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Utilization of Plastic Polymers, Fish Waste, and Corn Husk Ash as Partial Additives in Sustainable Paver Blocks

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ABSTRACT:

Plastic and organic waste continue to be a concern because of improper disposal and limited waste management practices. With this, the study used plastic polymers, fish waste, and corn husk ash as partial additives in producing paver blocks. Three mixtures were prepared for the experimental treatments. T1 contained 80% cement, with 10% corn husk ash, 5% plastic waste, and 5% ground fish waste. T2 contained 75% cement, 10% corn husk ash, 5% plastic waste, and 10% ground fish waste. In T3, the mixture consisted of 65% cement, 15% corn husk ash, 10% plastic waste, and 10% ground fish waste. Before mixing, the fish waste was pre-treated with hydrated lime, while the plastic waste was washed and shredded and the corn husks were processed into ash. The paver blocks were evaluated through water absorption, drop, flexural strength, and compressive strength tests. Water absorption was 4.96% for T1, 17.26% for T2, and 5.88% for T3. During the drop test, T1 showed only minor cracks after the third drop, while T2 developed major cracks and T3 experienced partial breakage. The flexural strength of T1 was 6.55 MPa, compared with 6.82 MPa for T2 and 7.36 MPa for T3. For compressive strength, T1 recorded 16.50 MPa, followed by T2 at 15.00 MPa and T3 at 11.74 MPa. T1 also recorded the lowest water absorption among the experimental treatments, showed the least damage during the drop test, and had the highest compressive strength. T3, on the other hand, obtained the highest flexural strength but the lowest compressive strength. The differences observed across the tests were associated with the varying proportions of cement and waste materials used in the mixtures. The study supports the use of plastic polymers, fish waste, and corn husk ash as partial additives in paver block production and their potential use in construction.

Keywords: Paver blocks, Plastic polymers, Fish waste, Corn husk ash, Compressive strength, Flexural strength, Water absorption, Drop test, Sustainable construction materials

Introduction:

The construction industry contributes to infrastructure development and economic growth by providing materials used for roads, walkways, and other public facilities. Repurposing waste materials for construction can provide another use for discarded materials while addressing some of the waste generated in communities. The Department of Environment and Natural Resources (DENR) stated that the Philippines generates approximately 2.7 million tons of plastic waste every year. Around 20% of this plastic waste eventually reaches marine ecosystems, threatening biodiversity and environmental quality. The country also produces about 61,000 metric tons of solid waste daily. According to the Food and Agriculture Organization (FAO, 2021), fish heads, bones, and scales account for approximately 30%–70% of the total fish waste. In municipal hubs such as San Miguel, Bulacan, improper disposal of these biological materials can lead to bacterial decomposition, unpleasant odors, and public health concerns. Recent studies have examined the use of plastic polymers and processed biological waste in construction materials. Plastic waste can replace traditional sand or coarse aggregates and serve as a hydrocarbon-based binder that traps pollutants within a dense matrix (Lamba et al., 2022). Fish bones and scales can also be used as mineral additives because of their high calcium content (Ujwal & Kumar, 2026). The proposed paver block uses thermoplastic polymers, specifically LDPE, PET, and BOPP, together with calcium-rich fish waste from *Chanos chanos*, *Pterygoplichthys*, and *Oreochromis niloticus*, and agricultural Corn Husk Ash (CHA). Before incorporation into the mixture, the fish waste is pre-treated using a hydrated lime solution. According to Abubakar, et al., (2024), Polyethylene Terephthalate (PET) can partially replace natural aggregate in creating sustainable concrete and can be used for low-load-bearing structural applications. Using shredded plastic wastes as partial replacement along with fly ash in making paver blocks improves strength (Babar, et al., 2025). In the study conducted by Fauzan, et al., (2023), the researchers replaced 0%, 5%, 10%, and 15% of the sand with plastic waste. The results showed that adding plastic reduced the strength of the paving blocks. But even though the strength decrease, the paver blocks were still strong enough, they still meet the minimum standard of 12.5 MPa for Quality C paving blocks. Fishery by-products, particularly fish bones and fish scales, have gained increasing attention as sustainable mineral additives in cement-based construction materials due to their high calcium and hydroxyapatite content (Dineshkumar & Kirubakaran, 2025). Ground fish bone and fish scale powders improve the performance of cementitious composites by acting as micro-fillers that occupy microscopic voids between cement and fine aggregate particles, thereby enhancing particle packing density and reducing internal porosity (Oluchiri, 2022). One widely adopted method involves soaking the fish waste in a hydrated lime ($\text{Ca}(\text{OH})_2$) solution, which raises the pH to approximately 11 or higher, creating an alkaline environment capable of suppressing bacterial activity and reducing

odor-causing microorganisms (Putri et al., 2024). Following alkaline treatment, the fish waste is thoroughly rinsed with clean water, sun-dried for approximately 24 hours, and ground into a uniform powder. When used as a partial replacement for Portland cement, the amorphous silica present in CHA reacts with calcium hydroxide $[Ca(OH)_2]$, a by-product of cement hydration, through the pozzolanic reaction (Adugna et al., 2025). This reaction forms additional calcium silicate hydrate (C-S-H) gel, the primary compound responsible for the strength and durability of cement-based materials. Consequently, the incorporation of CHA enhances the resistance of paver blocks to sulfate, chloride, and acidic environments while minimizing drying shrinkage and crack formation (Suclupe et al., 2024). The study is also related to the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production).

Methodology:

The methodology of this study outlines the procedures used to determine the potential of plastic polymers, fish waste, and corn husk ash as partial additives in sustainable paver block production. It covers the preparation and processing of the experimental materials, the production of different treatment batches, and the testing of the developed paver blocks. Proper handling of the materials were observed throughout the conduct of the study.

Figure 1.

Flowchart of Activities

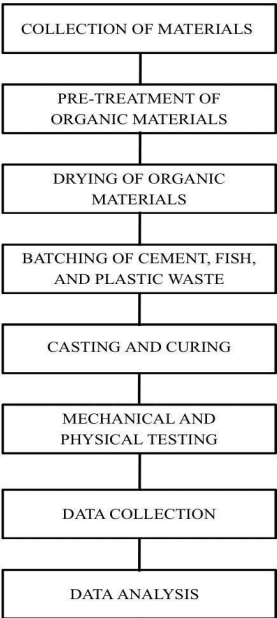


Figure 1 presents the sequence of procedures carried out in the study. The process began with the collection of the required materials, followed by the preparation of the fish waste, plastic waste, and corn husks for use in the paver block mixtures. The materials were then combined according to the specified treatment proportions and formed into paver block specimens. After the curing process, the developed specimens were evaluated through water absorption, drop, flexural strength, and compressive strength testing to assess their performance.

Collection of Materials

One kilogram of plastic waste, specifically LDPE, BOPP, and PET from food sachets and plastic bags, **was collected** in San Miguel, Bulacan. Then, one kilogram of fish waste from janitor fish, tilapia, and milkfish **was collected** by garbage collectors in San Miguel, Bulacan. One kilogram of corn husks, 500 grams of hydrated lime, and one sack of cement **were purchased** from a store in San Miguel, Bulacan.

Pre-Treatment of Organic Materials

The fish waste was pre-treated for two weeks using hydrated lime to eliminate fishy odors and help the fish waste decompose more slowly, then washed with clean water (Putri, W. E., et al., 2024). It was then carefully sun-dried under direct sunlight for approximately 24 hours and ground using a blender. To avoid contamination and moisture absorption, it was stored in waterproof bags.

The plastics were washed with clean water and dried before being shredded into small pieces suitable for mixing with cement (Olubunmi et al., 2023).

The corn husks were turned into ash by first being cleaned and then air-dried for 7 days. They were then burned in an oven until they turned dark gray. This process converted the organic material into fine ash rich in silica and other mineral oxides. After burning, the ash was allowed to cool naturally and then ground using a mortar and pestle. The ground ash was passed through a standard sieve to achieve a uniform particle size suitable as a partial cement replacement (Hailemariam, B. Z. et al., 2025).

Drying of Pre-Treated Organic Materials

After pre-treatment using hydrated lime and washing with clean water, the fish waste was carefully sun-dried under direct sunlight for approximately 24 hours. The drying process helped reduce the moisture content of the fish waste before further processing. After drying, the fish waste was ground using a blender to produce a finer material suitable for mixing with the other components. The ground fish waste was then stored in waterproof bags to minimize exposure to moisture and prevent contamination before being used in the preparation of the paver block mixtures.

Batching of Cement, Fish, and Plastic Waste

The study utilized four mix proportions for the production of paver blocks: T0 (100% cement) as the control treatment, T1 (80% cement, 10% corn husk ash, 5% plastic waste, and 5% fish waste powder), T2 (75% cement, 10% corn husk ash, 5% plastic waste, and 10% fish waste powder), and T3 (65% cement, 15% corn husk ash, 10% plastic waste, and 10% fish waste powder). These treatments were evaluated to determine the optimum mix proportion that provided the highest compressive strength and durability while promoting sustainable waste management.

Drying of Mixtures

The molds were left open for 24 hours before undergoing wet curing. This initial drying period allowed the mixtures to set and maintain their shape before the curing process. After 24 hours, the paver blocks underwent wet curing to support proper cement hydration and help reduce the formation of cracks. This process also helped improve the strength and durability of the paver blocks.

Data Collection

Once the curing period ended, we tested the physical and mechanical properties of the paver blocks across all treatment groups (T0, T1, T2, and T3). We measured water absorption, impact resistance (via drop test), flexural strength, and compressive strength. The flexural and compressive strength tests were carried out at the Sta. Maria Precision Construction Materials Testing Center. These tests provided the empirical data needed to evaluate whether combining plastic polymers, ground fish waste, and corn husk ash can serve as viable additives for eco-friendly paver blocks.

Data Analysis

We organized and tabulated the raw data to compare how each mixture performed. We analyzed water absorption rates, drop test survival counts, flexural strength (MPa), and compressive strength (MPa) to spot key trends and differences between the control group (T0) and the experimental groups (T1–T3). Finally, we ran statistical tests to see how replacing part of the cement with agricultural, plastic, and fishery waste impacted the blocks' structural integrity, strength, and overall performance.

Water Absorption Test

The water absorption capacity of the developed paver blocks was determined using a simple gravimetric method. Each specimen was first dried completely and weighed using a digital weighing scale to obtain its initial dry weight (W_1). The specimens were then immersed in water for a period of 24 hours. After soaking, the specimens were removed, surface-dried using a clean cloth, and weighed again to determine their saturated weight (W_2). The percentage of water absorption was calculated using the formula: $\text{Water Absorption (\%)} = [(W_2 - W_1) / W_1] \times 100$

$$\text{Water Absorption (\%)} = \left[\frac{W_2 - W_1}{W_1} \right] \times 100$$

Where W_1 was the dry weight of the specimen, and W_2 was the saturated weight after immersion, measured after twenty-four hours of soaking in clean water under controlled laboratory conditions before testing.

Drop Test (Impact Resistance Test)

The impact resistance of the paver blocks was evaluated through a drop test. Each specimen was dropped vertically from a predetermined height of 1 meter onto a hard concrete surface. The test was repeated for a specified number of trials or until visible cracks or failure occurred to determine the material's overall impact resistance performance.

Flexural Strength Test

The flexural strength of the developed paver blocks was determined through laboratory testing at Sta. Maria Precision Construction Materials Testing Center. The specimens were subjected to a gradually increasing load using a flexural testing machine until failure occurred. The maximum load sustained by each specimen before breaking was recorded and used to determine its flexural strength, which indicated the material's resistance to bending under different loading and environmental conditions.

Compressive Strength Test

The compressive strength of the developed paver blocks was also determined at Sta. Maria Precision Construction Materials Testing Center. Each specimen was placed in a compression testing machine, where a continuously increasing load was applied until the specimen failed or fractured. The maximum load sustained by the specimen was recorded and used to calculate its compressive strength, which reflected the material's ability to withstand compressive forces.

Objective:

1. To evaluate the water absorption and density of the eco-pavers across different formulation ratios and compare them to traditional concrete blocks.
2. To test the compressive strength, flexural strength, and drop impact resistance of the paver blocks to assess their structural integrity.
3. To determine the ideal proportion of fish waste to plastic polymers that achieves maximum strength and durability for practical use.
4. To assess the viability of upcycling LDPE, PET, BOPP, and organic fish waste to reduce local waste streams..

Results

This section presents the results obtained from the different tests conducted on the developed paver blocks containing plastic waste, ground fish waste, and corn husk ash as partial additives. The findings are organized and discussed according to the research objectives, focusing on the effects of the different treatment mixtures on the performance of the paver blocks.

1. Effect of fish waste as a filler on the water absorption rate and porosity of the paver blocks compared to traditional cement pavers.

The water absorption results are used to determine the differences in water absorption among the control and experimental treatments and to examine the effect of the varying material proportions.

Table 1

Water Absorption Test

Sample No.	Wet mass (kg)	Dry mass (kg)	Absorption (%)
T0	2.07	2.00	3.42
T1	2.22	2.12	4.96
T2	2.45	2.09	17.26
T3	2.15	2.03	5.88

Table 1 presents the water absorption results of the paver blocks containing varying proportions of corn husk ash, plastic waste, and ground fish waste. T0, which consisted of 100% conventional cement, recorded a water absorption of 3.42%. T1, composed of 80% cement, 10% corn husk ash, 5% plastic waste, and 5% ground fish waste, recorded 4.96% water absorption. T2, containing 75% cement, 10% corn husk ash, 5% plastic waste, and 10% ground fish waste, exhibited the highest water absorption at 17.26%. Meanwhile, T3, consisting of 65% cement, 15% corn husk ash, 10% plastic waste, and 10% ground fish waste, recorded 5.88%. These results show that T2 had the highest water absorption among the experimental treatments, while T1 and T3 exhibited considerably lower absorption values.

The results indicate that the proportion of the incorporated materials influenced the ability of the paver blocks to absorb water. The notably high absorption of T2 suggests that its combination of 10% corn husk ash, 5% plastic waste, and 10% ground fish waste may have produced greater accessible pore spaces within the mixture. Greater water absorption may indicate increased porosity or less compact internal structure, which can allow more water to enter the paver block and potentially affect its durability when exposed to repeated wetting and drying. In contrast, the lower absorption of T1 and T3 suggests that their particular material combinations may have resulted in a more compact structure or better pore filling. This is consistent with the study's basis that corn husk ash can provide silica that participates in cementitious reactions and may help seal internal pores.

The findings are generally consistent with Hailemariam et al. (2025), who investigated corn husk ash as a pozzolanic cement substitute and demonstrated that its incorporation can influence the properties of cement-based materials. The present results also agree with Dineshkumar and Kirubakaran (2025), whose study investigated fish scales as a bio-admixture for concrete, supporting the potential of fish-derived materials to influence the properties of cementitious mixtures. In addition, the study by Fauzan et al. (2023) on PET and LDPE plastic waste in paving blocks supports the finding that incorporating plastic waste can affect the physical and mechanical characteristics of paving materials. However, the present findings differ from a simple expectation that increasing the amount of corn husk ash would always increase water absorption, since T3 contained the highest CHA proportion at 15% but showed only 5.88% absorption, considerably lower than T2's 17.26%. This suggests that water absorption was influenced not by a single material alone but by the combined proportions of cement, corn husk ash, plastic waste, and fish waste in each treatment.

1. Effect of varying proportions of plastic waste, fish waste, and corn husk ash on the binding properties and drop resistance of the paver blocks.

The binding and drop resistance results are used to determine the differences in the ability of the paver blocks to maintain their structural integrity and resist breakage or damage under impact among the different experimental treatments.

Table 2

Drop Test

Sample No.	Drop Height (cm)	No. Of Drops	Condition After Test
T0	100	1	No Damage
T0	100	2	Minor Surface Crack
T0	100	3	Major Cracks
T1	100	1	No Damage
T1	100	2	Minor Surface Crack
T1	100	3	Minor Cracks
T2	100	1	No Damage
T2	100	2	Minor Surface Crack
T2	100	3	Major Cracks
T3	100	1	Minor Surface Crack
T3	100	2	Major Cracks
T3	100	3	Partial Breakage

As shown in Table 2, all paver blocks were dropped from a height of 100 cm or 1 meter for up to three times. After the first drop, T0, T1, and T2 showed no damage, while T3 showed a minor surface crack. After the second drop, T0, T1, and T2 developed minor surface cracks, while T3 showed a major crack. On the third drop, T0 and T2 developed major cracks, T3 experienced partial breakage, while T1 only showed a minor crack. Among the experimental treatments, T1 showed the best performance, while T3 showed the weakest result.

The results imply that the proportion of cement and alternative additives affected the impact resistance of the paver blocks. T1 contained 80% cement and 20% alternative additives, while T2 contained 75% cement and 25% alternative additives. T3 contained 65% cement and 35% alternative additives, which was the highest proportion of additives among the treatments. The weaker performance of T3 suggests that its higher amount of alternative additives and lower cement content may have affected its ability to withstand repeated impact.

These findings are comparable to Fauzan et al. (2023), who reported that increasing the amount of plastic waste generally reduced the strength of paving blocks. Their study found that higher plastic content made the blocks weaker, although they could still meet the required strength for certain applications. The present findings similarly show that the treatment with the highest proportion of alternative additives, T3, experienced the greatest damage during the drop test.

3. Effect of varying proportions of plastic waste, fish waste, and corn husk ash on the flexural strength of the paver blocks.

The flexural strength results are used to determine the differences in the ability of the paver blocks to withstand bending stress before failure among the different experimental treatments.

Table 3*Flexural Strength Test*

Sample No.	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Flexural Strength (MPa)	MD (KN)
T0	220.0	110.00	55.00	2,85.82	7.5	8.32
T1	220.0	110.00	55.00	2,120.15	6.55	6.60
T2	218.0	110.00	55.00	2,093.32	6.82	6.88
T3	212.0	110.00	55.00	2,036.50	7.36	8.01

Table 3 presents the flexural strength of the paver blocks produced using different proportions of cement, corn husk ash, plastic waste, and ground fish waste. Among the experimental treatments, T3 records the highest flexural strength at 7.36 MPa, followed by T2 at 6.82 MPa, while T1 records the lowest value at 6.55 MPa. The results indicate that the flexural strength varies across the different mixture proportions. T3, which contains 15% corn husk ash, 10% plastic waste, and 10% ground fish waste, records the highest flexural strength among the experimental treatments. In contrast, T2, which contains 10% corn husk ash, 5% plastic waste, and 10% ground fish waste, records the lowest value.

The differences in flexural strength may be associated with the varying proportions of materials used in each treatment. Hailemariam et al. (2025) report the potential of corn husk ash as a pozzolanic material and as a partial cement substitute. Similarly, Pratiwi et al. (2023) investigate the use of fish bone waste as a cement substitute in concrete. These studies support the use of agricultural ash and fish-derived waste as alternative materials in cement-based composites. Babar et al. (2025) also examine the incorporation of waste plastic in paver block production, demonstrating its potential application in paving materials.

The higher flexural strength recorded by T3 may be related to its particular combination of additives. T3 contains the highest proportions of corn husk ash and plastic waste among the experimental treatments, together with 10% ground fish waste. Although T2 also contains 10% ground fish waste, it has lower proportions of corn husk ash and plastic waste and records the lowest flexural strength. This difference suggests that the proportion and combination of the additives may influence the flexural performance of the paver blocks. Thus, the results indicate that the mixture proportions play an important role in the flexural strength of the developed paver blocks.

4. Effect of varying proportions of plastic waste, fish waste, and corn husk ash on the compressive strength of the paver blocks.

The compressive strength results are used to determine the differences in the ability of the paver blocks to withstand compressive loads before failure among the different experimental treatments.

Table 4*Compressive Strength Test*

Sample No.	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Compressive Strength (MPa)	MK (KN)
T0	220.0	110.00	55.00	2,85.76	21.00	508.20
T1	220.0	110.00	55.00	2,127.00	16.50	399.30
T2	219.0	110.00	55.00	2,096.60	15.00	361.35
T3	212.0	110.00	55.00	2,036.50	11.74	271.25

Table 4 presents the compressive strength of the paver blocks produced using different proportions of cement, corn husk ash, plastic waste, and ground fish waste. T0, which served as the control treatment, recorded the highest compressive strength at 21.00 MPa. Among the experimental treatments, T1 recorded 16.50 MPa, followed by T2 at 15.00 MPa, while T3 obtained the lowest value at 11.74 MPa.

The results show that the compressive strength differed across the treatments based on the proportions of materials used. The results suggest that the amount of cement and alternative materials affected the ability of the paver blocks to withstand compression. T1 contained 80% cement and 20% alternative additives, while T2 contained 75% cement and 25% alternative additives. T3 had the lowest cement content at 65% and the highest proportion of alternative additives at 35%. The lower compressive strength observed in T3 may be related to its reduced cement content and greater amount of corn husk ash, plastic waste, and ground fish waste. This pattern indicates that the balance between cement and the added materials is important in producing paver blocks with better compressive strength.

These findings agree with Pratiwi et al. (2023) and Babar et al. (2025), who reported the potential use of fish waste and plastic waste as alternative materials in cement-based and paving products. The results also show that using these materials in different proportions can lead to differences in the strength of the finished product. In this case, the treatment with the highest proportion of alternative additives, T3, recorded the lowest compressive strength, while T1 performed better among the experimental treatments.

Conclusion

The study showed that plastic polymers, fish waste, and corn husk ash have potential as partial additives in paver block production. Differences were observed among the treatments in water absorption, impact resistance, flexural strength, and compressive strength. The lowest water absorption among the experimental treatments was 4.96%, which was obtained by T1. T3 recorded the highest flexural strength among the three treatments at 7.36 MPa. For compressive strength, the highest value was 16.50 MPa in T1, followed by 15.00 MPa in T2 and 11.74 MPa in T3. The waste materials used in the study therefore have potential for incorporation as partial additives in paver block production. However, the proportions of the materials still need further improvement to obtain better strength and durability.

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