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Experimental Study of Mechanical Properties of M30 Grade Hybrid Concrete Incorporating Mineral Admixture and Steel Fibers

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Abstract—*Hybrid Concrete has gained attention to the development of buildings, highways and other civil engineering structures. In this paper a comprehensive study was carried out for mechanical properties of hybrid concrete incorporating mineral admixture namely Ground Granulated Blast Furnace Slag (GGBS) and stainless steel fibers with aspect ratio 50. The machanical properties M30 grade hybrid concrete was prepared by using GGBS in replacement with cement ratio of 5 %, 10 %, 15 %, 20 % and steel fiber in ratio of 0.5%,1% and 1.5%. Mechanical properties were checked at 28 days and 56 days by performing compression test, flexural test and split tensile test. It was observed that from the optimized result that the replacement of cement by 15% with GGBS and 0.5% with steel fiber gave a higher compressive strength and the replacement of cement by 15% and 1.5% steel fiber gave higher split tensile and flexural strength at all ages. This mix can be utilized in hybrid buildings, bridges, mega stadiums and precast work.*

1. INTRODUCTION

. Concrete is the 2nd most used material on the earth after water. According to the surveys, 58% of concrete production increases CO2. So, the best way to decreases the content of CO2 some other admixtures were replaced with cement. To improve the properties of concrete with the help of many other materials like silica fume, fly ash, metakoalin, GGBS, rice husk ash, etc. These admixtures play an important role in the formation of concrete. A new high performance hybrid material has been developed by combination of Ground granulated blast furnace slag (GGBS) and steel fiber. So, the advantages of both materials, namely high strength, durability, surface quality and cost efficient production. It Can be implemented in one hybrid material. Hybrid concrete is which integrates precast concrete and cast in situ concrete to make best advantages of their different inherent qualities. Researchers at all over the world are attempting to develop high performance concrete by using hybrid material. Fibers provide improvements in tensile strength, durability, shrinkage characteristics of concrete. GGBS improve mechanical and durability properties of concrete. Concrete has high compressive strength but, weak in tensile. So, to improve the behavior of tensile in concrete we used stainless steel fibers. The main reason for incorporating fiber with cement matrix is to increase the tensile strength, flexural strength of concrete and also it improves the cracking deformation characteristics of the concrete composite.

2. MATERIAL AND PROPERTIES

Cement

The cement used in this experimental work is sanghi cement of 53 grade ordinary Portland cement. The specific gravity of cement is 3.15, Standard consistency of cement is 31.3%.All properties of cement are tested by references of IS 12269-1987.

3. GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Granulated Blast Furnace Slag is obtained by rapidly chilling the molten ash from the furnace with the help of water. During this process, the slag gets fragmented and transformed into amorphous granules (glass). GGBS is also referred as slag cement that significantly improves durability and strength of concrete. Slag cement begins in an iron blast furnace, which is carefully controlled amount of iron ore along with limestone, which are further fed into blast furnace and heated to1400^0c 1600^0 c During molten state iron is tapped for production of steel and diverted to a Granulator. Slag is rapidly quenched with large quantities of water along with the process it minimizes the crystallizations and develops granulated slag, which is basically composed formation of calcium alumino silicate glass.

At this stage, the slag is the uniform fine sand and develops up to fine powder to form Granulated Blast Furnace Slag (GGBS) or slag cement. The GGBS used in this present study was

obtained from Suyog Element Pvt.Ltd at Palej, Gujarat. The property of GGBS is in following Table 1.

Table 1: Properties of GGBS

Characteristic	Requirement as per BS:6699	Test result
Fineness (M2/KG)	275 (Min.)	420.00
Residue by wet sieve on 45u (%)	-	2.00
Initial setting time (Min)	Not less than IST of opc	195
Insoluble residue (%)	1.5 (Max)	0.28
Magnesia content (%)	14.0(Max)	8.06
Sulphidesulphur (%)	2.00(Max)	0.53
Sulfate content (%)as SO3	2.50(Max)	0.24
Loss on Ignition(%)	3.00(Max)	0.29
Manganese content(%)	2.00(Max)	0.23
Chloride content(%)	0.10(Max)	0.001
Moisture content(%)	1.00(Max)	0.03
Glass content(%)	67(Min)	94.00
Compressive strength(N/mm2)		
After 7 days	12.0(Min)	24.74
After 28 days	32.5(Min)	46.24
Chemical moduli		
CaO+MgO+SiO2	66.66(Min)	82.00
CaO+MgO/SiO2	>1.0	1.30
CaO/SiO2	<1.40	1.06

C. Fine aggregates

Locally available sand passed through of 4.75mm IS sieve is to be used. The specific gravity of sand is 2.60 and fineness modulus of 2.84 is used. Water absorption of sand is 1.23%.

D. Coarse aggregates

The coarse aggregates with the sizes of 20mm and 10 mm aggregates are used. Specific gravity of 20mm CA is 2.88 and for 10 mm it is 2.87. And fineness modulus is 7.38.

E. Water

Water should be free from all injurious amounts of acids, organic and inorganic impurities. And it should be used for proper mixing and curing of concrete.

F. Steel fibers (SF)

Steel fiber is one of the most usually used fibers. Generally round fibers are used. The steel fiber sometime gets rusted and loses its strength. It has a high modulus of elasticity. The use of steel fibers makes significant improvements in flexure, impact and fatigue strength of concrete. It has been used in various types of structures. Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. Some types of fibers produce more impact, abrasion, and shatter resistance in concrete. Aspect ratio defines about fiber to be having ratio varying from 30 to 150; generally bigger aspect ratios gives lead to strength and toughness up to 100. For this experiment study we like to use stainless steel fiber with aspect ratio of 50. (Length 25mm and Diameter 0.5mm). Steel fiber used in this present study was obtained from Fiber zone Pvt. Ltd in Ahmedabad; Gujarat with the following details is in table 2.

Table 2: Properties of Steel fiber

Properties	Dimension
Length	25mm
Diameter	0.5mm
Appearance	Clear, Bright, and Straight
Aspect ratio L/D	50
Carbon content C (%)	0.002
Manganese content Mn (%)	1.40
Silicon content Si (%)	0.370
Nickel content Ni (%)	8.040
Chromium Cr (%)	18.180
Phosphate p (%)	0.039

G. Admixture

Super plasticizer is the one of the most popular chemical admixture used in concrete technology. This admixture is also known as the high range of water reducers. Sikament FF is a highly effective water, reducing agent and super plasticizer for promoting accelerated hardening and free flowing concrete. With specification of super plasticizer is in following details.

Color: color less, specific gravity: 1.1875, PH value: 8-12, Chloride content: nil, Addition rate (by weight of cement): 0.4-2%.

4. EXPERIMENTAL WORK

A. Mix proportion

The mix proportion shown in table 3.was made for a concrete with the slump of 66.5mm (50mm-75mm),the design of M30 OPC concrete as per IS:10262-2009.

Table 3: Mix proportion

Material	Weight kg/m3
Cement	383.16
Water	153.26
Fine aggregate	785.94
Coarse aggregate (20mm)	771
(10mm)	514
Admixture	7.66
w/c ratio	0.40

B. Casting and curing

Casting was done as per the combination of GGBS and steel fiber for hybrid concrete. 5G0.5SF means 5% replacement of GGBS with cement and 0.5 % steel fiber added to weight of cement so other mix proportion as per above parameters. Table 4. Shown the different proportion with the design of mix hybrid concrete.

Casting and curing was done as per IS: 516 for mixing of hybrid concrete. After mixing the concrete, it was filled it out with cubes, beam and cylinders for the different test. The specimens were removed after 24 hours and install into the water curing tank. After curing time of 28 days and 56 days specimens were taken out for a test.

Table 4: Design of Mix

Mix proportion	GGBS (%)	Steel fiber (%)
0G0SF –M30	0	0
5G0.5SF	5	0.5
5G1SF		1
5G1.5SF		1.5
10G0.5SF	10	0.5
10G1SF		1
10G1.5SF		1.5
15G0.5SF	15	0.5
15G1SF		1
15G1.5SF		1.5
20G0.5SF	20	0.5
20G1SF		1
20G1.5SF		1.5

5. TESTING

To find out the mechanical properties of hybrid concrete at ages of 28 days and 56 days at above mix proportion by performing following test:

A. Compression test

Compression test was carried out on concrete specimen cubes. The size of the cubes is 150mm×150mm×150mm were casts of M30 hybrid concrete. After curing for 28 days and 56 days were tested on a compression test machine as per IS: 516-1959, and the failure load noted. Each category of three cubes was tested and their average value is noted.

B. Flexural test

Flexural test was performed on beams. The size of beams is 150mm×150mm×700mm were tested on a universal testing machine as per IS: 516-1959. And the failure load was noted to find to the flexural strength.

C. Split tensile test

In this test the size of specimen (cylinders) is 150mm×300mm were tested on a compression test machine as per IS: 5816-1999. The failure load is noted to find out the split tensile strength of cylinders.

6. RESULTS AND DISCUSSION

A. Compressive strength

From Fig. 1. It was observed that increase in content of steel fiber 0.5 % to 1.5%. It decreases the compressive strength of the concrete up to all ages. Here concrete with 15% replacement of GGBS and 0.5% of steel fiber added into concrete performed well. At 28 days and 56 days increase in compressive strength is 11.89%, 9.20% respectively in comparison with control concrete. After 20% replacement of GGBS it was decrease the strength up to all ages. When the steel fiber increase the compressive strength is decreased. Because of the pozzolanic action of GGBS and converted action of calcium hydroxide into the gel of C-S-H was not proper bonded.

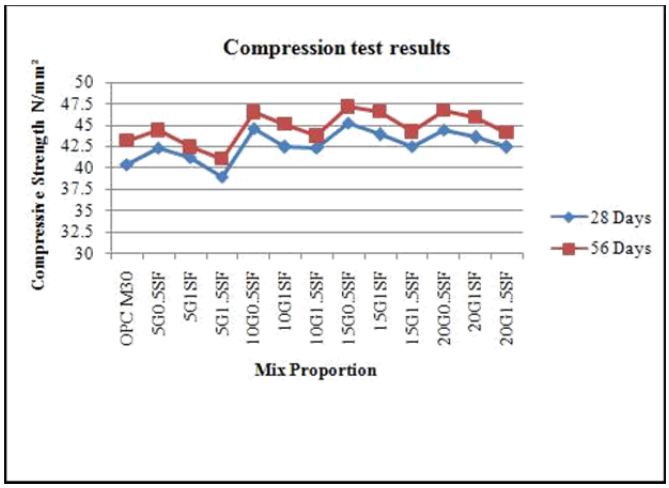

Fig. 1: Compressive strength results

B. Flexural strength

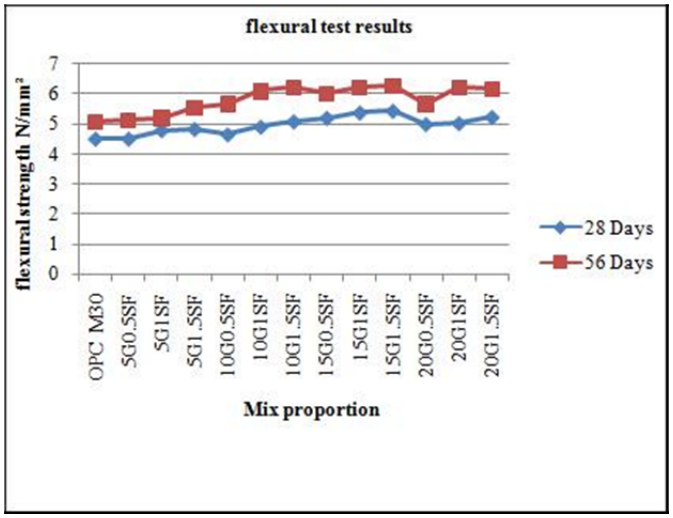

Fig. 2: Flexural strength results

The test of flexural strength of concrete specimen is shown in Fig. 2. The optimum dosage of the concrete mixture is on 15%with GGBS and 1.5% steel fiber has the highest flexural strength was achieved for 28 days and 56 days. At 28 & 56 days increase in flexural strength is 21.11% & 23.37% respectively in comparison with control concrete. This is due

to geometric form and more aspect ratio of steel fiber added into the mixes that enable them to develop a high bond between the matrix and the fiber.

C. Split tensile strength

The results of split tensile in shown in Fig. 3. The concrete mix with 15% GGBS and 1.5% steel fiber is the optimum dosage for hybrid concrete in tensile strength and its gave the highest split tensile strength performance at all ages. At 28 days and 56 days increase

In split tensile is 29.43% and 22.80% respectively in comparison with OPC M 30 concrete. Concrete became less brittle and more ductile because of steel fiber. So, the split tensile strength is increase comparison to M30 concrete.

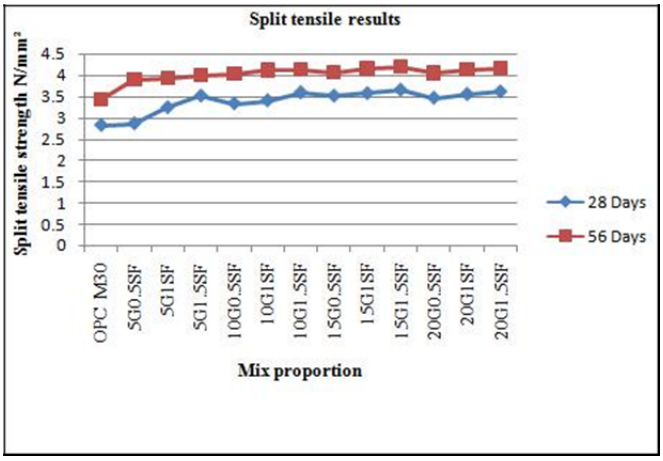

Fig. 3: Split tensile strength results

7. CONCLUSION

A. The concrete mixture with 15% GGBS and 0.5% steel fiber has the highest compressive strength. At 28 days and 56 days increase in compressive strength is 11.89%, 9.20% respectively comparison with all control mixture of M30 concrete.

B. The concrete mix with 15% GGBS and 1.5% steel fiber has the highest flexural strength and split tensile strength of concrete. At 28 days and 56 days increase in split tensile strength is 29.43% and 22.80% and in flexural strength is being increased up to 21.11% & 23.37% at all ages.

C. The optimum value is achieved in 15% GGBS and 0.5% steel fiber in compressive strength and in split tensile, flexural strength the optimum values are 15% GGBS and 1.5% steel fiber

D. GGBS can be utilized as a mineral admixture in concrete due to economic and environmental benefits, without any compromise with its performance.

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