Comparison of Compressive Strength by Partial Replacement of Cement using Glass Powder, Red Clay, and Rice Husk Ash

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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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Section: (25B)

Semester – Summer-2025

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DECLARATION

It is hereby declared that this thesis/project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Dedicated

to

“OUR PARENTS & TEACHERS”

ACKNOWLEDGEMENTS

First and foremost, praises and thanks to the almighty, Allah, for His showers of blessings throughout our research work to complete the research successfully. We would like to express our deep and sincere gratitude to our research supervisor Zeba Fariha, Department of Civil Engineering, Sonargaon University, for providing us with invaluable guidance throughout this research. Her dynamism, vision, sincerity and motivation have deeply inspired us. She has taught us the methodology to carry out the research and to present the research work as clearly as possible. It was a great privilege and honor to work and study under her guidance. Besides our advisor, we would like to thank the rest of our teachers for their encouragement, insightful comment and hard questions. We also wish to acknowledge (Md Robiullah's) instrumental help in locating pertinent materials, who patiently taught us his method for synthesizing a number of other laboratory techniques, and who worked closely with us to present this thesis.

Last but not the least, we are extremely grateful to our friends & parents for their love, prayers, caring and sacrifices for educating and preparing us for our future.

ABSTRACT

Cement is one of the most widely used construction materials with huge consumption rate. The mass production and consumption of cement not only contributes to environmental pollution but also reduces overall natural resources; cement manufacturing is responsible for around 7–8% of global CO_2 emissions with large amount of resource (limestone, clay, gypsum, and fuel etc.) depletion. Today it has become essential to address this problem and research on alternative cementitious materials. Therefore, this research investigates partial replacement of cement with Rice Husk Ash (RHA), Glass Powder (GP), and Red Clay (RC) by 25%, 50%, and 75%. A total of 10 cases were designed with 90 cylindrical concrete specimens in each case. Particularly for this study, specimens were prepared for 1:1.5:3 mix ratio with water-to-binder ratio of 0.5. Compressive strength test was conducted at curing periods of 7, 21, and 28 days respectively. 28 days' compressive strength data shows that concrete achieves 1.18% increased compressive strength for 25% replacement with red clay than control mix with ordinary Portland cement (OPC). This finding aims to evaluate the influence of alternative materials on performance of concrete while reducing conventional resources.

TABLE OF CONTENT

ABSTRACT vii

LIST OF FIGURES x

LIST OF TABLES xi

CHAPTER 1 1

CHAPTER-1 1

INTRODUCTION 1

1.1 Background and Motivations 1

1.2 Research Objectives and Overview 2

1.3 Organization of the thesis 2

CHAPTER 2 4

CHAPTER-2 4

Literature Review 4

2.1 Introduction 4

2.2 Content 6

2.2.1 Rice Husk Ash (RHA) in Concrete 6

2.2.2 Glass Powder (GP) in Concrete 6

2.2.3 Red Clay (RC) in Concrete 7

2.3 Summary 7

CHAPTER 3 8

CHAPTER-3 8

Methodology 8

3.1 Introduction 8

3.2 Methodology Overview 8

3.2.1 Cement 9

3.2.2 Fine Aggregates 10

3.2.3 Coarse Aggregates 11

3.2.4 Water 12

3.2.5 Rice Husk Ash 13

3.2.6 Glass Powder 14

3.2.7 Red clay 15

3.2.8 Procedure of Making the Cylinder 16

3.2.9 Materials Selection and Preparation 16

3.2.10 Specimen Casting 17

3.2.11 Curing Regime 18

3.2.12 Compressive Strength Testing 18

3.2.13 Data Collection and Analysis 19

3.3 Summary 22
CHAPTER 4 23
CHAPTER-4 23
Results and Discussion 23
4.1 Introduction 23
4.2 Result 23
4.3 Density 23
4.3.1 Compressive Strength 23
4.4 Summary 30
CHAPTER 5 30
CHAPTER-5 31
Conclusions and Future Works 31
5.1 Conclusions 31
5.2 Limitations 31
5.3 Recommendations for Future Works 31
5.4 Scope for Future Study 32
REFERENCES 33

LIST OF FIGURES

Figure 1.1 Rice Husk Ash 2
Figure1. 2 Red Clay 2
Figure1. 3 Glass Powder 2
Figure 3-1. Overview of the methodology. 9
Figure 3-2. Ordinary Portland Cement (OPC) 10
Figure 3-3. Fine Aggregate 11
Figure 3-4. Coarse Aggregates 11
Figure 3-5. Water Mixing 13
Figure 3-6. Rice Husk Ash 14
Figure 3-7. Glass Powder 14
Figure 3-8. Red Clay 15
Figure 3-9. Concrete mixing with Glass Powder 16
Figure 3-10. Specimen Casting 17
Figure 3-11. Curing Regime 18
Figure 3-12. Compressive Strength Testing 19
Figure 3-13. Unite Weight of (Bricks) 19
Figure 3-14. Unite Weight of (Sand) 21
Figure 4-1. Compare Compressive Strength with Normal Concrete & Glass powder 24
Figure 4-2. Compare Compressive Strength with Normal Concrete & Red Clay 24
Figure 4-3. Compare Compressive Strength with Normal Concrete & Rice Husk (RH) 25

LIST OF TABLES

Table 3-1. Fine Aggregate Data Sheet 11

Table 3-2. Course Aggregate Data Sheet 12

Table 3-1. Summary Average unit Weight 20

Table 3-2. Apparent Specific Gravity Bricks 20

Table 3-3. Unite Weight of (Sand) 21

Table 3-4. Specific Gravity of Sand 22

Table 4-1. Summary of the goodness-of-fit of the prediction models. (Glass Powder 7 Days Curing) 25

Table 4-2. Summary of the goodness-of-fit of the prediction models. (Glass Powder 21 Days Curing) 26

Table 4-3. Summary of the goodness-of-fit of the prediction models. (Glass Powder 28 Days Curing) 26

Table 4-4. Summary of the goodness-of-fit of the prediction models. (Red Clay 7 Days Curing) 27

Table 4-5. Summary of the goodness-of-fit of the prediction models. (Red Clay 21 Days Curing) 27

Table 4-6. Summary of the goodness-of-fit of the prediction models. (Red Clay 28 Days Curing) 28

Table 4-7. Summary of the goodness-of-fit of the prediction models. (Rice Husk 7 Days Curing)) 28

Table 4-8. Summary of the goodness-of-fit of the prediction models. (Rice Husk 21 Days Curing) 29

Table 4-9. Summary of the goodness-of-fit of the prediction models. (Rice Husk 28 Days Curing) 29

Table 4-10. All the data summary shown in MPa 30

CHAPTER-1

INTRODUCTION

1.1 Background and Motivations

The rapid growth of the construction industry has led to an increasing demand for cement, which in turn contributes significantly to environmental issues such as CO_2 emissions, energy consumption, and depletion of natural resources. In response to these challenges, there is a growing global focus on developing sustainable and eco-friendly alternatives to traditional construction materials. One promising approach involves the partial replacement of cement with industrial and agricultural waste materials, thereby not only conserving natural resources but also mitigating environmental pollution caused by improper waste disposal.

In recent years, various waste materials such as rice husk ash (RHA), waste glass powder (GP), and red clay (RC) have gained attention due to their Supplementary properties and their potential to enhance the performance of concrete. Rice husk ash, a by-product of rice milling, is rich in silica and has been found to improve the strength and durability of concrete when properly processed. Similarly, finely ground glass powder show Supplementary activity and can contribute to long-term strength development. Red clay, which is found in Specific Area, can provide additional binding properties and help reduce the amount of cement while maintaining the workability and structural integrity of the concrete.

The motivation for this research stems from the dual necessity of reducing the Environmental footprint of cement production and finding productive uses for waste materials readily available in countries like Bangladesh. By investigating the combined use of RHA, glass powder, and red clay as partial cement replacements, this study aims to develop a sustainable, cost-effective concrete mix that aligns with green construction practices. The use of these materials not only promotes the circular economy by

recycling industrial and agricultural waste but also offers potential improvements in concrete performance, such as increased durability and resistance to chemical attack.

This research seeks to characterize the physical and mechanical properties of the modified concrete, evaluate its feasibility for structural use, and contribute valuable data to the ongoing efforts of the construction industry toward sustainability. Ultimately, the study aspires to bridge the gap between environmental responsibility and engineering performance, making way for a more sustainable future in construction.



Figure 1.1 Rice Husk Ash



Figure1. 2 Red Clay



Figure1. 3 Glass Powder

1.2 Research Objectives and Overview

1. To investigate the effects of partial replacement of cement with rice husk ash, red clay, and glass powder at 25%, 50%, and 75% replacement levels on compressive strength of concrete.
2. To minimize cement consumption by incorporating alternative materials, thereby promoting a sustainable and environmentally friendly approach in concrete production.

1.3 Organization of the thesis

This section has a brief description of the thesis outline. Of the thesis.

Chapter 1: Introduction and Objective. This chapter provides the background and motivations of the research. The overall objectives and expected outcomes are also described in this chapter.

Chapter 2: Literature Review. This chapter reviews the related works in the Compressive strength analysis with a special focus on Cementite's Materials.

Chapter 3: Methodology. This chapter describes the methodology adopted to carry out the research.

Chapter 4: Results and Discussion. This chapter describes the results of Sample testing and compression testing.

Chapter 5: Conclusions and Future Work. This chapter summarizes the conclusions and major contributions of this study and provides recommendations for future studies.

CHAPTER-2

Literature Review

2.1 Introduction

Prof Dr Abdullah Saand, Engr. Manthar Ali keerio, Engr. Rabnawaz juj, a et al. Utilization of Waste Glass as Partial Replacement for Coarse Aggregate in Concrete for Low-Strength Structural Applications. Crushed glass was tested in different amounts (5% to 50%) to see how it affects concrete properties like strength, workability, and durability. The results show that waste glass improves workability and keeps strength within safe limits for low-strength structures, though density decreases slightly. Using glass also adds a nice look to the concrete and helps the environment by reducing waste and saving natural resources. The study confirms that waste glass is a good option for low-strength concrete, but care must be taken to avoid long-term problems like alkali-silica reaction (ASR). More research is suggested to improve its use in different construction areas. [1]

This study by M. Anwar (2025) explores the use of rice husk ash (RHA) as a replacement for cement in concrete, especially in countries facing cement shortages. The research focuses on the properties of RHA, its effect on fresh and hardened concrete, and its durability. The research involves developing a comprehensive engineering data-base on RHA concretes including durability aspects such as long term performance in artificial sea water (5% NaCl solution). Tests were done to check how RHA concrete performs in saltwater and how it resists chloride attacks. Other tests looked at concrete porosity. The results showed that RHA improves several important properties of concrete, making it a useful and eco-friendly material for construction. [2]

Jalull, Ghassan Ab. Omran. The Use of Waste and By-Product Materials to Reduce Cement Content in Paving Blocks. This study aimed to reduce Portland cement usage in paving block production to lower carbon emissions without compromising performance. Various non-hazardous industrial by-products—such as GGBS, BOS, ROSA, PG, BPD, IBAA, RCG, RCA, RB—along with steel and PVA fibers were used in binary and ternary blends. Ten mix groups were tested for strength, durability, slip resistance, density, and weathering, with XRD/XRF analyses conducted. Results showed that BOS (up to 70%), ROSA (up to 60%), GGBS (up to 45%), BPD (up to

20%), and PG (up to 5%) can replace Portland cement while meeting BS EN 1338:2003 standards. An optimal ternary mix (OPC50-GGBS45-BPD5) achieved a 30% cement reduction—using only 150 kg/m³—without significant loss in strength or durability, promoting more sustainable paving block production. [3]

Le Li, Paul Joseph, Xuelin Zhang, Lihai Zhang a et al. Cement, the key ingredient in concrete, is responsible for 8% of the world's CO2 emissions. Thus, reducing the amount of cement used in concrete is highly desirable to lower the total embodied carbon in concrete manufacturing. Furthermore, an increasing amount of ceramic waste powder (CWP) is generated during the ceramics manufacturing process, which can result in severe environmental problems such as soil, air, and groundwater pollution. This paper reports the use of CWP as a cement replacement agent in concrete to reduce environmental pollution in both concrete production and CWP waste management fields. For this purpose, comprehensive labo ratory work was carried out to replace different levels of cement with CWP. It was found that changes in compressive strength and water absorption value are within the acceptable tolerance when 20% CWP replaces cement. In addition, there was an improvement in thermal conductivity, and no significant damage to the mechanical properties of concrete after 30 min of fire exposure when CWP replaced 20% of cement was observed. Therefore, using up to 20% of CWP to replace cement in concrete manufacturing is feasible without compromising the essential properties of the finished products. The microstructural studies of the test specimens further proved that the added CWP was evenly scattered in the concrete matrix. [4]

C.Marthong, Cement is widely noted to be most expensive constituents of concrete. The entire construction industry is in search of a suitable and effective the waste product that would considerably minimize the use of cements and ultimately reduces the construction cost. Rice husk ash (RHA) which has the pozzolanic properties is a way forward. The possibility of using RHA as a construction material need to be investigates. Three grades of ordinary Portland cement (OPC) namely; 33, 43 and 53 as classified by Bureau of Indian Standard (BIS) are commonly used in construction industry. A comparative study on effects of concrete properties when OPC of varying grades was partially replaced by RHA is discussed in this paper. Percentage replacement of OPC with RHA was 0, 10, 20, 30 and 40% respectively. The compressive strength, water absorption, shrinkage and durability of concrete were mainly studied. The study suggests that up to 20% replacement of OPC with RHA has

the potential to be used as partial cement replacement, having good compressive strength performance and durability. [5]

C. Oliko, C. K. Kabubo, and J. N. Mwero, This paper presents the properties of concrete made with cement partially replaced with rice straw ash and eggshell ash. The rice straws and eggshells were incinerated, sieved, and ground, and the physical and chemical properties of the resultant ash and the other materials incorporated in the concrete mixes were determined. A class 35 concrete mix with no partial replacement of cement with rice straw ash designed with the British Research Establishment method with a water/cement ratio of 0.5 was considered as the control mix. The cement in concrete was partially replaced with rice straw ash by 5% to 30% and its compressive and splitting tensile strength was determined after 7, 14, 28, 56, and 90 days of curing. Durability, resistance to acid attack, and other wet and hardened properties of concrete with cement partially replaced with rice straw ash were also determined. An increase in compressive strength above the control mix was observed for concrete with 5% and 10% partial replacement of cement with rice straw ash. When eggshell ash was added to concrete mixes made with cement partially replaced with rice straw ash at 15% and 20%, the 28, 56, and 90-day compressive strength was found to increase. It can be concluded that rice straw and eggshell ash can be used to partially replace cement in concrete and result in a concrete whose properties compare favorably with control. [6]

2.2 Content

2.2.1 Rice Husk Ash (RHA) in Concrete

- Previous studies on the use of RHA as a partial replacement for cement.
- Effects of RHA on compressive strength, durability, and workability.
- Benefits of RHA as a low-cost and eco-friendly material.
- Limitations of using high percentages of RHA.

2.2.2 Glass Powder (GP) in Concrete

- Research findings on waste glass powder as a cement replacement.
- Influence of GP on compressive strength, density, and thermal properties.
- Advantages of GP in recycling waste and reducing cement use.
- Challenges such as reduced workability at higher proportions.

2.2.3 Red Clay (RC) in Concrete

- Studies related to industrial red clay waste in cement and concrete.
- Role of RC in strength development and bonding.
- Environmental benefits of recycling clay waste from industries.
- Weaknesses when used in large quantities.

2.3 Summary

The literature highlights the potential of Rice Husk Ash (RHA), Glass Powder (GP), and Red Clay (RC) to improve concrete properties when used as partial replacements for cement. These materials can contribute to making concrete more sustainable while still maintaining adequate strength. Glass Powder helps in increasing compressive strength, Rice Husk Ash improves bonding and durability, and Red Clay shows potential as a supplementary material.

However, using these materials in high proportions may reduce workability. Overall, their proper proportioning is important to balance strength, durability, and workability. This study further investigates the effects of RHA, GP, and RC on the performance of concrete.

CHAPTER-3

Methodology

3.1 Introduction

The methodology employed in this study focuses on analyzing the compressive strength of concrete through the partial replacement of cement with Rice Husk Ash (RHA), Glass Powder (GP), Red Clay (RC). The mixing process, Sieve analyses, casting of test samples, and curing methods are also explained. After casting the specimens, they are cured for specified periods (7, 21 and 28 days), followed by compressive strength testing using a Universal Testing Machine. This methodology aims to provide a comparative analysis of how these eco-friendly materials affect the structural performance of concrete, offering potential applications in lightweight and sustainable construction practices.

3.2 Methodology Overview

The methodology employed for investigating the compressive strength of concrete using Rice Husk Ash (RHA), Glass Powder (GP), and Red Clay (RC) involves a step-by-step experimental process. This study focuses on replacing cement with these materials at different levels (25%, 50%, and 75%) and testing their effect on concrete strength. The research includes the selection of materials, preparation of concrete mixes, casting of cylinders, curing, and compressive strength testing at 7, 21, and 28 days. This section gives an overview of the main methods followed in the research to ensure reliable and repeatable results.

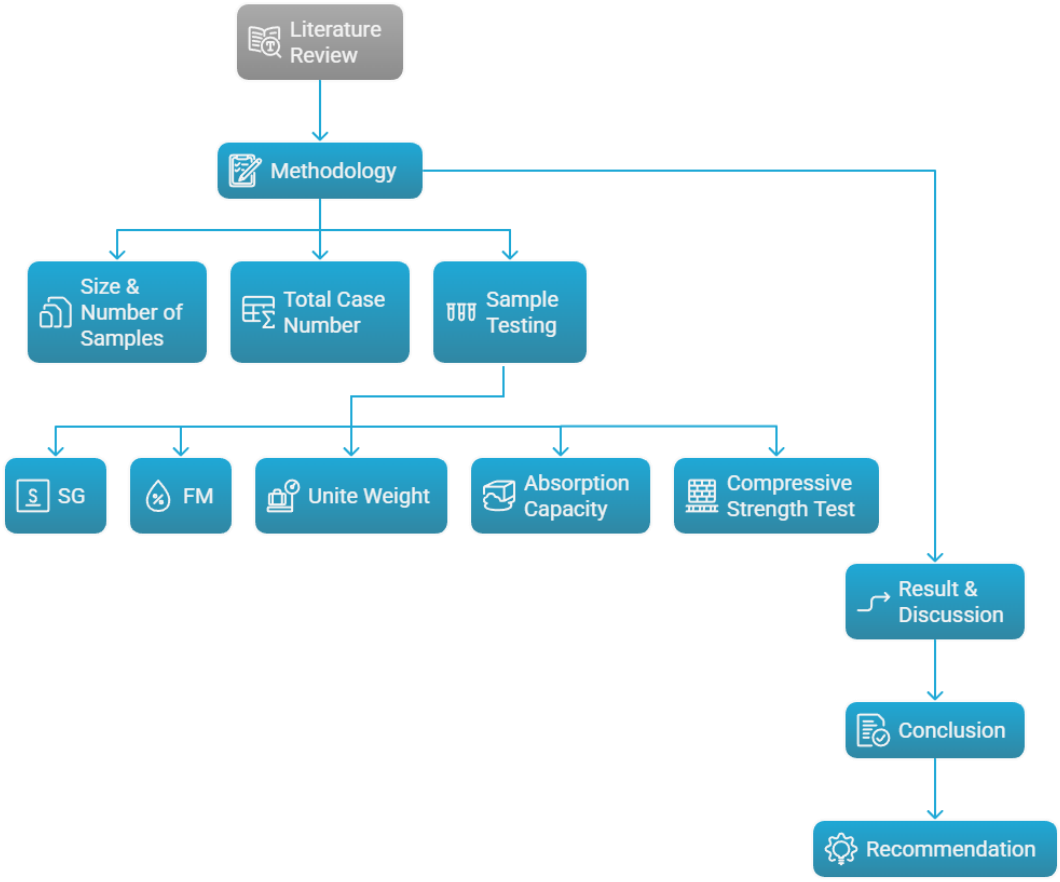


Figure 3-1. Overview of the methodology

3.2.1 Cement

Ordinary Portland Cement (OPC) was used as the main binding material. Cement is one of the most important components in concrete, as it reacts with water to form a hard and durable mass that binds the aggregates together. OPC was selected because it is widely available in Bangladesh and is commonly used in construction works.

The cement used in this study was tested before use to confirm its quality. The main properties considered were fineness, specific gravity, and setting time. These properties ensure that the cement will provide good bonding strength and proper hydration during the curing process.

Cement was partially replaced with rice husk ash (RHA), glass powder (GP), and red clay (RC) at different replacement levels (25%, 50%, and 75%). The remaining portion

of cement ensured that the concrete maintained its binding ability, while the replacement materials were expected to improve sustainability and reduce overall cost.

By combining cement with these replacement materials, the study aimed to check how the compressive strength of concrete changes over different curing periods (7, 21, and 28 days).



Figure 3-2. Ordinary Portland Cement (OPC)

3.2.2 Fine Aggregates

Fine aggregates are essentially any natural sand particles won from the land through the mining process. Fine aggregates consist of natural sand or any crushed tone particles that are ¼" or smaller. This product is often referred to as ¼" minus as it refers to the size, or grading, of this particular aggregate. They are granular materials, typically smaller than 5mm in diameter, that play a crucial role in enhancing the workability, strength, and durability of construction mixes. Here's an in-depth overview of fine aggregates. Sylhet sand was used for producing lightweight cylinders for performing compressive strength tests.



Figure 3-3. Fine Aggregate

Table 3-1. Fine Aggregate Data Sheet

Sieve Number	Sieve Opening (mm)	Materials Retained (gm)	% Materials Retained	Cumulative % Retained	Percent finer
4	4.75	16	1.6	1.6	98.4
8	2.36	58	5.8	7.4	92.6
16	1.19	152	15.2	22.6	77.4
30	0.59	230	23	45.6	54.4
50	0.3	439	43.9	89.5	10.5
100	0.15	94	9.4	98.9	1.1
Pan		11	1.1	100	0

Fineness Modulus = (1.6+7.4+22.6+45.6+89.5+98.9)/100 = 2.656

3.2.3 Coarse Aggregates

In this research, brick chips were used as the coarse aggregate. Before use, sieve analysis was carried out to determine the particle size distribution of the aggregate. The sieve analysis ensures that the coarse aggregate falls within the standard grading limits and is suitable for use in concrete.



Figure 3-4. Coarse Aggregates

The sieve analysis results are as follows:

- **3/4-inch sieve** → 233 gm retained
- **3/8-inch sieve** → 705 gm retained
- **No. 4 sieve** → 62 gm retained

Table 3-2. Course Aggregate Data Sheet

Sieve Number	Sieve Opening (mm)	Materials Retained (gm)	% Materials Retained	Cumulative % Retained	Percent finer
3/4	19.05	233	23.3	23.3	76.7
3/8	9.5	705	70.5	93.8	6.2
4	4.75	62	6.2	100	0
8	2.36	0	0	100	0
16	1.19	0	0	100	0
30	0.59	0	0	100	0
50	0.3	0	0	100	0
100	0.15	0	0	100	0

Fineness Modulus = (23.3+93.8+100+100+100+100+100+100) / 100 =7.171

From the test, it was observed that most of the aggregates passed through the 3/4-inch sieve and were retained on the 3/8-inch sieve, which indicates that the aggregate mainly falls in the medium range of coarse particles. A smaller portion was retained on the No. 4 sieve, showing the presence of finer coarse particles as well.

Brick chips were chosen as the coarse aggregate because of their easy availability, cost-effectiveness, and relatively good bonding properties in concrete. The grading obtained through sieve analysis shows that the aggregate is well-graded and suitable for preparing concrete mixes for compressive strength testing.

3.2.4 Water

Water was used as a key component in the preparation of concrete mixes. Water used as per BNBC 2020 standards, water used for mixing and curing must be clean and free from harmful substances such as oils, acids, alkalis, salts, sugars, or organic materials that could adversely affect the quality of concrete or the reinforcement steel. Potable water is generally regarded as satisfactory for concrete production, provided that its pH value is not less than 6.

For this project, the water–cement ratio was maintained at 0.5 to ensure proper hydration of the cement and achieve the desired workability of the mix. This ratio was carefully selected to balance strength and durability while preventing issues such as excessive shrinkage or reduced compressive strength.

Water served not only as a mixing medium but also played a vital role in curing, ensuring the continuous hydration of cement and promoting the development of the concrete's mechanical properties. By maintaining a consistent water–cement ratio throughout all mixes, the experimental results could be accurately compared, particularly when evaluating the effect of partial cement replacement with Rice Husk Ash, Glass Powder, and Red Clay.



Figure 3-5. Water Mixing

3.2.5 Rice Husk Ash

In this project, Rice Husk Ash (RHA) was prepared through a systematic process starting from collection at local rice mills. The collected husk was first cleaned to remove dust, soil, and other impurities, and then dried to eliminate surface moisture. After drying, the husk was subjected to controlled burning at a temperature range of 500–700°C to obtain ash rich in amorphous silica, which is highly effective as a binding material. The resulting ash was allowed to cool naturally before being finely ground to increase its surface area and passed through a 90-micron sieve to achieve the required fineness. Finally, the processed RHA was stored in air-tight containers in a dry environment until used as a partial replacement of cement in concrete mixes.



Figure 3-6. Rice Husk Ash

3.2.6 Glass Powder

Waste glass was utilized as a partial replacement for cement. The process began with the collection of waste glass from sources such as bottles, windows, and other glass products. The collected glass was carefully cleaned to remove dust, dirt, and impurities, and then sorted to separate unwanted materials like plastics or metals. After cleaning, the glass was crushed into smaller fragments using a crushing machine, followed by grinding in a ball mill until it became a fine powder with particle size comparable to that of cement. The powdered glass was then sieved to achieve uniform fineness, and the fine glass powder was stored in dry, airtight containers to prevent moisture absorption. During concrete preparation, the glass powder was mixed with cement as a partial replacement in proportions of 25%, 50%, and 75%. The mixture was then combined with sand as fine aggregate, brick chips as coarse aggregate, and water at a constant water-to-cement ratio of 0.5. The prepared concrete was cast into cylindrical molds, cured for 7, 21, and 28 days, and finally tested for compressive strength to evaluate the performance of glass powder as a cement replacement material.



Figure 3-7. Glass Powder

3.2.7 Red clay

Red clay is some naturally available material rich in silica and alumina, which makes it suitable for partial replacement of cement in concrete. In this research, the red clay was collected from a tiles factory named ATI Ceramics. After collection, the clay was dried to remove moisture and ensure better quality for use. The prepared red clay powder was stored in dry containers to avoid contamination or absorption of moisture. For the experimental work, red clay was used as a partial replacement of cement at ratios of 25%, 50%, and 75%. The concrete mixtures were made with sand as fine aggregate, brick chips as coarse aggregate, and water at a fixed ratio of 0.5. Cylinders were then cast, cured for 7, 21, and 28 days, and tested under compression to evaluate the effect of red clay on the strength and performance of concrete.



Figure 3-8. Red Clay

3.2.8 Procedure of Making the Cylinder

The mixture composition paving cylinder used the ratio of 1:1.5:3 which is 1kg cement, 1.5kg sand, and 3kg Coarse Aggregates, Expanded Glass powder, Rice husk ash and Red clay with the addition of 0.5% of water (not too much water should be added in order to get maximum water-cement ratio). The ratio will be 25%, 50% and 75% of all Aggregates weight were added. The mixture compositions were mold. The mold was hit 9 times in order to even up the mixture so there were no air voids. The finished mixture was taken out from the mold into plywood.



Figure 3-9. Concrete mixing with Glass Powder

3.2.9 Materials Selection and Preparation

These substances for concrete components have been:

- Plain Cement Concrete (PCC)
- Fine aggregate
- Coarse aggregate
- Glass powder
- Rice husk ash
- Red clay

High-quality materials will be selected to ensure accurate and repeatable results.

3.2.10 Specimen Casting

Concrete specimens were cast in the form of cylinders to evaluate compressive strength. The cylinder molds used had a diameter of 100 mm and a height of 200 mm. Before casting, all molds were properly cleaned and oiled to ensure smooth demolding and to avoid surface defects. The concrete mix was prepared using sand as fine aggregate, brick chips as coarse aggregate, and cement as the main binder. Cement was partially replaced with Rice Husk Ash (RHA), Glass Powder (GP), and Red Clay (RC) at proportions of 25%, 50%, and 75%. The water-to-cement ratio was maintained at 0.5 for all mixes to ensure uniformity. The fresh concrete was carefully poured into the cylinder molds in layers. Each layer was compacted using a tamping rod to remove air voids and ensure proper density. After filling, the top surface was leveled and smoothed. The specimens were left in the molds for 24 hours under room temperature.



Figure 3-10. Specimen Casting

3.2.11 Curing Regime

After 24 hours of casting, the concrete cylinders were carefully removed from the molds and immediately placed in a water curing tank. The curing process is an essential step because it helps maintain the required moisture content in the specimens, allowing proper hydration of cement and the pozzolanic reaction of the replacement materials such as Rice Husk Ash (RHA), Glass Powder (GP), and Red Clay (RC). Clean potable water was used for curing to avoid any chemical reaction that could affect the strength of concrete. The specimens were cured for different periods of 7 days, 21 days, and 28 days to study the variation in compressive strength over time. During the curing period, the water temperature was kept at room condition to ensure uniform hydration. Proper curing ensured the prevention of cracks, reduction of shrinkage, and development of sufficient strength in the concrete. After the curing period, the specimens were taken out of the tank, surface-dried, and prepared for compressive strength testing.



Figure 3-11. Curing Regime

3.2.12 Compressive Strength Testing

After completing the curing period of 7 days, 21 days, and 28 days, the concrete cylinders were taken out from the curing tank. The surface water was wiped off and the specimens were allowed to dry for a short time before testing. The compressive strength test was carried out using a Compression Testing Machine (CTM). Each specimen was placed carefully in the machine between the upper and lower plates in a vertical position, ensuring that the load was applied uniformly along the axis of the cylinder. A gradual load was applied without shock, at a constant rate, until the specimen failed.



Figure 3-12. Compressive Strength Testing

3.2.13 Data Collection and Analysis

The obtained compressive strength values from different mixtures will be compiled and analyzed statistically. The effects of varying proportions of Rice Husk Ash (RHA), Glass Powder (GP), and Red Clay (RC) on the compressive strength will be studied. Comparative analysis will be conducted between the modified concrete mixes and the control mixes.

Unite Weight of (Bricks)

Shoveling Condition --------- 6348 gm (Bucket + Sample)

Rodding Condition ---------- 6709 gm (Bucket + Sample)

Jiggling Condition ---------- 6823 gm (Bucket + Sample)

Bucket Height (H) - 6”

Bucket Dia (D) - 6”

Bucket Weight (W) - 4000 gm

Volume of Bucket ---------- = 0.00278 m3



Figure 3-13. Unite Weight of (Bricks)

Table 3-3. Summary Average unit Weight

Type of Procedure	Weight of Bucket gm (T)	Weight of Bucket + Material gm (G)	Weight of Material (G-T)	Volume of Bucket (V) m3	Unit Weight Material kg/m3	Average Unite Weight Material
Shoveling	4000	6348	2348	0.00278	845	945
Rodding	4000	6709	2709	0.00278	974	
Jiggling	4000	6823	2823	0.00278	1015	

Specific Gravity of Bricks

A ---------- 1120 gm

B ---------- 1280 gm

C ---------- 600 gm

Table 3-4. Apparent Specific Gravity Bricks

Test	Formula	Calculation	Results
Apparent Specific Gravity	$\frac{A}{A-C}$	$\frac{1120}{1120-600}$	2.15
Bulk Specific Gravity (S.S.D Basis)	$\frac{B}{B-C}$	$\frac{1280}{1280-600}$	1.88
Bulk Specific Gravity (Oven Dry Basis),	$\frac{A}{B-C}$	$\frac{1120}{1280-600}$	1.65
Absorption Capacity, D%	$\frac{(B-A)x100}{A}$	$\frac{(1280-1120)x100}{1120}$	14.29

1. **SSD Basis (Sp. Gravity = 1.88)**

   Void =$\frac{(S\,x\,W)-M}{SxW}\ x\ 100 = \frac{(\,1.88x\,998)-945}{1.88x998}$x100=48.03%

2. Oven Dry Basis (Sp. Gravity = 1.65)

$$\text{Void} = \frac{(S\,x\,W)-M}{SxW}\ x\ 100 = \frac{(1.65x\,998)-927}{1.88x998}\text{x}100=43.7\%$$

Unite Weight of (Sand)

Shoveling Condition --------- 7498 gm (Bucket + Sample)

Rodding Condition ---------- 7720 gm (Bucket + Sample)

Jiggling Condition ---------- 8187 gm (Bucket + Sample)

Bucket Height (H) - 6”

Bucket Dia (D) - 6”

Bucket Weight (W) - 4000 gm

Volume of Bucket ---------- = 0.00278 m3 "



Figure 3-14. Unite Weight of (Sand)

Table 3-5. Unite Weight of (Sand)

Type of Procedure	Weight of Bucket gm (T)	Weight of Bucket + Material gm (G)	Weight of Material (G-T)	Volume of Bucket (V) m3	Unit Weight Material kg/m3	Average Unite Weight Material
Shoveling	4000	7498	3498	0.00278	1258	1368
Rodding	4000	7720	3720	0.00278	1338	
Jiggling	4000	8187	4187	0.00278	1506	

Specific Gravity of Sand

A ---------- 284 gm
B ---------- 654 gm

C ---------- 833 gm

S ---------- 300 gm

Table 3-6. Specific Gravity of Sand

Test	Formula	Calculation	Results
Apparent Specific Gravity	$\frac{A}{B+A-C}$	$\frac{284}{654+284-833}$	2.70
Bulk Specific Gravity (Oven Dry Basis)	$\frac{A}{B+S-C}$	$\frac{284}{654+300-833}$	2.35
Bulk Specific Gravity (S.S.D Basis), G	$\frac{S}{B+S-C}$	$\frac{300}{654+300-833}$	2.48
Absorption Capacity, D%	$\frac{S-A}{A}$x100	$\frac{300-284}{284}$x100	5.63

3.3 Summary

The "Results and Discussion" section stands as the culmination of empirical data. The materials and steps used in the research were described. Cement was partially replaced with Rice Husk Ash, Glass Powder, and Red Clay at 25%, 50%, and 75% ratios. Concrete cylinders were cast, cured in water, and then tested for compressive strength at 7, 21, and 28 days. The process also included proper preparation of materials, casting, curing, and testing to ensure reliable results. This methodology allows the study to clearly show how different waste materials affect the strength of concrete.

CHAPTER-4

Results and Discussion

4.1 Introduction

This chapter shows the compressive strength test results of concrete cylinders where cement was partly replaced with Rice Husk Ash, Glass Powder, and Red Clay. The results are compared with normal concrete to see the effect of each material and ratio. The discussion explains the reasons for strength changes, highlights both benefits and limits of using these materials, and identifies the most suitable replacement percentage for durable and sustainable concrete.

4.2 Result

4.3 Density

The measured density of the concrete specimen in this study is approximately 2010 kg/m³**,** which is lower than the typical density of conventional concrete (about 2300–2500 kg/m³). This reduction in density is mainly due to the partial replacement of cement with Rice Husk Ash (RHA), Glass Powder (GP), and Red Clay (RC). These supplementary materials are generally lighter in weight compared to ordinary Portland cement.

4.3.1 Compressive Strength

This rise is the result of the cement hydration process becoming more advanced with time. and both provide a comparison of the compressive strengths of several specimens at 7, 21 and 28 days of age.

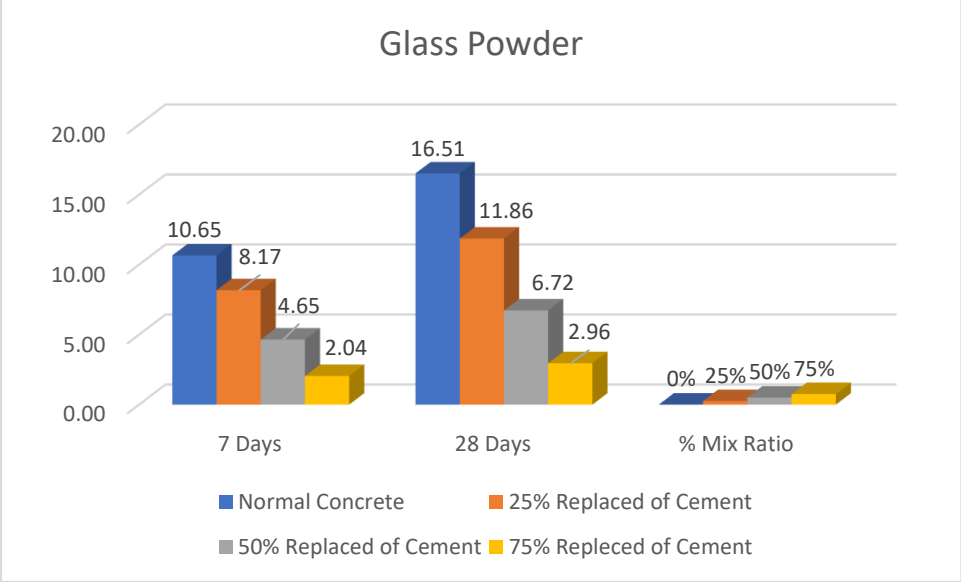


Figure 4-1. Compare Compressive Strength with Normal Concrete & Glass powder

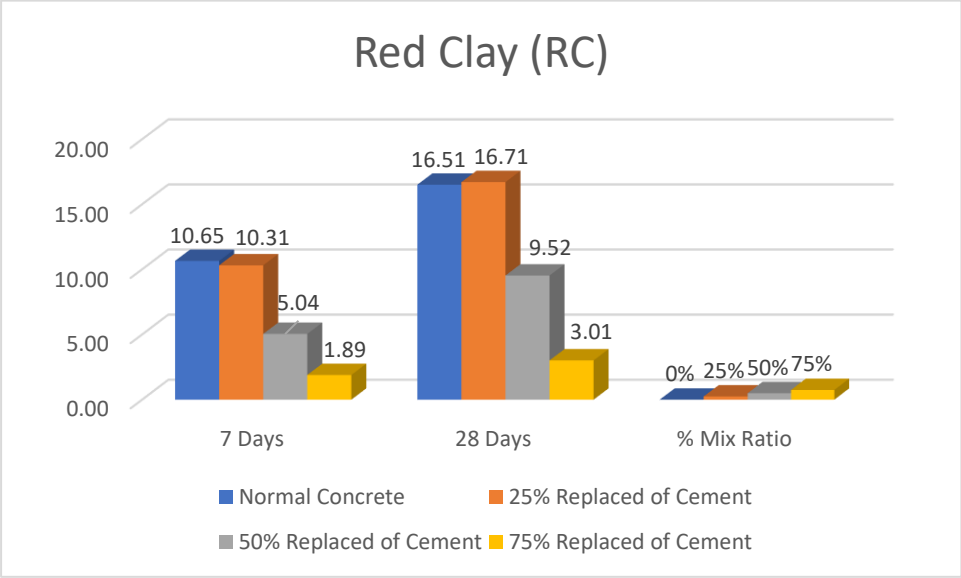


Figure 4-2. Compare Compressive Strength with Normal Concrete & Red Clay

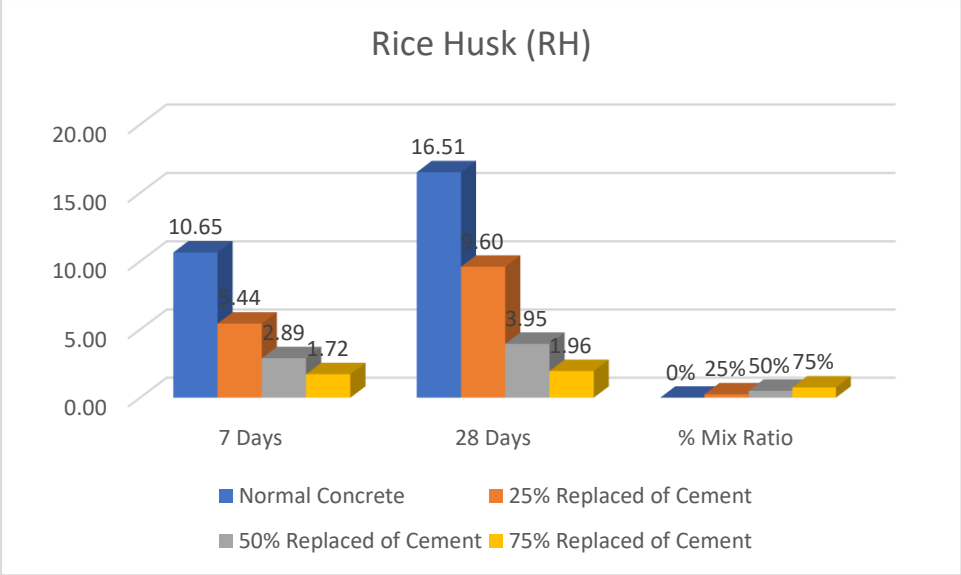


Figure 4-3. Compare Compressive Strength with Normal Concrete & Rice Husk (RH)

Table 4-1. Summary of the goodness-of-fit of the prediction models. (Glass Powder 7 Days Curing)

Glass powder			inch	inch				
CL	Curing Days	%	Cylinder Height(mm)	Cylinder Dia (mm)	Cylinder weight	Load (KN)	Average Crushing Strength (kn)	PSI
1	7	0	205.00	103.36	3398	77	89	1545
			207.00	103.48	3477	84		
			205.50	102.60	3482	106		
2		25	206.00	103.47	3440	62	67	1184
			206.50	102.48	3498	68		
			206.50	101.44	3421	72		
3		50	205.50	103.29	3477	41	38	674
			207.00	101.97	3448	36		
			205.50	102.20	3369	38		
4		75	205.00	102.73	3456	18	17	296
			205.50	103.17	3467	17		
			205.00	102.92	3339	16		

Table 4-2. Summary of the goodness-of-fit of the prediction models. (Glass Powder 21 Days Curing)

Glass powder			inch	inch				
CL	Curing Days	%	Cylinder Height(mm)	Cylinder Dia (mm)	Cylinder weight	Load (KN)	Average Crushing Strength (kn)	PSI
1	21	0	206.00	100.05	3301	120	117	2112
			205.00	101.82	3393	100		
			205.00	101.99	3405	132		
2		25	206	102.96	3433	75	84	1470
			207	103.62	3484	97		
			207	101.56	3366	80		
3		50	205	102.8	3356	55	53	931
			205	102.60	3353	57		
			206	102.19	3401	47		
4		75	206	103.68	3432	18	17	300
			206	103.52	3435	18		
			205	102.49	3339	16		

Table 4-3. Summary of the goodness-of-fit of the prediction models. (Glass Powder 28 Days Curing)

Glass powder			inch	inch				
CL	Curing Days	%	Cylinder Height(mm)	Cylinder Dia (mm)	Cylinder weight	Load (KN)	Average Crushing Strength (kn)	PSI
1	28	0	206	102.23	3398	130	136	2395
			206	103	3380	137		
			205	102.37	3302	142		
2		25	207	101.98	3441	90	98	1720
			206	102.07	3370	97		
			205	103.18	3315	106		
3		50	205	102.19	3200	56	55	975
			205	103.08	3382	50		
			207	101.83	3215	60		
4		75	206	102.00	3274	24	24	429
			206	103.28	3297	25		
			206	101.77	3189	24		

Table 4-4. Summary of the goodness-of-fit of the prediction models. (Red Clay 7 Days Curing)

Red Clay			inch	inch				
CL	Curing Days	%	Cylinder Height(mm)	Cylinder Dia (mm)	Cylinder weight	Load (KN)	Average Crushing Strength (kn)	PSI
1	7	0	205.00	103.36	3398	77	89	1545
			207.00	103.48	3477	84		
			205.50	102.60	3482	106		
5		25	206.00	101.93	3405	84	86	1495
			206.00	103.26	3467	83		
			205.00	103.4	3418	90		
6		50	206.00	101.7	3452	40	42	732
			206.50	102.87	3378	45		
			205.50	103.07	3337	40		
7		75	205.00	102.81	3375	15	16	275
			205.00	102.29	3297	16		
			205.00	102.72	3240	16		

Table 4-5. Summary of the goodness-of-fit of the prediction models. (Red Clay 21 Days Curing)

Red Clay			inch	inch				
CL	Curing Days	%	Cylinder Height(mm)	Cylinder Dia (mm)	Cylinder weight	Load (KN)	Average Crushing Strength (kn)	PSI
1	21	0	206.00	100.05	3301	120	117	2112
			205.00	101.82	3393	100		
			205.00	101.99	3405	132		
5		25	205	102.45	3372	112	110	1934
			206	101.57	3414	107		
			206	102.94	3432	110		
6		50	207	102.58	3336	56	60	1048
			207	103.03	3443	61		
			203	101.98	3225	62		
7		75	207	104.00	3355	23	21	359
			207	103.16	3332	21		
			207	102.25	3360	18		

Table 4-6. Summary of the goodness-of-fit of the prediction models. (Red Clay 28 Days Curing)

Red Clay			inch	inch				
CL	Curing Days	%	Cylinder Height(mm)	Cylinder Dia (mm)	Cylinder weight	Load (KN)	Average Crushing Strength (kn)	PSI
1	28	0	206	102.23	3398	130	136	2395
			206	103	3380	137		
			205	102.37	3302	142		
5		25	206	102.87	3303	135	139	2423
			207	102.73	3365	147		
			205	103.17	3362	135		
6		50	205	102.67	3185	82	79	1381
			206	102.42	3128	77		
			205	102.55	3168	77		
7		75	205	101.70	3292	26	25	437
			206	103.92	3389	25		
			205	102.69	3317	24		

Table 4-7. Summary of the goodness-of-fit of the prediction models. (Rice Husk 7 Days Curing))

Rice Husk			inch	inch				
CL	Curing Days	%	Cylinder Height(mm)	Cylinder Dia (mm)	Cylinder weight	Load (KN)	Average Crushing Strength (kn)	PSI
1	7	0	205.00	103.36	3398	77	89	1545
			207.00	103.48	3477	84		
			205.50	102.60	3482	106		
8		25	205	103.00	3199	42	45	788
			205	102.28	3302	45		
			206	102.72	3315	48		
9		50	204	101.98	3150	25	24	420
			204	102.00	3118	22		
			205	102.15	3240	24		
10		75	205	102.73	3093	14	14	250
			207	103.06	3042	15		
			206	103.00	3090	14		

Table 4-8. Summary of the goodness-of-fit of the prediction models. (Rice Husk 21 Days Curing)

Rice Husk			inch	inch				
CL	Curing Days	%	Cylinder Height(mm)	Cylinder Dia (mm)	Cylinder weight	Load (KN)	Average Crushing Strength (kn)	PSI
1	21	0	206.00	100.05	3301	120	117	2112
			205.00	101.82	3393	100		
			205.00	101.99	3405	132		
8		25	206	102.00	3264	66	63	1096
			206	103.71	3360	64		
			205	103.41	3284	59		
9		50	206	102.05	3098	26	27	480
			206	102.21	3130	29		
			205	101.45	3077	26		
10		75	206	102.87	3043	16	16	280
			205	102.05	3067	16		
			204	103.21	2938	16		

Table 4-9. Summary of the goodness-of-fit of the prediction models. (Rice Husk 28 Days Curing)

Rice Husk			inch	inch				
CL	Curing Days	%	Cylinder Height(mm)	Cylinder Dia (mm)	Cylinder weight	Load (KN)	Average Crushing Strength (kn)	PSI
1	28	0	206.00	102.23	3398	130	136	2395
			206.00	103	3380	137		
			205.00	102.37	3302	142		
8		25	206	103.53	3368	77	80	1393
			206	103.31	3381	83		
			205	102.11	3308	80		
9		50	206	101.51	3141	35	32	573
			206	102.54	3229	30		
			206	102.22	3154	32		
10		75	206	103.55	3134	16	16	284
			205	102.75	3105	16		
			206	102.98	3150	17		

Table 4-10. All the data summary shown in MPa

Curing Days	MPa	7 Days	28 Days	% Mix Ratio
Control Case	**1**	10.65	16.51	0%
Glass Powder (GP)	**2**	8.17	11.86	25%
	3	4.65	6.72	50%
	4	2.04	2.96	75%
Red Clay (RC)	**5**	10.31	16.71	25%
	6	5.04	9.52	50%
	7	1.89	3.01	75%
Rice Husk (RH)	**8**	5.44	9.60	25%
	9	2.89	3.95	50%
	10	1.72	1.96	75%

4.4 Summary

The test results of concrete with Rice Husk Ash, Glass Powder, and Red Clay as cement replacement were presented and discussed. The results showed how strength and density changed with different replacement levels and curing ages. The study found both benefits and limits of using these materials in concrete. From the discussion, the main findings were highlighted to support the overall aim of the research.

CHAPTER-5

Conclusions and Future Works

5.1 Conclusions

Here are the results that we got form our research:

1. The research successfully demonstrates that integrating Rice Husk Ash, Glass Powder, and Red Clay into concrete mixtures enhances properties while offering improved compressive strength under optimal conditions.
2. Specifically, concrete with 25% Red Clay significantly increases compressive strength, particularly at 28 days of curing.
3. In others cases, lower replacement levels such as 25% gave better performance compared to higher levels like 75%, which showed a reduction in strength.
4. The results showed that concrete strength depends on both the replacement percentage and the curing period.
5. These modifications make the concrete suitable and sustainable building applications, aligning with modern needs for green construction practices.

5.2 Limitations

These are the limitations that we face during study:

1. The study only considered replacement levels of 25%, 50%, and 75%; other ratios were not tested.
2. Only compressive strength was measured, while other properties like durability, permeability, and flexural strength were not included.
3. The curing period was limited to 7, 21, and 28 days, so long-term performance was not studied. If there was some more time, the test results could have been seen by curing for 90 days.
4. The preparation of Rice Husk Ash, Glass Powder, and Red Clay was done in a basic way without advanced treatment, which may have influenced the results.
5. All experiments were carried out in a laboratory setting, which may differ from real construction site conditions.

5.3 Recommendations for Future Works

These are the recommendations that could be followed in future work:

1. Future studies can try different replacement ratios (below 25% and between 25–75%) to find the most effective mix
2. Testing with steel reinforcement (like in buildings).
3. Long-term effects like corrosion over many years.
4. Full life-cycle cost or carbon footprint analysis.
5. More tests should be done on other concrete properties such as durability, flexural strength, water absorption, and permeability.
6. Longer curing periods (such as 56 days or 90 days) should be included to study long-term strength development.
7. The waste materials (Rice Husk Ash, Glass Powder, Red Clay) can be given advanced treatment or processing to improve their reactivity and performance.
8. Large-scale trials at real construction sites should be carried out to confirm the laboratory results.
9. A cost analysis and environmental impact study can be added to better show the economic and ecological benefits of using these materials.

5.4 Scope for Future Study

1. Try more mixing ratios like 10%, 15%, or 30% to find the best combination for strength and cost.
2. Use steel bars in concrete to test how it performs in real buildings
3. Study how the concrete behaves over many years, especially with rain, heat, and corrosion.
4. Check the total cost and carbon footprint to see if it’s good for the environment and budget.
5. Test other important properties like flexibility, water resistance, and durability.
6. Cure the concrete for longer times (like 56 or 90 days) to see if strength keeps improving.
7. Use better machines or chemicals to treat Rice Husk Ash, Glass Powder, and Red Clay for stronger results.
8. Do large-scale experiments at actual construction sites to compare with lab results.
9. Add a detailed cost and environmental study to show how useful and eco-friendly the method is.

REFERENCES

[1] C. Oliko, C. K. Kabubo, and J. N. Mwero, "Rice Straw and Eggshell Ash as Partial Replacements of Cement in Concrete," Engineering, Technology & Applied Science Research, vol.10,no.6, pp. 6481–6487, Dec. 2020, https://doi.org/10.48084/etasr.3893.

[2] N. Bheel, R. A. Abbasi, S. Sohu, S. A. Abbasi, A. W. Abro, and Z. H. Shaikh, "Effect of Tile Powder Used as a Cementitious Material on the Mechanical Properties of Concrete," Engineering, Technology & Applied Science Research,vol.9,no.5,pp.4596–4599,Oct.2019. https://doi.org/10.48084/etasr.2994.

[3] Bhat Veena V, Rao N. Bhavanishankar Dz) influence of Glass Powder On The Properties Of Concretedz) international Journal of Engineering Trends and Technology (IJETT), ISSN: 2319 –8753, Volume16, Number-5, October 2016.

[4] S. Sohu, N. Bheel, A. A. Jhatial, A. A. Ansari, and I. A. Shar, "Sustainability and mechanical property assessment of concrete incorporating eggshell powder and silica fume as binary and ternary cementitious materials," Environmental Science and Pollution Research, vol. 29, no. 39, pp. 58685–58697, Aug. 2022, https://doi.org/10.1007/s11356-022-19894-5

[5] Bheel N, Ali MOA, Khahro SH, Keerio MA (2021d) Experimental study on fresh, mechanical properties and embodied carbon of concrete blended with sugarcane bagasse ash, metakaolin, and millet husk ash as ternary cementitious material. Environ Sci Pollut Res:1–16. https://doi.org/10.1007/s11356-021-15954-4

[6] Batayneh M, Marie I, Asi I (2007) Use of selected waste materials in concrete mixes. Waste Manag 27:1870–1876. https://doi.org/10.1016/j.wasman.2006.07.026

[7] ASTM (2019) C618 - 19, Standard specification for coal fly ash and raw or calcined natural pozzolan for use in concrete. ASTM International, West Conshohocken

[8] Le Li a a , Paul Joseph a , Xuelin Zhang a , Lihai Zhang b "A study of some relevant properties of concrete incorporating waste ceramic powder as a cement replacement agent, Mar. 2024
https://doi.org/10.1016/j.jobe.2024.109106

[9] V. Malhotra, Fly ash, slag, silica fume, and rice husk ash in concrete: a review, Concr. Int. 15 (4) (1993) 23–28.
Scopus - Document Details

[10] A.S. El-Dieb, D.M. Kanaan, Ceramic waste powder an alternative cement replacement–Characterization and evaluation, Sustainable Materials Technologies 17 (2018) e00063.
https://doi.org/10.1016/j.susmat.2018.e00063

[11] M. Bhargav, R. Kansal, Experimental investigation to substitute of cement with ceramic tiles powder in concrete, Int. J. Res. Appl. Sci. Eng. Technol. 8 (9) (2020) 302–307
fileserve.php

[12] Bommisetty, J., Keertan, T. S., Ravitheja, A., & Mahendra, K. (2019). Effect of waste ceramic tiles as a partial replacement of aggregates in concrete. Materials Today: Proceedings, 19(xxxx), 875–877.
https://doi.org/10.1016/j.matpr.2019.08.230