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Compressive strength and cost analysis of concrete hollow blocks with upcycled plastics as replacement for choker aggregates

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Abstract

This study was conducted to test the compressive strength of concrete hollow blocks (CHBs) prepared from four treatments, with 0%, 1%, 2%, and 3% proportion of upcycled plastics as partial replacement to choker aggregates, find out which proportion is the most acceptable in terms of compressive strength, and ascertain the economic cost of CHBs for each proportion. Randomized Complete Block Design (RCBD) was utilized where the four proportions with upcycled plastics were replicated three times and cured in 28 days. The Universal Testing Machine (UTM) was utilized to test the CHBs compressive strength. Results showed that the control treatment had comparable features with the other treatments. It got the highest mean unit weight and compressive strength while Treatment C had the lowest in both aspects. Since the minimum standard compressive strength for CHBs is 1.50 MPa, the control and all treatments passed the standard compressive strength. However, the control treatment was the most acceptable of the four proportions having the highest compressive strength. As to cost, the CHBs prepared with 0% upcycled plastics had the lowest price, with Treatment C getting the highest expense value. With these findings, it can be deduced that the properties of CHBs are affected by the different proportions of aggregates used as mixture substitutes.

Keywords: *concrete hollow blocks, compressive strength, upcycled plastics, choker aggregates, Randomized Concrete Block Design (RCBD)*

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1. Introduction

Plastic waste has become an environmental problem throughout the world much more in the Philippines. The National Solid Waste Management Commission (NSWMC) reported that there is a total of 30,000 tons per day of solid waste in the Philippines. In addition, 500 to 700 grams of solid waste per day is generated by each person living in urban areas and 300 grams in rural areas. Of these numbers, plastics account for 17% of total solid waste generated in the country. As a consequence, landfill areas are required to dispose of the waste generated. A large volume of plastic waste is discarded or burned which leads to the contamination of the environment and air (Singh et al., 2017).

Several options have been forwarded and implemented to resolve this concern. One of the possible solutions to this problem is recycling. As reported, 8.4% of plastic waste is recycled in the Philippines. As the quantity of waste generated increases yearly, it is vital to find ways to recycle these wastes. Recycling plastic has advantages since it is widely used worldwide and has a long service in life where plastic wastes are collected and removed from the waste stream (Madlangbayan et al., 2017). Recycling and upcycling are environment-friendly practices that should not only be within the hands of the fabricators but should also be taught to other stakeholders in the community – students, country folks, and the general population if our intention is not only to reuse what needs to be recycled and at the same time save the environment. The large volume of materials required for construction materials is potentially a major area for the recycling of waste materials. Concrete mixed with plastic wastes has become the subject due to its significance in helping alleviate solid waste problems. The use of waste plastics in infrastructure has been tried and reported (Singh et al., 2017). Actions taken by the Philippine government to reduce the dumping of plastic waste in the environment included the practice of recycling. The Bulacan-based company, The Green Antz Builders, Inc. has experimented with using bricks added with plastic waste in their infrastructure construction. Because of its result, this was adopted by the local government units, schools, and companies in the Philippines (Galang, 2018).

With the boom in the Philippine construction industry propelled by the Build! Build! Build (BBB) program of the Duterte administration, the annual growth rate of this sector rose to 9.2% in 2022 (Siman, 2023), and by 3.5% based on the initial Philippine Statistics Authority (PSA) in 2023 (Ballard, 2023). But this also boosted the increase in the construction materials wholesale price index (CMWPI), averaging 8.3% in 2022, faster than the increase in 2021 which was only 3.2%. Even with the zero-tariff policy of the Philippine government on cement imports, its prices continue to go up (Aldaba, 2010). Thus, there is a need to identify alternatives that are not only costly but also eco-friendly (Dy, 2022). Along this line, an innovation would be a welcome option. The discovery of alternatives to commercial cement could ease the production cost of masonry or hollow blocks. The introduction of a new mixture limiting the use of commercial cement may also decrease its cost. Al-Tarbi et al. (2022) recommended the use of waste materials such as rubber and plastic particles in the production of concrete blocks not only to reduce power consumption and thermal conductivity but also to reduce carbon dioxide pollution in the world.

Considering these scenarios, this study aims to establish the mass and compressive strength of concrete hollow blocks (CHBs) when mixed with different proportions of upcycled plastics as partial replacements for choker aggregates. Likewise, this would find out if a significant difference in compressive strength in three proportions of CHBs exists, as well as determine the most acceptable proportion of CHBs with upcycled plastics, and finally come up with the cost analysis of said products mixed with upcycled plastics. With this, it is hypothesized that no significant difference in the compressive strength of concrete hollow blocks (CHB) with upcycled plastics would be established.

2. Literature Review

2.1. Recycled Wastes as Concrete Additive and Compressive Strength of Hollow Blocks

Concrete hollow blocks (CHBs) used in building constructions are usually made from sand and cement. Lately, however, there were variations introduced in the market as substitutes due to the spiraling cost of cement. These were either the proportions of materials differentiated or mixtures other than cement introduced.

Binag (2016) found that powdered aquatic animal shells, such as those from oysters, mussels, and mollusks, can be used as a substitute for Portland cement as these have similar properties, particularly in compressive strength. But according to Lejano et al. (2019), the strength of CHB with the addition of plastic waste additives (PWA) decreases. It was also shown that the decrease due to the 2.5% of plastic waste aggregates can be augmented by mussel shell (MS) and fly ash (FA). It was concluded based on the results of the study that partial cement replacement with FA or MS increased the compressive strength of CHB even with plastic waste aggregates.

The study of Madlangbayan et al. (2017) indicated that polypropylene (PP) was pelletized and incorporated in concrete hollow blocks as a partial replacement for sand to test the compressive strength. Moreover, there were five batches of specimens, each with 0%, 10%, 20%, 30%, and 40% PP replacement per volume were molded and cured for 28 days and determined and compared the compressive strength and bulk density. The results showed that compressive strength and bulk density decreased as per percent replacement increased. However, it was observed that the compressive strength of the specimens from the batch with 10% PP replacement was higher compared to the batch with 0% PP replacement. Conversely, when crumb rubber aggregates are mixed with fine aggregates in different proportions, the fabricated concrete hollow blocks did not meet the standard minimum requirements of the National Structural Code of the Philippines (NSCP) on compressive strength of conventional load bearing. As proportions are increased the compressive strength is reduced (Cabahug et al., 2016).

According to De Jesus et al. (2017), concrete beams with shredded plastics had a slightly higher compressive strength of 22.24 MPa versus 21.82 MPa, and tensile strength of 4.25 MPa versus 3.95 MPa, and flexural strength of 6.39 MPa versus 5.56 MPa than plain concrete. In addition, their study showed the applicability of elastic flexural theory to concrete beams with plastic.

Singh et al. (2017) studied the properties of bricks manufactured by mixing sand and waste plastics. The results of sand plastic bricks are compared with those of traditional local bricks. It was observed that the sand plastic bricks have low water absorption, low apparent porosity, and high compressive strength. Likewise, Waroonkun et al. (2017) tested the density and compressive strength of concrete blocks when fine aggregates were replaced by plastic bottle flakes. Based on the experiments, the study indicated that the concrete blocks with plastic flakes replacing sand in the mortar mix at a ratio of 20% by weight, can be used in the construction of a non-load-bearing wall. Many of the blocks in the study had a compressive strength slightly higher than the maximum standard value (2 MPa).

Safinia and Alkalbini (2016) examined the possibility of using plastic bottles in concrete blocks to create voids at an equal distance between them in masonry units. The study utilized 500mL plastic bottles placed inside the concrete masonry units to analyze their compressive strength. It used the ASTM C140 standard to test the compressive strength and the result showed that 57% of strength was improved by using plastic bottles compared to local concrete blocks. On the other hand, Dutta et al. (2016) experimented with the use of waste plastic bottles as cellular reinforcements with fly ash in fabricating hollow blocks. The study emphasized the use of waste plastic bottles in civil engineering applications. The fine fly ash based on the study appeared to be an effective infill material. The use of coarse stone aggregates as infill material produced better load-carrying capacity as the composite cells increased. The study confirmed that plastic bottles with suitable infill material can act as an ideal compression member.

When coarse aggregates are partially replaced in different proportions of expanded polystyrene (EPS) in hollow blocks fabrication, and tested as to granulometric composition, specific mass unit, surface analysis, water absorption, and compressive strength. Fabiche and Minillo (2023) have established that hollow blocks showed satisfactory results in surface analysis, had almost similar performance in water absorption, had not had significant changes in mass and dimensional variability but had met the standard compressive strength requirements.

Further, the study of Praveen et al. (2016) used non-biodegradable materials to test the effect of plastic aggregates on the compressive strength of concrete blocks. The study compared the strength of solid concrete blocks with ordinary concrete blocks. The compressive strength of solid concrete blocks with plastic aggregates is slightly lesser than that without replacement while the optimum percentage of substitution of coarse aggregates with plastic aggregates gives maximum compressive strength of 15%. In addition, comparing the cost of solid concrete blocks with plastic as a partial replacement and without replacement, the cost of the former is lower than the latter when made in a large quantity.

Muyen et al. (2016) used polyethylene terephthalate (PET) bottles as bricks to test the compressive strength. According to the result of the study, the compressive strength of bottle bricks increased with the size of the bottle. Among the five different sizes of waste, PET bottle bricks were tested and filled with fine sand, the largest bricks gave a compressive strength of 17.44 MPa. Moreover, the 9-bottle brick cubes gave a compressive strength of 35 MPa and 12 bottle bricks gave a compressive strength of 33.7 MPa. These bottle brick-filled cylinders exhibited double the compressive strength of conventional cylinders.

According to Jibrael and Peter (2016), the compressive strength indirect tensile strength, and modulus of rupture are found to be decreased with increasing percentages of the waste plastic bottles and waste plastic bags. Furthermore, when percentages of the waste plastic bottle are increased from zero to 5% of the sand in the mix, the compressive strength and tensile and flexural strength of concrete are found to increase by 4.1% at 7 days age of curing, and also the concrete strength decreased by ratios 7.93, 28.6 and 23.6% at 28 days of curing.

Shiri et al. (2015) in India revealed that waste plastics are effectively converted into useful building materials like bricks, interlocks, roof tiles, railways sleepers, paving slabs, retaining blocks, using either single-origin plastic waste material or a mixture of different plastic wastes along with waste rubber powder as filler. It was observed that the maximum compressive load sustained by the polypropylene/rubber composite brick was 17.05 tons followed by LDPE/rubber composite brick with 16.55 tons which is much higher than the clay brick which sustained only 9.03 tons after conducting the study with the variety of plastic wastes processed into composite brick. Meanwhile, Wonderlich (2014) utilized plastic bottles in concrete building constructions and found that the plastic bottle that contains recycled plastic increased the compressive strength of the masonry unit because harder plastic bottles created an internal force. Moreover, the diameter of the bottles was greater, creating less net area for compressive force.

In an interview with GMA-7 last July 14, 2008, City Engineer Cris Roxas of Mandaluyong City said "*The by-product of the plastic waste-brick cement will then be used for the beautification of city pavements. Plastic materials are very good binder for cement and sand*". This was the same finding of Shoubi et al. (2013) that in different factors such as time of execution, cost, load capacity, flexibility, reducing waste, and energy efficiency, plastic bottles can be more effective compared to some conventional building materials such as brick, concrete, and ceramic block.

2.2. Cost of Concrete Hollow Blocks Mixed with Recycled Additives

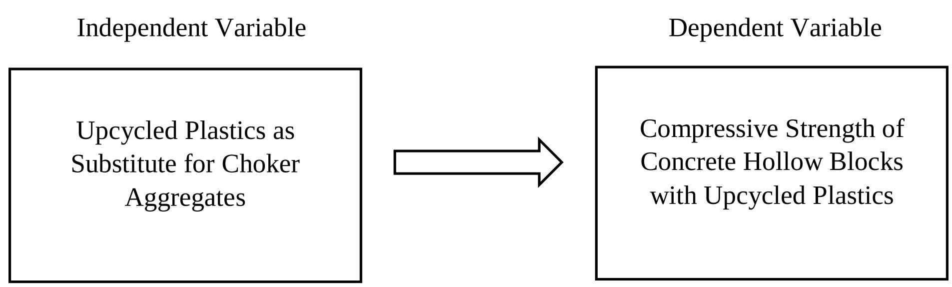
In 2020, the cost of the normal CHB in the Philippines was P11.58 per piece while those mixed with 5% rice husk (RH) was P11.48, and with 10% RH was P11.37. This means that even if the compressive strength of CHB is affected by the mixture of RH, the cost is less than the normal CHB (Ignacio et al., 2020). The same observation by Araya et al. (2016) was highlighted when they found out that CHB with 100% recycled crushed concrete (RCC) was 18.24% cheaper than the normal block. In India, Shekhar and Godihal (2024) concluded that using recycled concrete aggregate and fly ash as replacements for conventional materials can decrease the cost by 17%. Indeed, the cost of concrete hollow blocks mixed with solid waste aggregates is very competitive with the price of regular cement (Al Fakhoury et al., 2021).

2.3. Theoretical framework

The theory of micromechanics was used as the reference for this study, particularly in testing the compressive strength of the fabricated CHB. This theory was developed for both homogenization predicting the macroscopic properties, and de-homogenization, or predicting the stress and strain fields within the microstructure. This is necessary for evaluating the strength of heterogeneous materials like the mixture proportions in CHB fabrication (Peng & Yu, 2018).

Figure 1

The compressive strength of concrete hollow blocks (CHB) as influenced by upcycled plastics



3. Methodology

3.1. Research Design

The experimental method of research was used in this investigation where there is time priority in a causal relationship, consistency in a causal relationship, and the great magnitude of the correlation. The experimental design specifies an experimental group and a control group. In this research, experiments have control, randomization, and manipulation (Kabir, 2018).

The Randomized Complete Block Design (RCBD) was used as an experimental design where standard designs for experiments in which similar experimental units are grouped into blocks or replicates. It is used to control variation in an experiment with defining features of the RCBD in which each block sees each treatment exactly once (Ullah, 2019).

The data from the treatments were analyzed using percentage, mean, and standard deviation, and Kruskal Wallis to determine the significant difference of compressive strength in three proportions as descriptive and inferential statistical tools, respectively. The acceptability of the null hypothesis was set at a 0.05 level of significance.

To describe the mass of CHB based on the Department Order 230 Series of 2016 of the Department of Public Works and Highways (DPWH), the parameter was categorized as follows:

Description	***Mass (kg)***
Lightweight	Less than 11.50
Medium weight	11.50 to 13.50
Normal weight	13.50 up

The compressive strength of concrete hollow blocks might be described as meeting or not meeting the minimum compressive strength of 1.50MPa for non-load bearing according to *construction.org*.

To determine the Return on Working Capital (ROWC) as an economic indicator, the formula used is:

$$ROWC = \frac{Net\ profit}{Production\ Cost}\ x\ 100$$

3.2 Materials

The CHBs under study are products of mixed materials and fabricated using implements and procedures described as follows:

Table 1

Proportion of raw materials for different treatments

Treatment	**Percentage of Upcycled Plastics and Choker Aggregates (%)**		**Water (L)**	**Shredded Plastic (kg)**	**Cement (kg)**	**Aggregates (kg)**	
	Upcycled Plastics	**Choker Aggregates**				**Fine Sand**	**3/8" Choker**
Control	0	100	9	0	20	40	80
A	1	99	9	0.8	20	40	79.2
B	2	98	9	1.6	20	40	78.4
C	3	97	9	2.4	20	40	77.6

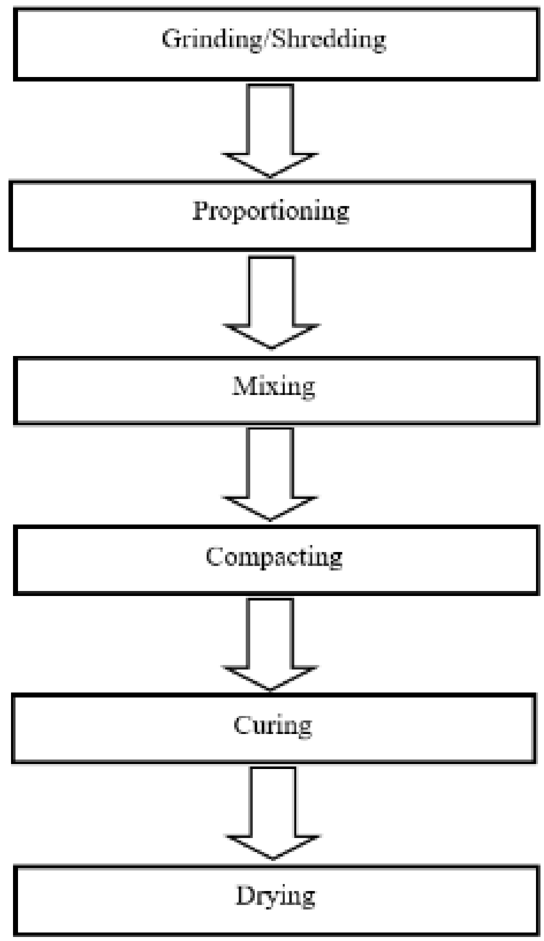
3.3. Masonry Tools and Equipment

The masonry tools and equipment used in fabricating CHBs were pails, pallets, weighing scales, shovels, coco lumber, and hollow block molding machines.

3.4. Processing and Fabrication in Experiment Stages

Figure 1

Process flowchart in the fabrication of concrete hollow blocks (CHB)



The production of the CHB was conducted at a hollow block fabrication site located in Brgy. Pook Tugbungan, Kalibo, Aklan, and the finished products were tested using the Universal Testing Machine (UTM) at the Terms Concrete and Material Testing Laboratory, Inc., located in Makato, Aklan, Philippines. Field notes were used throughout the study to record all the materials, tools, equipment, and procedures utilized including observation from Day 1 of the experiment up until the compressive strength testing of CHBs.

Standard-size CHBs were used as test specimens whose mixtures were composed of cement, fine sand, choker aggregates, water, and upcycled plastics cured for 28 days.

Upcycled plastics replaced a certain volume of choker aggregates by weight at different levels of percentage with a constant volume of cement and water ratio. The standard concrete masonry unit dimensions set by the National Building Code of the Philippines and National Structural Code of the Philippines for non-load-bearing walls with dimensions 4” x 8” x 16” was utilized as a basis for determining the compressive strength of the products.

Pre-experimental stage. At this stage, a junkshop with a plastic crusher machine, a hollow block fabricator, upcycled plastics (polyethylene terephthalate/PET), and other raw materials for fabricating CHB were identified. All tools and equipment were prepared and ensured that these were in good condition.

For the Control group, the proportion was 9 liters of water, 20 kilograms of cement, 40 kilograms of fine sand, 80 kilograms of choker aggregates, and no upcycled plastics. For Treatment A, the proportion was 9 liters of water, 20 kilograms of cement, 40 kilograms of fine sand, 79.2 kilograms of choker aggregates, and 0.8 kilograms of upcycled plastics. For Treatment B, the proportion was 9 liters of water, 20 kilograms of cement, 40 kilograms of fine sand and 78.4 kilograms of choker aggregates, and 1.6 kilograms of upcycled plastics. And, for Treatment C, the proportion was 9 liters of water, 20 kilograms of cement, 40 kilograms of fine sand and 77.6 kilograms of choker aggregates, and 2.4 kilograms of upcycled plastics.

Experimental stage. At the beginning of the experiment, plastic bottles were shredded into smaller pieces using a plastic crusher. The shredded upcycled plastics were sent to the materials testing processor to ensure that the upcycled plastics were in exact sizes before the conduct of the study. Afterwards, sieving analysis was performed to determine the gradation or distribution of aggregates.

The first step in CHB fabrication was the determination of suitable amounts of raw materials needed to produce the concrete of desired quality under given conditions of mixing, placing, and curing. This process is known as proportioning. The next step was mixing where all raw materials and different proportions of upcycled plastics with a constant volume of cement and water ratio were mixed manually until cement water paste completely covered the surface of aggregates. The treatments, including the control group, were prepared and conducted to ensure the consistency of the result.

After the cement water paste had completely covered the surface of the aggregates, the process of compacting was done where the cement water paste was molded on the platform of the molding machine ensuring that the formwork was clean before pouring the mixture. The concrete should be well compacted through joggling and pounding to make sure that the air is trapped in the concrete. The excess mixture was leveled off using coco lumber. The molded CHBs were then removed in a pallet to the curing yard.

The compacted CHBs were kept moist by regular spraying of water for 28 days to obtain sufficient strength. All the CHBs were carefully identified and labeled to avoid confusion and were exposed to the heat of the sun during the curing stage. When curing was over, the CHBs were allowed to dry out gradually in the shade to complete the initial shrinkage before they were subjected to testing.

Post Experimental Stage. After 28 days of curing and drying, the CHBs were subjected to testing. The CHBs were tested through the Universal Testing Machine (UTM) to measure the weight and compressive strength of each treatment. The results of the test for both the control and experimental groups were recorded, tabulated, and analyzed using appropriate statistical tools.

4. Findings and Discussion

The descriptive and the inferential data analyses, such as the mass and compressive strength of concrete hollow blocks are presented and discussed in detail, as follows:

Mass of CHBs. Table 2 shows the mean mass of every treatment of concrete hollow blocks in different proportions.

Table 2

Concrete Hollow Blocks' Mass (kg)

Treatment	Replication			Mean	Descriptive
	I	II	III	(kg)	Rating
Control Group	11.565	11.286	11.230	11.36	Lightweight
Treatment A	11.498	10.308	11.315	11.04	Lightweight
Treatment B	11.725	10.754	10.693	11.06	Lightweight
Treatment C	10.940	10.252	10.289	10.49	Lightweight

Note: *13.50kg up = Normal weight

Table 2 shows that the control group had the highest mean mass of 11.36 kilograms while Treatment C had the lowest mean mass of 10.49 kilograms. Treatment B and Treatment C had almost the same mean mass with 11.04 kg and 11.06 kg, respectively. This indicates that the mass of CHBs in all treatments is lightweight which conforms with Department Order 230 Series of 2016 of Department of Public Works and Highways (DPWH) Standard Specification for Item 1046-Masonry Works, including weight classification of non-load bearing concrete hollow blocks, at 13.50 kg as normal weight. This result supports the finding of Cuartero and Villanueva (2016) that despite the percentage of substitution is increased, the weight of the CHBs remains normal. Further, Fabiche and Minillo (2023) established that there were no significant changes in the mass of CHBs when coarse aggregates were partially replaced by expanded polystyrene (EPS).

Compressive strength of CHBs. Table 3 shows the mean of the compressive strength of concrete hollow blocks in different proportions.

Table 3

Concrete Hollow Blocks' Compressive Strength (MPa)

Treatments	Replication			Mean (MPa)	Descriptive Rating
	I	II	III		
Control	5	5	4	4.67	Meets minimum compressive strength
Treatment A	4	2	2	2.67	Meets minimum compressive strength
Treatment B	4	2	2	2.67	Meets minimum compressive strength
Treatment C	2	2	2	2.00	Meets minimum compressive strength

Note: *1.50MPa = Minimum Compressive Strength

The results showed that the control group had the highest compressive strength with a mean of 4.67 MPa while Treatment C had the lowest compressive strength with a mean of 2.00 MPa. The compressive strength of Treatments A and B were equal.

Since the minimum compressive strength is 1.50 MPa according to The Constructor (2022), it could be deduced that the control group, Treatment A, Treatment B, and Treatment C passed the minimum compressive strength. Hence, the most acceptable proportion of concrete hollow blocks is the control group having the highest mean compressive strength of 4.67 MPa.

The result supported the study of Waroonkun et al. (2017) on concrete blocks where fine aggregates were replaced by plastic bottle flakes. The said study concluded that the non-load-bearing concrete blocks are useful for construction which has a compressive strength standard value of 2.00 MPa. On the other hand, the result on the compressive strength of concrete hollow blocks with 0% of upcycled plastics contradicted the study of Madlangbayan (2017) which stated that the compressive strength of concrete hollow blocks with pelletized polypropylene increases as per percent replacement compared to 0% replacement.

Differences in compressive strengths of CHBs. Table 4 shows the result of the significant difference in compressive strength of concrete hollow blocks.

Table 4

Kruskal Wallis Test of the compressive strength

	Kruskal-Wallis		
	χ^2	df	p
Compressive Strength	7.33	3	0.062^{ns}

Not significant at 0.05

The table showed that the Kruskal Wallis Test of the compressive strength is equal to p = 0.062, which is below the level of significance (p = 0.05). This can imply that the concrete hollow blocks with upcycled plastics can be a good replacement for the commercial hollow blocks in the market. This product can also be used in building constructions such as wall partitions and concrete fences. Therefore, the null hypothesis which states that there is no significant difference in compressive strength of concrete hollow blocks (CHB) with upcycled plastics is accepted.

Most acceptable proportion of CHBs. Given the minimum compressive strength of 1.50 MPa of non-load-bearing concrete hollow blocks by constructor.org., all treatments have resulted in acceptable compressive strength. The result showed Treatment C had the lowest compressive strength of 2.00 MPa, while the control had the highest with the compressive strength of 4.67 MPa. Hence, the control was the most acceptable proportion among the treatments in terms of compressive strength.

This result is dissimilar to the findings of Dolores et al. (2020) where mixing 10% low-density polyethylene (LDPE) pellets as a replacement for sand, the compressive strength of the CHB is increased. However, for Musalamah et al. (2016) the minimum proportion of 1:5 (cement to sand) was proven to have quality compressive strength.

Cost analysis of CHB. Table 5 presents the data on the price per concrete hollow block prepared at different proportions of upcycled plastics as a partial replacement for choker aggregates. The total expenses for raw materials and other costs in preparing concrete hollow blocks are also reflected in the same table.

Table 5

Return of Working Capital (ROWC) of Concrete Hollow Blocks

	Treatments			
	Control	**A**	**B**	**C**
A. Materials				
Cement (kg)	122.50	122.50	122.50	122.50
Fine Sand (kg)	12.26	12.26	12.26	12.26
Choker (kg)	15.00	14.85	14.70	14.55
Water (L)	-	-	-	-
Upcycled Plastics (kg)	-	20.00	40.00	60.00
Sub-Total A	149.76	169.61	189.46	209.31
B. Other Expenses				
Labor	20.00	20.00	21.42	21.42
Sub-Total B	20.00	20.00	21.42	21.42
Total Cost (A+B)	169.76	189.61	210.88	230.73
Total Yield (pc)	15	15	14	14
Price per pc.	12.22	13.64	16.34	17.88
Total Sales	183.30	204.60	228.76	250.32
Net Profit	13.54	14.19	17.88	19.59
ROWC (%)	7.98%	7.48%	8.47%	8.49%

This implies that the price of concrete hollow blocks with upcycled plastics per proportion is slightly more expensive compared to the commercial hollow blocks in the market. According to Cabarle (2023), the cost of an ordinary non-load-bearing concrete hollow block with the size of 4”x8”x16” is 12.50 pesos per piece. However, this economic analysis is different from the finding established by Al Fakhoury et al. (2021) that when cement is added to solid waste aggregates, the cost becomes very competitive and marketable. Furthermore, the result shows that the price per piece of concrete hollow blocks is identifiably related to the proportion of upcycled plastics in concrete hollow blocks.

5. Conclusion

Based on the findings, it can be deduced that the different proportions of concrete hollow blocks on the composition of materials in the fabrication of concrete hollow blocks resulted in varying mean scores but did not affect the mass. Generally, the CHBs with upcycled plastics in all treatments including the control group passed the minimum compressive strength of 1.50 MPa. This indicated that the concrete hollow blocks replacing choker aggregates at 1-3% by weight can be used in the construction as a non-load-bearing concrete hollow block. Although statistical tests showed that the compressive strength of concrete hollow blocks was not significant, the increase in compressive strength is a testament that the partial replacement of upcycled plastics for choker aggregates from 1% to 3% by weight is not detrimental to the strength properties of concrete.

As to the ROWC, it can be concluded that the more the upcycled plastics are incorporated in concrete hollow blocks, the higher the ROWC. This implies that the higher the return, the more expensive the price of concrete hollow blocks per piece becomes. Thus, concrete and manufacturing industries may consider the use of concrete blocks using upcycled plastics as part of construction materials in projects as the compressive strength and price are comparable with the commercial hollow blocks. They may also venture into the production of said concrete blocks using upcycled plastics to encourage backyard economy, recycle wastes, and help in the conservation of the environment.

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