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To Study the Effect on Mechanical Properties of Concrete by Partially Replacement of OPC with Fly Ash and GGBS

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***Abstract:** This study investigates the mechanical properties of concrete with partial replacement of ordinary Portland cement (OPC) by fly ash and ground granulated blast furnace slag (GGBS). Various mix proportions were tested to evaluate compressive, tensile, and flexural strength over different curing periods. Results show a reduction in early-age strength due to slower hydration but improved long-term strength, and workability. The use of fly ash and GGBS also reduces the environmental impact, highlighting their potential as sustainable alternatives in concrete production.*
***Keywords:** Mechanical Properties, Portland Cement, Fly Ash, GGBS, Environmental Impact.*

I. INTRODUCTION

The growing need for sustainable construction has prompted the use of alternative cementitious materials. While Ordinary Portland Cement (OPC) is common, its production emits significant CO_2. Supplementary cementitious materials (SCMs) like Fly Ash and Ground Granulated Blast Furnace Slag (GGBS), byproducts of thermal power and steel industries, offer eco-friendly alternatives. Their partial replacement in concrete improves mechanical properties such as compressive, tensile, and flexural strength, while reducing heat of hydration, shrinkage, and permeability. This study investigates the impact of Fly Ash and GGBS on concrete performance, aiming to identify optimal replacement levels for enhanced durability and sustainability.

II. METHODOLOGY

The methodology for this study follows a systematic approach to evaluating the effects of partially replacing cement with fly ash and GGBS in concrete. It begins with identifying the need for sustainable and cost-effective alternatives to conventional concrete, followed by collecting relevant literature and resources. The next step involves arranging the necessary materials for sample preparation, ensuring consistency in mix design. The prepared samples undergo testing to assess their mechanical properties, such as compressive, tensile, and workability. The results are then compared with existing research to validate findings. A thorough analysis leads to meaningful conclusions regarding the performance of fly ash and GGBS in concrete, ultimately helping to define the scope and potential applications of the study in sustainable construction practices.

III. MATERIALS USED

1) Cement: is the primary binding material in concrete, and its partial replacement with supplementary cementitious materials like Fly Ash and GGBS is the focus of this study. The inclusion of Fly Ash and GGBS, which are industrial byproducts, can enhance concrete properties such as strength, durability, and workability while reducing the carbon footprint. Ambuja Cement is used for the project.

Fig. No.1

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2) Fly Ash: Fly ash is a fine, powdery byproduct obtained from the combustion of pulverized coal in thermal power plants. It primarily consists of silica, alumina, and calcium oxide, making it a suitable pozzolanic material for partial replacement of cement in concrete.

Fig. No.2

3) GGBS: Ground Granulated Blast Furnace Slag (GGBS) is a byproduct of the steel manufacturing industry, obtained by rapidly cooling molten iron slag and then grinding it into a fine powder. It is a highly reactive supplementary cementitious material composed mainly of calcium silicates, which enhances the durability and strength of concrete.

Fig. No.3

4) Fine Aggregates: Fine aggregate, commonly referred to as sand, is a crucial component of concrete that fills voids between coarse aggregates and contributes to the overall workability and strength of the mix. In this project, natural river sand or manufactured sand (M-sand) conforming to IS: 383-2016 is used as fine aggregate.

Fig. No.4

5) Coarse Aggregates: Coarse aggregate is a key component in concrete, providing strength, stability, and volume to the mix. In this project, crushed stone or gravel with a nominal size of 10mm to 20mm, conforming to IS: 383-2016, will be used. Coarse aggregates improve the mechanical properties of concrete by reducing shrinkage and enhancing loadbearing capacity.

Fig. No.**5**

6) Water: Water is an essential ingredient in concrete, playing a crucial role in the hydration of cement and the overall workability of the mix. In this project, potable water free from impurities such as acids, oils, alkalis, salts, organic materials, and suspended solids will be used, conforming to IS: 456-2000 standards.

IV. MIX DESIGN

1) Actual quantities required for the mix per bag of cement
   i. Cement = 50 kg
   ii. Sand = 71.0 kg
   iii. Coarse Aggregate – 155 kg
2) Actual quantities for 1 m3 of concrete production, for w/c ratio of 0.45
   i. Extra quantity of water to be added for absorption in Case of CA. at 0.5 % mass = 1.255 lit.
   ii. Quantity of water to be deducted for moisture present in Sand at 2% by mass = 11.14 lit.
   iii. Actual Quantity of Water = 25 + 1.255 - 11.14 = 15.11 lit.
   iv. Actual quantity of sand required after = 557 + 11.14 = 568.14 kg
   v. Specific Gravity - Coarse Aggregate = 2.65
      Fine Aggregate = 2.65
   vi. Water Absorption – Coarse Aggregates = 0.81
      Fine Aggregates = 0.60
   vii. Quantity of Coarse Aggregates = 1211 kg

V. TEST PERFORMED

1) Compressive Strength: The compressive strength test determines the ability of concrete to withstand loads that tend to compress it. It is one of the most important properties of concrete and is usually tested using cube or cylinder specimens. The standard specimens are cured and then subjected to compressive loading in a universal testing machine (UTM) until failure. The maximum load divided by the cross-sectional area gives the compressive strength, typically measured in MPa. This test helps assess the quality and structural capacity of concrete.
2) Workability: Workability refers to how easily fresh concrete can be mixed, placed, and finished without segregation. The most common test for workability is the slump test, where a concrete sample is placed in a cone-shaped mould, lifted vertically, and the slump (or drop) in height is measured. A higher slump indicates more workable concrete. Other methods include the compacting factor test and flow table test, especially for different types of mixes. Workability affects the ease of construction and the quality of the finished structure.

VI. TEST RESULTS AND ANALYSIS

1) *Compressive Strength after 7 Days of Curing*

Sr. No.	Percentage of OPC Replacement	Load Taken by Sample in KN	Compressive Strength in N/mm^2
1.	0	237.38	10.55
2.	30	199.00	8.84
3.	50	143.20	6.35

Table No.1

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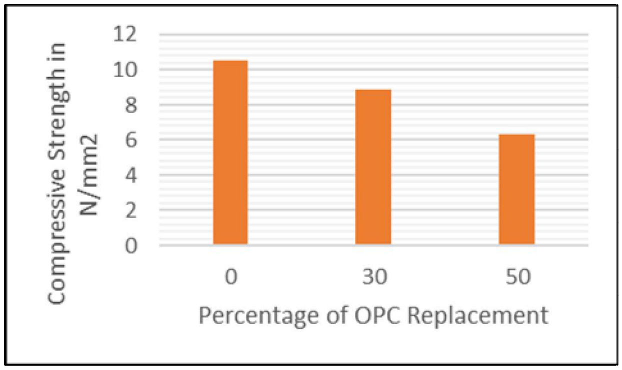


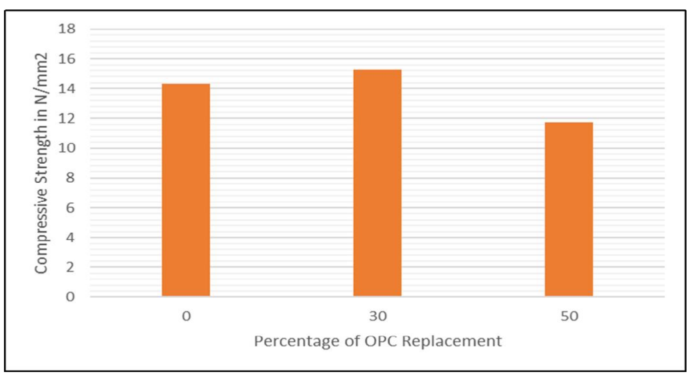
Graph No.1

From above chart, it is seen that concrete gets highest strength after 7 days of curing for 0 % replacement of OPC.

2) Compressive Strength after 14 Days of Curing:

Sr. No.	Percentage of OPC Replacement	Load Taken by Sample in KN	Compressive Strength in N/mm^2
1.	0	322.65	14.34
2.	30	343.00	15.24
3.	50	264.44	11.75

Table No.2



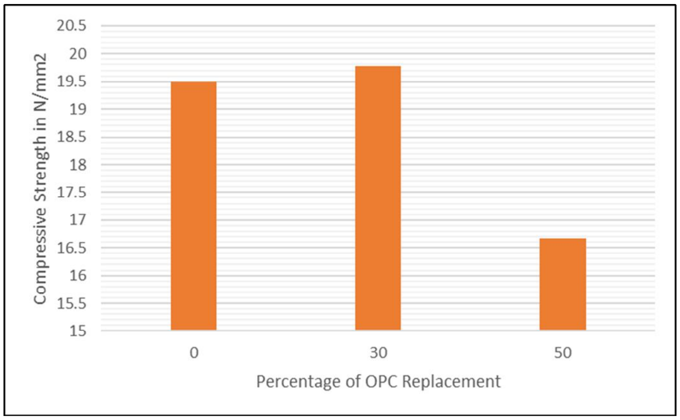
Graph No.2

From above chart, it is seen that concrete gets highest strength after 14 days of curing for 30 % replacement of OPC.

3) Compressive Strength after 28 Days of Curing:

Sr. No.	Percentage of OPC Replacement	Load Taken by Sample in KN	Compressive Strength in N/mm^2
1.	0	438.75	19.5
2.	30	445.05	19.78
3.	50	375.07	16.67

Table No.3



Graph No.3

From above chart, it is seen that concrete gets highest strength after 28 days of curing for 30 % replacement of OPC.

4) Workability Test Results

Sr. No.	Percentage of OPC Replacement	Slump in mm
1.	0	70
2.	30	85
3.	50	115

Table no.4

From above table, it is seen that concrete gets highest workability for 50 % replacement of OPC.

VII. CONCLUSION

The study highlights the effectiveness of replacing Ordinary Portland Cement (OPC) with a combination of Fly Ash and GGBS in concrete. the combination of Fly Ash and GGBS not only enhances the long-term strength and workability of concrete but also plays a crucial role in mitigating environmental impact, aligning with the growing need for sustainable construction practices.

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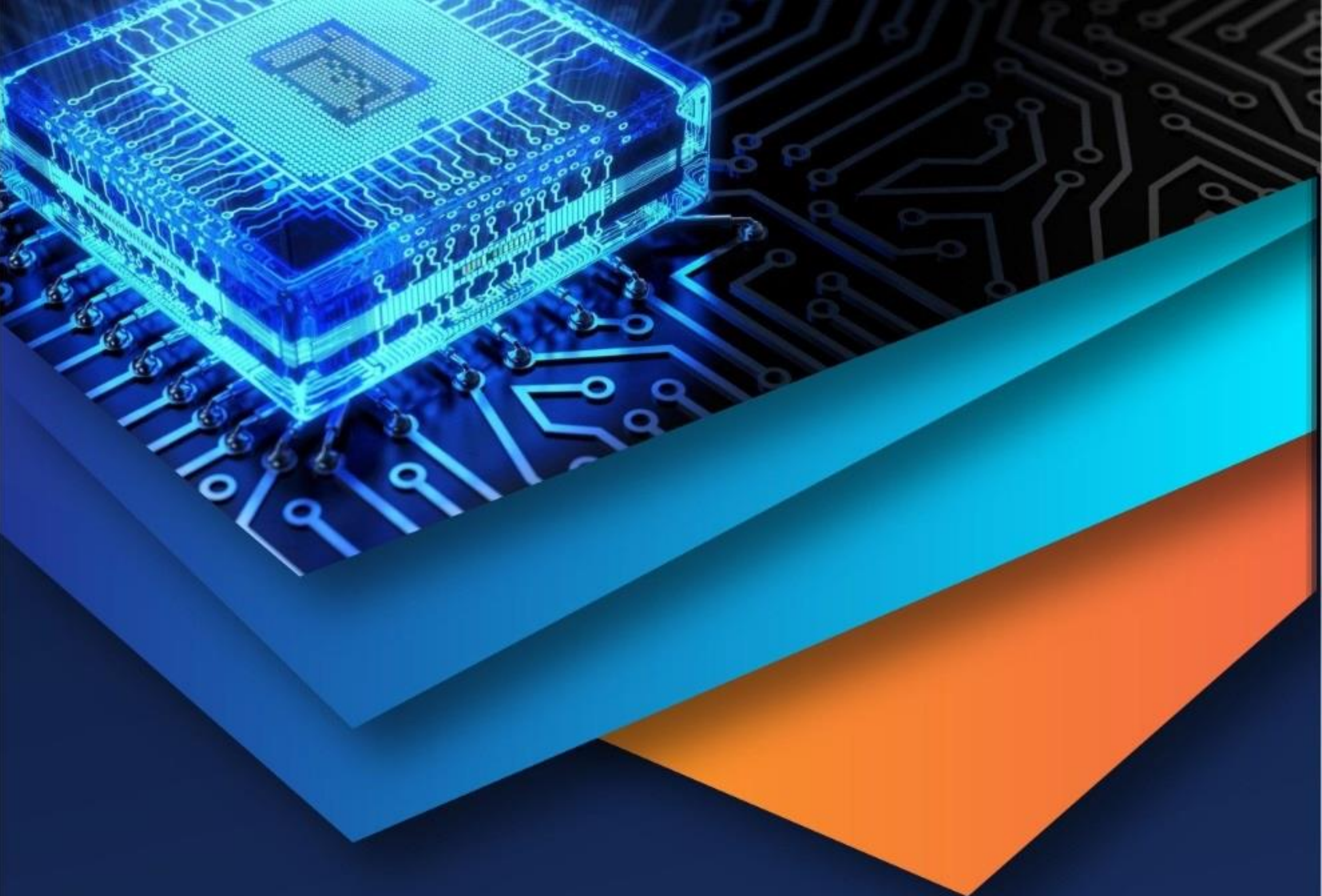

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