Progress in Engineering Application and Technology Vol. 3 No. 1 (2022) 306–316

PEAT

Homepage: http://penerbit.uthm.edu.my/ojs/index.php/peat
e-ISSN : 2773-5305

Study on Mechanical Properties of Concrete Contain Untreated and Treated Pineapple Leaf Fiber

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DOI: https://doi.org/10.30880/peat.2022.03.01.032
Received 16 January 2022; Accepted 11 April 2022; Available online 25 June 2022

Abstract: Waste material assimilation into concrete has recently become a trend, making this concrete competitive with normal composite concrete. This has indirectly succeeded in generating new solutions to address resource exploitation in the building sector, as well as lowering agricultural waste in landfills that better manage the environment. Agricultural waste may be utilized as a fiber, additive, or filler in concrete mixtures. This study employed pineapple leaf fiber as an alternative steel source in concrete mixtures to increase strength. This research evaluates the tensile strength of PALFs treated with various sodium hydroxide solutions (5.00 %, 7.00 %, and 10.00 %), as well as untreated PALFs for use as concrete additives. Each specimen of this percentage underwent a tensile strength test using a Universal Testing Machine (UTM). It is used to establish the ideal ratio of PALF mixed in concrete to determine the tensile and compressive strength to be compared with normal concrete. The characteristics studied are compressive strength as well as tensile strength in PLAF and concrete. PALF acts as an additive with percentages of 0.10 %, 0.20 %, and 0.30 % mixed into the concrete according to the volume weight of the material used to produce the concrete. Then the mixture is poured into a cube mould and a cylinder for the mixture, which results in 24 cubes and 12 cylinders. This specimen underwent laboratory tests for 7 and 28 days for the cubes and cylinders on the 28th day. The tests carried out on the cubes are compressive strength tests as well as tensile strength tests carried out on cylinders. The cube specimens treated with 0.20 % PALF had the maximum compressive strength (30.05 MPa) and tensile strength (2.70 MPa) on the 28th day. Finally, using treated PALF may assist boost compressive and tensile strength beyond regular concrete.

Keywords: Pineapple Leaf Fiber (PALF), Concrete, Untreated, Treated

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1. Introduction

The construction industry is one of the main sources of the country's economic development, which covers various construction sectors, including buildings. The main aspect of construction is safety for the community as well as the building so that it can function during the service period. Building development uses concrete as the main material because it has strengths and advantages in terms of economy, workability, and durability. Concrete is produced from a mixture according to a certain ratio of cement, sand, coarse aggregates, and water. It has compressive properties but low tensile strength [1], as well as weakness towards bending as well as brittle properties [2]. In order to improve the properties of conventional concrete and control the brittleness of concrete, the use of fibre as an additive in the concrete mix [1]. This study, focuses on the grade and type of normal concrete because it is often used in construction and has high compressive stress and weak at tensile.

Fiber can be obtained from natural plants through the agricultural process. Through the agricultural process, will produce agricultural waste covering 998 million tonnes of agricultural waste produced annually and 1.2 million tonnes of agricultural waste disposed of in landfills throughout Malaysia each year [3]. Due to that, the alternative to control this agricultural waste is to recycle it to be part of the material that can be used as an additive or substitute in construction. From these alternatives, it is possible to minimise the agricultural waste generated each year. Fiber from the pineapple plant or known as Pineapple Leaf Fiber (PALF) is the best choice to use because it has remarkable mechanical properties [4]. The function of PALF is not as a substitute for steel as it is an organic material but it works in improving the working standards on concrete. The use of PALF as an additive in concrete mixes can have an impact on increasing the density and tensile which allows to reduce cracking on the concrete surface. Moreover, it is derived from low cost and bio-degradability which can improve the purity [1].

The use of PALFs produced from natural fibres has disadvantages in terms of the balance between fibres and metrics as well as high relative moisture absorption rates [5]. Therefore, to ensure that the use of PALF can be used to control the brittle properties, the evaluator of the physical surface properties of PALF should be emphasized. This is because the fibre-based properties of organic materials such as PALF will be affected by their effectiveness as a reinforcing material in concrete composites. To ensure PALF can be used as a reinforcement in concrete composites, the use of chemical treatment is required. In this study, the alkali treatment used different percentage ratios of sodium hydroxide solution, namely (5.00 %, 7.00 %, and 10.00 %) to modify the properties of the surface of PALF before use in concrete. Through this treatment process, the PLAF produced from this treatment will be analysed using a tensile strength test to assess the increase in bond strength between the PALF surface and the highest matrix depending on what percentage of solution is used. Through the PALF, produced from the high tensile value of the sodium hydroxide (NaOH) solution, a 30-33 mm long and 0.02-diameter sample will be formed to be used as the main sample of additives in this study. This sample will be used according to each mixture ratio (0.10 %, 0.20 %, and 0.30 %).

The purpose of this study was to evaluate the physical, chemical, and mechanical properties of treated and untreated PALF that are appropriately added to concrete. In addition, evaluate the effectiveness of the mechanical properties of concrete with treated and untreated PALF against tensile strength. As well as studying the optimum ratio of PALF in concrete mixes, which can be determined through a series of laboratory tests on concrete on tensile strength compared to conventional concrete that uses two different types of concrete sizes, namely cube and cylinder,

1.1 PALF Additives in Concrete

An additive is a type of material other than cement, aggregate, and water that is mixed into concrete during mixing. This is to further improve or modify the working standards of the concrete. Moreover, the quantity of additives included in the concrete mix should not exceed 2.00 % of the total cement because if the addition of additives exceeds the cement, it will affect the strength of the concrete [6]. In this study, we focus on the type of additive accelerator that uses organic fibre from pineapple leaves to increase the workability, strength, and hardening of concrete.

2. Materials and Methods

Materials and methods are used to grade physical properties, evaluate mechanical properties, and study the optimum ratios for the tensile strength of untreated and treated PALF mixtures against concrete. This section briefly discusses the materials and method used in the process performed in this study.

2.1 Materials

A short summary of the ingredients used in the production of concrete, as well as the PALF that has been processed for use as an addition in concrete mixtures.

- Cement

Ordinary Portland Cement (OPC) type 1 consists of concrete of about 7.00 %–14.00 % complying with MS 522: Part 1: 2003 has been used. Cement is an important material and the most expensive material for binding aggregates. There are many types of cement used to produce concrete.

- Coarse aggregate

Aggregate is essential in giving volume to the concrete, reducing shrinkage, and affecting the economy. In this experiment, the combination of crushed gravel with the size of 10,14 and 20 mm was used complying to BS 5328: 1991 [7]. The coarse aggregate had been clean from dust or dry crushed granite before used for mixing.

- Fine Aggregate

The fine aggregate (typically natural sand) is a material that passed a No. 4 sieve: the sieve with four openings per linear inch. It used as a filler and known as the sand that complies with coarse, medium or fine grading requirement. In this project, the combination of size from 2.36 mm to 300 μm was used to combine with coarse aggregate, coconut shell, cement and water.

- Water

The water used for mixing should be fresh and free of any organic or harmful solutions that will lead to deterioration of the properties of the mortar.

- Pineapple Leaf Fiber (PALF)

Pineapple leaf fiber composites play an important role as strengthening agents between composite materials (such as mortar, cement, and concrete) as well as having great additional potential as supports in thermoplastic composites [4]. PALF is used as an additive in concrete mixes. This is because PALF contains hydrophilic properties as well as high specification stiffness and strength due to its high cellulose content [4]. There are chemical elements contained in PALF, such as polysaccharide and lignin in multicellular lignocellulose fibers [8]. Pineapple leaves have fibre made up of a vascular package system taken up in bunches. The PALF used in this study was the PALF that had been treated with the percentage of NaOH that reached the highest stress. PALF uses the Yankee pineapple tree because it has a tensile strength of 390 MPa compared to the leaves of other pineapple trees [9] shown in Figure 1. PALF processing from mechanical peeling on the entire leaf attachment through the process of dissociation from the skin surface of pineapple leaves after the corrosion process.

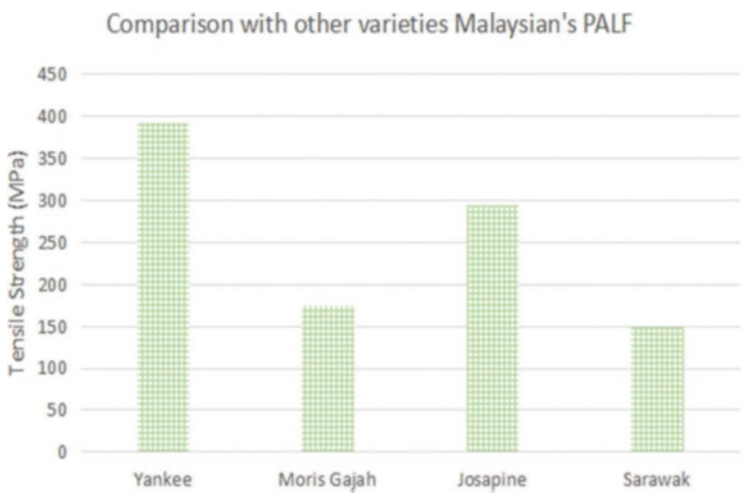

Figure 1: A comparison of the tensile strength of PALF types is available in Malaysia [9]

- Sodium Hydroxide (NaOH)

Sodium Hydroxide (NaOH), also known as alkaline caustic soda, is part of the caustic metal base. This material is hygroscopic and easily absorbs carbon dioxide from the air, so it should be stored in an airtight area. This material is also easily soluble in water. In addition, sodium hydroxide (NaOH) reacts strongly with ethanol and methanol. In this study, the use of sodium hydroxide (NaOH) as the main ingredient to treat PALF was achieved through several concentrations of NaOH-like solutions (5.00 %, 7.00 %, and 10.00 %). Several researchers have previously used sodium hydroxide (NaOH) as a chemical treatment on fibers, known as alkali treatment.

2.2 Methods

The method performed on the treatment of PALF as well as the procedure of producing concrete specimens by adding the treated PALF because of the peritus value of the high stress results 2.3 Equations

- PALF Alkaline Treatment

The procedure for partial processing of PALF was treated by using alkali treatment with different percentages of NaOH solution (5.00 %, 7.00 %, and 10.00 %) to evaluate the characteristics and properties of PALF against stress. Figure 2 is based on previous literature reviewers. [8], [11], and [12] and guidelines in the laboratory

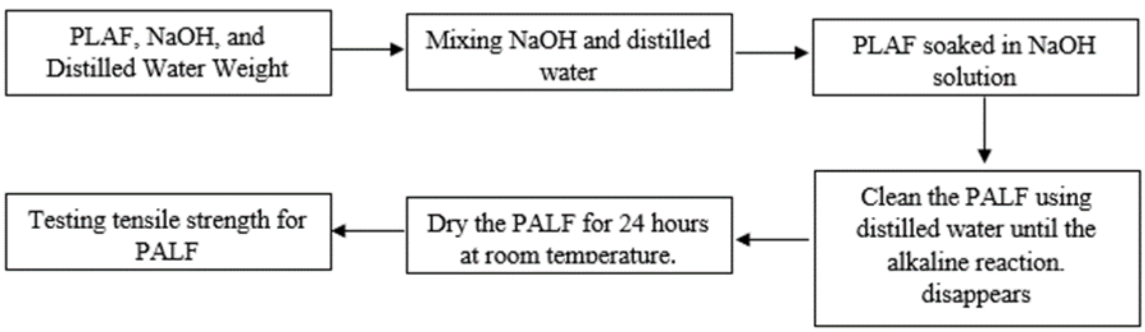

Figure 2: The PALF treatment procedure using NaOH

Alkaline treatment is performed to chemically modify the surface of PALF and increase the surface roughness, to reduce the hydrophilic content, as well as produce better mechanical bonding and reduce the amount of cellulose visible on the surface of PALF. This increases the number of possible reaction sites and improves the physical properties of PALF. The possible reaction of fiber and sodium hydroxide (NaOH) is seen as [11],

$$\text{Fiber} - \text{OH} + \text{NaOH} \rightarrow \text{Fiber} - \text{O} - \text{Na}^{+} + \text{H}_2\text{O} \quad Eq.1$$

PALF was cleaned and soaked for 1 h in different percentages of NaOH solution, i.e., (5.00 %, 7.00 %, and 10.00 %) were used to measure the weight of NaOH used as shown in Table 1 in this study. Then, the PALF is cleaned using distilled water to remove unreacted alkali until the fibers are free of alkali. The cleaned fibers were dried for 24 hours at room temperature.

Table 1: Weight of Sodium Hydroxide (NaOH) and Distilled Water Used for Testing PALF Improvement Treatment

Percentage	Weight of Sodium Hydroxide (NaOH) (gram)	Weight of Distilled Water (gram)	Total (gram)
5%	50	950	1000
7%	70	930	1000
10%	10	900	1000

- Production of Concrete Specimen

The process of producing concrete specimens for ordinary concrete as well as concrete containing PALF treated with a percentage of solution having high tensile strength through tensile strength tests. Figure 3 is derived from a previous literature review such as [1]. [5] and [13], as well as laboratory guidelines

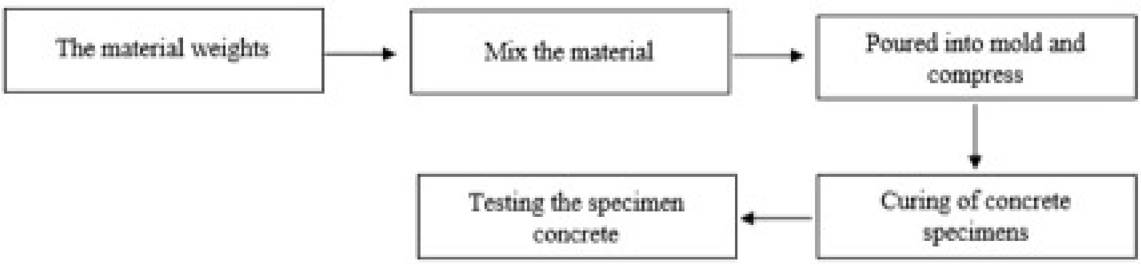

Figure 3: Laboratory guidelines

This method begins with designing a concrete mix that conforms to the standards in [14] using grade in class C20/25 used in the DOE method. The ratio of water to cement required for a minimum strength of 25 MPa is 0.55. The ratios of PALF used as additives were 0.00 %, 0.10 %, 0.20 %, and 0.30 % of the total density of PALF used. In Table 2, which displays the total value of material required based on the DOE method on the volume of mixture in the cube and cylinder.

Table 2: Concrete Mix Design calculation amount of material that required based on DOE Method

Quantity	Cement (kg)	Water (L)	Fine aggregate (kg)	Coarse aggregate (kg)		
				10 mm	20 mm	40 mm
Per m^3 (to nearest 5kg)	454.5	250.0	658.182	987.268	-	-

Per trial mix of 0.006m^3 for cube	2.727	1.5	3.949	5.924	-	-
Per trial mix of 0.0048m^3 for cylinder	2.182	1.20	3.159	4.739	-	-

The weight percentage of pineapple leaf fiber (PALF) treated with a percentage obtained high tensile value through a tensile strength test shall be used as the proportion of main additive material used in this procedure required for this section. The treated PALF using a percentage of NaOH solution that achieved high tensile strength was added to the concrete mix with weight percentages of 0.10 %, 0.20 % and 0.30 % of the weight density of PALF as shown in Table 3 and Table 4.

Table 3: The concrete mixture properties were determined by using the DOE Method for each trial mix of 0.006 m^3 for cube concrete

Specimen	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Density Fiber (kg/m^3)	Pineapple leaf Fiber (kg)	Cube Sample (Days)	
						7	28
0%	2.727	3.949	5.924	0	0	3	3
0.1%	2.727	3.949	5.924	1528.999	0.009	3	3
0.2%	2.727	3.949	5.924	1528.999	0.018	3	3
0.3%	2.727	3.949	5.924	1528.999	0.027	3	3

Table 4: The concrete mixture properties were determined by using the DOE Method for each trial mix of 0.0048 m^3 for cylinder concrete

Specimen	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Density Fiber (kg/m^3)	Pineapple leaf Fiber (kg)	Cylinder Sample
0%	2.182	3.949	4.739	0		3
0.1%	2.182	3.949	4.739	1528.999	0.007	3
0.2%	2.182	3.949	4.739	1528.999	0.015	3
0.3%	2.182	3.949	4.739	1528.999	0.022	3

The mixture is then mixed manually by adding water gradually until it meets its homogeneous mixture. The mixture is placed in a 100 mm x 100 mm x 100 mm cube mold as well as a 100 mm diameter and 200 mm high cylindrical mold coated with oil to ensure the dough does not stick to the surface and facilitate the deformation process. In this study, specimens were produced of 24 cubes and 12 cylinders of concrete to determine the compressive strength and tensile strength of concrete.

3. Results and Discussion

This section briefly discusses the results and conclusions obtained through test results on PALF and concrete. There are several laboratory tests performed on PALF and concrete to obtain results. The aim of this study was to look at the percentage that obtained high tensile in the treated PALF as well as the use of this additive in concrete mixes against tensile strength.

3.1 Tensile Strength of PALF

Tensile strength tests were performed on the samples to determine the strength values for each percentage ratio of PALF treated with sodium hydroxide (NaOH) and untreated PALF. Through this test, focusing on determining the appropriate percentage value according to the highest value on the fibre tensile test, can be finalised for use in the process of producing the treated PALF as shown in Figure 4.

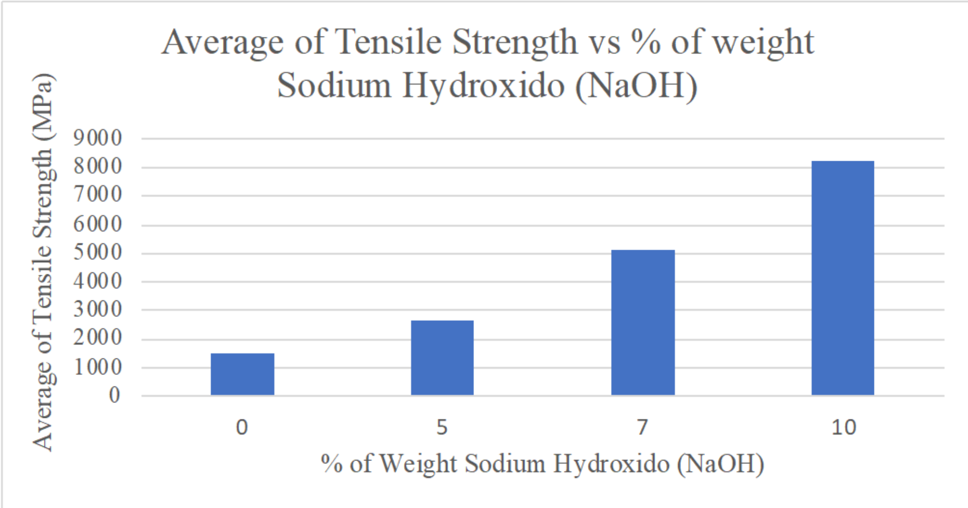

Figure 4: Graph of average tensile strength vs. Sodium Hydroxide (NaOH) weight percentage

According to the figure above, the average tensile strength for each percentage is obtained from the tensile strength test data for PLF treated and untreated using Sodium Hydroxide (NaOH). The average of 10.00 % NaOH solution was the highest value of tensile strength for the fibre obtained at 5830.16 MPa. Meanwhile, the lowest tensile strength value is at 0.00 %, which is 1077.68 MPa, and at 5.00 % and 7.00 %, it increases by about 50.00 %-60.00 %.

3.2 Concrete Workability

This reduction test process is performed on wet concrete to determine the workability of the concrete as well as identify the actual mix reduction scale to produce good concrete. Concrete workability assessors should be emphasized to facilitate concrete production work. Figure 5 shows the results of the drop test on wet concrete according to the ratio of different PLAF application percentages.

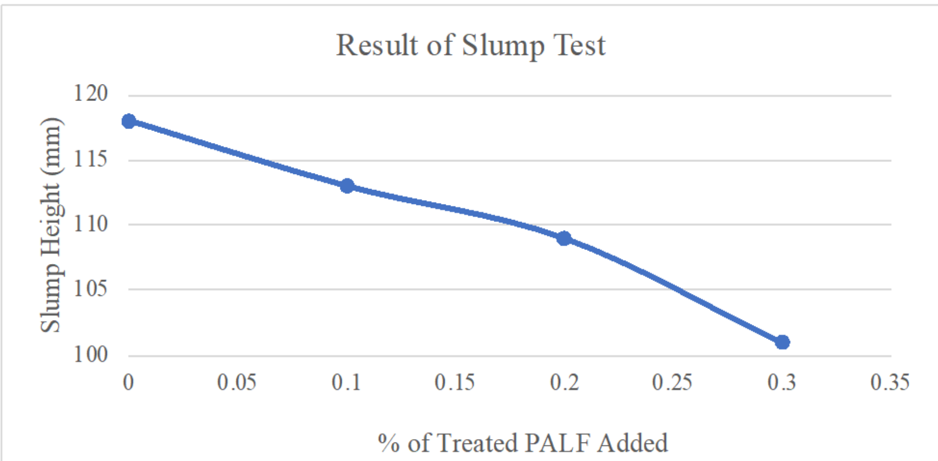

Figure 5: The graph height of the slump in relation to the percentage of treated PALF added

The workability that can be assessed from the drop test results decreased due to the increased content of PALF that had been treated using NaOH solution added to the concrete. The results of the concrete mix with PALF that has been treated show that the type of collapse produced is the degradation of crumbs as well as a high degree of workability.

3.3 Density Test

The density of concrete is one of the important aspects in the production of concrete. This is to determine whether the concrete has a high quality in terms of strength but has the optimum weight to facilitate transportation work. Figure 6 shows the results of the recorded data on the density of concrete

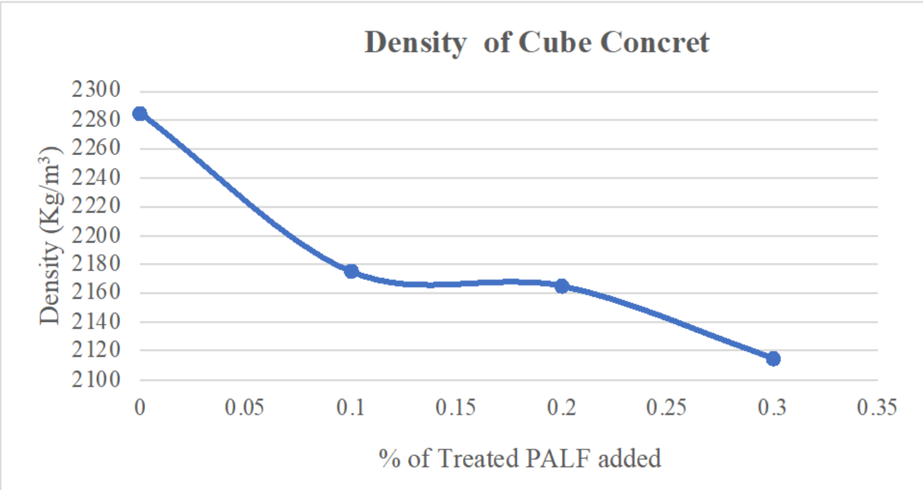

Figure 6: The graph density of concrete is against the percent of treated PALF

Based on the results obtained, the addition of PALF treated in the concrete mix resulted in a significant weight reduction compared to conventional concrete. PLAF treated be seen in Figure 7 The density of the concrete mix is 2,175, 2,165, and 2.15 kg/m^3 for each concrete mix, against increments of 0.10 %, 0.20 %, and 0.30 % treated PLAF as part of the additive, compared to 0.00 % concrete using PALF treated, 2285 kg/m^3. In summary, it is seen that the increase in density will occur as the hydration period increases, while the density decreases as the content of the treated PLAF in the concrete increases.

3.4 Compressive Test

Concrete strength tests are carried out on samples of hard and dry concrete cubes to identify the ability of concrete to withstand a predetermined load. For this study, the test was conducted after cubes with a volume of 100 mm x 100 mm x 100 mm were preserved in water for 7 and 28 days. The compressive strengths of ordinary concrete and PALF-treated concrete partially treated with additives with different conversion rates (0.10 %, 0.20 %, and 0.30 %) for 25 N/mm^2 grade specimens were summarised in Figure 7.

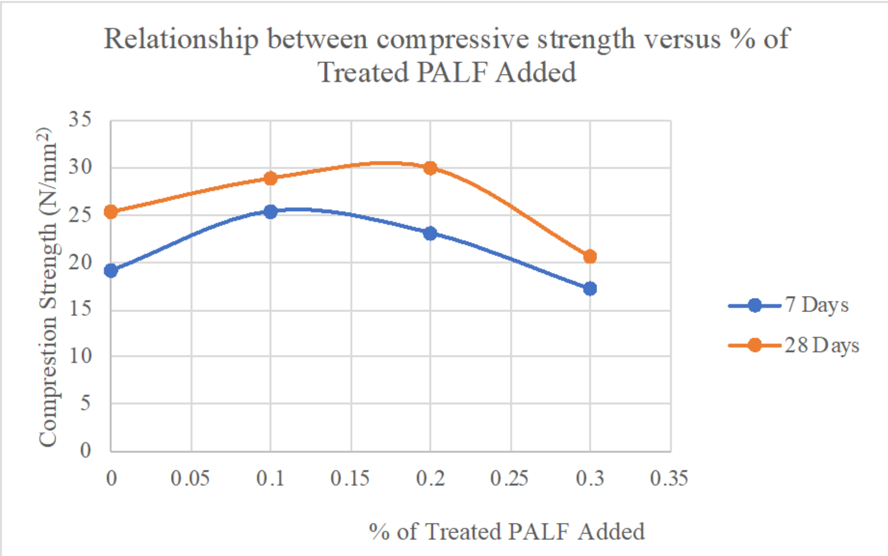

Figure 7: Compressive strength against percentage of pineapple leaf fiber

Through the graph above, it can be concluded that the formula for the relationship between the strength of concrete and PALF treatment at each age of concrete can be found. From these results, it can be concluded that the strength of concrete at the age of 28 days increased compared to the age of 7 days because the concrete has reached the maturity level of its actual concrete strength. However, there was a decrease in strength over ordinary concrete as well as a failure to reach the level of compressive strength for grade M25 at the use of 0.30 % PALF treated. This is because the addition of over-treated PALF can be attributed to the adhesion properties due to the smooth texture of PALF in the mix, which reduces the bonding properties of concrete mixes. Through the compressive strength test, we can conclude the most optimal percentage value for the age of concrete that has reached the age of maturity on the 28th day is 0.20 %.

3.5 Split Tensile Strength

The breaking tensile strength is one of the parameters of the mechanical properties of concrete that has an important role in structural planning. The tensile strength test can be determined where one pressure splits on a concrete cylinder. In this study, the resulting specimens will be tested at the age of 28 days using a compressive strength machine. Figure 8 shows the results of the tensile strength test of ordinary concrete together with concrete containing the percentage of use of treated PLAF between 0.10 %, 0.20 %, and 0.30 %.

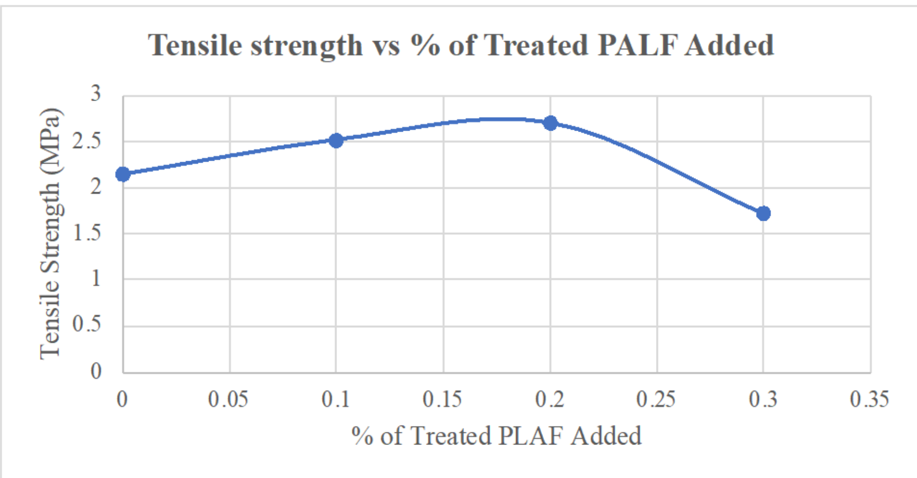

Figure 8: Tensile strength versus the percentage of treated PALF added

The fractional tensile strength of concrete was also influenced by the addition of the treated PALF. The addition of 0.10 % of treated PALF resulted in approximately a 38.00 % increase in tensile strength compared to conventional concrete. Also, in 0.20 % of the treated PALF addition, an increase in tensile strength of up to 17.40 % of concrete containing 0.10 % PLAF was obtained. However, there was a decrease of 98.10 % with the addition of 0.30 % PALF treated into concrete. This is likely the placement properties due to the smooth PALF texture in the concrete, which reduces the bonding properties of the concrete mix. In conclusion, it indicates that the percentage quantity of PALF applied treated plays a role in increasing or decreasing the tensile strength of the concrete mix.

4. Conclusion

The use of PALF treated using percentages that produce high tensile values for use as additives in concrete results in good performance in compressive and tensile strengths to improve the characteristics and properties of conventional concrete. However, the decline in compression and tension of concrete with the use of high PALF is due to the smooth texture of PALF in concrete, which reduces the bonding properties of the concrete mix. This study has identified the optimal percentage of PALF and PALF treatment for use in concrete mixes, which is 10.00 % for the use of NaOH solution and 0.2% for the use of PALF treated concrete.

Overall, this study shows that it is possible to make additives in concrete that are made from PALF. However, the material is still subject to further study to improve every property and characteristic of the concrete, as well as the PALF, to obtain optimum conditions in all criteria. Future work is to add a weight percentage of the NaOH solution before evaluating the mechanical and physical properties of concrete and assisting in determining the material parameters used in concrete production operations.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support

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