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Thermal Performance of Pineapple Leaf Fibers as Admixture in Cement Brick

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Abstract: Sustainable development of the built environment in developing countries is a significant challenge in the 21st century. Pineapple leaf fibers are widely available worldwide as agricultural waste from pineapple cultivation. Thus, an innovation by incorporating the pineapple leaf fibers into concrete has been produced. The aim of this innovation is to study the characteristics of pineapple leaf fiber as intermixture in the cement brick, the optimum mix ratio of pineapple leaf fiber in the cement brick. In order to find the optimum mix design, the focus is on the use pineapple leaf fibers as intermixture in cement brick with different percentages that 0% and 2%, produced with dimensions of 50mm x 50mm x 50mm. The samples were tested for compressive strength test at different age of curing, which was 7, 14, and 28 days. Based on the results, it shows that the strength of concrete which contains pineapple leaf fibers is increased as the number of curing days increased. The research results show that the optimum mix design for tests is 2% pineapple leaf fiber test showed a good result of 16.90 N/mm2 where it was higher compared to the control sample of 14.15 N/mm2 at a curing age of 28 days. In other words, pineapple leaf fiber is suitable to use as intermixture in cement brick and applicable in the construction industry.

Keywords: Sustainable Development, Pineapple Leaf Fibers, Strength

1. Introduction

In Malaysia, natural fibre, known as biofiber, is one of the main agricultural biomasses that contributes to the Malaysian economy. A wide area of oil palm, banana and pineapple plantations of 5.85 million hectares, 35.15 thousand hectares and 13.03 thousand hectares, respectively, can yield large amounts of cellulose and non-cellulose raw materials during harvesting. [1] Pineapple leaves are one of the abundant waste items in the agricultural sector that are widely grown in Malaysia and Asia. [6] The natural fibres are regularly used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also improve the permeability of concrete and thus reduce water bleeding.

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Any forms of natural fibres add to the increased damage, abrasion and fracturing of cement bricks. Latest study has shown that the use of natural fibre in cement bricks has a small effect on the resistance of the materials.

Since thermal insulator is an important aspect in home construction in the west, builders are searching ways other than the conventional method to insulate the walls of their homes to make their house much cooler and comfortable during summer without spending much money on air conditioning [2]. The same principle can be used in Malaysia whereas this country also experience hot climate with high humidity. With the increasing awareness on global warming and its impact towards increasing temperature, it is expected that the weather that we experience now will gradually change [3].

As a result, most of the people who live in the city choose for air conditioner to be put in their house in order to cool the interior of the house. Although there is plenty energy efficient air conditioner in the market, not all people can afford to buy one and have to depend on natural ventilation. Therefore, using thermal insulation materials in cement brick construction can decrease the rate of heat transfer through the building envelope from outside to inside during the summer and from inside to outside during the winter. Thermal insulation will also lower the air-conditioning load during the summer and the heating load during the winter, which in turn lowers the energy demand for the building and the consumption of electricity.

2. Materials and Methods

2.1 Materials

The materials used in this study were cement, sand, pineapple leaf fibers and water. Previous studies have shown that adequate surface treatments allow for mechanical bonding and thus enhance matrix-reinforcement interaction. Cellulosic fiber alkali treatment is the usual process of manufacturing high-quality fibres. Alkali therapy increases the conformity of the fibre matrix due to the elimination of natural and artificial impurities. As a result, the development of rough surface topography and aspect ratio enhancement give enhanced fiber-matrix interface adhesion and an improvement in mechanical properties [4].

2.2 Characteristics of Pineapple leaf Fibers

The high content of PALF cellulose will generate strong fibers [5] PALF that was slightly better than the other biofibers. Table 1 show the composition of studied pineapple leaf fibers. Cellulose content in PALF is higher than in kenaf, jute and bagasse, as pineapple leaves have high basic strength and hardness, likely due to the comparatively higher weight of the fruit that they need to preserve [6].

Table 1: Composition of pineapple leaf fibers [7]

Constituents	Percentage (%)
Cellulose	70 – 82
Hemicelluloses	18
Lignin	5 – 12.7
Ash	0.7 – 0.9
Pectin	1.1

2.3 Pineapple Leaf Fibers Chemical Treatment

Alkali treatment increases the surface roughness resulting in better mechanical bonding and the amount of cellulose visible to the cloth surface. This increases the number of possible reaction sites and improves the wetting of the fabric. Possible reactions of fibre and Sodium Hydroxide (NaOH) are seen as, Fiber–OH + NaOH → Fiber–O–Na+ + H2O.

The pineapple leaf fibres were cleaned and soaked in 6% NaOH solution for 2 hours at room temperature as seen in Figure 1 and then washed thoroughly in a clean water tank to eliminate non-reacted alkali until the fibres were alkali free. They were then rinsed under running water and filtered. The filtered fibres were then dried in the oven at 80 °C for 24 hours [9].

Figure 1: Submerging pineapple leaf fibers in naoh solution

2.4 Specimens Preparation

The table 2 show the additional percentage of pineapple leaf fiber. The mixed ratio that will be used in this study is 1:3, which represents cement and sand. The water cement ratio of 0.45 per cent is used to manufacture cement bricks. Pineapple leaf fiber is the admixture to the cement brick. However, the production of cement brick has different percentages that 0% and 2%, which are 0% as a control concrete brick.

Table 2: Additional percentage of pineapple leaf fibers

Proportion			
Cement	Sand	Pineapple Leaf Fiber (%)	Water-Cement Ratio
1	3	0	0.45
1	3	2	0.45

2.5 Production Process of Pineapple Leaf Cement Brick

The amount of cement, sand and pineapple leaf fibers that required will be weighed, and the water needed will be measured by using a measuring cylinder. A batch of different materials is put into the large mixer, and mixing procedure starts. Big blades blend all the materials in the mixer, and water is added little by little to the mixture to ensure the mix is thorough.

Then, the mixture will be transferred into the block, forming mould on pallets right after the interior surface of the mould is oiled with grease. This avoids the mix from sticking to the mould. Each batch must be compacted in the mould provided, and levelling of the mix needs to be done to ensure the upper surface of the block is smooth as shown in Figure 2.

Blocks should be protected and kept safe from rain with plastic sheets during the first day and from the drying effect of the sun and the wind until the curing begins after 24 hours of production, the brick must be removed from the mould and placed in the stacking area, ready to be curing. Blocks will be curing for at least 7 days, 14 days and 28 days, and each day will be tested with laboratory tests such as compressive strength test.

Figure 2: Casting of cement brick in mould

2.5 Curing

The curing process is designed to promote the hydration of cement, the development of strength and the durability of concrete. A part from that, it is therefore important to monitor the flow of temperature and humidity from and into concrete. The curing times depends on the temperature of the concrete. Concrete should be curing for at least three days, and preferably for a week, it is placed. In this study, the most effective of all known curing methods for prevention of mix water evaporation is air curing process. The other techniques are water retaining method and steam curing.

2.6 Compressive Strength Test

This concrete is poured into a mould with a dimension of 50mm x 50mm x 50mm and is properly tempered so as not to have any voids. Within 24 hours, these moulds shall be removed and the specimens examined shall be air-curing until they are tested at 7 days, 14 days and 28 days of age. The test method consists of applying a compressive axial load to the cement brick at a rate within the specified range before the compressive strength of the bricks has collapsed.

3. Results and Discussion

The results of the compression strength test of all samples are shown in Table 3 and Figure 3. For the 7 days of age of curing, the compression strength for control cement brick was 9.89 N/mm². The compression strength was drastically dropped to 3.20 N/mm² for cement brick with percentage 2% of pineapple leaf fibers. The result was followed by 13.05 N/mm² which was slightly increased for control cement brick at the 14 days of curing. Then, the compression strength for cement brick with percentage 2% of pineapple leaf fibers was slightly dropped to 9.90 N/mm².

As expected, the result of compression strength for cement brick with 28 days of curing was a bit different from both 7 and 14 days. Cement brick with a proportion of 2% of pineapple leaf fibers was higher than the percentage with compression strength 16.9 N/mm² compare the control brick was 14.15 N/mm2.

After the result of compression strength for all cement bricks were obtained, it can be concluded that the compression strength was also increased as the number of curing days increased. The good compression strength for 7 and 14 days of curing was the cement brick with percentage 2% of pineapple fibers as intermixture. Meanwhile, for the age of curing of 28 days, the good compression strength was the cement brick with percentage of 2%. According to Uddin [9] The brick with the highest proportion of natural fibre has the highest compressive strength. In end, the workability of fibres and concrete was strong as the proportion of fibres increased to 2% and had the maximum compression strength.

Table 3: Data of compressive strength test

Curing period (days)	Percentage	
	0%	2%
7	9.89 N/mm2	3.20 N/mm2
14	13.05 N/mm2	9.90 N/mm2
28	14.15 N/mm2	16.90 N/mm2

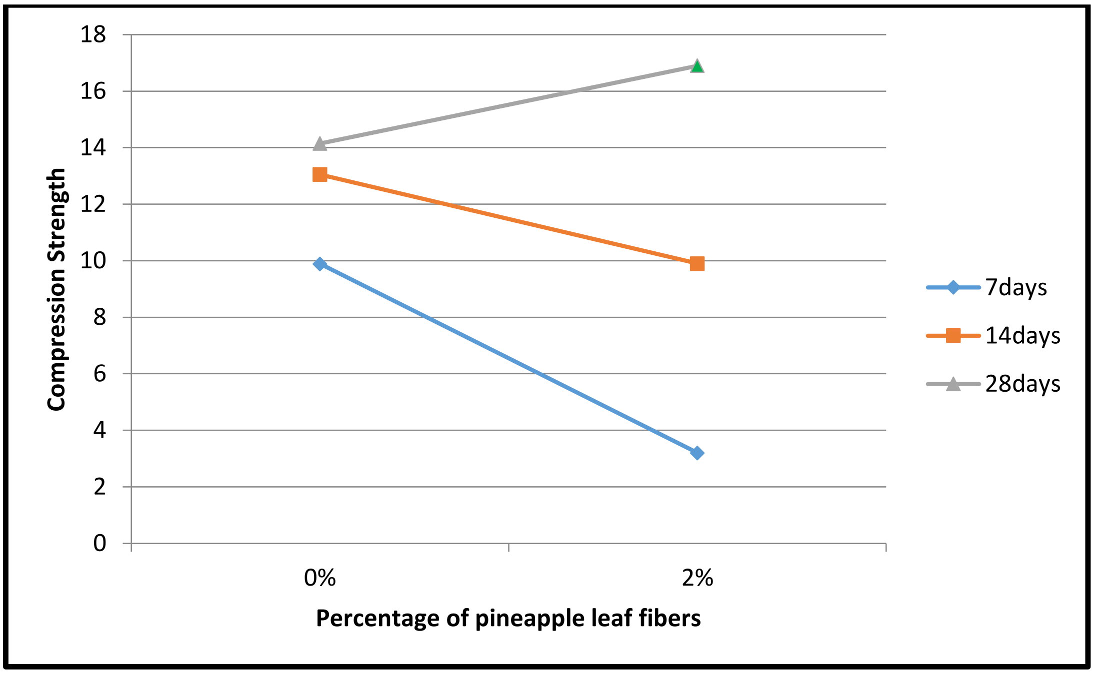

Figure 3: **Compressive strength against percentage of pineapple leaf fiber**

4. Conclusion

The chemical properties of pineapple leaf fibers and cement is mutually compatible and has the capacity to produce cement blocks. The cement brick with a percentage of 2% of pineapple leaf fibers gives the highest value of compressive strength 16.90 N/mm2 where it was higher compared to the control sample of 14.15 N/mm2 at a curing age of 28 days. This study could not determine the intersection value is consistent with masonry cement ASTM C207 Category because insufficient data.

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