Earthquake acceleration amplification based on single microtremor test

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Abstract. Understanding soil dynamics is needed to understand soil behaviour, including the parameters of earthquake acceleration amplification. Many researchers now conduct single microtremor tests to obtain amplification of velocity and natural periods of soil at test sites. However, these amplification parameters are rarely used, so a method is needed to convert the velocity amplification to acceleration amplification. This paper will discuss the proposed process of changing the value of amplification. The proposed method is to integrate the time histories of the synthetic earthquake acceleration of the soil surface under the deaggregation at that location so the time histories of the velocity earthquake will be obtained. Next is to conduct a "fitting curve" between amplification by a single microtremor test with amplification of the synthetic earthquake velocity time histories. After obtaining the fitting curve time histories of velocity, differentiation will be conducted to obtain fitting curve acceleration time histories. The final step after obtaining the fitting curve is to compare the acceleration of the "fitting curve" against the histories time of the acceleration of synthetic earthquake at bedrocks to obtain single microtremor acceleration amplification factor.

1. Introduction

Single microtremor test is a field test used to obtain parameters of velocity amplification and natural period of soil. However, this test is not perfect. There is still uncertainty about the proportion of body waves (primary and secondary) with surface waves captured by microtremor causing inaccurate amplification value generated [1]. Currently, in general, the process of calculating the amplification and the natural period of microtremor test is using the Nakamura method without additional methods [2,3]. On the other hand, some methods use Rayleigh wave HVSR correction at a certain proportion to obtain a more realistic amplification value [1]. However, according to the authors, this is still quite complicated because we have to ascertain how much the proportion of Rayleigh waves to body waves microtremor received.

Another problem is the doubt about the relationship between velocity amplification and acceleration amplification, and also uniformity of acceleration amplification value generated by microtremor on wave propagation 1D modeling either by linear or nonlinear method [4, 5] which is the basis of the calculation of Indonesian seismic standards [6]. The rule of seismic describes the acceleration amplification values based on soil class at a particular location. Therefore, in this paper, we will discuss the method to obtain the acceleration amplification value of single microtremor test.

The propagation mechanism of the source/wave input in the 1D and single microtremor analyzes is different. This difference can be observed in the illustration of Figure 1. It appears that in the 1D test the source propagates from the bedrock to the surface (vertical upward direction), while on the microtremor single the source is reflected from the surface source to the reflector layer and returns to
the surface [7]. Another difference is the proportion of surface waves and different body waves in both tests.

![Figure 1](image)

**Figure 1.** 1D wave propagation from bedrock to ground level [8].

2. **Deaggregation**

Deaggregation is the process of determining the magnitude (M) and distance (R) dominant results of PSHA which contributes the greatest danger to a site in the period of earthquake repetition and period of a particular building structure. The dominant forces and distances that provide the most significant threat to a place are determined by the concept of the emphasis of the deaggregation curve. The equations used can be observed in the formula below [9].

\[
M_{dominant} = \frac{\sum M_i \text{ (event contribution/year)}}{\sum \text{(event contribution/year)}}
\]

\[
R_{dominant} = \frac{\sum R_i \text{ (event contribution/year)}}{\sum \text{(event contribution/year)}}
\]

3. **Single microtremor test**

As described in the previous chapter, the single microtremor test has been widely applied to obtain the amplification values of the velocity and natural periods of the soil. However, on this side there are deficiencies in which the amplification value is rarely used because it is a function of velocity, not acceleration. Figure 3 is a map of single microtremor test and the sample of processing done at the location of Bandung Basin [11]. According to the study, the Bandung basin area is surrounded by inter-mountain terrain located in West Java, with an altitude between + 665 and 2,400 m above sea level. Geological development in Bandung basin area in the final quarter based on lithostratigraphy shows the magnitude of the effect of volcanoclastic deposition process and lake system. Older debris is dominated by river sediments and weathered sediments (palaeosols) covered with sedimentary deposits of lakes throughout the basin [12]. Meanwhile, the data processing test was done by using Fast Fourier Transform (FFT) method to accelerate the calculation when compared with Discrete Fourier Transform. Furthermore, by using horizontal spectra ratio, equation to the vertical obtained graph relation between natural period and velocity amplification. Currently, the last national scale map of deaggregation can be observed in Figure 2 [10].
Figure 2. Map of magnitude (M) deaggregation and distance of earthquake source (R) on PGA with 2% probability exceeded in 50 years (2475 years quake period) from deaggregation analysis.

4. Proposed Method
By using the synthetic earthquake of the deaggregation and determining the dominant earthquake mechanism at that location, the time histories of acceleration are obtained on the bedrock. Next, the amplification is achieved using Fast Fourier Transform [13], so that time histories of acceleration on the surface are obtained. The next step is integration to obtain time histories of surface velocity. This velocity time histories will be used for fitting curve against velocity amplification of single microtremor. Having got this fitting curve, the next step is to differentiate, so acceleration time histories at the surface are obtained. The amplification value of single microtremor acceleration was obtained by comparing
the surface acceleration curve fitting and historical time acceleration of bedrock using synthetic earthquake. These steps can be seen in Figure 4. After all, the above steps can be illustrated using the graph with the relation of velocity and acceleration amplification by microtremor test based on the specific site class as standardized by the Indonesian seismic standard [6].

Figure 3. Microtremor test point map and sample of microtremor processing data.
5. Conclusions
The proposed method is to integrate the acceleration time histories of the earthquake synthetic at the soil surface under the deaggregation at that location to obtain the velocity time histories. Next step is to conduct a "fitting curve" velocity time histories between the velocity amplification value of a single microtremor and velocity amplification of a synthetic earthquake. Having obtained the fitting curve time histories of velocity, differentiation was done, so that it obtained fitting curve time histories acceleration. The final step after obtaining the fitting curve is to compare the acceleration of the "fitting curve" against the historical time of the acceleration of synthetic earthquake at bedrock to obtain acceleration amplification value of single microtremor.

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