

Original Article

# Experimental Investigation On Partial Replacement of Cement With Glass Powder In Concrete

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**Abstract** - The potential use of left over glass powder as a 20% replacement level of cement in concrete is investigated in this study. This research aims to develop a more sustainable and ecologically friendly building material in light of the growing environmental problems associated with the production of traditional cement, such as significant energy consumption and carbon dioxide emissions, as well as the growing issue of waste glass accumulation in landfills. The experimental approach focuses on evaluating the mechanical and physical properties of concrete mixtures that contain finely ground glass powder. Compressive strength, workability, durability, and overall performance under typical curing circumstances are the main variables being studied. Making use of left over glass powder has two benefits: it reduces the need for cement while also promoting effective resource allocation and waste management. The results of this study show that, without compromising structural soundness, replacing 20% of the cement with glass powder yields compressive strength metrics comparable to those of conventional concrete. Additionally, improvements in certain durability attributes and long-term performance were seen. As a result, adding glass powder to concrete offers a potentially advantageous strategy for environmentally friendly building techniques.

**Keywords:** Glass Powder, Cement Replacement, Sustainable Concrete, Waste Utilization, Compressive Strength.

## I. INTRODUCTION

Concrete is the most extensively used construction material across the globe due to its excellent compressive strength, durability, adaptability, and cost-effectiveness. It is essential to the construction of infrastructure, such as roads, bridges, buildings, and dams. Cement is a crucial component of concrete, especially Ordinary Portland Cement (OPC), which serves as the main binding agent. In recent years, the manufacture of cement has become a significant environmental concern despite its benefits. The energy-intensive process of making cement involves calcining limestone at high temperatures, which results in large carbon dioxide (CO<sub>2</sub>) emissions. Cement manufacture is one of the main causes of climate change, accounting for an estimated 7-8% of worldwide greenhouse gas emissions.

The disposal of household and industrial trash has emerged as a crucial issue, in addition to environmental concerns arising from the production of cement. Waste glass is one such substance that is produced in significant amounts by homes, businesses, and construction projects. Glass accumulates in landfills due to its non-biodegradability, polluting the ecosystem and taking up important land resources. Glass can be recycled, but due to contamination and financial limitations, not all waste glass can be effectively reused. Researchers have been investigating the use of waste materials as partial cement substitutes in concrete as a solution to these problems. When waste glass is crushed into a fine powder, it demonstrates pozzolanic properties, which allow it to react with calcium hydroxide in the presence of water to create compounds that increase durability and strength. Glass powder is therefore a promising additional cementitious ingredient.

This study focuses on using glass powder in place of cement at a 20% substitution level. The goal is to assess how it affects important concrete characteristics like durability, workability, and compressive strength. The project attempts to cut carbon emissions, use less cement, and encourage environmentally friendly building methods by adding leftover glass powder to concrete. Additionally, by transforming a non-biodegradable substance into a useful building resource, this strategy promotes efficient waste management and supports the concepts of the circular economy and environmental preservation.

## II. LITERATURE REVIEW

### A. Y. Deepti et al. (2026)

Y. Deepti et al. (2026) conducted a study on the use of waste glass powder in concrete to evaluate its strength, durability, and fire resistance properties. The researchers replaced cement with varying percentages of glass powder and

tested concrete specimens under normal and elevated temperature conditions. The results showed that glass powder exhibits pozzolanic behavior, improving the microstructure and durability of concrete while maintaining acceptable compressive strength at moderate replacement levels. The study also highlighted enhanced fire resistance and sustainability benefits due to reduced cement usage. It was concluded that glass powder can be effectively used as a partial replacement material in concrete, particularly at optimum levels, for producing eco-friendly and durable construction materials.

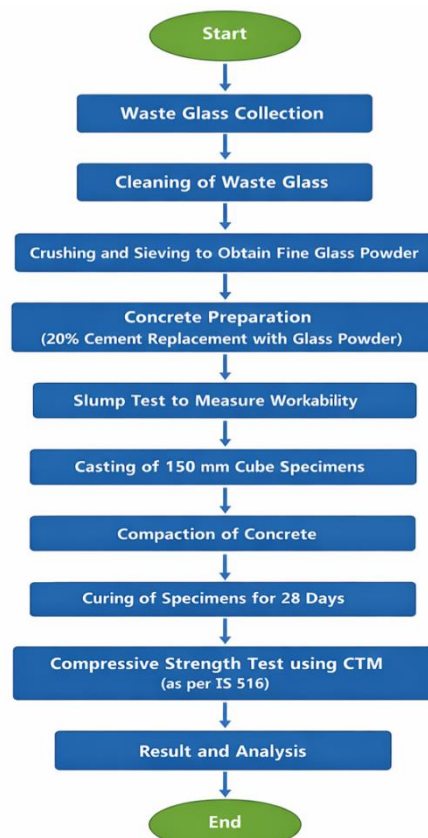
### B. Gaurav Chand et al. (2025)

Gaurav Chand et al. (2025) investigated the potential of using high percentages of waste glass powder as a partial replacement for cement in concrete, focusing mainly on the chemical reactions and strength development mechanisms. The study revealed that glass powder reacts with calcium hydroxide produced during cement hydration to form calcium-silicate-hydrate (C-S-H), which contributes to strength development. The authors highlighted that while conventional studies limit replacement to around 20%, it is theoretically possible to exceed this limit without significant strength loss. However, factors such as incomplete reaction of glass particles, slower pozzolanic activity, particle size, and delayed strength gain beyond 28 days may restrict higher replacement levels. The research concluded that with proper optimization, waste glass powder can be effectively used as a sustainable cement replacement material, reducing environmental impact while maintaining acceptable concrete performance.

### C. Mohammad Sheikh Hassani et al. (2023)

Mohammad Sheikh Hassani et al. (2023) conducted a comprehensive literature review on the use of waste glass powder as a partial replacement for cement in concrete, analyzing around 78 research studies published between 2015 and 2023. The study focused on mechanical, durability, and microstructural properties of glass powder concrete and found that finely ground glass powder exhibits strong pozzolanic and filler characteristics, which enhance concrete density, strength, and resistance to durability issues such as chloride penetration. The authors emphasized that smaller particle sizes significantly improve performance, while also reducing environmental impact by lowering cement consumption. Overall, the research concluded that glass powder is a promising sustainable material for green concrete, though further studies are required to optimize mix design and long-term performance.

## III. METHODOLOGY



**A. Materials Used**

- Cement (ppc)
- Fine Aggregate (Zone II sand)
- Coarse Aggregate (20 mm size)
- Glass Powder (passing 75  $\mu$ m sieve)
- Water

**B. Mix Proportion**

- Grade: M30
- Water-cement ratio: 0.45
- Cement replaced by 20% glass powder

**C. Mix design 20% replacement glass powder**

**Cube Volume**

- 150 mm = 0.15 m
- Volume =  $0.15 \times 0.15 \times 0.15$
- Volume =  $0.003375 \text{ m}^3$

**D. Mix Design for 1 Cube (20% Glass Powder Replacement – M20)**

Material	Quantity for 1 Cube
Cement	1.03 kg
Glass Powder (20%)	0.26 kg
Fine Aggregate (Sand)	2.27 kg
Coarse Aggregate	4.08 kg
Water	0.64 kg

**E. Explanation**

Total cement in normal mix  $\approx$  1.29 kg per cube, 20% replaced by glass powder

- Cement = 1.03 kg
- Glass Powder = 0.26 kg

**F. Final Mix (for one 150 mm cube)**

- Cement = 1.03 kg
- Glass Powder = 0.26 kg
- Sand = 2.27 kg
- Coarse Aggregate = 4.08 kg
- Water = 0.64 kg

**G. Workability Test Result**

Slump value = 80 mm

**H. Compressive Strength Calculation**

- Given:
- Load = 650 kN = 650000 N
- Area =  $22500 \text{ mm}^2$

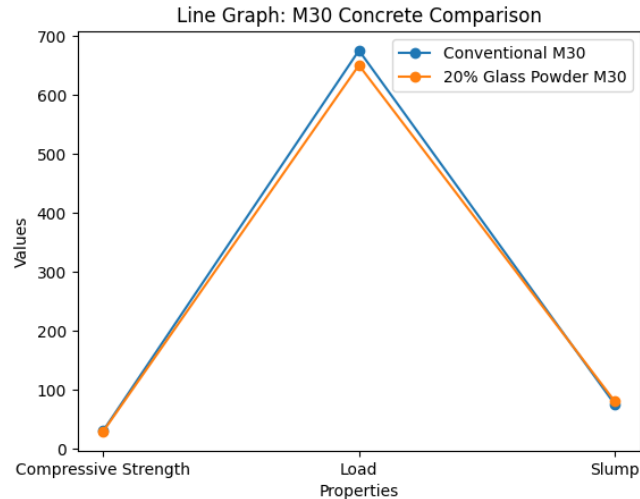


Property	Conventional M30 Concrete	M30 with 20% Glass Powder
Compressive Strength (MPa)	30	28.89
Load (kN)	675	650
Slump Value (mm)	50-100	80
Workability	Medium	Medium (Good)
Strength	Full strength	Slightly reduced
Durability	Good	Slightly reduced
Eco-friendly	No	Yes

**I. Result**

28-day compressive strength = 28.89 MPa

Slump = 80 mm

**IV. DISCUSSION**

Strength is close to M30 (30 MPa)

Slight reduction due to 20% glass powder replacement

**V. CONCLUSION**

This study investigated the effect of partial replacement of cement with 20% glass powder in M30 grade concrete. From the experimental results, it is observed that the concrete achieved a compressive strength of 28.89 MPa at 28 days, which is slightly lower than the target strength of M30 concrete. The slump value of 80 mm indicates medium workability, making the mix suitable for normal construction practices.

**VI. RECOMMENDATION**

Use superplasticizer to improve workability

Optimum replacement level: 10–15%

Ensure proper compaction and curing

**VII. REFERENCES**

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