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Socialization of Earthquake Friendly House Planning with a Theme "Nagari is Resilient to Earthquake Disasters" in Nagari Kajai, West Pasaman Regency

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ABSTRACT

West Pasaman Regency is an area that has a fairly large threat of earthquake and tsunami disasters. The 6.2 Mw West Pasaman earthquake that occurred on February 25 2022 was quite large and resulted in 25 people dying, 465 people being injured and at least 16,000 people being displaced. This earthquake was located on the slopes of Mount Talamau at a depth of 10 km which was triggered by the activity of the Semangko fault fault, precisely in the unmapped Talamau segment. Apart from loss of life, another impact caused by this earthquake disaster was the large number of collapses in people's houses. People's houses that have simple construction have a greater potential for collapse compared to other buildings whose designs comply with existing regulatory standards. In general, people's houses are only built by builders who do not know the technicalities of building earthquake-friendly houses. Builders are the main key to the quality of housing construction in society, so more attention is needed from people who are experts in their field because it is in their hands that the structural strength of a house is built. The community service organized by the Institute for Research and Community Service (LP2M) Padang State University together with several Civil Engineering lecturers aims to channel their knowledge to the community, especially to builders to increase knowledge in building earthquake-friendly houses. This activity is also expected to reduce damage in the future if an earthquake occurs, which has been designed according to standards applicable in Indonesia. From the results of interviews with several builders and local residents, it turns out that their knowledge of the basic techniques for building earthquake-friendly houses is still limited. So that this outreach can provide a useful contribution to builders' knowledge of the basics of earthquake-friendly house construction.

Keywords: *Earthquake; Construction Worker; Earthquake Friendly House*

INTRODUCTION

Indonesia is geologically located between three main plates, namely the Eurasian Plate, the Pacific Plate and the Indian Ocean Plate. This makes Indonesia prone to earthquakes. There are more than 1200 earthquake events of more than 4 on the Ritcher scale that occur in Indonesia every year [1]. Sumatra Island, one of the main islands in Indonesia, was formed due to tectonic activities, namely Sumatra low angle oblique subduction zone, Mentawai Thrust Fault, and Great Sumatra Fault Zone [2]. Earthquakes affiliated with the Sumatran fault zone are moderate to strong earthquakes with potential shallow depths, less than 20 km. Strong earthquakes with shallow depths can cause great damage and are very likely to occur in the form of landslides, this will increase the risk of losses that can be caused by earthquakes in the

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region.

West Pasaman Regency is an area that has a great threat of earthquakes. West Pasaman has two faults, namely the cyanok fault and the angkola fault which is included in the clover fault along the island of Sumatra. Based on the results of previous research on seismic zoning based on the level of soil vulnerability, Nagari Kajai located in Talamau District has a fairly high vulnerability index.

The 6.2 Mw West Pasaman earthquake that occurred on February 25, 2022 was quite large resulting in 25 deaths, 465 injuries and at least 16,000 people displaced. This earthquake was located on the slopes of Mount Talamau at a depth of 10 km which was triggered by the activity of the Semangko fault fault, precisely on the uncharted segment of Talamau. This earthquake also caused flash floods and landslides at several points. The landslide also cut off road access, hampering the process of distributing aid and community activities as usual. In addition to casualties, another impact caused by this earthquake disaster is the many collapses from people's houses.

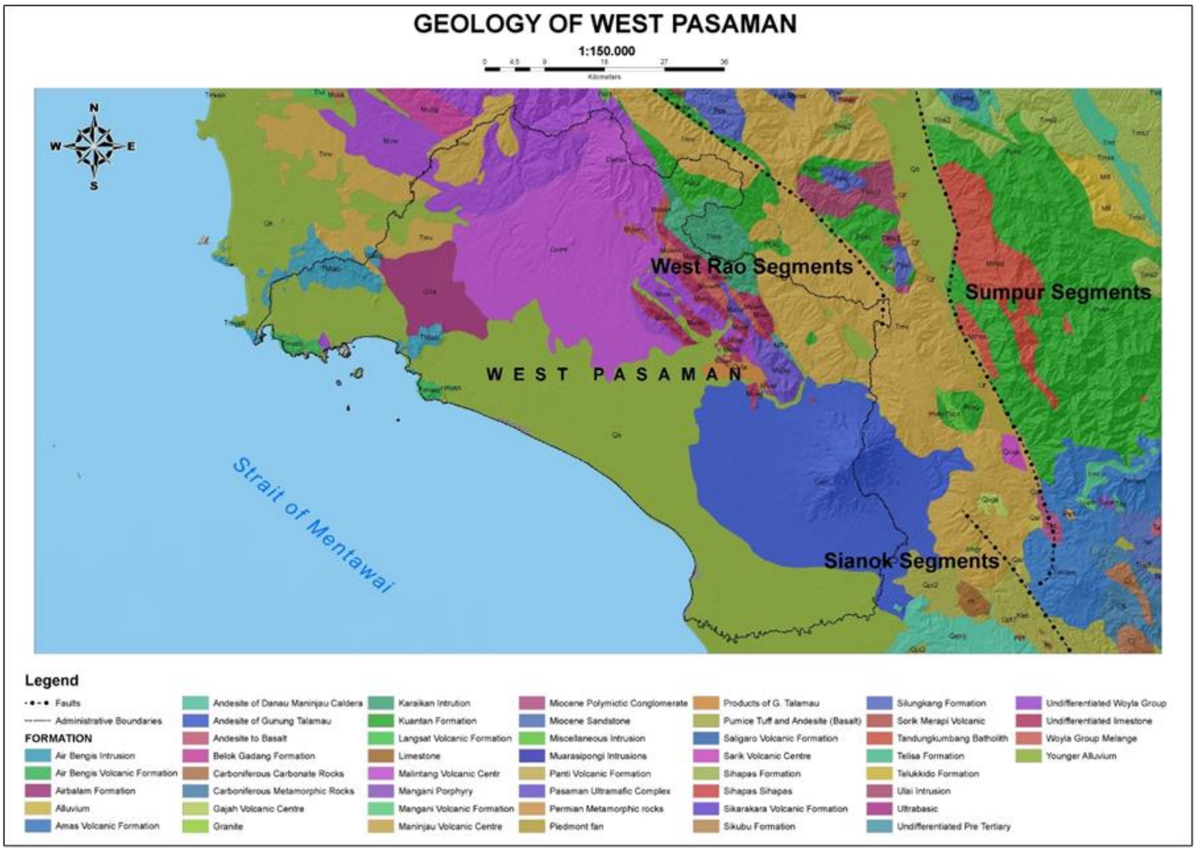

Figure 1. Geologic Map of West Pasaman Regency 2022

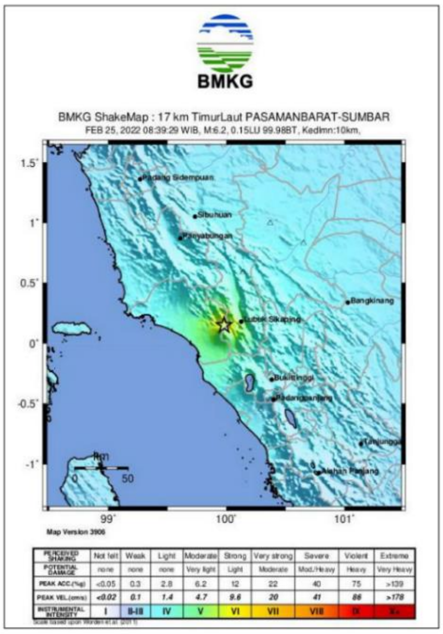

Figure 2. West Pasaman Regency Earthquake Intensity Map 2022

From the results of a field review after the earthquake, the problem found in Talamau District, especially in Nagari Kajai, is the non-application of standard rules in planning the construction design of simple earthquake-friendly houses. In general, community houses that are damaged do not have good building structures such as very small reinforcement sizes and the amount of reinforcement that does not meet standards and there are even houses that do not use reinforcement in their structures. So with this situation, many houses collapsed when the earthquake occurred. To overcome this problem, community service activities with the theme "Nagari Tangguh Bencana Earthquake" to builders and the community. This activity aims to increase the knowledge of builders and the public about basic construction techniques for earthquake-friendly house construction.

(a) (b)

Figure 3. Earthquake Damage (a) House Collapse and (b) Landslides

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Microtremor and Predominant Period Measurement

Microtremors are very small ground vibrations that can be recorded at ground level. Microtremor recording can be described from one vertical component and two horizontal components. Data collection was carried out in this study using the GPL-6A3P microtremor device. First, the ratio of horizontal to vertical spectrum (HVSR) is calculated for all locations. The peak period of HVSR is known to correspond to the resonance period of the site. This method postulates a form of the Fourier spectrum. (1)

This study used 64 microtremor recording data spread across all sub-districts in West Pasaman. Equation (1) shows the method used to calculate HVSR using the results of the recorded data.

$$HVSR = \sqrt{\frac{F_{NSi}(\omega)^2 + F_{FWi}(\omega)^2}{F_{UDi}(\omega)^2}}$$

The horizontal (NS and EW) and vertical (UD) components were recorded simultaneously for 10 min with a sampling frequency of 100 Hz according to the guidelines [3].

Microtremor measurement using spectral ratios is the most reliable and simplest method for determining soil structure and dynamic characteristics such as soil natural frequency. The HVSR method proposed by [4],[5] has been widely used for other studies[6],[7] which is basically useful for estimating local seismic ground responses. Estimates of HVSR ground frequency and peak amplitude only give an indication of initial soil site frequency and amplification without earthquake influence [8],[9]. Complete microtremor recordings can be taken from one vertical component and two horizontal components [10]. Recording points are randomly assigned but prioritized more in areas that experienced the worst damage from the last 6.1 Mw earthquake. Observations were made in February and July 2022. In Figure 5., it can be identified that the value of *f0* at the point of the Aur River is 0.974 hertz.

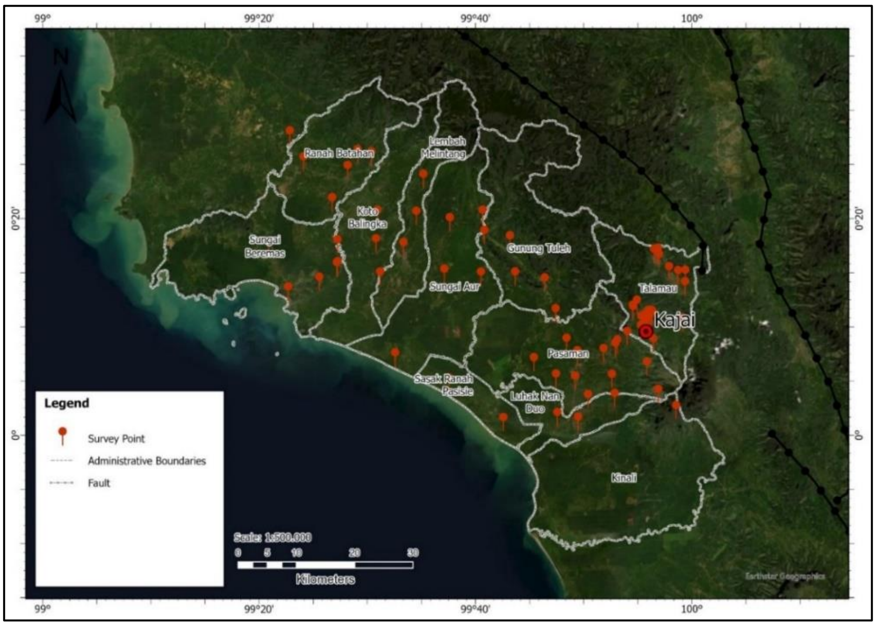

Figure 4. Distribution of microtremor recording sample points in the study area

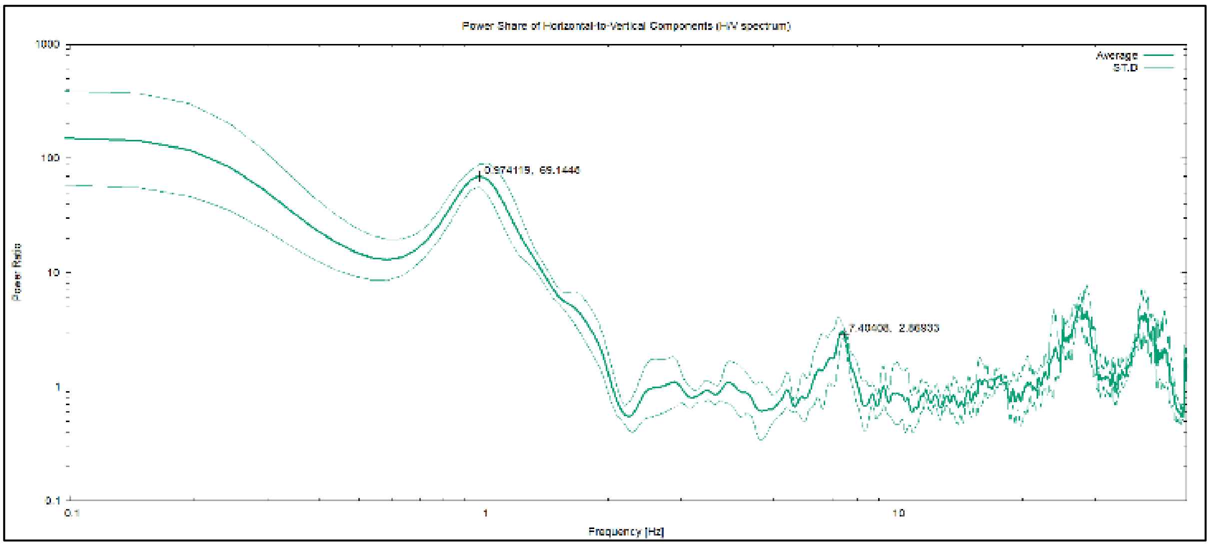

Figure 5. Clear Peak at Sungai Aur Site

Since T = 1/*f* where T is the predominant period and *f* is the frequency, the relationship between the predominant period based on microtremor recording [11] and soil classification can be seen in Table 1.

Table 1. Correlation of predominant frequency with soil classification

Soil classification	Predominant Frequency (Hz)	Era Predominan (Secon)	Information
Type I	6,67 – 20	0,05 – 0,15	Tertiary or older rocks. Consists of hard sandy gravel
Type II	4,6 – 6,67	0,15 – 0,25	Alluvial rocks with a thickness of 5 m. Consists of sandy gravel, sandy hard clay
Type III	2,5 – 4,0	0,25 – 0,4	Alluvial rocks are almost the same as type II, distinguished only by the presence of unknown formations (buff formation)
Type IV	< 2.5	> 0.4	Alluvial rocks formed from delta sedimentation, top soil, mud with a depth of 30 m.

Seismic Susceptibility Index

The seismic vulnerability index is an index that shows the level of vulnerability of the surface soil layer to deformation during an earthquake. This index is useful for identifying areas that are relatively weak at the time of an earthquake To determine the value of the sesmic susceptibility index of an area, it is necessary to pay attention to the factors of the geological conditions of the local area. (2)

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The seismic susceptibility index is influenced by natural frequency and amplification values obtained from the results of microtremor spectrum analysis. High levels of soil susceptibility index are usually found in areas with low resonance frequency. [12] has shown that there is a high-quality correlation between the seismic vulnerability index (Kg) and the distribution of damage from earthquakes. The results of the seismic susceptibility index are obtained by squaring the peak value of the microtremor spectrum divided by the resonance frequency as stated by [5] below:

$$Kg = \frac{A^2}{f_0}$$

Where A is the amplification factor and f_0 is the natural frequency of the soil at the local site. Figure 7. shows the seismic vulnerability index map for West Pasaman District. The image shows various seismic vulnerability values for the study area. The greater the value of Kg, the more potential to cause damage to an area due to an earthquake, conversely, the lower the lower an area has the potential to experience damage due to an earthquake.

On the map, Nagari Kajai is included in a zone that has high vulnerability. Even though it is on hard soil Figure 6, this could happen because of the large soil amplification value in the area. The next area that has high vulnerability is the northern part, namely the transverse Valley and the Fault Realm and in areas along the coast.

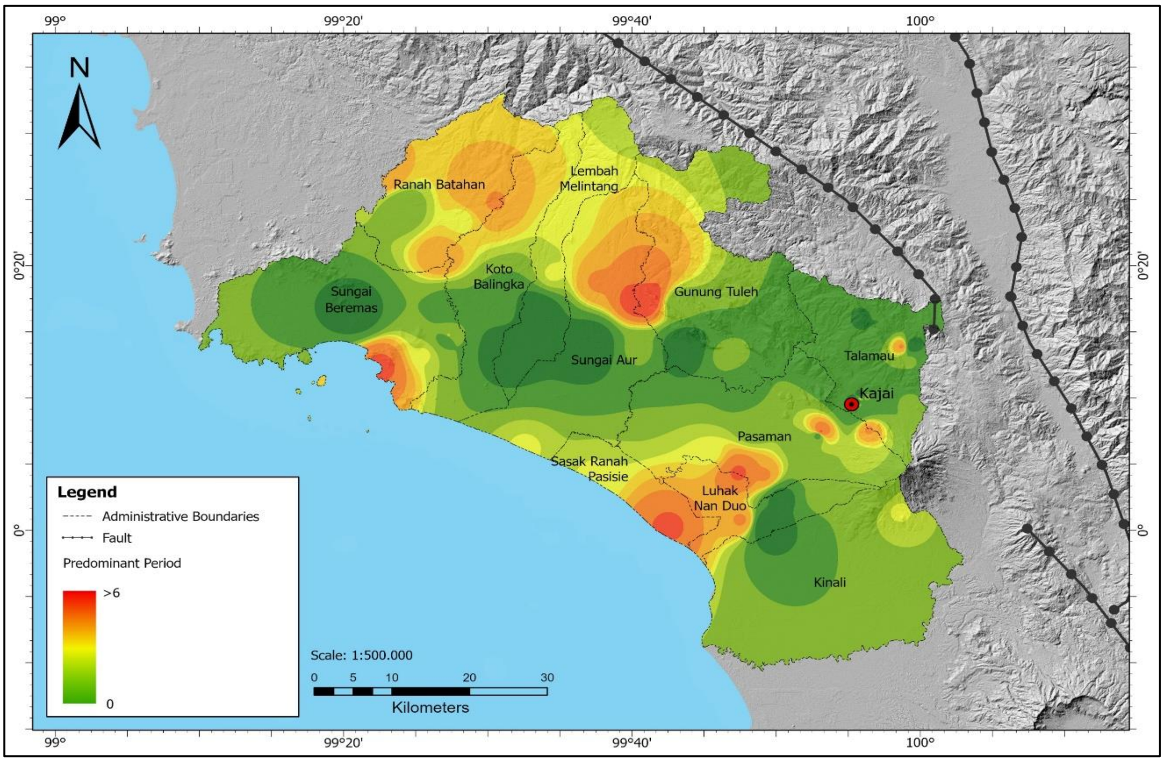

Figure 6. Map of *Predominant Period* of West Pasaman Regency

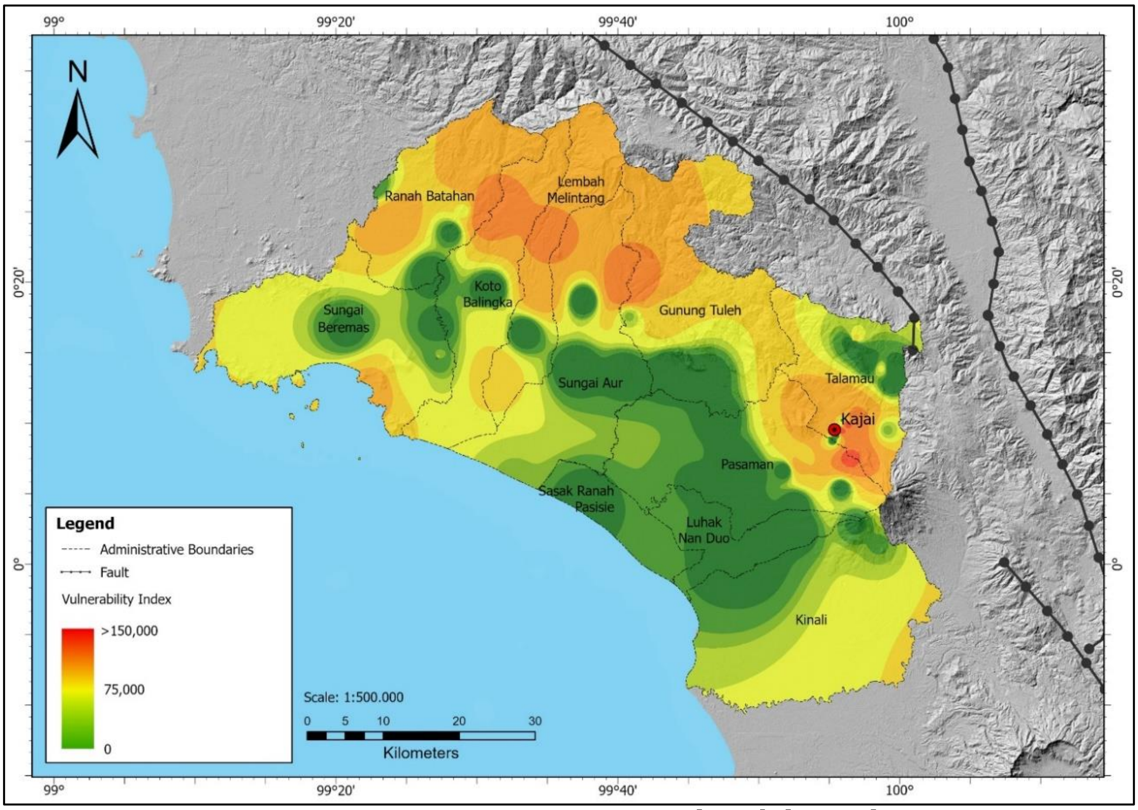

Figure 7. West Pasaman District Seismic Vulnerability Index Map

GRound Shear Strains and Liquifaction Potential

Earthquakes will affect soil stability depending on the nature and properties of the soil [13]. Liquifaction can occur due to loss of effective ground tension due to cyclic loading due to earthquake shaking [14]. Cyclic loads transfer the voltage in the pores to the effective ground tension. This phenomenon occurs when loose sandy soils are saturated with water. As a result, the soil cannot withstand the load and causes deformation [15].

In determining liquefaction potential, any point with a higher Kg value is more likely to cause damage [4]. The kg value comes only from the strain of the soil structure. According to [16], liquefaction can occur if the Kg value is greater than 5.0. It can be defined as follows:

$$Kg = \frac{A^2}{f_0} > 5 \quad (3)$$

Figure 8. shows the characteristics of the soil obtained from HVSR in accordance with the liquefaction potential for the study area based on Equation (3). This map shows the potential for each area, if earthquakes are predicted in the future. These results provide important information, especially references in vulnerability maps, and design disaster prevention measures in West Pasaman.

Ground shear strain on the soil layer is a value that can describe the ability of soil layer material to stretch or shift each other during an earthquake. *Ground shear strains* are notated with γ. The greater the value of *the ground shear strain*, the more susceptible the soil is to deformation such as landslides and liquefaction.

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The value of the ground shear strain is obtained using the following equation [5].

$$\gamma = K_g \times a_b \times 10^{-6} \quad (4)$$

Where Kg is the seismic vulnerability index, αb is the maximum ground acceleration (gals). Based on [17] the value used for the design of the maximum soil acceleration for West Pasaman is 0.6 g or 588.40 gals.

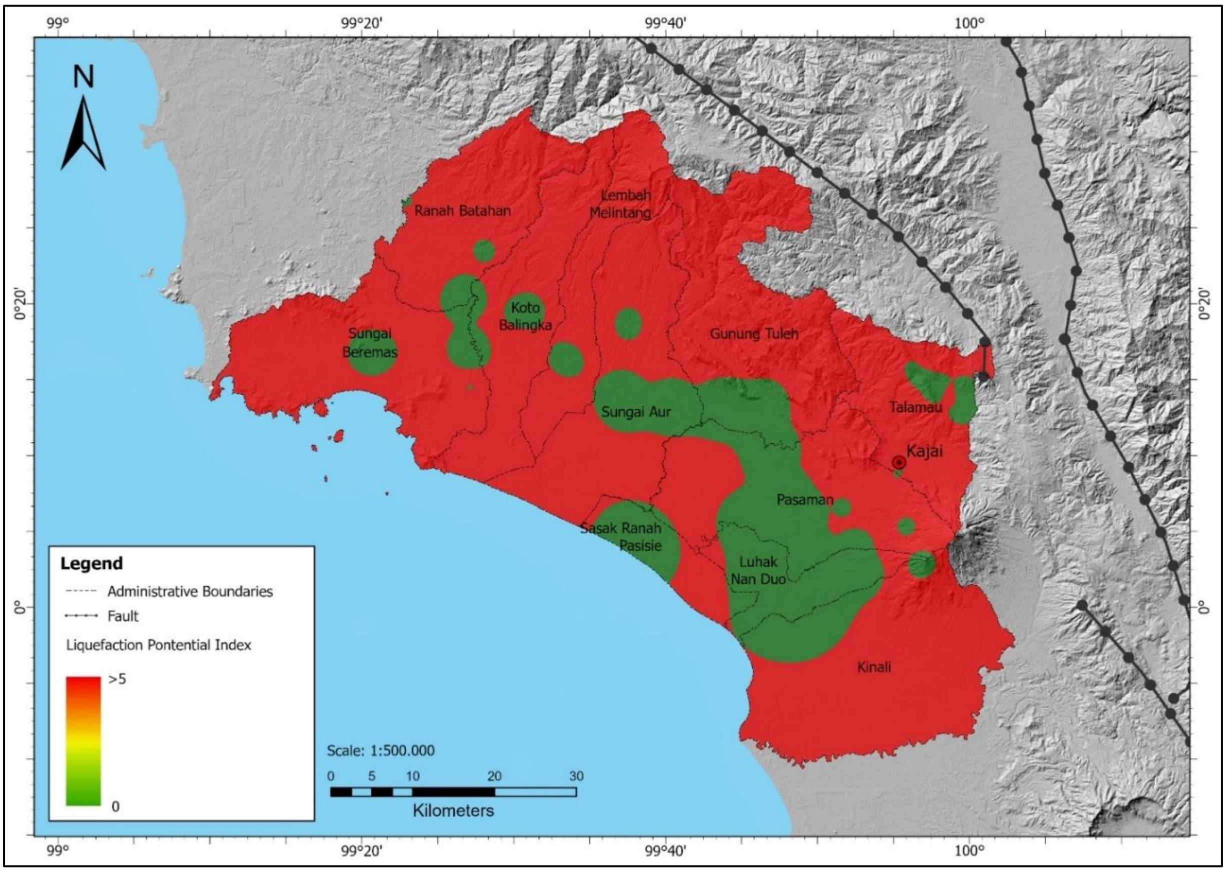

Figure 8. Liquifaction Map of West Pasaman Regency

The relationship of ground shear strain with the impact of soil behavior reaction according to [18] is shown in Table 2.

Table 2. Soil strain based on soil dynamic properties

Size of Strain γ	Phenomena	Dynamic Properties
10^{-6}	Wave	Elasticity
10^{-4}	Vibration	Elasticity
10^{-3}	Crack	Elasto-plasticity
10^{-2}	Settlement	Elasto-plasticity
10^{-1}	Landslide, Liquefaction	Collapse

The results of Ground Shear Strain mapping for the study area are shown in Figure 9. Based on the results of the shear strain value of West Pasaman Regency obtained according to equation (3), by taking data on the maximum soil acceleration is 588.40 gals, it is clear that the entire West Pasaman region has the potential to experience soil stretching which results in *landslides* and liquefaction.

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This is in line with the prediction of liquefaction potential in the previous figure using equation (4), where most of West Pasaman has the potential to be threatened with liquefaction. Meanwhile, when referring to the latest West Pasaman Earthquake, February 25, 2022, there are three areas that are very potentially dangerous for liquefaction, namely Kajai, Mount Tuleh and Melintang Valley.

Based on the results of this research data, it is clear that Nagari kajai is located in an area that is very prone to earthquakes. So it is necessary to prepare the community in facing future earthquake disasters by building earthquake-friendly houses.

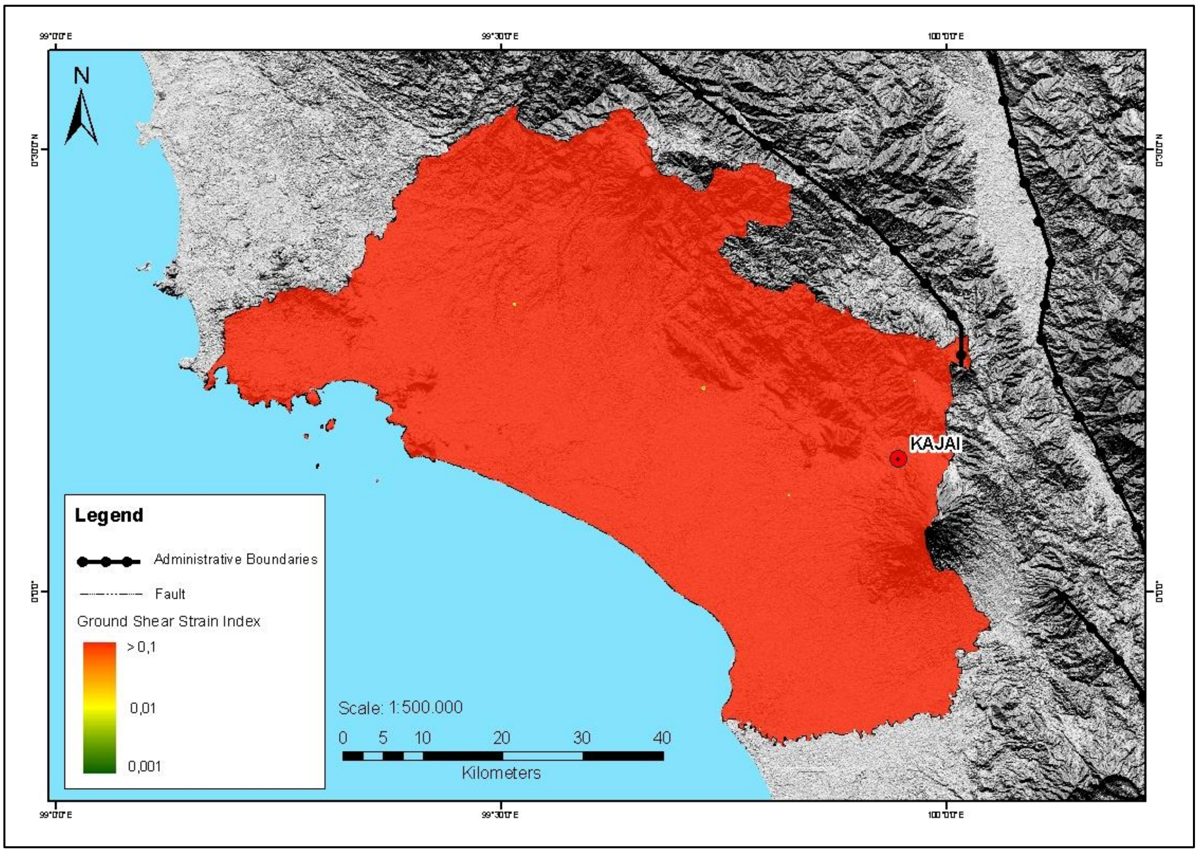

Figure 9. West Pasaman Regency Ground Shear Strain Map Based on PGA Standard Design Indonesia (0.6 g)

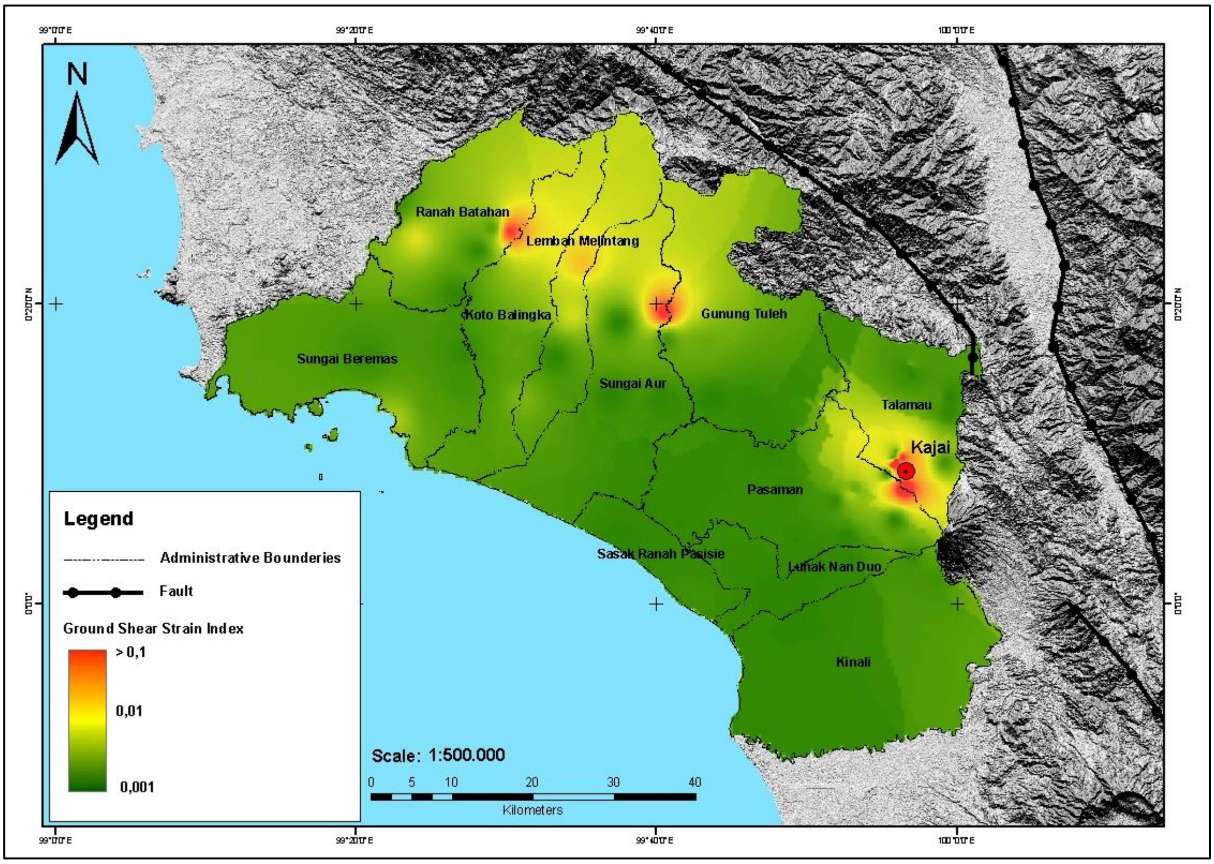

Figure 10. West Pasaman Regency Ground Shear Strain Map Based on PGA Earthquake February 25, 2022 (0,16 g)

METHODS

Socialization of Earthquake-Friendly Houses

This socialization on how to build earthquake-friendly houses was carried out in August 2022. This activity was carried out simultaneously in 3 locations in Talamau District, namely Nagari Kajai, Nagari Kajai Selatan and Nagari Simpang Timbo Abu. The speakers in this socialization activity are UNP Civil Engineering lecturers who are experts in their respective fields. The material presented in this activity included how to build earthquake-friendly building structures from the foundation to the roof. In addition, it is also explained how the piping system and electrical installations are good for earthquake-friendly homes.

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Figure 11. Opening of the event

Figure 12. Delivery of material from presenters

Figure 13. Atmosphere During Socialization

Figure 14. Q&A Session

Wall Modeling Practicum

As a continuation of the socialization activities in August 2022, the team again held community service in Talamau District in September 2023. This activity focuses on practicum in the construction of earthquake-friendly house building structures. Participants in this practicum are prioritized by builders in Talamau District, especially Nagari Kajai.

In this practicum, several builders made wall modeling with a length of 2 meters and a height of 2 meters. The dimensions of the columns made measure 15cm x 15cm while for sloofs and beams measuring 15cm x 20cm. The materials used in making this wall modeling include cement, gravel sand, red brick, 10 diameter reinforcement for the main reinforcement and 6 diameter for the sting. While the additional material in this case as one of the materials for strengthening earthquake-resistant walls is chicken wire.

In practice, what must be considered in this job is the distance between the sengkang. The distance between the sengkang uses the principle of 1/4L for the pedestal and 1/2L for the field. For the stinger itself, it must have a clutch at the end of at least 5cm at each end with a function so that it can lock more if attached to the main reinforcement. The sengkang is tied to the main reinforcement using bendrat wire. After that, what must be considered again is the installation of armature reinforcement in each column. This armature reinforcement serves to connect the walls to the column structure.

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Next to the main part in making the reinforcement of the walls of this earthquake-friendly building is the installation of additional chicken wire material that is installed diagonally on both sides of the wall. The installation of this chicken wire is carried out before plastering the walls. This chicken wire is also tied using bendrat wire from one side through to the other side on the wall. The function of this chicken wire is to bind the wall with the column structure, so that if an earthquake occurs, part of the wall will not collapse first and will follow the collapse of the column structure. So with that it will provide additional time for residents to save themselves from collapse during an earthquake.

Figure 15. Making Earthquake Friendly House Wall Modeling

RESULTS AND DISCUSSION

The results obtained from community service activities in Nagari Kajai, Talamau District, West Pasaman Regency are as follows:

1. The number of participants who attended this activity was 90% of the total number of invitations distributed.
2. The participants gained knowledge about how the basic technical construction of earthquake-friendly house construction according to applicable standards in Indonesia.
3. The participants were very enthusiastic during the activity as shown by the many interactions asked Java B during the activity.
4. The participants in this case, especially builders, get a practicum simulation in making earthquake-friendly house wall modeling.
5. The participants knew additional materials that were cheap and functioned in strengthening the walls of earthquake-friendly houses.

CONCLUSION

Community service activities in Nagari Kajai, Talamau District, West Pasaman Regency for builders and other communities were successfully carried out and ran smoothly according to the time and conditions previously expected. The socialization participants were very enthusiastic in delivering the material so that the question and answer session lasted for quite a long time. Some participants were also directly involved in making earthquake-friendly house wall modeling and other participants were able to witness all stages of the work. From the results of interviews with several surrounding communities after the activity was completed, it can be concluded that the people of Nagari Kajai have increased their knowledge in terms of building earthquake-friendly houses.

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