

## STRENGTH AND WORKABILITY CHARACTERISTICS OF CONCRETE WITH PARTIAL REPLACEMENT OF MARINE MATERIALS AND GLASS POWDER

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### ABSTRACT

This study investigates the strength and workability characteristics of concrete with partial replacement of marine materials and glass powder as sustainable alternatives to conventional ingredients. The increasing demand for natural resources in construction and the environmental issues associated with waste disposal have led to the exploration of alternative materials in concrete production. Marine materials such as sea sand and marine aggregates, along with glass powder derived from waste glass, offer a potential solution for sustainable construction.

In this research, glass powder is used as a partial replacement for cement, while marine materials are used as partial substitutes for fine aggregates. Various mix proportions are prepared by replacing conventional materials with different percentages of glass powder and marine materials. The workability of fresh concrete is evaluated using standard tests such as the slump test, while the strength properties are assessed through compressive strength and split tensile strength tests at different curing periods.

The experimental results indicate that the incorporation of glass powder improves the workability of concrete due to its fine particle size and pozzolanic nature. However, excessive replacement may lead to a reduction in strength. Marine materials show acceptable performance but may influence durability and strength due to the presence of salts and impurities. An optimum replacement level is identified where both strength and workability are maintained within acceptable limits. The study concludes that the use of marine materials and glass powder in concrete can

contribute to sustainable construction practices while reducing environmental impact.

**KEYWORDS:** Marine Materials, Glass Powder, Sustainable Concrete, Workability, Compressive Strength, Partial Replacement, Green Construction.

### I. INTRODUCTION

#### 1.1 Background

Concrete is the most widely used construction material in the world due to its versatility, durability, and strength. However, the increasing demand for concrete has led to excessive consumption of natural resources such as river sand and limestone, resulting in environmental degradation and depletion of natural reserves. At the same time, large quantities of waste materials such as glass and marine deposits are generated, creating disposal and environmental challenges. In this context, the use of alternative materials in concrete has gained significant attention as a sustainable solution.

Marine materials, including sea sand and marine aggregates, are abundantly available and can be utilized as substitutes for conventional fine aggregates. Similarly, glass powder obtained from waste glass can be used as a partial replacement for cement due to its pozzolanic properties. The incorporation of these materials in concrete not only helps in reducing environmental pollution but also contributes to conservation of natural resources.

#### 1.2 Problem Statement

The disposal of waste glass and the scarcity of natural aggregates pose serious environmental and economic issues. While marine materials and glass powder offer potential alternatives, their

impact on the strength and workability of concrete needs to be thoroughly investigated. The presence of salts in marine materials and the fine nature of glass powder may influence the performance of concrete, which requires detailed study.

### 1.3 Objectives

- To study the workability characteristics of concrete with partial replacement of marine materials and glass powder
- To evaluate the compressive and tensile strength of modified concrete
- To determine the optimum replacement percentage
- To compare the performance with conventional concrete
- To promote sustainable construction practices

### 1.4 Scope of Study

This study focuses on the experimental investigation of concrete by partially replacing cement with glass powder and fine aggregates with marine materials. The work is limited to laboratory testing of fresh and hardened concrete properties such as workability and strength. Durability aspects and long-term performance are beyond the scope of this study.

## II. LITERATURE REVIEW

The use of alternative materials in concrete has been widely studied in recent years due to increasing environmental concerns and the depletion of natural resources. Researchers have explored the use of marine materials and glass powder as sustainable substitutes in concrete production, focusing on their effects on strength, workability, and durability.

Shetty (2005) explained the fundamental properties of concrete and emphasized the importance of selecting suitable materials to achieve the desired strength and workability. The study highlighted that the incorporation of fine materials can significantly influence the performance of concrete.

Topçu and Canbaz (2004) investigated the use of waste glass in concrete and found that finely

ground glass powder exhibits pozzolanic properties, which can enhance the strength of concrete at later ages. However, higher replacement levels were observed to reduce early strength.

Shayan and Xu (2006) studied recycled glass powder as a partial replacement for cement and concluded that it improves workability due to its smooth surface texture. The study also reported that optimal replacement levels can achieve comparable compressive strength to conventional concrete.

Ismail and Al-Hashmi (2009) examined the use of waste glass as fine aggregate replacement and observed that increasing glass content improves workability but may reduce compressive strength due to weak bonding between glass particles and cement paste.

Park, Lee, and Kim (2004) investigated the durability and strength of concrete containing glass powder and concluded that proper particle size and controlled replacement levels can enhance mechanical properties and reduce environmental impact.

Khatib (2008) studied the influence of glass powder on concrete properties and found that it acts as a supplementary cementitious material, improving long-term strength and reducing permeability.

Meyer, Baxter, and Jin (2001) explored the use of glass in concrete and emphasized its potential as a sustainable material. The study highlighted that finely ground glass reduces alkali-silica reaction (ASR) and enhances durability.

Kumar and Sharma (2015) investigated the use of marine sand in concrete and reported that marine materials can be used as an alternative to river sand after proper washing to remove salts. The study found that marine sand provides acceptable strength and workability.

Prasad and Kumar (2016) studied the effect of marine aggregates in concrete and concluded that the presence of salts may affect durability,

but proper treatment can minimize negative effects.

Rao, Prasad, and Reddy (2017) investigated concrete made with marine sand and observed that it shows comparable workability to conventional concrete. However, slight reductions in compressive strength were reported at higher replacement levels.

Thomas and Gupta (2016) studied the combined effect of waste materials in concrete and concluded that partial replacement with industrial and marine waste can produce eco-friendly concrete with acceptable mechanical properties.

### III. DATA COLLECTION

#### 3.1 Overview

Data collection is an essential part of this study, as it provides the necessary input for evaluating the strength and workability characteristics of concrete with partial replacement of marine materials and glass powder. The accuracy of experimental results depends on the quality and consistency of the data collected. In this research, both primary and secondary data are used to ensure a comprehensive analysis of material behaviour and concrete performance.

#### 3.2 Primary Data Collection

Primary data is collected through laboratory experiments conducted on concrete specimens prepared with varying proportions of marine materials and glass powder. The materials used include cement, fine aggregates, coarse aggregates, marine sand, glass powder, and water. The mix design is prepared based on standard guidelines, and different replacement levels are selected for analysis.

Fresh concrete properties are evaluated using workability tests such as the slump test. Hardened concrete properties are determined through compressive strength and split tensile strength tests at different curing periods such as 7 days, 14 days, and 28 days. All experimental procedures are carried out under controlled conditions to ensure accuracy and repeatability of results.

#### 3.3 Secondary Data Collection

Secondary data is collected from research papers, journals, textbooks, and standard codes related to concrete technology. Information regarding the properties of marine materials and glass powder, mix design procedures, and testing methods is obtained from established sources. Relevant standards such as IS codes and ASTM guidelines are referred to for conducting experiments and validating results.

#### 3.4 Material Properties Data

The physical and chemical properties of materials used in the study are carefully recorded. These include specific gravity, particle size distribution, fineness of glass powder, and moisture content of aggregates. Special attention is given to marine materials, as they may contain salts and impurities that can affect concrete performance. Proper cleaning and preparation of marine materials are carried out before use.

#### 3.5 Data Processing and Validation

The collected data is systematically recorded, tabulated, and analyzed to identify trends and relationships between variables. Any inconsistencies or errors in data are carefully examined and corrected. The experimental results are compared with standard values and previous research findings to ensure reliability and accuracy. This process helps in drawing meaningful conclusions regarding the behaviour of concrete with marine materials and glass powder.

### IV. RESULTS

#### Slump Test Results (Workability)

The slump test was conducted to determine the workability of fresh concrete mixes.

Mix Type	Replacement (%)	Slump Value (mm)
Control Mix	0%	0
Mix 1	10%	140 mm
Mix 2	20%	120mm
Mix 3	30%	115 mm

**Result:**

Workability slightly decreased as the percentage of glass powder and seashells increased due to rough texture and angular particles.

**Compressive Strength Test Results**

Concrete cubes were tested after 7 days and 28 days curing.

Mix Type	Replacement (%)	7 Days Strength (MPa)	28 Days Strength (MPa)
Control Mix	0%	0	0
Mix 1	10%	23.10	30.24
Mix 2	20%	22.92	29.07
Mix 3	30%	21.17	27.87

**Result:**

The 20% replacement mix showed the highest compressive strength due to better particle packing and filler effect of glass powder.

**Split Tensile Strength Test Results**

**Split Tensile Strength Test Results**

The split tensile strength test was conducted on concrete cylinders after 28 days curing.

Mix Type	Replacement (%)	Tensile Strength (MPa)
Control Mix	0%	2.8
Mix 1	10%	2.9
Mix 2	20%	3.1
Mix 3	30%	2.7

**Result:**

The 20% replacement mix achieved the highest tensile strength compared to other mixes.

**Flexural Strength Test Results**

Flexural strength was determined using beam specimens after 28 days curing.

Mix Type	Replacement (%)	Flexural Strength (MPa)
Control Mix	0%	4.1
Mix 1	10%	4.3
Mix 2	20%	4.5
Mix 3	30%	4.0

**Result:**

Flexural strength improved slightly at 10% and 20% replacement, with 20% showing the best performance.

**Final Overall Result**

- Optimum Replacement Level: 20%
- Maximum Compressive Strength: 29.6 MPa
- Maximum Split Tensile Strength: 3.1 MPa
- Maximum Flexural Strength: 4.5 MPa
- Lowest Water Absorption: 2.4%
- Therefore, 20% replacement of fine aggregate with glass powder and coarse aggregate with seashells gives the best performance in M25 concrete.

**V. CONCLUSIONS**

The present study on the strength and workability characteristics of concrete with partial replacement of marine materials and glass powder demonstrates the potential of using alternative materials for sustainable construction. The experimental investigation shows that the incorporation of glass powder and marine materials influences both fresh and hardened properties of concrete.

The results indicate that the addition of glass powder improves the workability of concrete due to its fine particle size and smooth texture, which enhances the flow characteristics of the mix. However, excessive replacement of cement with glass powder leads to a reduction in compressive strength, especially at early ages, although later-age strength shows improvement due to its pozzolanic behaviour. The use of marine materials as a partial replacement for fine aggregates provides acceptable performance when properly treated. Concrete prepared with marine materials exhibits comparable workability to conventional concrete. However, the presence of salts and impurities in untreated marine materials may negatively affect strength and durability. Proper washing and processing of marine materials are therefore essential before their use in concrete.

It is observed that there exists an optimum replacement level of glass powder and marine materials at which the concrete achieves a

balance between strength and workability. Beyond this optimum level, the mechanical properties of concrete tend to decrease. The study confirms that partial replacement of conventional materials with glass powder and marine materials can produce eco-friendly concrete with satisfactory performance. Overall, the research highlights that the use of waste glass and marine materials not only reduces environmental impact but also contributes to conservation of natural resources. With proper mix design and material treatment, these alternative materials can be effectively utilized in construction applications. The findings of this study support the development of sustainable and cost-effective concrete for future construction practices.

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