Seismic Property and Its Effect on Abrasion in the West Leihitu Coastal region, Ambon Island

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Abstract. This research was carried out in the West Leihitu coastal region, Ambon Island. The purpose of this study is to study seismic properties and their effects on coastal abrasion based on seismic geological conditions as an indicator of abrasion rate. Peak Ground Acceleration (PGA) values of each coastal area have a range (19,722-41,130) gal, with the highest value in the Negeri Liliboi at 41,130 gal. PGA values do not represent Ground Shear Strain (GGS) levels or have an impact on rock deformation in coastal areas. This can be seen from the GGS of the Negeri Liliboi coastal area which is higher ($\gamma = 1.459 \times 10^{-5}$) when compared to Negeri Alang coastal area ($\gamma = 2.561 \times 10^{-5}$) although the Peak Land Acceleration (PGA) value is large. Based on these results, Negeri Alang and Negeri Liliboy have high soil susceptibility resulting in soil structure cracking and soil degradation. This is the potential for abrasion in coastal areas. Geological conditions on the West Leihitu coastal region consist of land classification types II, III and IV namely gravel sand, alluvial rocks, and buff formations and alluvial rocks formed from sedimentation with a very thick layer thickness in general.

1. Introduction
Ambon Island is one of the thousands of islands in Maluku Province, which has different characteristics and uniqueness. One of its uniqueness, this island has many beach attractions along the West Leihitu peninsula. Community activities usually occur in coastal and coastal areas. Utilization of coastal and coastal areas in this region such as tourism, settlements (dwelling), sand mining and other activities that are very important in meeting their daily needs. Coastal beaches as a transition area, many of which influence the area bordering it. Open beaches have a higher level of dynamics than closed beaches. Various activities that occur from upstream to downstream can be changed due to abrasion and sedimentation processes. Beaches can be classified into several types based on the morphological and geological structure of the coastal area. To find out the seismic nature and its effect on abrasion in the West Leihitu Peninsula, Ambon Island used microseismic measurements. Information through the seismic property can identify beach characteristics that can be identified
quantitatively. The research locations of the West Leihitu coast are (3°43'14.06"So - 3°46'5.72"So) and (128° 4'22.59"Eo - 128° 0'30.46"Eo), as in Fig.1.

![Map of The Research Location is West Leihitu Coastal Area.](image)

**Figure 1.** Map of The Research Location is West Leihitu Coastal Area.

2. Methods

2.1 Types of research

This research is a type of field survey research. In this study, the survey was conducted using direct measurements in the field using a TDL 303S seismograph. This tool is used to describe 3 wave components, namely one vertical component (top and bottom), and two horizontal components (North-South and East-West). HVSR was given to four coastal locations in the western Leihitu peninsula in a different geology condition. The first location is in Negeri Laha, the second location in Negeri Hatu, the third location in Negeri Liliboi and the fourth location in Negeri Alang. The Geopsy Program is used for calculations from HVSR method. This program is based on the Nogoshi and Igarashi method [1] and developed by Nakamura [2]. This method is based on interpretation in the SESAME project [3]. The type of smoothing with the Konno-Ohmachi method is used by Konno and Ohmachi [4].

2.2 Seismic Vulnerability Index

Earthquake damage is not only influenced by the magnitude of the earthquake force from the earthquake epicenter but can also be influenced by local geological conditions or the effects of local locations and coastal abrasion. Some factors considered include grain size, groundwater level, and maximum ground vibration acceleration [5]. In general, coastal abrasion is caused by external factors, especially wave strength beat the beach. However, in this study which is an internal factor, Coastal abrasion is the seismic vulnerability of the coast which is often caused by earthquakes. Analysis and microtremors can be done using the Horizontal to Vertical Spectrum Ratio (HVSR) method. The HVSR method is useful for identifying resonance responses in basins containing sedimentary material. Seismic Vulnerability Index \( K_g \) interprets the level of susceptibility of surface soil layers that have changed shape during an earthquake. Thus \( K_g \) can be considered as an index to indicate easiness of deformation of measured points which is expected useful to detect weak points of the ground. As we can consider \( Cb = 600 \text{ m} / \text{s} \), we obtain \( 1 / (\pi^2 Cb) = 1.69 \times 10^{-6} \text{ (s} / \text{cm}) \). If we put \( e = 60\% \), then \( K_g \) is expressed as follows.

\[
K_g = \frac{A_g^2}{F_g} \tag{1}
\]
The effective strain can be estimated by multiplying $K_e$ value with a maximum acceleration of basement ground in Gal ($= \text{cm/s}^2$) [6].

### 2.3 Peak ground acceleration

Peak Ground Acceleration (PGA) is the value of vibration acceleration by an earthquake. The maximum ground acceleration value is calculated based on the magnitude and distance of the source of the earthquake that has happened to the point calculation, as well as the predominant period value of the area’s land. Kanai formulated the Peak Ground Acceleration as [7]:

$$a_g = \frac{5}{16} 10^{0.61M - 1.66 + \frac{3.6}{R} + 0.167 \frac{1.83}{R}}$$  \hspace{1cm} (2)

### 2.4 Ground shear strain

Ground Shear Strain (GSS) values in the soil layer illustrate the ability of soil material to shift during an earthquake. Table 1 shows the relationship of GSS to the disasters caused by soil. From these data that are recognized when GSS is worth $1000 \times 10^{-6}$, the land begins to show non-linear character and when GSS is valued more than $10,000 \times 10^{-6}$, the land will experience changes in deformation and collapse [8]. The amount of Ground Shear Strain ($\gamma$) can be calculated using the equation:

$$\gamma = K_e \times 10^{-6} \times a_g$$  \hspace{1cm} (3)

with $\gamma$ is the ground shear strain, $K_e$ is the seismic vulnerability index, and $a_g$ is the peak ground acceleration.

#### Table 1. Soil classification based on the soil dominant frequency [9]

| Size of Strain ($\gamma$) | $10^{-6}$ | $10^{-5}$ | $10^{-4}$ | $10^{-3}$ | $10^{-2}$ | $10^{-1}$ |
|--------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Phenomena                | Wave, Vibration | Crack, Diff Settlement | Lanslide, oil Compaction Liquefaction | Lanslide, Soil Compaction Liquefaction | Lanslide, Soil Compaction Liquefaction |
| Dynamic Properties       | Elasticity | Elasto-Plasticity | Repeat-Effect of Loading | Speed-Effect of Loading | Speed-Effect of Loading |

### 2.5 Land Classification

Lachet and Brad [10] suggested that there is a relationship between dominant frequency and geological conditions, with simulations using 4 simple geological structures in combination variation in contrast of wave velocity and soil thickness, as shown in Table 2.

### 3. Results and Discussion

Microtremor data analysis results using the HVSR method for four measurement locations in the coastal regions of the West Leihitu Peninsula have the possibility of spectral shapes that change with the type of coastal region from each research location can be seen below. Seismic property is presented through the shape of the spectrum that produces, the dominant frequency ($f_d$), peak spectrum ($A_g$), Seismic Vulnerability Index ($K_v$), Peak Ground Acceleration ($a_g$) and Ground Shear Strain ($\gamma$) of each type of beach can be seen at Fig 2.
Table 2. Soil classification based on the soil dominant frequency [10]

| Soil Classification | Dominant Frequency Hz | Kanai Classification | Explanation |
|---------------------|-----------------------|----------------------|-------------|
| Type I              | 6.6 - 20              | Tertiary rocks       | The layer is not thick and consists of hard rocks (< 5m) |
|                     |                       |                      | The layer’s thickness is thicker than that of type I (5-10) |
| Type II             | 4-10                  | Pebbly sand          | The layer’s thickness is 10-30m |
| Type III            | 2.5-4                 | Alluvial rocks and buff formation | The layer’s thickness is very thick. |
| Type IV             | <2.5                  | Alluvial rocks formed from sedimentation | |

Figure 2 HVSR Spectrum of the: (a). Negeri Laha Coastal Region, (b). Negeri Hatu Coastal Region, (c). Negeri Lilibo Coastal Region and (d). Negeri Alang Coastal Region

Seismic property is presented through the shape of the spectrum that produces, the dominant frequency ($f_d$), peak spectrum ($A_g$), Seismic Vulnerability Index ($K_v$), Peak Ground Acceleration ($a_g$) and Ground Shear Strain ($\gamma$) of each type of beach, while the results of property seismic calculations can be seen in Table 3.
Table 3. Microtremor Data Analysis Results Using The HVSR Method For Four Measurement Locations in The Coastal Regions of The West Leihitu Peninsula

| Coastal Region | Position                | Dominant Frequency \((f_d)\) Hz | Peak Spectrum \((A_g)\) s | Seismic Vulnerability Index \((K_g)\) s²/cm | Peak Ground Acceleration \((a_g)\) gal | Ground Shear Strain \((\gamma)\) |
|----------------|-------------------------|---------------------------------|--------------------------|------------------------------------------|-----------------------------------|-------------------------------|
| Negeri Laha    | 3°43'14.06"S 128° 4'22.59"E | 3.235                           | 1.116                    | 0.384                                    | 22.228                            | 8.557 x 10⁻⁶                  |
| Negeri Hatu    | 3°44'3.20"S 128° 2'14.33"E | 1.933                           | 0.871                    | 0.392                                    | 19.722                            | 7.774 x 10⁻⁶                  |
| Negeri Liliboi | 3°44'41.94"S 128° 1'42.19"E | 4.993                           | 1.331                    | 0.354                                    | 41.130                            | 1.459 x 10⁻⁵                  |
| Negeri Alang   | 3°46'5.72"S 128° 0'30.46"E | 1.502                           | 1.306                    | 1.135                                    | 22.558                            | 2.561 x 10⁻⁵                  |

Property seismic which influences the level of seismic vulnerability in each coastal region in the West Leihitu Peninsula varies because it is an internal factor that results in abrasion. The seismic property included was the seismic vulnerability index \((K_g)\) at the four study sites. Based on the research data in Table 3, Negeri Laha coastal area with a vulnerability index 0.384, Negeri Hatu coastal area with a seismic vulnerability index 0.392, Negeri Liliboi coastal area with a seismic vulnerability index 0.354 and Negeri Alang coastal area with a seismic vulnerability index 1.135. Based on the seismic vulnerability index, there are indications of abrasion in the coastal regions of Liliboi and Negeri Alang. The Peak Ground Acceleration (PGA) value of each coastal area has a range \((19.722-41.130)\) gal, with the highest value being in the Negeri Liliboi of 41.130 gal. The PGA values do not yet represent the level of Ground Shear Strain (GGS) or have an impact on the deformation of rocks in the coastal area. This can be seen from the GGS of the Negeri Liliboi coastal area which is higher \((\gamma = 1.459 x 10^{-5})\) when compared to the territory of the coast of the Negeri Alang \((2.561 x 10^{-5})\) even though its Peak Ground Acceleration (PGA) value is large Fig 3. Based on these results, Negeri Alang and Negeri Liliboy have high soil susceptibility resulting in cracked soil structure and soil degradation. This is the potential for abrasion in coastal areas.

**Figure 3.** Relationship between Peak Ground Acceleration and Ground Shear Strains for each West Leihitu Coastal region

Based on Table 2 and Table 3 the frequency values for the coastal areas of Negeri Hatu and Negeri Alang have frequencies in the range between \((1.502-1.933)\)Hz included in the classification soil type...
IV with frequencies < 2.5 Hz. In this classification, rock types are alluvial rocks formed from sedimentation where the thickness of the layer is very thick. The coastal area of Negeri Laha has a frequency of 3.235 Hz having a type III soil classification with Alluvial rock type and buff formation where the thickness of the layer is 10-30m. The coastal area of Negeri Liliboy has a frequency of 4.993 Hz with type II soil classification having a Pebbly sand type where the layer’s thickness is thicker than that of type I (5-10).

4. Conclusions
Negeri Laha coastal area with a vulnerability index 0.384, Negeri Hatu coastal area with a seismic vulnerability index 0.392, Negeri Liliboi coastal area with a seismic vulnerability index 0.354 and Negeri Alang coastal area with a seismic vulnerability index 1.135. Based on the seismic vulnerability index, there are indications of abrasion in the coastal regions of Liliboi and Negeri Alang. The Peak Ground Acceleration (PGA) value of each coastal area has a range (19.722-41.130) gal, with the highest value being in the Negeri Liliboi of 41.130 gal. The PGA values do not yet represent the level of Ground Shear Strain (GGS) or have an impact on the deformation of rocks in the coastal area. This can be seen from the GGS of the Negeri Liliboi coastal area which is higher ($\gamma = 1.459 \times 10^{-5}$) when compared to the territory of the coast of the Negeri Alang ($2.561 \times 10^{-5}$) even though its Peak Ground Acceleration (PGA) value is large. Based on these results, Negri Alang and Negri Liliboy have high soil susceptibility resulting in cracked soil structure and soil degradation. This is the potential for abrasion in coastal areas. Geological conditions on the west coast of Leihitu consist of land classification types II, III and IV namely gravel sand, alluvial rocks, and buff formations and alluvial rocks formed from sedimentation with a very thick layer thickness in general.

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