Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 8 ~ Issue 11 (2022) pp: 115-120
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Identification of Seismic Susceptibility Index on The Pendidikan Diponegoro Dam, Semarang

Ana Matswana[1], Dwi P. Sasongko[1], Sugeng Widada[2], Gatot Yuliyanto[1]
[1]*Departement of Physics, Faculty of Science and Mathematics, Diponegoro University, Semarang, Indonesia*
[2]*Department of Oceanography, Faculty of Fisheries and Marine Science, Diponegoro University, Semarang, Indonesia*
Corresponding Author: Ana Matswana

ABSTRACT: *The Pendidikan Diponegoro Dam was built to prevent flooding, provide irrigation and provide water reserves. Some dams can experience damage that results in dam failure. One of the causes of dam damage is geological symptoms caused by deformation of a layer or earthquake. Horizontal to Vertical Ratio (HVSR) is one of the passive geophysical methods that can map the subsurface to obtain the value of vulnerability to seismic waves of the Dam. Data was collected using a GL 240 Data Logger and a 3-component Geophone to record vibrations. Measurements were taken at 12 points. Microtremor data was processed using Geopsy software. The results of data processing show that the dominant frequency (f_0) value is 6.67-20 Hz, which is composed of tertiary rocks consisting of sandstone with hard pebbles, the thickness of surface sediments is very thin, dominated by hard rocks. The Amplication (A_0) value is around 1.19 - 6.18. Seismic vulnerability based on the seismic vulnerability index (K_g) ranges from 0.32 to 45. Based on these results, it is indicated that the Pendidikan Diponegoro Dam area is generally stated to be in a relatively safe.*
KEYWORDS: *Dam, Microtremor, Seismic Vulnerability Index*

*Received 15 Nov., 2022; Revised 28 Nov., 2022; Accepted 30 Nov., 2022 © The author(s) 2022. Published with open access at **www.questjournals.org***

I. INTRODUCTION

The Pendidikan Diponegoro Dam is located in the Tembalang Village, Semarang. This Dam is able to accommodate normal water up to 478,24 m³ with a catchment area of 7,134 ha with a river length of 7.52 km, a dam body height of 22 m and the type of dam is landfill core impermeable clay [1]. The Pendidikan Diponegoro Dam was built to have a function to maintain the balance of ecosystems and the environment, protect the area around the UNDIP Tembalang campus from flooding, increase groundwater absorption capacity as a conservation effort and recreation area [2].

Some dams can experience damage that results in dam failure. One of the causes of dam damage is geological symptoms caused by deformation of a layer or earthquake. Dam vulnerability needs to be known so that Diponegoro Education Reservoir can continue to be a means of regulating water around the UNDIP Tembalang campus area.

One of the methods used for damage mitigation is the HVSR method. The HVSR method compares vertical signal components with horizontal signal components from microtremor signal measurements [3]. The parameters produced by HVSR method are dominant frequency and amplification. The dominant frequency data and amplification factor are used to determine the value of the seismic vulnerability index.

II. METHODOLOGY

The research was conducted in July-August 2022 using microtremor data. Administratively, the research area is located in Tembalang Village, Semarang. Data collection amounted to 12 measurement points with a spacing distance between points of 150 meters (Figure 1). The equipment used was GL 240 as data logger and 3-component geophone (X,Y,Z) (Figure 2). Acquisition results recorded three types of waves, namely horizontal seismic waves East-West, north-south, and up-down vertical components [3].

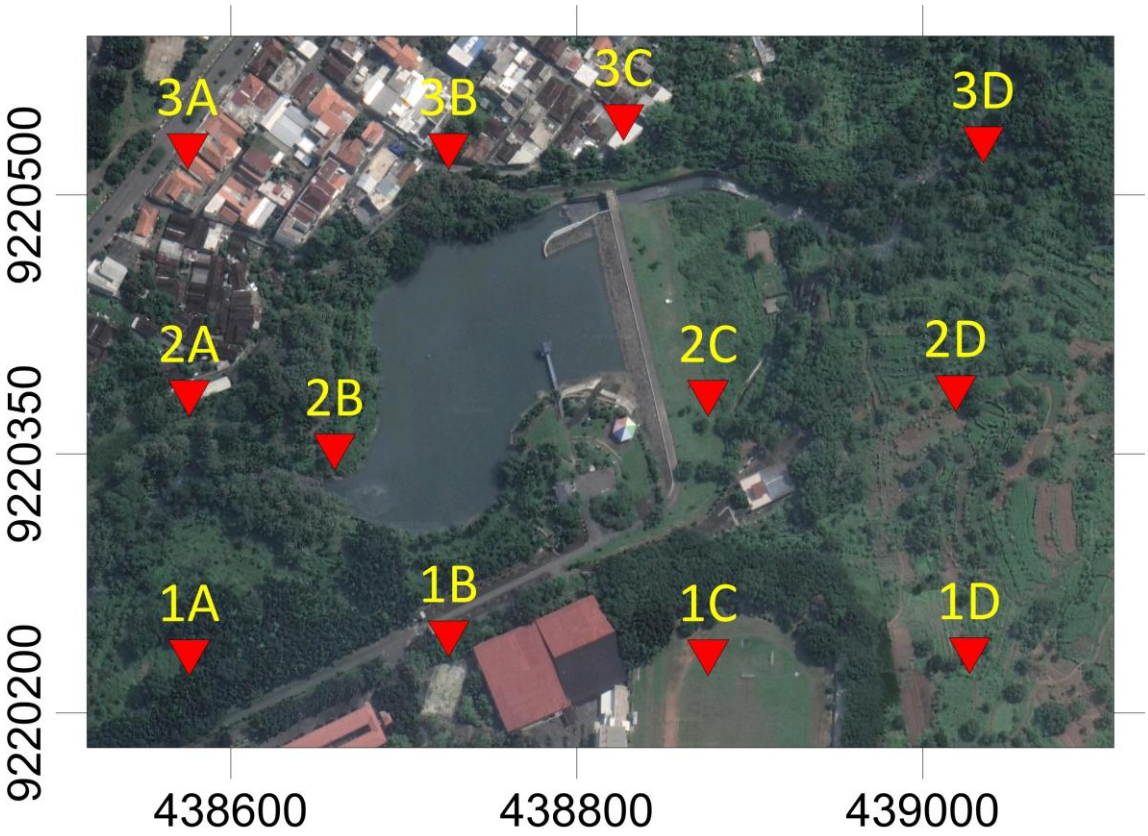

Fig. 1. Location map of microtremor measured sites at the study area.

Data processing was done using Geopsy to filter out signals that have major noise (Figure 3). Nakamura [3] stated that the HVSR method compares the vertical signal component with the horizotal component as in equation (1).

$$H/V = \frac{\sqrt{(A_{NS})^2 + (A_{EW})^2}}{(A_V)^2} \quad (1)$$

where H/V is the ratio of the horizontal component spectrum to the vertical component spectrum, is the amplitude value of the North-South component frequency spectrum, is the amplitude value of the East-West component frequency spectrum.

HVSR method analysis is used to obtain amplification data and dominant frequencies related to subsurface physical parameters [4]. The amplification data and dominant frequency obtained are then used to determine the susceptibility index. The seismic susceptibility index is used to identify the level of susceptibility of a deformed soil layer. The equation used to determine the seismic susceptibility index is shown in equation (2) [3].

$$K_g = \frac{{A_0}^2}{f_0} \quad (2)$$

where K_g is the value of the seismic vulnerability index, A_0 is the Amplification value or also called the peak of the microtremor spectrum and f_0 is the size of the resonance frequency. The stability of the soil structure is determined by vulnerability, the greater the K_g value, the smaller the stability of the soil structure so that damage can occur when there is deformation or earthquake.

a) Logger Data GL 240 b) Geophone 3 Component

Fiq. 2. Acquition equipment

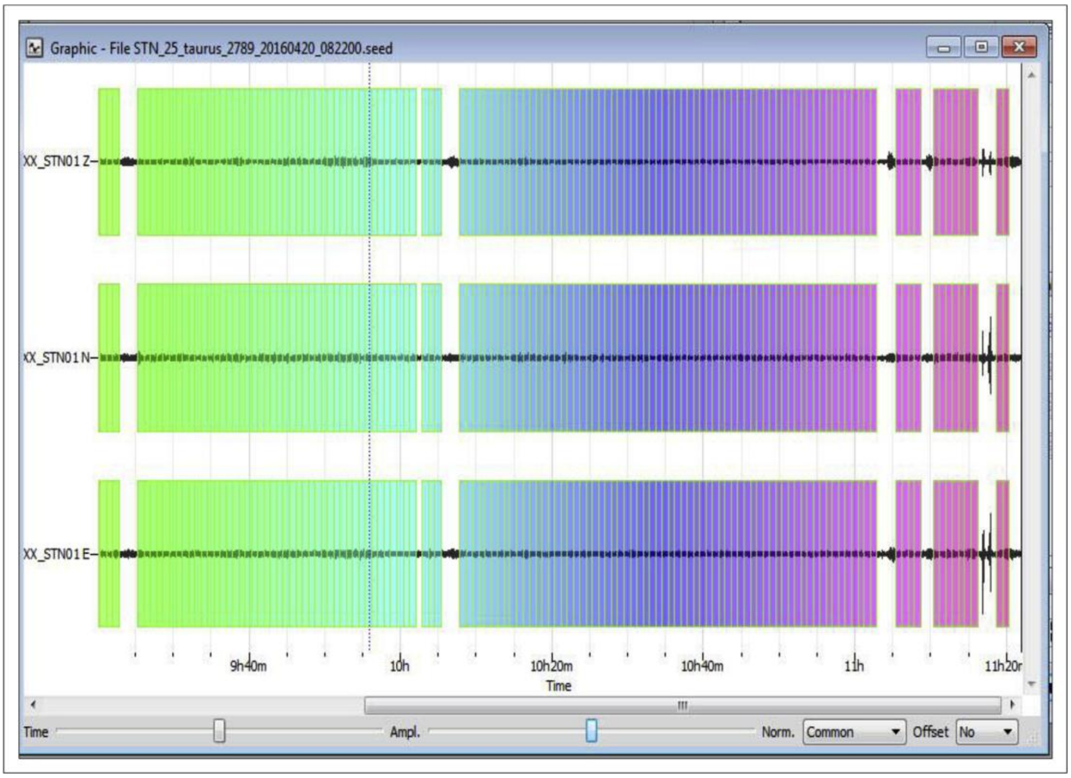

Fig. 3. Windows selection in Geopsy software for the recorded microtremor data [5]

III. RESULT AND DISCUSSION

Measurement data taken at the study site was processed using the HVSR method, obtaining the dominant frequency and amplification values. These values were then used to find the susceptibility index. The dominant frequency value in the study area is shown in (Figure 4). Low natural frequencies indicate thick and soft sediments, while high natural frequencies indicate sediments that have a thin thickness [6].

Table 1. Data Station of Measurement

No	Station	East.	North.	Elev. (m)	f_0 (Hz)	A_0	K_g
1	1A	438576	9220232	196	0,634956	1,56006	3,833001347
2	2A	438576	9220382	195	8,98823	1,70689	0,324143182
3	3A	438575	9220525	201	1,77273	2,53149	3,615012788
4	1B	438726	9220243	189	0,659882	1,97165	5,89105889

No	Station	East.	North.	Elev. (m)	f_0 (Hz)	A_0	K_g
5	2B	438660	9220351	180	1,10753	1,84553	3,075294557
6	3B	438726	9220525	195	0,731011	1,18945	1,935389895
7	1C	438876	9220232	194	0,688543	1,25821	2,299191778
8	2C	438876	9220382	172	0,79509	3,60997	16,39045064
9	3C	438827	9220542	191	8,02215	5,666	4,001864338
10	1D	439027	9220233	189	0,608818	5,27504	45,70503336
11	2D	439019	9220385	187	5,27998	6,17779	7,228263987
12	3D	439035	9220529	162	0,702685	1,9542	5,434722016

The study area has natural frequency (f_0) values ranging from 0-9 Hz. Based on the natural frequency map, areas with high f_0 values are located in the western, northern and southern parts of the study area, which are around 6.7-9 Hz. This shows that the research area has relatively thin sediments and there are hard and compact rocks [6]. The area includes the type of classification I because it has a dominant frequency between 6.67-20 Hz which is composed of tertiary rocks or older rocks consisting of sandstone with hard gravel, the thickness of the surface sediment is very thin, dominated by hard rock [6]. The southern, central, northwestern and northeastern areas of the study area have low f0 values, which are below 2.5 Hz, indicating that the area includes the type of classification IV which is composed of top soil, mud, soft soil with a fairly thick layer with a depth of ± 30 m [6]. The reservoir is located in a low dominant frequency area which can increase seismic vulnerability Index (K_g), potentially causing damage in the event of an earthquake.

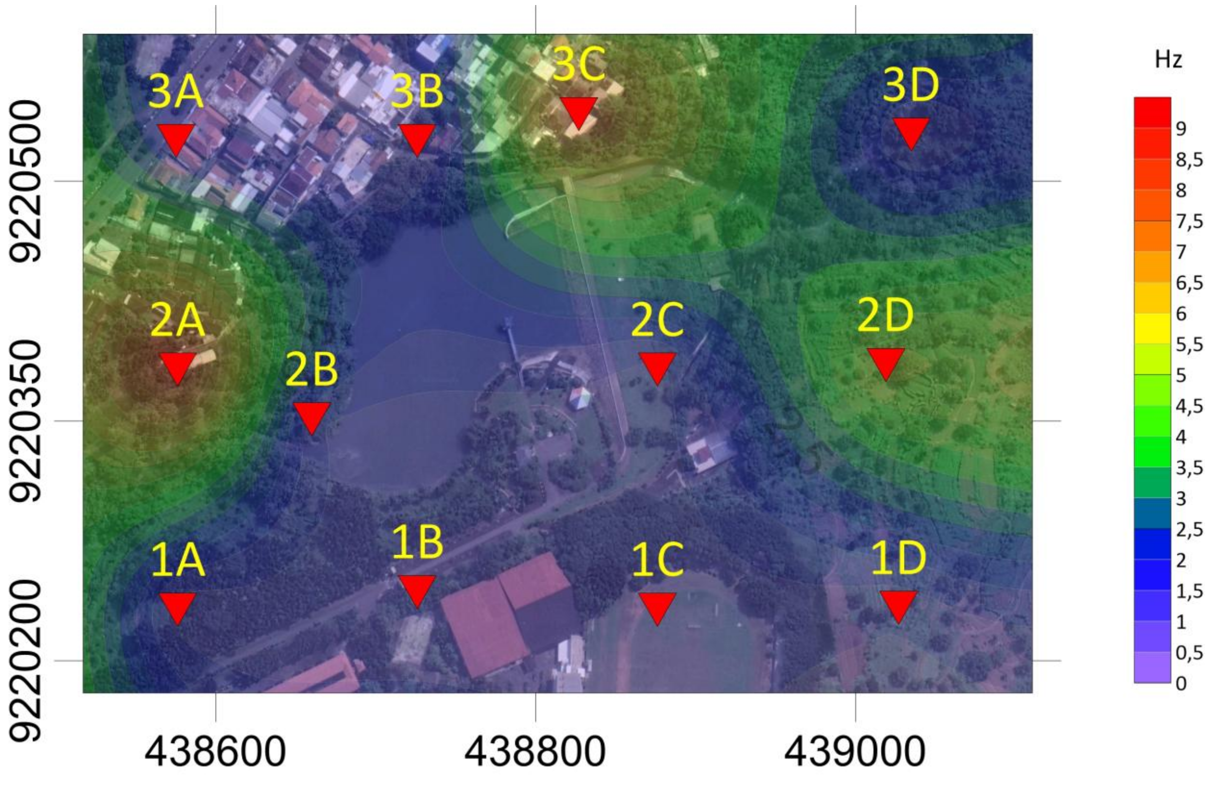

Fig. 4. Zonation map of the fundamental frequency (f_0) derived from H/V's results.

The amplification factor (A_0) is related to the density of a rock. A high amplification factor value means that the rock density is low and consists of soft rock, while a low amplification factor value means that the rock density is high [7]. The distribution of amplification factor values is shown in fig. 5. Based on these results, the amplification value of the study area ranges from 1.19 - 6.18 with high amplification values in the area to the north, east and southeast of the study area and low amplification values in the area to the west, south, northwest northeast. High amplification values cause an area to have a high vulnerability when an earthquake occurs.

Overall, the amplification value around the dam when classified based on the classification of Setiawan [8] falls into the low to medium category.

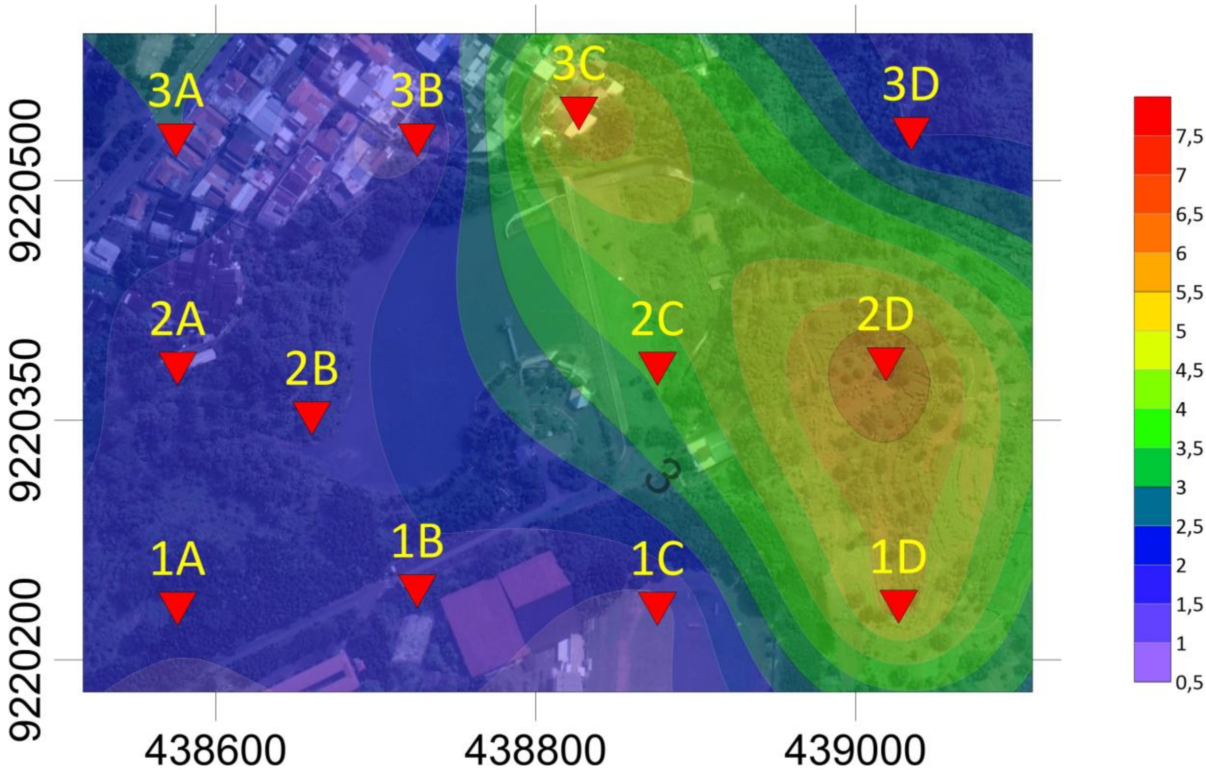

Fig. 5. Zonation map of the H/V amplitude levels (A_0)

The results of the amplification values and dominant frequencies obtained are used to determine the susceptibility index. The susceptibility index is a parameter to identify the level of vulnerability of an area due to strong ground motion [3]. The greater the seismic susceptibility index value, the greater the earthquake-induced ground motion susceptibility value. The soil susceptibility index of the study area is around 0.32- 45. The highest seismic susceptibility index value is in the southeast area of the study area. According to Daryono's [9] classification of seismic susceptibility values, the research area falls into the low to medium category except for the southeast area of the reservoir. This makes the vulnerability in the dam body still safe.

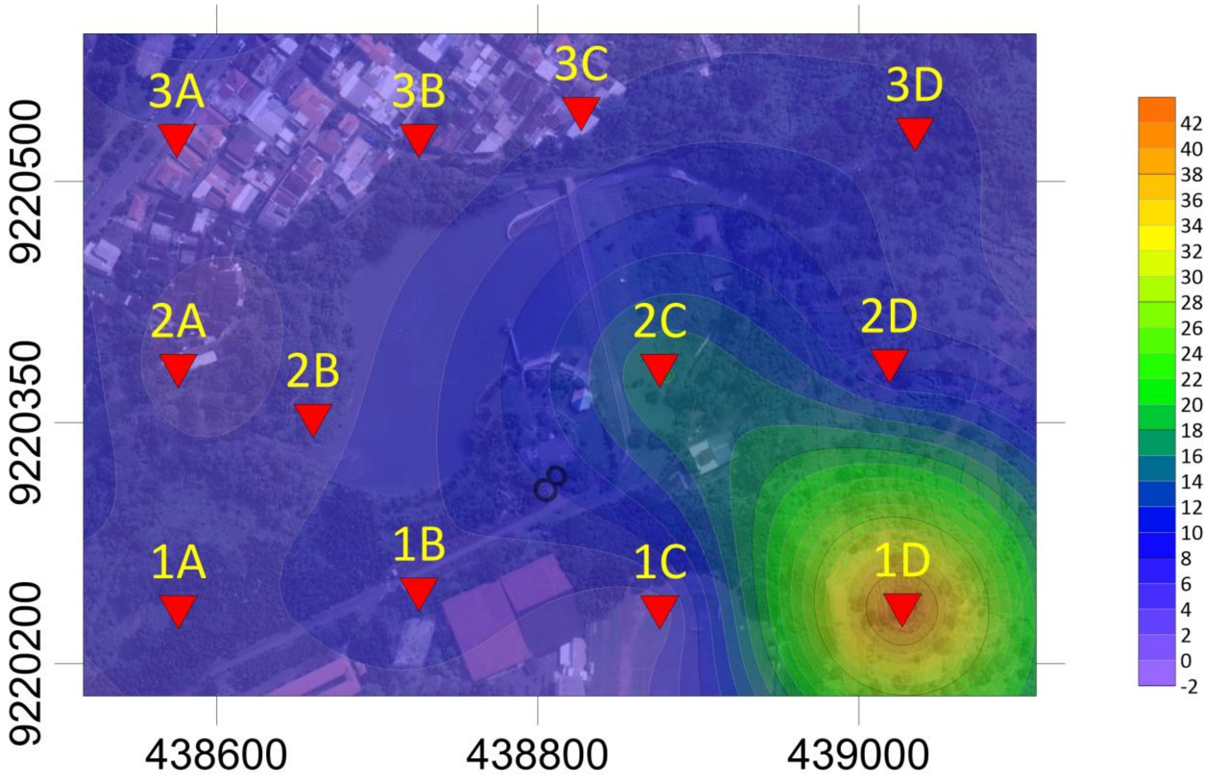

Fig. 6. Zonation map of Seismic vulnerability (K_g)

IV. CONCLUSION

In this study, the results of the discussion can be concluded that:

1. Based on the distribution of the dominant frequency value (f0) of the diponegoro reservoir area, it has a low frequency value. It shows that the diponegoro reservoir area has many layers of sediment or thick weathered layer.
2. Based on the distribution of Amplification (A0) values, the Diponegoro reservoir area has low to medium amplification values. This shows that the Diponegoro reservoir area has soft-somewhat hard rocks.
3. Based on the distribution of seismic vulnerability values (Kg), the Diponegoro reservoir area has a low seismic vulnerability value. This indicates that the Diponegoro reservoir area is relatively not vulnerable to ground movement due to earthquakes or deformation.

Based on the value of the dominant frequency, ampilification, and seismic vulnerability index, in general, the Diponegoro reservoir can be stated that the area is in a relatively safe zone from earthquakes and deformation.

REFERENCES

[1]. PT. Jasapatria Gunatama. 2008. Studi dan Detail Desain Waduk Diponegoro. Presentasi Konsep Laporan Akhir.

[2]. Setiadi et.al. 2020. Studi Deformasi Waduk Pendidikan Diponegoro Tahun 2019. Jurnal Geodesi Undip. Volume 9, Nomor 1, Tahun 2020, (ISSN : 2337-845X)

[3]. Nakamura, Y., 1989, A Method for Dynamic Characteristics Estimation of Subsurface Using Microtremor on the Ground Surface, Quarterly Repost of the Railway Technical Research Institute, 30-1, h.25-33

[4]. Herak, M., 2008, Computers and Geosciences, Vol. 34 p 1514–26.

[5]. Helbary, et al. 2019. Application of HVSR technique in the site effects estimation at the south of Marsa Alam city, Egypt. Journal of African Earth Sciences. 154. Vol 89-100 https://doi.org/10.1016/j.jafrearsci.2019.03.015.

[6]. Kanai, K., 1983, Engineering Seismology, Tokyo University:Japan.

[7]. Sitorus, N., Purwanto, S., Utama, W., 2017, Analisis Nilai Frekuensi Natural Dan Amplifikasi Desa Olak Alen, Blitar Menggunakan Metode Mikrotremor HVSR, Jurnal Geosaintek, Vol. 03, no. 02, 2017, pp. 89–92.

[8]. Setiawan J.R. 2009. Mikrozonasi Seismitas Daerah Yogyakarta dan Sekitarnya. Bandung: Institut Teknologi Bandung

[9]. Daryono. 2009. Pengkajian Local Site Effect di Graben Bantul Menggunakan Indeks Kerentanan Seismik Berdasarkan Pengukuran Mikrotremor. Jurnal Kebencanaan Indonesia Vol. 2, No.1 Mei 2009. Yogyakarta: PSBA