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RESEARCH ARTICLE OPEN ACCESS

Investigation of the Properties of Concrete Roof Tiles with Bamboo Fiber and Waste Polyethylene Terephthalate Plastics

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Abstract:

The Philippines generates significant agricultural waste due to its tropical climate, posing threats to ecosystems and public health. Innovative efforts aim to convert this waste into valuable engineering materials. One approach uses bamboo fiber to enhance concrete roofing tiles' strength and sustainability. Additionally, the rising number of Polyethylene terephthalate (PET) bottles, which contribute to environmental issues, can be repurposed as concrete additives.Research examines the impact of bamboo fiber and shredded PET on concrete tiles' strength and water absorption. By varying the amounts of these materials in concrete mixtures (with specified amounts of bamboo fiber and PET), researchers create standardized tile samples (33x42 cm) to evaluate after a 28-day curing period. Results show tiles with 0.35 kg of bamboo fiber and 0.40 kg of PET have the highest strength, although conventional tiles absorb less water. The use of these materials also reduces tile weight, simplifying handling and transport, thus streamlining construction processes.

Keywords: **Polyethylene terephthalate, Bamboo Fiber**

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I. INTRODUCTION

Roofing is an essential element in every household, acting as a shield between the inside of your home and the external environment. Concrete roof tiles have earned their reputation as one of the most globally trusted roofing materials, with a history dating back as far as 10,000 B.C. Crafted from a natural blend of cement, sand, water, and oxide, concrete roof tiles offer an extensive array of design options.

The weight of concrete roof tiles is an issue. Due to its weight concrete can be more difficult to install. The roof has to be reinforced in order to support its weight. Furthermore compared to lighter materials like felt or fiberglass moving concrete tiles requires more work and time. Concrete is a composite material even though it is strong. As a result concrete roof tiles are brittle and prone to irreversible damage if they are dropped stepped on or fall off the roof. Investing in a concrete tile roof, especially higher-quality profiles, represents a significant financial commitment. While a well-maintained concrete tile roof can surpass the lifespan of many other roofing materials, it demands a sustained and long-term commitment to upkeep. Homeowners should consider both the initial investment and ongoing maintenance to ensure the longevity and performance of this durable roofing option [1].

Concrete roof tiles are known for their durability and resistance to damage, making heavy repairs unnecessary. These tiles typically have a long lifespan, requiring minimal maintenance. Regular cleaning to remove moss or debris accumulation is usually the extent of necessary upkeep. Overall, concrete roof tiles provide a low-maintenance and long-lasting roofing solution for decades to come [2]. Not only are they affordable but concrete tiles also perform exemplarily well in seismic areas where they meet the requirements for load related to earthquake in building materials. Homeowners who want strong construction materials that will last long and give them flexibility of choice on their aesthetics can consider these options [3].

There has been a notable surge in the use of environmentally friendly materials in construction in recent years, owing to the numerous benefits they offer in building projects [4]. Natural fibers have several advantages including cheapness, wide availability, renewable nature, lightness, low density, high durability, and biodegradability. These are seen as a good replacement for conventional reinforcements in composites especially where good strength-to-weight ratios and further weight savings are needed. Due to their availability locally within a wide range and adequate quantities it is highly recommended to use these natural fibers in the production of concrete. This concept is old and hence adding such fibers for enhancing invulnerability with respect to brittle materials is not new [5].

Due to a wide range of advantages that comprised bamboo fiber possessing good physical properties, the researchers show interests to utilize bamboo fiber as a structural material and as a reinforcement in concrete. Conventional concrete is subject to fatigue failure, tensile failure, creep and cracking. Bamboo fibers are included in the concrete mix to address these problems and to improve the ductility of the concrete. This outcome is a composite material called fiber reinforced concrete [6].Bamboo, a type of grass renowned for its rapid growth and impressive stature, undergoes a short but vigorous growth spurt in the summer. During this growth phase, bamboo sprouts emerge from the ground and can reach their full height in as little as two to three months.

It is critical to ensure the building industry functions smoothly. As a result, it is crucial to search for alternatives to traditional aggregates for concrete.After mechanical treatment, several types of waste plastic are repurposed as aggregate, fillers, or fibers in cement mortar and concrete[7]. Consequently, recycling plastic waste is emerging as an alternative method to traditional landfill disposal. A potential solution involves incorporating recycled plastic materials into concrete construction, creating what is known as "green concrete" [8]. Polyethylene terephthalate has emerged as a recent solution in the realm of concrete mixtures, either in shredded or fibrous form, as an innovative means to tackle the problem of plastic waste.

Review of Related Literature

A. ***Natural Fiber***

The surge in environmental consciousness has spurred a growing embrace of natural fiber composites. Additionally, their cost-effectiveness, lightweight properties, favorable specific characteristics, easy separability, enhanced energy recovery, carbon neutrality, biodegradability, and recyclability have recently garnered considerable attention for integrating natural fibers into composite materials. These materials, known for their durability, reliability, lightweight nature, and superior mechanical properties compared to traditional materials, are driving the growing demand for natural fibers in industries like automotive, construction, and building [9].

B. *Bamboo Fiber*

There are many advantages over other reinforcing materials including greater toughness and lower cost of natural fibers like bamboo [10]. Phong et al. extracted bamboo fiber from raw bamboo of various ages using a combination of steam explosion, mechanical extraction, and alkaline treatment techniques. Furthermore, research was done on how CO2 gas affected the pH of alkaline effluent. In conclusion, a scanning electron microscope study of the microstructures of bamboo fiber showed that the individual fibers were flatly aligned longitudinally. Both hemicelluloses and lignin, with varying degrees of bonding, held these fibers together [11].

C. *Synthetic Fiber*

The synthetic fibers, which are approached explicitly for the use in concrete based on the "Concrete in Practice" article of 2014 are known to show outstanding toughness in alkaline environment of concrete. These fibers are made up of tailored polymer-based materials like polypropylene, nylon, or polyethylene. They provide benefits for concrete both at plastic and hardened states. Concrete when reinforced with synthetic fibers can improve its tensile strength [12].

D. *Concrete Roof Tile*

During the mid-19th century in Bavaria, a blend of cement, sand, and water was initially employed to create concrete roof tiles. Remarkably, many houses constructed with these earliest concrete roof tiles are still standing today, demonstrating their exceptional durability [13]. There is a significant lot of aesthetic flexibility in the concrete tiles' ability to mimic other roofing textures, such as wood and slate. A range of roof shapes and slopes can be accommodated by using different systems and profiles[13].

Maintenance for roof tiles is minimal to nonexistent. Before being released, these tiles undergo rigorous quality assurance assessments to ensure they can withstand the harshest conditions, exceeding expectations. Their natural strength and durability translate to rare maintenance requirements, making them a sound long-term investment. Furthermore, due to their effective thermal properties, roof tiles help regulate temperature, providing cooler interiors in summer and warmer ones in winter [14]. Moreover, roof tiles are highly regarded for their fire resistance, boasting a Class A rating for fire performance, which not only guards against external fires like bushfires but also protects home-based fires [14].

During the pre-World War era,research findings indicate that there are significant advantages associated with the development of lighter-weight fiber-reinforced concrete tiles. These added benefits encompass a reduction of 30% in transportation expenses and a 40% savings in installation costs. Moreover, it delivers a 50% enhancement in impact resistance. The reduced weight of these tiles enables them to be affixed to a smaller support structure, thereby further lowering construction expenses. Additionally, this weight reduction contributes to a decreased seismic risk for the roof structure and makes it highly suitable for re-roofing projects [15].

Roof tiles are centuries-old construction material, and were used in various parts of the world. Both the connection to architectural tradition and maintaining workability of structures from one nation to the next are reasons why this method is important. Its ongoing nature reminds us of the importance in the practice of both cultural preservation and physical architecture that gives life to place [16].Roof tiles' different shapes, portions, and accessories produce a wide range of aesthetic effects. Variations in design, color, and texture allow for artistic expression and customization of building styles. [17].

Cady (2021) opines that ordinary roofing materials are not always the best for your seaside home because winds, rain, sunlight, and salty air from the sea are harmful to roofs[18]. In doing so, Clay Tiles are often featured commonly among coastal homes owing to their sheer compatibility with some coastlines that tend to have the Mediterranean-inspired architecture in few coastal regions. Clay tiles not also look more beautiful but also help the homes situated in the coastal regions. They are extremely durable by nature and it enables them to hold up against the weathering effect of water and sea air [18].

Additionally,these tiles are also strong and can withstand torrential rains, which is very helpful for places with typhoons where everyone is worried about roof leaks or strong wind attacks during rainy season[18].

E. *PET Plastic as Aggregate in Concrete*

Study findings indicate that PET aggregates yield high-quality mixtures with reduced volume weight, exhibiting mechanical properties similar to those of natural concrete with suitable particle sizes [19]. PET-infused concrete does not experience the same heat-related issues as traditional concrete. However, it is worth noting that the cement consumption is higher in PET-infused light concrete compared to natural concrete [19].

The addition of waste PET to concrete mixtures has been extensively examined, generating several conclusions. One particularly intriguing finding was that when 5% of the fine aggregate (natural sand) in the concrete was replaced with an equivalent weight of PET aggregates, the Waste-PET concrete showed comparable workability, a slightly lower compressive strength, and a marginally lower splitting tensile strength than the ordinary concrete. This proposes a viable approach to the use of more environmentally friendly building materials. [20].

The findings indicate that when it comes to plastic composite tiles, substituting them with recycled PET (Polyethylene Terephthalate) yields superior results compared to using Ordinary Portland Cement (OPC) after 28 days. In summary, these plastic composite tiles exhibit both impressive strength and exceptional water-absorbing properties suitable for roofing [21].

F. *Bamboo Fiber as an Additive on Reinforced Concrete*

There was a 2% increase in compressive strength with bamboo fiber-reinforced concrete. The findings showed that adding bamboo fiber to concrete increased bending strength up to 2%, but then decreased slightly beyond that level in terms of flexural strength. In conclusion, the research findings indicated that bamboo fiber-reinforced concrete offers increased strength in comparison to traditional concrete, especially when bamboo fiber is included at a 2% ratio. [6].

Since the 1960s, the employment of fibre-reinforced concrete has been growing to address these deficiencies. Fibers have historically been used in various types of mortars and concretes to give them added strength and stability. Traditional fibre materials are such as steel, glass, carbon, asbestos and cellulose. Bamboo fibres can be deployed in place of synthetic ones in concrete thereby improving its properties. Flowability and performance of the concrete may affect by the ratio

II. METHODOLOGY

A. *Research Design*

To find out the effects of bamboo fiber and waste polyethylene terephthalate plastics on the strength of concrete roof tiles, quantitative and experimental methods of research were used. By using different instruments and apparatuses, data are gathered. American Society for Testing and Materials (ASTM Standards) was used as a reference in the study.

B. ***Materials***

The following materials were collected and used to develop concrete roof tile samples; cement; sand; bamboo fiber; water; waste PET plastics; and caustic soda.

C. ***Tools and Equipment***

The following tools and equipment were used by the researchers to perform the experiment; masonry trowel; shovel; sand sifter; pail; drum; gloves; GI pipes; plyboard; basin; molder; measuring tape; weighing scale; knife and reciprocating saw; universal testing machine; oven; and plastic-shredding machine.

D. ***Material Gathering***

The bamboo used in this study was gathered from Santos Farm in Sta. Barbara Bacolor, Pampanga. Kawayan tinik (bambusa blumeana) only was used in this research. The Polyethylene Terephthalate (PET) bottles were collected around the premises of Don Honorio Ventura State University. The researchers collected PET bottles inside the DHVSU campus because of the increase in the volume of plastic bottle waste from the students. Garbage bags, protective gloves, and sanitizing equipment were used by the researchers to gather the plastic bottles safely. Only clear mineral water bottles were picked and used in this study.

E. ***Preparation of Materials***

Bamboo cutting adhered to the standardized length of roof tiles, maintaining an average gap of 7-10cm between nodes. Researchers cut the bamboo into two halves and exposed it to sunlight for approximately 24 hours, aiming to eliminate excess moisture and safeguard against decay and mold formation. In the process of treating bamboo, the researcher employed a caustic soda solution to ease the separation of bamboo strands, converting them into fibers. A solution consisting of caustic soda and water was prepared, and the bamboos were submerged in the mixture for exactly 48 hours.

The Bamboo fibers were separated through the use of steel pipe and plyboard. First, the researchers used plastic gloves as a safety material to avoid any contact with the chemical solution that can bring harm to the human skin. By applying force using bare hands to the pipe against the plyboard with the bamboo in between, the fibers were extracted. The researchers flattened the bamboo until the fiber was extracted, and then proceeded to the separation process of the fibers. The fibers are required to be thin, the researchers manually separated the flattened bamboo into thin strands of fibers. After the separation process, the bamboo fibers were trimmed to lengths of 25mm-50mm and the researchers placed the extracted bamboo fibers into a cool and dry place without direct contact with sunlight.

The collected pet bottles were sanitized first by using dishwashing liquid soap and a brush. After the sanitizing process, the researchers placed all the bottles in a room without direct sunlight and let them dry for 24 hours. After the plastic bottles were dried for 24 hours, the researcher started to shred the plastic bottles into smaller pieces between 5mm and 10mm. By using a shredding machine, the researchers cut the plastic bottles into smaller pieces and created aggregates made of plastic. After the shredding process, the researchers stored the plastic bottle aggregates in a dry place without sunlight to avoid any expansion.

F. ***Design Mixture of Specimen***

i. Ordinary Concrete Roof Tile

The production utilized Ordinary Portland Cement and readily available fine aggregates (sand). The test procedure involved employing a concrete mix with a ratio of 1:1.5, meaning for every part of cement, one and a half parts of sand were used.

ii. Modified Concrete Roof Tile

For the modified concrete roof tiles same approach was followed as for the regular concrete mix. A ratio of 1:1.5 was maintained, incorporating an admixture of bamboo fibers and replacing certain portions of the sand (10%, 15%, and 20%) with shredded PET bottles. Three design mixtures of specimens containing bamboo fiber and PET were then prepared.

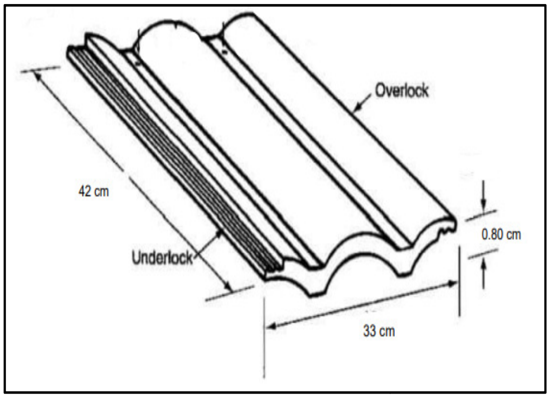
Table 1
Details of the Concrete Rooftile Mixtures

Proportion	Cement (kg)	Sand (kg)	Bamboo Fiber Content (kg)	Shredded PET Plastic Content (kg)
Control	1.75	2.625	0	0
#2	1.75	2.3625	0.175	0.2625
#3	1.75	2.225	0.35	0.4
#4	1.75	2.1	0.525	0.525

G. ***Production of Specimen***

All the materials were mixed properly as water was added to the concrete mix. Bamboo fiber and PET were added to the concrete mix. Concrete fiber reinforced Concrete mixture was poured into the roof tile mold with dimensions 33 cm x 42 cm.

Figure 1
Profile drawing of the Concrete Roof Tiles



The roof tiles were designed based on the tegula roofing tile having dimensions of 42 cm in length, 32 cm in width, and 3.43 cm in thickness. It has two fastening holes and an overlock with a recess for receiving a ridge of an underlock of a neighboring tile.

H. ***Curing of Specimen***

The samples were kept in a temperature range of 60 to 80 degrees Fahrenheit (15 to 27 degrees Celsius) in a setting that prevents moisture loss for a maximum of 48 hours. They were taken out of the molds 24 hours post-casting and lightly sprayed with water the following day. The tiles were stacked but continued to undergo moisture curing daily for 28 days before testing.

I. ***Testing***

The data used in the study are results from Laboratory tests conducted at two different locations: **Universal Testing Laboratory and Inspection, Inc.** in Barangay Bagong Ilog, Pasig City, and **ASTEC Material Testing Corporation** in San Fernando, Pampanga. Various tests were performed on the concrete roof tile, including transverse rupture strength, water absorption, and unit weight tests, to assess its mechanical and physical properties. These tests were conducted indoors within the laboratory to ensure precise and reliable results.

- ***Transverse Rupture Strength***

The determination of the transverse rupture strength for roofing tiles typically follows standards such as ASTM 1167-11 / ASTM C-78. This test, which was conducted in the laboratory, aimed to estimate the breaking transverse load for the roofing tile.

Test Procedure:
1. Set up the testing machine with the roofing tile to be tested.
2. The test span will be 30.5 cm or 2/3 of the tile length.
3. Conduct a three-point bending test.
4. Apply a uniform and continuous load on the tile, not exceeding 2000 N/min, until fracture.
5. Document the load, measured in kilograms, at the point of fracture for each tile.

The transverse strength (f) can be calculated using the equation:

$$f = \frac{PL}{bd^2}$$

Where:
f- the modulus of rupture (MPa),
P- the breaking load,
L- the span length (mm),
b- the tile width where the load is applied (mm),
d- the tile depth where the load is applied (mm).

Based on Testing Application Standard (TAS) No. 112-95 (Standard Requirement for Concrete Roof Tiles), the classification of the tested tile based on the transverse strength test is provided in a table.

Table 2
Classification of Roofing Tiles based on Transverse Strength

Transverse Breaking Strength, min, N	
Tile Profile	Individual Tile
High Profile	1557
Low Profile	1157
Flat Profile	956

- ***Water Absorption***

The water absorption test is carried out to assess the amount of moisture that concrete roofing tiles may absorb under defined conditions. According to ASTM C67, the results are reported as a percentage of the weight of water absorbed relative to the dry weight of each tile. In alignment with IS 13801, the chosen dimensions for the test are 33 x 42 cm.

Test Procedure:

1. Submerge the tile specimen in fresh, clean water at room temperature (27±2°C) for 24 hours.
2. Take the specimens out of the water and let them drain for 1 minute. Eliminate any apparent surface water using a damp cloth, and promptly weigh the specimens to the nearest gram (M1) within 3 minutes of removal from the tank.
3. After saturation, dry all specimens in a well-ventilated oven at temperatures ranging from 212 to 239°F (100 to 115°C) for at least 24 hours until a consistent weight is achieved. Subsequently, allow the specimens to cool to room temperature and reweigh them (M2).

The percentage of water absorption can be calculated using the following equation:

$$W = \frac{M1 - M2}{M2} X100$$

Where:

W – the water absorption of the specimen expressed as a percentage

M1 – is the initial weight of the specimen after removing surface water (in grams).

M2 – is the weight of the specimen after drying (in grams).

Based on Testing Application Standard (TAS) No. 112-95 (Standard Requirement for Concrete Roof Tiles), the classification of the tested tile based on the water absorption test is provided in a table.

Table 3
Classification of Roof Tiles Based on Water Absorption

Tile Ratings and Maximum Water Absorption	
Weight Classification	Maximum Water Absorption (kg/m^3)
Class I	288
Class II	240
Class III	208

- ***Unit Weight***

Procedure:

1. Weigh the Concrete Roof Tile - record the value to the nearest tenth.
2. Measure the length, width, and thickness of the concrete roof tile
3. Divide the weight of concrete by the known volume = density or fresh unit weight

$$\rho = \frac{m}{v}$$

ρ = density

m = mass in kg

v = volume (Length x Width x Thickness)

ASTM C 1492- 03

Standard Specification for Concrete Roof Tile

Table 4
Classification of Roof Tiles Based on Dry Unit Weight

Weight Classification	
Weight Classification	Oven Dry Weight of Tile (lb/ft^3)
Normal	Greater than 125
Medium	105 to 125
Lightweight	Less than 105

III. RESULTS AND DISCUSSION

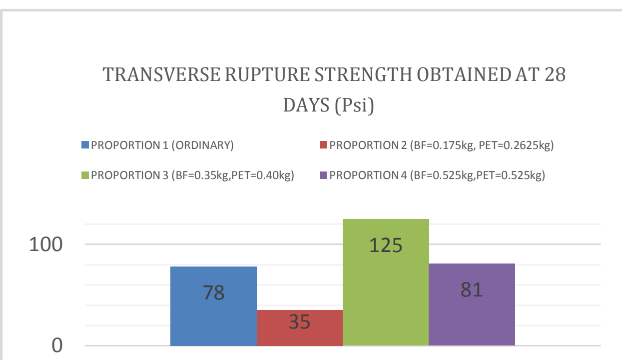
A. *Transverse Rupture Strength Test (ASTM 1167-11/ASTM C-78)*

The examination of the transverse strength of concrete roofing tiles stands as a crucial prerequisite for ensuring the project's objectives are upheld. To meet this requirement, tests were carried out, altering the proportions of bamboo fiber and shredded PET plastics within the mixture. Roof tiles were formed incorporating varying amounts of fiber (0, 0.175, 0.35, and 0.525 kg) and PET plastics (0, 0.2625, 0.40, and 0.525 kg). The table illustrates the diverse transverse rupture strength test results at 28 days for the different proportions.

Table 5
Transverse Rupture Strength Obtained in 28 Days

Proportion	Sample Represented (Kg)	Breaking Strength (N)	Transverse Rupture Strength	
			MPa	Psi
1	BF =0 PET = 0	1600	0.54	78
2	BF =0.175 PET=0.2625	900	0.24	35
3	BF =0.35 PE = 0.40	2700	0.86	125
4	BF=0.525 PE =0.525	2100	0.56	81

Figure 2
Transverse Rupture Strength Obtained in 28 Days



As depicted in the figure, the outcome after twenty-eight days of curing revealed that Proportion 3 exhibited the highest flexural strength of 125 Psi compared to Proportion 1 (standard), 2, and 4. As indicated in the table, Proportion 4 achieved a flexural strength of 81 Psi higher than the standard roof tile and Proportion 2 but lower than Proportion 3. Notably, despite incorporating additional admixtures, Proportion 1 (standard) demonstrated superior flexural strength compared to Proportion 2. Among the four samples, Proportion 2 registered the lowest flexural strength in Psi.

To classify the different proportions of concrete roofing tiles, based on Testing Application Standard (TAS) No. 112-95 (Standard Requirement for Concrete Roof Tiles), a classification system based on breaking strength was utilized. According to the table 2, a roof tile is categorized as High Profile if its breaking strength is equal to or above 1557 N, Low Profile if it falls between 1157 N to 1556 N, and Flat Profile if it ranges from 956 N to 1156 N.

Proportion 1, with a breaking strength of 1600 N, is classified as High Profile. Similarly, Proportions 3 and 4, with breaking strengths of 2700 N and 2100 N respectively, also fall under the High Profile category. In contrast, Proportion 2 achieved the lowest breaking strength among Proportion 1, 3, and 4.Proportion 2 with 900 N does not reach the minimum breaking strength. In summary, all three samples are classified as High Profile tiles based on their breaking strengths.

B. *Water Absorption Test*

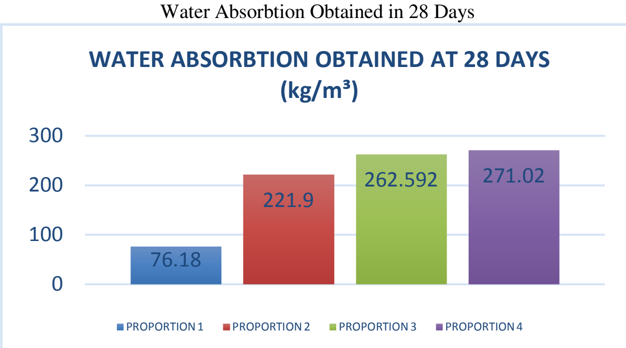
This test evaluates the suitability of the roofing tile for use. Excessive water absorption could lead to undesired cracking in the tile. Factors influencing water absorption may encompass the type of plastic, natural fibers utilized, temperature, and duration of exposure. The data provides insights into the material's performance in water or humid conditions. Roof tiles were formed incorporating varying amounts of fiber (0, 0.175, 0.35, and 0.525 kg) and PET plastics (0, 0.2625, 0.40, and 0.525 kg). The table illustrates the different water absorption test results at 28 days for the different proportions.

The data provides insights into the material's performance in water or humid conditions. Roof tiles were formed incorporating varying amounts of fiber (0, 0.175, 0.35, and 0.525 kg) and PET plastics (0, 0.2625, 0.40, and 0.525 kg). The table illustrates the different water absorption test results at 28 days for the different proportions.

Table 6
Water Absorbtion Obtained in 28 Days

Proportion	Sample Represented (Kg)	Saturated Weight (kg)	Oven Dry Weight (kg)	Absorption	
				kg/m^3	%
1	BF =0 PET = 0	5.45	5.15	76.18	5.83
2	BF =0.175 PET=0.2625	4.4	3.51	221.9	25.36
3	BF =0.35 PET=0.40	4.85	3.77	262.59	28.65
4	BF=0.525 PET=0.525	4.44	3.38	271.02	31.36

Figure 3
Water Absorbtion Obtained in 28 Days



Tile utilized in the High-Velocity Hurricane Zone jurisdiction shall be rated and shall meet the absorption requirements noted in the classification of roof tile based on water absorption. Based on Testing Application Standard (TAS) No. 112-95 (Standard Requirement for Concrete Roof Tiles), the table 3 illustrates that a roof tile is under Class I if it is equal to 288 kg/m^3, and Class II if it ranges from 240 to 287 kg/m^3. And lastly, falls under Class III if it ranges from 208 to 239 kg/m^3.

Proportion 1 (Ordinary) with 76.18 kg/m^3 falls behind **Class III**. Proportion 2 falls behind **Class II** with 221.9 kg/m^3 While Proportion 3 and 4 with 262.59 kg/m^3 and 271.02 kg/m^3 maximum water absorption, respectively, fall under the **Class I** category.

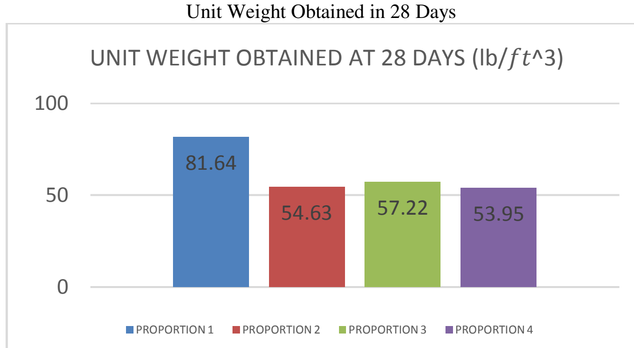
C. ***Unit Weight Test***

This test shows the difference between ordinary concrete roof tiles and various samples with different proportions in terms of density. Lightweight roof tiles should be easier to handle, transport, install, and can help reduce the overall structural load on buildings. Roof tiles were formed incorporating varying amounts of fiber (0, 0.175, 0.35, and 0.525 kg) and PET plastics (0, 0.2625, 0.40, and 0.525 kg). The table illustrates the different densities of concrete roof tiles at 28 days.

Table 7
Unit Weight Obtained in 28 Days

Proportion	Sample Represented (Kg)	Weight (kg)	Unit Weight	
			lb/ft^3	kg/m^3
1	BF =0 PET = 0	5.150	81.64	1307.74
2	BF =0.175 PET=0.2625	3.510	54.63	875.13
3	BF =0.35 PE = 0.40	3.770	57.22	916.64
4	BF=0.525 PE =0.525	3.380	53.95	864.209

Figure 4
Unit Weight Obtained in 28 Days



This unit weight test evaluates the weight of the roof tile samples. According to table 4, ASTM C1492-03 weight classification, if a roof tile weighs more than 125 lb/ft^3, it is considered normal weight. If the weight falls between 105 and 125 lb/ft^3, it is classified as medium weight. Anything under 105 lb/ft^3 is considered lightweight.

After 28 days of curing the concrete roof tile samples, variations in density values were observed. All samples showed values below 105 lb/ft^3

indicating **lightweight** properties. The control sample had the highest density at 81.640 lb/ft^3, followed by the second sample at 54.633 lb/ft^3, the third at 57.224 lb/ft^3, and the fourth at 53.951 lb/ft^3. Despite the control sample falling under the lightweight classification, the samples of roof tiles with different proportions of added bamboo fiber and PET plastic still have lighter weights.

III. CONCLUSION

1. The flexural strength of the regular concrete roof tile mixture is increased by adding 0.35 kg of Bamboo Fiber and 0.40 kg of shredded PET plastic. This indicated that Proportion 3 is the appropriate weight of admixtures to be added to concrete roof tiles among the proportions given.
2. The modified roof tiles (Proportions 2, 3, and 4) exhibited fewer cracks and remained intact after reaching the maximum breaking load, primarily due to the addition of bamboo fiber. In contrast, Proportion 1, which had no admixtures, broke into pieces due to its less intact material.
3. In conclusion, after 28 days of curing, the concrete roof tile samples demonstrated lightweight properties, with densities below 105 lb/ft^3. Although the control sample had the highest density at 81.640 lb/ft^3, the samples with added bamboo fiber and PET plastic still showed lighter weights. This suggests that the incorporation of these materials can further enhance the lightweight characteristics of the roof tiles.
4. The incorporation of fiber and PET resulted in the production of lightweight roof tiles. Analysis of the recorded weights revealed that the weight of the specimen decreases as the amount of fiber and PET added increases.
5. However, the modified roofing tiles absorbed more water compared to the control sample due to the presence of voids and improper curing of bamboo fiber, which led to higher water absorption rates in the modified tiles.

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