JIIF (Jurnal Ilmu dan Inovasi Fisika)
Vol. 05, No. 02 (2021) 88 – 94

MICROZONATION OF CISARUA DISTRICT USING HORIZONTAL VERTICAL SPECTRAL RATIO

ERLANGGA IBRAHIM FATTAH[1*], RIZKI WULANDARI[1], GABRIO HIKMA JANUARTA[1], ADRIN TOHARI[2], TEDI YUDISTIRA[3]

[1]Teknik Geofisika, JTMB, Institut Teknologi Sumatera
Jl. Jalan Terusan Ryacudu, Desa Way Hui, Kecamatan Jatiagung, Lampung Selatan 35365

[2]Lembaga Ilmu Pengetahuan Indonesia
Kompleks LIPI, Gedung 70 Jl. Cisitu Sangkuriang Bandung 40135

[3]Teknik Geofisika, Institut Teknologi Bandung
Jl. Ganesha No 10 Bandung

[*]email : erlangga.fattah@tg.itera.ac.id

Abstract. The Bandung region is part of the framework of the Indonesian tectonic system, namely the tectonic plate meeting zone, where the Indo Autralia plate is infiltrated under the Eurasian plate in a convergent manner. The subduction process produces an effect in the form of an active fault geological structure in the Bandung area. One of these active faults is the Lembang Fault, which has a length of ± 29 kilometers and a shear acceleration of 3 to 5.5 millimeters per year. The microtremor measurement method is a passive geophysical method that utilizes natural subsurface vibrations so that it can provide dominant frequency data and amplification factors for soil layers. Based on the results of seismic susceptibility research using microtremor measurements using the HVSR method in the Lembang Fault zone in Cisarua Sub-District, it can be seen that the distribution of the dominant frequency values tends to be influenced by lithology and topography. In the research area, it is known to have a dominant frequency value that varies due to the different types of lithological units. In general, the dominant frequency ranges from 1-3 Hz because it is dominated by tuff sand and tuff pumice, and areas composed of volcanic breccias have a dominant frequency value between 3-6 Hz. Meanwhile, the amplification factor value will be influenced by rock deformation and weathering. The area that has a very high amplification factor value is in the southeast of the study area with an A0 value greater than 5. This indicates that the area is composed of a layer of thick and not dense tuff sand.

Keywords: HVSR, Microtremor, Lembang Fault

Abstrak. Wilayah Bandung merupakan bagian dari kerangka sistem tektonik Indonesia yaitu zona pertemuan lempeng tektonik, dimana lempeng Indo Autralia menyusup ke bawah lempeng Eurasia secara konvergen. Proses subduksi menghasilkan efek berupa struktur geologi sesar aktif di wilayah Bandung. Salah satu sesar aktif tersebut adalah Sesar Lembang yang memiliki panjang ± 29 kilometer dan percepatan geser 3 hingga 5,5 milimeter per tahun. Metode pengukuran mikrotremor merupakan metode geofisika pasif yang memanfaatkan getaran alam bawah permukaan sehingga dapat memberikan data frekuensi dominan dan faktor amplifikasi lapisan tanah. Berdasarkan hasil penelitian suseptibilitas seismik menggunakan pengukuran mikrotremor menggunakan metode HVSR pada zona Sesar Lembang Kecamatan Cisarua dapat diketahui bahwa sebaran nilai frekuensi dominan cenderung dipengaruhi oleh litologi dan topografi. Di daerah penelitian diketahui memiliki nilai frekuensi dominan yang bervariasi karena perbedaan jenis satuan litologi. Secara umum frekuensi dominan berkisar antara 1-3 Hz karena didominasi oleh pasir tuf dan batu apung tuf, serta daerah yang tersusun dari breksi vulkanik memiliki nilai frekuensi dominan antara 3-6 Hz. Sedangkan nilai faktor amplifikasi akan dipengaruhi oleh deformasi batuan dan pelapukan. Daerah yang memiliki nilai faktor amplifikasi sangat tinggi berada di sebelah tenggara daerah penelitian dengan nilai A0 lebih besar dari 5. Hal ini menunjukkan bahwa daerah tersebut tersusun atas lapisan pasir tuf yang tebal dan tidak rapat..

Kata Kunci: HVSR, Microtremor, Patahan Lembang

1. Introduction

The Bandung region is part of the framework of the Indonesian tectonic system, namely the tectonic plate meeting zone, where the Indo Autralia plate is infiltrated under the Eurasian plate in a convergent manner. The subduction process produces an effect in the form of an active fault geological structure in the Bandung area. One of these active faults is the Lembang Fault, which has a length of ± 29 kilometers and a shear acceleration of 3 to 5.5 millimeters per year. This fault is a type of normal fault with its northern part further down to a depth of 450 meters, especially in the eastern part of the fault [1]. Considering the movement of the fault that can cause an earthquake with a scale of 6.5 to 7.0 Mw and the calculation of the Lembang Fault is entering an energy release cycle [2]. Therefore, in the change of disaster risk, a seismic microzonation study is needed in the research area to determine the soil dynamics in the Lembang Fault area.

The microtremor measurement method is a passive geophysical method that utilizes natural subsurface vibrations so that it can provide dominant frequency data and amplification factors for soil layers based on the strong impedance difference between the soil layer and bedrock [2]. This method uses Horizontal to Vertical Spectral Ratio (HVSR) calculations which can be used to estimate the value of the dominant frequency and amplification factor from microtremor measurement data (Nakamura). Based on the analysis of microtremor data, it is possible to map the dominant frequency values, amplification factors and compile a seismic microzonation map based on the seismic vulnerability index in the study area.

conditions.

2. Methods

In this study, there were 8 microtremor measurement points located in Cisarua Sub-District, West Bandung Regency, West Java Province. Instruments used for microtremor measurements use 3 components of McSEIS–MT NEO from the Indonesian Institute of Sciences (LIPI). The result of microtremor measurements with three-component sensors, namely North-South (NS) components, East-West components (EW) as horizontal axes, and Up-Down components (UD) as vertical axes. Figure 1 shows the geological map of the research area, the map shows the litology of the research area. In general the research area is a sedimentation area with a supply of sediment derived from Mount Tangkuban Perahu [3].

GEOPSY software was used to process microtremor signal, the data process is separating between microtremor and recorded noise. In addition of that, to improve improving of the quality of data used e the result of noise correction is done the selection of data that is considered noise manually based on the measurement diary of activity around the measurement point.

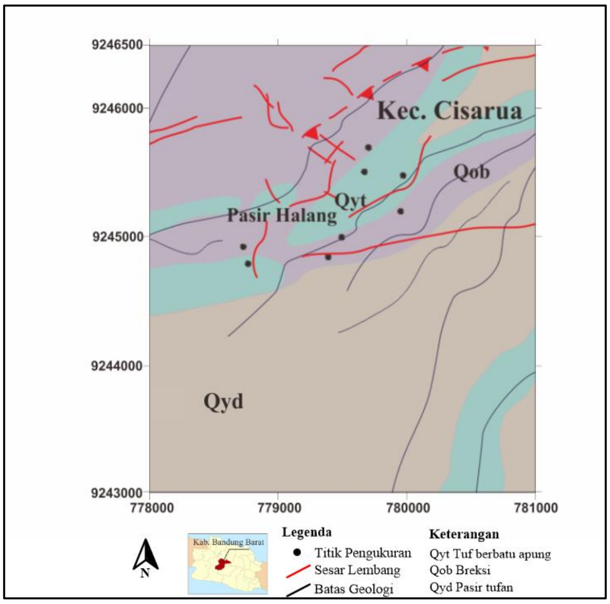


Figure 1. Geological map of the research area. The red line indicates Sesar Lembang, and the black dot is the measurement point of the microtremor

Furthermore, data transformation will be performed to convert data in time function into frequency function with Fast Fourier Transform (FFT) algorithm. Then each fourier spectrum of horizontal components is numbered with squared average roots and divided by a vertical spectrum mathematically written as follows.

$$HVSR = \frac{\sqrt{S^2{}_{NS}\ (f) + S^2{}_{EW}\ (f)}}{S_{UD}(f)}$$

where HVSR is a horizontal to vertical spectral ratio, S_{NS} is a horizontal component spectrum with a North-South direction, S_{EW} is a horizontal component spectrum with an East-West direction, and S_{UD} is a vertical component spectrum with an Up-Down direction. The HVSR method is used to estimate the dominant frequency value (f_0) and amplification factor value (A_0) of the peak of the H/V curve [5]. The seismic vulnerability index (K_g) is a parameter related to the level of vulnerability of an area during an earthquake [6], which is mathematically stated as follows:

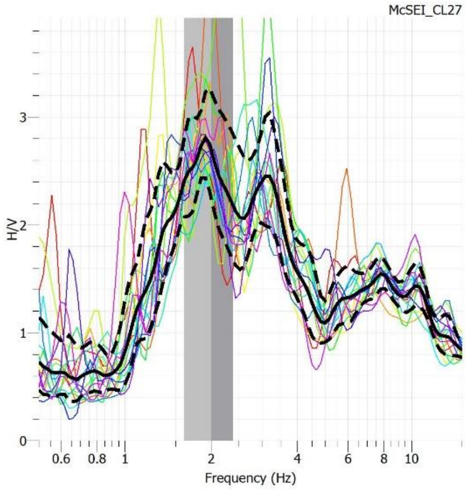
$$Kg = \frac{A_0{}^2}{f_0}$$

3. Results and Discussion

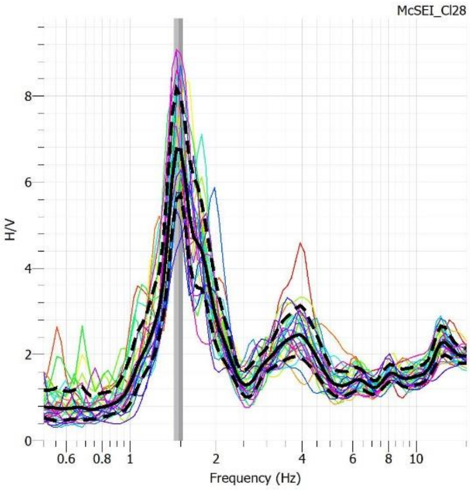
In this study, the value of the dominant frequency (f_0) ranged from 1 Hz to 6 Hz as shown in Figure 2. In general, the relatively small dominant frequency (f_0) is at the foot of the mountain and the high dominant frequency value is on the slope. Hill that is experiencing erosion. The dominant frequency has a close relationship with bedrock, if the dominant frequency is low it will be associated with a deep bedrock depth. In the lithological unit of tuff sand (Qyd) and tuff pumice (Qyt) have a low dominant frequency value (1-3 Hz).

Characteristics of the H/V Spectral Ratio

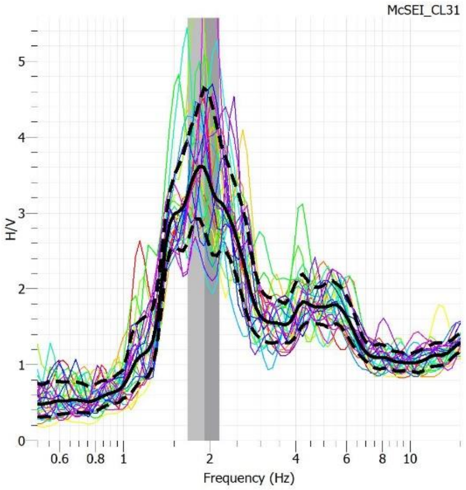
In this study, an analysis of the H/V curve was carried out which aims to check the reliability criteria of the curve which refers to the SESAME European Research Project standard [7]. In Figure 2 there are several H/V curves that have met the reliability criteria and can be categorized into clear peak and unclear peak curves. The peak projection of the H/V curve on the X axis is the value of the dominant frequency (f_0), while the peak point of the curve on the Y axis is the value of the amplification factor (A_0).



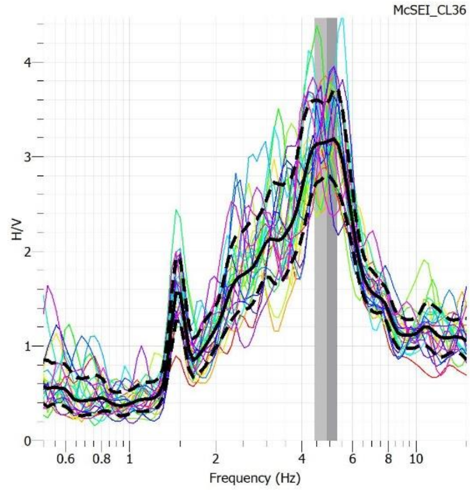
(a) Unclear Broad Peak



(b) Clear Peak



(c) Unclear Two Peak Case



(d) Unclear Sharp Peaks

Figure 2. Characteristics of the H/V curve based on SESAME criteria

Dominant Frequency Value (f0)

In this study, the value of the dominant frequency (f_0) ranged from 1 Hz to 6 Hz as shown in Figure 3. In general, the relatively small dominant frequency (f_0) is at the foot of the mountain and the high dominant frequency value is on the slope. Hill that is experiencing erosion. The dominant frequency has a close relationship with bedrock, if the dominant frequency is low it will be associated with a deep bedrock depth. In the lithological unit of tuff sand (Qyd) and tuff pumice (Qyt) have a low dominant frequency value (1-3 Hz). Meanwhile, areas that have a relatively high dominant frequency of 3–6 Hz are associated with the breccia lithology unit (Qob). This indicates that the breccia layer is thinner than the tuff layer.

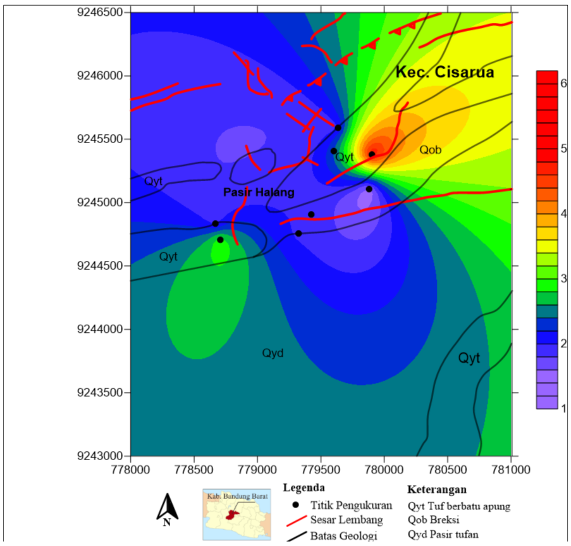


Figure 3. Map of the distribution of the dominant frequency (f0) of soil layers around the Lembang Fault zone. The red line shows the lithological unit limit, the red line shows the Lembang Fault, and the black point is the microtremor measurement point

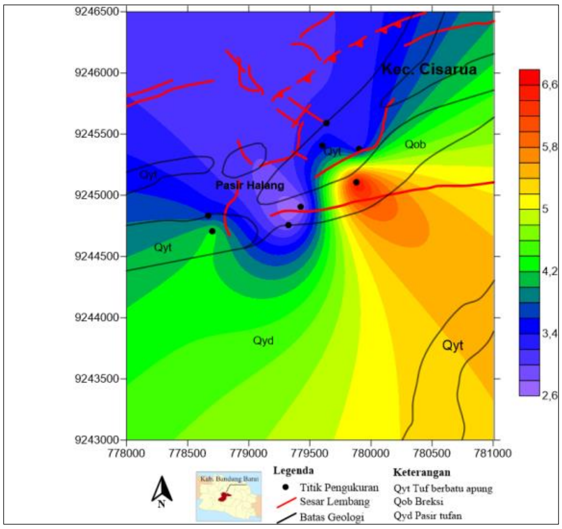


Figure 4. Map of the distribution of the amplification factor (A0) of soil layers around the Lembang Fault zone. The red line shows the lithological unit limit, the red line shows the Lembang Fault, and the black point is the microtremor measurement point

Amplification Factor Value (f0)

The value of the soil layer amplification factor in the Lembang Fault zone in Cisarua Sub-District is shown in Figure 4. The amplification factor value obtained from the determination of the amplitude peak of the HVSR spectrum. The amplification factor value explains the impedance contrast between the soil layers of the bedrock layer [3]. Areas that have a high amplification factor value will experience waves and severe damage to buildings during an earthquake.

Seismic Vulnerability Index Value (Kg)

In this study, the seismic susceptibility index values ranged from 1 to 30 shown in Figure 5. Areas with high to very high seismic vulnerability ranging from 20-30. This area is dominated by areas composed of tuff layers and has quite thick sedimented. These areas have a high potential for earthquake hazard, which can lead to damage to buildings that are prone to shocks. Meanwhile, areas of moderate seismic vulnerabilities with a K_g value of 10 to 20 are located in areas composed of tuff sand and areas that have low seismic vulnerability are scattered in high-relief hilly areas in the Northwest of the study area. Based on the analysis of the seismic susceptibility index, it shows that lithological factors and topographic conditions will control seismic vulnerability. The seismic susceptibility will decrease in the hilly topography

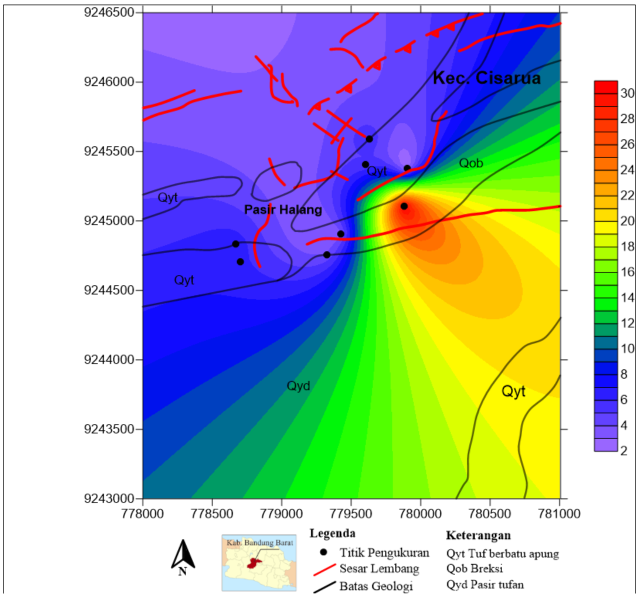


Figure 5. Map of the distribution of the amplification factor (A0) of soil layers around the Lembang Fault zone. The red line shows the lithological unit limit, the red line shows the Lembang Fault, and the black point is the microtremor measurement point

4. Conclusions

Based on the results of seismic susceptibility research using microtremor measurements using the HVSR method in the Lembang Fault zone in Cisarua Sub-District, it can be seen that the distribution of the dominant frequency values tends to be influenced by lithology and topography. In the research area, it is known to have a dominant frequency value that varies due to the different types of lithological units. In general, the dominant frequency ranges from 1-3 Hz because it is dominated by tuff sand and tuff pumice, and areas composed of volcanic breccias have a dominant frequency value between 3-6 Hz. Meanwhile, the amplification factor value will be influenced by rock deformation and weathering. The area that has a very high amplification factor value is in the southeast of the study area with an A_0 value greater than 5. This indicates that the area is composed of a layer of thick and not dense tuff sand. Based on the value of seismic vulnerability (K_g), the research area has a high to very high seismic vulnerability value in the South-Southeast. These areas have a high potential for earthquake hazard, which can lead to damage to buildings that are prone to shocks.

References

1. B. Brahmantyo, 2011. Sesar Lembang, hearthquake di jantung Cekungan Bandung. Geo Magz, 1(1), 17–25.
2. M.R. Daryono, D.H. Natawidjaja, B. Sapiie, P. Cummins, 2019. *Earthquake geology of the Lembang Fault, West Java, Indonesia*. Tectonophysics, 751, 180-191.
3. A. Ansal, 2004. Recent Advances in Earthquake Geotechnical Engineering and Microzonation. Kluwer Academic Publishers, Dordrecht, 354 pp.
4. R.W. Van Bemmelen, 1949. The Geology of Indonesia. Government Printing Office, The Hague, Netherlands (732 p).
5. Y. Nakamura, 1989. A method for dynamic characteristics estimation of subsurface using microtremor on the ground surface. Quarterly Report Railway Tech. Res. Inst., 30, 25-30.
6. Y. Nakamura, 2000. Clear identification of fundamental ideal of Nakamura’s technique and its application. The 14th World Conference on Earthquake Engineering, Auckland.
7. SESAME, 2004. Guidelines for The Implementation Of The H/V Spectral Ratio Technique on Ambient Vibrations. Europe: SESAME European research project