Analysis Palm Oil Midrib Fiber Brick Against Compressive Strength, Cost of Production and CO$_2$ Emissions

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Abstract. The palm oil midrib has not been utilized so it has the potential to become waste. If it allowed to accumulate more and more, in the dry state palm oil midrib are very flammable and can cause land fires that often occurs in Riau Province. Waste that often cause problems can still be utilized, for example in making fiber bricks. The purpose of this research was to calculate the compressive strength of fiber brick, cost of production and production of carbon dioxide (CO$_2$) emissions. The method used is descriptive method that prioritizes the type of quantitative research and uses an experimental approach with laboratory research and field survey to calculate the cost of production and calculation of CO$_2$ emissions. Result of this research is that the fiber from palm oil heap is better added to the production of brick because it raises the value of compressive strength and presses the cost of production and the low carbon emission. The conclusion obtained is the value of the compressive strength by 111.34 kg/cm$^2$; Cost of Production of a fiber brick is Rp 2,667.00 under the ordinary cost of production brick Rp 3,055.00; the production of CO$_2$ emissions is 0.00178 tons/m$^3$.

Keywords: brick; CO$_2$; emission; fiber.

1. Introduction

The palm oil midrib has not been utilized so it has the potential to become waste. If it allowed to accumulate more and more, in the dry state palm oil midrib are very flammable and can cause land fires that often occur in Riau Province. Waste that often cause problems can still be utilized, for example in making fiber bricks with an additional material of palm oil midrib fiber. The use of palm oil fiber on brick making [1]. The results of this study found that the addition of palm fiber as much as 1% of the weight of cement used can increase the value of compressive strength of brick and put the product on the quality I SNI 03-0349-1989. Palm oil midrib fiber derived from Kampar regency is better than two other locations, Dumai and Pekanbaru.
The potential of palm oil midrib waste in Riau Province is very large about 89,479,518.912 tons/year with 2,399,172 hectares of oil palm plantation [2] and can also adversely affect the incidence of forest and land fires in Riau Province. The results of [3] study found that forest and land fires in Siak Regency were more prevalent in non-forest areas where CO$_2$ emissions from burning in 2010 were estimated to be 107,260 tons/year from natural forests, 151,600 tons/year from plantations and peatlands 2,176 tons/year. CO$_2$ emissions from forest and land fires like these are very harmful to human health and other living things, causing environmental damage in relatively short time and more severe than illegal logging.

In order for palm oil midrib waste does not cause problems such as the triggers of land fires then the exploitation or utilization of such waste must be done. Thus, efforts to utilize palm oil midrib waste in brick making is one of the best works and can be implemented with simple technology and less capital that is simple technology for fiber separation and a small additional capital for fiber separation technology. Research on the use of palm fiber as an additional material in the manufacture of brickworks became the target of this study. The purpose of this study was to calculate the compressive strength of the fiber brick, the cost of production and the production of carbon dioxide (CO$_2$) emissions generated from the activity.

2. Research Method

The method used in this research is descriptive method that prioritizes the type of quantitative research and uses experimental approach with laboratory research, sampling in brick factories and field survey to calculate the cost of production and calculation of CO$_2$ emissions.

Jobmix design for making brick in this research is the brick with the quality number I with the comparison of basic material 1 cement compared by 5 sand. The required sample is 6 pieces for product strength test. The planned sample dimension is (20 x 10 x 6) cm. Normal jobmix is calculated to make 6 samples, test brick with additional palm stem fiber. The amount may vary according to the volume of fiber added.

In accordance with the results of [1] study which concluded that the addition of palm fiber as much as 1% of the weight of cement can increase the value of the compressive strength of the brick, the results can be considered in determining the design of the jobmix used. According to the needs of the sample, the fiber fiber jobmix used is:

- Cement : 2.72 kg
- Concrete sand : 8.15 kg
- Urug sand : 5.43 kg
- Water : 0.10 liter
- 1% Palm Oil Midrib Fiber : 0.03 kg

Jobmix that used is still considering on the results of [1] research before, the difference is not separating the origin of palm midrib fiber used as an added material in the manufacture of brick.

After the brick sample is completed, at 28 days brick’s age a compressive strength test is required which requires 6 test samples. The compressive strength test is performed using a cube sample so that each sample object is cut with dimensions (6 x 6 x 6) cm. The compressive strength test of fiber brick sample was performed in the laboratory using the formula:

\[
f_{c'} = \frac{P}{A}
\]

\[ (1) \]
The cost of production is calculated according to the jobmix used and the price of the appropriate materials at the time of the research. Cost of production obtained compared to similar market price of brick. With these comparisons can be determined which products are more profitable to produce. CO₂ emissions are counted when producing fiber brick as a comparison when waste is dumped and becomes the cause of forest fires. CO₂ emissions in the manufacture of fiber bricks are the result of burning of fuel oil required by the generator to move the press tool when printing bricks. The calculation to estimate CO₂ emissions from fiber brick producing activities is done using emission calculation formula referring to the Intergovernmental Panel on Climate Change [4]. The formula used is:

\[ \text{Emisi}_{\text{GRK}} = \Sigma A_i \times E_{fi} \times \text{NCV} \]

Information:
- Emisiₜₚₙ : Total CO₂ emissions (ton)
- Aₖ : Fuel oil consumption type (ton/year)
- Eₖ : Fuel emission factor type (kg/TJ)
- NCV : Net Calorific Value per mass or fuel value unit (TJ/kg)

In doing the calculations required some additional data that is the average data of fuel consumption and emission factor value. The emission factors of each type of fuel oil (BBM) vary and the emission factor values are listed in the following table.

| Table 1. Fuel emission factors |
|--------------------------------|
| No. | Fuel Type | Unit | CO₂ Emission Factor |
|-----|-----------|------|---------------------|
| 1   | Gasoline  | kg/TJ| 69,300              |
| 2   | Solar     | kg/TJ| 74,100              |
| 3   | Kerosene  | kg/TJ| 71,900              |

Source : Volume 2 energy IPCC. (2006)

Another data needed in CO₂ emission calculations is the value of the Net Calorific Value (NCV) of each type of fuel that still refers to [4]. These values are listed in the following table.

| Table 2. Net Calorific Value (NCV) by type |
|-------------------------------------------|
| No. | Fuel Type | Net Calorific Value (NCV) (TJ/Gg) | Net Calorific Value (NCV) (TJ/kg) |
|-----|-----------|---------------------------------|---------------------------------|
| 1   | Gasoline  | 44.3                            | 0.0000443                       |
| 2   | Solar     | 43.0                            | 0.0000430                       |
| 3   | Kerosene  | 43.8                            | 0.0000438                       |

Source : Volume 2 energy IPCC. (2006)

3. Result and discussion

3.1 Fiber Brick Compressive Strength Test Result

Fiber brick that made using quality I jobmix with the material ratio of 1 cement: 5 sand. Non-fiber bricks are made in comparison to fiber bricks, both in terms of quality (compressive strength) and quantity (amount generated by jobmix). The dimensions of the samples made are (20 x 10 x 6) cm, according to the smallest mold available in the brick making plant.

Tests on samples follow SNI 03-0349-1989 standard [5] with cube-shaped sample measurements. According to the standard, the sample of brick is cut into size (6 x 6 x 6) cm. Each sample only cut 1 cube which means each cube represents a sample. The test results of the compressive strength value of the product with the highest average on the 28 day sample age with the
Following comparison of normal brick 104.24 kg/cm$^2$ and fiber brick 111.34 kg/cm$^2$, both entered at SNI quality standard. The addition of palm fiber as much as 1% of the weight of cement can increase the average compressive strength value of 7.10 kg/cm$^2$. Thus it is stated that the manufacture of fiber bricks is better than normal brick production without using fiber. This is also reinforced by the results of [6] study which states that the addition of palm fiber bark is 1% better than the addition of 3% and 5% fiber. In addition of 3% and 5% fibers there is a decrease in compressive strength so that the composition is not recommended in the brick products.

Another study of the addition of fiber in brickwork using coco fiber. Examines the effect of addition using lime and coconut husk in brick making [7]. From the research, it was found that the addition of coconut husk 75 gram, the brick became light with the difference of weight average 1,055.6 gram compared to the weight of ordinary brick in market. Brick which has the highest compressive strength with the addition of 50 grams of coir with a value of 19.74 kg/cm$^2$. Thus, the addition of fiber in a brick with a certain portion can add a compressive strength value

### 3.2 Cost of Production

Cost of Production is the amount of costs that must be incurred to make a product with a certain unit. This study uses calculations with units of 1,000 pieces of products. The calculation of these costs includes the cost of materials used, labor wages, land rent, electricity and water, as well as the cost of depreciation of equipment used in production and others. Total Cost of Products (HPP) to produce 1,000 pieces of fiber bricks per day are:

| Item                        | Cost          |
|-----------------------------|---------------|
| a. Material Cost            | Rp 2,586,125.00 |
| b. Labor Cost               | Rp 325,000.00  |
| c. Water and Electricity Cost | Rp 12,000.00  |
| d. Depreciation Cost        | Rp 9,466.00   |
| e. Land Rent                | Rp 23,333.00  |
| f. Meal, Medication, and Bonus | Rp 99,500.00 |
| **Total**                   | **Rp 3,055,424.00** |

The Cost of Production of a brick for 1,000 pieces is Rp 3,055.00. The effect of the addition of palm oil midrib fiber in the mortar is the increase of the number of bricks produced. Based on the previous research job mix for 6 pieces of brick, if added palm fiber as much as 1% then the resulting brick sample will increase 1 piece to 7 pieces of brick. This should be taken into account in producing fiber bricks.

The main material that calculated for 1,000 pieces of brick. After the added fiber causes the number of bricks produced to be more 166 pieces so that it is generated into 1,166 pieces or 16.6% more than non-fiber bricks. With the increase of batako products have an impact on the increase of wage labor. The cost of labor can be increased by increasing the number of fiber bricks produced by Rp 325,000.00 x 16.6% = Rp 53,950.00, so the total cost for production calculation is Rp 3,055,424.00 + Rp 53,950.00 = Rp 3,109,374.00 with total production of fiber brick as much as 1,166 pieces. The Cost of Production of a fiber brick is Rp 2,667.00 cheaper than producing non-fiber bricks.

The market price of normal bricks (no added materials) in Pekanbaru is based on data from several places of sale of bricks as follows:

| Quality | Ratio of cement and sand | Price per piece |
|---------|--------------------------|-----------------|
| a. Quality 3 brick | 1 : 9 | Rp 2,000.00 |
| b. Quality 2 brick | 1 : 7 | Rp 3,000.00 |
| c. Quality 1 brick | 1 : 5 | Rp 4,000.00 |
Fiber bricks made with the main ingredient composition 1 : 5, placing the product on the quality I brick with greater strength than the normal non-fiber brick. The calculated cost of production of Rp 2,667.00 is still below the selling price of Rp 4,000.00 with the amount of profit \( ((4,000 - 2,667) / 2,667) \times 100\% ) = \pm 49.98\% . 

The advantage of producing fiber bricks is greater than producing normal bricks with the same quality. If the production of fiber brick for 1,000 pieces with cost of production is Rp 3,055.00 and the selling price is Rp 4,000, then the profit is obtained \( ((4,000 - 3,055) / 3,055) \times 100\% ) = \pm 30.93\% . 

Profit prediction is lower than \pm 49.98\%.

### 3.3 CO₂ Emission Production

Analysis of environmental impacts is carried out to determine how much CO₂ emissions are generated due to the production of brick blocks with the utilization of palm oil fiber. Based on the survey, it is known that the machine to produce fiber bricks using diesel fuel type. The average amount of diesel consumption used in one day to produce 1,000 pieces of bricks is 3 liters/day. Specific weight of diesel fuel is about 0.82 kg/liter - 0.86 kg/liter and in this study the specific gravity used is 0.84 kg/liter. The annual consumption of diesel is calculated to be 0.76 tonnes (3 liters/day x 300 days x 0.84 kg/liter): 1,000 kg/ton).

| Table 3. Estimated production of CO₂ emissions of fiber brick production |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Fuel Type       | Fuel Consumption per Year(ton) | CO₂ Emission Factor (kg/TJ) | Net Calorific Value (NCV) (TJ/kg) | CO₂ Afterburn (ton/year) |
|-----------------|--------------------------------|-----------------|-----------------|-----------------|
| Solar           | 0.76                           | 74,100          | 0.0000430       | 2.41            |

Source: Data analysis. (2018)

So the production of CO₂ emissions produced from the production machine of fiber brick maker in 1 m³ are:

\[ \text{Emission}_{GRK} = 2.41 \text{ ton/year : } ((0.30 \times 0.15 \times 0.10) \times 1,000 \text{ pcs x 300 days}) \]

\[ = 2.41 \text{ ton/year : } 1,350 \text{ m}^3/\text{year} \]

\[ = 0.00178 \text{ ton/m}^3 \]

Carbon emissions from the utilization of palm oil midrib waste as an added brick making material is much smaller than CO₂ emissions resulting from forest fires triggered by dry palm oil. Research into estimating of carbon emissions (CO₂) caused by forest and land fires in various types of land cover in Riau province year 2000-2009 [8]. From the research, it was found that the largest carbon dioxide emissions in 2000 were found in oil palm plantations of 72,312 tons CO₂/ha in peat soils, while in 2005 the largest carbon dioxide emissions were in open land areas of 795,376 tons CO₂/ha in peat soils, and carbon dioxide emissions the largest in 2009 was found in secondary forests of 441,572 tonnes of CO₂/ha in mineral soils.

Result of this research is that the palm oil midrib fiber is better added to the production of the brick because it increases the value of compressive strength and lowers the cost of production and low carbon emissions in producing the material.
4. Conclusion

The conclusions obtained from the production of fiber bricks against compressive strength, Cost of Production and CO$_2$ emission production are:

a. The average compressive strength value of palm oil midrib fiber brick is 111.34 kg/cm$^2$.

b. Cost of Production of a non-fiber brick Rp 3,055.00 and a fiber brick cost Rp 2,667.00.

c. Production of CO$_2$ emission resulting from fiber brick production machine in 1 m$^3$ are 0.00178 ton/m$^3$.

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