurements were made directly at points that were damaged by the 2006 Yogyakarta earthquake, namely the ISI Yogyakarta, STIE Kerjasama, BPKP DIY, Lippo Plaza, Amongrogo, Purawisata, and Mount Ireng for comparison. The tools and materials included: 1) laptop; 2) Matlab 2010 software; 3) Geopsy software; 4) Microsoft Excel and 5) single station microtremor data. This study produces a MatLab script in data processing shown in Figure 1.

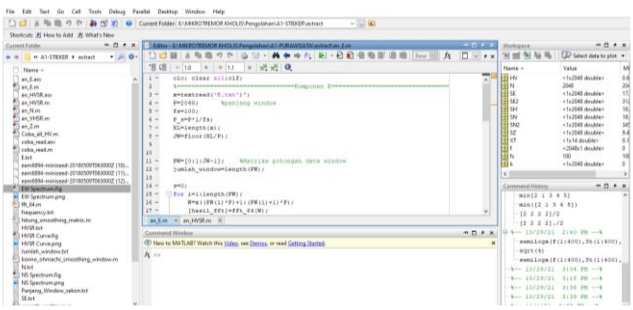

Figure 1. The Matlab Script for Microtremor Data Processing

In the first stage, the measurement data was read by loading or reading. The research data were in the form of time, signal component x, component y, and component z. Furthermore, the calculation process used the Fast Fourier Transform (FFT). This process was executed to change the time domain to the frequency domain and was performed on all components. The HVSR calculation was done by comparing the value of the horizontal spectrum and the vertical spectrum. Finally, the H/V value was obtained and could be interpreted.

Results and Discussion

The study was conducted in the Yogyakarta areas affected by the 2006 earthquake. Microtremor data was processed using the Horizontal-to-Vertical Spectral Ratio (HVSR) method to study local site effects. The results obtained were HVSR curves in the form of dominant frequency parameters (f_0) and amplification factor (A_0). Amplification is the peak value of the HVSR curve, while the dominant frequency is the frequency that often appears marked by a high amplitude value. It can be said that the shape of the HVSR curve is related to the geological conditions of the research area. In this study, Matlab and Geopsy software were used to process the microtremor data. The HVSR curve in Yogyakarta has a similar shape; this shows geological conditions of the areas are not significantly different. This is possible because the study areas were dominated by the formation of young Merapi deposits. There are several types of HVSR curves, including single peak (clear peak), double peaks, flat H/V curve, and many peaks (multi peaks). In the areas involved, a pattern of double peaks was found which is shown in Figure 2.

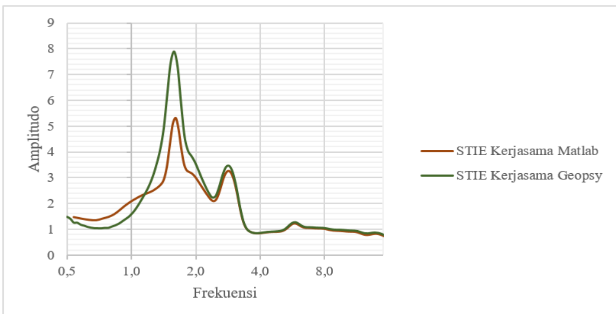

Figure 2. Double Peaks Type of HVSR Curve at STIERS Building

The Double Peak type according to SESAME (European Research Project, 2004) and Kyaw et al (2015) shows that there are two impedance contrasts between the two sediment layers against the bedrock layer. Peaks at low frequencies indicate deep sediment responses, while peaks at high frequencies indicate shallow sediment responses. On the HVSR curve at STIE Kerjasama, it appears that there were two peaks. This shows that the area had impedance contrast so that amplification occurred. This study also compares the results of two software i.e Matlab and Geopsy. Figure 2 compares the values processed with Matlab and Geopsy software and they have slightly different amplification factors and dominant frequencies. However, they produce the same HVSR curve pattern. This is because each software has a different accuracy value. In STIE Kerjasama building, the data processing using Matlab software shows that the amplification factor value is 5.3 with a dominant frequency of 1.6 Hz, while the second peak is 3.1 with a dominant frequency of 2.9 Hz. On the other hand, the processing with Geopsy software reveals that the amplification factor value is 7.9 with a dominant frequency of 1.58 Hz, while the second peak is 3.4 with a dominant frequency of 2.8 Hz. The dominant frequency value is not significantly different. The slight difference was caused by the windowing processes: geopsy software uses windowing cosine tapered while Matlab is rectangular.

In a study conducted by Perdhana R (2019) and Soebowo et al (2007) and based on the UNOSAT map, it was found that the hilly areas of Wonosari, which are close to the epicenter, did not appear to be severely damaged. Measurements in hilly areas were carried out at Mount Ireng Patuk, Gunung Kidul. The hilly area of Wonosari has a harder layer than the Yogyakarta area which is full of Merapi sediments. Measurements at Mount Ireng were used as a comparison in the study as shown in Figure 3.

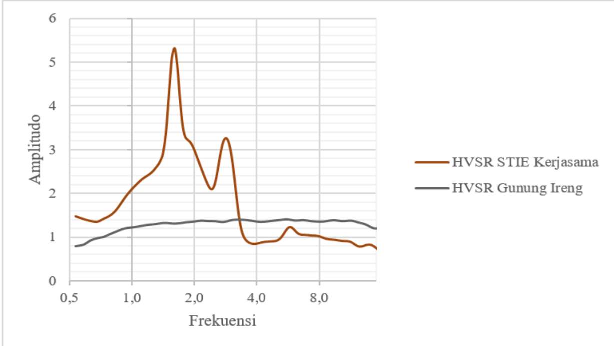

Figure 3. Comparison of the HVSR Curve of STIE Kerjasama with Gunung Ireng Using Matlab Software

The HVSR curve shown in Figure 3 shows that there is no peak at Mount Ireng, which means in such area there was no impedance contrast so that no amplification occurred. The hardpoints of the Wonosari hills are not prone to earthquakes and less vulnerable because there is no strengthening of the waves that pass through the sediment layer. The same result was also obtained by Iswanto E.R et al (2019) who contended that in hard rock, the spectrum of horizontal and vertical components approaches the same value so that there is no visible peak on the HVSR curve. The HVSR curve of Gunung Ireng is an example of a Flat Curve type. Such soil can be categorized as hard soil as it does not show impedance contrast between sedimentary layers and bedrock. Measurement of microtremor data in buildings that were damaged by the 2006 Yogyakarta earthquake was carried out directly. The results of data processing using Matlab software are shown in Figure 4.

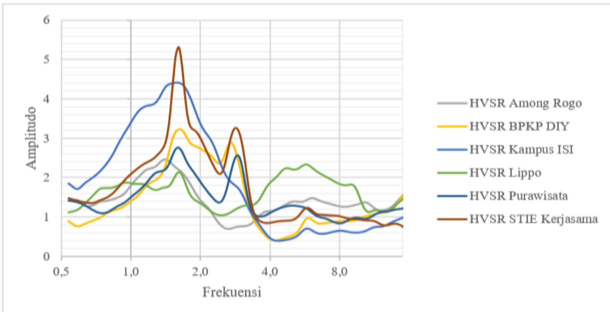

Figure 4. HVSR Curves Using Matlab Software in the Research Areas

Figure 4 presents the amplification factors obtained using the Matlab software. At Amongrogo measurement point, an amplification of 2.6 is obtained with a dominant frequency of 1.3 Hz; at the Lippo point of 2 with a dominant frequency of 1.7 Hz; at BPKP DIY office it has two peaks of 3 with a dominant frequency of 1.6 Hz while the second peak is 2.8 with a dominant frequency of 3 Hz; at ISI Yogyakarta, the point reaches 4.2 with a dominant frequency of 1.5 Hz; at Purawisata the point is 2.7 with a dominant frequency of 1.6 Hz while the second peak is 2.5 with a dominant frequency of 2.8 Hz; at the STIE Kerjasama building, there is the point of 5.3 with a dominant frequency of 1.6 Hz, while the second peak is 3.1 with a dominant frequency of 2.9 Hz. Figure 4 shows a correlation between the amplification value and the affected buildings. In addition, Januarta GH et al (2020) also stated the same thing, namely the correlation between the dominant frequency value (f_0) and the amplification factor (A_0) with the level of damage to the building. The buildings which collapsed due to the 2006 Yogyakarta earthquake had at least an amplification factor of 2. Regarding the Yogyakarta earthquake, geologically the research area is located in a basin area containing material from the Merapi eruption (Daryono, 2011).

Conclusion

This study has successfully conducted microtremor data processing using the Matlab programming language. The drawn conclusion is that microtremor data processing can be done using Matlab software. The results of processing microtremor data using geopsy and MatLab are not significantly different. The HVSR curve using Matlab software shows that there is a correlation between the amplification value and buildings damaged by the 2006 Yogyakarta earthquake.

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