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Mechanical Properties of Masonry Brick Using Pineapple Fibre

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ABSTRACT

Sustainable development in the construction sector should be a participant in utilising the waste materials for the betterment of the industry. Turning waste materials into some application can contribute to the attainment and greening of the planet. In addition, research needs to be carried out to encourage the waste materials into useful building materials and economic. An idea of practicing environmental awareness should be adopted as opposed to simply considering the rapid development as the whole project objective. Inclusion of natural fibres in bricks has been proved to enhance strength development. This study investigates the pineapple fibres inclusion on the mechanical properties of masonry bricks. Experiments were conducted on masonry bricks with pineapple fibre percentage of 0, 0.25%, 0.50% and 0.75% to determine the compressive strength and water absorption of the bricks according to ASTM C67-17 Standard (2017). It was found that by incorporating an 0.5% of pineapple fibres into masonry bricks, the strength properties of the bricks were significantly improved. As a result, this research paper recommends using 0.5% of pineapple fibre as an optimal fibre content in masonry bricks reinforced with pineapple leaf fibre in the application in construction industry.

Keywords: Pineapple fibre; compressive strength; water absorption; masonry bricks

INTRODUCTION

For thousands of years, bricks have been playing a major role in design and construction. At present, due to its cost and negligible effects on the natural surroundings, more attention has been paid to the use of earth as a building material to produce rammed earth, adobe block or adobe brick (Tran et al. 2018). It is widely known that the production of fired clay brick has always been a very energy- and resource-intensive operation, despite its reliable workability and accessibility. Many researchers have suggested the use of several types of stabilisers, such as cement and lime in order to enhance the mechanical properties of the earthen material (Donkor & Obonyo 2016). Considering that cement and lime-based calcium silicate hydrate bricks are also not sustainable, the inclusion of natural fibre such as pineapple fibre, with the corresponding analysis of mechanical properties, is a preferred way to produce bricks. Natural fibres tend to be a good substitute, as they are easily available in a fibrous shape and can be harvested from plant leaves at very affordable prices (Indra Reddy et al. 2018).

As the compressive strength of the brick increases, the water absorption of the brick decreases (Logeswaran et al. 2020) Furthermore, this paper indicates that the focus of future brick-related research may be fibre-based masonry bricks, and the key focus is to enhance the mechanical strength of both fibre and masonry bricks. Masonry bricks are weak, brittle and most susceptible to natural disaster. There is a need for structural strengthening/retrofitting of masonry structures due to their vulnerability to damage in the event of earthquake and deterioration (Khaleel et al. 2020). The failure of the masonry walls during the earthquakes has contributed to the development of new reinforcement techniques. Pineapple fibre has been gradually introduced to substitute man-made fibres in building materials because of its renewable and biodegradable properties (Sarikanat & Demirci 2014). Pineapple also is easy to get as it is widely planted in

Pontian, Johor, Malaysia. Singha et al (2020) stated that pineapple fibre is currently extremely common among researchers because of its numerous advantages such as scaled and smooth morphology, low thickness, low weight as well as superior mechanical characteristics. The same researchers also said that the fibre has different values for mechanical testing, which include tensile strength, flexural strength, tearing and compressive strength, represents benchmarks relative to other naturally occurring fibres. Therefore, the focus of this paper is to minimise waste disposal in landfills by harvesting pineapple leaves. The objective of this paper is to investigate the mechanical properties of masonry brick with inclusion of pineapple fibres.

METHODOLOGY

The overall research flowchart of this research is shown in Figure 1.

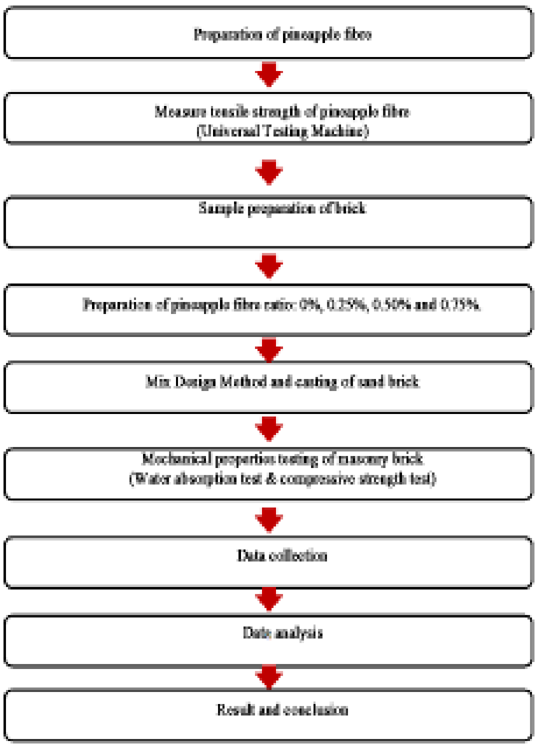

FIGURE 1. Overall research flow chat

Pineapple fibre used in this study will be obtained from MARDI Serdang. The pineapple leaf fibres will be extracted by first soaking and softening the leaves, proceeded by scraping to extract the cellulose fibres as shown in Figure 2. The fibres then allowed to dry naturally at room temperature. The fibres will be divided into lengths of 10 mm for use in the samples. The exact length is 1/10 of the length of the brick specimen (100 mm) selected to prevent interfering with the uniform mixing phase.

FIGURE 2. Pineapple leaf fibre

For the mix design between pineapple fibre and masonry brick, the different specimens were prepared as follows. First, Portland cement and sand was mixed in proportions of ratio 1:6 respectively while water and cement ratio are normally half of the cement. Water was added to form a paste of acceptable range of moisture content. For the specimen, PALF was added in proportions of 0.25%, 0.50% and 0.75%. The length of pineapple fibre that was used in this study is 10 mm since the fibre needed to be short and straight to allow rapid dispersal without clinging (Vodounon et al. 2018) .Hand shovel mixing was used to ensure that the fibres in the cement were well spread to avoid baling up. After mixing the cement with the fibres, water and sand were added. The mixing process took 15 minutes to ensure that all materials were uniformly distributed. After mixing, the components were poured into a manually stabilised soil block system to create the bricks. The size for brick sample is 225 x 105 x 72 mm. The bricks are then covered in plastic film to prevent fast drying and kept in a sheltered area for 7 days. The samples were stored in the open air for curing for 21 days. The samples of the bricks is shown in Figure 3.

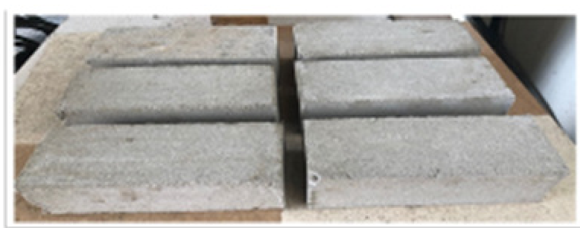

FIGURE 3. Pineapples bricks sample

A size total of 1 m^3 and 24 bricks specimen was produced according to the percentage of pineapple fibre as shown table 1.0.

TABLE 1. Composition of sample brick by percentage

Test	Cement (%)	Sand (%)	Pineapple Fibre (%)	Water (%)	Quantity
1	16.7	75.00	0.00	8.3	6
2	16.7	74.75	0.25	8.3	6
3	16.7	74.50	0.50	8.3	6
4	16.7	74.25	0.75	8.3	6

Compression test was conducted using Compressive Testing Machine and three identical samples was tested at the age of 28 curing days. The compressive strength test of the brick sample was carried out as per ASTM C67-17. Test brick specimens flatwise which the load shall be applied perpendicular to the bed surface of the brick with the brick in the stretcher position. Test structural clay tile specimens in a position such that the load is applied in the same direction as in service. Centre the specimens under the spherical upper bearing within 1.59 mm. Three specimens of brick were tested for each percentage of pineapple fibre. Testing of the compressive strength is shown in Figure 4.

Water absorption test is conducted on brick to determine the amount of moisture content absorbed by brick under extreme conditions according to ASTM C67-17. The specimen was first being dried and cooled. Each one of the specimens was weighed. The sample was immersed in a clean distilled water at 15.5ºC to 30ºC for 24 hours. Then, the specimen is removed, wiped off with a damp cloth and the weight is determined. The weighing of each specimen is completed within 5 min after removing it from the distilled water. An average of 3 sample is taken for each pineapple fibre percentage. The absorption of water for each specimen is calculated to the nearest 0.1% using Equation 1.0

FIGURE 4. Compressive strength test

$$Absorption, \% = \frac{100\,(W_s - W_d)}{W_d}$$

Where;
W_d = dry weight of the specimen
W_s = saturated weight of the specimen after submersion in cold water.

RESULTS AND DISCUSSION

Table 2 and Figure 5 shows the information of the compressive strength test results of the masonry brick with pineapple fibre addition. The results show that the performance of bricks with 0.75% of pineapple fibre content was higher than that with 0% of pineapple fibre. The compressive strength increased with pineapple fibre content, this results collarets with the finding by Logeswaran et al. (2020).

TABLE 2. Compressive strength test results

% PALF	Maximum Load (kN), W			Average (kN)	Average (N)	Area (mm^2), A	Compressive Strength, C=W/A (N/mm^2)
	Sample						
	1	2	3				
0.00	15.3	16.6	15.8	15.9	15900.0	23625	0.67
0.25	18.6	19.4	17.3	18.4	18433.3	23625	0.78
0.50	21.4	20.1	20.7	20.7	20733.3	23625	0.88
0.75	19.5	18.9	17.6	18.7	18666.7	23625	0.79

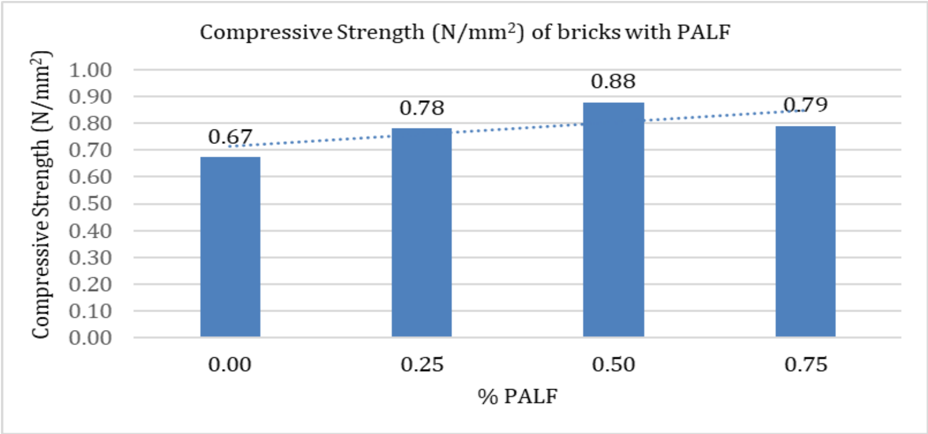

FIGURE 5. Compressive strength with respective PALF percentage

It was observed that the increase in compressive strength of bricks with pineapple fibre addition is due to the excellent adhesion between the fibre and the bricks' composition. The pineapple fibres can withstand the compressive strength load applied to bricks when the normal percentage of fibre in the bricks' composition is used. It is also possible that the increment is attributable to the increase in friction between the fibre and the bricks' composition. The association of fibres and masonry bricks helps to avoid the distribution of crack formation in the bricks, resulting in increased strength. However, as shown in Figure 5 the compressive strength of the bricks with the inclusion of fibre decreases 0.75% fibre content. This happens due to high fibre content in the bricks. Instead of reinforcing the bricks, the fibres began to stick together, forming a waste matrix within the bricks, causing the bricks to weaken. Vodounon et al. (2018) and Danso et al. (2015b) who also studied the properties of natural fibre in soil blocks, issued similar observations. Increased fibre content results in a decrease in strength as the fibres start to knot together. The failure mode of the masonry bricks under compressive loading is shown in Figure 6.

Figure 6 shows that the failure pattern of the bricks only indicates multiple fine cracks. This demonstrates that the failure was more gradual. This outcome is parallel with a research performed by Danso et al. (2015b). which also investigate the mechanical properties of blocks with natural fibres.

FIGURE 6. Failure mode of bricks specimen

The bricks were broken and scattered during removal from the compression testing machine, however some parts of the bricks were still bound together by the fibres when they were placed back in their original positions after the test. This indicates that the brick will experience a slow failure mode and will still be able to withstand the load for a period of time before it fails completely, compared to conventional bricks which will fail immediately.

As the percentage of fibres increases from 0.25% to 0.50%, the compressive strength also increases, giving optimum compressive strength at 0.50% fibre content. Additionally, fibres act as bridges or connections throughout brick failures, preventing the propagation of cracks from spreading farther. Therefore, fibre inclusion in bricks reduces the ability of the bricks to break and thus contributing to the improvement in structural strength. Figure 7 shows the pineapple fibre inclusion for 24-hour water absorption.

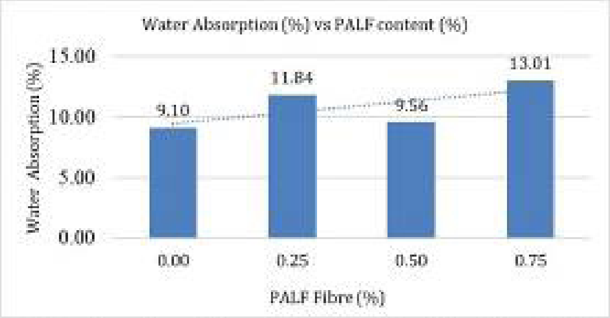

FIGURE 7. Water absorption test results

According to figure 7 the experiment demonstrates that bricks containing 0.75 % fibre absorb more water than bricks containing 0% fibre. As the amount of pineapple fibres increases from 0.25 % to 0.75 % the percentage of water absorbed increases as well, giving the optimal level of water absorption occurring at 0.50% fibre content.

CONCLUSIONS

This study shows that the water absorption is high with increased in fibre content. The fibre reinforced bricks demonstrated a high-water absorption rate, which was attributed to the hydrophilic fibre behaviour in the bricks. This means that soil bricks with a high fibre percentage may absorb more water during the heavy rain season, affecting certain engineering properties of the bricks. Thus, the optimum fibre content of masonry brick by using pineapple fibres for water absorption is made at 0.50% fibre content. Pineapple fibre bricks typically perform at their peak with an optimal content that achieves maximum performance. The research also concludes that increasing the fibre content of bricks improves their compressive strength in general, giving optimum compressive strength at 0.50%. As a result, natural fibre addition in bricks lowers the risk of the bricks to crack, adding value to increased strength properties. Improper fibre content will reduce the brick's strength and water absorption due to natural fibre properties in nature.

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DECLARATION OF COMPETING INTEREST

None.

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