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Experimental Investigation on the Compressive Strength of Glass Powder Waste Concrete

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This project explores the integration of waste glass powder as a supplementary material in concrete production, specifically examining its effect on compressive strength. Concrete specimens were prepared with varying proportions of waste glass powder replacing cement, spanning from 0% to 40% replacement levels. Compressive strength tests were conducted on these specimens alongside a control mix absent of glass powder. Results indicated a marginal enhancement in compressive strength with a 20% replacement, suggesting potential benefits for structural integrity and durability. However, a diminishing return was observed with a 40% replacement, underscoring the importance of careful replacement percentage selection. This study contributes to sustainable construction practices by highlighting waste glass powder's promise as a viable additive in concrete production, offering insights for optimizing its utilization to balance environmental benefits with structural performance.

Keywords: Glass powder, waste concrete.

1. Introduction

In contemporary times, the imperative to mitigate ecological concerns has led to a heightened emphasis on the reuse of waste materials, particularly those generated from construction sites and industrial processes. Glass powder, a byproduct of glass processing operations, has emerged as a promising alternative to address these concerns. Glass powder, derived from discarded glass products, poses significant environmental and human health impacts due to its widespread production. However, glass powder presents an opportunity for sustainable resource utilization and offers potential environmental benefits. This introduction explores the significance of transitioning towards eco-friendly practices in various industries by replacing marble with glass powder, thereby contributing to environmental conservation efforts. Glass powder waste in construction typically consists of finely ground particles primarily composed of silica (SiO_2), the main constituent of glass. Alongside silica, glass compositions often contain alkaline metal oxides like sodium oxide (Na_2O) and potassium oxide (K_2O). These oxides influence the reactivity of the waste material, affecting its potential applications. Silica is valued for its binding properties, making it useful as a supplementary cementitious material in concrete. However, airborne silica particles pose health hazards, necessitating safety precautions during handling. Understanding the composition of glass powder waste is crucial for devising efficient management strategies in construction, balancing its potential benefits with the need for environmental and occupational safety considerations. Glass waste powder, a byproduct of various industrial processes such as glass manufacturing, cutting, and shaping, presents both challenges and opportunities in the construction industry. Glass powder waste typically consists of finely ground particles primarily composed of silica, the main constituent of glass, along with alkaline metal oxides. This waste stream has traditionally posed disposal challenges due to its inert nature and potential environmental impacts. However, advancements in research and technology have paved the way for its effective integration into modern construction practices, offering numerous benefits across environmental, economic, and structural domains.

In present-day construction industries, the effective utilization of glass waste powder holds significant promise. One of its primary applications lies in its use as a supplementary cementitious material (SCM) in concrete production. Incorporating glass powder as a partial replacement for cement not only reduces the environmental footprint associated with cement production but also enhances the durability and mechanical properties of concrete structures. Moreover, glass powder can improve the workability and rheological properties of concrete mixes, leading to more efficient construction processes. Mazen Al-Kheetan and Seyed Hamidreza Ghaffar et al. (2020), researched investigation on the utilization of waste glass powder in concrete pavements, assessing its effects on interfacial bonding, physical, and mechanical properties. Two types of glass powder, untreated (neat) and silane-treated, were used as partial replacements for sand. Results after 7 days revealed a 5% reduction in compressive strength and 2% in flexural strength with neat glass powder, attributed to weak interfacial bonding. However, silane-treated glass powder exhibited significant improvements: a 22% increase in compressive strength, 28% in flexural strength, and 8% reduction in water absorption due to improved bonding. After 28 days, both types showed enhanced compressive strength (neat: 15%; treated: 22%) and reduced water absorption (neat: 5%; treated: 7%). Silane treatment notably enhanced concrete properties, showcasing potential for sustainable pavement solutions. Erfan Najaf and Hassan Abbasi et al. (2020), research explores sustainable concrete production by replacing 80% of cement with recycled materials: 20% recycled concrete powder, 15% each of micro-silica, fly ash, waste plastic powder, and waste glass powder. Results show comparable compressive and flexural strengths, indicating potential for entirely sustainable concrete with minimal cement usage. Kishan Lal Jain, Gaurav Sancheti, Lalit Kumar Gupta et al. (2020), This paper explores the utilization of solid waste, specifically granite powder from granite industries and discarded soda-lime glass powder from waste glass bottles, in concrete production. Experimental investigation assesses the durability of blended concrete incorporating varying levels of waste glass powder (5% to 25%) and granite powder (10% to 50%) as partial substitutes for cement and sand respectively.

Durability performance was evaluated through water absorption, water permeability, acid and sulphate attack, and rapid chloride penetration tests. Microstructure analysis via SEM and XRD was conducted. Enhanced durability properties were observed particularly with 15% GP and 30% GrP substitutions, showing improved water permeability, absorption, and resistance against chemical attacks.

2. Materials and Methods

According to IS 10262:2009, the mix proportion has been calculated and is shown in table 1.

Table 1 Mix proportion

CONSTITUENTS	QUANTITY
Cement	320 kg/m^3
Water	140 kg/m^3
Fine aggregate	905 kg/m^3
Coarse aggregate	1150 kg/m^3
Chemical Admixtures (SP)	7 kg
Glass Waste Powder	1.6 kg

The process of integrating glass waste powder into the concrete mixture began with manual mixing of the constituents based on the proportions specified in Table 1. Cement and glass waste powder were blended dry in a mixer for approximately 4-5 minutes to ensure even distribution of the glass particles within the cement matrix. Following this dry mixing stage, water was gradually added to the mixer, adjusting the quantity to achieve the desired workability of the concrete mix. Careful consideration was given to the water-cement ratio to maintain adequate strength and durability while accommodating the characteristics of the glass powder.

Subsequently, a superplasticizer solution, mixed with water, was introduced slowly into the mix to enhance workability and flowability without compromising the integrity of the concrete structure. This step was crucial for ensuring proper dispersion of the glass waste throughout the mixture, facilitating optimal bonding between the cementitious materials and the glass particles.

Once the mixing process was complete, the concrete mixture was cast into 150 mm x 150 mm x 150 mm molds. Compaction was carried out using a tamping rod to ensure proper consolidation of the mixture and elimination of air voids. After allowing the specimens to set for 24 hours, demolding was performed gently to prevent any damage to the concrete samples.

This meticulous approach to incorporating glass waste powder into the concrete mixture aimed to produce specimens with the desired properties, highlighting the potential of using recycled materials in sustainable construction practices.

According to IS 516:1959 Compressive strength is the capability of the concrete to withstand the load without any deflection. Place the specimen with flat faces horizontally, and mortar-filled faces facingupwards between two 3-ply plywood sheets each of 3 mm thickness, and carefullycentered between plates of the testing machine. Applied load axially at a uniform rate of14 N/mm^2 (140 kg/cm^2) per minute till failure occurred and noted the maximum load atfailure. The load at failure should be the maximum load at which the specimen failed to produce any further increase in the indicator reading on the testing machine. Fig 3.10 shows the compression testing of the specimens.

F=P/A

Where,

F: is the compressive strength (MPa)

P: is the maximum load (load until the failure) N

A: area of cross section of the material resting the load (mm^2)

3. Experimental Results

The compressive strength values of the control mix table 2 Compressive strength of control mix of a conventional concrete and 20% and 40% glass waste powder table 2, are measured and specimen casting and cubes are shown in figure 1,2,3 and 4. Compressive strength results are shown in figure 5.

Figure 1. mixing and casting of specimens

Figure 2. Control concrete (0%)

Figure 3. Concrete with 20% glass waste powder

Figure 4. Concrete with 40% glass waste powder

Table 2 Compressive strength results

S.NO	SPECIMEN	AVERAGE COMPRESSIVE STRENGTH
1	0%	40 MPa
2	20%	41 MPa
3	40%	39 MPa

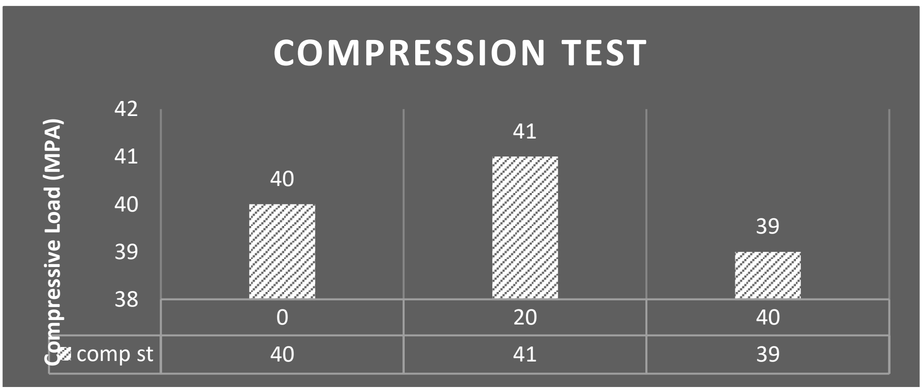

Figure 5. Compressive strength results

4. Conclusions

The following conclusions are drawn from the result of the experiment.

1. The incorporation of waste glass powder in concrete shows potential for enhancing compressive strength.

2. A 20% replacement of cement with waste glass powder resulted in a slight increase in compressive strength compared to the control mix.

3. However, further increasing the replacement percentage to 40% led to a decrease in compressive strength compared to the 20% replacement.

4. These findings suggest an optimal replacement percentage exists, beyond which the beneficial effects on compressive strength diminish.

5. Careful consideration of the replacement percentage is crucial to maximize the benefits of waste glass powder while maintaining concrete strength and durability.

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