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TO ANALYSE THE COMPRESSION STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH AND GGBS

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Abstract: This study is to analyze the compressive strength of concrete by partially replacing cement with Fly Ash and Ground Granulated Blast Furnace Slag (GGBS). The use of supplementary cementitious materials, such as Fly Ash and GGBS, in concrete production has gained significant attention due to its potential to enhance the sustainability and durability of concrete structures.
This study is to work out the effect of mineral admixture GGBS and Fly ash in concrete of grade M-40 when it is added in & replaced for the fresh state and hardened state i.e. for workability and strength of concrete using OPC (43 grade). As mineral admixture GGBS and Fly ash have been added to OPC which varies from 20% and 40% at interval of 20% &40% by total weight of OPC, various range of addition and replacement of cement by GGBS and Fly Ash in the concrete. All mixes of concrete will examined for workability as slump test of fresh concrete. Hardened concrete is examined for Compressive strength for 7days,14days and 28 days. Slump will be analysed as compared to that of addition of GGBS & Fly ash.The research findings contribute to the understanding of the performance of concrete mixtures containing supplementary cementitious materials and offer practical recommendations for their utilization in construction.
By addressing these objectives, this research endeavors to advance the knowledge and practice of sustainable concrete production and promote the responsible use of Fly Ash and GGBS in the construction industry.

Index Terms:: Cement, Coarse aggregates, Fine aggregates, Fly Ash, GGBS(GROUND GRANULATED BLAST- FURNACE SLAG)

I. Introduction

The compression strength of concrete is influenced by various factors including the type and proportions of materials used. Cement provides the binding properties in concrete, while fly ash and ground granulated blast furnace slag (GGBS) are supplementary cementitious materials that can enhance properties like durability and strength Fly ash and GGBS are often used as partial replacements for cement, leading to a reduction in the amount of cement needed in concrete mixes. This can positively impact the compressive strength of concrete, especially in the long term, as these materials can contribute to denser concrete with fewer voids, resulting in higher strengths. However, the exact impact on compressive strength can vary depending on factors such as the quality and properties of the materials, the curing conditions, and the specific mix proportions used. Generally, a balance needs to be struck between reducing cement content (which can reduce costs and environmental impact) and maintaining or improving the desired strength properties of the concrete mix. Overall, while fly ash and GGBS can contribute to the compression strength of concrete, their effects are part of a complex interplay of factors that need to be carefully considered in the concrete mix design process.

II. MATERIAL DETAILS

Cement

Definition: Cement is a fine powder made from a mixture of limestone, clay, shells, and silica, which hardens when mixed with water.

Types of Cement: Portland cement, White cement, Blast furnace cement, Expansive Cement.

Handling and Storage: Cement should be stored in a dry place to prevent moisture absorption and handled with care to avoid contact with skin and eyes due to its caustic nature.

Innovation: Ongoing research and development in the cement industry aim to reduce its environmental impact and improve performance.

Fig. 1. Cement

FINE AGGREGATES:Fine aggregates are essentially any natural sand particles won from the land through the mining process. Fine aggregates consist of natural sand or any crushed stone particles that are ¼” or smaller.

Coarse aggregates :Coarse aggregates refer to irregular and granular materials such as sand, gravel, or crushed stone, and are used for making concrete.

Compressive strength :Compressive strength can be defined as the capacity of concrete to withstand loads before failure. Of the 3 tests applied to the concrete

FIG:2&3

Fly ash is a fine, powdery material that is a byproduct of the combustion of pulverized coal in power plants

Fly ash is a valuable material in the construction industry, providing economic and environmental benefits when used wisely in various applications

Composition: Fly ash primarily consists of small, solid particles rich in silica, alumina, and iron. It is collected from the flue gases of coal-burning power plants.

Benefits –(1)Strength Enhancement (2)Reduced Carbon Emissions (3)Waste Reduction.

Fig. 4.

GGBS stands for Ground Granulated Blast Furnace Slag. It is a byproduct of the iron and steel industry and is commonly used as a supplementary cementitious material in the construction and concrete industry.

GGBS is a valuable material in the construction industry, contributing to the improvement of concrete properties and reducing its environmental impact.
Source: GGBS is obtained by quenching molten iron slag (a byproduct of the iron and steel-making process) with water or steam, which leads to the rapid cooling and solidification of the slag.
Benefits:(1)Strength and Durability (2)Reduced Heat of Hydration (3)Environmental Benefits

Fig. 5. GGBS

Test Conducted On Cement

Sl No.	Test Conducted	Units	Results	Method of Test	Standard Value
1.	Sp. Gravity	-	3.14	IS2720-Part 3	3.10-3.15
2.	Initial Setting Time	mins.	32	IS 12269 (1987)	>30

Test Conducted On Fine Aggregate

Sl. No	Test conducted	IS Codes of Reference	Test values	Standard Value
1	Specific gravity of fine aggregate	IS 2386: Part 3: 1963	2.64	2.2-2.9
2	Elongation	IS 2386: Part 1: 1963	21.2%	< 45%
3	Sieve analysis of fine aggregate	IS 2386: Part 1: 1963	Fine aggregate is within grading zone 2 based on % passing as per IS 383	

Test Conducted On Coarse Aggregate

Sl. No	Test conducted	IS Codes of Reference	Test values
1	Sieve analysis of course aggregate	IS 2386: Part 1: 1963	Samples are within the limit as per IS 383
2	Aggregate impact value test	IS 2386: Part 4: 1963	12.5%
3	Aggregate Crushing Test	IS 2386: Part 4: 1963	31%
4	Flakiness	IS 2386: Part 1: 1963	12.6%
5	Specific gravity of coarse aggregate	IS 2386: Part 3: 1963	2.64

Mix Design (for 6 cubes)

20% of Fly Ash and GGBS (IS 10262 : 2019)

Cement : 8.40 kg
Fine Aggregate : 13.94 kg
Coarse Aggregate : 19.26 kg
Fly Ash : 1.92 kg
GGBS : 1 kg
Water : 4L

40% of Fly Ash and GGBS (IS 10262 : 2019)

Cement : 6.3 kg
Fine Aggregate : 13.03 kg
Coarse Aggregate : 18.065 kg
Fly Ash : 2.2 kg
GGBS : 2kg
Water : 4L

RESULT AND DISCUSSION

COMPRESSION STRENGTH RESULTS FOR M40 GRADE

MIX NO.	MIX SPECIFICATI-ON	MIX COMB-INATION	CA(%)	FA(%)	CEMENT(%)	FLY ASH(%)	GGBS (%)	7 DAYS (N/mm2)	28 DAYS (N/mm^2)
1	NORMAL MIX FOR 20% REPLACEMENT	FA+CA+ WATER + CEMENT + FLY ASH + GGBS	100	100	80	10	10	36.8	49.8
2	NORMAL MIX FOR 40% REPLACEMENT		100	100	60	20	20	38.1	50.2

III. CONCLUSIONS

For M40 grade concrete, the maximum compressive strength is achieved when approximately 20-20% of the cement is replaced with a combination of Fly ash and GGBS.

In terms of strength efficiency factors, concrete with GGBS replacement generally exhibits higher values compared to concrete incorporating fly ash as a replacement material. This suggests that GGBS is more effective in enhancing the strength of the concrete.

Concrete incorporating fly ash and GGBS often exhibits higher long-term strength due to continued pozzolanic reactions over time. This leads to increased durability and resistance to chemical attack.

The use of fly ash and GGBS as cement replacements promotes sustainability by reducing the consumption of Portland cement.

Utilizing fly ash and GGBS can also offer economic advantages, as these materials are often cheaper than cement. However, transportation costs and availability should be considered.

3.FUTURE SCOPE

1. **Long-Term Performance and Durability**: While initial compression strength is important, understanding the long-term performance and durability of concrete is crucial for real-world applications. Future research could focus on assessing the durability properties such as resistance to freeze-thaw cycles, chemical attack, and carbonation for concrete mixes containing fly ash and GGBS.
2. **Environmental Impact Assessment**: Conducting a comprehensive life cycle assessment (LCA) to evaluate the environmental impact of concrete with partial replacement of cement by fly ash and GGBS would be beneficial. This includes analyzing factors such as greenhouse gas emissions, energy consumption, and resource depletion throughout the entire life cycle of the concrete, from raw material extraction to end-of-life disposal.
3. **Optimization of Mix Proportions**: Further research can delve into finding the optimal mix proportions of cement, fly ash, and GGBS to achieve the desired compression strength while maximizing sustainability and cost-effectiveness. This could involve experimental testing coupled with computational modeling to explore a wide range of combinations efficiently.

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