A STUDY ON HARDENED PROPERTIES OF CONCRETE MADE WITH WASTE TILES AND GLASSES AS PARTIALLY REPLACED AGGREGATES.

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering



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(Spring-2025)

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Dedicated

to

In the name of Allah, the Most Gracious, the Most Merciful. To our beloved family and cherished teachers,

we dedicate this thesis to you with profound gratitude. Your unwavering support, encouragement, and wisdom have been my guiding lights throughout this academic journey. May Allah bless you abundantly for your kindness, patience, and dedication.

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Yours Obediently,

Md Nadim Mahmud
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ABSTRACT

Concrete is a primary construction material, yet its reliance on natural resources raises environmental concerns. This study examines the potential of waste glass and crushed tiles as partial replacements for fine and coarse aggregates, respectively, alongside sand and cement, to foster sustainable construction practices. By repurposing materials like sand, waste glass, and tiles—often discarded in landfills—the research addresses ecological challenges and offers a cost-effective solution.

Hardened properties such as compressive strength, tensile strength, and durability were assessed to evaluate the feasibility of these alternative aggregates. Concrete mixes were designed with crushed tiles, cement and proportions of glass are mixed with sand at percentages of 30%, 50%, and 70%. All the test procedure were done according to the standard ASTM methods. Testing Their performance after curing for 7 21 and 28 days.

The inclusion of sand alongside waste tiles and glass further improved particle distribution and reduced voids, enhancing compressive strength. Waste glass also contributed a pozzolanic effect, which boosted durability over time. Higher replacement ratios showed minor trade-offs in workability, which could be mitigated with the use of admixtures.

This study highlights the practical application of waste materials, demonstrating their effectiveness in producing eco-friendly concrete. By utilizing waste glass, crushed tiles, sand, and cement, this approach not only manages construction waste but also reduces environmental impact. The findings pave the way for developing sustainable concrete mix designs suitable for a range of construction projects. Future research should focus on long-term performance and scalability in large infrastructure.

Applications. *Keywords:* Lightweight concrete, Compressive strength, waste tiles and waste glass, Universal Testing Machin

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INTRODUCTION

1.1 Background and Motivations

Concrete is an essential material in construction, but its heavy dependence on natural resources poses significant environmental challenges. Traditional concrete production demands extensive use of natural aggregates, which contributes to resource depletion and environmental degradation. Simultaneously, waste materials such as broken tiles and discarded glass are frequently sent to landfills, leading to inefficient waste management and ecological harm. These issues necessitate exploring alternative, sustainable solutions that align with global environmental goals. Repurposing waste materials not only reduces the burden on natural resources but also offers an innovative approach to developing eco-friendly construction practices. The motivation for this research stems from the urgent need to address two pressing concerns: environmental sustainability and effective waste management. Incorporating waste glass and crushed tiles into concrete as partial replacements for traditional aggregates achieves a dual purpose.

Minimizing Waste: Utilization of materials like waste glass and tiles reduces the volume of waste directed to landfills.

Sustainable Construction: Using recycled materials lowers the demand for natural aggregates, contributing to resource conservation and reduced environmental impact.

This research also has the potential to enhance the mechanical properties of concrete. Preliminary studies suggest that waste glass contributes to a pozzolanic reaction, improving durability and compressive strength. By integrating these alternative aggregates into concrete production, this study aims to promote practical, scalable solutions for sustainable infrastructure development. Fiber Reinforced Concrete, there are four categories namely, SFRC – Steel Fiber Reinforced Concrete

1.2 Research Objectives and Overview

1: to examine the feasibility of partially replacing natural fine and coarse aggregates with waste glass and crushed tiles in concrete. This includes evaluating the hardened properties of concrete such as compressive strength, tensile strength, and durability to determine if these waste materials can serve as effective and reliable alternatives in construction.

2: To promote environmental sustainability by utilizing construction and industrial waste materials in concrete production. The study aims to reduce landfill pressure and conserve

natural resources by encouraging the reuse of waste glass and crushed tiles, thus contributing to waste management and eco-friendly building practices.

3. To develop and compare multiple concrete mix designs using various ratios of sand, waste glass, and crushed tiles. The research applies standard ASTM testing methods to analyze performance differences and draw conclusions about the long-term potential of these mixes in sustainable construction applications.

1.3 Organization of the thesis

Chapter 1: Introduction and Objective

This chapter provides an overview of the study, beginning with the background and motivation behind utilizing construction and demolition waste in concrete production. It highlights the environmental concerns associated with conventional aggregates and the potential of waste tiles and glass as sustainable alternatives. The research problem is defined, and the main objectives, scope, and significance of the study are clearly outlined. A brief description of the methodology and the structure of the thesis is also presented.

Chapter 2: Literature Review

This chapter presents a critical review of previous studies related to the use of recycled materials—particularly ceramic tiles and glass—in concrete. It discusses findings from earlier research, identifies research gaps, and establishes the context for the present investigation.

Chapter 3: Methodology

This chapter details the materials used in the experimental program, including waste tiles, waste glass, cement, and natural aggregates. It describes the mix design process, the preparation of concrete specimens, and the procedures followed for testing various hardened concrete properties.

Chapter 4: Results and Discussion

The results of the laboratory tests conducted on concrete specimens—such as compressive strength, split tensile strength, and flexural strength—are presented and analyzed in this chapter. The effects of varying replacement levels of waste materials are discussed in detail, with comparisons to conventional concrete mixes.

Chapter 5: Conclusions and Future work

This chapter summarizes the key findings of the research, emphasizing the performance of concrete with waste tile and glass aggregates. It outlines the practical implications, suggests optimal replacement levels, and provides recommendations for future research and industrial applications.

CHAPTER 2

Literature Review

2.1 Introduction

The global construction industry is one of the largest consumers of natural resources. With growing environmental concerns and the scarcity of natural aggregates, researchers and engineers are exploring the use of alternative materials to make concrete more sustainable. Among these alternatives, **waste ceramic tiles** and **waste glass** have emerged as promising materials for partial replacement of coarse and fine aggregates, respectively. This chapter presents a comprehensive review of previous studies that investigated the effects of using these waste materials in concrete.

2.2 Content

Waste Glass as Fine Aggregate Replacement

Waste glass is a non-biodegradable material with high silica content, making it a potential pozzolanic material when finely ground or a replacement for fine aggregates in crushed form. Several studies have focused on its impact on concrete properties

Workability: Researchers observed that workability tends to decrease slightly with higher glass content due to the angular and smooth texture of crushed glass (Taha & Nounu, 2008).

Compressive Strength: According to Shao et al. (2000), replacing fine aggregates with up to 20% waste glass can increase compressive strength due to better particle packing and improved pozzolanic activity when finely ground.

Durability: Some studies raised concerns about alkali-silica reaction (ASR), especially when using unprocessed glass in large quantities. However, the use of finely crushed or pre-treated glass minimizes this risk.

Waste Ceramic Tiles as Coarse Aggregate Replacement

Bonding and Durability: The rough texture and porosity of ceramic aggregates enhance bonding with the cement paste, potentially improving tensile strength and long-term durability. Environmental Benefits: The use of ceramic waste reduces landfill impact and conserves natural stone resources.

Combined Use of Waste Glass and Tiles

Research into the combined use of waste glass and tiles is limited but growing. Some key findings include:

Research Gaps Identified

Despite promising results, the following research gaps remain:

Limited long-term studies on the durability of concrete with both waste materials.

Need for standardized mix design guidelines for combined waste use.

Insufficient data on field performance and life cycle assessment.

Lack of research on optimal combination ratios for both waste types in various concrete

2.3 Summary

The literature reveals that both waste glass and ceramic tiles can be successfully used as partial replacements for fine and coarse aggregates, respectively. Their use improves concrete sustainability and, under optimal conditions, maintains or enhances strength and durability. However, further research is needed to establish long-term performance data, define best practices, and promote widespread application in the construction industry.

CHAPTER 3
Methodology

3.1 Introduction

The methodology adopted in this study focuses on analyzing the hardened properties of concrete by partially replacing fine aggregates with waste glass and natural sand in various proportions. This experimental process is designed to assess the potential of waste glass as an alternative fine aggregate to improve the strength, durability, and sustainability of concrete. The hardened properties, particularly compressive strength, are evaluated over different curing periods.

This study involves the preparation of concrete cube specimens with three different ratios of sand and waste glass as fine aggregates:

1. 30% sand + 70% glass
2. 50% sand + 50% glass
3. 70% sand + 30% glass

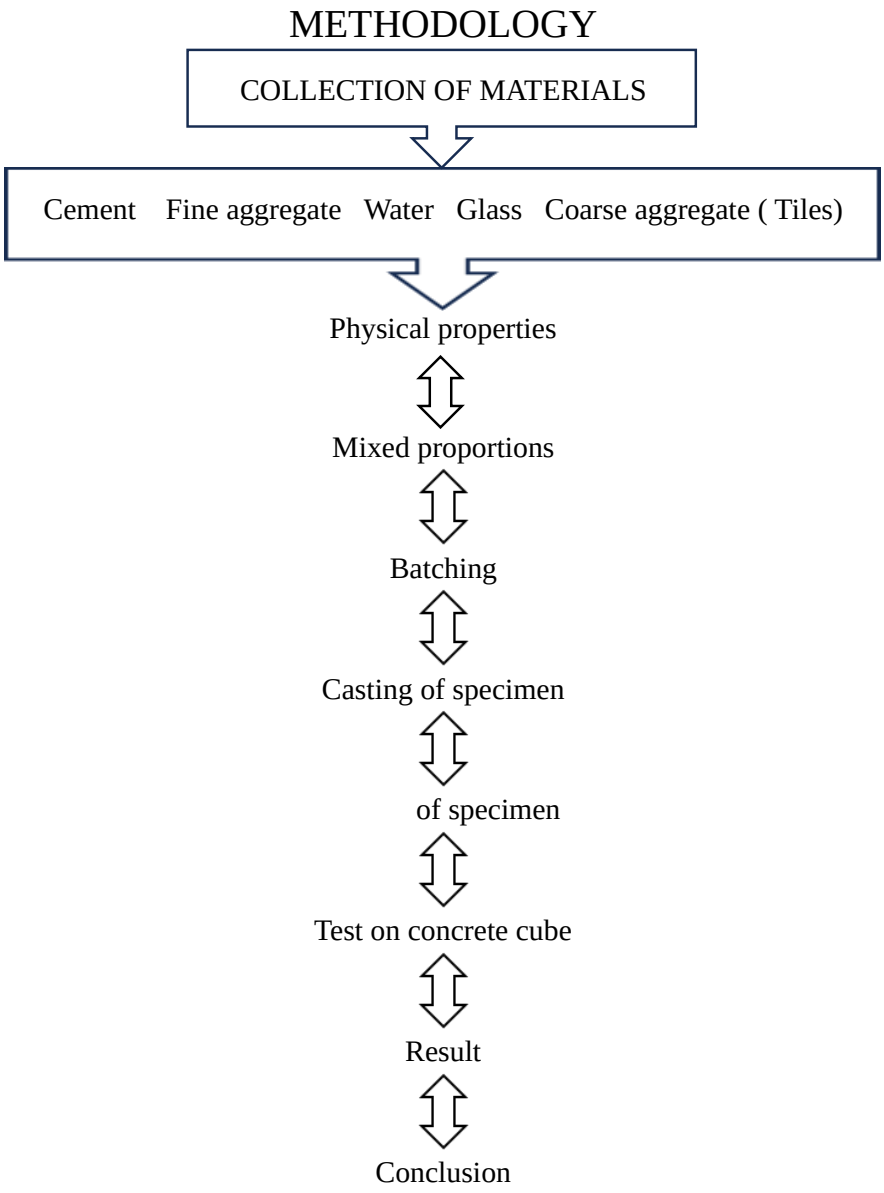
Ordinary materials such as PPC (Portland Pozzolana Cement), coarse aggregates, and potable water are used along with the modified fine aggregate mix. After casting, the cubes are cured for 7, 21, and 28 days. The compressive strength of the specimens is then tested using a Universal Testing Machine (UTM).

Based on previous research studies, this work aims to determine the suitability and impact of waste glass on the hardened properties of concrete in comparison to traditional fine aggregates. The concrete mix is designed for M20 grade as per IS 10262:2009. The mixing, casting, and curing processes follow standard procedures outlined in IS codes. Slump tests are also performed to ensure proper workability of the fresh mix.

The study uses 27 concrete cube specimens in total. For each replacement ratio (30%-70%, 50%-50%, and 70%-30%), 3 specimens are cast and tested at each curing interval (7, 21, and 28 days), allowing a comparative evaluation of compressive strength.

The primary goal of this methodology is to explore the effectiveness of using waste glass as a partial replacement for sand in concrete, with the aim of promoting sustainable and eco-friendly construction practices. The results from the compressive strength tests across different curing periods will help determine the optimum replacement ratio.

Figure 3-1: Schematic Representation of Methodology



- The following materials were used for preparing the concrete mix.

1) Cement
2) Fine aggregate (Sylhet Sand)
3) Coarse aggregate (tiles)
4) Water
5) Glass

- **Cement:**

  Portland Pozzolana Cement (PPC) was used in this study. It is a blended cement consisting of a mixture of Portland cement and pozzolanic materials such as fly ash. PPC enhances the durability and long-term strength of concrete, making it suitable for sustainable construction.

  Key properties of PPC:

  -Fine particle size and smooth texture

  - Better workability and water retention

  - Slower strength gain but higher ultimate strength

  - Improved resistance against chemical attack and alkali-silica reaction



Figure 3-2: Cement

- **Sylhet sand**: Natural rivers sand was used as the fine aggregate in this study. Sand plays a crucial role in filling voids between coarse particles and providing strength to the mix.

  Key properties:

  - Clean and free from clay or organic impurities

  - Well-graded according to standard sieve analysis

  - Free from alkalis or reactive compounds

  - Suitable moisture content and particle shape



Figure 3-3: Sylhet Sand

- **Waste Tiles:**

  Crushed and discarded ceramic or porcelain tiles were used as partial replacements for coarse aggregates in the concrete mix.

  Key properties:

  - High compressive strength and stiffness
  - Low water absorption
  - Environmentally sustainable as a recycled material
  - Reduces dead weight of concrete while maintaining strength.



Figure 3-4: Crushed Tiles

Water: According to IS 456: 1000ml , water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. The pH value of water shall be not less than 6.

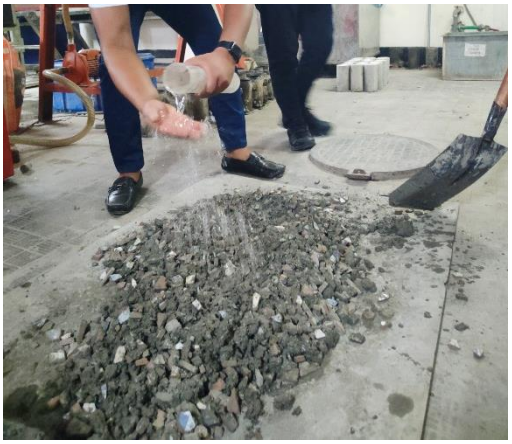


Figure 3-5: Water

- **Waste Glass**

Waste glass collected from bottles and domestic sources was crushed and ground to fine powder and used as a partial replacement for sand.

Key properties:

- High silica content
- Environmentally friendly and recyclable material
- Improves the strength characteristics when used in proper proportion
- Needs careful use to avoid alkali-silica reaction (ASR), though risk is low when used in powdered form





Figure: 3-6 Glass

Table 3-1: Quantity of Materials

SL-No.	MATERIALS	QUANTITY
1	Cement	19 kg
2	Fine Aggregate+ Glass (by ratio)	32 kg
3	Coarse Aggregate (Tiles)	63 kg

Test Data Materials:

Values in this section should be based on the laboratory tests. Here, standard values of different materials are assumed for the mix design of M20 grade concrete.

Name	Specific Gravity of	Sieve Analysis	Water Absorption
Cement	. Test - IS: 2720	3.10	0.7%
Sand	3.80	2.6	2.47%
Glass	2.5	2.9	0.50%
Tiles	2.50	7.1	1.78%

Table 3-2: Properties of Materials

6.2 Mix Proportioning:

A series of concrete mixtures will be designed with varying proportions Glass and tiles. The mix design will be based on established guidelines for achieving the desired compressive strength. The control mixtures without any additives will also be prepared for comparison.



Figure: 3-7 Mix Proportioning

3.2.4 Concrete Mix Design: **i**n this thesis, a concrete cylinder was prepared using a 1:1.5:3 mix ratio, where crushed tiles replaced conventional coarse aggregates. Fine aggregates consisted of sand mixed with crushed glass in varying proportions of 30%, 50%, and 70%. PPC cement was used as the binder, and a specific amount of water was added to achieve proper workability. During the filling process, the concrete was compacted in three layers,

with each layer being rodded 25 times to ensure proper densification. This mix was designed to evaluate the feasibility of incorporating waste materials into concrete while maintaining structural integrity and performance.



Figure: 3-8 Concrete Mixing

3.2.5 Specimen Casting:

The freshly mixed concrete will be cast into standard cylindrical or cubic molds, adhering to relevant testing standards. Special care will be taken to prevent segregation during casting. The molds will be properly vibrated to eliminate air void.



Figure: 3-9 Specimen Casting

3.2.6 Curing Regime The cast specimens will undergo a controlled curing process to simulate real-world conditions. This process will involve both moist curing and air curing, as per established concrete curing practices. The curing duration will be chosen to ensure proper hydration and development of strength.



Figure 3-10: Curing Regime

3.2.7 Compressive Strength Testing: After the curing period, the specimens will be carefully demoded and tested for compressive strength using a Universal Testing Machine (UTM)

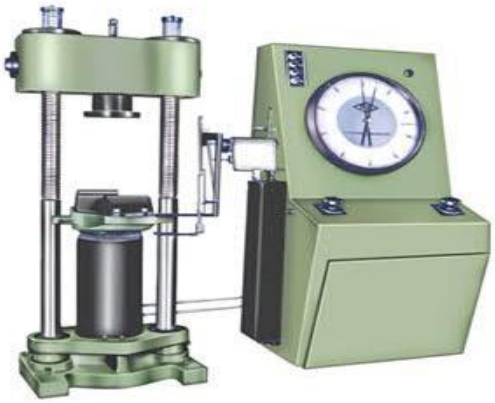


Figure 3-11: Universal Testing Machine





Figure 3-12: Compressive Strength Testing

The load will be applied gradually and uniformly until failure occurs. The maximum load at failure and the corresponding stress will be recorded to calculate the compressive strength.

3.2.8 Data Collection and Analysis:

The obtained compressive strength values from different mixtures will be compiled and analyzed statistically. The effects of varying proportions Glass and tiles on the compressive strength will be studied. Comparative analysis will be conducted between the modified concrete mixes and the control mixes.

3.3 Summary

The methodology of this study focuses on evaluating the compressive strength of concrete with partial replacement of coarse aggregate using crushed tiles. Portland Pozzolana Cement (PPC), fine aggregates, and natural coarse aggregates were used alongside varying percentages of sand and glass (30%, 50%, 70%) Concrete cylinders were cast following a standard mix ratio and water-cement ratio. The specimens were cured in controlled environments for 7, 21, and 28 days. Compressive strength tests were conducted using a Universal Testing Machine to assess the performance of the different concrete mixes. The methodology also included data analysis to compare the performance of modified concrete mixes with normal concrete.

This experimental approach aims to provide insights into the viability of crushed tiles as a sustainable alternative to traditional coarse aggregates in concrete while evaluating the impact of sand and glass ratios on concrete performance.

CHAPTER 4

Results and Discussion

4.1 Introduction

In the experimental study, twenty-seven (27) cylinder specimens were prepared for the compression test in the lab. These specimens consisted of concrete with varying ratios of sand and glass (30%, 50%, 70%) while using crushed tiles as a replacement for coarse aggregate. All cylinder specimens were placed under ambient conditions for air curing at 7, 21, and 28 days before conducting the compression test.

4.2 Specific Aim

Compressive Strength: Compressive strength is defined as the resistance of concrete to axial loading. The cylinders were placed in a Universal Testing Machine (U.T.M), and load was applied. The readings were recorded up to the final crack of the cylinder, and compressive strength was calculated. The results of compressive strength are presented in a table for analysis.

Calculations: Compressive Strength = Maximum load/Cross Sectional Area = P/A

Table 4-1: 7 Days of Maturation.

Case	Diameter mm	Diameter inch	Area inch	Height mm	Weight gm	Load KN	Load Psi	Load Mpa
30%	102	4.015748	12.66514	204	3504	110	1952.4459	13.46514
	101.8	4.007874	12.61552	205	3505	135	2405.6081	16.5904
	103.3	4.066929	12.99003	205	3614	120	2076.669	14.32185
50%	100.6	3.96063	12.31986	206	3478	107	1952.4256	13.465
	102	4.015748	12.66514	204	3539	107	1899.1974	13.09791
	103.5	4.074803	13.04038	205	3654	105	1810.0696	12.48324
70%	103	4.055118	12.91469	205	3551	117	2036.5641	14.04527
	102	4.015748	12.66514	206	3509	130	2307.4361	15.91335
	102.1	4.019685	12.68999	206	3478	108	1913.1937	13.19444

Table 4-2: 21 Days of Maturation.

Case	Diameter mm	Diameter inch	Area inch	Height mm	Weight gm	Load KN	Load Psi	Load Mpa
30%	102.3	4.02756	12.7398	205	3559	165	2911.5171	20.0794
	102	4.01575	12.6651	206	3576	135	2396.1836	16.5254
	102.7	4.04331	12.8396	206	3586	152	2661.2726	18.3536
50%	103	4.05512	12.9147	207	3640	150	2610.9796	18.0068
	102.5	4.03543	12.7896	206	3647	150	2636.5147	18.1829
	101.6	4	12.566	204	3563	160	2862.3269	19.7402
70%	102.7	4.04331	12.8396	206	3567	173	3028.9485	20.8893
	103.6	4.07874	13.0656	207	3544	155	2666.8516	18.3921
	103.6	4.07874	13.0656	205	3533	160	2752.8791	18.9854

Table 4-3: 28 Days of Maturation.

Case	Diameter mm	Diameter inch	Area inch	Height mm	Weight gm	Load KN	Load Psi	Load Mpa
30%	102.38	4.015748	12.66514	206	3686	177	1952.446	13.46514
	103.07	4.007874	12.61552	204	3507	165	2405.608	16.5904
	102.83	4.066929	12.99003	206	3567	170	2076.669	14.32185
50%	103	3.96063	12.31986	205	3628	155	1952.426	13.465
	102.5	4.015748	12.66514	205	3670	162	1899.197	13.09791
	101.67	4.074803	13.04038	205	3592	167	1810.07	12.48324
70%	102.92	4.055118	12.91469	206	3708	147	2036.564	14.04527
	103.17	4.015748	12.66514	206	3627	152	2307.436	15.91335
	102.1	4.019685	12.68999	205	3653	150	1913.194	13.19444

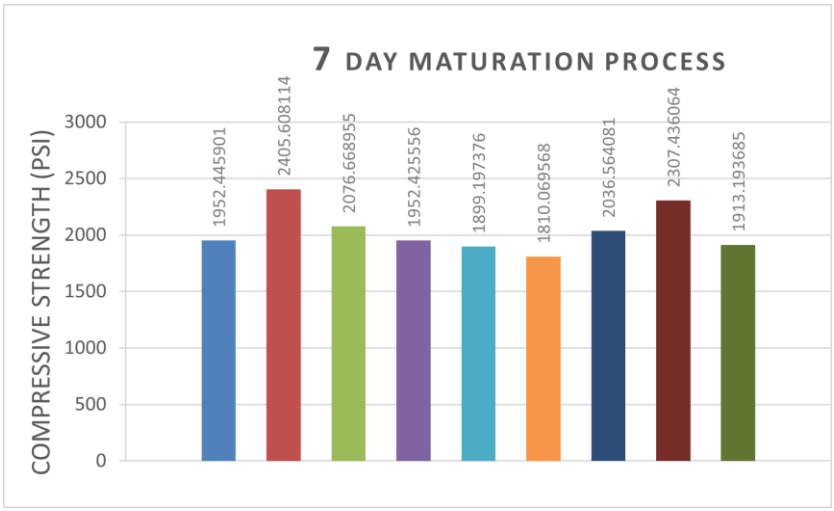


Figure 4-1: 7 Days Compare Compressive Strength with glass and Tiles Concrete

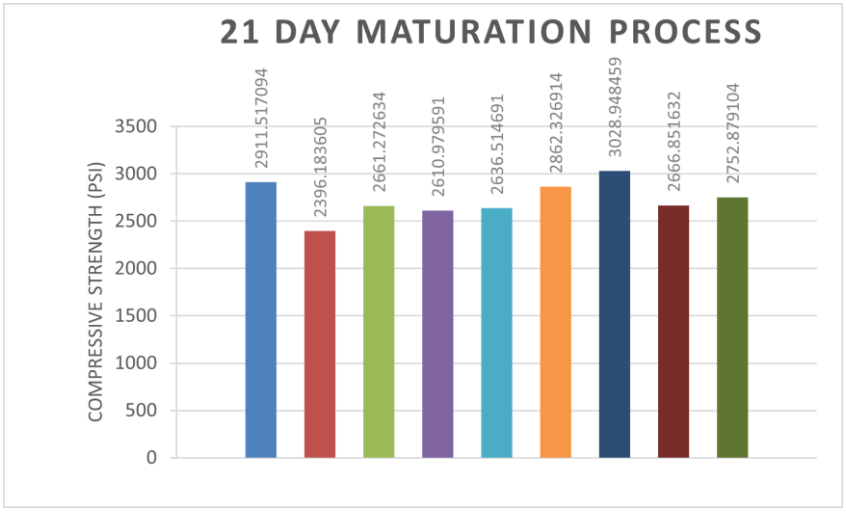


Figure 4-2: 21 Days Compare Compressive Strength with glass and Tiles Concrete

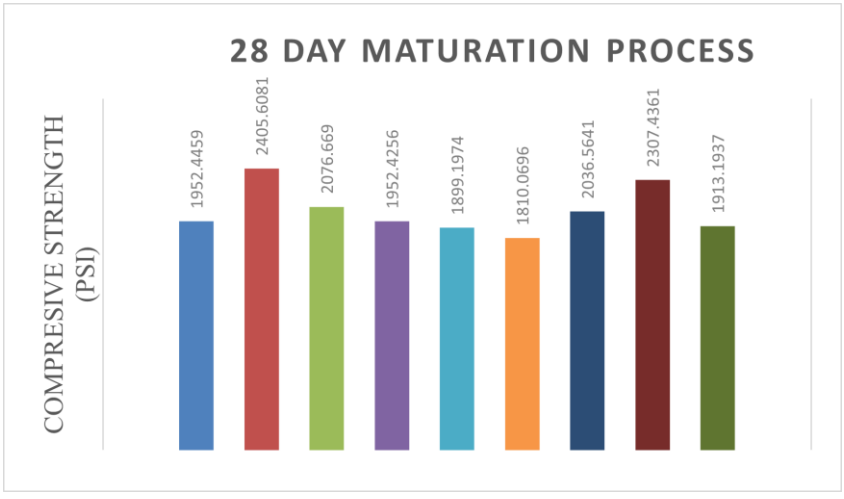


Figure 4-3: 28 Days Compare Compressive Strength with glass and Tiles Concrete

4.3 Summary

From the graph we are finding results of 7 days, 21 days and 28 days' compressive strength of concrete with mixed of coconut fiber reinforcement and normal concrete compressive strength. In the Lab test After 7 days normal concrete applied load of 93KN cylinder crushing compressive strength was 1682.89psi. Comparing with 5% coconut fiber after 7 days with applied load of 73KN cylinder crushing compressive strength was 1282.53psi. Graph figure shows the compare compressive strength of concrete with 0%, 1%, 3% and 5% ratio of coconut fiber by the different color markings. Then, 14 days, 21days and 28 days cylinder crushing process same process followed by the 7 days compressive strength upper shown in the graph by different percentages of normal concrete and with coconut fiber reinforcement.

CHAPTER 5

Conclusions and Future Recommendations

5.1 Conclusions

Compressive Strength: Concrete incorporating up to 20% waste ceramic tiles maintained comparable compressive strength to conventional mixes. Higher replacement levels led to reduced strength due to increased porosity and weaker bonding between the cement paste and recycled aggregates.

Tensile and Flexural Strength: Inclusion of waste glass improved tensile strength at lower replacement levels, attributed to reduced porosity and enhanced bonding. However, flexural strength decreased with higher glass content, likely due to increased brittleness.

Durability: The water permeability of concrete decreased with the addition of waste glass, enhancing durability. However, the risk of alkali-silica reaction (ASR) increased with larger glass particle sizes.

Sustainability: Utilizing waste materials reduced the environmental impact by decreasing landfill waste and the demand for natural aggregates, contributing to more sustainable construction practices.

5.2 Limitations and Recommendations for Future Works

Material Variability: Inherent differences in the properties of waste tiles and glass, such as particle size and composition, led to inconsistencies in concrete performance.

Durability Concerns: Concrete with recycled aggregates exhibited increased porosity and water absorption, potentially compromising durability.

Alkali-Silica Reaction (ASR): The use of glass aggregates introduced the risk of ASR, leading to expansion and cracking.

Economic and Logistical Challenges: The collection, processing, and transportation of waste materials involved additional costs and logistical complexities.

Material Standardization: Develop standardized guidelines for the characterization and classification of waste tiles and glass aggregates to ensure consistent quality control.

Advanced Processing Techniques: Investigate and implement advanced processing methods, such as surface treatment and grading optimization, to improve the bonding between recycled aggregates and the cement matrix.

Long-Term Durability Studies: Conduct comprehensive long-term studies to evaluate the performance of concrete containing recycled aggregates under various environmental conditions.

Mitigation of Alkali-Silica Reaction: Explore strategies to mitigate ASR, including the use of supplementary cementitious materials (SCMs) like fly ash or slag, which can reduce the alkali content in concrete and enhance its resistance to ASR.

Economic Analysis and Life Cycle Assessment: Perform detailed economic analyses and life cycle assessments to evaluate the cost-effectiveness and environmental impact of using recycled aggregates in concrete production.

Integration with Emerging Technologies: Investigate the integration of recycled aggregates with emerging construction technologies, such as 3D printing and automated mixing processes, to enhance the efficiency and scalability of their application in the construction industry.

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