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EXPERIMENTAL STUDY ON STRENGTH CHARACTERISTICS OF CONCRETE OBTAINED BY PARTIAL REPLACEMENT OF CEMENTWITH FLY ASH, SILICA FUME &GGBS

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Abstract— Concrete is the most used construction material in the civil engineering and it is the world's most consumable product next to water. The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete. Unfortunately, production of cement involves emission of large amount of carbon dioxide gas into the atmosphere, a major contributor for the greenhouse effect and global warming. Large scale production of cement is causing environmental problems. Many efforts are being made to reduce the use of Portland cement in construction. These efforts include the utilization of supplementary cementitious materials in place of Portland cement. In this present work cement has been replaced with Fly ash (FA), Silica fume (SF) & GGBS by the weight of cement by keeping constant percentages of cement at 50% and SF at 10% for M30 mix. The properties studied are 7 days & 28 days Compressive strength, Split tensile strength and Flexural strength and compared with the conventional concrete by maintaining a water-cement ratio of 0.45 for each mix. The results indicate that the incorporation of various cementitious materials (FA, SF & GGBS) in concrete rendered less strength when compared to conventional concrete. The individual results of mix M-3 (OPC 50%, SF 10%, FA 10% & GGBS 30%) & mix M-4 (OPC 50%, SF 10%, FA 15% & GGBS 25%) have achieved M30standards.

Keywords - Ordinary Portland Cement (OPC), Fly Ash (FA), Silica Fume (SF), Ground Granulated Blast Furnace Slag (GGBS), flexural strength.

I. INTRODUCTION

Concrete is the most widely used construction material in the world and Ordinary Portland Cement (OPC) is the major ingredient used in concrete. The production of cement releases a large amount of carbon dioxide (CO_2) to the atmosphere that significantly contributes to greenhouse gas emissions. It is estimated that one ton of CO_2 is released into the atmosphere for every ton of OPC produced. In view of this, there is a need to develop sustainable alternatives to conventional cement utilizing the cementitious properties of industrial byproducts such as fly ash and ground granulated blast furnace slag. On the other side, the abundance and availability of fly ash and GGBS worldwide create an opportunity to utilize these by-products, as a partial replacement or a performance enhancer forOPC.
Various percentages of Silica fume were incorporated in concrete & studied its effect in research studies [2], [3] & [4]. Beyond 10% it was found that strength is decreasing with increase in percentage of Silica fume.
Cement is replaced with Fly ash (FA), Silica fume (SF) & GGBS by the weight of cement by keeping constant percentages of cement at 50%, SF at 10% and remaining 40% replaced by FA & GGBS as different proportions in the concrete mix of M30 grade with proportions of 1:1.679:2.31:0.45 (cement: fine aggregate: coarse aggregate: w/c). The concrete specimens like 42 cubes, 42 cylinders, and 28 prisms were cast and tested for compressive, split tensile and flexural strength after 7days & 28days of curing.

Objectives

- To achieve good strength, less porous, less capillarity so that the durability will bereached.
- To reduce the cement content with industry waste by-products like SF, FA, and GGBS for decrease the emission of Co_2 and Environmental pollution.
- To evaluate the hardened properties of concrete like compressive strength, split tensile strength, a flexural strength of M30 grade concrete at 7days &28days.
- To compare the results of different mix proportions carried out with conventional concrete.

II. MATERIALS AND MATERIALPROPERTIES

Cement: In this present work Birla gold cement of OPC 53 grade was used for casting. The basic properties of cement as per the code IS456:2000 are tested and results are mentioned below in TableI:

TABLE I
Physical properties of cement

Properties	Standard Consistency	Fineness	Specific Gravity	Initial Setting Time	Final Setting Time
Test Results	32%	6%	3.15	150 minutes	220 minutes

Fly ash (FA): The fly ash used in this study was class F fly ash, which is collected from Kakatiya thermal power station and it is located in Chelpur village, Bhupalpalle, Telangana.

TABLE II
Physical properties of Fly ash

Properties	**Test Results**
Specific Gravity	2.25

GGBS: GGBS was collected from JSW cement Limited (Venkat Sai Enterprises) and it is located at Hunter Road, Warangal Urban (District), Telangana.

TABLE III
Physical properties of GGBS

Properties	**Test Results**
Specific Gravity	2.75

Silica Fume (SF): Silica Fume was collected from Jai Shri Mineral And Chemicals and it is located at Sarawagi Mohalla, Beawar, Rajasthan, India.

TABLE IV
Physical properties of Silica fume

Properties	**Test Results**
Specific Gravity	2.2

Aggregates: River sand of size below 4.75mm conforming to zone II of IS 383-1970 was used.

TABLE V
Physical properties of aggregates

Properties		**Specific Gravity**	**Bulk Density**	**Fineness modulus**	**% of Voids**	**Void Ratio**
Test Results	Fineaggregate	2.45	1.5gm/cm^3	2.7	35%	0.53
	Coarse aggregate	2.77	1.402gm/cm^3	7.89	49.8%	0.9

Water: Portable tap water is used for the preparation of specimens and for curing specimens.

Fig. 1 Curing of specimens

III. MIX DESIGN AND STUDY METHODOLOGY

Mix design: The mix design procedure adopted in the present work to obtain M-30 grade concrete is in accordance with IS: 10262- 2009 and IS: 456-2000.

TABLE VI
Mix proportions for M30 Grade Concrete

Materials	**Cement**	**Fine aggregate**	**Coarse aggregate**	**Water (lit.)**
Quantity (kg/m^3)	437.77	735.091	1011.285	197
Proportions	1	1.679	2.31	0.45

TABLE VII
Various mix proportions

Mix No.	**Replacement percentages of (by weight of cement)**				
	OPC 53	**SF**	**FA**	**GGBS**	**TOTAL**
M-1	100	0	0	0	100
M-2	50	10	05	35	100
M-3	50	10	10	30	100
M-4	50	10	15	25	100
M-5	50	10	20	20	100
M-6	50	10	25	15	100
M-7	50	10	30	10	100

IV. EXPERIMENTALWORK

The main aim of this experimental work is to study the compressive strength, split tensile strength and flexural strength of concrete by partial replacement of cement about 50% using Silica fume, Fly ash and GGBS. For each mix proportion 6 cubes of size 150mm×150mm×150mm, 6 cylinders of 150mm diameter and 300mm in height and 4 prisms of 500mm×100mm×100mm are cast. Totally 42 cubes, 42 cylinders, and 28 prisms are cast for the 7days & 28days strength.

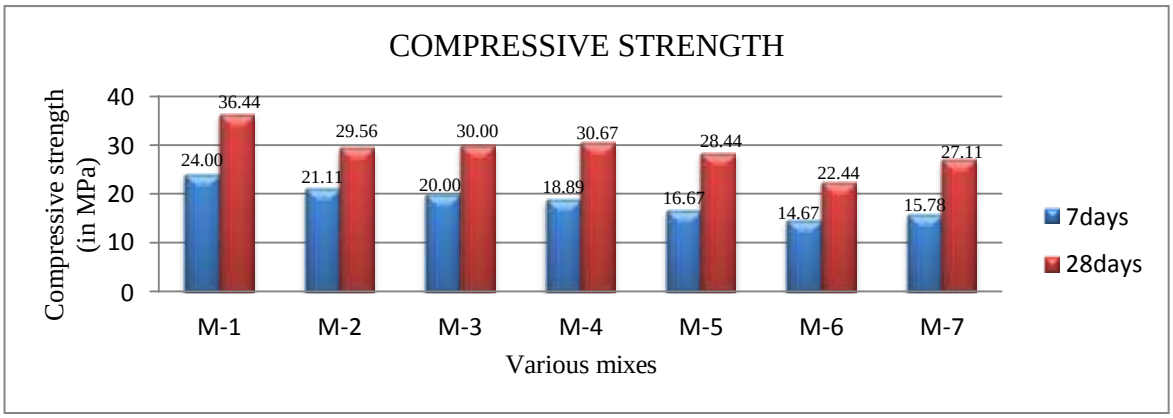
Testing of specimens:
Compressive strength test on cubes, split tensile strength test on cylinders and flexural strength test on prisms are carried out as shown in figures below:

Fig. 2 Testing of cubes

Fig. 3 Testing of cylinders

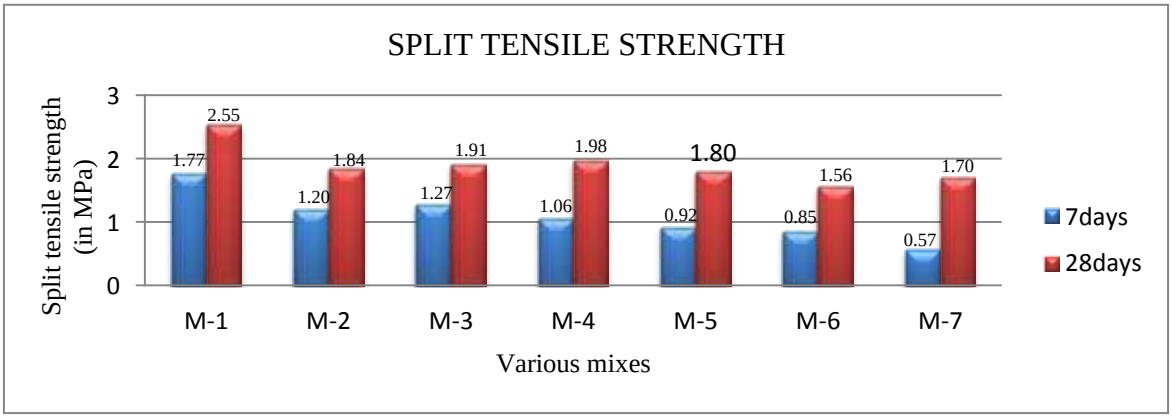
Fig. 4 Testing of a prism

V. RESULTS &DISCUSSIONS



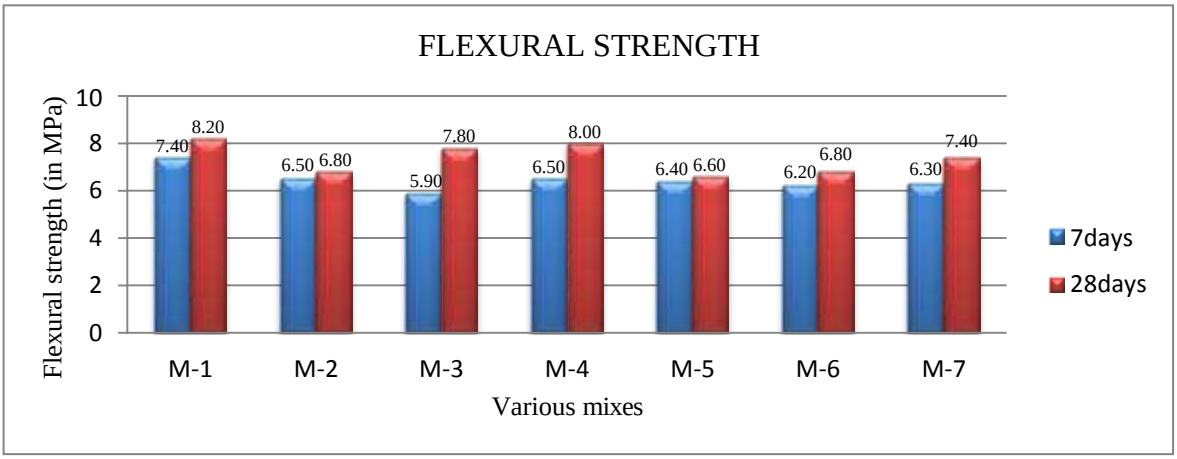
Graph 1 Compressive strength values comparing with conventional concrete mix (M-1)

Graph 1 represents the compressive strength of concrete with various percentage replacement of cement by fly ash, silica fume and GGBS. The compressive strength of conventional concrete mix (M-1) achieved the highest strength and after mix M-4 (OPC 50%, SF 10%, FA 15% & GGBS 25%) got the highest strength for 28 days.



Graph 2 Split tensile strength values comparing with conventional concrete mix (M-1)

The above Graph 2 represents the split tensile strength of concrete with various percentage replacement of cement by fly ash, silica fume and GGBS. The split tensile strength of conventional concrete mix (M-1) achieved the highest strength and after mix M-4 (OPC 50%, SF 10%, FA 15% & GGBS 25%) got the highest strength for 28 days.



Graph 3 Flexural strength values comparing with conventional concrete mix (M-1)

Graph 3 represents the flexural strength of concrete with various percentage replacement of cement by fly ash, silica fume and GGBS. The flexural strength of conventional concrete mix (M-1) achieved the highest strength and after mix M-4 (OPC 50%, SF 10%, FA 15% & GGBS 25%) got the highest strength for 28days.

VI. CONCLUSIONS

1. The M30 grade of concrete has attained the compressive strength, split tensile strength and flexural strength of 24MPa, 1.77 MPa, and 7.4 MPa respectively for 7days.
2. The M30 grade of concrete has attained the compressive strength, split tensile strength and flexural strength of 36.44 MPa, 2.55 MPa, and 8.2 MPa respectively for28days.
3. When all the mixes (M-2 to M-7) are compared with conventional mix (M-1), they all rendered less strength.
4. Mix M-3 (OPC 50%, SF 10%, FA 10% & GGBS 30%) & M-4 (OPC 50%, SF 10%, FA 15% & GGBS 25%) have achieved M30 standards.
5. Out of all the mixes barring conventional mix (M-1), mix M-4 (OPC 50%, SF 10%, FA 15% & GGBS 25%) has greater compressive strength, split tensile strength & flexural strength at 28days.

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