Builder perception on the implementation of earthquake resistant non-engineered house construction practice in Padang City

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Abstract. Disaster preparedness from the builder is crucial due to the increase of earthquake vulnerability in Padang City. To ensure that the house is built following the concept of an earthquake-resistant non-engineered house must be followed in building the house to secure and minimizes the risk of casualties and losses caused by the earthquake. Previous experience shows that technical factors are not enough to increase the awareness of the builders. It requires non-technical factors that may play a significant role in disaster reduction in the community. That is why this study intends to identify builder perception about indicators of earthquake-resistant non-engineered house development and its implementation in the field. Questionnaires are used to gather the data to 30 housing projects in Padang City. In general, all statements about the concept of earthquake-resistant houses are strongly considered by the builders. However, it does not implement in the field run smoothly. Many construction practices found did not meet the principles. Government and stakeholder participation are needed to enhance the competency and knowledge of the homeowners and builders.

1. Introduction

People living in a dangerous city/location are becoming more vulnerable to natural hazards just by still living in that location. But the option to move the community to a new safe area is not easy because of the social and economic impact factor of the community. Hence the disaster mitigation program should be implemented to the target community. Some studies investigated that disasters can make a disturbance to communities and cause physical, social, economic, and environmental damage [1].

An effective disaster mitigation program cannot be achieved and implemented effectively without the participation of the community in general. Get involved by the vulnerable community in the disaster mitigation process is the prime component [2]. Newport et al. [2] also argued disaster mitigation also requires the involvement of government institutions and the NGOs the participation, not only the individual or group within the community.

With the increase of earthquake vulnerability, demanding preparedness from people in Padang City to ensure the houses built are following the concept of earthquake resistant. Research from Hesna and Hidayat [3] states that one of the factors that play a role in increasing community participation in the
implementation of an earthquake-resistant non-engineered house is social capital found in the community. In this case, social bonding, linking, and networking between homeowners and builders.

But involving local communities in disaster mitigation and preparedness program cannot be realized easily [4]. Khan et al. [4] summarized that many interventions by the authorities, ignoring local input, and lack of coordination are the source of failure in a community-based disaster management program. The community members are also being excluded from the process of decision making [5]. Disaster experience and perception of risk are crucial in disaster preparedness, mitigation, and prevention program [4]. The perception and practices of builders need to be taken into account. However, it is not yet known how the influence of perceptions of builders on indicators of earthquake-resistant non-engineered house development and its implementation in the field. This research is carried out to fill this gap.

2. Theoretical background of non-engineered house
As it functions as a community residence, it is important to the non-engineered house to secure the inhabitant. The earthquake damage to the non-engineered house is of particular concern because it can harm the inhabitant [3]. From the observation in many experiences, the earthquake damage causes the largest number of infrastructure damage [6].

Non-engineered house is defined as those that are informally constructed in the traditional manner [7]. The owner and the builder work together without a formal contractual relationship. Another characteristic of the non-engineered house is that the house is built by a simple construction method, without any intervention from the engineer's structural analysis and technologies [6]–[8]. Boen [9] divided the non-engineered house into two main categories. The non-engineered house usually uses local material and follow local tradition and culture, generally called indigenous or vernacular house. The second categories are urban-type masonry construction. It is designated as the first category, but not adopting the traditional craftsmanship and materials. Such buildings involve fieldstone, fired brick, concrete blocks, wood, or a combination of these materials informing the wall construction [7]. Cement, lime, or clay mud are used for the mortars. This type of masonry house will include load-bearing masonry wall buildings, either confined or unconfined [9].

In Indonesia, confined masonry is the most common construction method used for single-story houses. This type of construction method has many advantages, such as lower construction cost, less engineering input required, and lower skill of worker needed. Basic concepts of confined masonry are all four sides of masonry walls confined by reinforced concrete members – bond beams and tie columns. Masonry walls constructed first, tie columns, and bond beams are poured in afterward to confine the wall. Last, walls assumed to carry all vertical and lateral loads.

3. Research method
A questionnaire is an information-gathering technique to study the attitudes, beliefs, behaviors, and characteristics of the respondents concerned about the problems raised. The questionnaire was addressed to the builders in the construction of earthquake-resistant non-engineered houses in Padang City.

The questionnaires about the perception of builders on an earthquake-resistant non-engineered house are compiled and adapted from the reference book [10], [11]. The questionnaires consist of three parts. First, it is about information about builders. The second, builder perception on Basic Principles of Earthquake Resistant Non-Engineered House. The third, builder perception of Specification and Main Structure of Earthquake Resistant Non-Engineered House. Complete indicators for builder perception can be seen in table 1 in the appendix.

Data collection began in July 2018 until December 2018, based on a purposive sampling method. The number of samples in this study is 30 residential development projects whose distribution of location can be seen in the following figure.
Generally, the houses built are categorized as small houses, with the size of the house can be seen in figure 2.

![Figure 1. Project location distribution.](image)

An assessment of the perceptions of homeowners on the implementation of earthquake-resistant non-engineered house construction was carried out on a Likert scale with the following scores:

- Very Considerable (VC) = 4
- Consider (C) = 3
- Don't Know (DK) = 2
- Not considered (NC) = 1
- Very Not Considered (VNC) = 0

The respondent's answers were processed with descriptive statistics.

4. Respondent profile
In the field area, there are three positions of the builder. These are the head of builders, builders, and labor. We conducted this survey to the head of builders who are functioned as the director of builders. Most of the head of builders are in the age of 41 - 50 years old. The proportion of respondent’s age can be seen from figure 3.
The distribution of builders based on the educational background can be found in figure 4 below. Most of the builder has their education in Junior High School (JHS) and Senior High School (SHS). Only 6.7% of builders were in engineering vocational senior high (VHS).

5. Perception of the builder on earthquake resistant non-engineered house

For the basic principle of the concept of earthquake-resistant houses, get an average score of 4.89. Likewise, the use of building materials has an average score of 4.95. The main structural part has an average score of 4.85. So, it is concluded that all of the indicators of the non-engineered house get strongly considered by the builder. The builders consider the requirement of the basic principle, building material, and the main structure are important to implement at project locations to fulfill the principles of earthquake-resistant non-engineered house.

All projects were built on stable land, none of which were on sloping land. The houses made with a simple house plan. However, the window openings have not been placed systematically. And the relationship between the column-sloof is not very good because it is not given anchorage for the seismic hook.

However, in certain locations, there are discrepancies found, as shown in figure 6. The perception of the builders is different from the implementation. What found in the fields do not prove the builder's perception on the implementation of earthquake-resistant non-engineered house.
It found at the location the available gravel is irregular in size, and some gravels are more than 20 mm in size. Also, there was no apparent anchor between the pairs of bricks and columns. Likewise, in the implementation of casting, there are not many that impose casting each one meter gradually and are punctured so that casting is evenly distributed. So that it cannot be ascertained highly considered of builder's perceptions on an earthquake-resistant non-engineered house will be carried out well in the field.

![Image of construction site](image_url)

**Figure 6.** Examples of problems on non-engineered house construction practice.

There are many mistakes in practice due to the lack of knowledge from the builders. This can be explained from the source of the builder's knowledge. All of the respondents have a different answer to the source of knowledge. Some of the respondents said that self-experience in developed his own house, but the majority get knowledge from the guidance of senior colleagues.

All respondents did not have attended competency training and did not have certain certificates of expertise. None of the respondents joined either certain institutions or associations in the construction sector. And they also rarely participate in socialization/workshop related to guidelines for earthquake-resistant non-engineered houses. All respondents did not use technical guidelines for implementation. According to respondents 4, specifications used usually follows the request of the homeowner. Whereas according to respondents 18, the specifications used are not far away different on each project, so it doesn't need specific guidelines at work. 90% of respondents knew the concept of earthquake-resistant houses from socialization; only 10% said they did not know.

This research confirmed the result from Juliafad et.al.[12], that the low quality of Reinforced Concrete building due to cultural ethic work. Because most builders do not have an engineering educational background, so their skills and knowledge are transferred by their senior. Juliafad et.al. [12] stated that the influence of previous experience is dominant compared to the contribution of knowledge from construction workshop. The builders tend to learn and adopt the same mistakes from their seniors.

6. Conclusion and recommendation

Based on the responses of the respondent, it was found that the builders highly consider all statements about the concept of the earthquake-resistant non-engineered house. Except for comments about gradual casting, which get mixed responses. However, the high consideration given by the builder's perception of earthquake-resistant house indicators does not implement in the field run smoothly. Many construction practices found did not meet the principles. This is due to the lack of understanding and knowledge of the builders. For this reason, socialization and education activities must continue.

This research concludes that the success of the implementation of an earthquake-resistant non-engineered house in Padang City is far away. Research by Bempah and Olav [8] is often attributed to the awareness of the house owners and builders, training, and transferring the proper technical skills to the builders as an effective method for non-engineered construction.

Besides that, it is interesting to explore in the next research about builder motivation and builder risk perception to take pre-disaster risk reduction action. Khan et al. [4] also argued that community risk
perception has a significant impact on disaster preparedness as Alam et al. [13] also said that lack of motivation is the problem of the earthquake-resistant non-engineered house, even though the additional cost incurred are small.

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## Appendix

### Table 1. Indicators of Earthquake Resistant Non-Engineered House.

|   | Basic Principles of Earthquake Resistant Non-Engineered House | VC | C | DK | NC | VNC | Score | Mean Score | Dev. St |
|---|---------------------------------------------------------------|----|---|----|----|-----|-------|------------|---------|
| 1 | The house is built on stable land                            | 29 | 1 | -  | -  | -   | 4.97  |            |         |
| 2 | Simple building plan                                          | 25 | 3 | 2  | -  | -   | 4.77  |            |         |
| 3 | Placement of insulation walls and door/window openings are made symmetrical | 26 | 3 | 1  | -  | -   | 4.83  |            |         |
| 4 | All building components (foundations, columns, beams, walls, roofs and roof trusses) are joined together | 30 | - | -  | -  | -   | 5.0   |            |         |

### II Building Materials

#### A Concrete

1. Concrete mixture has a composition of 1: 2: 3: 0.5 (comparison of cement, sand, gravel, and water)  
   - Score: 4.77  
   - Mean Score: 4.95  
   - Dev. St: 0.05

#### B Mortar

1. Mortar mixture has a composition of 1: 4 (cement and gravel)  
   - Score: 5.0  
   - Mean Score: 4.95  
   - Dev. St: 0.05

#### C River stone

1. The stone size is uniform (not too varied)  
   - Score: 4.93  
   - Mean Score: 4.77  
   - Dev. St: 0.05

#### D Wood

1. The wood used is straight and dry  
   - Score: 5.0  
   - Mean Score: 4.97  
   - Dev. St: 0.05

2. There are not many wood eyes  
   - Score: 3.9  
   - Mean Score: 4.77  
   - Dev. St: 0.05

### III Main Structure

#### A Foundation

1. The arrangement of stones is made alternately  
   - Score: 5.0  
   - Mean Score: 4.77  
   - Dev. St: 0.05

2. The foundation is given anchor every 1 m from Sloof  
   - Score: 4.97  
   - Mean Score: 4.85  
   - Dev. St: 0.14

#### B Rebar

1. Curved bends form an angle of 45° at least 5 cm  
   - Score: 4.77  
   - Mean Score: 4.85  
   - Dev. St: 0.14

2. Connection of column, beam, and sloof  
   - Score: 5.0  
   - Mean Score: 4.97  
   - Dev. St: 0.05

#### C Casting

1. The concrete is watered periodically, and even the formwork is removed  
   - Score: 5.0  
   - Mean Score: 4.77  
   - Dev. St: 0.05

2. Column casting is carried out in stages every 1 m height  
   - Score: 3.9  
   - Mean Score: 4.85  
   - Dev. St: 0.14

3. Concrete casting is pierced with iron or bamboo, so the concrete is evenly distributed and not porous  
   - Score: 5.0  
   - Mean Score: 4.97  
   - Dev. St: 0.05

4. Column, formwork, sloof, and beams are opened after three days  
   - Score: 5.0  
   - Mean Score: 4.77  
   - Dev. St: 0.05

5. Hanging beam formwork is minimally opened after 14 days  
   - Score: 5.0  
   - Mean Score: 4.97  
   - Dev. St: 0.05

#### D Roof Structures

1. Each connection of the easel is given a steel clamp/plate clamp  
   - Score: 4.7  
   - Mean Score: 4.77  
   - Dev. St: 0.05

2. The connection of easel and beams is given iron anchor planted  
   - Score: 5.0  
   - Mean Score: 4.97  
   - Dev. St: 0.05

3. Wind ties bind mountains with horses  
   - Score: 5.0  
   - Mean Score: 4.97  
   - Dev. St: 0.05

#### E Walls

1. Installation of 1/2 alternating brick wall and anchored every six layers of brick  
   - Score: 4.77  
   - Mean Score: 4.77  
   - Dev. St: 0.05

2. The maximum wall area is 9 m², and the maximum column distance is 3 m, give a practical column if more  
   - Score: 5.0  
   - Mean Score: 4.97  
   - Dev. St: 0.05