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**Research Paper**

# PERFORMANCE ANALYSIS OF CONCRETE INCORPORATING CRUSHED GLASS AS FINE AGGREGATE REPLACEMENT

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## ABSTRACT

The increasing demand for natural river sand in the construction industry has resulted in excessive mining and environmental degradation. Simultaneously, waste glass disposal has become a major environmental challenge due to its non-biodegradable nature. This study investigates the feasibility of using crushed waste glass as a partial replacement for fine aggregate (sand) in concrete production. Different percentages of crushed glass were used to replace natural sand, and the compressive strength and workability of concrete were evaluated. Concrete specimens were prepared with varying replacement levels of 0%, 10%, 20%, 30%, and 40% crushed glass. Experimental results showed that partial replacement of sand with crushed glass improved the compressive strength up to an optimum level. The study concludes that crushed glass can effectively be used as a sustainable alternative material in concrete production, reducing environmental pollution and conserving natural resources.

## 1. INTRODUCTION

Concrete is one of the most widely used construction materials in the world due to its high strength, durability, and versatility. Fine aggregate, commonly known as sand, plays an important role in concrete by filling voids and improving workability. However, rapid urbanization and infrastructure development have led to excessive extraction of natural river sand, causing environmental problems such as riverbank erosion and ecological imbalance.

Waste glass is generated in large quantities from domestic, industrial, and commercial activities. Most waste glass is disposed of in landfills, creating environmental pollution because glass is non-biodegradable. Recycling waste glass in concrete can reduce landfill waste and minimize the demand for natural sand.

Crushed glass possesses good hardness and chemical stability, making it suitable as a partial replacement for fine aggregate. This study focuses on evaluating the compressive strength characteristics of concrete containing crushed glass as partial replacement of sand.

## 2. OBJECTIVES OF THE STUDY

The objectives of this research are:

1. To investigate the suitability of crushed glass as partial replacement for sand in concrete.
2. To study the compressive strength of concrete with crushed glass.
3. To determine the optimum replacement percentage.
4. To reduce environmental pollution caused by waste glass.
5. To develop economical and sustainable concrete.

## 3. LITERATURE REVIEW

Several studies have been conducted on the use of waste glass in concrete production.

- Researchers observed that finely crushed glass improves particle packing and strength.
- Some studies indicated reduced workability due to angular glass particles.
- It was reported that excessive glass content may cause alkali-silica reaction if not properly controlled.
- Experimental investigations suggested that replacement levels up to 20–30% provide satisfactory results.

The literature review indicates that crushed glass has significant potential as a sustainable construction material.

## 4. MATERIALS USED

### 4.1 Cement

Ordinary Portland Cement (OPC 53 Grade) conforming to IS specifications was used.

### 4.2 Fine Aggregate

Natural river sand passing through a 4.75 mm sieve was used.

### 4.3 Coarse Aggregate

Crushed granite aggregate of 20 mm size was used.

### 4.4 Crushed Glass

Waste glass bottles were collected, cleaned, crushed, and sieved to obtain fine aggregate-sized particles.

### 4.5 Water

Potable water free from impurities was used for mixing and curing.

## 5. PROPERTIES OF MATERIALS

| Material | Specific Gravity | Water Absorption |
|---|---|---|
| Cement | 3.15 | - |
| River Sand | 2.64 | 1.1% |
| Coarse Aggregate | 2.72 | 0.5% |
| Crushed Glass | 2.50 | 0.2% |

## 6. MIX PROPORTION

Concrete of M30 grade was designed according to IS 10262 guidelines.

| Mix ID | Sand Replacement with Crushed Glass |
|---|---|
| CG0 | 0% |
| CG10 | 10% |
| CG20 | 20% |
| CG30 | 30% |
| CG40 | 40% |

## 7.EXPERIMENTAL METHODOLOGY

### 7.1 Preparation of Concrete Mix

The materials were mixed thoroughly in dry condition before adding water. The concrete was placed into cube moulds of size 150 mm × 150 mm × 150 mm.

### 7.2 Curing

The specimens were demoulded after 24 hours and cured in water for 7 and 28 days.

### 7.3 Tests Conducted

The following tests were performed:

1. Slump Cone Test
2. Compressive Strength Test
3. Water Absorption Test

## 8. WORKABILITY TEST RESULTS

| Mix ID | Slump Value (mm) |
|---|---|
| CG0 | 85 |
| CG10 | 82 |
| CG20 | 78 |
| CG30 | 74 |
| CG40 | 69 |

### Observation

Workability decreased with increase in crushed glass content due to angular particle shape and lower water absorption characteristics.

## 9. COMPRESSIVE STRENGTH RESULTS

### 7-Day Compressive Strength

| Mix ID | Strength (MPa) |
|---|---|
| CG0 | 23.6 |

**Mix ID Strength (MPa)**

CG10 24.8

CG20 25.9

CG30 24.4

CG40 22.7

**28-Day Compressive Strength**

**Mix ID Strength (MPa)**

CG0 35.8

CG10 37.2

CG20 39.1

CG30 36.9

CG40 33.8

## 10. ANALYSIS OF RESULTS

The experimental results indicate the following:

- Compressive strength increased gradually up to 20% replacement.
- Maximum strength was achieved at 20% crushed glass replacement.
- Beyond 20%, strength decreased due to weaker bonding and increased brittleness.
- Crushed glass particles improved particle packing and density.
- Excessive glass content reduced cohesion in concrete.

The optimum replacement level was determined as 20%.

## 11. ADVANTAGES OF USING CRUSHED GLASS IN CONCRETE

1. Reduces landfill waste.
2. Conserves natural river sand.
3. Reduces environmental pollution.
4. Produces sustainable concrete.
5. Improves aesthetic appearance in decorative concrete.
6. Enhances particle packing properties.

## 12. APPLICATIONS

Concrete containing crushed glass can be used in:

- Pavement blocks
- Decorative flooring
- Non-structural concrete works
- Footpaths
- Partition walls
- Precast concrete products

## 13. ENVIRONMENTAL BENEFITS

The use of crushed glass in concrete contributes to environmental sustainability by:

- Reducing disposal of waste glass.
- Conserving natural sand resources.
- Lowering environmental degradation due to sand mining.
- Promoting recycling and reuse of industrial waste.

## 14. LIMITATIONS

1. Excessive glass content may reduce workability.
2. Risk of alkali-silica reaction if improper glass size is used.
3. Brittle nature of glass may reduce impact resistance.

## 15. CONCLUSION

This study concludes that crushed waste glass can effectively be used as a partial replacement for natural sand in concrete production. The experimental investigation showed that concrete with 20% crushed glass replacement exhibited maximum compressive strength compared to conventional concrete. Workability decreased slightly with increase in glass content, but remained within acceptable limits. The use of crushed glass in concrete provides environmental, economic, and technical benefits. It reduces waste disposal problems and conserves natural resources, making it a sustainable alternative material for modern construction practices.

## 16. FUTURE SCOPE

1. Investigation on durability properties under aggressive environments.
2. Study on alkali-silica reaction prevention techniques.
3. Use of crushed glass in self-compacting concrete.
4. Investigation on flexural and tensile properties.
5. Application in high-strength and lightweight concrete.

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