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Training on the Utilization of the HVSR Geophysical Method Based on the Concept of Mechanical Wave Propagation for Earthquake Hazard Potential Analysis in Kuto Rejo Village

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ABSTRACT

Kepahiang Regency has a high potential for earthquake hazards. This is because the Kepahiang area is located in the subduction zone of the Indo-Australian tectonic plate movement in the ocean and the movement of the Musi segment of the Sumatra fault on land as the main fault. As an area with high earthquake hazard potential and its location near the Musi segment fault, efforts are needed to reduce the risk of disasters due to earthquakes through the activity "Training on the Utilization of the Horizontal to Vertical Spectral Ratio (HVSR) Geophysical Method". The HVSR method is a geophysical method based on the concept of mechanical wave propagation. HVSR measurements can be used to understand the structural properties of subsurface. The target audience for this activity is Village Apparatus and Residents of Kuto Rejo Village, Kepahiang Regency. This activity aims to provide an understanding of the basic concepts of mechanical wave propagation in rocks and provide training in the use of the HVSR method. The method used is through the stages of focus group discussion (FGD), field data acquisition, processing, interpretation and evaluation. The indicator of the achievement of the objectives of this activity is if each activity participant can acquisition, process, analyze, and interpret and answer the questionnaire related to the community service material correctly. The results of this activity provide insight into the importance of local wisdom-based earthquake hazard mitigation for disaster risk reduction. Village Apparatus and Residents of Kuto Rejo Village will continuously share their knowledge with other villagers from this activity.

Keywords: HVSR; Wave Propagation; Earthquake Mitigation; Kuto Rejo Village

1. INTRODUCTION

The Horizontal to Vertical Spectral Ratio (HVSR) method is a geophysical method based on the concept of mechanical wave propagation (Rabbani et al., 2025). This HVSR method states the relationship between the ratio of horizontal and vertical components (H/V spectrum) to ellipticity in mechanical waves, especially surface waves or Rayleigh waves. The H/V spectrum ratio as a function of frequency is closely related to the site transfer function for mechanical waves and the fundamental resonance frequency of the soil (Nakamura, 2000, 2008). HVSR measurements can be used to understand the structural properties of subsurface layers from the propagation of mechanical waves in rocks received by geophones. Based on the propagation of mechanical waves in the rock, information can be obtained about the structural conditions of the subsurface soil layers. The condition of the subsurface layer structure is closely related to the level of potential earthquake hazard at a study location.

So far, to understand the concept of mechanical wave propagation, conventional equipment or media are still used, namely springs, ropes, and others (Sunardi et al., 2016). In general, people do not yet know the application of mechanical waves that propagate in the rock medium beneath the earth's surface because they cannot be seen with the naked eye. For this, an instrument is needed in the form

of a set of broadband seismometers that can "see" the propagation of mechanical waves via a monitor screen, so that the public can more easily understand the concept.

The phenomenon of mechanical wave propagation in the rock medium is a symptom that occurs during earthquakes. Understanding the phenomenon of mechanical wave propagation is very important for the public, especially in earthquake-prone areas, which can be applied directly in the field by utilizing the HVSR geophysical method (Hadi et al., 2023). The use of the HVSR geophysical method based on the concept of mechanical wave propagation can be used to analyze the level of potential earthquake hazard in the Kepahiang Regency and its surroundings, including in Kutorejo Village, as the target audience in community service activities.

Kepahiang Regency has a high potential for earthquake hazards. This is because the Kepahiang area is located in the subduction zone of the Indo-Australian tectonic plate movement in the ocean and the movement of the Musi segment of the Sumatra fault on land as the main fault (Hadi et al., 2021; Megawati et al., 2005; B. M. Petersen et al., 2007; M. D. Petersen et al., 2004; Pusgen, 2022). Kuto Rejo Village, Kepahiang District, is located near the Musi segment of the Sumatra fault (Gafoer, S., Amin, T.C., 2012; Irwanto et al., 2013). The Musi segment fault experienced a destructive earthquake on December 15, 1979, with Ms = 6.6 at coordinates 3.299 °S and 102.712 °E at a depth of 33 km. As a result of this earthquake, around 500 houses were severely damaged, and cracks formed in the ground around the location of the incident (USGS, 2025). As an area with high earthquake hazard potential and its location near the Musi segment fault, efforts are needed to reduce the risk of disasters due to earthquakes through the activity "Training on the Utilization of the HVSR Geophysical Method Based on the Concept of Mechanical Wave Propagation for Earthquake Hazard Potential Analysis in Kuto Rejo Village". This activity is very necessary to be implemented as a manifestation of local wisdom that exists at the service location as well as an effort to apply the material on the concept of mechanical wave propagation according to the characteristics of the local area.

The first objective of this community service activity is to provide an understanding of the basic concept of mechanical wave propagation in rocks below the earth's surface using a set of broadband seismometers, so that the symptoms of mechanical wave propagation can be seen visually. The second is to provide training on the use of the Horizontal to Vertical Spectral Ratio (HVSR) geophysical method to the community of Kuto Rejo Village, Kepahiang Sub-district, Kepahiang Regency for analysis of potential earthquake hazards in the study area for disaster risk reduction based on local wisdom. In this activity, we only provide examples of the use of the HVSR method for analyzing potential hazards in the study area, especially around the community service location.

2. METHOD

The method used to achieve the objectives of community service activities is through the following stages:

2.1. Focus Group Discussion (FGD) Stages

The FGD was conducted to discuss mechanical wave propagation in subsurface rock media, earthquake potential, and disaster mitigation according to the disaster characteristics in the Kepahiang area, including the villages supported by the Faculty of Mathematics and Natural Sciences, Universitas Bengkulu.

2.2. Field Data Acquisition Stages

This activity involves acquiring field data using mechanical waves propagating in rocks beneath the Earth's surface using broadband seismometer equipment. The Community Service Team will explain proper field data acquisition procedures to the community of Kutorejo Village, Kepahiang Sub-district, Kepahiang Regency. For this activity, we explain examples of research data that have been collected around the service location.

2.3. Data Processing Stages

After data is obtained from the field, the next step is data processing. This data will be processed using Geopsy software. In this activity, the Community Service Team explained how to process field data to produce output in the form of dominant frequency values and their amplification factors.

2.4. Data Interpretation Stage

Data interpretation is performed through analysis of the predominant frequency and its amplification factor. A low predominant frequency value is associated with a large sediment thickness, and vice versa. A high amplification factor value is associated with a large level of ground deformation, and vice versa. Areas with high earthquake hazard potential are those with low predominant frequency values and large amplification factors.

2.5. Activity Evaluation Stage

In this stage, participants will be evaluated through feedback and discussions on the stages of field data acquisition, processing, and interpretation. If participants still do not fully understand the material, more intensive guidance will be provided. During the evaluation stage, questions will also be asked via a questionnaire related to the material presented by the resource persons, both before and after the FGD. The success of this activity will be determined by the target audience's understanding of the concepts of mechanical wave propagation in subsurface rock, earthquake potential, and disaster mitigation through correct answers to the questionnaire. This evaluation can measure the success of the activity. The activity will be successful if the target audience can answer the questionnaire correctly and their scores increase after participating.

This activity is closely related to the conditions in Kepahiang Regency, Kabawetan Sub-district, and Kutorejo Village, Kepahiang Sub-district, which are areas prone to earthquake disasters, especially land earthquakes triggered by the movement of the Musi segment of the Sumatra fault. In addition, the concept of mechanical wave material is still not well understood by the general public. Meanwhile, the Geophysics Undergraduate Study Program has sophisticated and modern equipment to explain this phenomenon, so that this activity can contribute to increasing understanding of this phenomenon.

Evaluation of activities is carried out by observing activity participants in data acquisition, data processing, analysis, and data interpretation. The indicator for achieving this success objective is if each activity participant can acquire data, process data, analyze, and interpret data properly and correctly using a broadband seismometer.

3. RESULTS AND DISCUSSION

This community service activity was carried out on Thursday, July 10, 2025, in Kuto Rejo Village, Kepahiang District, Kepahiang Regency. This activity was attended by Village Apparatus and Residents of Kuto Rejo Village, Kepahiang Sub-district, Kepahiang Regency, totaling 22 people as the target audience. The selection of target audiences is based on the potential of areas whose locations are very vulnerable to the threat of earthquake hazards, based on local wisdom, especially the study of the concept of mechanical wave propagation. To that end, this activity utilized sophisticated and modern equipment in the form of a broadband seismometer to apply mechanical wave propagation in the field and analyze potential earthquake hazards. Documentation of the activity is shown in Figure 1 and Figure 2.

Figure 1. Welcome speech by the Secretary of Kuto Rejo Village, Kepahiang Sub-district, Kepahiang Regency.

Figure 2. Presentation of activity material with the title "Training on the Utilization of the HVSR Geophysical Method Based on the Concept of Mechanical Wave Propagation for Earthquake Hazard Potential Analysis in Kuto Rejo Village" by the Community Service Team.

This activity began with the provision of material on the use of the HVSR geophysical method based on the concept of mechanical wave propagation for the analysis of potential earthquake hazards. This was then followed by a discussion of the material on mechanical wave propagation in subsurface rock media, earthquake potential, and disaster mitigation according to the characteristics of disasters in the Kepahiang area, including the villages fostered by the Faculty of Mathematics and Natural Sciences, Universitas Bengkulu. In general, the Village Apparatus and Residents of Kuto Rejo Village, Kepahiang District, Kepahiang Regency were very enthusiastic in discussing, especially about the existence of the Musi segment of the Sumatra fault and

secondary faults in the Kepahiang Regency area. The Musi fault is the main fault which is part of the Sumatran fault which has a length of 70 km in the southeast-northwest direction (Sieh & Natawidjaja, 2000), while the secondary faults around the service area are the Babakan Bogor fault (14 km long in the southeast-northwest direction) and the Bogor fault (8 km long in the southwest-northeast direction) (Hadi et al., 2025). Historically, the Musi fault experienced a major earthquake on December 15, 1979, with a magnitude of 6.6 and a depth of 33 km. This major earthquake caused nearly 3,600 buildings to be heavily and lightly damaged, formed cracks, and caused major landslides at several locations, as well as loss of life (Ardiansyah, 2014; USGS, 2025). Another destructive earthquake that occurred in the Musi segment was the earthquake on May 15, 1997 with a magnitude of 5.0 which resulted in 65 buildings being damaged (Ardiansyah, 2014). The next earthquake on October 28, 2014, with a depth of 3 km and a magnitude of 3.6, centered approximately 1 km southwest of Kepahiang City. This earthquake was caused by the local fault of the Musi segment of Kepahiang Regency and caused damage to the ground cracks in residential areas, house walls, floors of 12 houses, one mosque and one house of church and formed a 30 m long ground crack (Ardiansyah, 2017). Then, on October 14, 2017, an earthquake with a magnitude of 3.7 occurred. The earthquake was located at coordinates 3.70 °S and 102.48 °E at a depth of 10 km, with its epicenter 2 km southwest of Kepahiang City. The earthquake was caused by the Sumatran fault in the Babakan Bogor segment of the Bengkulu mainland (BMKG, 2017). The results of this discussion provide a deep understanding of the potential for disasters and their mitigation for disaster risk management in the service area.

The next activity was to provide training in data acquisition, processing, and interpretation from the HVSR method using broadband seismometer equipment. In this activity, Village Apparatus and Residents of Kuto Rejo Village, Kepahiang Sub-district, Kepahiang Regency gained knowledge about the application of mechanical waves that propagate in rocks below the earth's surface, how to process field data, so that output is obtained in the form of dominant frequency values and their amplification factors, and how to interpret the parameters generated from the HVSR method. Furthermore, the activity evaluation was carried out by giving questions from the presentation material to the participants of the activity. Based on the answers from the respondents, the activity participants showed that before the presentation, the average score was 62, while after the presentation, the average score was 95 (on a scale of 100), consisting of 10 questions indicating an increase of 33% from before and after the presentation given (Figure 3). These results also provide an illustration that the Village Apparatus and Residents of Kuto Rejo Village, Kepahiang Sud-district, Kepahiang Regency increasingly understand the basic concept of mechanical wave propagation in rocks beneath the earth's surface as well as the use of the HVSR geophysical method for analyzing potential earthquake in the service area as a means of reducing disaster risks based on local wisdom.

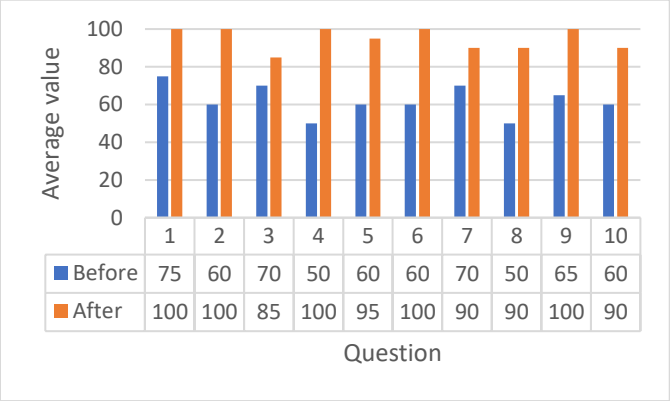

Figure 3. Average respondent scores before and after the activity presentation.

Through this activity, it is hoped that it can contribute directly to reducing disaster risks at the service location, namely Kutorejo Village, Kepahiang District, Kepahiang Regency, as a fostered village under the auspices of the Faculty of Mathematics and Natural Sciences Universitas Bengkulu. After this activity is completed, it is hoped that understanding of the concept of mechanical wave propagation, disaster potential, and mitigation can be "transmitted" to other target audiences.

4. CONCLUSION

The basic concept of mechanical wave propagation in subsurface rocks using a set of broadband seismometers through the utilization of the HVSR geophysical method can be understood by the Village Apparatus and Residents of Kuto Rejo Village, Kepahiang Sub-district, Kepahiang Regency, which is reflected in the increase in knowledge from the questionnaire answers. The results of this activity also provide insight into the importance of earthquake hazard mitigation based on local wisdom for disaster risk reduction. Village Apparatus and Residents of Kuto Rejo Village will continuously share their knowledge with other villagers through this activity. Through this activity, the Geophysics Undergraduate Program of the Faculty of

Mathematics and Natural Sciences Universitas Bengkulu will indirectly become known to the target audience, especially residents of Kuto Rejo Village, Kepahiang District, Kepahiang Regency, and the surrounding areas.

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