Comparative Study on the Cost of Building Public House Construction Using Red Brick and Interlock Brick Building Material in the City of Banda Aceh

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Abstract. Red brick and interlocking brick are the building materials that are often used for wall installation work on houses construction. In the development of building materials technology and cost savings, interlocking brick can be alternative to replace red bricks. In Aceh Province, the use of interlocking bricks is less popular compared to other big cities in Indonesia. Interlocking brick is made from a mixture of clay, concrete sand and compacted cement and one of the environmentally friendly materials because it does not burn the process like red brick material. It is named interlocking brick because the installation method is locked together and it serves as a structural and partition wall of residential buildings. The aims of this study are to compare the cost of building a house in Banda Aceh City using red brick and interlock brick building materials. The data were obtained from interviews and questionnaires distributed to respondents who had built houses in Banda Aceh City. The results concluded that the house construction cost using interlock brick offer lower construction cost at comparable quality rather than using red brick.

1. Introduction

After the tsunami disaster in 2004, Aceh Province had been introduced to several building material replacements such as red brick that serves as a wall in house construction projects. One of which is called the interlocking brick. Interlocking brick was introduced to the community in Baitussalam Sub-district, Aceh Besar District, Aceh Province of Indonesia by an NGO’s during Aceh and Nias tsunami reconstruction period. This interlocking brick is known as elephant brick among the Aceh people because it sizes is bigger than the sizes of ordinary red brick. The elephant brick production tool called the Soeng Thai Model BP6 compactor was used, which is capable of producing elephant bricks with the size of 300 x 150 x 100 mm (12"x 6" x4") in 9 different types of elephant bricks by adding or reducing parts of the mold. The mixture of elephant brick material used in this industry is cement, clay, and sand with a ratio of 1: 1: 2. However, production is not continuous and only produced when there is demand from consumers. These caused due to lack of promotion and knowledge-sharing to quantify and verify the benefits for the community about the use and adoption of this model.
Interlocking brick is made from a mixture of cement, clay, sand, and water compacted and is one of the environmentally friendly materials because it does not burn the process like red brick material. Interlocking brick or also called Interlocking Compressed Earth Block (ICEB) is a mixture of cement and compacted soil [1]. It is said interlocking brick because the material that serves as a wall in this system has an interlock or locked arrangement between one brick with another.

Method of installation of elephant bricks that do not use mortar (a mixture of cement, water, and sand) are possible because the bricks are shaped with projecting parts, which fit exactly into depressions in the bricks placed above and are automatically aligned horizontally and vertically. This locked system reduces labor and waiting time consumes for mortar mixing and cement drying. In addition, the attractive outward appearance of interlock brick causing unnecessary plastering and painting works to be done. The sloof position on the foundation was replaced with interlocking brick and placing vertical reinforcement at an angle, sides opening for the door, windows, on the deviation and apart, that has a large enough area. The Installation continues just like regular brickwork but does not use mortar with the addition of horizontal reinforcement on the side of the doors, windows and every 4-block layer [2].

Interlocking brick has a compressive strength of 2.6 MPa or equivalent to 7800 kg/beam with a mutual lock system (interlock), so it can function as part of building structure [2]. The use of interlocking brick as structural can eliminate the cost of reinforced concrete work such as sloof, column and ring balk. Therefore, there is no cost needed for reinforced concrete material and formwork. Interlocking brick masonry has the propensity to provide affordable, sustainable construction around the world and relatively low cost [3, 4, 5, 6].

Red brick definition according to Indonesian National Standard Number SNI 15-2094-1991 is a solid red brick made from clay with or without a mixture of other ingredients, which are burned at a sufficiently hot temperature until it has water resistance when soaking and has a cross-sectional area of less than 15% of pieces cutting flat areas [7]. Red bricks are usually traded with thick or 5 cm high, 10 cm wide, 20-24 cm long and weight less than 3 kg/pcs. The raw material requires red brick wall works are sand and cement.

Several studies have been conducted to get the cost of labor wage per unit of public house construction, type 36 house in Banda Aceh City from preparatory work until finishing by the method of wage per house. A wall work using red brick building material in 2012 is Rp. 19.500.000 with a duration of 65 days to completed [8].

This research will find out whether the use of interlocking brick as structural and filler wall can offer lower cost when compared to red brick wall work. The study also tries to obtain a cost comparison in public houses construction in the City of Banda Aceh using red brick and interlocking brick building materials. Further research for such comparisons is still required by weighting each of the aspects of the review [9].

2. Methods
The research was conducted in Aceh Besar district because respondents, who are the producer of interlocking brick, is located. The data sampling from the city of Banda Aceh were selected because it was assumed that most of the public houses construction type-36 are built in this location. The subject of the research is the cost of building public house construction type-36 from preparatory work to finishing. While the object of the research is the cost of reinforced concrete work and walls using red brick and elephant brick building materials.

The data used in this study consists of primary and secondary data. Primary data are respondent's characteristic, requirement, material cost, labor cost, duration, workforce composition per house, and implementation method of both for red brick and interlocking brick. These primary data was obtained by visiting workshop, interviewing the producer and head of worker for both red brick and interlocking brick. The head of worker are who had experienced on building public house construction using interlocking brick and red brick building material. Data about the interlocking brick is compulsory to gather because it is not included in the list of material units and wages in the Regulation.
of Governor of Aceh No 72 of 2016 [10]. Methods of the guided interview are selected in collecting primary data. Guided interviews are interviews conducted by the interviewer by making complete and detailed inquiries [11]. The collection of primary data is conducted for a duration of 1-2 months by guiding and explain directly to respondents.

Secondary data in the form of DED (Detail Engineering Design) of public house construction (type-36) is used as a model for quantity of work. The data for material unit price and wage per unit was refer to the Aceh Governor Regulation Year 2016 (in section of Banda Aceh area) [10].

Data analysis was conducted by steps: (1) calculating the cost of each buildings of public house construction (type-36) that using red brick. The method of cost calculation uses Unit Price Analysis. The unit price analysis refers to the Regulation of the Minister of Public Works and Public Housing. 28/ PRT/M/2016 [12]; (2) analyzing the actual price of materials and labor wages for wall installation work and reinforced concrete that using interlocking brick; (3) calculating the cost of each buildings of public house construction (type-36) that using interlocking brick. The method of cost calculation is similar to red brick in the point one. The differences of both building type are on the material of wall and material of the reinforced concrete works which are using the analysis at point (1) and (3).

3. Result and Discussion

3.1. Analysis of the Project Situation

This research assumed public housing construction project will be developed in the city of Banda Aceh for wall work using red brick building material as alternative 1 (one) and using interlocking brick as alternative 2 (two). Type of the Public housing is Type-36 that consists of 1 living room, 2 bedrooms, 1 bathroom and 1 kitchen. The specification of building uses a continuous foundation, tiled floors, wooden frame and zinc tile for roofing. The descriptions of works for both alternatives are same, the exception for concrete work, walls works, plastering and painting works. Table 1 describes the differences of the job description for both alternatives. The alternative 1 (one) is using reinforced concrete for sloof, column, ring balk, with additional plastering and painting works. While alternative 2 (two) for sloof, column, and ring balk just need placing a plain steel in horizontal and vertical directions. The attractive outer appearance on interlocking brick allows without plastering works and painting works.

| Job description | Alternative 1 | Alternative 2 |
|-----------------|---------------|---------------|
| Concrete Reinforced Works |               | Uses interlocking brick, sloof, column and ring balk are replaced by placing plain steel in vertical and horizontal direction |
| 1. Sloof        | √             |               |
| 2. Column       | √             |               |
| 3, Ring Beam    | √             |               |
| Wall Works      |               | Using Interlocking Brick |
| 1. Brick Work 1: 2 | √             | X             |
| 2. Brick Work 1: 4 | √             | X             |
| 3. Plastering Work 1: 2 | √             |               |
| 4. Plastering Work 1: 4 | √             |               |
| Painting Work   | √             | X             |

3.2. Unit Price of Interlocking Brick Building Material

The price per unit of material, the type, and the interlocking brick function are obtained from the literature and the results of the interviews with the respondents. The requirement of unit quantity for interlocking brick material of building type 36 houses is obtained from the analysis of quantity that refer to DED drawing. The data can be seen in table 2 below.
Table 2. The unit price of interlocking brick material

| No. | Brick Type                | Interlocking Picture | Price (IDR) | Function                        | Requirement for type-36 house (piece) |
|-----|---------------------------|----------------------|-------------|---------------------------------|---------------------------------------|
| 1   | Building Block            |                      | 3.400       | General Wall                    | 3.297                                 |
| 2   | Building Block corner     |                      | 3.400       | Corner Wall                     | 553                                   |
| 3   | Building Block Channels   |                      | 3.400       | Horizontal Wall edification     | 744                                   |
| 4   | Block Pillar              |                      | 3.400       | Pillars / Columns               | 0                                     |
| 5   | Block Channel Angle       |                      | 3.400       | Horizontal Enlargement in Wall in Angle | 74                                     |
| 6   | Half Building Block       |                      | 1.800       | Junction Frame Not to Cut       | 340                                   |
| 7   | Half Channel Block        |                      | 1.800       | Horizontal Wall edification     | 72                                     |
| 8   | Half-Angle Block          |                      | 1.800       | Corner Wall                     | 82                                     |
| 9   | Half Channel Corner Block |                      | 1.800       | Horizontal Wall edification     | 82                                     |

The requirement of 1 m² wall works is 33,333-pieces of interlocking brick, 3.13 kg of Portland cement and 0.008 m³ of sand. Each holes in the interlocking brick will be poured with sand. These works do not require mortar that serves as specie. Requirement for 1 m vertical iron reinforced works are 0.888 kg of plain iron, 0.25 kg of Portland cement and 0.011 m³ of sand. Iron reinforced work on vertical direction serves as column and placed on the sides of the door and windows frames. Every column will be stick in hole of the interlocking brick with 4 pieces of iron and the other sides inserted 2 pieces of iron. For 1 m horizontal iron reinforced work requires 0.888 kg plain iron, 0.630 kg Portland cement and 0.0027 m³ of sand. Iron reinforced work on horizontal direction function as sloof and ring balk, in addition toward this direction iron reinforced works are placed on every 4-layer block of interlocking brick with 1 piece of iron steel with dia.10. The requirement coefficient of interlocking brick material can be seen in table 3 below.
Table 3. Material requirements of interlocking brick

| No. | Jobs Description                 | material      | Unit | Coefficient |
|-----|----------------------------------|---------------|------|-------------|
| 1.  | 1 m² interlocking brickwork      | Interlocking brick | piece | 33,333 |
|     |                                  | Portland cement | kg   | 3,130 |
|     |                                  | Sand           | m³   | 0,008 |
| 2.  | 1 m Vertical iron reinforced work| Plain iron     | kg   | 0,888 |
|     |                                  | Portland cement | kg   | 0,250 |
|     |                                  | Sand           | m³   | 0,0011 |
| 3.  | 1 m horizontal iron reinforced work | Plain Iron | kg   | 0,888 |
|     |                                  | Portland cement | kg   | 0,630 |
|     |                                  | Sand           | m³   | 0,0027 |

The quality of the initial design in the form of the reinforced concrete frame structure and red brick works as a filler is certainly safe if it is implemented in accordance with the existing Indonesian National Standard code requirements. For interlocking brick material as structural as well as filler, the wall is having no Indonesian National Standard code that could determine the criteria for safe implementation. Buildings that have been built in Aceh Province from 2007 to 2010 still use designs with horizontal reinforcement every 8-layers.

3.3. Composition and wages of labor

According to the respondents to build public house construction such as the model in this study for the red brick and interlocking brick wall work requires Foreman, head of workers and worker in 1 day with a ratio of:

- Alternative 1 composition 1 Foremen: 3 Head of Workers: 5 workers
- Alternative 2 compositions 1 Foreman: 2 Head of Workers: 3 workers

So, for 1 m² area the required labor is: 1/36 X 6 = 0,167. This value is converted into the foreman and worker indexes by dividing it. The Head of workers has a larger contribution compared to workers. The ratio 60:40 then is used to generate the index needs between the head of worker and worker. The worker then the 60:40 ratio is compared to the worker and the builder in their index needs. The result of requirement index analysis for interlocking brickwork for every 1 m² horizontal/vertical works is shown in table 4. In this analysis, the head of workers requirement index is assumed 5% of the foreman requirement index.

Table 4. Labor requirements of interlocking brick

| No. | Description                               | Labor         | Unit | Coefficient |
|-----|------------------------------------------|---------------|------|-------------|
| 1.  | 1 m² interlocking brickworks             | Workers       | P / day | 0,100 |
|     |                                          | Head of Workers | P / day | 0,067 |
|     |                                          | Foreman       | P / day | 0,005 |
| 2.  | 1 m vertical/horizontal reinforced works | Workers       | P / day | 0,100 |
|     |                                          | Head of Workers | P / day | 0,067 |
|     |                                          | Foreman       | P / day | 0,005 |

The wages for works in alternative 1 is calculated based on the List of price per unit provided by the Aceh Governor Regulation Year 2016 for the city of Banda Aceh, while for alternative 2, in particular, the interlocking brickwork is fro, interview results with the respondents. The comparison of wages per day can be seen in table 5 below.
Table 5. Comparison of labor wages per day

| No. | Type          | Wages per day (IDR) |
|-----|---------------|---------------------|
|     |               | Foreman     | Head of Workers | Workers   |
| 1   | Alternative 1 | 130.000,-     | 98.000,-        | 87.000,- |
| 2   | Alternative 2 | 200.000,-     | 125.000,-       | 100.000,-|

The difference in wages for both alternative are caused by the difference in actual wage. It is possible because the alternative 2 (two) is having additional skill on interlock brick and the number of worker are limited in availability that area. This constraint will affect the wages per day of workers which is higher compared to alternative 1 (one).

3.4. Comparison of Alternative Costs 1(one) and 2 (two)

This comparison utilized the Minister of Public Works and Public Housing No. 28 / PRT / M / 2016 regulation for calculation in of the unit price analysis of, except for interlocking brickworks, which used the result of coefficient need analysis based on the table below. In alternative 1 for red brick wall works the volume is 160, 58 m², the waged is IDR. 7,179,850, -, and the cost of materials is IDR.25,737,600,-. While the wall works using interlocking brick the volume is 163,93 m², wages is IDR. 3,652,524, - and the cost of material is IDR. 24,673,596. Table 6 below explains the cost comparison between alternatives 1(one) and 2 (two).

Table 6. Comparison of alternative costs 1 and 2

| No | Job description                  | Alternative Cost 1 (IDR) | Alternative Cost 2 (IDR) |
|----|----------------------------------|---------------------------|---------------------------|
| 1  | Preparatory work                 | 500.000,00                | 500.000,00                |
| 2  | Land Works                       | 3.467.642,66              | 3.467.642,66              |
| 3  | Foundation work continuously     | 12.690.198,77             | 12.690.198,77             |
| 4  | Reinforced concrete work (Sloof, Column, Ring Beam) | 29.329.071,79          |                              |
| 5  | Horizontal & Vertical Iron Works | 23.898.161,87             |                              |
| 6  | Pair Brick Works                 | 32.917.455                |                              |
| 7  | Plastering Work                  | 18.681.380,71             |                              |
| 8  | Pair Interlocking Brick Work     | 9.771.134,16              | 28.326.120                |
| 9  | Wall Painting work               | 1.500.000,00              | 1.500.000,00              |
| 10 | Frame Door/Window/Ventilation Painting Works | 16.444.592,76 | 16.444.592,76 |
| 11 | Frame and Door/Window/Ventilation Works | 16.444.592,76 | 16.444.592,76 |
| 12 | Floor and Ceramic Work           | 3.366.475,99              | 3.366.475,99              |
| 13 | Roof and Ceiling Work            | 29.548.479,33             | 29.548.479,33             |
| 14 | Sanitation Work                  | 4.160.000,00              | 4.160.000,00              |
| 15 | Mechanical and Electrical Work   | 2.685.000,00              | 2.685.000,00              |
| 16 | Other Miscellaneous Works        | 4.222.115,39              | 4.222.115,39              |

Total Cost (IDR) 169.280.000,- 130.800.000,00

In alternative 1 (one) the budget plan is IDR 169.280.000,- while in alternative 2 have a budget of IDR. 130.8 million, with the cost difference of IDR 38.480.000, - or there is a cost saving of 23% when using alternative 2. In alternative 1 the largest cost occurred in the reinforced concrete work in form of the formwork, iron and casting, while reinforced concrete work on alternative 2 is replaced with interlocking brick, where there is a hole that will be filled with plain iron with a diameter of 10 or D10, and in addition the horizontal and vertical direction is filled with a mixture of cement and sand.
The problems in this research have been answered, where building the public-house construction type-36 using interlocking brick is cheaper than using red brick. This outcome can be given to consumer, society, and public for consideration in selecting a substitute for red brick building material in for walls works used in Aceh Province.

4. Conclusion
Result of cost comparison for public houses (type-36) that are assumed to be built in Banda Aceh City using interlocking brick (elephant brick material) is cheaper than using the red brick material. Buildings that using interlocking brick (elephant bricks) in Banda Aceh from 2007 to 2010 have not collapsed and cracked despite being shaken by earthquakes several times. Research on the structural strength of elephant brick wall is underway at the Syiah Kuala University Building Materials and Structures Laboratory. Knowledge of elephant bricks to consumers will be provided by promoting the products through the event held in Aceh Province.

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