STUDY ON STRENGTH CHARACTERISTICS OF GGBS BASED CONCRETE MIX

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Abstract:

Concrete, renowned for its versatility, finds application in a myriad of purposes, adapting to diverse conditions. However, conventional concrete might fall short in meeting specific requirements for quality, performance, and durability. To address this challenge, a viable approach involves minimizing construction costs while enhancing structural concrete performance through the incorporation of suitable pozzolanic materials. This study focuses on replacing cement in concrete with ground granulated blast furnace slag (GGBFS).

The primary objective is to investigate the fresh and hardened state properties of concrete with a high percentage of GGBFS replacement. The study examines the strength characteristics of concrete with 40%, 50%, and 60% replacement of cement by GGBFS. Four distinct concrete mix proportions were employed, and for each mix, standard-sized cubes, cylinders, and prisms were cast. Subsequently, these specimens underwent testing for compressive strength at 7 and 28 days, modulus of elasticity, and flexural strength at 28 days. The results obtained are then compared with those of conventional concrete, emphasizing the importance of resource conservation and sustainable development.

Key Words: High performance concrete, ground granulated blast furnace slag concrete, Indian cement

Introduction

The cement industry contributes approximately 0.82 tons of CO_2 emissions per ton of cement, constituting 10% of total Greenhouse Gas (GHG) emissions. To mitigate GHG emissions, reducing cement utilization by incorporating suitable pozzolanic materials is a

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viable strategy. Ground granulated blast furnace slag (GGBS or GGBFS) is a by-product of iron and steel manufacturing, obtained by quenching molten iron slag in water or steam. This process produces a granular product that is subsequently dried and ground into a fine powder. The reactivity and fineness of GGBS influence its cementitious and pozzolanic efficiency in concrete composites. GGBS, exhibiting latent hydraulic properties, forms C-S-H gel upon reaction with water, a process accelerated by the presence of CaOH produced during the primary hydration of Ordinary Portland Cement (OPC).

Concrete composites that incorporate GGBS as a separate cementitious material at a batching plant are known as ground granulated blast furnace slag concrete (GGBSC). Blended cements, like those incorporating GGBS, are gaining popularity due to cost savings, energy efficiency, environmental protection, and resource conservation. GGBS is recognized as a desirable ingredient in concrete, serving as a valuable replacement for cement and imparting specific qualities to the composite cement concrete.

Concrete constitutes a substantial cost and energy-intensive component, and partial replacement with GGBS can reduce its unit cost. The disposal of GGBS poses environmental concerns, making its utilization instead of dumping as waste material economically and environmentally beneficial. GGBS serves as a pozzolana for partial cement replacement, offering advantages such as lower demand for similar workability and enhanced sulphate resistance.

Methodology:

Cement: 53-grade Portland cement conforming to IS-12269:1987 was utilized, with a specific gravity of 3.15.Fine aggregate: Natural river sand passing through a 4.75 mm IS sieve was employed, exhibiting a specific gravity and fineness modulus of 2.61 and 2.57, respectively.Coarse aggregate: Crushed granite of 20 mm was used, with a specific gravity and fineness modulus of 2.66 and 7.66 respectively.GGBS: Ground Granulated Blast Furnace Slag (GGBFS), a mineral admixture with pozzolanic properties, was sourced from Vizag Steel Plant in Visakhapatnam (Andhra Pradesh), conforming to BS: 6699-1992. Physical properties are detailed in Table (1).

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Mix Design: The American Concrete Institute (ACI) method was employed for mix design, targeting a compressive strength of 40 MPa at 28 days. The mix proportion adopted was 1:1.59:1.80 by weight of constituent material, with a water-binder ratio of 0.40.Mixing: A tilting-type rotary drum mixer machine facilitated the mixing of concrete ingredients. Water was added during rotation, with 80% initially incorporated, and the remaining water added after one minute. Mixing continued for an additional two minutes.Casting and Curing: Specimens were cast in standard molds, vibrated on a standard vibrating table, and demolded after 24 hours. They were then placed in curing tanks until testing.Testing: Four series of mixes were cast and tested, comprising standard cubes, cylinders, and prisms of sizes 150mm×150mm, 300mm×150mm, and 500mm×100mm×100mm.Compressive Strength: Testing involved three cubes of size 150mm×150mm using a compression testing machine of 2000 KN capacity as per IS 516:1959. Flexural Strength: Prisms were tested under digital UTM of 200 KN capacity as per IS 516:1959. The beams underwent symmetrical loading under two-point loading conditions.Modulus of Elasticity: Extensometers were attached at the ends of the specimen, parallel to its axis. The specimen was centered in the testing machine, and the load was applied continuously until reaching an average stress of (C + 5) kg/sq cm. Readings were taken at regular intervals.

Results And Discussion:

It was observed that the 7 days curing of G3 mix attained almost same compressive strength compared to other mixes. The maximum compressive strength obtained for 28 days was attained for G1 mix compared to other mixes. At the age of 28 days the G2 mix is attained maximum flexural strength more than the G0 mix (control mix). The addition of GGBS enhances the mechanical properties of GGBSC. From fig 3.0 the modulus of elasticity at the age of 28 days was more for G2 mix compared with control mix.

PHYSICAL PROPERTIES OF GGBS

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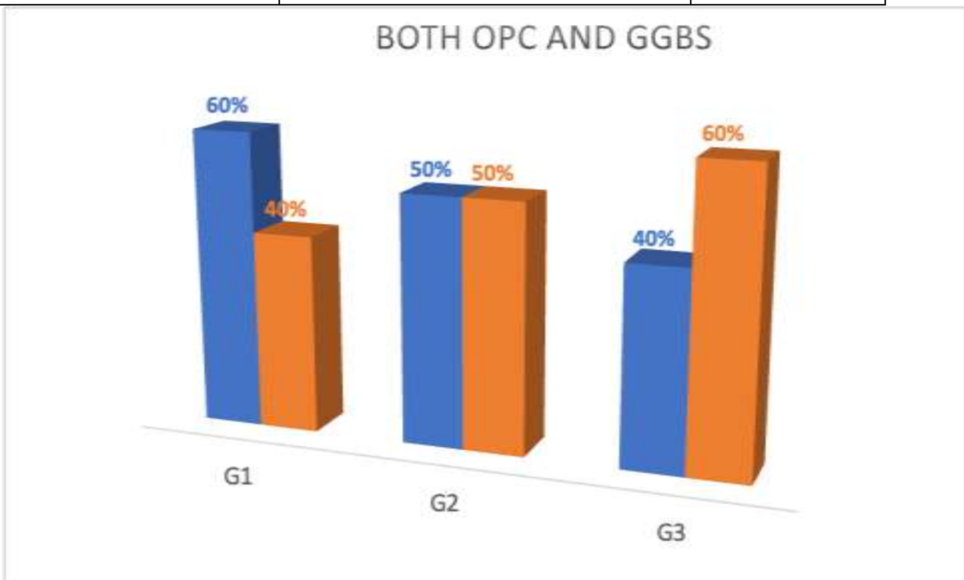
S.No	Characteristics	Properties of slag used
1	Fineness (m^2/Kg)	365
2	Glass content percent	93.00
3	Setting time- Initial (min)	250
4	Soundness (mm)	NIL
5	Colour	Dull white

MIX PROPORTIONS

Mix	OPC	GGBS
G0	100%	-
G1	60%	40%
G2	50%	50%
G3	40%	60%



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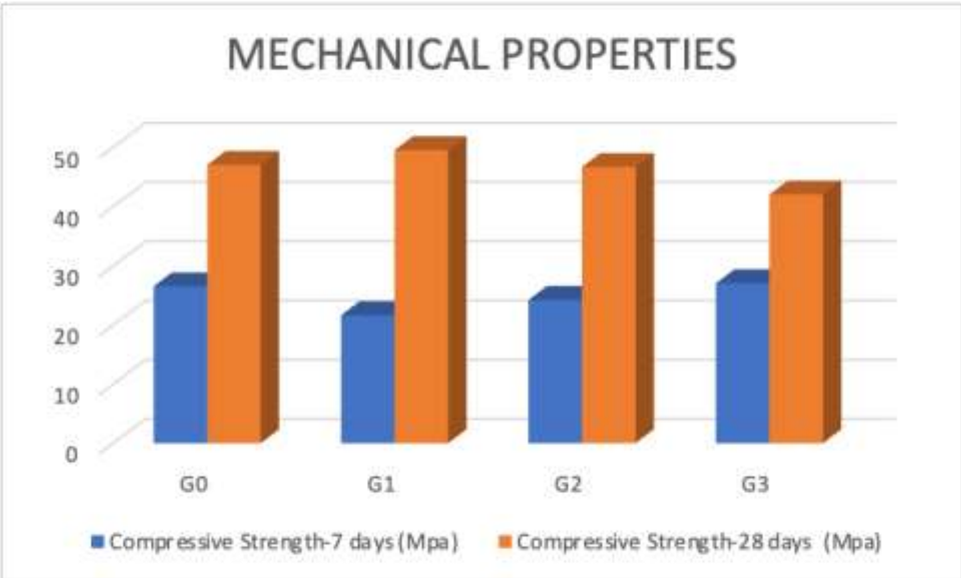
MECHANICAL PROPERTIES

Mix Designation	Compressive Strength-7 days (Mpa)	Compressive Strength-28 days (Mpa)
G0	26.5	47
G1	21.6	49.50
G2	24.2	46.66
G3	27.0	42



Conclusion:

The examination of compressive strength at 7 days reveals that G3 mix demonstrates a comparable performance to the control concrete. However, a notable observation emerges when analyzing the compressive strength at 28 days, where the G1 mix exhibits a higher strength than the other two mixes. This observation suggests a marginal yet discernible improvement in compressive strength with the incorporation of Ground Granulated Blast Furnace Slag (GGBS).In terms of flexural strength, the G2 mix at 28 days surpasses the other two mixes, indicating an enhanced ability to withstand bending forces. This higher flexural strength in G2 mix implies a positive influence attributed to the addition of GGBS. Furthermore, the modulus of elasticity for the G2 mix at 28 days is notably higher than that of

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the other two mixes. This observation underscores the improved stiffness and deformation resistance of the G2 mix, affirming the positive impact of GGBS on the material properties.

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