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Comparative Study on the Compressive Strength and Infiltration Rate of Pervious Concrete Reinforced with Pineapple Leaf and Snake Plant Fibers

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ABSTRACT: This study examined the influence of Snake Plant fibers and Pineapple Leaf Fibers (PALF) on the compressive strength and infiltration rate of pervious concrete, with emphasis on sustainability and alignment with the United Nations Sustainable Development Goals (SDGs). Compressive strength was tested at 7-, 14-, and 28-days following ASTM C39, while infiltration rate was assessed in accordance with ASTM C1701.

Results showed that Snake Plant fibers provided modest strength improvement, with the 0.3% mix achieving 8.93 MPa at 28 days, slightly higher than the control. The most notable effect was on permeability, where the 0.2% mix attained the highest infiltration rate of 0.0203 m/s, highlighting its suitability for drainage-critical applications. In contrast, PALF demonstrated a stronger influence on strength development, with the 1.0% PALF mix reaching 21.02 MPa at 28 days, outperforming the control at 16.24 MPa. Although PALF slightly reduced infiltration compared to the control, its values remained within the standard range for pervious concrete. Statistical analysis ($p > 0.05$) indicated no significant differences between control and fiber-reinforced mixes, though consistent performance trends were observed.

Overall, the findings suggest that PALF is more effective for enhancing compressive strength, while Snake Plant fibers are more effective for improving infiltration. The use of these natural fibers not only improves pervious concrete performance but also promotes sustainability by utilizing agricultural waste. This aligns with SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production), contributing to eco-friendly construction materials and resilient urban infrastructure.

KEYWORDS: Pervious concrete, Pineapple Leaf Fiber (PALF), Snake Plant Fiber, Compressive strength, Infiltration rate, Sustainable materials, Flood management

I. INTRODUCTION

The increasing frequency of floods in the Philippines highlights the urgent need for construction materials that support better water management. Conventional concrete, though widely used for its load-bearing capacity, contributes to surface runoff because of its impermeable nature. In contrast, pervious concrete offers an eco-friendly alternative by allowing rainfall to seep through its interconnected pores. Despite this advantage, its relatively low structural strength limits broader utilization.

Natural fibers present a potential solution by serving as reinforcing agents that improve the durability of porous mixes. Among these, Pineapple Leaf Fibers (PALF) and Snake Plant Fibers (Dracaena trifasciata) are locally available, biodegradable, and often considered waste resources. PALF is valued for its rigidity and toughness, while Snake Plant Fibers are recognized for their flexibility and resistance to cracking.

This study compares the performance of PALF- and Snake Plant-reinforced pervious concrete in terms of compressive strength and infiltration capacity. By highlighting their differences, the research aims to determine which fiber provides more effective reinforcement while maintaining the essential permeability required for sustainable drainage applications.

A. General Objective

To compare the effects of Pineapple Leaf Fibers (PALF) and Snake Plant Fibers (Dracaena trifasciata) on the compressive strength and infiltration rate of pervious concrete.

B. Specific Objectives

1. Determine the compressive strength of pervious concrete reinforced with PALF and Snake Plant Fibers at 7, 14 and 28 days using ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
2. Evaluate the infiltration rate of pervious concrete with PALF and Snake Plant Fibers using ASTM C1701 – Standard Test Method for Infiltration Rate of In Place Pervious Concrete.
3. Compare the results of PALF- and Snake Plant-reinforced specimens through t-test analysis to identify significant differences in performance.

II. METHODOLOGY

Natural fibers of Pineapple Leaf Fiber (PALF) and Dracaena trifasciata (Snake Plant) were collected from nearby areas of Cabanatuan. The fibers were extracted by drying the leaves for three days and manually separating the strands. Natural coarse aggregates, fine aggregates, and Portland cement were also acquired from local suppliers. Molds (150 mm × 150 mm × 150 mm) were fabricated using phenolic plyboard. A cement-to-aggregate ratio of 1:4 was adopted following pervious concrete guidelines, and four mix designs were prepared: a control sample (0% reinforcement) and three fiber-reinforced mixtures incorporating 0.1%, 0.2%, and 0.3% fiber content by volume of coarse aggregate.

Fresh properties of each mixture were evaluated using a slump test to assess workability. After casting, the specimens were demolded after 24 hours and subjected to curing periods of 7, 14, and 28 days under a combination of air curing and water curing. Mechanical testing was then conducted to evaluate structural and functional performance. Compressive strength testing was performed in accordance with ASTM C39, while permeability was assessed using the field infiltration test based on ASTM C1701.

A total of thirty-six samples were tested, with three replicates prepared for each mix proportion. The collected data on compressive strength and infiltration rate were analyzed using descriptive statistics to obtain mean and standard deviation values. A paired t-test was then applied to compare the control and reinforced mixes, allowing the determination of whether the incorporation of PALF and Snake Plant Fiber had a statistically significant effect on the mechanical properties of pervious concrete.

Figure II.1 Snake Plant & Pineapple Plant

Figure II.2 Snake Plant Fiber & Pineapple Plant Fiber

Figure II.3 Permeability Test and Compressive Strength Test

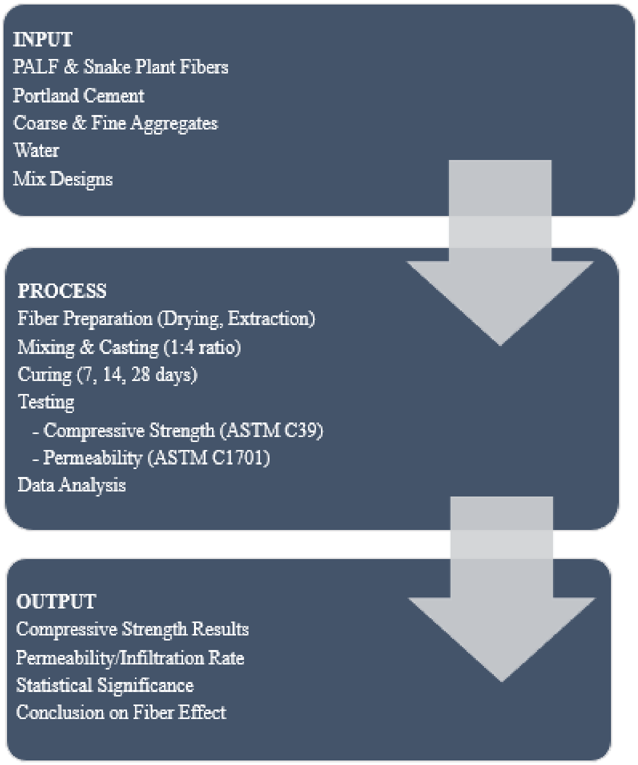

Figure II.4 Research Flow

III. RESULTS AND DISCUSSION

Compressive Strength of Fiber-Reinforced Pervious Concrete

The compressive strength of pervious concrete was evaluated at 7-, 14-, and 28-days following ASTM C39. For Snake Plant fiber-reinforced mixes, results showed that compressive strength varied with fiber content across curing ages. At 7 days, estimated strengths ranged from 5.03 MPa (0.1%) to 7.90 MPa (0.3%), with the control recording 6.53 MPa. At 14 days, strengths ranged from 5.17 MPa (0.2%) to 6.87 MPa (0.3%), while the control was 6.23 MPa. At 28 days, compressive strength further improved, with the 0.3% Snake Plant mix reaching 8.93 MPa, surpassing the control at 6.83 MPa. This indicates that Snake Plant fibers had the most positive influence at higher fiber content, particularly 0.3%.

For Pineapple Leaf Fiber (PALF) mixes, strength enhancement was more pronounced and consistent. At 7 days, the 1.0% PALF mix achieved 13.64 MPa, compared to the control at 10.70 MPa. At 14 days, the PALF mix recorded 12.55 MPa, while the control recorded 16.10 MPa. At 28 days, PALF specimens achieved 21.02 MPa, outperforming the control's 16.24 MPa.

These results suggest that PALF fibers provide a stronger reinforcing effect than Snake Plant fibers, particularly at later curing ages. Snake Plant reinforcement enhanced compressive strength modestly at 0.3%, while PALF demonstrated a more significant long-term effect, nearly doubling the compressive strength compared to Snake Plant mixes.

Table I Predicted Flexural Strength

Mix	7-day (MPa)	14-day (MPa)	28-day (MPa)
Control (Snake Plant)	6.533	6.233	6.833
0.1% Snake Plant	5.034	5.400	4.667
0.2% Snake Plant	5.583	5.167	6.000
0.3% Snake Plant	7.899	6.867	8.930
Control (PALF)	10.700	16.100	16.240
1.0% PALF	13.640	12.547	21.020

Infiltration Rate of Fiber-Reinforced Pervious Concrete

The infiltration rate test was conducted in accordance with ASTM C1701.

For Snake Plant mixes, infiltration rates ranged between 0.0097 m/s and 0.0203 m/s, depending on fiber proportion. The control mix recorded 0.0177 m/s, while the 0.2% Snake Plant Fiber mix achieved the highest infiltration rate of 0.0203 m/s. For PALF mixes, the infiltration rate was recorded at 0.0114 m/s, slightly lower than the control (0.0119 m/s). Despite the reduction, both PALF and control values remained within the standard pervious concrete range of 0.001–0.012 m/s.

These results suggest that Snake Plant fibers, particularly at 0.2%, can enhance infiltration, while PALF reinforcement maintains permeability at acceptable levels without significantly altering porosity.

Table I Predicted Flexural Strength

Mix	Infiltration Rate (m/s)	Remarks
Control (SP)	0.0177	Within range
0.1% SP	0.0097	Lower than control
0.2% SP	0.0203	Highest infiltration
0.3% SP	~0.0140	Estimated midrange
Control (PALF)	0.0119	Within standard range
1.0% PALF	0.0114	Slightly lower than control

Statistical Comparison

A paired t-test analysis was applied to compare control and fiber-reinforced mixes. Results showed no statistically significant difference ($p > 0.05$) between most control and reinforced mixes. While PALF and Snake Plant Fibers both improved compressive strengths, their influence on infiltration rate was statistically negligible. Overall, PALF showed greater structural benefits in compressive strength over time, whereas Snake Plant fibers demonstrated more favorable permeability performance at certain proportions.

Property	Comparison Groups	p-value	Interpretation
Compressive Strength	Control vs. Snake Plant (0.1–0.3%)	> 0.05	No statistically significant difference
	Control vs. PALF (1.0%)	> 0.05	No statistically significant difference, though PALF values were consistently higher
Infiltration Rate	Control vs. Snake Plant (0.1–0.3%)	> 0.05	No statistically significant difference, despite higher infiltration at 0.2% Snake Plant
	Control vs. PALF (1.0%)	> 0.05	No statistically significant difference

CONCLUSIONS

The study demonstrated that natural fibers can influence the performance of pervious concrete in terms of compressive strength and infiltration rate. Snake Plant fibers exhibited modest improvements in compressive strength, with the 0.3% mix showing the most favorable result at 28 days (8.93 MPa), surpassing the control. More notably, Snake Plant fibers enhanced permeability, with the 0.2% mix achieving the highest infiltration rate (0.0203 m/s), indicating its potential for drainage-critical applications.

In contrast, Pineapple Leaf Fiber (PALF) reinforcement showed a more significant effect on compressive strength, particularly at later curing ages. The 1.0% PALF mix reached 21.02 MPa at 28 days, outperforming the control (16.24 MPa) and nearly doubling the strength improvement observed in Snake Plant mixes. However, PALF slightly reduced infiltration compared to the control, though still within the standard pervious concrete range.

Statistical analysis confirmed that the differences between control and fiber-reinforced mixes were not statistically significant ($p > 0.05$), suggesting that while trends in strength and permeability were evident, they did not constitute strong statistical variations.

Overall, the results indicate that PALF is more effective for enhancing structural performance, making it suitable where higher compressive strength is required, while Snake Plant fibers are more effective for enhancing permeability, beneficial for applications where infiltration capacity is a priority. The selection between the two fibers should therefore be based on the desired balance between strength and permeability in pervious concrete design.

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