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Sensitivity to the Presence of Subsurface Cavities From Microtremor Response Data

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Abstract
In large urban locations, typical geophysical approaches confront numerous obstacles, including limited site accessibility and heavy industrial influence. With the increasing development of the urban area and to get a suitable result, it is hugely valuable to have a geophysical approach with a high resolution that is suited to the complicated urban conditions.
In this study, we present a 2D microtremor survey strategy based on compute the HVSR (Horizontal to Vertical Spectral Ratio) by using H/Vprocedure. It employs H/V method to derive the Surface wave's frequency F0 and amplification Ao from 3components geophones recording data, and then inverts these values to replicate the apparent S-wave velocity Vs. This technology provides a precise and effective tool for mapping near-surface geological anomalies, such as subsurface holes and cracking zone, which are commonly occurring in urban engineering projects. The practical application of the microtremor survey in Physic Department of Diponegoro University project reveals that this technique is highly effective to detecting sensitivity of abandoned subsurface structures.
Key words*:Subsurface Cavities, Passive seismic, Sensitivity*

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I. Introduction

Identifying cavity sensitivity is crucial for the optimal use of subsurface space, which includes determining the method of construction, the placement of the underground hole, and the design of the old buried drainage. Commonly, an ancient vertical boring is performed to determine the sensitivity and depth of a cavity's sensitivity. Nevertheless, drilling a borehole to measure depth and sensitivity in a limited urban project space is typically a time-consuming and noisy operation. In moreover, the cost of drilling a borehole is cost prohibitive and raises environmental concerns because the transportation of drilling equipment necessitates the destruction of plants and trees.

There are a variety of near-surface geophysical methods and their applications in geotechnical engineering, including the microtremor method, which has also been applied to a variety of components(Test, 2015).With consideration of the three wavefield components, surface waves are often collected and examined. Typically, the Vs (shear-wave velocity) profile of the studied site is obtained by inverting theRayleigh wave velocity(Xia et al., 2009) from H/V values of an automatically picked modal, This method are available in urban places where active measurements are typically impossible due to lack of experimental space(Fäh et al., 2001). The acquisition and analysis of that 3-components data passive recording (Fig1) used horizontal to vertical H/V for the start steps and continue to inverting using ellipticity curve.

II. METHODOLOGY

Three components collected data in the Taman Rumah kita area, 38 points were measured using a Graphtec Instruments midi LOGGER GL240 seismometer at a distance of between 1 m (Figure 4), with a measuring duration of 5 minutes per point and a sampling frequency of 20 Hz. Geopsy software processes microtremor data derived from seismometer measurements using the H/V method. The HVSR analysis calculates the horizontal and vertical component spectrum (Yuliyanto, 2020). The preceding formula is used to calculate the energy spectral ratio across horizontal components by vertical components:

- H/V ratio

$$[H/V](X;\omega) = \sqrt{\frac{E_1(X,\omega) + E_2(X,\omega)}{E_3(X,\omega)}} \quad (2.5)$$

where $E_{1,2,3}$ Energy and the second number 1, 2 denote horizontal (north, East) degrees and that number 3 denote vertical degrees, respectively. The H/V technic generates the resonance frequency and amplification;and then, the average levels of the H/V curve with its key parameters(Sánchez-Sesma, 2017).

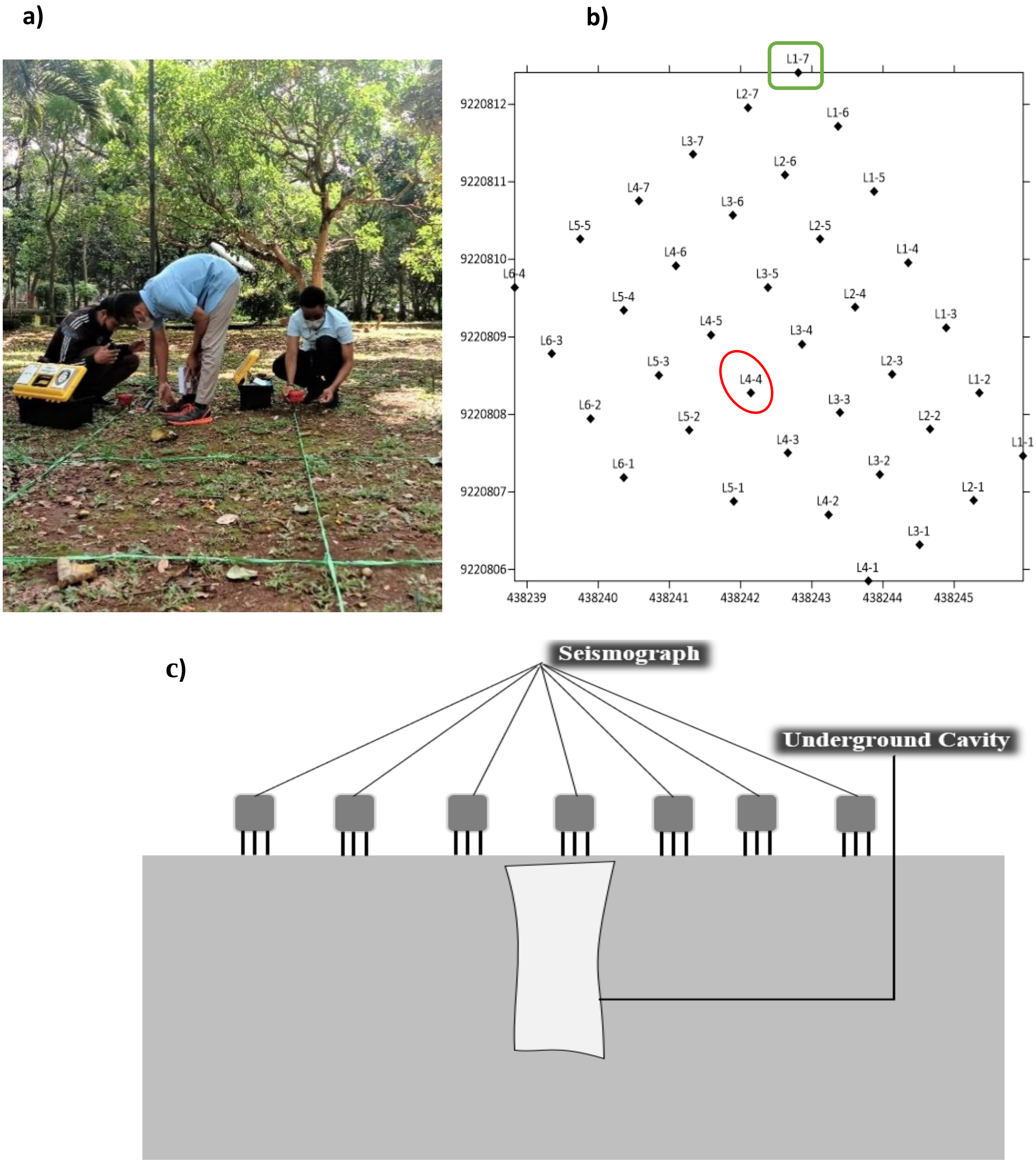


Figure 1: Acquisition Data: a)3D-displayed area;b)Map of acquisition measurement all lines; C)A couple of Vertical, East- and North-component geophones are installed above an underground cavity.

Geopsy software performs computational operations, we just used the default window length of 25s for every data batch, the number of sampling rate is 100, and all of the left parameters are set to their default values. Then, as a result of the process, a H/V curve describing the maximum frequency, minimum frequency, and resonance amplification will be created (Fig2). Afterwards, by importing that H/V curve saving result in into dinver tool, an inversion procedure was conducted using the ellipticity curve method, which generates a 3-maximumnumber of profilesconsistingVp, Vs, and density.

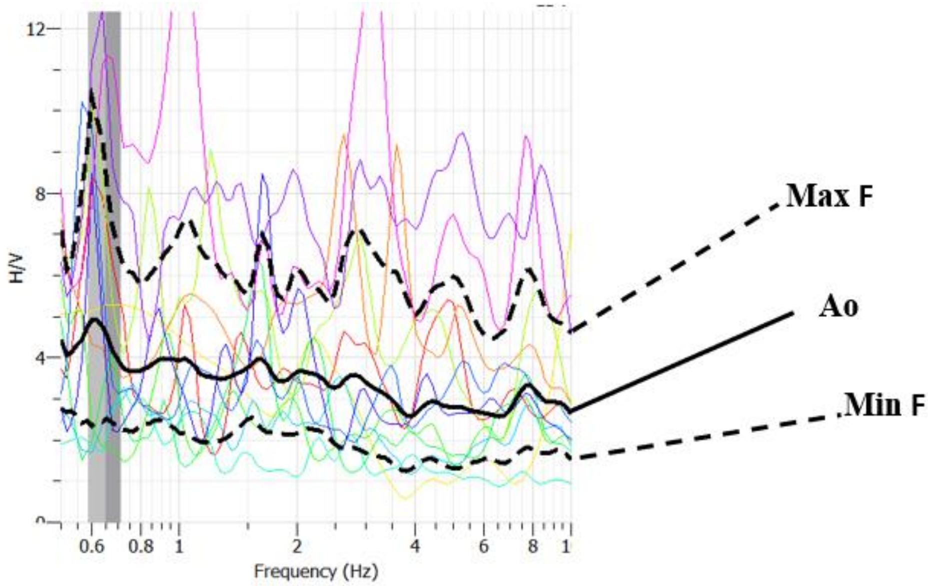
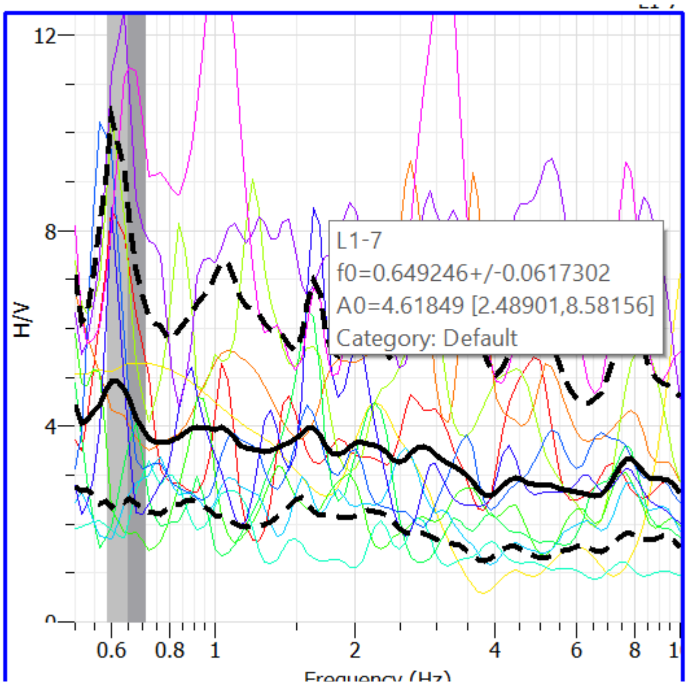


Figure 2: The H/V curve illustrates the greatest and minimum frequency, whereas the Amplification

III. RESULT AND ANALYSIS

Using the outcomes of H/V computation, understood to be the main frequency and amplification value depicted in (Figure 3.a) on the area is probably fo0.649246 and Ao4.61; however, the providing effective values for the frequency in the area are dispersed around 0 and 8Hz (Figure 3. b) and the amplification dissemination value ranges from 1 to 10 (Figure 3.c).The peak of the HVSR frequency in a location can realistically represent the change in the depth of the bedrock layer at many points(Harmoko et al., 2021).Upon analyzing the values of frequency and amplification factor distribution, it was determined that there is no connection between them; nevertheless, there is also no significant difference between them; the numbers are not significantly different.Based on the response spectra , researchers offer a reasonable estimate of the amplification and frequency of surface ground motion over subsurface cavities for certain example cases of considerable interest(Baker, 2007). According to the significant frequency amplification value, the area has a higher sensitivityexist, In the stratified area, there is a ground interaction complex system of wave scattering and subsurface hole diffraction(Haghshenas et al., 2005), so that demonstrating the existence of the subsurface cavity.

a)



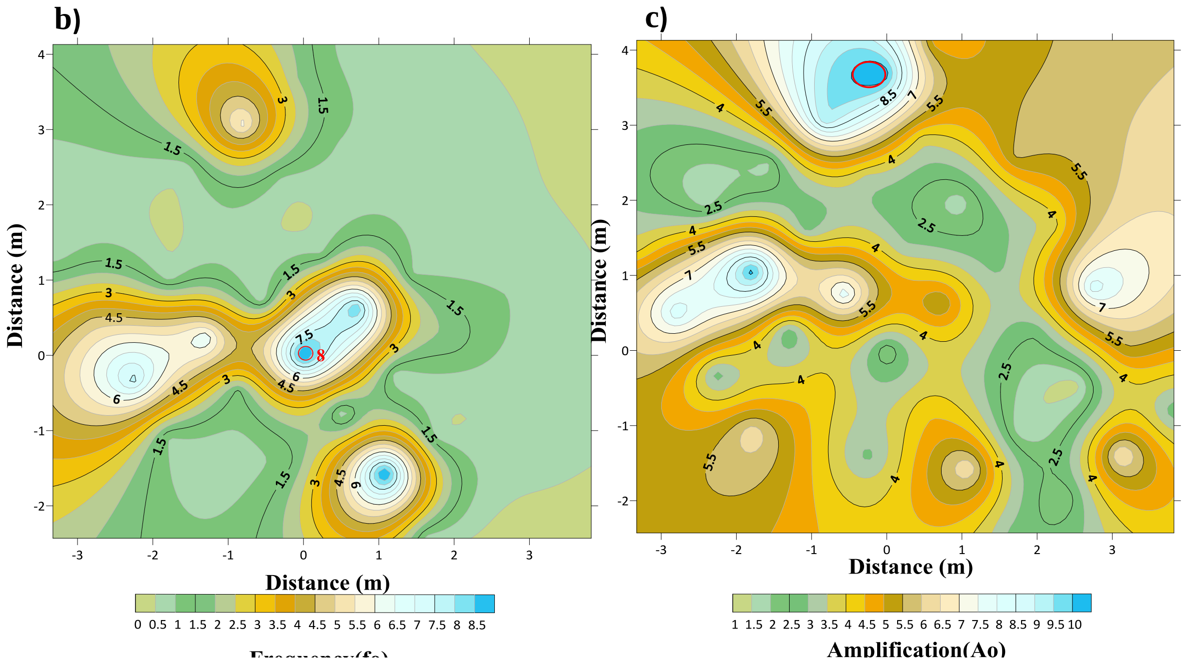
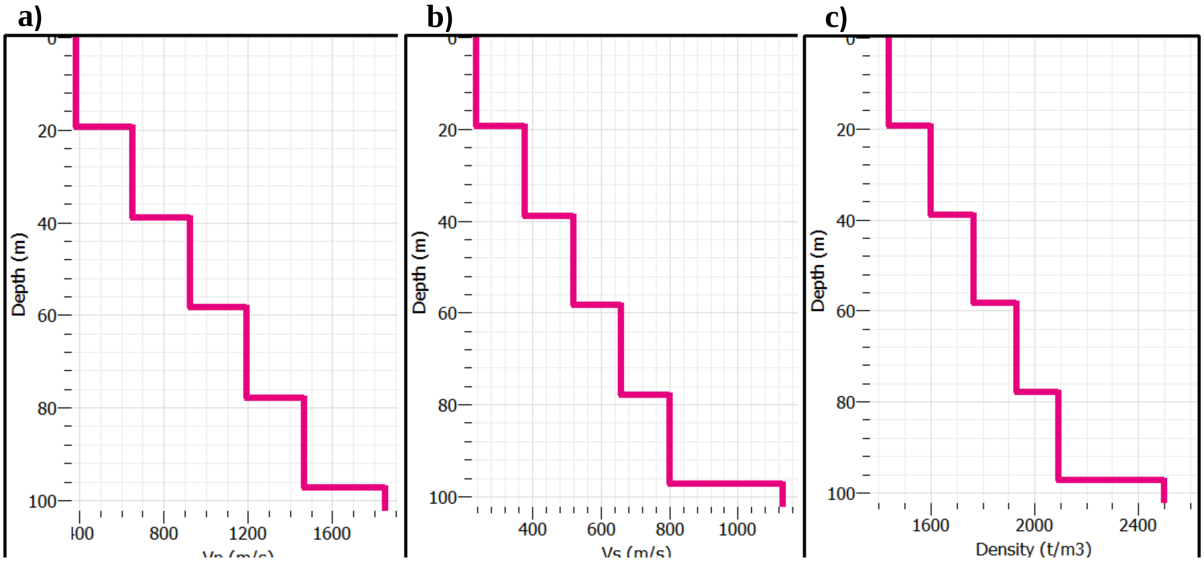


Figure 3: a)H/V overall average curve and H/V paramete; b) Distribution frequency contour (fo);c) Contour with distribution Amplification (Ao).

In the line1-7 (fig 1. b), the results of inverting H/V curve were displays on Figure 4. We got the profiling Vp, Vs, and density values generated by ellipticity curve inversion using Dinver.At 38 measuring points, the ellipticity curve inversion produced a range of Vp values between 283.85m/s to 2148.64m/s, a range of Vs values between 134.85m/s to 1330.74m/s, and a range of Vp/Vs values (fig 4. d)in this following research are between 1.35 to 4.13;under varied temperature and pressure settings, the Vp/Vs ratio of rocks with varying compositions can range around nearly 1.782 and 2.1191(Christensen, 1996). The distribution for Vp and Vs values coincides to that of the increase in Vp/Vs as depth, which may indicate lithological variations or increased plasticity in the subsurface cavity(J. Lin et al., 2015).After then, the cross cavity distribution values for Vp/Vs are 2.8, and these high Vp/Vs values demonstrate the abnormal of onshore caused by the existence of a cavity under the ground and are connected with pore fluid pressure(J. Y. Lin et al., 2004). A higherVp, Vp/Vs ratio and a lower Vscan be interpreted as the absence of rock continuity; in this research, the mixture depicted under L4-4 and represents the prospective area.



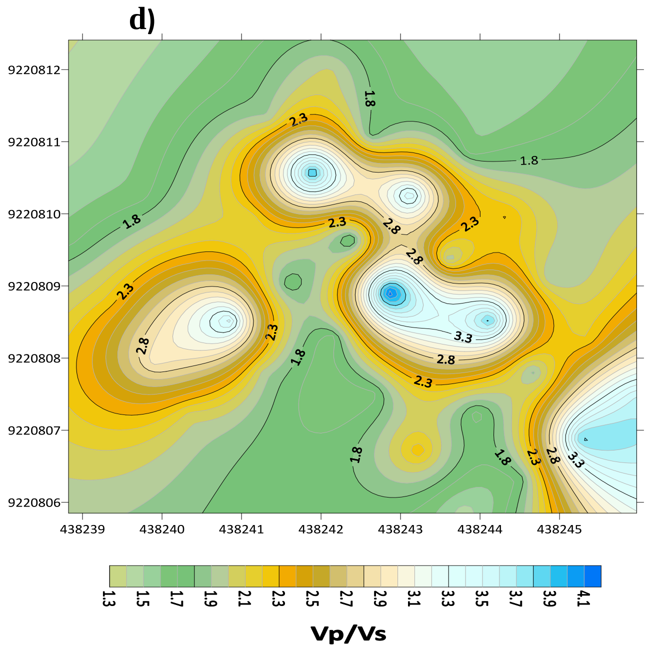


Figure4:a)Curveof Compression wave velocity; b) Curve of Shear wave velocity; c) Curve of Density; d) Cure showing the compression wave velocity by shear wave velocity

IV. CONCLUSION

In this research, the HVSR approach may be the single best way in terms of experimental verification and analysis simplicity. The strategy is much more advantageous in situations where geophone array assembly is impractical. Applying microtremor records, the three-dimensional modelling and simulation data illustrate the feasibility of discovering and determining the sensitivity of subsurface holes. The technique depends on the collection of wave propagation created in the area between the surface of the ground and the external portion of the subsurface cavity as a result of microtremors. The frequency and amplitude distribution of wave propagation on the observation surface permits the characterization of subsurface cavities.

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