Utilizing Limestone Waste Factory Cement Using Fiber Palm Oil Fiber as Power Forming mush on Light Brick

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Abstract Lighting of limestone from PT Semen Padang Indarung street Padang has been done by variation of the addition of empty palm oil bunches to form pores derived from palm oil plantation waste in Pematang Siantar area with mixed percentage of 5%, 10%, 15%, 20% and 25%. The duration of drying varies from 1 week, 2 weeks, 3 weeks, 4 weeks and 5 weeks. Sintering temperatures are made varying from 700°C, 800°C and 900°C. The sample dimension is made in the form of beams and cylinders. The parameters tested were shrinkage of fire, density, porosity, water absorption, compressive strength and impact strength. The test results showed that optimum results on 85% of Limestone composition and 15% empty palm oil bunches with 4 weeks of sun drying and sintering temperature of 800°C. The results obtained are 0.56%, density 1.31 g/cm³, porosity 26.02%, water absorption 12%, compressive strength 96.39 Kgf/cm² and impact strength 26.46 Kgf/cm².

1. Introduction
Waste is the waste generated from an activity in the production process, whether household scale, agriculture, industry, mining and so on. Waste form can be gas, dust, liquid or solid. Among the various types of waste there are non-toxic and toxic wastes or hazardous wastes known as toxic and hazardous waste [1], [2].

Limestone as Cement Plant waste. Along with the increasing need for cement, the cement factories will also increase the waste. One of the cement plant waste is Limestone which currently has no high economic value because this waste is used as a pile of soil, for the material of the road hardening foundation layer viewed from the deflection values [3] and as a mixture of cement, which is actually less effective because the waste is very weak bonds it requires engineering materials to obtain new materials that have higher economic value.

Limestone material has been tested its chemical composition will change from the original form of limestone before the cement making process occurs. Oil Palm Empty Bunches as Plantation Waste. The waste generated in the palm oil industry varies among other shells of oil palm, empty palm oil bunches and so on. Oil palm empty bunches are useful in life such as organic fertilizer, as activated charcoal, pulp, particle board and fuel. A plant with a capacity of 30 tons of fresh fruit bunches per hour, as well as producing 30 tons of empty palm fruit bunches every day. The utilization of TKKS is still very limited by palm oil mills (PKS) in Indonesia still burns TKKS in incinerators (prohibited by government), open dumping, used as mulch in oil palm plantations, or processed into compost. TKKS is the largest waste of PKS but until now has not been utilized optimally. Oil palm empty bunches can be a conversion for the manufacture of useful fibers and has the potential to be a product that has
economic value added that is utilizing TKKS as the formation of pores on the manufacture of light bricks [4].

Limestone’s chemical composition can be seen as in table 1 below [5]. From the table of chemical elements it is seen that the percentage of SiO$_2$ is quite high and this is likely to form the cavity in the manufacture of light bricks.

| No | Ingredients | Composition (%) |
|----|-------------|-----------------|
| 1  | TiO$_2$     | 0.095           |
| 2  | MgO         | 2.291           |
| 3  | BaO         | 0.003           |
| 4  | Na$_2$O     | 2.634           |
| 5  | F$_2$O$_7$  | 0.754           |
| 6  | CaO         | 34.600          |
| 7  | K$_2$O      | 0.912           |
| 8  | SiO$_2$     | 36.700          |
| 9  | Al$_2$O$_3$ | 13.980          |
| 10 | LOI         | 8.050           |

The largest components in empty bunches of palm oil are cellulose (40%), Hemicellulose (24%), Lignin (21%) and Ash (15%). The flammable cellulose is expected to form pores and simultaneously as a binder [6], [7].

Bricks are one of the elements of building in the construction of buildings. Bricks made of clay/water clay mixed with or without added materials. The utilization of waste in brick making is one of the alternatives to reduce production cost. Waste utilized in this research is waste of palm factory that is TKKS. Utilization of TKKS is very advantageous because TKKS is easy to find. In terms of material improvements, on efforts to improve product quality by utilizing TKKS is also environmentally friendly [8]. Another benefit of mixing TKKS on brick making is that because TKKS can cause pores, the bricks can absorb the noise from outside the building so that staying in the building is more comfortable. Making bricks through several stages such as digging, processing, mixing, printing, sunning and sintering at high temperatures and conditioned to harden and not destroyed when immersed in water [9], [10].

Generally ceramics have a crystalline structure, which is stronger and more stable and typically has a three-dimensional network that has the same strong bond in all directions [11]. In the brick the crystal arrangement is not yet perfect, it is marked by the fragility of the brick material [12]. Bricks have the following properties: metal or non metal, having ionic and covalent bonds, are insulators, have a high elastic modulus. Based on the strength of the bricks are classified into three levels: first grade brick has a compressive strength of more than 100 Kg/cm$^2$, level II brick has a compressive strength between (80-100) Kg/cm$^2$ and level III brick with compressive strength (60-80) Kg/cm$^2$.

Rigid bricks or porous bricks are bricks that have less density than bricks in general [13][14]. Bricks are classified into normal brick (density 2.2 – 2.4) g/cm$^2$ and light brick (density 1.8 g/cm$^2$). Lightweight bricks are classified into 2 parts, namely: porous light brick and porous light brick. Porous light brick is a brick made to structure many pores and pore formers are usually mild aggregates such as pumice, diatome, siona, etc. mixed with a mixture of CaCO$_3$ gypsum sand cement and aluminum catalyst. Making lightweight bricks principally makes air cavities in the brick [15].
There are 3 kinds of ways to make porous bricks: by giving aggregate stuffing, blowing or filling air bubbles, and eliminating fine aggregates. By not using sand, brick contains many cavities so that the weight becomes low.

Fuel losses are the ratio of the length of the sample to the length of the sample before sintering. The grilled burn is calculated by the equation:

\[
\text{Shrinkage Burn (\%)} = \frac{L_o - L_t}{L_o} \times 100 \%
\]  

(1)

where \(L_o\) is length of sample before sintering (cm) and \(L_t\) is length of the sample after sintering (cm).

To calculate the porosity can be calculated by weighing the wet mass and dry mass of the sample with the analytical balance, then calculated by equation:

\[
\text{Porosity(\%)} = \frac{M_b - M_k}{M_k} \times 100 \%
\]  

(2)

where \(M_b\) is wet mass (g) and \(M_k\) is dry mass (g).

Density is the ratio between mass and sample volume, calculated by equation:

\[
\text{Density } \rho = \frac{m}{V}
\]  

(3)

where \(m\) is mass of sample (g), \(V\) is volume (cm\(^3\)) and \(\rho\) is density (g/cm\(^3\)).

The compressive strength is the ratio between the maximum load and the surface area, calculated by equation:

\[
\text{Compressive Strength } F_0 = \frac{P}{A}
\]  

(4)

where \(P\) is maximum load (Kgf), \(A\) = Surface area (cm\(^2\)) and \(F_0\) = compressive strength (Kgf/cm\(^2\)).

The sample to be measured is strongly measured by the width (d), height (b) and the distance between the pedestal (L), the impact strength value is calculated by the equation:

\[
\text{Value Impact } K = \frac{3GP}{2Ld^2}
\]  

(5)

where \(G\) is force breaks the specimen (Kgf), \(P\) is distance between pedestals (cm), \(L\) is width of specimen (cm) and \(K\) = impact strength.

2. Experimental Method
The materials used are Limestone is a cement factory waste taken from PT. Semen Padang road Indarung Padang and Oil palm empty bunch is an agricultural waste from Pematang Siantar.

Equipment used: 250 Kg / hour grinding device, sieve (200 mesh), analytical balance with 5000 g capacity, stirring place (cemented floor), stirring spoon, plastic protector, board mold (beam size 220 mm x 110 mm x 55 mm and cylindrical with diameter of 5.9 cm, height 5 cm and diameter 3.2 cm and height 5 cm), oven, tensile testing machine (UTM) and impact test machine (0-300) Joule.

The research includes the preparation of materials, mixing, printing, drying, sintering, conditioning and testing. The Limestone and TKKS ingredients were prepared in a powder state and mixed with percentage ratio (95:5, 90:10, 85:15, 80:20, 75:25)% and given enough water (<10%) and stirred until homogeneous and ready to print. After being molded for ± 4 hours in the shade and dried for (1, 2, 3, 4, 5) weeks then sintered with varying temperatures (700, 800, 900) °C. It is then conditioned for ± 24 hours and the sample is ready to be tested.

3. Result and Discussion
The fuel losses of one of the parameters that indicate the occurrence of sintering process is the shrinkage due to the microstructure change. The combustion losses are calculated using the equations and the results obtained in Table 2:
Table 2. Result of Wrinkle Fuel Test 4 Weeks

| Variation (%) | Temperature (°C) | Start length (cm) | End Legth (cm) | Shrinkage Burn (%) |
|---------------|------------------|-------------------|----------------|-------------------|
| 5             | 700              | 19.73             | 19.49          | 1.22              |
|               | 800              | 19.63             | 19.42          | 1.07              |
|               | 900              | 19.73             | 19.47          | 1.32              |
| 10            | 700              | 19.73             | 19.53          | 1.01              |
|               | 800              | 19.66             | 19.49          | 0.86              |
|               | 900              | 19.63             | 19.37          | 1.32              |
| 15            | 700              | 19.60             | 19.26          | 1.73              |
|               | 800              | 19.77             | 19.66          | 0.56              |
|               | 900              | 19.67             | 19.48          | 0.97              |
| 20            | 700              | 19.67             | 19.53          | 0.51              |
|               | 800              | 19.77             | 19.71          | 0.30              |
|               | 900              | 19.70             | 19.56          | 0.71              |
| 25            | 700              | 19.73             | 19.67          | 0.30              |
|               | 800              | 19.63             | 19.60          | 0.15              |
|               | 900              | 19.73             | 19.69          | 0.20              |

From the data obtained (table 2) a graph of the relation of shrinkage to TKKS as shown in Figure 1:

![Figure 1. Graph of Relation of Fuel Burn on TKKS Variation](image)

From the data obtained (table 2) a graph of the relation of shrinkage to TKKS as shown in Figure 1:

From the graph of the relation between shrinkage to the TKKS composition it is seen that the shrinkage of the soil decreases with the increase of the TKKS composition. Bricks with 4 weeks of drying in all mixed compositions at sintering temperature of 700°C of burning values between (0.34 - 1.22)%, at a temperature of 800°C of burning values between (0.27 - 1.08)% and at temperature sintering 900°C shrinkage rate between (0.48 - 1.30)%. Means at each sintering temperature, the shrinkage of burn well on the composition of the mixture starting 15%.

From the data obtained (table 3) we can graph the relationship of porosity and density to TKKS as shown in Figures 2 and 3:

![Figure 2. Graph of Porosity Relation to TKKS Variation](image)
From the graph shows that the higher the composition of TKKS, porosity is increasing. This is because TKKS is rich in cellulose, where cellulose is flammable, of course, when the cellulose sintering sample will burn and leave a cavity called pore. From the calculation results obtained porosity between (29.05 - 37.60) %.

![Graph of Density Relation to TKKS Variation](image)

**Figure 3.** Graph of Density Relation to TKKS Variation

From the graph shows that the higher the composition of TKKS the density decreases, this is because there are many cavities.

**Table 3. Porosity Test Results and Drying Density 4 Weeks**

| Variation (%) | Temperature (°C) | Wet Mass (g) | Dry Mass (g) | Porosity (%) | Density (g/cm³) |
|---------------|------------------|--------------|--------------|--------------|-----------------|
| 5             | 700              | 41.75        | 34.45        | 21.19        | 1.37            |
|               | 800              | 44.09        | 36.00        | 22.47        | 1.42            |
|               | 900              | 41.08        | 33.49        | 22.66        | 1.32            |
| 10            | 700              | 41.97        | 34.22        | 22.65        | 1.36            |
|               | 800              | 42.74        | 34.28        | 24.86        | 1.36            |
|               | 900              | 43.07        | 35.09        | 22.74        | 1.49            |
| 15            | 700              | 40.66        | 32.39        | 25.53        | 1.27            |
|               | 800              | 43.40        | 34.44        | 26.02        | 1.31            |
|               | 900              | 42.17        | 33.68        | 25.21        | 1.34            |
| 20            | 700              | 41.61        | 33.02        | 26.01        | 1.32            |
|               | 800              | 43.49        | 34.10        | 27.54        | 1.34            |
|               | 900              | 43.35        | 34.53        | 25.54        | 1.38            |
| 25            | 700              | 42.55        | 33.43        | 24.59        | 1.32            |
|               | 800              | 42.63        | 33.12        | 28.71        | 1.31            |
|               | 900              | 42.62        | 34.20        | 24.62        | 1.37            |
From the data obtained (table 4) we can graph the relationship of compressive strength to TKKS as shown in Figures 4:

Figure 4. Graph of Compressive Strength Relation to TKKS Variation

From the graph shows that the pressure decreases with the increase of TKKS composition. This is because the higher the composition of TKKS, the more pores are formed so that the more fragile the sample. From the calculation results obtained compressive strength between \((78.00 - 96.57)\) Kgf/cm\(^2\), means that bricks are classified in grade II and III bricks.
Table 5. The results of 4 weeks of heavy impact test

| Variation (%) | Temperature (°C) | Lift Distance (cm) | Breaking Style (Kgf) | Wide (cm) | Thick (cm) | Strong Impact (Kgf/cm²) |
|---------------|-----------------|--------------------|----------------------|-----------|------------|-------------------------|
| 5             | 700             | 15                 | 243                  | 9.6       | 4.5        | 28.13                   |
|               | 800             |                    | 252                  | 9.7       | 4.6        | 27.62                   |
|               | 900             |                    | 236                  | 9.5       | 4.7        | 25.30                   |
| 10            | 700             |                    | 238                  | 9.7       | 4.6        | 26.09                   |
|               | 800             |                    | 245                  | 9.5       | 4.8        | 25.19                   |
|               | 900             |                    | 229                  | 9.7       | 4.6        | 25.10                   |
| 15            | 700             |                    | 224                  | 9.5       | 4.5        | 26.20                   |
|               | 800             |                    | 231                  | 9.7       | 4.5        | 26.46                   |
|               | 900             |                    | 215                  | 9.7       | 4.6        | 23.57                   |
| 20            | 700             |                    | 201                  | 9.6       | 4.7        | 21.33                   |
|               | 800             |                    | 218                  | 9.6       | 4.6        | 24.15                   |
|               | 900             |                    | 190                  | 9.7       | 4.7        | 19.95                   |
| 25            | 700             |                    | 174                  | 9.7       | 4.7        | 18.27                   |
|               | 800             |                    | 192                  | 9.6       | 4.6        | 21.27                   |
|               | 900             |                    | 169                  | 9.7       | 4.6        | 18.53                   |

From the data obtained (table 5) we can graph the strong impact relationship to the TKKS as shown in figure 5:

![Figure 5. Graph of Strong Impact Relation to TKKS Variation](image)

From the graph shows that the pressure decreases with the increase of TKKS composition. This is because the higher the composition TKKS more and more pores are formed so that the more fragile the sample. From the calculation results obtained by compressive strength between (78.00 - 96.57) Kgf/cm², means the bricks are classified in second and third level bricks.

4. Conclusions
After doing research and sample test it can be concluded that: mixed composition between (15-20)% TKKS with 4 weeks drying time and sintering temperature 800°C. The results obtained are 0.55% shrinkage, 25.75% porosity, 1.37 g / cm³ density, 12% water absorption, 96.39 Kgf / cm² compressive strength and 26.46 Kgf / cm² impact strength. Overall value of compressive strength (78.85 - 96.41) Kgf / cm² and impact strength between (18.27 - 28.13) Kgf / cm². So all samples include the compliant brick force standard (SNI 15-2094-1991) ie grade III (60 - 80) Kgf / cm², level II (80 - 100Kgf / cm² and level I grades greater than Kgf / cm². Of all the density test samples ranged from (1.30 - 1.53) g/cm³ which means belonging to the type of light brick because the normal brick density is greater than 1.6 g/cm³.
References

[1] Sunu Pramudya, 2001, *Melindungi Lingkungan dengan Menerapkan ISO 14001* Gramedy Widiasarana Indonesia Jakarta

[2] Agustinus, Eko Tri Sumartriadi, 2007 *Prosiding Seminar Geoteknologi Kontribusi Ilmu Kebumian dalam Pembangunan Berkelanjutan* ISBN: 978-979-799-255-5 207

[3] Fajar Andi Baihaqi, Bambang Setiawan, R. Harya Danan Jaya H.L, 2017 *e-jurnal MATRIKS TEKNIK SIPIL* 5 831

[4] Rinaldry Sirait, 2016 *Warta konservasi Lahan Basah (WKLB)* 24 3

[5] Lanny Sapei, Karsono Samuel Padmawijaya, Agustina Sutejo, Liliana Theresia, 2015 *Jurnal Teknik Kimia* 9 38

[6] Muthia Egi Rahmasita, Moh. Farid, Hosta Ardhyanta, 2017 *JURNAL TEKNIK ITS*, 6 584

[7] Salmina, 2016 *Jurnal Spasial* 3 33

[8] Faisol Khoufi As, Dyong Novareza, Purnomo Budi Santoso, 2017 *Prosiding Seminar Nasional Multi Disiplin Ilmu & Call for Papers Unis Bank ke-3* ISBN: 9-789-7936-499-93 175

[9] Mastura, 2010 Pemanfaatan Abu Sekam Padi sebagai Campuran pada Pembuatan Batu Bata. *Skripsi* Medan FMIPA USU

[10] H. Lawrance, Van Vlac, 2004 *Elemen-elemen Ilmu dan Rekayasa Material* Erlangga Jakarta

[11] Adjat Sudrajat, Darsa Permana, Harta Haryadim, 1997 *Pusat Penelitian dan Pengembangan Teknologi Mineral PPPTM* ISBN:979-8641-04-3 200

[12] Darnoko, 1992 *Potensi Pemanfaatan Ugnoselulosa Kelapa Sawit Melalui Biokonversi*, Berita Penelitian Perkebunan 2 (2) Pusat Penelitian Perkebunan (RISPA), Medan