Pulverized Glass and Plastic Bottles as an Alternative for Lightweight Non-Load Bearing Concrete Blocks

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***Abstract*: This study explores using pulverized glass and shredded plastic bottles as partial replacements for fine aggregates in lightweight, non-load bearing concrete blocks. With growing glass and plastic waste posing environmental risks, the research evaluates sustainable alternatives for the construction sector. Concrete mixes with varying replacement levels (10%– 90%, 30%–70%) were tested following ASTM and BS standards for strength, density, and water absorption. Results show that up to 30% waste replacement reduces unit weight by 25%, maintains acceptable compressive strength (optimal at 20%), and improves water resistance. The study confirms the technical and environmental feasibility of incorporating such waste in concrete, promoting sustainable construction and circular economy practices.**

***Keywords*: Alternative building materials; Concrete blocks; LEGO bricks; Low-cost construction.**

1. Introduction

The Philippines generates approximately 14.66 million tons of solid waste annually, with a large portion attributed to the construction industry [1]. This sector significantly contributes to environmental pollution and climate change due to the extensive use of materials like concrete, steel, and wood, which consume vast energy and resources while producing considerable waste [2]. Urbanization, population growth, and higher living standards further drive the rising waste volume. As a response, recycling is being explored as a viable solution. It involves collecting, processing, and reusing materials that would otherwise end up in landfills [3]. By incorporating recycled materials into construction, such as pulverized glass and shredded plastic bottles, it is possible to reduce reliance on natural resources, cut waste generation, and lower greenhouse gas emissions.

In this study, the researchers aim to design lightweight, non-load-bearing concrete blocks using 100% recycled aggregates without sand. These blocks are modeled after LEGO bricks, utilizing a tube-and-stud system that allows the blocks to interlock firmly without needing mortar [4]. The project investigates both the advantages and limitations of using pulverized glass and plastic bottles as alternative aggregates. This initiative not only seeks to address the growing issue of construction waste but also promotes sustainable building practices. Additionally, the researchers consider the integration of supplemental cementitious materials (SCMs) and industrial waste to further lessen the environmental impact of concrete production [5]. Ultimately, this study contributes valuable insights into the practical application of recycled materials in environmentally friendly construction.

A. Scope and Delimitation

The focus of this study is "Pulverized Glass and Plastic Bottles as Alternative Aggregate for Lightweight Non-Load Bearing Concrete Blocks." This study centers on the utilization of pulverized glass and plastic as alternative aggregate and includes an in-depth examination of the physical, and mechanical properties of these materials to assess their suitability for lightweight non-load- bearing concrete blocks. This study will not cover variable control, time constraints, or economic fluctuations. Furthermore, the researchers intend to only use bottles with Polyethylene Terephthalate (PET) for plastic bottles and soda-lime-silica glasses for glass materials. All materials will be collected within the premises of Baler, Aurora, Philippines. The study's applicability to some construction scenarios, such as building houses, is limited by its concentration on non-load-bearing concrete blocks. The results will only be used as a theoretical approach and may not be immediately relevant to load-bearing constructions. Further study may be required to determine whether alternative aggregates are feasible for use in load-bearing applications.

B. Framework of the Study

Figure 1 displays the research study's input, procedure, and results. Initially, the materials needed, including plastic bottles, glass bottles and jars, cement, and water, will be gathered by the researchers. Upon assembling all required materials, the researchers will experiment with various mix ratios to ascertain the optimal and most productive ratio to employ. The second aspect of the process is where the product is developed, and tested, data from the test is analyzed, and test results are evaluated. In conclusion, the result clearly denotes the accomplishment of the endeavor to create a lightweight concrete block using plastic and glass fragments as substitute aggregate.

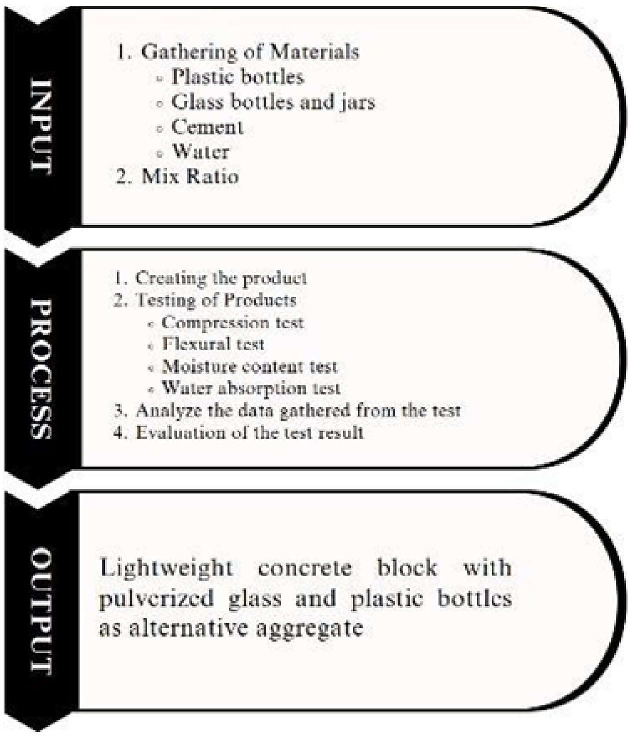

Fig. 1. Conceptual framework of the research

C. *Statement of the Problem*

One issue that Central Aurora is dealing with is its waste as a result of the growing population of its area. The use of recycled matter in building materials is one of the strategies to lessen the impact of the construction industry on the environment. The study produced an innovative way to lessen the issue.

1. What is the most efficient and effective ratio of pulverized glass and plastic bottles as an alternative aggregate for lightweight non-load-bearing concrete blocks?
2. What are the cost differences between producing lightweight concrete blocks with traditional aggregates and those with pulverized glass and plastic, considering the following:
   a) Material Costs
   b) Production Expenses
3. What are the mechanical properties and physical properties of using alternative aggregate for making concrete blocks in terms of:

Mechanical Properties
a) Compressive strength
b) Moisture content
c) Water absorption

Physical Properties
d) Mass
e) Durability
f) Malleability

2. Review of Related Literature

Modern construction utilizes a range of materials such as structural steel, in-situ concrete, and precast components. Despite advancements, environmental concerns persist due to the accumulation of plastic and glass waste in landfills and through illegal dumping. As part of a movement toward sustainable construction, researchers are investigating the reuse of these materials to reduce environmental impact. The construction industry, once a leading source of pollution, is gradually adopting greener technologies [6]. Research indicates that recycling plastic and glass can reduce landfill volumes and energy consumption. For instance, PET plastic waste has shown promise as a partial replacement for fine aggregates in self-compacting concrete, achieving strengths over 35 MPa [7]. However, plastic's non-biodegradability still poses pollution risks, especially to aquatic ecosystems [8], [9], [10].

Glass, known for its aesthetic and energy- efficient qualities, is also being evaluated for use in concrete mixtures [11]. Crushed glass has been tested as a replacement for natural aggregates, but issues like Alkali-Silica Reaction (ASR)—which leads to swelling and internal pressure from silica gel—pose durability challenges [12], [13], [14]. Studies on concrete incorporating 10–40% waste glass have explored compressive strength, tensile strength, and overall durability [14]. While the environmental benefits of reusing plastic and glass in construction are evident, ongoing research is necessary to fully assess their mechanical properties and long-term stability. This paper further examines these aspects by addressing environmental concerns like plastic additive leaching and the structural performance of recycled aggregates in concrete mixtures.

3. Discussion

A. *Concrete Blocks as Building Materials*

Research shows that substituting plastic waste and glass for traditional aggregates in concrete often leads to decreased mechanical strength and durability compared to standard concrete. This review outlines existing studies on incorporating waste materials into Ordinary Portland Cement

(OPC), noting both the potential environmental benefits and performance drawbacks [15]. The construction industry, which consumes large amounts of natural resources—such as sand, limestone, and quarried aggregates that make up 60– 70% of concrete volume—faces increasing pressure to adopt more sustainable practices [16]. Although recycled aggregate concrete typically underperforms compared to its natural counterpart [16], enhancements like alccofine can improve workability due to its ultra-fine particles, while additives like glass fibers may impair concrete flow [16]. Meanwhile, Portland slag cement has emerged as a greener alternative, providing superior long- term performance and reducing environmental impact [16].

Various studies have explored how different levels of recycled aggregate replacement affect concrete properties.

Recycled concrete aggregates often have higher water absorption rates [17] and increased abrasion values [18] due to the residual old mortar, which limits their use in structural applications and relegates them mainly to sub-base layers in road construction [19]. Nonetheless, findings suggest that concrete mixes combining both recycled coarse and fine aggregates can achieve comparable strength and elasticity to natural aggregate concrete, provided the particle size distribution remains unchanged [18]. These results highlight the potential for balancing sustainability and performance in future construction materials.

1) *Alternative Aggregates Using Plastic*

Plastic waste management failure contributes significantly to plastic pollution, with improper disposal methods such as incineration and landfilling exacerbating environmental issues [8]. The construction industry has increasingly turned to using plastic waste as a partial replacement for aggregates, offering both environmental and cost benefits [20]. However, as the percentage of plastic waste in concrete mixes increases, both fresh and hardened state properties tend to decline, although these mixes can be used for low workability applications [7].

Research has shown that replacing up to 40% of sand with plastic waste increases compressive strength, split tensile strength, and flexural strength, and up to 55% replacement yields mechanical strength comparable to normal concrete [21]. Additionally, plastic bottles used as admixtures in cement-sand brick production improve compressive strength and reduce water absorption, with larger plastic sizes leading to better performance [22]. Furthermore, recycled plastic aggregates, such as those made from polyolefin and polyethylene terephthalate, have shown improved interaction with binders and fire resistance properties [23]. The overall potential for plastic waste in construction materials is still under investigation, with various studies assessing its mechanical and durability properties [10].

2) *Alternative Aggregates Using Glass*

Waste glass has gained attention as a sustainable alternative material in concrete production, serving as a partial replacement for both fine and coarse aggregates, and even as a substitute for cement due to its pozzolanic properties [24]. Incorporating recycled glass into concrete not only improves certain mechanical properties but also reduces CO_2 emissions associated with cement production [11]. Studies on concrete bricks demonstrate that replacing up to 20% of fine aggregate with waste glass enhances compressive strength and lowers water absorption [25]. Similarly, the use of crushed glass in cement- stabilized fly ash bricks has shown strength improvements, albeit not always matching the performance of control samples [26].

Further research highlights the benefits of waste glass in paving blocks, with fine aggregate replacements of up to 45% showing no detrimental effects on compressive strength [26]. Particle size is a key factor—smaller glass particles reduce porosity and enhance overall strength [27]. In fired clay bricks, the inclusion of waste glass positively influences firing shrinkage, bulk density, and compressive strength, particularly with finer particles [28]. Additionally, substituting sand with waste glass has consistently improved compressive strength and decreased water absorption in various types of concrete and brick materials [14]. These findings suggest that, when used properly, waste glass can enhance both the performance and sustainability of construction materials.

B. *Mechanical and Physical Properties of Concrete*

1) *Physical Properties*

The integration of plastic and glass as alternative aggregates in concrete commonly results in a reduction in unit weight and overall density, primarily due to the inherently lower densities of these materials compared to conventional aggregates. Research has demonstrated that incorporating plastic waste—particularly polyethylene terephthalate (PET)—into concrete mixtures leads to notable decreases in both fresh and hardened concrete density. For example, replacing aggregates with 5%, 10%, and 15% plastic pellets resulted in density reductions of 5%, 8.7%, and 10.75%, respectively [29]. Other studies involving polypropylene granules and PET have similarly confirmed a decline in concrete density, largely attributed to the lightweight nature of plastic materials [30][31].

Waste glass also contributes to decreased concrete density, especially when used as a fine aggregate replacement. Because glass is lighter than sand, its inclusion makes concrete more lightweight, particularly at higher replacement levels. When more than 50% of the sand is substituted with waste glass, the concrete's density can drop below 1850 kg/m^3—qualifying it as lightweight concrete [32][33]. This density reduction has implications for specific construction applications, particularly where weight savings are critical without significantly compromising structural integrity.

2) *Mechanical Properties*

The mechanical properties of concrete incorporating plastic waste and glass as aggregates can show both positive and negative effects, depending on the replacement ratio.

- *Plastic Waste*: The addition of plastic waste leads to a decrease in compressive, flexural, and tensile strength as the plastic content increases. For example, the compressive strength decreased by 27.7%, 47.7%, 71.9%, and 81.9% with increased plastic content [7]. The slump (workability) also decreases as the plastic ratio increases, though these mixes are suitable for low-workability applications.
- *Glass Waste*: In contrast, concrete with glass as a fine aggregate replacement can show improvements in mechanical properties, particularly at moderate replacement levels. A 50% replacement of sand with waste glass resulted in a 27% increase in compressive strength and a 9% increase in split tensile strength [32]. Flexural strength also improved by 50% compared to control specimens. However, after 75% replacement, the bonding between aggregates weakens, leading to a slight decrease in compressive

strength due to the formation of internal voids in the glass aggregates [32].

- *Combination of Plastic and Glass*: Studies have observed that replacing up to 40% of sand with plastic waste can enhance compressive, split tensile, and flexural strength, and up to 55% replacement with plastic waste shows comparable mechanical properties to normal concrete [21]. In the case of waste glass, compressive strength increases with glass content up to 30%, but after 45%, the strength begins to decrease [33].

In conclusion, both plastic and glass waste can be used as alternative aggregates in concrete, with glass generally providing better mechanical performance at higher replacement levels. However, the physical properties like density are consistently reduced with both types of waste, making the concrete lighter. Further optimization is needed to balance the strength and workability of these materials in concrete production.

C. *Research Gap*

While there exists an abundant amount of research studies regarding the utilization of glass and plastic as an aggregate, there remains a lack of studies regarding the application of both glass and plastic as an aggregate in making concrete hollow blocks (CHB). However, after reviewing some of these studies, this research found a common application of the latter which is the use of plastic or glass sand in bricks. The results indicate 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 [34] . The best effect on the mechanical properties was observed at 20% waste glass percentage [35]. These studies proved that the use of glass and plastic as an aggregate in making concrete blocks is feasible. However, there are still challenges that need addressing: 1. The use of waste glass sand with different shapes for molders (cylindrical, etc.), 2. The effect of different grain sizes for waste glass sand on the mechanical performance of the concrete, 3. The effectiveness of different mix design ratios when making concrete bricks, 4. Long-term performance and volume change, and 5. Transportation of waste glass into desired building construction resources.

Table 1: Challenges on using glass and plastic waste as an alternative aggregate

This table presents the challenges of using plastic waste and glass as an alternative aggregate.

Table 1

Challenges	Citation
Waste Glass Sand with different shapes for molders	[32]
Effect of different grain sizes for waste glass sand on the mechanical performance of concrete	[32]
Effectiveness of different mix design ratios when making concrete bricks	[34] [36]
Long-term performance and volume change of recycled aggregate	[18]
Transportation of waste glass into desired building construction resources	[11]

4. Methodology

The process begins with the collection of glass bottles and PET plastic waste. The plastic is shredded, and the glass is crushed into particles ranging from 0.05 to 1.6 mm. These materials are mixed until a homogeneous blend is formed, then combined with cement and water in specified proportions. The mixture is poured into silicone- coated molds (300mm × 230mm × 100mm) and tapped to reduce air voids. After casting, the blocks are cured for 28 days at room temperature. Once the curing is complete, the samples undergo testing and data analysis to assess their properties and support the design of the waste-based concrete blocks.

This study employed a quantitative experimental approach to evaluate innovative concrete blocks incorporating shredded plastic and glass as an alternative to aggregates. The research methodology was structured to systematically investigate these materials' physical and mechanical properties for potential application in wall construction.

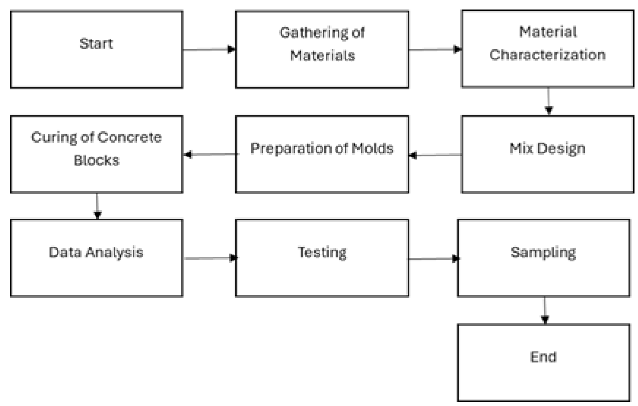

Fig. 2. Process flow diagram showing the method used to produce waste concrete blocks

The experimental design involves systematic testing to determine the optimal mix proportions and evaluate the resulting material properties, particularly its mechanical and physical properties. Statistical analysis of the collected data will ensure unbiased and reliable results, enabling the development of concrete blocks incorporating shredded plastic and glass as an alternative to aggregates.

The experimental process followed a sequential protocol:

For Materials

Step 1: Collecting and Material Characterization

A. *Shredded Plastic Bottles*

- *Shredding*: Plastic bottles are shredded using the shredding machine at the Municipal Environment and Natural Resources Office (MENRO).

- After sorting and cleaning to remove any contaminants such as labels, caps, and leftover liquids, the plastic bottles are fed into a high- powered shredding machine specifically designed to handle various types and sizes of plastic waste.

Fig. 3. Shredding of plastic bottles

- *Sieving and Grading*: Separate shredded plastic bottles by particle size for uniform concrete mixes. Use #4 mm sieve.

Fig. 4. Sieving and grading of pulverized glass

B. *Pulverized Glass*

- *Pulverization*: Glass bottles are pulverized by using industrial-grade glass crushers. The bottles are first fed into a hopper, where a series of heavy-duty rotating hammers or impact blades subject them to primary fragmentation. The resulting shards are further ground in a secondary crushing chamber, where centrifugal force and repeated impacts reduce the glass to fine cullet or sand-like particles. Integrated vibrating screens then separate the pulverized material by particle size, ensuring consistency for downstream applications such as recycled glass production, construction aggregates, filtration media, or abrasive materials. Dust extraction systems are employed to control airborne particulates, enhancing both material purity and worker safety during the process.

Fig. 5. Pulverizing of glass

- *Sieving and Grading*: Separate shredded plastic bottles by particle size for uniform concrete mixes. Use #4 mm sieve.

Fig. 6. Sieving and grading of pulverized glass

Step 2: Preliminary Mix Design

A. *Proportioning:*

- *Cement*: Define the base Portland cement content based on the standard concrete block mix ratio.
- *Aggregates Replacement*: Experiment with different replacement levels of aggregates with shredded plastic bottles and pulverized glass as its alternative. Using 100% no sand, containing only shredded plastic bottles (e.g. 30%, 10%), and pulverized glass (e.g. 70%, 90%).

B. *Mix Preparation & Casting:*

- *Batching*: Measure and mix all ingredients accurately using appropriate equipment.
- *Mixing*: Employ proper mixing techniques using manual method to achieve a uniform and homogeneous mixture, to ensure even distribution of materials, minimize air entrapment, and optimize the workability and strength of the concrete.
- *Casting*: Immediately after mixing, place the fresh concrete into pre-prepared molds for specimen preparation. Ensure proper compaction, either by rodding, tapping, or using a vibrating table, to eliminate air pockets and achieve maximum density. Surface finishing should be carried out carefully, and molds should be properly labeled for identification and curing.

Step 3: Testing & Optimization

A. Mechanical & Physical Properties:

- *Compressive Strength*: Test cured samples (e.g., 28 days) to ensure adequate load-bearing capacity.
- *Water Absorption*: Analyze the post- immersion of samples that were surface- dried and reweighed to determine water uptake.
- *Moisture Content*: Measure Moisture content was determined following ASTM C566, which involves oven-drying the concrete hollow block samples at 110 ± 5°C until a constant mass is reached. The moisture content is calculated as the percentage loss in mass relative to the dry weight. This parameter is critical for assessing curing quality and potential effects on strength, durability, and dimensional stability.
- *Mass*: Place the sample on the scale to determine its mass.
- *Durability*: Perform a drop test to determine the durability of the samples.
- *Malleability*: Examine how the samples deform when subjected to manual pressure.

D. Mix Design

To acquire the desired strength, durability, and consistency, and achieve the acceptable workability of the concrete blocks. The researcher uses a different mixture shown in Table N, of dimensions and ratios of cement, water, shredded plastic bottles, and pulverized glass.

Test Specimen Dimensions:

Volume of each block (V)= l x w x h

So, V(body) = 400mm x 100mm x 200mm

=8000000mm^3

V(studs)= 2(150mm x 50mm x 30mm)

=450000mm^3

V(hollow) = 2(150mm x 50mm x 40mm)

=600000mm^3

V(Total)= V(body) + V(studs) - V(hollow)

=8000000mm3+450000mm3-600000mm3

=7850000mm^3

=0.00785m3

No. of buckets for Water = ½ bucket

Table 2
Material specifications

Materials	Classification	Description	Specification
Pulverized glass	Fine (4 mm)	Clean and free from contaminants. Classified by particle size and passed through a sieve smaller than 4.0 mm but greater than 2.0 mm.	ASTM standard; particle size: >2.0 mm and <4.0 mm
Shredded plastic Bottles	Fine (0.075 mm)	Polyethylene terephthalate (PET) bottles, 1–1.5 mm thick, were cleaned and ground to a size range of 4.0 mm to 0.075 mm using a blade mill.	Particle size: 4.0 mm to 0.075 mm
Cement	Portland Pozzolana Cement (PPC)	ASTM C150 Type I Portland Cement; used when other special cement types are not required.	Passes through sieve no. 200
Water		Potable water sourced from household faucets.	Suitable for mixing and curing as per construction standards

B. Data Analysis

- Analyze test results and compare them against set performance targets.

FOR CONCRETE LEGO BLOCKS

Step 1: Mixing of water, cement, shredded plastic bottles, and pulverized glass as aggregates.

Step 2: Pour the concrete mixture into the mold. Step 3: Create samples

Step 4: Curing

- *Sample 1*: 7 days
- *Sample 2*: 14 days
- *Sample 3*: 28 days

Step 5: After curing days, conduct tests.

C. Material Requirements

The following is the tabulated list of materials necessary for producing concrete blocks.

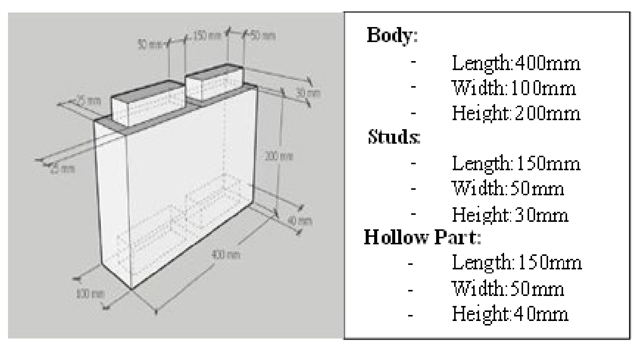

Fig. 7. Concrete lego block

E. Specimen Details

This part of the study shows the details of specimen samples used to determine the initial data that the researchers will use in determining the necessary test.

1) Mixture 1

- Shredded Plastic Bottles

- Pulverized Glass

No. of buckets for Cement = 1 bucket No. of buckets for Sand = 7 buckets No. of buckets for Water = ½ bucket

- Cement
- Water

2) Mixture 2

- Shredded Plastic Bottles (10%)
- Pulverized Glass (90%)

No. of buckets for Cement = 1 bucket

No. of buckets for Shredded Plastic = 6.3 buckets No. of buckets for Pulverized Glass= 0.7 buckets

No. of buckets for Water = ½ bucket Figure 8. Concrete Lego Block 2

- Cement
- Water

3) Mixture 3

- Shredded Plastic Bottles (30%)
- Pulverized Glass (70%)

No. of buckets for Cement = 1 bucket

No. of buckets for Shredded Plastic = 4.9 buckets No. of buckets for Pulverized Glass= 2.1 buckets

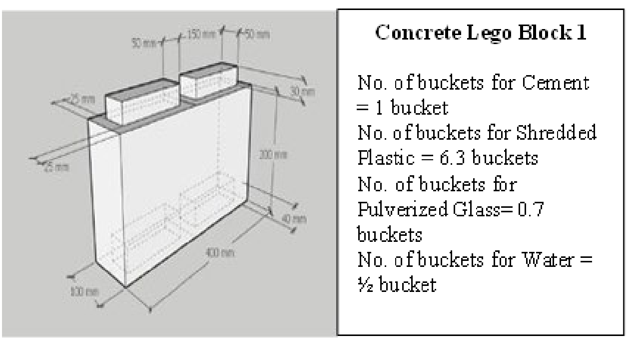

Fig. 8. Concrete lego block 1

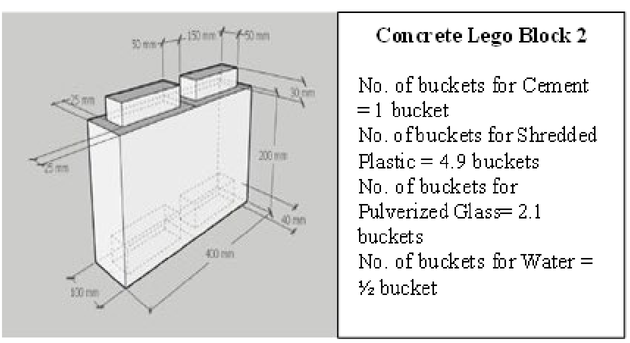

Fig. 9. Concrete lego block 2

F. Laboratory/Experiment/Field Experiment

1. Compressive Strength Test
2. Water-Absorption Test
3. Moisture Content
4. Density Test
5. Mass
6. Drop Test
7. Malleability Test

G. Description of Research Instrument Used

This experimental research aims to determine the potential of mixing shredded plastic bottles and pulverized glass as an alternative aggregate in creating concrete blocks. In order to produce lightweight, non-load bearing concrete blocks, this study investigates the viability of partially substituting standard aggregates with crushed glass and plastic bottles. To guarantee precise assessment of the concrete's mechanical and physical characteristics, a number of standardized tools and apparatus will be utilized. Glass and plastic debris will be crushed into fine, granular forms that can be mixed using a mechanical pulverizer. To guarantee consistent mixing of cement, water, and other particles, a concrete mixer will be used.

A Concrete Compression Testing Machine that complies with ASTM C39 requirements will be utilized to measure the produced concrete blocks' compressive strength. This apparatus gives test specimens a controlled compressive load, enabling the researchers to gauge and contrast the strength of concrete mixtures with different ratios of pulverized glass and shredded plastic. In order to track the strength's evolution over time and assess the alternative aggregates' suitability for real-world uses, compressive strength tests will be performed at 7, 14, and 28 days.

A digital weighing scale will also be used to measure the mass of each block, which is essential for calculating density in accordance with ASTM C138. Additionally, water absorption tests will be performed following ASTM C140 to assess the porosity and potential durability of the blocks. These measurements are crucial in determining the material’s suitability for construction where load- bearing is not required but reduced weight and sustainability are key considerations.

This quantitative experimental approach using statistical tools and graphical representations will facilitate a robust analysis to determine the optimal mix proportions of pulverized glass and shredded plastic as sole aggregate to achieve the desired strength, density, and durability for Lightweight Non-Bearing concrete blocks from total replacement of aggregates.

5. Result and Conclusion

A. Compression Test of Concrete Lego Block

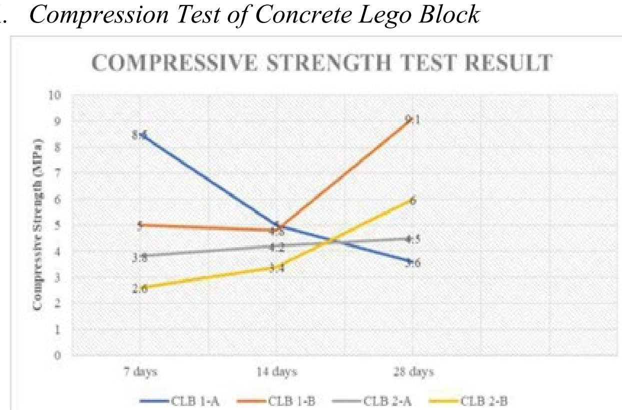

Fig. 10. Compressive test result

In accordance with, ASTM C140, the compression test was performed on lightweight non-load-bearing concrete blocks correspondingly. The load was applied at a controlled rate, based on the data of a single block with a cross-sectional area of 0.08 m².

The load was gradually applied at a rate of 0.5 to 1 MPa/s. Two specimen groups were tested, with each group consisting of 1 of the same properties.

Based on the graph in Figure n, the compressive strength of CHB with 90% aggregate of pulverized glass and 10% aggregate of shredded plastic has the highest compressive strength among the samples. There's slight increase in terms of compressive strength in CLB 2. The compressive strength continues to increase as the aggregates of pulverized of glass increases as shredded plastic decreases, shows that the higher percentage of pulverized as an aggregate fo concrete blocks the higher the compressive strength. Concrete Lego Block surpassed the compressive test result of traditional Concrete Hollow Blocks. Based on ASTM C129 in accordance to ASTM C140 the mean is 4.14 MPa on average for three samples and

3.45 MPa for a single unit. This indicates that all of samples cured in 28 days are feasible in terms of compressive strength.

B. *Water - Abroption Test*

These findings imply that, in contrast to conventional CHB, the addition of crushed glass and shredded plastic bottles to the mixture improves water absorption. The increased porosity brought about by the substitute materials—especially the shredded plastic—may result in larger voids, which explains the higher absorption rates in CLB 1 and 2. But out of the two specimens, CLB 2 showed superior resistance to water absorption, suggesting that a larger percentage of shredded plastic would lessen water absorption since it is hydrophobic and non-porous.

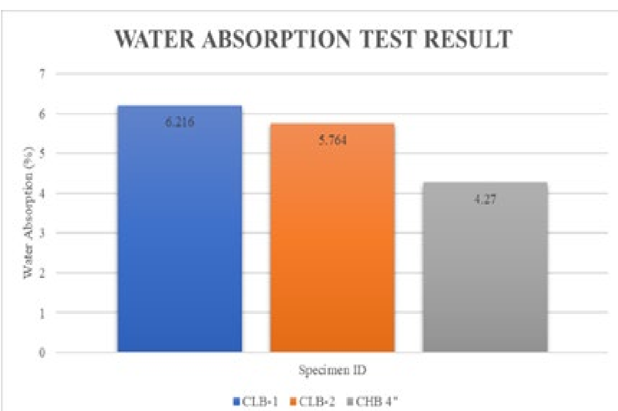

Fig. 11. Water - Absorption test result

Although the water absorption of both modified specimens was higher than that of the conventional CHB, their values are still within permissible bounds for non-load bearing applications, where less moisture exposure is anticipated.

C. *Moisture Content*

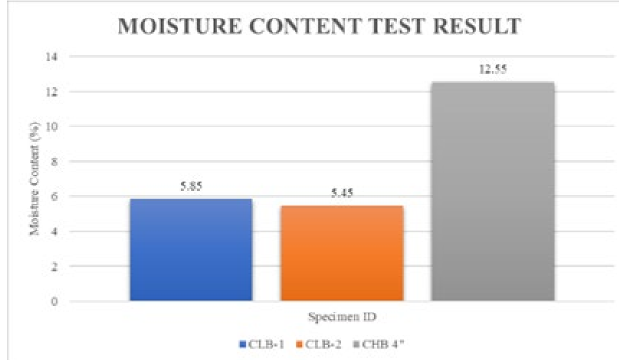

Fig. 12. Moisture content test result

These results suggest that compared to the conventional CHB, both alternate specimens absorbed and retained less moisture. Pulverized glass and plastic are non-porous, which lowers the unit's ability to retain water, which explains CLB 1 and 2's reduced moisture content. The notion that adding more hydrophobic material (plastic) further reduces water retention is further supported by the fact that Specimen 2, which had a higher percentage of shredded plastic, had the lowest moisture content.

This decrease in moisture level can help minimize problems like efflorescence, shrinking, and possible mold growth. Therefore, using recycled materials like glass and plastic may improve the longevity of non-load bearing blocks in dry or humid environments in addition to promoting sustainability.

D. *Density*

These results indicate that increasing the proportion of shredded plastic bottles leads to a decrease in overall density, likely due to the lightweight nature and low specific gravity of plastic. On the other hand, pulverized glass contributes to a higher density because of its heavier, more compact characteristics.

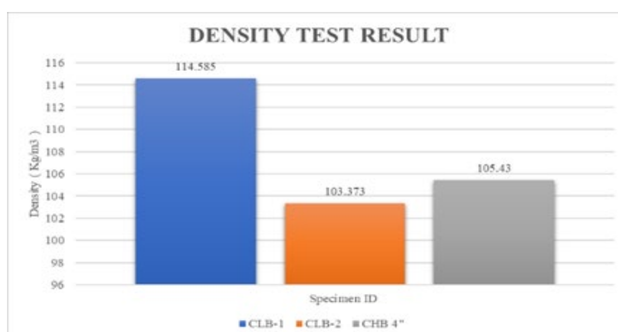

Fig. 13. Density test result

CLB 1, having the highest pulverized glass content, produced a unit denser than the traditional CHB, suggesting potential improvements in strength and durability. In contrast, Specimen 2, while slightly less dense than the traditional block, may still be suitable for non-load bearing applications where lighter weight is desirable.

E. Drop Test

Fig. 14. Drop test result

The drop test was conducted to evaluate the impact resistance and structural integrity of concrete blocks made with pulverized glass and shredded plastic bottles as total replacement for traditional aggregates. The block was dropped from a standardized height specifically, 3,4 and 6 feet onto a hard surface to simulate real-life handling or accidental impacts during transport and installation. Remarkably, the test block did not crack or break upon impact, indicating a high level of toughness and cohesion within the composite material.

In contrast, because of its increased porosity and lesser toughness, a conventional hollow block of comparable dimensions usually exhibits a higher propensity to fracture or shatter when put through the same drop test. Conventional blocks could not have the binding flexibility that recycled plastic offers because they only use natural aggregates. Therefore, the findings of the drop test show that alternative aggregates are appropriate for non-load bearing applications since they not only help with sustainability and weight reduction, but they may also improve durability and lessen on-site damage.

F. Mass

Fig. 15. Mass result of CLB 1 and 2, respectively

All concrete blocks were weighed using a digital scale with 0.1 kg accuracy. The mass data were used for both density and water absorption calculations, and also to compare the weight reduction between control and experimental blocks.

The CLB 1 weighing 14 kg while CLB 2 weighing 13.9 kg, which is lighter than a typical traditional hollow block weighing 17–20 kg. This reduction in mass indicates the effectiveness of using recycled materials as lightweight aggregates. The lower weight improves handling, reduces structural dead load, and supports sustainable construction practices. Compared to traditional blocks, the alternative mix offers similar functionality with added benefits in terms of weight and environmental impact, making it suitable for non-load bearing applications.

G. Malleability Test

Fig. 15. Malleability test result

Using a pinch and palm press, the malleability test showed that the CLB 1 AND CLB 2 had not exhibit surface fissures when pressure was applied by hand. The block retains its high surface hardness and structural integrity in spite of being lightweight and composed of recycled materials. The alternative block showed more toughness and resilience to mild stress than a standard hollow block, which may exhibit surface cracking or minor chipping under identical conditions because it is brittle. This implies that adding glass and plastic to the block not only lightens its weight but also increases its durability, making it a strong choice for non-load bearing applications.

H. Cost Analysis

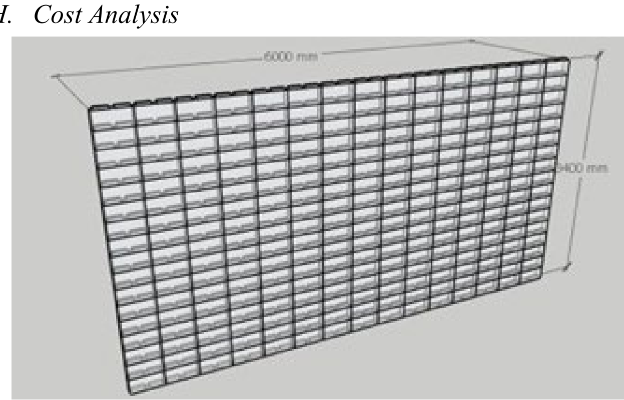

Fig. 16. 20.4 m2 wall area using pulverized glass and plastic bottles as alternative aggregates for lightweight non-load bearing concrete blocks

Theoretically, the samples involve constructing a wall having 6 m length and 3.4 m high using non- load-bearing concrete blocks. The block dimensions are 0.4 meters (length) x 0.2 meters (height) x 0.1 meters (depth).

$\boldsymbol{Total\ wall\ area, Awall} = \mathbf{6\ m \times 3.4\ m}$

$= \mathbf{20.4\ m2}$

Block calculation

$Block\ dimension = 0.4\ m \times 0.2\ m \times 0.1\ m$

$Area\ per\ Block = 0.4\ m \times 0.1\ m = 0.04\ m^2$

$Total\ number\ of\ blocks\ needed$

$= 20.4\ m^2/0.04\ m^2\ per\ block$

1) What are the Cost Differences Between Producing Lightweight Concrete Blocks with Traditional Aggregates and Those with Pulverized Glass and Plastic, Considering the Following

a. Material Cost

Using Pulverized Glass And Plastic

Table 3
Concrete Lego blocks cost

Item	Price (₱)
Glass	0
Plastic	2/kg
Cement	250

The Pulverized Glass and Plastic may be much cheaper than the traditional aggregates because it comes from the waste from the Material Recovery Facility, or you can get it for free. The Availability might depend on recycling rates in the area, but here in Baler, Aurora, there is a lot of waste, where you can get glass and plastic. Making the glass turn into pulverized glass and shredded plastic is free from the area where in Material Recovery Facility.

Traditional Concrete Hollow Blocks

Traditional Aggregates (like sand and gravel) are generally well established in the market. The Availability of aggregates is widely available and sourced locally, which helps keep costs down. Lower transportation costs due to local sourcing.

Table 4
Traditional concrete hollow blocks cost

Item	Price (₱)
Cement	250
Aggregates	625/cu.m.

b. Production Expenses

Using Pulverized Glass And Plastic

The process of crushing glass and shredding plastic can consume more energy than traditional processing due to the hardness of the material.

Operators may require training on specific handling and processing techniques for glass and plastic.

Traditional Concrete Hollow Blocks

According to the worker at Suklayin, Baler, Aurora. In 1 (one) cement bag and 50 (fifty) scoops of shovel, they can make a hundred pieces of CHB. The worker said that the labor cost depends on how many CHB he produces. If he produces 300 pieces, the labor cost is 690 pesos. The production process is well established and may require less energy than the pulverized glass and plastic. Training and a workforce familiar with traditional production techniques often leads to consistent labor costs. Standard machinery is readily available.

6. Conclusion

The study evaluated the effects of using shredded plastic bottles and pulverized glass as alternative aggregates in concrete blocks, focusing on key factors such as compressive strength, water absorption, moisture content, density, mass, durability, and malleability.

- *Compressive Strength*: The compression test according to ASTM C140 showed that blocks with 90% pulverized glass and 10% shredded plastic had the highest compressive strength. As glass content increased, so did the strength. Concrete Lego Blocks (CLB) outperformed traditional Concrete Hollow Blocks (CHBs), and all 28-day cured samples met ASTM C129 standards, confirming the feasibility of using these modified blocks for structural applications.
- *Water Absorption*: Water absorption tests revealed that adding crushed glass and shredded plastic to CHBs increased their water absorption due to the higher porosity, especially from the shredded plastic. However, CLB 2, with a higher plastic content, demonstrated better water resistance, likely due to the hydrophobic nature of the plastic. Despite higher water absorption than conventional CHBs, both modified blocks remain suitable for non- load-bearing use.
- *Moisture Content*: The moisture content tests showed that both CLB 1 and CLB 2 retained less moisture than conventional CHBs. This is attributed to the non-porous properties of pulverized glass and the hydrophobic nature of plastic. CLB 2, with more plastic, had the lowest moisture content, which could help reduce issues like efflorescence, shrinkage, and mold, improving block durability and promoting sustainability.
- *Density and Mass*: Shredded plastic reduced the block density due to its lightweight nature, while pulverized glass increased the density. CLB 1, with more glass, was denser than traditional CHBs, indicating potential gains in strength and durability. CLB 2, though slightly less dense, is still suitable for non-load-bearing applications where lighter weight is preferred. Both CLB 1 and 2 were lighter than traditional CHBs (14 kg and 13.9 kg, respectively, compared to 17–20 kg for conventional blocks), highlighting the effectiveness of recycled materials in reducing dead load and enhancing handling.
- *Impact Resistance*: The drop test demonstrated that the modified blocks, made with pulverized glass and

shredded plastic, remained intact after being dropped from 3, 4, and 6 feet, showcasing strong impact resistance. This suggests that the alternative aggregates enhance flexibility and cohesion, which reduces the risk of cracking compared to conventional CHBs. This makes the modified blocks suitable for non-load-bearing applications where durability and impact resistance are important.

- *Malleability*: The malleability test showed that both CLB 1 and CLB 2 resisted surface fissures under hand pressure, maintaining their integrity despite their lightweight, recycled composition. Unlike traditional CHBs, which may crack or chip, the modified blocks demonstrated greater toughness and durability, further supporting their suitability for non-load- bearing use.

7. Recommendation

In light of the results, the researchers recommend the continued exploration and adoption of shredded plastic bottles and pulverized glass as alternative aggregates in concrete block production, particularly for non-load-bearing applications. The superior compressive strength, reduced moisture content, and enhanced impact resistance observed in the modified Concrete Lego Blocks (CLBs), especially those with higher glass content, highlight their potential as a sustainable and durable alternative to traditional Concrete Hollow Blocks (CHBs).

Future studies should consider conducting long- term field performance evaluations under varying environmental conditions to better understand the aging behavior and durability of these blocks over time. Additionally, exploring optimal ratios of plastic and glass for different construction needs— such as thermal insulation, soundproofing, or even aesthetic applications—could further broaden their usability. It is also recommended that local government units and construction stakeholders be involved in pilot projects using these alternative blocks to promote sustainable construction practices and reduce plastic and glass waste in communities.

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