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Build back better and stronger the 2022 earthquake-damaged houses in Talamau–Pasaman Barat District

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Abstract. The earthquake on Friday, February 25, 2022, centered 18 km northeast of Simpang Empat city with a magnitude of 5.2 M, occurred at 08.35 WIT. After 4 minutes, there was a larger aftershock with a magnitude of 6.2 M. The earthquake that hit Nagari Malampah, Pasaman District and Nagari Kajai, Pasaman Barat District, which caused a number of people to die and minor, moderate to severe damage to people's houses. Based on the large number of houses damaged, it is necessary to assess the vulnerability of buildings in Nagari Kajai. The vulnerability assessment was obtained from the results of building evaluations where the results of building vulnerability were in the moderate vulnerability category 47 houses and 53 houses with high vulnerability. Most of the vulnerability occurred due to community buildings that were not built according to building standards therefore it was necessary to educate the public on how to repair houses that meet house standards. This paper provides one solution to the community whose houses were damaged through community service activities which the Team carried out with training activities for retrofitting community houses that were moderately or lightly damaged and provided examples. Retrofitting houses is highly expected by the community.

1 Introduction

On Friday, February 25, 2022, there was an earthquake centered in the Pasaman Barat District. The foreshock earthquake occurred at 08:35:51 WIT with the epicenter on land at coordinates 0.14° north latitude and 99.99° east longitude, with a magnitude of 5.2 at a depth of 10 km, 18 km east of Hindia Ocean. The United States Geological Survey released that the earthquake occurred at coordinates 99.984° east longitude and 0.222° north latitude, magnitude (M 5.0) at a depth of 10 km. The main earthquake occurred on Friday, February 25, 2022, 08:39:29 WIT with the epicenter on land at coordinates 99.98° east longitude and 0.15° north latitude, about 17 km northeast of Pasaman Barat District, with a magnitude of M 6,2 at a depth of 10 km. After the main earthquake, there were several aftershocks of lower magnitude [1]. The Pasaman earthquake killed 10 people, injured 465 people, and damaged 3,312 houses. In addition, this earthquake also displaced about 16,000 people [2]. Residents in the earthquake disaster area evacuated due to security reasons their houses were damaged. There are three types of damage categorized by the National Disaster Management Agency, namely heavy damage, moderate damage, and minor/light damage [3].

Conceptually, apart from the magnitude of the earthquake force received by the house, the damage that occurred was caused by several factors, namely: the strength of the material to make the house, the shape of the tread of the house, how to work or construct the house, resulting in the construction of the house not meeting building standards.

Based on a review conducted by a team from Universitas Andalas, the earthquake in Pasaman Barat District resulted in damage to buildings with various levels of damage, such as minor damage, moderate damage, to heavy damage. Most of the damage occurred due to residents' buildings that were not built according to earthquake-resistant building standards.

The importance of this activity is partly because the government's house repairs have not yet started, and people are worried about living in houses that have not been repaired or living in temporary shelters (HUNTARA) if one day there is another earthquake. So some people who have money have started repairing their houses at their own expense with standards that have been tested both in the laboratory and from the experience of retrofitting houses after the earthquake in West Sumatra Province September 30, 2009.

To help community houses with the rehabilitation and reconstruction after the earthquake, the Universitas Andalas, Post Graduate School Team carried out community service activities in Pasaman Barat District by conducting training and retrofitting one of the community houses in moderately damaged condition in Nagari Kajai, Pasaman Barat District.

This activity was carried out after assessing the vulnerability of buildings in Nagari Kajai with a sample

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of 100 houses. The vulnerability of the building is obtained by filling out the vulnerability assessment form, which the form first evaluates the building, which consists of the main structure of a simple residential building, and each of its parameters must be filled in/assessed according to the condition of the house in the location studied. From the evaluation of the building, it was obtained the quality of the building along with the score for each house, from this score, the vulnerability value of the building was obtained.

On the vulnerability form, there are values for each component and parameter. This value is based on the importance of the main structure for simple residential buildings regarding safety and security.

2 Methods

2.1 Studi area

The study was carried out in the Pasaman Barat District earthquake-affected areas. The Pasaman Barat District is one of the north-western Districts in West Sumatra Province, Indonesia. As can be seen in Figure 1 below, Pasaman Barat District is surrounded by Agam District, Pasaman District, North Sumatra Province, and the Mentawai Strait (Figure 1).

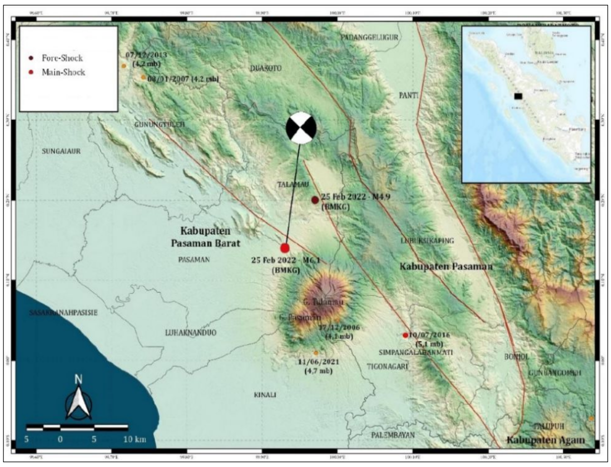

Fig. 1. Study area.

2.2 Data

Based on information from the Geological Agency of the Ministry of Energy and Mineral Resources, the position of the epicenter of the earthquake and its depth as well as a geological structure lineage, the epicenter of this earthquake is suspected to be associated with the Sumatran fault zone in the West Pasaman area and is known as the active Sumatran fault in the Lubuk Sikaping segment, ± 65 km long, an average shift of 14 mm/year with features of bearing, fault escarpment, triangular facets. These faults are found in Paleozoic – Cenozoic rocks and rocks of Talamau Volcano, and Sarik Volcano (Pleistocene-Holocene).

This earthquake was felt at the Talang Volcano Observation Post with an intensity scale of III MMI (Modified Mercalli Intensity) and based on Meteorology Climatology and Geophysics Board it was felt at V MMI in Pasaman District, Pasaman Barat District; IV MMI in Agam District, Bukit Tinggi City, Padang Panjang City; III MMI in Padang City, Payakumbuh City, Aek Godang City, Gunungsitoli City; II MMI in Pesisir Selatan District, Rantau Parapat City, Nias Selatan District, Bangkinang District, Malaysia, Singapore. Earthquake shocks were also felt in Lima Puluh Kota District, Jambi Province. According to data collected, this earthquake has resulted in disasters in the form of damage to buildings and ground movement in Pasaman District and Pasaman Barat District.

Primary data were obtained by checking several houses with minor/lite damage, moderate damage, and heavy damage in Nagari Kajai, based on the disaster management law. Get information on the willingness of workers who want to learn to retrofit houses according to building standards.

The secondary data were obtained from the Geological Agency, the Ministry of Mineral Resources obtained data on house damage from the Regional Government of Pasaman Barat District and the National Disaster Management Agency Team, as well as interviews with the community who own the houses. The experience of repairing houses after the September 30th, 2009 West Sumatra earthquake is a good lesson learned [4], and the experience of the Indian State in carrying out house retrofitting [5].

2.3 Methodology

Vulnerability assessment is obtained from building evaluation using a form made from the results of focused discussions by experts. In determining the sample, there are certain considerations according to the desired criteria: simple house buildings with practical column reinforcement and simple house buildings without reinforcement. On-site vulnerability assessment is carried out in conjunction with experts.

After carrying out the next vulnerability assessment activity, rebuilding a house damaged by an earthquake can be done using a combination of wire mesh and ordinary mortar. This method will provide better strength than the initial strength of the building. However, not all houses can be repaired with this method. Building houses damaged by earthquakes can be applied to houses that are lightly and moderately damaged. The first step is to select the damaged buildings. Damaged houses can be categorized into three classes: lightly damaged, moderately damaged, and heavily damaged. The selection of this house is to involve experts to predict the level of damage to the house. For houses that are categorized as lightly damaged and moderately damaged, this repair method can be applied (Figures 2 and 3). Houses that are in a badly damaged condition cannot be repaired using this method (Figure 4).

Fig. 2. Lite damaged house.

Fig. 3. Moderately damaged house.

Fig. 4. Heavily damaged house.

The next step is to conduct training for local communities/builders to repair houses and assist communities affected by the earthquake by retrofitting a house that was moderately damaged and minor damaged condition by the earthquake. Training can be done by showing pictures and animations of repair work that has been done elsewhere or in the laboratory. The training is given by experts who already can explain and do homework well. Furthermore, repairs can be started directly by the employer with on-the-job training (Figure 5).

Fig. 5. Checking the damaged house.

3 Results and discussion

Inventory of damaged houses that was recorded by the Government of Pasaman Barat District and the National Disaster Management Agency, houses with severe damage condition of 544 units, moderate damage 895 units, and minor damaged condition of 1,973 units, as shown in Table 1 and the location of the distribution as shown in figure 6.

Table 1. Damage to houses in Pasaman Barat District.

Nagari/Sub-district	Heavy damage	Moderate damage	Minor/ Lite damage	Total
Kajai/Talamau	433	614	901	1,948
Sinuruik/ Talamau	1	0	0	1
Talu/Talamau	0	1	1	2
Aua Kuniang/ Pasaman	107	265	775	1,147
Koto Baru/Pasaman	0	0	2	2
Lingkung Aua/Pasaman	0	0	2	2
Ujung Gading /Lembah Melintang	0	1	1	2
Kinali/Kinali	3	13	190	206
Muaro Kiawai/ Gunung Tuleh	0	1	1	2
Total	544	895	1,873	3,312

Table 2 is the form used in building vulnerability assessment. The on-site assessment is carried out by experts.

Table 2. Vulnerability assessment form.

Num	Component Value	Component	Parameter		Parameter Value	Aspect Value			Score
						Yes (1)	Defiecient (0.5)	No (0)	
I	7,5	Construction drawing	1	Drawing used building construction	100%				
II	12,5	Foundation (rubble stone)	1	Minimum depth 60 cm, top width 30 cm, bottom width 60 cm	15%				
			2	Column reinforcement is embedded in the foundation to 40 cm or more depth	30%				
			3	Mortar mix ratio 1 pc: 4 sand	15%				
			4	There are anchors connecting the foundation and beam foundation with a minimum size of Ø 10 mm with a minimum installation distance of 1 meter	40%				
III	12,5	Foundation beam	1	Minimum size 15 cm x 20 cm	12,5%				
			2	Main reinforcement minimum 4, size Ø 10 mm	12,5%				
			3	Minimum stirrup size Ø 8 mm, spacing 15 cm	12,5%				
			4	Concrete mix ratio 1 pc: 2 sand : 3 gravel	12,5%				
			5	The thickness of the concrete blanket is 1.5 cm from the outer side of the stirrup	12,5%				
			6	At the angle between the reinforcement, add 40 cm in length	25%				
			7	Concrete in good condition (not porous)	12,5%				
IV	17,5	Column	1	Minimum size 15 cm x 15 cm	12,5%				
			2	Main reinforcement minimum 4, size Ø 10 mm	12,5%				
			3	Minimum stirrup size Ø 8 mm, spacing 15 cm	12,5%				
			4	Concrete mix ratio 1 pc: 2 sand : 3 gravel	12,5%				
			5	The thickness of the concrete blanket is 1.5 cm from the outer side of the stirrup	12,5%				
			6	At the angle between the reinforcement, add 40 cm in length	25%				
			7	Concrete in good condition (not porous)	12,5%				
v	10	Wall	1	The area of the walls bounded by columns is not more than 9 m^2/3m between columns.	30%				
			2	Whole plastered walls	20%				
			3	Mortar mix ratio 1 pc: 4 sand	20%				
			4	Between the column and the wall is anchored with a minimum size of Ø 10 and a minimum length of 40 cm for every 6 layers of bricks	30%				
VI	12,5	Ring beam	1	Minimum size 12 cm x 15 cm	12,5%				
			2	Main reinforcement minimum 4, size Ø 10 mm	12,5%				
			3	Minimum stirrup size Ø 8 mm, spacing 15 cm	12,5%				
			4	Concrete mix ratio 1 pc: 2 sand : 3 gravel	12,5%				
			5	The thickness of the concrete blanket is 1 cm from the outer side of the stirrup	12,5%				
			6	At the angle between the reinforcement, add 40 cm in length	25%				
			7	Concrete in good condition (not porous)	12,5%				
VII	5	Lintel	1	Main reinforcement minimum 4, size	15%				

Num	Component Value	Component	Parameter		Parameter Value	Aspect Value			Score
						Yes (1)	Defiecient (0.5)	No (0)	
				Ø 10 mm					
			2	Minimum stirrup size Ø 8 mm, spacing 15 cm	15%				
			3	Concrete mix ratio 1 pc: 2 sand : 3 gravel	15%				
			4	At the angle between the reinforcement, add 40 cm in length	40%				
			5	Concrete in good condition (not porous)	15%				
VIII	12,5	Reinforced concrete beam	1	Minimum size 12 cm x 15 cm	12,5%				
			2	Main reinforcement minimum 4, size Ø 10 mm	12,5%				
			3	Minimum stirrup size Ø 8 mm, spacing 15 cm	12,5%				
			4	Concrete mix ratio 1 pc: 2 sand : 3 gravel	12,5%				
			5	The thickness of the concrete blanket is 1 cm from the outer side of the stirrup	12,5%				
			6	At the angle between the reinforcement, add 40 cm in length	25%				
			7	Concrete in good condition (not porous)	12,5%				
IX	10	Engineered roof truss	1	Minimum wood size 8 cm x 12 cm	30%				
			2	Embedded truss anchor	40%				
			3	Binder	30%				
TOTAL SCORE									

After knowing the total score from the form, enter the value into the vulnerability category. There are three vulnerability categories which can be seen in Table 3. If the vulnerability results are high, then the quality of the building is low. Otherwise, if the vulnerability is low, then the quality of the building is high.

Table 3. Building vulnerability values based on class intervals.

Num	Building Vulnerability Value	Interval Class
1	Low	66,68 – 100
2	Medium	33,34 – 66,67
3	High	0 – 33,33

Findings in the field: a). From the results of the vulnerability assessment of community housing buildings with a total of 100 houses, the results of the vulnerability are more than 50% in the high vulnerability category. While the description of low vulnerability is 0 houses, moderate vulnerability is 47 houses, and high vulnerability is 53 houses; b). In building houses, many people build houses independently, with sand material taken from rivers that may contain mud and are not clean; c). The dimensions of the columns concrete beams, and the main column are not standard, in fact, there are still many houses that do not have concrete columns/beams; d). The quality of the concrete in the house structure and wall plaster is not good; e). Some people understand the correct standard of house construction, but it is not supported by a good economy; f). Many people don't think there will be an earthquake as big as an earthquake like last February 25th, 2022.

After the vulnerability assessment, repair, and strengthening activities for housing start with community training or construction work, the provision of this training material is carried out by several methods, including:

1. Through presentation.

The presenters provided material regarding earthquake-safe house buildings. Starting from basic knowledge about earthquakes, the requirements that must be met to be able to obtain buildings that are safe against earthquakes, good implementation and by earthquake safe house building rules, and how to repair buildings that have been damaged, but not completely collapsed.

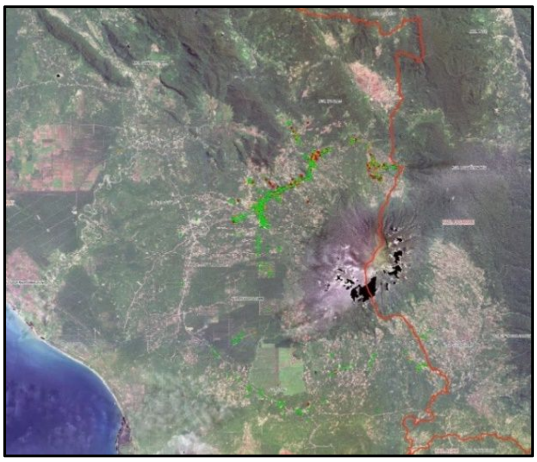

Fig. 6. The distribution of the locations of heavily damaged, moderately, and minor damaged houses in Pasaman Barat District.

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2. Discussion.

The discussion was carried out at the end of the delivery of the presentation. This is done to provide an opportunity for workers who still do not understand the presentation provided to be able to ask directly. In addition, this discussion was also carried out to discuss the obstacles that are often encountered by workers in building earthquake-safe houses.

3. Field practice.

The presentation that has been obtained is immediately put into practice to ensure that the workers understand theory and practice. Practice will also make it easier for the workers to remember what has been given because it has been done directly.

In this activity, training on building strengthening technology through wire mesh technology was carried out for workers. Wire mesh technology or also known as ferrocement technology is a technology for strengthening the plaster layer with a wire mesh, this technology is able to strengthen the tensile stress that occurs in brick walls, so as to increase the strength of the building against earthquake shocks. This technology is suitable for use in the community because it is easy to do and inexpensive. For implementation, the team conducted a study to determine one house as a sample house (Figure 7).

Fig. 7. Worker's training; Reciprocal stripping of stucco on cracks; The wall, the corner of the wall meeting has been peeled and ready to be installed with wire mesh; and the wall after the reciprocal wire mesh is installed and ready to be plastered.

4 Conclusions

The results of the vulnerability assessment of houses in Nagari Kajai were 47 houses with moderate vulnerability and 53 with high vulnerability. Factors that make these community houses vulnerable based on building evaluations are that many community houses do not meet earthquake safety standards, such as the dimensions of the columns that are too small, the size of the reinforcement of the beams and columns used is too small, the angles between the reinforcement do not meet earthquake safety standards. And the fact is that many houses do not use concrete columns or beams.

In building repair and strengthening activities, the workers or builders get the knowledges needed as a provision to be able to enter the community and play an active role in spreading and implementing rules for building earthquake safe houses. Great enthusiasm was also shown by the participants during the activity as seen from the many participants who asked questions.

Based on the findings in the field, it is recommended that: a. Make a simple guide book that is easy for the community to understand to build houses independently in earthquake areas b. Carry out training for community members and workers who are domiciled in disaster areas; c. Making examples of repairing (retrofitting) community houses that were damaged by the earthquake.

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