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Utilizing Chicken Eggshells and Waste Glass Powder as Cement Fillers for Environmental Stability

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Abstract:- The use of chicken eggshells and waste glass powder as additives in concrete mixes presents an approach for enhancing the concrete properties while also promoting sustainability. This study was conducted to investigate the viability of chicken eggshells and waste glass powder as components in a concrete mixture to improve its durability and strength using an experimental research design. One-Way Analysis of Variance (ANOVA) was utilized and assessed at a significance level of 0.05 to see if there was a statistically significant difference between the groups. The ANOVA results showed that the groups had a p-value of 0.305 from the collected data, which implies that the null hypothesis cannot be rejected because there was also no significant impact of eggshells on the durability and strength of the concrete. Based on the average PSI (pounds per square inch) results: (a) concretes with glass powder filler is more durable and can be used as a strengthening additive. (b) Concretes with eggshell filler are not durable and cannot be used as strengthening additives. (c) Concretes with a combination of both substances cannot ensure their durability because of the eggshell filler. (d) Traditional concrete is durable after waste glass fillers. Nevertheless, concrete mixes with substances can offer an environmentally friendly solution for waste management.

Keywords:- *Chicken Eggshells, Waste Glass Powder, Concrete Properties, Viability, Experimental Research Design, One Way Analysis of Variance, Average PSI, Strengthening Additive, Durability, Waste Management, Sustainability.*

I. INTRODUCTION

The United Nations Environment Programme (UNEP) estimates that 11.2 billion tons of solid waste is collected annually worldwide. Waste management has often been a hindsight for urban development because one's health, environment, and immeasurably more could be negatively impacted by it. Thus, regardless of the procedures and techniques used, waste must be reprocessed.

Eggshell waste contributes considerably to environmental pollution owing to inappropriate disposal. According to Murthi et al. (2022), an increase in egg production produces an increased amount of eggshell waste, which is typically thrown in trash and culminates in landfills. Owing to its abundance and chemical composition, this solid waste poses a serious environmental pollution risk if improperly treated. Primary calcium carbonate, or CaCO3, which makes up eggshells, can lead to pollution because microbial activity can produce unpleasant smells (Darkun et al., 2022).

However, waste glass has become a significant environmental problem. According to the World Bank Group, approximately 130 million glass tons are produced each year generated annually, of which approximately 100 million tons are disposed of as waste. Because waste glass (WG) is not biodegradable, it occupies space in landfills and raises environmental concerns (Chu et al., 2022). Thus, to reduce waste glass in landfills, it can be recycled.

Glass and eggshells can be converted into environmentally friendly products through recycling and repurposing techniques, specifically using these substances as organic and inorganic mixtures in cement concrete for production in construction, so that we can support a more sustainable and environmentally responsible method of handling these materials and minimizing waste.

However, because of its widespread use, researchers initially concentrated on how cement production affects the environment by releasing carbon dioxide (CO2), which has led to societal and environmental problems, such as global warming (Nandhini & Karthikeyan, 2022). Therefore, researchers have conducted their study with the aim of conserving the environment by replacing it with recyclable alternatives. And by means of that, we want to encompass our study by taking into account the cement concrete's durability by only mixing it with the said substances, in which also contributes to waste reduction and sustainability.

Limestone powder is an essential additive that is used in cement, concrete, and bricks. As a result, eggshells can be used in place of some cements as they are a source of calcium carbonate (CaCO3), which can replace limestone because eggshells contain calcite, a pure and more stable form of CaCO3, whereas limestone can also contain sand, clay, and other minerals. (Shiferaw et al., 2019). According to Paruthi et al, (2023): Silicon dioxide (SiO2) is the primary chemical component of glass. Because of its high SiO2 content and generally amorphous form, glass is essential for concrete from the point of binder hydration to its ultimate strength of development (Siddika et al., 2022). Lime (CaO), soda (Na20), and other important substances are also present. It has been

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shown that waste glass powder has pozzolanic properties and qualities, which enable it to combine with calcium hydroxide to form cementitious compounds in the presence of water. The workability, strength, and durability of concrete can be improved by partially replacing it, thereby reducing its carbon footprint as a result (Hassan et al., 2023).

By encouraging sustainable development and waste reprocessing, this study investigated the effect of the addition of glass powder and eggshell powder on the strength and durability of concrete. Positive results of this study might establish this mixture as a competitive substitute for a range of construction uses.

Numerous businesses, associations, experts, professionals, and local individuals will benefit significantly from the study upon adding eggshells and leftover glass to concrete mixtures to investigate the qualities and possible benefits of using these waste substances in concrete, including cost effectiveness, favorable environmental impact, and entrepreneurial business benefits by acquiring enough information to deal with this matter.

The aim of producing cement concrete using waste glass powder and chicken eggshells as fillers is to ascertain and identify how these materials may affect the durability and strength of concrete materials, while also aiding in waste management and environmental stabilization.

II. LITERATURE REVIEW

Our society has faced various issues that have affected our environment, specifically the mismanagement of waste, which has contributed to pollution. Eggshells are among the most common agricultural waste discarded by homes, bakeries, restaurants, and factories. Despite its beneficial qualities and uses, it has been cast off in large quantities and disposed of incorrectly, much like waste glass.

Hence, we conducted this study to address the issue of waste mismanagement by proposing sustainable and environmentally friendly solutions. Pollution and inefficient waste management are unavoidable, but can be mitigated by recycling products that are still capable of being put to good use, such as glass and chicken eggshells, which are particularly useful in the construction industry.

The utilization of eggshells and glass powder in cement has been accompanied by benefits; it improves the durability of cement concrete, which has been proven by reliable studies, and promotes environmental stability.

According to Razali et al. (2020), the purpose of this study was to examine the possibility of using chicken eggshell as a substitute for fine aggregates in concrete mixtures because of the comparably high calcium carbonate (CaCO3) content of limestone. Additionally, the results demonstrate that the addition of calcium carbonate to the aggregates is highly noticeable in terms of the compression strength (up to 58.4%) and carbonation rate (up to 2%).

According to Siddika et al. (2022), waste glass is essential to the concrete process, from the hydration of binders to the last stage of strength development, because of its high SiO2 content and generally amorphous character. Therefore, it can be utilized to partially substitute cement in concrete to increase its strength, longevity, and workability, while simultaneously lowering its environmental impact (Hassan et al., 2023)

Given that most prior research has substituted the aforementioned materials for cement, our research focuses on examining how these materials, when used as fillers in cement, can affect the strength of concrete. This approach not only supports sustainable objectives, but also explores creative ways to repurpose waste products for practical use in the construction sector.

A. Research Objectives

➢ *General Objectives*

The primary goal of this study was to utilize chicken eggshells and waste glass powder as concrete fillers and to determine their potential effect on the durability strength of concrete while contributing to environmental stabilization.

➢ *Specific Objectives*

- To generate environmentally friendly cement concrete using chicken eggshells and waste glass powder as cement fillers.
- To identify the potential effect of cement concretes' durability using chicken eggshells and waste glass powder as cement fillers while measuring its compressive strength at a specified measured content:

✓ Cement concrete with the substance of chicken eggshells as filler.
✓ Cement concrete with the substance of waste glass powder as filler.
✓ Cement concrete with the substances of chicken eggshells and waste glass powder as fillers.
✓ Cement concrete with no substances in chicken eggshells or waste glass powder.

B. Hypothesis

- H_o: The application of chicken eggshell and waste glass powder in cement mixtures has no significant impact on the durability of cement concrete with respect to its compressive strength.
- H_a: The utilization of chicken eggshell and waste glass powder in cement mixtures has a significant impact on the durability of cement concrete with regard to its compressive strength.

III. METHODOLOGY

This study utilized a true experimental research design, which is a type of quantitative research that involves various scientific methods that guarantee structured and processed results by establishing cause-and-effect linkages. It can carefully change factors and control conditions, and find

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cause-and-effect relationships among the given variables. As our study encompasses the generation of cement concrete by utilizing chicken eggshells and waste glass powder as concrete fillers, it can be performed with actual intervention and can be investigated with the aid of an experimental research design. It offers a strict framework for gathering information relevant to the subject, guaranteeing the legitimacy and dependability of possible conclusions.

This research design involved manipulating the independent variables (chicken eggshell powder and waste glass powder) and measuring the dependent variables (durability strength of concrete) to determine their potential effect on the durability strength of concrete as concrete fillers, taking into account the verification or refutation of the hypotheses. This method provides a structured approach to assess the development of these materials for various applications, enabling a systematic evaluation of their properties and potential uses. In summary, it increases the overall impact of the study by strengthening the validity, reliability, and generalizability of its conclusions and outcomes.

This experimental study, "Utilizing Chicken Eggshells and Waste Glass Powder as Concrete Fillers for Environmental Stability," was conducted at one of the researchers residence in Barangay Patun-an, Calatrava, Negros Occidental. The time frame for this experimental process was eight weeks, which started on February 10, 2024, until the day of the compressive strength test on April 7, 2024.

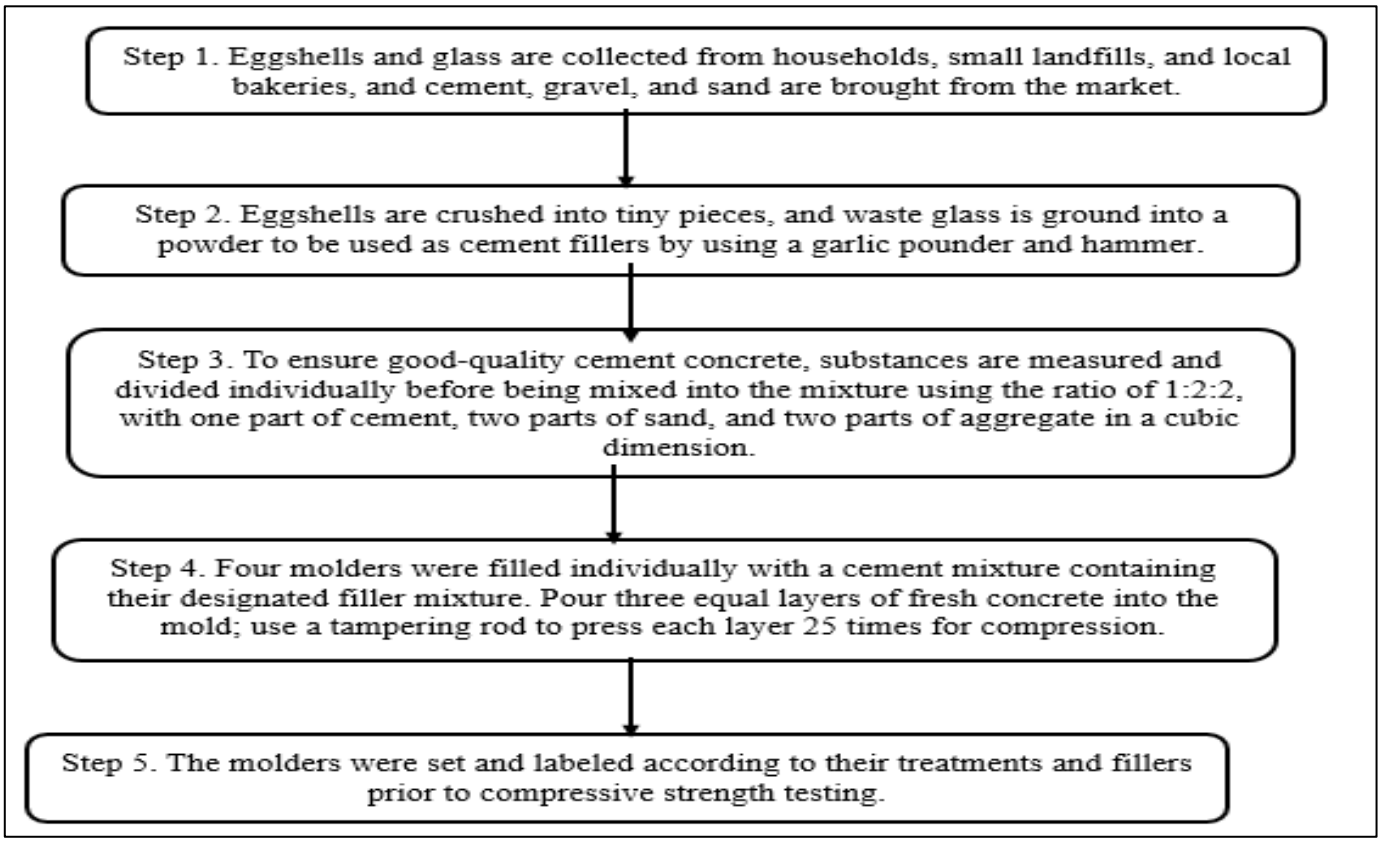
This study utilizes various materials, including eggshells, glass, cement, sand, gravel, water, plywood, hammer, strainer, garlic pounder, plastic distilled water bottle, weighing scale, plastering trowel, shovel, epoxy, and glue stick, to create a cement concrete sample.

➢ *Preparation of Samples*

The cement mixtures were grouped into three, namely T1 (Trial 1), T2 (Trial 2), and T3 (Trial 3) with 4 samples, consisting of 12 cubic concretes in total. Three groups have the same measurement of eggshell, waste glass, a combination of eggshell and glass, and no substances in the mixture. Therefore, each group contained an equal quantity of cement, sand, and aggregate with the same amount of the substances using the ratio of 1:2:2.

Table 1: Preparation of Samples

Groups	Substances (Eggshell and Waste Glass)	Cement	Sand	Aggregate	Water
Concrete with Eggshell Filler	1½ kg	1 kg	2 kg	2 kg	1.4 L
Concrete with Waste Glass Filler	1½ kg	1 kg	2 kg	2 kg	1.4 L
Concrete with Both Eggshell and Waste Glass	3⁄4 kg	1 kg	2 kg	2 kg	1.4 L
Traditional Cement Concrete	0 kg	1¼ kg	2½ kg	2¾ kg	1.4 L



Flowchart 1: Standard Operating Procedures

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IV. RESULTS AND DISCUSSIONS

The findings of the study were relative to the objectives of the study, particularly the specific goals, wherein:

- We have successfully generated environmentally friendly concrete samples by using chicken eggshells and waste glass powder as cement fillers.
- In order to identify the potential effect of cement concrete's durability using chicken eggshells and waste glass powder as cement fillers, the results of each group were compared by their PSI average. This means that the higher the average, the stronger and more durable the samples are among the other groups.

✓ For the concrete samples with eggshell filler, the PSI calculation recorded a mean of 140.203 psi from the data of each trial, which are 87.02 psi (6 bar) for 7 days, 188.55 psi (13 bar) for 14 days, and 145.04 psi (10 bar) for 24 days.

✓ For the concrete samples with waste glass powder filler, the PSI calculation recorded a mean of 681.677 psi from the data of each trial, which are 145.04 psi (10 bar) for 7 days, 1363.35 psi (94 bar) for 14 days, and 536.64 psi (37 bar) for 24 days.

✓ For the concrete samples with both eggshells and glass powder fillers, the PSI calculation recorded a mean of 183.713 psi from the data of each trial, which are 116.08 psi (8 bar) for 7 days, 130.53 psi (9 bar) for 14 days, and 304.58 psi (21 bars) for 24 days.

✓ And lastly, for the traditional concrete samples, the PSI calculation recorded a mean of 502.797 psi from the data of each trial, which are 290.08 psi (20 bars) for 7 days, 246.56 psi (17 bars) for 14 days, and 971.75 psi (67 bars) for 24 days.

According to the data gathered per trial from each group that were plotted in Table 1, the overall statistical results indicate that the group of concrete samples with waste glass filler, with a mean of 507.63, is the strongest and most durable among the other groups.

Table 2: Raw Data in Compressive Strengths (PSI)

Cement Groups	Trial 1 (7 days)	Trial 2 (14 days)	Trial 3 (24 days)	Average
Concrete with Eggshell Fillers	87.02 psi	188.55 psi	145.04 psi	140.203 psi
Concrete with Waste Glass Fillers	145.04 psi	1363.35 psi	536.64 psi	681.677 psi
Concrete with Both Eggshell and Waste Glass Fillers	116.08 psi	130.53 psi	304.58 psi	183.713 psi
Traditional Cement Concrete	290.08 psi	246.56 psi	971.75 psi	502.797 psi

To determine the hypothesis of the study, One-Way Analysis of Variance was performed. The results show that the aforementioned groups had a p-value of 0.305 from the collected data, which implies that if the p-value exceeded the alpha or significant level of 0.05, the null hypothesis cannot be rejected.

Therefore, based on the results shown in Figure 1, we can conclude that there have been no significant differences between the four groups. To identify using plotted points for visual presentation, descriptive plots results were shown in Figure 2, wherein cement concretes with waste glass filler received the highest data compared to the other groups.

ANOVA - Data ▼

Cases	Sum of Squares	df	Mean Square	F	p	VS-MPR*
Group	606255.094	3	202085.031	1.429	0.305	1.016
Residuals	$1.132 \times 10^{+6}$	8	141465.429			

Note. Type III Sum of Squares

* Vovk-Sellke Maximum *p*-Ratio: Based on the *p*-value, the maximum possible odds in favor of H_1 over H_0 equals $1/(-e\ p \log(p))$ for $p \leq .37$ (Sellke, Bayarri, & Berger, 2001).

Fig 1: Difference in Compressive Strength (One Way Analysis of Variance)

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Fig 2: Difference in Compressive Strength (Descriptive Plots)

V. CONCLUSION

➢ *Based on the Results and Findings Gathered, the Following Conclusions were Made:*

- Using waste glass powder as a filler in cement concrete mix demonstrates good results in improving the strength and durability of the concrete compared to the other groups.
- In contrast to waste glass, incorporating chicken eggshell into concrete mix as filler did not significantly alter key properties such as compressive strength and durability.
- There's no significant difference between the PSI average of the concrete mixtures with eggshells, waste glass, the combination of both substances, and traditional concrete.
- The null hypothesis cannot be rejected since utilizing eggshell fillers has no significant impact on the durability and strength of the concrete.
- Chicken eggshell waste and waste glass powder as additives in concrete mixes can offer an environmentally friendly solution for waste management.

RECOMMENDATION

The strength of cement concrete with eggshell and waste glass powder fillers was investigated in this study and compared to that of conventional cement. Consequently, a series of suggestions are hereby presented:

a. Future researchers should conduct various cement concrete tests to increase their validity and collect more valuable information about the study.

b. Future research should powder the eggshells, the same as with the waste glass, in order to achieve the exact consistency and well-dispersed filler.

c. Future researchers should conduct the actual intervention and experiment as early as possible since it takes a lengthy time to cure the cement to achieve more stable and reliable concrete samples.

d. Future researchers should use medium-sized aggregates to make fewer total surface area concrete samples, wherein they can provide higher durability because of the lower water ratio.

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