Quantifying the perceptions of the 2018 Palu earthquake survivors on the use of light bricks as a wall material of simple house

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Abstract. The construction of new housing for rehabilitation and reconstruction purposes must minimize the risks that may occur due to earthquakes, one of which is by using light materials (light bricks) as wall construction. However, the use of light bricks is often misunderstood by earthquake survivors because they are considered to have insufficient strength as a construction material. This paper intends to introduce light bricks to exposed communities and further quantify their perceptions of the application of this material to the rehabilitation and reconstruction of their buildings. The introduction of the material is done through socialization by displaying the results of laboratory tests of compressive strength and showing evidence of the application of this material in other places. The perceptions of the impacted community were analyzed from questionnaire results to 50 respondents with ten questions as the measurement reference. The results of the analysis show that almost all respondents show fairly good acceptance of light brick applications with a score of 3.70 of 5. Based on perception, the use of light bricks as a wall material has the opportunity to be applied for residential rehabilitation and reconstruction as a result of the 2018 Palu earthquake.

1. Introduction

Palu is a city located in a multi-disaster prone area, especially earthquakes. Apart from earthquakes, several disasters have also occurred and have the potential to occur in this area, such as tsunamis, liquefaction, floods and other disasters. Not even forgotten from our memory, an earthquake with a magnitude of 7.4 had a very devastating impact because it triggered a tsunami, liquefaction, and landslides at four locations (Balaroa, Petobo, Jono Oge and Sibalaya) and liquefaction has killed at least 2000 people. The National Disaster Management Agency (BNPB) of Indonesia reported that more than 50,000 houses had been damaged by the earthquake, tsunami and liquefaction.

Like the nature of earthquakes in general, residential houses are the most affected buildings. More than 50,000 housing units have been damaged throughout the city of Palu, especially buildings made of concrete. Conventional concrete with a large weight, has the potential to weaken the strength of the building due to its own load. Post-earthquake reconstruction has been carried out both by the government
and independently by the affected communities to date. The need for new housing units for the affected community is proportional to the number of damaged houses.

Due to the high risk of building with heavy materials such as conventional concrete, it is necessary to apply alternative materials [1] such as light bricks made of a mixture of concrete and husks [2-4]. The right composition arrangement is applied to get the physical quality and good strength of the brick with the minimum weight [5-6].

In general, light bricks are not well known by the local communities in the study area. They considered that light bricks were less acceptable as a construction material, especially simple houses, due to their weaknesses such as fragility and resistance to weather changes. In addition, they had never seen a building with walls made of light brick. Generally, they receive very little information about this new material.

In the context of applying new methods, materials and concepts, perception measurement is a very important study. If people have negative perceptions about this matter, recognition and understanding can be given to them either through socialization or training or workshops [7-11]. Based on this, the study in the paper is considered very important because it aims to measure the perceptions of disaster-affected communities about their acceptance of light materials as earthquake-resistant walls of simple houses.

2. Material and Methods

2.1. Light Brick
Light brick is a material introduced to respondents. This construction material is made from a mixture of concrete with the main ingredients being light materials such as lime, coal burning residue, fly ash, volcanic ash, rice husk ash, styrofoam and other light materials. This type of brick can be used as a building or house wall material with the aim of reducing the load on beams, columns and foundations. The typology of light bricks can be seen in Figure 1.

![Typical light brick](image)

Figure 1. Typical light brick

2.2. Respondent
Respondents were randomly assigned based on a list of participant candidates for the socialization and workshop of light brick making. Prospective participants are survivors of the 2018 Palu Earthquake and Liquefaction who live in the Petobo temporary residential (Huntara), Palu, Central Sulawesi, Indonesia approximately 4,000 people. Requirements for prospective participants are productive citizens according to the World Health Organization (WHO) aged 15 to 64 years and ideally a minimum of 10% of the population [12].

The activity plan was informed publicly by the sub-district officers. People of productive age are freely allowed to register independently. The number of participants is limited to a maximum of 50 people, taking into account the availability of funding for the workshop implementation and the requirements of the respondent's adequacy. Prospective registered participants are required to attend
socialization and workshops where the place and time of the implementation will be determined later. Based on the list, prospective participants are assigned as respondents and asked to do a questionnaire.

2.3. Methods

As has been stated in the previous section that the data collection technique is using a questionnaire. This method is executed by giving a set of written questions to the respondent. The questionnaire contains ten question items to measure respondents’ perceptions of the acceptance of light brick as a construction material. Respondents were asked to choose one of the five answers freely according to their perception of each question by circling the answer code (a, b, c, d, e and f). All qualitative answers to each question were given a score of 1-5 which corresponds to a-f. This scoring method is based on a Likert Scale, a psychometric scale that measures individual behavior quantitatively. Score 1 states the highest level of rejection (example: strongly disagree), and vice versa Score 5 represents the highest acceptance attitude (example: strongly agree).

Two tests were implemented to measure the goodness qualification of the questionnaire: the validity test and reliability. The validity test was implemented to assess the validity of an instrument [1-3]. An instrument qualifies for validity if the questions on the questionnaire are capable of expressing something that the questionnaire will measure. The level of validity can be measured by comparing the calculated correlation coefficient ($r_{cal}$) of the total score of each variable (equation) with table of critical values for Pearson's correlation coefficient ($r_{tab}$). If $r_{cal} > r_{tab}$, then the statement is valid and vice versa. Pearson’s $r$ of each question item score and the total score is expressed by:

$$ r = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right) \sum y^2 - \frac{(\sum y)^2}{n}}} $$

(1)

where $x =$ the score of the question item of each respondent and $y =$ the total score of the respondent and $n =$ number of respondent (sample). $r_{tab}$ in this test was determined with the degree of freedom ($df = n - 2$) and level of significance for 2-tailed test ($\alpha = 5\%$).

The validity test can also be performed by assessing the Sig. (2-tailed) or p-value of the total score of each variable (equation) using Sig. (2-tailed) or the reference p-value denoted by $\alpha$ (generally set at 0.05 or 5%) [15]. These two terms are used to describe the probability of the test results based on two hypotheses: H0 (invalid question item) and H1 (valid question item). If the $p$-value $< \alpha$, then H0 is rejected and H1 is accepted, and vice versa.

Table 1. Grouping coefficients to measure the level of validity and reliability

| Coefficient (Pearson’s Correlation and Cronbach’s Alpha) | Level of Validity and Reliability |
|-------------------------------------------------------|----------------------------------|
| 0.80 – 1.00                                            | very high                        |
| 0.60 – 0.80                                            | high                             |
| 0.40 – 0.60                                            | moderate                         |
| 0.20 – 0.40                                            | low                              |
| 0.00 – 0.20                                            | very low                         |

The reliability test was assigned to measure the stability of the questionnaire questions as an indicator of variable consistency [16-17]. Each question on the questionnaire is considered reliable if the respondent's answer is consistent. Respondents will consistently provide answers when the same question item is given at other times and occasions. The reliability of the questionnaire can be assessed by the instrument reliability coefficient which is expressed by the Cronbach's Alpha reliability coefficient ($r_{ac}$), such as the following equation:

$$ r_{ac} = \left(\frac{k}{k-1}\right) \left(1 - \frac{\sum_{i=1}^{k} \sigma_i^2}{\sigma_x^2}\right) $$

(2)
\[ k = \text{the total number of questions}, \quad \sigma_{y_i}^2 = \text{the variance of each question item score and} \quad \sigma_x^2 = \text{total varians dari skor total}. \]

A variable (question) is considered reliable if \( r_{a.c} > 0.7 \) and vice versa. In general, the levels of reliability and validity are grouped and referenced based on Table 1.

The final step of this analysis is an assessment of public perceptions of the acceptance of light bricks. This perception is evaluated by the mean score (\( \overline{SC} \)) of all respondents:

\[
\overline{SC} = \frac{\sum_{i=1}^{n} SC_i}{n}
\]

\( \overline{SC} \) = the average score of each respondent. The average score is converted into percent by the following equation:

\[
\overline{SC}(\%) = \frac{\overline{SC} - SC_{min}}{SC_{max} - SC_{min}} \times 100\%
\]

\( SC_{min} = 1 \) and \( SC_{max} = 5 \). The level of acceptance of respondents can be concluded based on the interval limits in Table 2.

| Score (%) | Acceptance Rate Criteria |
|-----------|--------------------------|
| < 65      | low                      |
| 65 - 85   | moderate                 |
| > 85      | high                     |

### Table 2. Acceptance rate criteria

#### 3. Result and Discussion

#### 3.1. Respondent Profile

Based on the predetermined criteria, 50 respondents were registered. All respondents are male because they will be trained to become skilled workers in light brick molding. Referring to the data collected in each questionnaire, most of the respondents were senior high school graduates and above levels such as diplomas and bachelors. Less than 20\% of them are junior high school graduates and below. Respondents with adequate education have a better chance of understanding and training success.

**Figure 2.** Respondent profile

More than three quarters of respondents are in the very productive age range (20-50 years) and the rest are still in the productive age according to WHO (15-64 years). The majority of respondents at very
productive age indicated that the opportunity to become a worker or light brick business owner was very high. Respondent profiles in detail are shown in Figure 2.

3.2. **Qualification of the Questionnaire**

As previously explained, the assessment of the quality of the questionnaire was performed by testing its validity and reliability. Based on these two tests, ten question items were declared valid with $r_{cal} > r_{tab}$ and $p$-value < 0.05 (Table 3) and proven to be reliable with overall $r_{ac} (0.8501) > 0.7$. However, when observed in the matrix plot between two variables (Figure 3), there are several items that show horizontal curves such as the question item Q01.

**Table 3.** The summary of the validity test results of 10 question items to 50 respondents

| Variables (Questions) | Pearson's correlation coefficient ($r_{cal}$) | Critical values for Pearson's correlation coefficient ($r_{tab}$) | $df = n - 2$ | $p$-value | Status | Remarks |
|-----------------------|---------------------------------------------|---------------------------------------------------------------|-------------|-----------|--------|--------|
| Q01                   | 0.369                                       | 0.2353                                                        | 0.000       | valid     | $r_{cal} > r_{tab}$ and $p$-value < 0.05 |
| Q02                   | 0.755                                       | 0.2353                                                        | 0.000       | valid     |        |
| Q03                   | 0.816                                       | 0.2353                                                        | 0.000       | valid     |        |
| Q04                   | 0.722                                       | 0.2353                                                        | 0.000       | valid     |        |
| Q05                   | 0.833                                       | 0.2353                                                        | 0.000       | valid     |        |
| Q06                   | 0.562                                       | 0.2353                                                        | 0.000       | valid     |        |
| Q07                   | 0.527                                       | 0.2353                                                        | 0.000       | valid     |        |
| Q08                   | 0.662                                       | 0.2353                                                        | 0.000       | valid     |        |
| Q09                   | 0.719                                       | 0.2353                                                        | 0.000       | valid     |        |
| Q10                   | 0.746                                       | 0.2353                                                        | 0.000       | valid     |        |

**Figure 3.** Matrix plot to assess the strength and direction of the relationship between two items or variables.
A positive linear curve is an indication that the questions applied have good validity and reliability. In general, Figure 3 shows the relationship between positive variables although the correlation is relatively weak, especially in Q01. Although overall shows a positive correlation, the quality of the questions still needs to be improved to increase their validity and reliability.

3.3. Perception

An assessment of the 10 questions given to 50 respondents with a score of 1-5 indicates that the highest average score is given by Q05 and the lowest score is in Q01 (Figure 4). Q01 with a score of 2.50 represents the perception of the respondent's level of recognition of light bricks including material, shape, usability, and strength. Respondents have a relatively very low level of introduction with a percentage of 37.5%. Information about light bricks is very minimal obtained by the respondent. Therefore, through socialization and workshops, respondents will be given a better and more comprehensive introduction to light bricks.

![Figure 4](image-url)

The average score of the ten question items on 50 respondents

The highest score in Q05 (88.0%) represents the respondent's willingness level to attend the workshop and develop light bricks as a construction material. Respondents show a high desire for light brick development. This also provides information that respondents show a fairly good acceptance perception of light bricks with a score of 67.55% (3.70 of 5).

4. Conclusion

The perception of 50 respondents has been assessed with 10 questions in the questionnaire. All respondents are survivors of the 2018 Palu Earthquake disaster who live in the Petobo temporary shelter (Huntara), Palu, Central Sulawesi, Indonesia. All question items in the questionnaire are intended to measure the perceptions of the survivors, represented by the respondent, regarding the acceptance of light bricks as the wall material of simple earthquake-resistant houses. The use of light materials aims to minimize the risk and impact of building failures in earthquake-prone areas such as Palu City.

The answers of the respondents contained in the questionnaire indicate that the majority of respondents gave a low score (average score: 37.5%) on the aspect of the introduction of light bricks. This means that most respondents have not received good information about light bricks. In the aspect of willingness to study and apply light brick as a construction material, almost all respondents gave a high score, with an average value of 88.0%. This indicates that the respondents actually have a positive perception of the acceptance of light bricks as a construction material, especially the walls of simple
houses with an average score of 67.55%. Therefore, knowledge of light bricks really needs to be given for its application in disaster-prone areas.

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Acknowledgements
The authors acknowledge the Ministry of Research and Technology/National Research and Innovation Agency for its support through the Community Partnership Program Grant No. 078/SP2H/PPM/DRPM/2021