

## Earthquake Safe Houses Training for Tsunami Preparedness in West Sumatra

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**Abstract**— Western parts of Sumatra Island has the potential to hit by big earthquakes that can generate a tsunami. The possible sources of those big earthquakes are located at the subduction zone about 50 km westward of Mentawai Island and seabed fault between Mentawai and Sumatra Island. Since the distance of the sources is not so far, the earthquake may impact severely on the mainland of Sumatra Island. The shaking may damage the buildings, including houses on the Sumatra and Mentawai Islands, shortly before the tsunami comes. Thus, before evacuation from a tsunami, people must first survive from the earthquake. The worst-case may happen if the earthquake-triggered tsunami hit in the night where people are gathering at home. Victims affected by collapsed houses during the earthquake will be unable to evacuate for a tsunami. Therefore, surviving from the earthquake is an absolute requirement before saving themselves from the tsunami. It can be done by building the house or retrofitting the existing houses to be earthquake safer constructions. Many manual books and guidance that contain methods for constructing or strengthening houses for earthquake safer construction have been widely circulated in the community. But in its implementation, the training is needed. Since many houses must be strengthened, all stakeholders, including government, experts, ordinary people, and housebuilders should involve in the process. Above all, the housebuilders are the most important element in building earthquake safer houses. The housebuilder training, including all the stakeholders, has been conducted in Pariaman City, West Sumatra. This paper describes the experiences in conducting and training models of earthquake safer houses. This model can be replicated in other places, particularly along the western side of Sumatra Island.

**Keywords**— earthquake safer; tsunami preparedness; builder training; non-engineered house.

### I. INTRODUCTION

Big earthquakes mainly trigger the tsunami disasters in western parts of Sumatra Island. The possible sources of those big earthquakes are located on the west side seabed of Sumatra Island. In West Sumatra Province, those earthquake sources could be located on sea-based faults between the Sumatra and Mentawai Islands, as well as from the subduction area in the western part of Mentawai Islands. This Mentawai segment becomes the possible future earthquake source with a return period of 200 years [1]. Many researchers have investigated the characteristics of the tsunami, which is triggered by the earthquake from the Mentawai segment [2], [3]. More recently, a series of stochastic tsunami simulations associated with 600 source inputs have been generated to assess the maximum tsunami height along Padang coastline [4]. That study indicated that the distance of the earthquake source is not far, so it may have a devastating effect on the surrounding lands. The earthquake may have damaged the buildings, including houses in the West Sumatra and Mentawai Islands before the tsunami.

Since the earthquake comes before the tsunami, then to proceed to tsunami evacuation, people must first survive the earthquake. Victims affected by collapsed houses during the earthquake will be unable to evacuate for a tsunami. So surviving from the earthquake is an absolute requirement before the tsunami. The worst-case may happen if the earthquake that triggered the tsunami strikes in the night where people are staying in their homes. Then it is essential that collapsed houses must not happen nor harm the people. It can be done by making or retrofitting the existing houses to be earthquake safer constructions (Fig.1).

The earthquake safe house is, in fact, a secure house for its inhabitants together with its resistance to earthquakes. The earthquake safe house, as well as other buildings, is the work of human collaboration between owner, planner, and a group of workers. Earthquake safe houses, in general, are non-engineered houses that are not analyzed with structural mechanics but adopting the principles of earthquake resistance. Therefore, the builders' skill in making the house is required. The builder's skill can be achieved by conducting training given by related experts. In addition to the costs, planning and implementation capabilities are also

urgently needed as it was reported in reconstruction settlements in Sri Lanka and India after the Indian Ocean tsunami in 2004 [5]. The Tsunami in West Sumatra is different from in other areas such as Thailand, Sri Lanka or India, which probably did not feel the earthquake before the tsunami. The similar tsunami hazard has united the nations around the Indian Ocean in the Indian Ocean Rim Association (IORA). The IORA countries work together on tsunami disaster risk reduction [6].

To support this study, primary data have been collected through respondent in Padang, Agam, and Pariaman. The respondents are selected people who work related to and concerned about the tsunami hazard in West Sumatra Province. All of them strongly agree that the tsunami along the coastline of the West Sumatra is predicted to occur after the earthquake. For that reason then the exposed people in the tsunami-prone area must be the first safe from the earthquake. This paper describes some factors that influence tsunami preparedness, especially regarding building the earthquake-safe house.

## II. MATERIAL AND METHOD

This study was conducted by the study of literature and best practice during the previous earthquake in West Sumatra: Bengkulu earthquake 2006 and Padang earthquake 2009. To support this study, primary data survey has been collected through respondent in Padang, Agam, and Pariaman. The respondents are selected disaster stakeholders who work related to and concerned about disaster, especially the tsunami hazard in West Sumatra Province. Most of those respondents (85%) also often live in tsunami-prone areas.

## III. RESULTS AND DISCUSSION

### A. Earthquake Safe House

An earthquake safe house can be defined as a non-engineered house that provides security to its occupants in the event of an earthquake whether a small earthquake or a very strong earthquake. The actual earthquake does not directly harm the people, but the collapsed house due to the earthquake could cause casualties. The earthquake safe house should be made in such a way that it does not cause any casualties to the residents in it as well as the people around it. Psychologically, safe houses also always provide a sense of security to the occupants. So, the earthquake-safe house must be able to provide safety to the occupants at any times, both psychologically and physically.

In the case of a small earthquake, the safe houses should not suffer from light damages regarding small cracks on the wall or meshing roof arrangement to protect the psychology to the house residents. Earthquake safe houses should not suffer from any heavy damages such as the collapsing wall or the falling roof construction due to the strong earthquake. The collapsing wall or the roof construction can harm the house residents. In case of a very strong earthquake, the safe houses should remain standing despite any damages on them. Every element of the earthquake safe houses must remain in place and still be tied to each other during a very strong earthquake (Fig. 1 a, b and c).

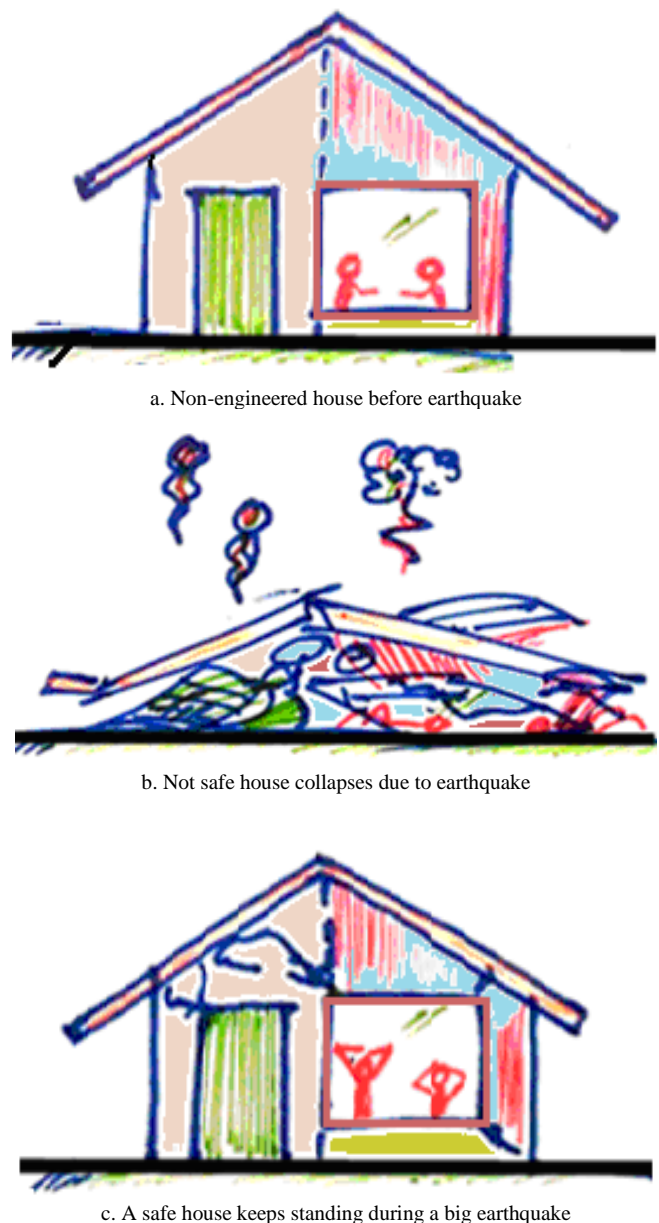


Fig. 1 Earthquake safe house principles

In the West Sumatra there are four elements of the human resources deal with the non-engineered house that is:

- Owner: as willing and responsible for the cost;
- Expert: a person or group that have good knowledge;
- Builder: a group of workers who physically build the house;
- Government: the authorized body(s) who give formal construction permissions;

Human resources have a responsibility for providing earthquake safe houses. To gain the information of the stake holder's perception of earthquake safe houses responsibility, the survey among them had been conducted [11]. The survey contents nine questions as follows:

- Does the stake older agree that to be able to evacuate before the tsunami happens, the community must be able to survive first from the earthquake?

- The worst case of an earthquake that triggered the tsunami usually (and may) occur in the night when people were resting in their homes is that correct?
- Does the stakeholder agree that people who will evacuate tsunamis must be safe from the earthquake at first?
- Does the stakeholder agree that the Guidelines containing methods for making or strengthening earthquake-safe houses have been circulating in many communities?
- Is to understand the method for making earthquake safe houses, the guidance/training is needed?
- The large number of houses that must be strengthened to deal with future earthquakes, who has the responsibility for making earthquake safe houses?
- Is the local worker/builder the key to creating earthquake safe houses?
- Do the stakeholders need to pay attention to the possibility of a tsunami in West Sumatra?
- Does the stakeholder live or often in a tsunami-threatened area?

The survey results show that 85% of respondents agree that all elements of human resources have the same responsibility (Fig. 2). Few pointed out that only the government, only the experts or only the builders take primary responsibility in providing earthquake safe houses for the community. Nevertheless, more than half agreed that the key factor of earthquake-safe housing was the builders (Fig. 3).

Governments can play a role in giving a small amount of financial assistance to a certain community. The government can rule building permits better in big cities. In fact, that for remote traditional villages, the government has very little interference with the community. Often people in remote villages do not need the building permit from the government to start constructing a house on their property. Then it can be said that the Government cannot rule better quality houses or earthquake safe houses.

The size and the cost of the house depending on the decision of the owner. However, the quality of the physical work of the house is determined by the builders. The position of the housebuilder is very important in generating earthquake safe houses. This profession is key to reducing people's vulnerability to seismicity (Fig. 3)

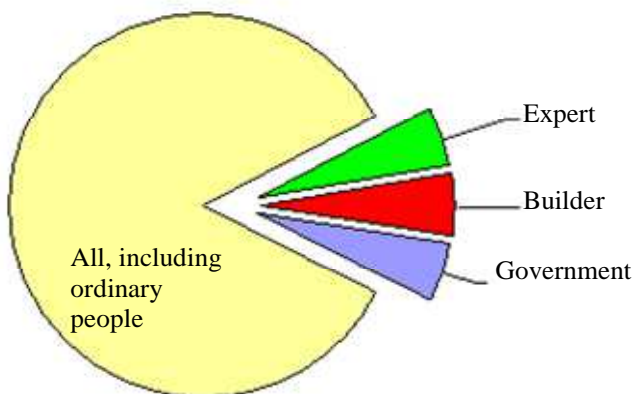


Fig. 2 Responsibility for earthquake safe houses

House builder as the key factor

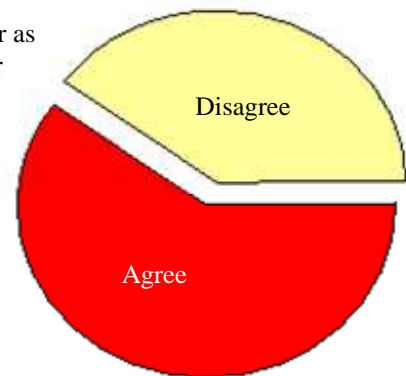


Fig. 3 Perception: builder as the key factor

### B. Earthquake Safe Guidance

Transforming a non-engineering house into an earthquake-safe house may require additional materials and installation budget. The extra budget depends on the concept of the earthquake-safe house to be adopted. Regarding structural engineering, additional reinforcement in a house undeniably provides additional resistance to earthquakes. So, the concept of applying additional reinforcement can be reasonable and applicable to that traditional building.

Before the earthquake-safe house became the concern of many experts, at the end of the last century, the Indonesia Government, through the Directorate General of Human Settlements has issued an Earthquake-Resistant Building Guideline [7]. Then, after the Padang Earthquake in 2009, the earthquake-safe house concepts in Indonesia become the attention of researchers from many countries (Fig. 4). However, the survey results indicate that half (50%+10% are unaware) of respondents still believe that the guidance for making safe houses has not been widely spread in the community. Non-governmental bodies issued one of the guidelines named the Simple Earthquake Safe Building Guidance [8]. In line with the growing culture in society, they are wanting a house made of bricks with the consideration of providing a better social status. The other guideline that is widely distributed and used in Padang is the concept of a safe earthquake brick house [9]. This concept stated that every element of the house starting from the foundation, beam circumference, columns, walls, upper beam, and roof construction must be tied up with each other. This concept needs an additional iron bar, which significantly increases the construction budget.



Fig. 4 Earthquake safe house guidance

The earthquake-safe houses have a main mission to avoid casualties from the collapsed house during the earthquake. On the other hand, people still want a simple and inexpensive house. Then the concept of the earthquake-safe house should not eliminate the traditional way that is generally adopted by the people as the survey results show that all respondents agree that the application of earthquake-safe concept still needs the existence of experts. Therefore, the experts who understand the earthquake-safe concepts will guide people in the application of earthquake-safe building construction. As the housebuilders is a critical part of the earthquake-safe house, the knowledge and skill must be upgraded to apply the earthquake-safe house technology to increase the resilience to earthquake and tsunami.

### C. Builder Capacity Building

The survey results showed that 60% of respondents thought that although not fully responsible, the builder is a key factor for safer houses. In line with house retrofitting programs, it is necessary to understand first the culture and customs adopted by the community. The same has also been

attention at the time of rebuilding the areas of post-disaster of the Indian Ocean tsunami in 2004 [10]. This study found that the Owner and Builder in Pariaman have an important role and have a special relationship in which will affect the quality of the house. The owners and builders are judged to have responsibility for the safer house [11]. Owners usually do not understand the things associated with building a house and fully trust the housebuilders. So, the safer house must be very dependent on both the Owner and the builder. A builder is a construction worker who has the responsibility to complete a part or all the housework. For a reason, the builders must be a master of a series of work such as a mason, carpenter, bar arranger, and others. Generally, the builder's capability of making a house is inherited from the old generation to the next. The builders learned the knowledge and skills from the previous builders, where they worked together. Knowledge and skills are taught on a job informally. Once a worker possesses knowledge and skills, and has the confidence to make a house, he will then proclaim himself as a builder.

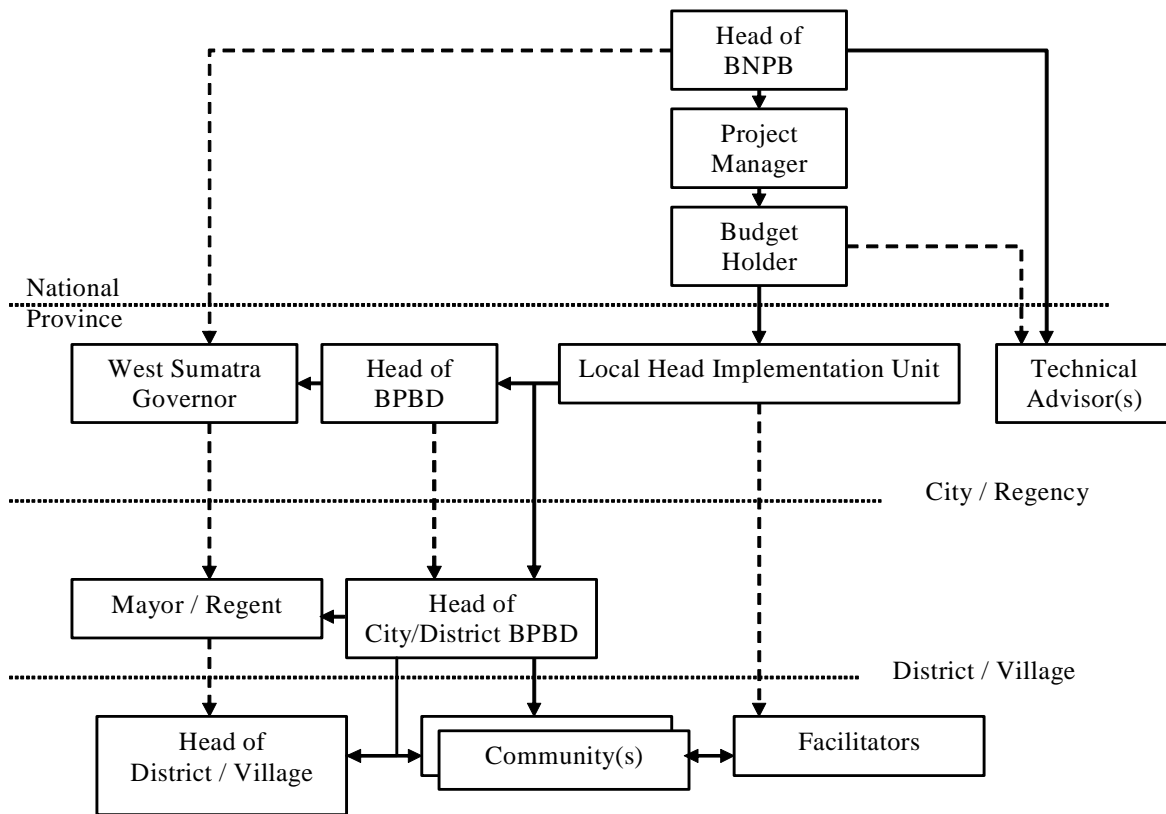


Fig. 5 Rehabilitation and Reconstruction Organization in West Sumatra

The knowledge and skills needed by the builders have involved two main things, the guidelines of the safer house and the expert who delivered the guidelines. The general people still think that the earthquake-safe house is a concept of applying complicated and advanced technology. On the other hand, an earthquake-safe house is also a masterpiece application of engineering and science which owned by experts.

The Builder capacity building by force through the provision of building permits (IMB) is an inappropriate

model. As previously described that the government's role as an authority for the IMB is sometimes not suited for specific societies. This forced top-down model will have implications on financial constraints that may increase the budget of non-physical things such as design and the building permit costs. Also, government supervision may also require additional costs. Then, the direct approach to the builders is a simple, cheap, and right targeted model for creating safer house programs.

For a larger program such as the National Rehabilitation and Reconstruction Post Padang Earthquake program in 2009, capacity building for these housebuilders could also be done through a more complicated model that were involving facilitators as intermediaries of experts [12]. That was the right decision at the time since of the lack of experts to be directly involved in builder training. The facilitators had the task of providing technical and non-technical assistance directly to the community. Each facilitator is at least involved in guiding for 40 house rebuilding activities. At that moment, the scheme of implementation (Fig. 5) was needed to control each step of the National Rehabilitation and Reconstruction Action in Padang, which involving so many and very large communities and budgets.

Since the role of house builders in the earthquakes risk reduction is crucial, the building capacity through training activities must be carried out. The safe house builder training is very important, especially to local builders who are culturally part and trusted by the community. In West Sumatra, this training has been conducted especially after

the Earthquake 2009. This training is aimed to increase the knowledge and skill capacities of local builders in making the earthquake-safe house. The training model is done through two main phases, first to improve the knowledge through the delivery presentations and discussions and enhance the skills through mentoring practical jobs.

The builder training was conducted by involving all four elements of the human resources that deal with non-engineered safe houses as well as the other factors influencing the earthquake safe houses (Fig. 6). In training, the presentation was conducted by the experts with the audiences from builders and house owners and the elements of the Government. The main subject of training materials is taken from safe house guidelines. The practical work of making a house is carried out by the builders accompanied by the others. In many activities, the raw materials for the safe house prototype are provided by the Government bodies. It can be seen that within this model, every element of human resources of safe houses can perform its role well.

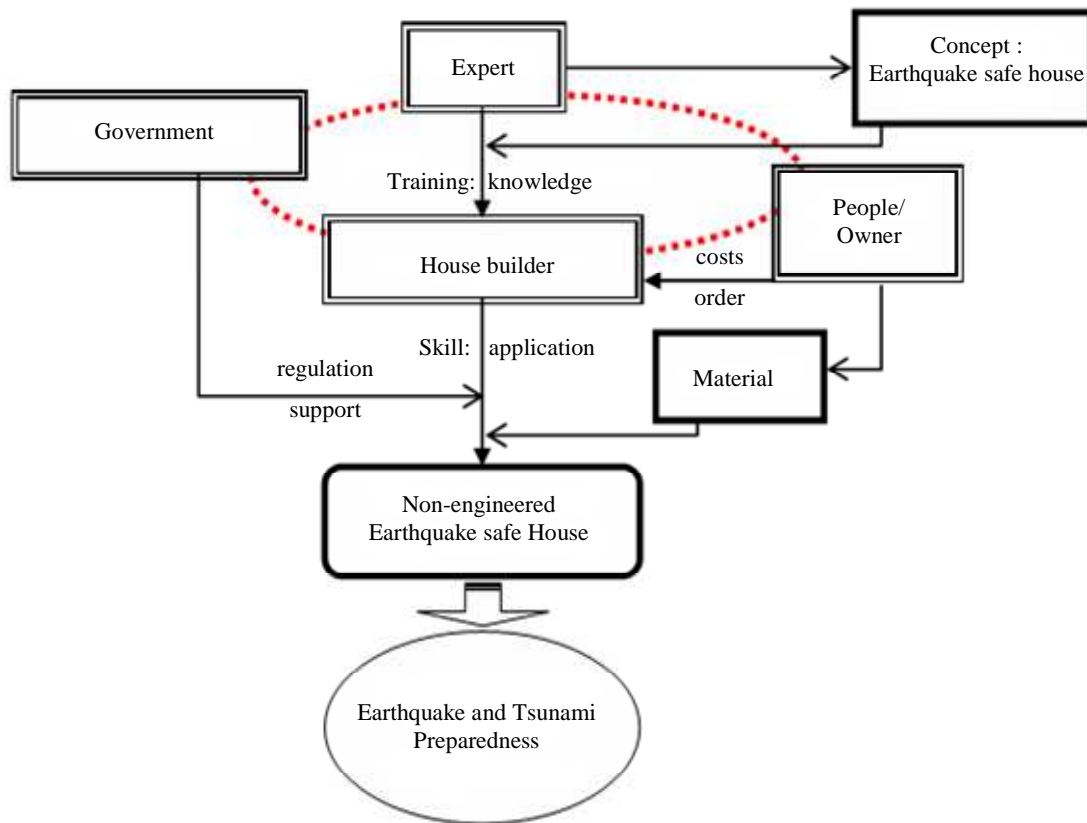


Fig. 6 Builder training model in West Sumatra



a. Brick Construction



b. Wiremesh attachment



c. Mortar Construction

Fig. 7 A prototype of the safe house in the training

Builder Capacity Building by providing knowledge and skills in associated with the earthquake-safe house can improve the capacity of the builder in constructing the earthquake safe houses. The guidelines used must be accepted by the builders. It is the most important component in the transfer of earthquake safe house technology. Based on the experience, there are no significant difficulties in its implementation even though there is the additional job from the whole the house construction. The good reason is there is no change in the sequence of house-building work (Fig. 7). There is only a crucial job that is inserted in the whole procedures for constructing a non-engineered house to be

transformed into an earthquake-safe house by adding wire mesh strengthening [13]–[17]. The rest of the procedures are still conducted without any change as traditionally adopted as a standard.

#### IV. CONCLUSION

Guidance books that contain methods for constructing or strengthening earthquake safer houses have been widely distributed. However, to implement it, training of those methods is needed. Since plenty of houses must be strengthened to deal with the earthquake, the construction of earthquake safer houses should involve all stakeholders, including government, experts, ordinary people, and housebuilders.

The housebuilders are the most important element in building an earthquake safer house. The housebuilder training involving all the stakeholders have been conducted in West Sumatra, especially in the city of Pariaman. The experiences in conducting local builder training are described in this paper. This training model may be replicated in other areas particularly along the western side of Sumatra Island.

A housebuilder is a professional job that carries out the construction of a house and has the responsibility to complete the sequence of house-building work. By giving additional knowledge and skills in making earthquake safe houses, the reduction of the number of victims due to the collapse of buildings during the earthquake can be made. To ensure that the capacity building training can be done well, then the original skill of the local builder must not be changed. The most important procedures for earthquake safe house then only inserted into the original sequence. The training model for strengthening the local builder's capacity should be done in cooperation with the government, owners as well as earthquake-safe experts. The new capacity of the builders from the training is very important to the earthquake and tsunami risk reduction program.

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