Polyethylene Terephthalate (PET) Bottles Filled with Treated Paper as an Alternative for Concrete Hollow Blocks for Wall Partition in Low-Cost Housing Construction

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***Abstract*: This research provides an overview of studies on the use of Polyethylene Terephthalate (PET) bottles and paper as a construction material. The most common waste materials are PET bottles and papers, which pose significant environmental challenges. Since the PET bottles and papers have been recycled and used in different materials, the bottles could be an additional component to hollow blocks known for its durability and strength. The research investigates the efficacy of PET bottles and papers as building materials, either as additives in various building materials or as independent components. It also focuses on the use of recycled materials as an alternative-materials in construction to reduce cost and could provide high strength materials in the construction applications. Understanding how well PET bottles and papers work has led to a study of these materials' individual progress; nonetheless, some issues remain unresolved and require more improvements such as material cost production. This review seeks to provide more and deeper knowledge of these materials to be more cost-effective and support the environment to be more-greener as recycling has been considered as well as the product are in high performance in terms of building usage and applications.**

***Keywords*: Alternative Hollow Block, ASTM C129, Concrete Hollow Blocks (CHB), Eco-bricks, Low-cost housing, Polyethylene Terephthalate (PET), Wall Partition, Mismo Bottle, Cutting Paper, Disposal.**

1. Introduction

As of year 2021, according to the National Solid Waste Management Commission (NSWMC) and the Officials of the Department of Environment and Natural Resources (DENR), the Philippines is producing solid waste beyond the capacity of current waste management capabilities. The Philippine population of over 100 million people produces more than 21 million metric tons of trash annually. "In 2019 alone, the Philippines produced a total of 214,265,676 metric tons of rubbish" (LBPPublished, 2021). Plastic bottle waste in the Philippines represents a significant portion of the country's SOLID trash. Polyethylene makes up the majority of the waste plastic, followed by Polyethylene terephthalate, or "PET" (Siddique et al., 2008). Another large portion of this trash problem is paper product waste and disposal. The Philippines' yearly per-capita usage of paper approximately 13 kg. Due to the limited space in landfills and growing expenses associated with disposal, recycling is becoming more and more important. To reduce the impact of growing consumption and consequential increase in production of recyclable waste this study is introduced. The modified CHB blueprint would aim to use waste materials design in construction to reduce production cost as well as environmental damage. Because plastics are used so extensively, their amount in solid trash is always rising (Siddique et al., 2008).

The primary objective of this research is to evaluate the mechanical properties and compressive strength of the modified PET Concrete Hollow Blocks as well as water absorption and density, to be tested by the Department of Public Works and Highways (DPWH). This study aims to answer questions about fibrous contributions to CHB mixtures, similar to the findings referenced below: "The fact that adding fibers to concrete reduces its workability to the point where fewer fibers are added is actually a disadvantage" (Foti, 2013).

A. Conceptual Framework

This section illustrates the flow of the experimental input, process, and output of the study. The conceptual framework of this study is presented below:

Figure 1 shows the conceptual framework of the study, outlining the progression of the experimental procedure. The study examines the strength of plastic bottles with paper inside of it through the compressive test and construction of wall partition for low-cost housing. The Polyethylene terephthalate "mismo" bottle that will be used. The PET bottles that will be collected are used bottles from trash within the province of Aurora, and the paper will come from the residue paper from the researchers.

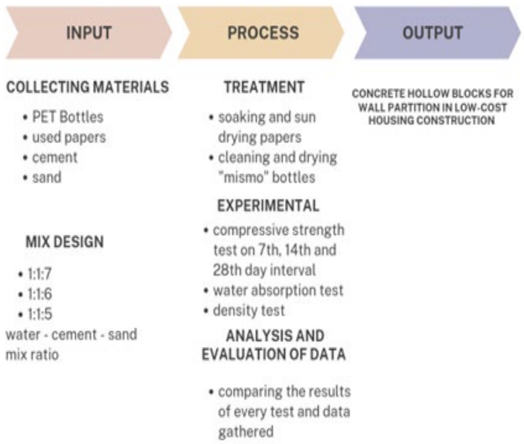


Fig.1. Conceptual Framework of the Study

The process includes the creation of a sample that is varied depending on the ratio of the needed material. The experimental approach included a compressive strength test and a water absorption test. The desired output phase outcome of the study is a concrete hollow block (CHB) for wall partitions in low-cost construction.

B. Statement of the Problem

This study aims to determine the viability of plastic bottles filled with treated papers as an alternative for Concrete Hollow Blocks in creating wall partition of a low-cost housing construction, and also to address the following queries:

1)What are the mechanical properties of polyethylene terephthalate bottles filled with treated papers in terms of :

- Compressive test
- Density
- Water absorption

2) What is the significant difference of using of ordinary Concrete Hollow Blocks (CHB) and alternative Concrete Hollow Blocks (CHB) using Polyethylene terephthalate “mismo” bottles and papers in terms of material cost production, construction and customer services?

3) What is the best ratio of cement and sand for alternative concrete hollow block (CHB) to increase its mechanical strength?

C. Scope and Limitations of the Study

This research focuses on alternative materials for construction that can result in cost-effective and sustainable options. Plastic bottles filled with paper are explored as an alternative to Concrete Hollow Blocks (CHB). The primary materials used in the study are waste plastic bottles and used paper. Specifically, the researchers will only use the “mismo” bottles for the uniform sizes of samples. Material gathering took place exclusively in Baler, Aurora. Testing followed the specifications and standard methods of the American Standard Test Methods for Nonloadbearing Concrete Masonry Units (ASTM C129). The alternative Concrete Hollow Blocks was tested solely in compressive strength testing, density and its water absorption to identify significant differences between ordinary and alternative Concrete Hollow Blocks. The study was carried out exclusively at the Aurora State College of Technology Campus and at the Department of Public Works and Highways (DPWH) in Riserva, Aurora.

2. Review of Literature Review

This chapter presents and discusses the literature studies gathered related to the research studies. This presents the findings and the data obtained from different articles, journals, and previous research.

A. Discussion

1) Classification of Polyethylene Terephthalate Bottles

Coca-Cola Philippines introduced Coke Mismo, a new product for the local market, in 2013. It came in a 300-milliliter (10-ounce) PET bottle and was introduced at a star-studded event attended by local celebrity endorsers and stars from the popular television show Glee (Mongabay et al., 2019). According to a brand audit assessment by an anti-plastic campaign, Coca-Cola was the leading source of plastic waste in the Philippines by 2018 and has done so again this year. The 300 ml mimso bottles are used in the production of the alternative hollow blocks which will serve as the braces inside to have an additional tensile and compressive strength. Thus, the 300 milligram (10 ounce) "mismo" PET bottles—such as those from Coca-Cola, Sprite, Royal, and other brands with comparable sizes—were the particular kind of bottles used in this study. They proved that the PET bottles have distinct strength and capacity to resist deformation when filled with different materials (Sybridge Technology, n.d.).

2) Mechanical Properties of Polyethylene Terephthalate (PET) Bottles as an Alternative Material for Concrete Hollow Blocks

PET is a polymer consisting of ethylene glycol and terephthalic acid, two materials that are combined to create hard plastic pellets (Karayannidis & Achilias, 2007). In addition to being lightweight, sturdy, and recyclable, Polyethylene Terephthalate bottles are favored for numerous applications because of their safety (Raheem et al., 2019). The polyethylene terephthalate bottles have chemical properties. Non-Intentionally Added Substances (NIAS) include breakdown products of monomers, additives, and/or contaminants present during the initial polymerization process that are not included in this rule. Reactants could exist in the wall of a PET bottle. Recycled PET may also contain unidentified chemical substances that are present in water. Each of these materials could move at some point from the wall of PET bottles to water bottles (Bach et al., n.d.).

3) Cleaning Process of the 295 milligrams "mismo" Bottles as an Additional Materials for Alternative Concrete Hollow Blocks

The bottles are further classified based on their size, material composition, and condition to make sure only clean and recyclable bottles are picked. Clean water is used to rinse the sorted bottles on a preliminary basis for the removal of huge amounts of dirt, dust, and residues sprawled all over. This is a very important step as substratum that could disturb the intensity of the CHB mixture is removed. A solution of warm water and a mild detergent is used on these bottles for around 30 minutes for soaking in order to dissolve oils, chemicals, and other sticky materials. Bottles are brushed or sponged all over for better cleanliness, and to further enhance the cleaning, the soft brush or sponge can be used to scrub the interior and exterior of every bottle. Bottles are soaked in either a water and bleach solution or vinegar disinfectant for 15 - 20 minutes so as to eliminate bacteria, fungi, and any potential contaminants. This method guarantees the bottle is sanitized and safe for the construction venture.Cleaning is followed by disinfection, where the bottles are thoroughly rinsed with clean water to get rid of detergent and disinfectant. To enhance the binding process with cement, the bottles are air dried in a well-ventilated area devoid of moisture.

Table 1
Mechanical Properties of Polyethylene Terephthalate Bottles and the Concrete Hollow Blocks

Materials	Characteristics/ Properties	Key Results	Citations
Polyethylene Terepthalate Bottles Concrete Hollow Blocks	Tensile strength: 11,500 psi Flexural modulus of elasticity: 400,000 psi Tensile elongation: 70% Shore hardness: D 87 Excellent insulation properties, both thermal and acoustic. Lightweight and durable.	To increase the strength of the "mismo" bottles, it can be filled with various materials as gravel, sand, concrete, plastic, and paper. Increasing the compressive strength capacity	(Sybridge Technology, n.d.) (Yesilata et al., 2009) (Rahman et al., 2021) (Gopi et al., 2020) (Taaffe et al., 2014)

Table 2
Cleaning Process of the "MISMO" Bottles

CLEANING PROCESS OF THE 295 ml "MISMO" BOTTLES	DESCRIPTION	KEY RESULTS/ CHALLENGES	CITATION
Selection of the "mismo" bottles	Selecting the desired type and sizes of the bottles specifically the 295 milligrams "mismo" bottles.	The hollow blocks' standard size would be paired with the 295 ml "mismo" bottles.	(Polygalov et al., n.d.)
Wash the bottles with water	To remove the dirt inside and out of the bottles.	To prevent the contamination of the paper infilled material	(Ahmed, 2023)
Drying up the bottles	Placing the bottles under the sun to easily dry.	To avoid gaps, the cement would adhere flawlessly to the bottles when dry.	(Sarwar et al., 2023)

4) Benefits of Polyethylene Terephthalate Bottles and Paper as Construction Materials in terms of Production Cost

The use of paper-filled "mismo" bottles as an additional material for concrete hollow block has the advantage of lowering the price of housing construction. The used polyethylene terephthalate bottles, like the 295 ml mismo bottles will be recycled that will be to reduce the cost of buying new raw materials. Also, polyethylene terephthalate bottle is strong, transparent, lightweight, and environmentally friendly it would benefit not only the researchers but also the environment (Sybridge Technology, n.d). The use of fillers and mortar is reduced when concrete hollow blocks are replaced with mismo bottles. Similar to regular hollow blocks, the bottles are coated with cement to create bricks, but this method conserves cement. When comparing the production costs of making concrete hollow blocks versus mismo plastic bottle bricks, it may be determined that plastic bottle bricks are more economical. Plastic bottle bricks made of polyethylene terephthalate bottles can be used as insulation, water resistance, and thermal protection. (Dadzie & Kaliluthin, 2022).

Table 3
A comprehensive analysis of the literature reviews

Impacts	Details	Study	Citation
Waste Reduction	Reusing PET bottles recycles plastic waste and minimizes plastic going into landfills.	PET bottles in buildings reduce landfill-bound waste by utilizing them as a building material.	Rachmawati, I., et al. (2020). Sharma, P., & Kumar, V. (2022). Reddy, A. M., & Gupta, A. (2021).
Reduction in Carbon Emissions	Recycling of PET bottles needs less energy to make compared to new plastic and concrete production, resulting in lowered carbon footprint.	PET recycling gives off less greenhouse gas emissions when compared to plastic production and making concrete.	Sharma, P., & Kumar, V. (2022). Rachmawati, I., et al. (2020). Reddy, A. M., & Gupta, A. (2021).
Energy Efficiency	PET bottles use less energy to process for building compared to the high energy requirements of steel and concrete manufacture.	Research suggests that construction with recycled PET is much less energy-intensive than using conventional materials.	Sharma, P., & Kumar, V. (2022). Rachmawati, I., et al. (2020). Singh, R., et al. (2020).
Thermal Insulation	PET bottles have the potential to offer thermal insulation characteristics, enhancing the energy performance of buildings.	PET wall dividers provide insulation characteristics that are able to decrease heating and cooling energy requirements.	Singh, R., et al. (2020). Sharma, P., & Kumar, V. (2022). Rachmawati, I., et al. (2020).
Chemical Risk	PET can emit toxic chemicals in the long run if not treated appropriately, which can have potential environmental and health hazards.	Leaching of PET can be problematic if it is not sealed or treated properly prior to its use in construction.	Ali, M., et al. (2021). Reddy, A. M., & Gupta, A. (2021). Sharma, P., & Kumar, V. (2022).

5) Impact on the environmental sustainability of using PET Bottles in Constructing Wall Partition as an Alternative for Concrete Hollow Block

Since plastic goods are increasingly common in the packaging industry, it is important to produce packaging materials in an environmentally responsible and sustainable manner to maintain a clean and balanced ecosystem (Sarwar et al., 2023). Plastic garbage is becoming a bigger environmental concern these days due to its slow rate of decomposition and tendency to cause issues such as clogging sewer pipes, flooding waterways, filling landfills, and health issues. Recycling and reusing plastic garbage are the best course of action. Day by day, plastic manufacturing rises, but relatively little of it is recycled. However, the building sector has a significant demand for concrete using recovered plastic trash to partially replace fine aggregate in the creation of sustainable concrete (Gopi et al., 2020). According to Sharuddin, plastics have been instrumental in advancing people's standard of living worldwide for more than 50 years. Due to plastic, numerous new advancements have only been made possible in a number of industries, such as construction, packaging, industrial uses, and medical and healthcare facilities (Haque & Islam, 2021).

B. Research Gap

A comprehensive analysis of the literature reviews was conducted, and the gaps in the publications are listed below.

Table 4
Research Gaps

No.	Research Gaps
1	Additional infilled materials such as sand, plastic, paper, concrete etc.
2	The PET bottles used could only resist 5 KN load. Use another infilled material.
3	The average strength of the 500 ml (about 16.91 oz) pet bottles could only resist up to 2.88 and 3.29 N/mm². Use bigger sizes of PET Bottles
4	Use the proper amount of cement and the design of the concrete mix
5	More laboratories test

Developing Polyethylene terephthalate bottles with different infilled materials as an alternative for concrete hollow block are essential and cost-effective in creating wall partition. It gives additional strength to the bottles that could resist deformation. By recycling polyethylene terephthalate bottles and treated paper, trash that would otherwise wind up in landfills is diverted from the ongoing production of plastic bottles and used to construct wall partitions. The search for environmentally friendly building materials, the use of treated paper in concrete hollow blocks, and polyethylene terephthalate bottles all show positive effects on the environment while meeting the need for creative and well-built structures.

3. Methodology

This part of the study explains all the details of the process and methodologies done by the researchers to carry out and answer the research questions.

A. Flowchart of Research Design

This section of the study outlined the procedures or processes that were followed with the aim of producing alternative concrete hollow blocks using "mismo" bottles filled with treated papers.

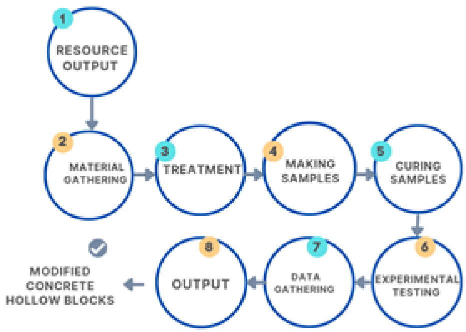


Fig.2. Flowchart of Research Design

Figure 2 simplifies the research process, ranging from developing alternative concrete hollow blocks (chb) using Polyethylene terephthalate bottles specifically "mismo" bottles filled with papers. Gathering materials, such as used plastic bottles, used paper, gravel, and cement, in Baler, Aurora. The process of treating plastic bottles involves cleaning and soaking in water until it become pliable. The bottle will be filled with treated papers, which will be compacted. For the experiment measuring water absorption, density and compressive testing. The researchers will create 18 samples total, 6 samples for each of the following days (7th, 14th, and 28th day). On such days, data collection and gathering will take place. To create alternative concrete hollow blocks (chb), the test results are analyzed.

B. Research Process

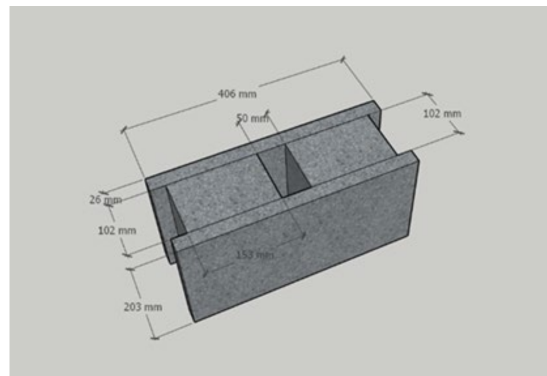
Preparation of materials
- Collecting PET bottles
- Collecting old/used Papers
- Portland Cement
- Screen Sand

Materials Treatment
- Cleaning Mismo Bottles
- Soaking and Drying of Paper

Creating Alternative Concrete Hollow Blocks Process
- Filling the Mismo Bottles with Treated Papers
- Weight of 1 bottle filled with paper = 0. 072 kg
- Weight of 8 bottle filled with paper for 1 sample= 0.576
- Sand needs to be retained on a 0.075-mm (No. 200) sieve

Modified CHB

. Mix Design
1) Mix Design 1: using 1:1:5 water-cement-sand
2) Mix Design 2: using 1:1:6 water-cement-sand
3) Mix Design 3: using 1:7 water-cement-sand



Specimen Details

1) Sample (1:1:5)
- Water = 0.011975 cu.m
- Cement = 0.011975 cu.m
- Sand = 0.058757 cu.m
- Treater Paper = 1.944 kg
- Plastic Bottles = 0.648 kg

2) Sample 2 (1:1:6)
- Water = 0.0113783 cu.m
- Cement = 0.0113783 cu.m
- Sand = 0.0628695 cu.m
- Treated Paper = 1.944 kg
- Plastic Bottles = 0.648 kg

3) Sample 3 (1:1:7)
- Water = 0.00931401 cu.m
- Cement =0.00931401 cu.m
- Sand = 0.0651978 cu.m
- Treated Paper = 1.944 kg
- Plastic Bottles = 0.648 kg

4. Result and Discussion

This chapter discusses the results of the laboratory testing that was done on the development of modified concrete blocks.

A. Compressive Strength Test

The researchers conducted a compressive strength test at the DPWH-Quality Section. The test was important to ascertain the amount of compression that the concrete hollow blocks can withstand and to understand how they could be used in construction projects for specific purposes. The findings from the 7th day, 14th day and 28th day compressive strength test.

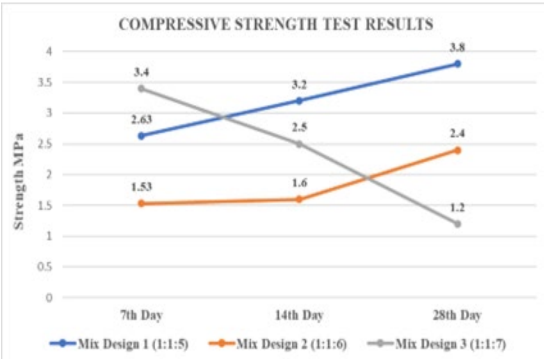


Fig.3. Compressive Strength Result

Mix design 1 emerges on top in terms of strength gain over time, having the highest 28-day compressive strength (3.80MPa). This reveals the most reliable mix for structural use. Although mix design 2 still improves with time, it maintains the lowest strength throughout the entire duration. Mix design 3 shows rather unusual trend. It has the highest early strength (7-day: 3.4MPa) but loses a significant amount of strength later which indicates either poor long-term performance or material instability.

B. *Density Test*

Finding the concrete hollow blocks' density was crucial because it aided in projects where weight was a concern and with certain building elements that had weight limitations. Following oven drying of the 28-day-cured samples in accordance with the DPWH Standard Specification for Item 1046.2.6, the table displays the tabular representation of data from the density test of concrete hollow blocks.

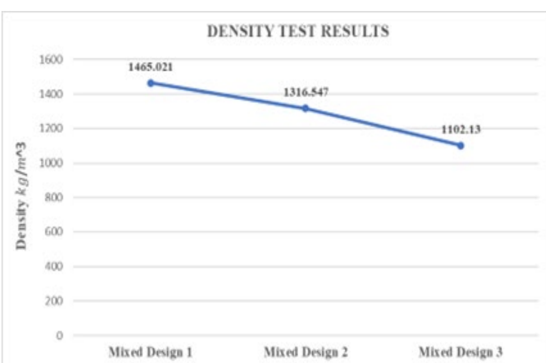


Fig.4. Density Test Results

Figure 3 shows the average densities of three concrete mix designs classified as lightweight concrete. Mix Design 1 weighed averagely at 1465.021 kg/m³, implying that it is less dense than normal concrete and, therefore, suitable for applications requiring reduced structural load.

Mix Design 2 showed a lower value of 1316.547 kg/m³, increasing its lightweight concrete characteristics compared to Blend 1. Mix Design 3 has the lowest average density of 1102.13 kg/m³ which makes it the lightest among the three. These values which are lighter than the previous ones indicate that the material composition was designed to achieve different grades of concrete in terms of weight, most likely for performance optimization regarding specific structure or insulation needs.

C. *Water Absorption Test*

The researchers employed the water absorption test, which involves direct observation, to ascertain the susceptibility of unsaturated concrete to water penetration. The results of the water absorption test for modified concrete hollow blocks are displayed in the table below. The ASTM Maximum Water Absorption Standard was applied.

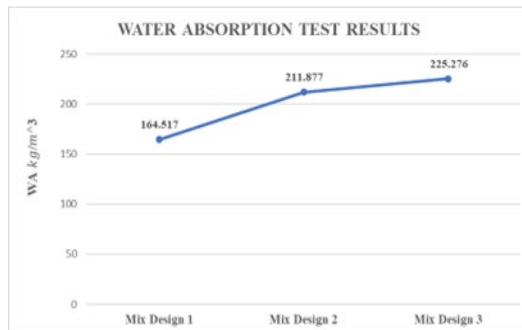


Fig.5. Water Absorption Test Result

The graph also depicts the average water absorption results for the three concrete mix designs recorded from 0 to 250 kg/m³, according to the data presented in the table. It demonstrates the same tendencies with respect to changes. From the graph, it is also visible that there is an increase in water absorption from Mix Design 1 (164.517 kg/m³) to Mix Design 3 (225.276 kg/m³). Despite this increase, however, the results from all three mixes remained under 250 kg/m³ – meaning all three mixes did, in fact, surpass the water absorption test and met standard requirements for performance.

D. *Materials and Cost Production*

The current materials used to produce concrete hollow blocks using modified concrete hollow blocks as a partial substitute for conventional concrete hollow blocks are broken down in Table 9 along with the corresponding quantity requirements and costs. 30 kilograms of Portland cement, .864 kg of used plastic bottles, 4 sacks of screened sand, and 7 kg of used papers were used to make 18 pieces of concrete hollow blocks. The total cost of the materials, including labor, came to Php319.32. Because the experimentally created concrete blocks had a selling price of Php18, including the incentives (OCM, profit, and VAT), the price of creating modified concrete hollow blocks was therefore the same as the market Price.

Table 5

Materials and Cost Production

Item no.	Description	Unit	Quantity	Cost (php)	Total cost (php)
I. Material Cost					
1	40 kg Portland Cement	kg	40	212	212
2	Screened sand	kg	1	30	30
3	Plastic bottles	kg	1	5	15
4	Used papers	kg	1	3	3
II. Production Cost of 6" mofified chb samples					
5	40 kg Portland Cement	kg	30	212	156
	Screened sand	sack	4	30	120
	Plastic bottles	kg	.864	5	4.32
	Used papers	kg	7	3	21
	Labor	pcs	18	1	18
Cost per 6" pcs chb					319.32
Sub-total cost of 1 chb					18
6	Overhead, Contingencies, and Miscellaneous (OCM)	15% of the cost			2.7
7	Profit	10% of the cost			1.8
8	Value Added Tax (VAT)	5% of the cost			0.9
Total					23.4

Table 6

Construction Cost

Item no.	Description	Unit	Quantity	Cost (php)	Total cost (php)
I. Construction Cost of Using 6" modified chb					
1	Concrete hollow blocks	kg	1030	18	18540
2	sand	cu.m	1.2627	380	479.828
3	cement	bags	7	212	1484
Total					**20503.828**
II. Construction Cost Using Commercially Available Concrete Hollow Blocks					
1	Concrete hollow blocks	kg	1030	18	18540
2	sand	cu.m	1.4057	380	534.166
3	cement	bags	8	212	1696
Total					**20770.166**

E. Construction Cost

According to Table 6, estimating modified concrete hollow blocks for comparison with standard concrete hollow blocks is one of the study's goals. To ascertain the overall dimensions and area of the concrete hollow blocks component, a floor plan with elevations and sections can be created. The cost comparison of concrete blocks used in building construction: 1,030 pieces of concrete blocks were needed. Accordingly, the commercially available concrete blocks cost Php18.00 per unit, whereas the experimentally produced concrete blocks cost Php18.00 per unit. The redesigned concrete hollow blocks can reduce the overall cost by using less cement and sand because plastering is not needed totaling Php20503.828. As a result, employing modified concrete hollow blocks was more affordable and practical than using the conventional blocks that are sold in stores.

5. Summary of Findings, Conclusion and Recommendation

This chapter gives the summary of the study, the conclusions drawn from the findings of the study, and the recommendations based on the conclusions arrived at.

A. Summary of Findings

In the search for environmentally friendly building materials, the use of treated paper and mismo PET bottles in CHB forms, shows positive and promising effects on the environment while meeting the need for creative and well-built structural materials. The testing of its mechanical properties including compressive testing, density and water absorption was conducted to evaluate their instantaneous state of damage and its resistance to compressive pressure. The compressive strength of 295 mL plastic bottles was found to be beneficial to the structural integrity of the building unit. Offering increased compressive capabilities and resilience to thermal change. The ASTM Standard for Maximum Water Absorption was used during the water absorption to determine how susceptible unsaturated concrete is to water penetration. The behavior of the alternative CHB after the three test meets the standard allowable compression, the exact amount of water penetration and considered as a lightweight hollow block.

B. Conclusions

- Mix design 1(1:1:5) and 2(1:1:6) both meet the standards for allowable compression, while mix design 3's compressive strength decreases.
- The 6" CHB cost Php18.00 in construction supplies; as well, the Alternative CHB design had a cost of Php 18.00 and effectively consumed a portion of the plastic and papers waste.
- The alternative CHB design offers greater insulating properties beyond that of traditional CHB and is concluded to be a low-cost option for housing construction.
- As a result, employing modified concrete hollow blocks was just as cost-effective and affordable as using the regular blocks that are sold in stores.
- Among the three samples, Sample 1 has a higher content of water.
- We come to the conclusion that PET bottle filled CHB design is more labor-intensive.

C. Recommendation

For future researchers who wish to replicate or extend this study for further improvement and development, the researchers would like to recommend the following;

- In making concrete hollow blocks, it needs to be arranged properly, especially the bottles, because they get damaged faster if they are not arranged properly or evenly.
- Consider the effects of expansion on the bottle, recommend testing with punctured bottle against the results of this study.
- In terms of curing, there should be a proper place so that it does not affect the strength of the concrete hollow blocks to avoid rain.
- Use an alternative sand to save money, high grit sand is recommended.
- We recommend that the materials for the CHB are already prepared and complete, this is necessary for reducing material acquisition time.
- Cutting papers or fibrous products without soaking them could provide similar result and also reduce test time requirements.
- We recommend developing a procedure for properly compact the materials in order to reduce or prevent voids, in both the concrete mold, and the PET bottle forms.
- Upon experiencing trial and error, we discovered that it "may" be necessary or beneficial to apply used oil to the concrete hollow blocks mold so that it can be easily removed from the mold. This could vary with different mixtures or grades of sand used in the CHB form.

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