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# ESTIMATION SEISMIC VULNERABILITY INDEX USING THE HVSR METHOD IN THE OUTER AMBON BAY COASTAL AREA AS A NATURAL DISASTER MITIGATION EFFORT

**H.Andayany[1], J. R. Kelibulin[2] and P. Nanlohy[3]**

[1,2,3]*Physics Department, Faculty of Mathematics and Natural Science*
*Pattimura University, Jln. Ir.M.Putuhena, Ambon.*

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***Correspondence to Author:***
**H.Andayany**
*Physics Department, Faculty of Mathematics and Natural Science Pattimura University, Jln. Ir.M.Putuhena, Ambon.*

**E-mail:**
helda.andayany@fmipa.unpatti.ac.id
jr.kelibulin@fmipa.unpatti.ac.id[2]
pieldrienanlohy@gmail.com[3]

## ABSTRACT

The research was carried out around the coast of the Outer Ambon Bay which is located on the island of Ambon. The purpose of this research is to determine the value of the dominant frequency and seismic vulnerability index. Data retrieval was carried out using TDL 303S Seismograph at 30 measurement points with spaces between measuring points 200 to 500 m. The results of microtremor measurements were analyzed using the Horizontal to Vertical Spectral Ratio (HVSR) method to obtain the dominant frequency value (*f0*) and amplification factor (*A*), so that the value of the seismic vulnerability index (*kg*) can be determined. The dominant frequency values obtained ranged from 0.634 Hz to 13.424 Hz, the amplification values obtained ranged from 1.011 to 1.957 and the value of the seismic susceptibility index obtained ranged from 0.143 cm/s$^2$ to 2.338 cm/s$^2$. Based on the dominant period, it is known that the measurement location in the coastal area of Teluk Ambon Subdistrict (Location 1-15) is generally dominated by class II land types which are composed of alluvial rocks, with a depth of 5 m consisting of sandy - gravel, sandy hard clay, loam. Whereas the measurement point 22-30 which is the coastal area of Nusaniwe Subdistrict is generally dominated by class IV soil types composed of alluvial rocks, which is formed from delta sedimentation, topsoil, mud, etc., with a depth of 30 m.



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## INTRODUCTION

The Maluku Islands is one of the areas that has the potential to be earthquake because it is a meeting area of three constituents of the Earth's crust namely Indoaustralia, Eurasia, and the Pacific. The three plates move relative to each other so that the earthquake activity in the Maluku Islands tends to be very high due to a fault that is also a generator of earthquake activity. The meeting of the three constituents of the earth's crust in Maluku is located in the Banda Sea. The conditions of tectonic plates that meet in the Maluku islands make this region very vulnerable to earthquakes and tsunamis.

Some earthquake damage is not only affected by the magnitude of the earthquake's strength from the epicenter of the earthquake, but can also be affected by local geological conditions or local site effects as well as coastal abrasion. Some earthquake events that occur in an area are very vulnerable to the occurrence of liquefaction events. Some factors considered include grain size, groundwater level and maximum ground vibration acceleration.

The HVSR method is usually used in three passive seismic components. Nakamura said that the HVSR method for microtremor analysis could be used to obtain the natural frequency of sediments and sediment thickness [4]. HVSR has been widely used to estimate the natural frequency and soil amplification [2],[3],[4];[5];[6]. Therefore, to determine the level of seismic vulnerability in the Outer Ambon Bay Coastal Area, Ambon City, it is very necessary to conduct research to minimize the impact of damage caused by the earthquake.

## BASIC THEORY

Several studies suggest that ambient noise, or weak motions, can be used to identify areas that might amplify earthquake ground motions in advance of earthquake occurrence [1]. Seismic vulnerability index is an index that describes the level of vulnerability of the surface soil layer to deformation during an earthquake [1]. According to Nakamura [8], seismic vulnerability index is obtained by squaring the peak value of the microtremor spectrum (amplification) divided by the resonance frequency, which is formulated as:

$$k_g = \frac{A^2}{f_o} \quad (1)$$

with: $k_g$ = Seismic vulnerability index, ($s^2$/ cm),
$A$ = Peak of the microtremor / amplification spectrum,
$f_o$ = resonant frequency, (Hz).

### Land Classification

Several microtremor measurements have been carried out in Japan to determine the relationship between the dominant period ($T_0$) and soil type. From the measurement results, a classification is then made which shows the relationship between the dominant period ($T_0$) with the type of soil. Kanai and Omete-Nakajima propose two methods for classifying soil profiles. According to Kanai's based on type I, II, III, IV and type A, B and C by Omete-Nakajima in Table 1 gives an indication of the type of soil [9]:

**Table 1.** Land Classification according to Kanai and Omote-Nakajima.

| No | Soil classification | | The dominant period (second) | Description | Character |
|---|---|---|---|---|---|
| | Kanai | Omete-Nakajima | | | |
| 1. | Type I | Type A | 0,05 -0,15 | Tertiary or older rock consisting of hard sandy rock, gravel etc. | Hard |
| 2. | Type II | Type A | 0,15 – 0,25 | Alluvial rocks, with a depth of 5 m. consists of sandy - gravel, sandy hard clay, loam etc. | Medium |
| 3. | Type III | Type B | 0,25 – 0,40 | Alluvial rocks, almost the same as II, are only distinguished by the presence of bulff formation | Soft |

| No | Soil classification | | The dominant period (second) | Description | Character |
|---|---|---|---|---|---|
| | Kanai | Omete-Nakajima | | | |
| 4. | Type IV | Type C | > 0,40 | Alluvial brick, which is formed from delta sedimentation, topsoil, mud etc.with a depth of 30m | Very soft |

## METHODS

### Description of the location of Ambon Outer Bay

The Outer Ambon Bay (TAL) is the outer part of the Ambon Bay area covering the Tantui coast to the Seilale coast in the south and the coast of the Rumahtiga to Alang in the north. Compared to Ambon Dalam Bay (TAD), TAL is broader, deeper and directly related to the Banda Sea. The bay area is around 143.5 km$^2$ and its length is around 30 km. The location of this research is the Outer Coastal Zone of Ambon Bay, Ambon City can be seen in Figure1.

Data that can be used in this research are primary data taken directly in the Outer Ambon Bay Coastal Area, Ambon City, using TDL 303S. Measurements are carried out at a distance of 200 m to 500 m. Then the measurement data is then processed using Geopsy software to obtain ground vibration data. Data was reprocessed using Geopsy software (2012) to estimate the Amplification (*A*) and fundamental frequency ($f_0$) factors for each observation point. Kg index was estimated for each site based on Nakamura technique [2],[3].

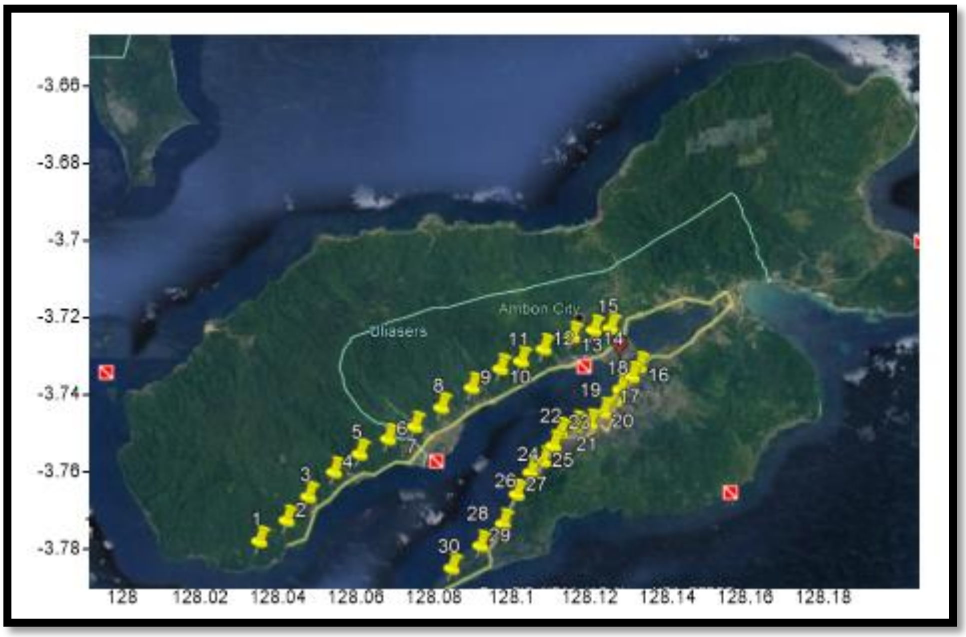


**Figure 1.** Map of the research location of the outer coastal bay of Ambon.

## RESULTS AND DISCUSSION

### Microtremor Measurement Results

This measurement is carried out for 15-30 minutes to find out the microtremor signal which consists of three components, namely the vertical component (Z), south-strand component (N-S) and the west east component (E-W).

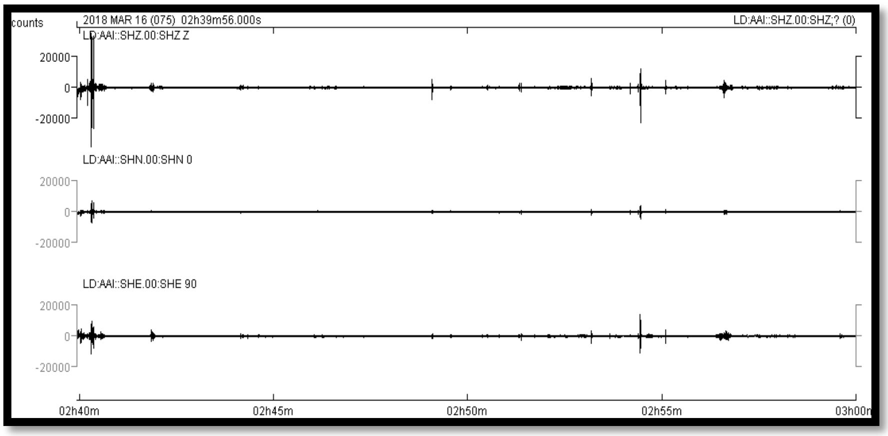


**Figure 2.** Microtremor Signal Measurement Point 22.

In Figure 2 describes the reading of the ground vibration signal at the measurement point 22 with the position 3° 42'24.80 "LS and 128° 9'53.38" BT. In processing data we used Geopsy software. This software contains information of recording time, the amount of data, and other supporting data. The result is a spectrum at each stasiun will then be analyzed to obtain the HVSR peak value (*A*) and predominant frequency ($f_0$).

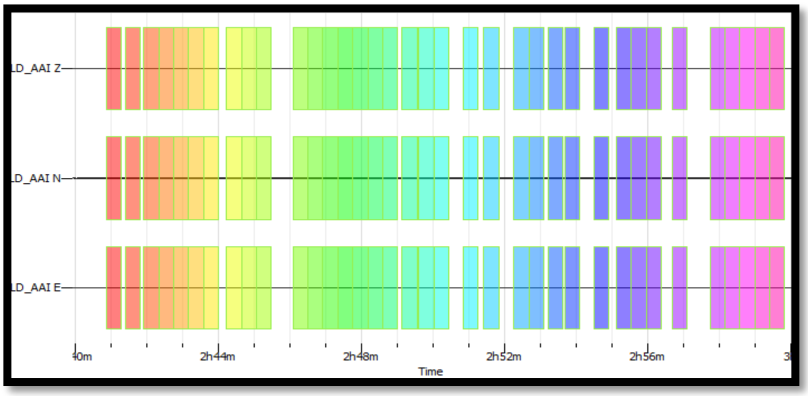


**Figure 3.** Sorting Windows Signal Measurement Point 22.

Windowing is the process to sort data between the tremor signals and transient event (especially specific sources such as footsteps and vehicle passes). The function of this process is to avoid the processing of transient events in the analysis. Comparison between the short term average (STA) and long term average (LTA) and also using anti triggering logarithm is the way to detect transient signals. STA is the average value of short-term amplitude (0.5-2.0 seconds) and LTA is an amplitude value of the average long-term (> 10 seconds).

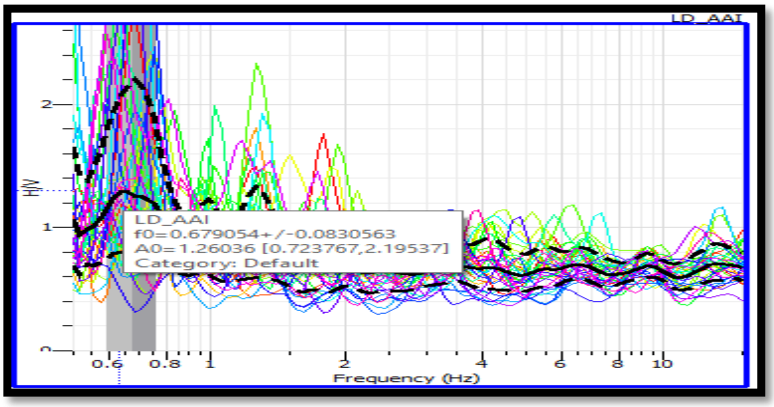


**Figure 4.** H / V Spectra Point of Measurement 22.

HVSR spectrum obtained from analysis of microtremor signal recording using Geopsy software. This process can be determined values of $A$ and $f_0$ for each measurement point. Figure 4 shown there are two dotted lines above and below which is standard deviation for all values of the ratio of the resulting spectrum. The line in the middle is the average value of the FFT analysis of the entire value of H/V ratio, while the thin line is colourful curves H/V spectrum ratio of each window. Can be seen in Figure 4.3.22 the measurement point 22 has the highest natural frequency ($f_0$) value of 0.679 Hz with an amplification factor ($A$) is 1.260. The main purpose of reprocessing data is using advanced tool to enhance the natural signal and minimize the artificial noise that may be included in the previous results of Fergany and Bonnefoy-Claudet (2009).

**Soil Dependency Index Value at Each Measurement Point in the Outer Coastal Area of Ambon Bay.**

**Table 2.** Value of Soil Density Index on Each Measurement Point in the Outer Coastal Area of Ambon Bay.

| Points Measurement | Latitude | Longitude | Amplifikation ($A$) | Frequency ($f_0$) Hz | Period T (s) | Seismic Vulnerability Index ($k_g$) $s^2$/cm |
|---|---|---|---|---|---|---|
| 1 | 3°46'19.75" | 127°59'32.26" | 1,228 | 3,923 | 0.255 | 0.384 |
| 2 | 3°45'37.09" | 128° 0'26.47" | 1,164 | 5,014 | 0.199 | 0.270 |
| 3 | 3°44'48.97" | 128° 1'8.99" | 1,029 | 3,016 | 0.332 | 0.351 |
| 4 | 3°43'58.69" | 128° 1'59.81" | 1,043 | 2,598 | 0.385 | 0.419 |
| 5 | 3°43'22.50" | 128° 2'48.99" | 1,444 | 5,358 | 0.187 | 0.389 |
| 6 | 3°42'51.46" | 128° 3'45.69" | 1,094 | 8,354 | 0.120 | 0.143 |
| 7 | 3°42'26.63" | 128° 4'37.16" | 1,448 | 12,763 | 0.078 | 0.164 |
| 8 | 3°41'48.20" | 128° 5'29.03" | 1,700 | 13,424 | 0.074 | 0.215 |
| 9 | 3°41'7.75" | 128° 6'29.04" | 1,560 | 4,513 | 0.222 | 0.539 |
| 10 | 3°40'29.24" | 128° 7'25.15" | 1,117 | 4,248 | 0.235 | 0.294 |
| 11 | 3°40'13.88" | 128° 8'5.78" | 1,196 | 5,868 | 0.170 | 0.244 |
| 12 | 3°39'48.91" | 128° 8'50.18" | 1,090 | 4,795 | 0.209 | 0.248 |
| 13 | 3°39'23.89" | 128° 9'45.86" | 1,513 | 1,118 | 0.894 | 2.048 |
| 14 | 3°39'10.38" | 128°10'28.18" | 1,571 | 8,857 | 0.113 | 0.279 |
| 15 | 3°39'6.47" | 128°11'0.95" | 1,192 | 5,328 | 0.188 | 0.267 |
| 16 | 3°40'24.45" | 128°11'56.89" | 1,490 | 5,062 | 0.198 | 0.439 |
| 17 | 3°40'44.66" | 128°11'43.39" | 1,014 | 0,652 | 1.534 | 1.577 |
| 18 | 3°41'11.64" | 128°11'20.22" | 1,059 | 1,002 | 0.998 | 1.119 |
| 19 | 3°41'32.83" | 128°11'10.58" | 1,183 | 4,755 | 0.210 | 0.294 |
| 20 | 3°41'57.85" | 128°10'47.41" | 1,957 | 13,063 | 0.077 | 0.293 |
| 21 | 3°42'20.95" | 128°10'20.42" | 1,382 | 9,553 | 0.105 | 0.200 |
| 22 | 3°42'24.80" | 128° 9'53.38" | 1,260 | 0,679 | 1.473 | 2.338 |
| 23 | 3°42'38.19" | 128° 9'22.60" | 1,125 | 0,676 | 1.479 | 1.872 |
| 24 | 3°43'4.91" | 128° 9'9.35" | 1,226 | 0,679 | 1.473 | 2.214 |
| 25 | 3°43'36.02" | 128° 8'49.74" | 1,131 | 2,765 | 0.362 | 0.463 |
| 26 | 3°43'58.89" | 128° 8'24.89" | 1,030 | 1,238 | 0.808 | 0.857 |
| 27 | 3°44'43.61" | 128° 7'57.74" | 1,046 | 0,664 | 1.506 | 1.648 |
| 28 | 3°45'43.37" | 128° 7'30.61" | 1,303 | 1,693 | 0.591 | 1.003 |
| 29 | 3°46'27.26" | 128° 6'46.71" | 1,182 | 1,580 | 0.633 | 0.884 |
| 30 | 3°47'13.93" | 128° 5'49.96" | 1,011 | 0,634 | 1.577 | 1.612 |

From table 2 data above, the results of very high seismic vulnerability index values are generally found at the 22nd measurement point of 2,338 s2 / cm in the coastal area of Nusaniwe Subdistrict, while the lowest is generally at the 6th measurement point, namely amounting to 0.143 s2 / cm in the coastal area of Teluk Ambon District. From the sum of each levitation point in the coastal area of the outer Ambon bay, illustrates that the value of the soil vulnerability index is at the level of vulnerability in an area from the threat of earthquakes can be seen in Figure 5.

**Dominant Period Analysis**

Based on Table 1 and the results of the seismic vulnerability index value in Figure 5, the value of the dominant period in the coastal area of Teluk Ambon District (Locations 1-15) is generally dominated by class II land types composed of Alluvial rocks, with a depth of 5 m consisting of sandy - gravel, sandy hard clay, loam. Whereas the measurement point 22-30 which is the coastal area of Nusaniwe Subdistrict is generally dominated by class IV soil types composed of alluvial Bataun, which is formed from delta sedimentation, topsoil, mud, etc., with a depth of 30 m.

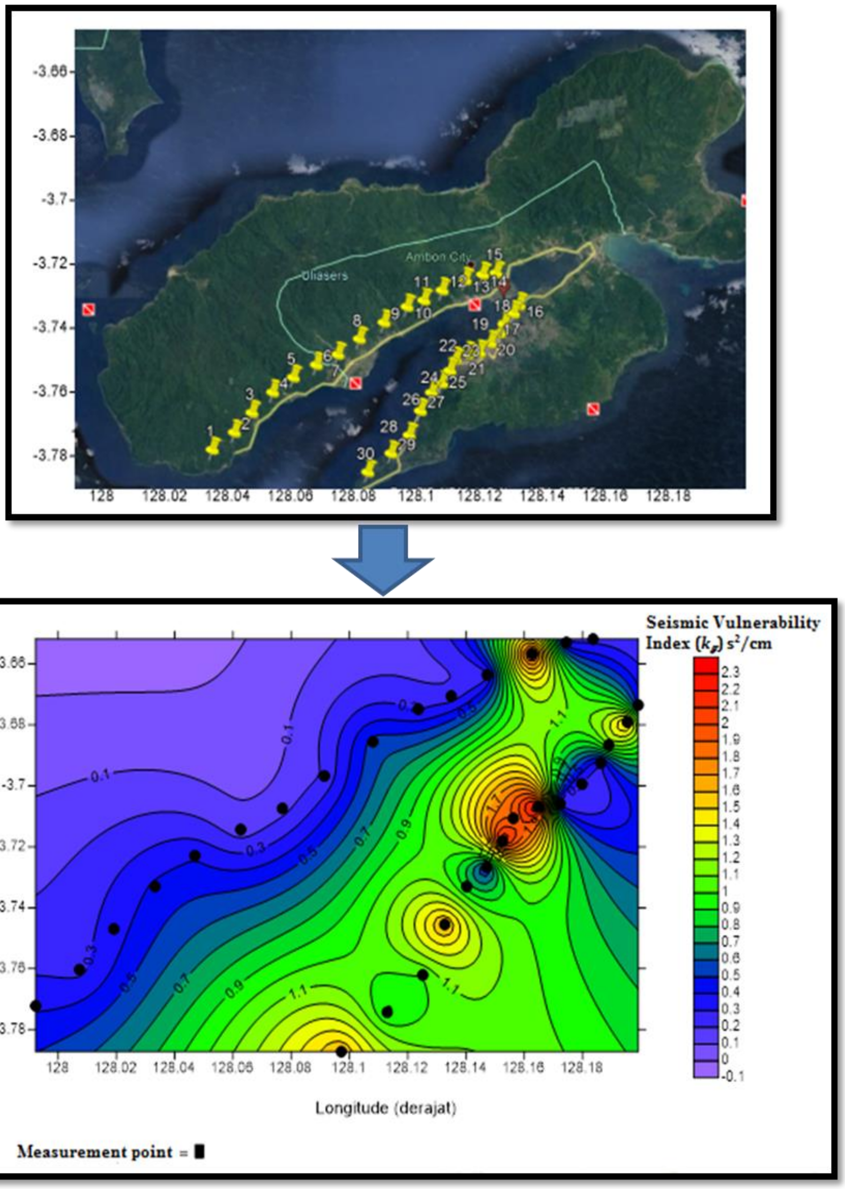


**Figure 5.** Seismic Vulnerability Index Map of the Outer Ambon Bay Coastal Area Research Area.

## CONCLUSION

Based on the results of data analysis and discussion, it can be concluded:

1. A very high seismic vulnerability index value is generally found at the 22nd measurement point of 2,338 $s^2$/cm in the coastal area of Nusaniwe Subdistrict, while the lowest is generally at the 6th measurement point that is equal to 0.143 $s^2$/cm in the coastal area Teluk Ambon District.
2. Based on the dominant period, it is known that the measurement location in the coastal area of Teluk Ambon Sub-district (Location 1-15) is generally dominated by class II land types composed of alluvial rocks, with a depth of 5 m consisting of sandy - gravel, sandy hard clay, loam. Whereas the measurement point 22-30 which is the coastal area of Nusaniwe Subdistrict is generally dominated by class IV soil types which are composed of alluvial rocks, which are formed from delta sedimentation, topsoil, mud, etc., with a depth of 30 m.

## REFERENCES

[1]. Nakamura, Y., A method for dynamic characteristics estimation of subsurface using microtremor on the ground surface. Q. Rep. Railway Tech. Res. Inst. 1989; 30(1): 25–33.

[2]. Nakamura, Y., Seismic vulnerability indices for ground and structures using microtremor. In: World Congress on Railway Research in Florence, Italy, November 1997.

[3]. Nakamura, Y., Clear identification of fundamental idea of Nakamura's technique and its applications. 12WCEE, 2656, Auckland, New Zealand 2000..

[4]. Nakamura, Y., On the H/V spectrum. In: The 13th Word Conference on the Earthquake Engineering, Beijing, China, 2008; October 12–17.

[5]. Bard, P.Y., Microtremor measurements: a tool for site effect estimation? In: Irikura, K., Kudo, K., Okada, H., Sasatami, T. (Eds.), The Effects of Surface Geology on Seismic Motion. Balkema, 1999; 1251–1279.

[6]. Gosar, A., Microtremor HVSR study for assessing site effects in the Bovec basin (NW Slovenia) related to 1998 Mw5.6 and 2004 Mw5.2 earthquakes. Eng. Geol. 2007; 91: 178–193.

[7]. Fergany, E., Bonnefoy-Claudet, S., Microtremor measurements in the Nile delta basin, Egypt: response of the topmost sedimentary layer. Seismol. Res. Lett. 2009; 80(4): 591–598.

[8]. Mufida, A., Santosa, B. J., & Warnana, D. D. Microtremor Inversion of H/V Spectrum to Measure the Speed of Shear Wave (Vs) Under Surface Layer and Microzonation of Surabaya Region. Teknik POMITS, 2013; 1-8.

[9]. Hartati, Lidia. Mapping the Level of Risk of Liwa and Surrounding Regional Earthquakes Based on Microtremor Measurement. Thesis.. Yogyakarta : UGM. 2014.

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