Physical and mechanical properties of clay sludge brick

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Abstract. There are approximately 450 water treatment plants in Malaysia which produce potable water to consumers. During coagulation process, huge volume of sludge was produced particularly when turbid water was treated. The main objective of this work is to study the physical and mechanical properties of clay sludge brick. In this research, the sludge from the water treatment plant was used as clay replacement material in brick production. Several design mixtures of sludge and clay with different moisture content were used to prepare the brick. These bricks were fired at two different temperature (500°C and 900°C) before being tested for its physical and mechanical properties. Result shows that the presence of sludge in brick would increase the water absorption capacity of the brick. The water absorption was increased from 5.5% to 51% when the 60% (w/w) of sludge was incorporated into the mix. In term of burning temperature, higher temperature would improve the physical and mechanical properties of the brick. Based on the results, sludge from the water treatment plant shows huge potential as clay replacement in brick making process. Recycling the sludge from water treatment plants could solve the sludge disposal problem face by most of the plant operators.

1. Introduction

Brick has been used widely as construction material to build house nor the high-rise building. There are several types of brick available in market such as engineering brick, interlocking brick, cement brick and fired clay brick. Fired clay brick is preferable brick due to its high strength and durability. In addition, fired clay also known as insulated material, heat resistance and soundproof. Clay brick is a product from the mixture of clayey soils and water. Since clayey soil cannot be replenish and available only in certain geological environment, researchers are looking for an alternative material to replace clayey soil without compromising the quality of the brick.

In Malaysia, sludge which being produced during the flocculation and coagulation process is gazetted as schedule waste by the Department of Environmental [1]. Hence, water treatment plant operators are required to dispose the sludge at secured landfill only. There is no doubt that this method can reduce the impact on the environment, but the high financial costs for transportation and disposal become a burden to the operator.
Sludge produced from other processes such as industrial effluent treatment and sewage treatment has been used to make brick as reported by Amsayazhi and Mohan [2] and Liew et. al [3] respectively. Sewage sludge contain more organic materials compared to sludge from water treatment plants. Due to high content of inorganic material such as silt and clay, sludge from water treatment plants has the potential to substitute the clayey soil in brick making. Besides silt and clay, sludge from the water treatment plant also contain alum, chlorine, sodium hydroxide or lime and fluoride. These chemical materials are added at any particular unit process during the treatment of raw water. Due to various compounds present inside the sludge, experimental works need to be carried out to study its suitability to replace clayey material in making bricks. Recycling the sludge will reduce the volume of sludge need to be transported and disposed in landfill. Hence, operators may lower their operational cost and at the same time protect the environment.

2. Methodology

2.1 Raw materials and chemicals
Sludge was taken from Arau Water Treatment Plant (Phase 4), Perlis. The sludge was sun dried, crashed, grinded and sieved. Sludge with diameter less than 300 µm was used in this study. Kaolin clay used in this study was purchased from Koalin (M) Sdn. Bhd.

2.2 Brick mix design
In this study, certain portion of clay was replaced by the sludge. Table 1 shows the mix design for the sludge brick preparation.

| Sample | Sludge | Kaolin |
|--------|--------|--------|
| Brick 1 | 100%   | 0%     |
| Brick 2 | 0%     | 100%   |
| Brick 3 | 80%    | 20%    |
| Brick 4 | 60%    | 40%    |
| Brick 5 | 40%    | 60%    |

2.3 Brick production
For each mixture, sludge and kaolin were mixed homogenously with 50% water contents. The mixtures were placed into the wooden mold as shown in figure 1 and placed under the sun to remove the excess water. Next, sun dried bricks were burned in a furnace at 900°C for two hours. After the burning process ended, bricks were taken out from the furnaces and cooled to ambient temperature.

Figure 1. The dimension of wooden mold for brick.
2.4 Brick testing
Brick samples were tested for its water absorption capacity and compared to Malaysia Standard MS 7.6: 1972 / British Standard BS 3921: 1985. In addition, the bricks were also undergone an efflorescence and shrinking test.

3. Result and discussion
Water absorption is a key parameter that establishes the strength and durability of the brick. Water absorption test was conducted to determine the amount of moisture content that the bricks absorbs. High percentage of water absorption indicate that large volume of pore present inside the brick. The maximum water absorption for brick is depend on its application. According to Malaysian Standard [4], the allowable water absorption for engineering brick Class A and Class B are 4% and 7% respectively. While there is no specific percentage of water absorption for load bearing bricks.

Table 2 shows the result for water absorption test for bricks burnt at 900°C for 2 hours. Result shows that brick which made of 100% clay recorded the lowest water absorption percentage (6%). The trend shows that brick with higher sludge content will absorb more water. Similar trend was observed by Juel et. al. [5] when they incorporated tannery sludge into the clay brick. It is also reported that when the bricks contain high percentage of sludge, the adhesiveness of the composition will decrease and the internal pores of the brick will increase [6]. As clay has a very tiny particle size compared to sludge, less void would present in the brick. As a result, less water being absorb during the test. Base on this data, the produced sludge brick is only suitable to be applied as a load bearing brick only.

In addition to increasing water absorption, the presence sludge created more pores hence reduced the density of brick. Table 3 show the density of bricks sample when different volume of sludge incorporated into the mix.

| Sample  | Sludge | Kaolin | Water Content During Mixing | Water Absorption |
|---------|--------|--------|-----------------------------|------------------|
| Brick 1a| 0%     | 100%   | 50%                         | 6                |
| Brick 2a| 20%    | 80%    |                             | 46               |
| Brick 3a| 40%    | 60%    |                             | 48               |
| Brick 4a| 60%    | 40%    |                             | 51               |

Through the efflorescence test, there was no white or crystal-like material present on the clay sludge brick surface. This show the kaolin clay and the water treatment sludge does not contain mineral salts which will give an effect to the brick. Same result was also reported by Elangovan & Subramanian [7]. The images of clay sludge brick after the efflorescence are shown in figure 2.
Figure 2. Sludge brick surface with no white or crystal-like material present

The dimensions of sludge brick before and after the burning process did not change when the volume of sludge used in the mix was between 0 – 40% of the total volume. Brick slightly shrunk when 60% of sludge present in the brick as shown in table 4.

Table 4. Bricks dimension before and after burning process.

| Sample | Sludge | Kaolin | Brick Dimension before burnt (mm) | Brick Dimension after burnt (mm) |
|--------|--------|--------|-----------------------------------|---------------------------------|
| Brick 1a | 0%     | 100%   | 70 x 140 x 70                     | 70 x 140 x 70                   |
| Brick 2a | 20%    | 80%    | 70 x 140 x 70                     | 70 x 140 x 70                   |
| Brick 3a | 40%    | 60%    | 70 x 140 x 70                     | 70 x 140 x 70                   |
| Brick 4a | 60%    | 40%    | 70 x 140 x 70                     | 69 x 140 x 69                   |

The inner structure of the bricks was investigated by cutting the bricks into half to observe for any defects. Black cores were noticed in some of the brick samples containing sludge as shown in figure 3. Presence of carbonaceous materials which were not fully oxidized is one of the reasons for black core. In addition, the presence of carbonaceous materials also lead to bloating problem as shown in figure 4.

Figure 3. Black core inside the clay-sludge brick.
4. Conclusion

The physical and mechanical characteristics of clay sludge brick highly dependent on the volume of sludge presence in the brick mixture. Higher sludge content would increase the water absorption capacity of the brick and also reduce its density. Based on results, clay sludge brick only applicable for load bearing brick only.

Reference

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