Experimental Investigation on glass fiber reinforced concrete by partial replacement of cement and fine aggregate with Ground granulated blast furnace slag and steel slag

Mohd Shabas Sharief P.G. Student, Civil Department, CMR Technical campus, Medchal, Hyderabad, India
Ch. Srinivasa Rao Professor and HOD, Civil Department, CMR Technical Campus, Medchal, Hyderabad,

Abstract:
Concrete is normally used in mass quantity for a construction. Concrete is a composite fabric composed of excellent and coarse mixture bonded with fluid cement that hardens over the years. Concrete consumption is extraordinarily high and its call for is growing rapidly. The manufacturing for cement produces large volumes of Greenhouse gas emissions, leading to net 8% of Global emissions and one Ton of cement production leads about one ton of Co2 emission. Due to speedy creation rate deficiency of materials takes place ensuing reduction in natural aggregate like dredging of sand in big scale creates impact on surrounding environmental imbalance. To lessen the emission of Co2 from the cement production and to reduce the best mixture utilization there is a requirement of eco-friendly alternative material along with Granulated blast furnace slag, Fly ash, Steel slag that's business with the aid of-products. In present investigation is performed using GGBS and steel slag as partial substitute for cement and pleasant mixture. The fibers serve a cause just like the reinforcing metal in strengthened concrete, and it provides flexure, tensile and compressive power. Concrete of grade M40 turned into used with the addition of glass fiber of zero. 5% and 1% by using weight of cement with partial alternative of GGBS in 30% and steel slag in 10%, 20%, 30% and 40% by using weight of quality combination. The cubes, cylinders and beams had been casted for 3days, 7days and 28 days of curing. The concrete fresh and hardened properties such as workability, compressive, split tensile and flexure strength respectively were determined.

Key words: Glass fiber, Ground Granulated Blast Furnace slag, Steel slag, Fresh concrete properties, Hardened properties

1. INTRODUCTION

Concrete intake is extraordinarily high and its demand is increasing swiftly and extraction of high quantity of natural aggregates leads to depletion river beds and motive environmental imbalance. To lessen the emission of Co2 from the cement manufacturing and protection of natural assets by using the use of waste materials from iron and steel industries there is a demand of eco-friendly replacement fabric such as Granulated blast furnace slag, Fly ash, Steel slag that is commercial by using-products. The compressive strength of the concrete increases and the optimum value was found at a steel slag replacement proportion of 40% for fine aggregate and after that any further replacement of slag decreases the compressive strength. The tensile strength and flexural strength values follow the same for all the replacement proportions. Addition of GGBS and steel fibers reduces bleeding and it improves the surface integrity of concrete. Also it increases the homogeneity and reduces the probability of cracks and increases the flexural strength of concrete at optimum content The replacing of industrial waste substances in concrete would assist to improve eco-friendly atmosphere and also acts as green concrete. The replacing of industrial waste materials in concrete would help to improve eco-friendly atmosphere and also acts as eco-friendly concrete. For M40 concrete with various percentages cement with GGBS adding 1% of steel fiber considering cost of construction drawn

attention of investigators to explore new replacement of concrete. Ten mixes studied using cubes ,cylinder, beams were tested for compressive split tensile and flexure with replacement level 10 % ,20%,30% ,40% and 50%. It is found that 30% replacement of cement with GGBS helped in improving strength of concrete. Compressive strength and split tensile strength in concrete enhances up to 1% of glass fiber and then decreases gradually.

2. OBJECTIVES

The main objective of this study is to determine the high strength and increased durability by partial replacement of fine aggregate by Steel Slag and addition of Glass fiber to the mixes and also to compare the results of mixes.

- To take a look at the fresh properties of concrete when steel slag is replaced by 10%, 20%, 30% and 40% of fine aggregate and glass fiber introduced with the aid of 0.5 and 1%.
- To observe the hardened properties of concrete whilst metallic slag is replaced through 10%, 20%, 30% and 40% of fine aggregate and glass fiber added via 0.5 and 1%.
- To determine the optimum percentage of steel slag and glass fiber.

3. MATERIALS

3.1 CEMENT

Ordinary Portland cement of 53 grades as per IS 269:2015 are considered. Physical Properties such as Fineness, normal consistency, Specific Gravity, Initial setting and final setting time values shown in table 1

Table 1. Physical properties of Cement

Physical property	**value**
Fineness of cement	1%
Initial setting time	45min
Final setting time	480 min
Specific Gravity	3.15
Consistency	32%

3.2 FINE AGGREGATE

River sand confirming to IS 383-2016 has been used in the current study. Hence, the river sand has been considered. Properties such as Specific Gravity, Fineness Modulus, Water Absorption, Zone of aggregate values shown in table 2.

Table 2. Properties of Fine aggregate

Physical property	**value**
Specific-gravity	2.54
Fineness Modulus	2.44
Zone	Zone -2
Water absorption	1.2%

3.3 COARSE AGGREGATE

Aggregate of 20mm confirming to IS 383-2016 is considered. Physical Properties such as Water absorption, Specific gravity values shown in table 3.

Table 3. Properties of Coarse aggregate

Physical property	**value**
Size of aggregate	20mm
Specific gravity	2.70
Water absorption	0.5%

3.4 GROUND GRANULATED BLAST FURNACE SLAG.

GGBS confirming to IS: 16714-2018 has been considered. The properties of GGBS such as Colour, Specific Gravity, Water absorption, Fineness are shown in table 4.

Table 4. Properties of GGBS

Physical property	**value**
Colour	White
Specific Gravity	2.77
Fineness	1%
Water absorption	0.75%
Chemical property	
Cao	37%
Sio_2	30%
MgO	5%
Al_2O_3	15.5%
Fe_2O_3	1.22%

3.5 GLASS FIBER

Glass fiber confirming to IS: 6432-1984 is considered. The physical properties of Glass fiber such as Density, Elastic modulus, Tensile strength, Length are shown in table 5.

Table 5. Properties of Glass fiber

Physical property	**value**
Density	2.68
Elastic Modulus (Mpa)	74Gpa
Tensile Strength (Mpa)	1800Mpa
Length (mm)	12 mm
Chemical property	**value**
Cao	16.88%
Sio_2	47.56%
MgO	4.63%
Al_2O_3	14.41%

3.6 STEEL SLAG

The physical and chemical properties of Steel slag as Specific gravity, Fineness modulus, Bulk density, Water absorption are shownin table 6.

Table 6. Properties of Steel slag

Physical property	**value**
Specific-gravity	2.68
Fineness modulus	2.9
Bulk density kg/m3	1512kg/m3
Water absorption	3%
Chemical property	**value**
CaO	42.52%
Sio_2	15.12%
MgO	6.17%
Al_2O_3	4.21%
Fe_2O_3	22.52%

3.7 MIX COMPOSITION

Design mix of M40 concrete grade is agreed as per IS 262-2019. Material required for binary concrete with various replacement are shown in table 7

Table 7. Material required for Binary concrete

Mix no.	Mix description GGBS% +STEEL SLAG%+ GLASS FIBER%	Cement Kg/m^3	Glass fiber Kg/m^3	GGBS Kg/m^3	Steel slag Kg/m^3	Fine aggregate Kg/m^3	Coarse aggregate Kg/m^3
CC	0%+0%+0%	450	-	-	-	605	1172
M1	30%+10%+0.5%	315	2.25	135	60.5	544.5	1172
M2	30%+20%+0.5%	315	2.25	135	121	484	1172
M3	30%+30%+0.5%	315	2.25	135	181.5	423.5	1172
M4	30%+40%+0.5%	315	2.25	135	242	363	1172
M5	30%+10%+1%	315	4.5	135	60.5	544.5	1172
M6	30%+20%+1%	315	4.5	135	121	484	1172
M7	30%+30%+1%	315	4.5	135	181.5	423.5	1172
M8	30%+40%+1%	315	4.5	135	242	363	1172

4. RESULTS AND DISCUSSION

The results from Workability, Compressive, Split tensile, and Flexure test are depicted below.

4.1 SLUMP TEST

Fresh concrete is measured by slump cone. The slump cone test was done as per IS: 1199-1959. The targeted slump values for M40 grade design mix was 100mm are displayed in the table 8

Table 8: Slump values

Mix design	Slump test results (mm)
CC	100
M1	98
M2	95
M3	91
M4	88
M5	96
M6	93
M7	89
M8	86

From table 8, Sump test values of M1, M2, M3, M4, M5, M6, M7 and M8 were 98mm, 95mm, 91mm, 88mm, 96mm, 93mm, 89mm and 86mm. As the steel slag and glass fiber percentage increases the slump values were steadily decreases.

4.2 HARDENED PROPERTIES

The concrete strength such as compressive, split tensile and flexure are mechanical properties on hardened concrete are investigated at 3, 7 and 28 days. Compressive, split tensile and flexure strengths of concrete at 3, 7 and 28 days of curing were considered.

4.3 COMPRESSIVE STRENGTH

The test was performed as per IS: 516-2018. The compressive strength test results are in table 9

Table 9: Compressive strength test results for 0.5% and 1% glass fiber

Mix Design	3 Days (Mpa)	7 Days (Mpa)	28 Days (Mpa)
CC	18.63	31.33	48.25
M1	20.52	33.61	50.86
M2	23.12	35.28	53.81
M3	25.34	37.42	56.63
M4	21.35	34.26	50.33
M5	22.32	35.41	52.68
M6	25.44	37.81	55.63
M7	28.54	39.12	58.85
M8	24.12	34.25	53.21

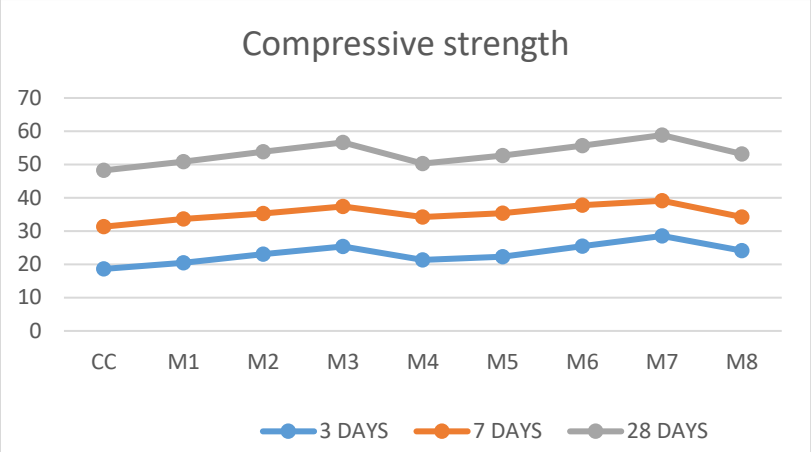

Figure 1. Compressive strength for 3, 7, 28 days

From table 9 and fig.1, Compressive strength of 28 days of M1, M2, M3, M4, M5, M6, M7 and M8 were 50.86Mpa, 53.81Mpa, 56.63Mpa, 50.33Mpa, 52.68Mpa, 55.63Mpa, 58.85Mp and 53.21Mpa. It is observed that all the trail mixes whose compressive strength is tested after 3, 7, 28 days of curing which shows the higher strength at M7 mix with strength as 58.85Mpa and glass fiber content 1%, steel slag content 30% and ground granulated blast furnace slag content 30% when compared with conventional concrete. At the mix M3 the strength values is 56.63Mpa with glass fiber content 0.5% and steel slag content 30%. After 30% of slag replacement the strength values were marginally decreased. The compressive strength was improved by partially replacing cement and fine aggregate with ground granulated blast furnace slag and steel slag. When collate to conventional concrete, glass fiber gained higher strength and the optimum for fiber is at 1%.

4.4 SPLIT TENSILE STRENGTH

The test was performed as per IS: 516-2018. The split tensile strength test results are depicted in table 10

Table 10: Split tensile strength test results for 0.5% and 1% glass fiber

Mix Design	3 Days (Mpa)	7 Days (Mpa)	28 Days (Mpa)
CC	1.85	2.92	3.83
M1	2.31	3.31	4.28
M2	2.83	3.63	4.86
M3	3.21	4.38	5.25
M4	2.65	3.73	4.67
M5	2.68	3.67	4.52
M6	3.13	4.23	5.07
M7	3.68	4.75	5.51
M8	3.17	4.12	5.14

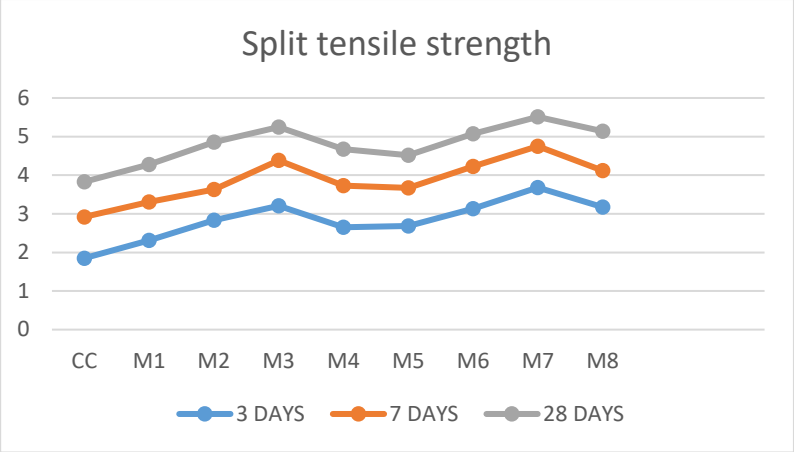

Figure 2. Split tensile strength for 3, 7, 28 days

From table 10 and fig.2, Split tensile strength of 28 days of M1, M2, M3, M4, M5, M6, M7 and M8 were 4.28Mpa, 4.86Mpa, 5.25Mpa, 4.67Mpa, 4.52Mpa, 5.07Mpa, 5.51Mpa and 5.14Mpa. It is observed that all the trail mixes whose split tensile strength is tested after 3, 7, 28 days of curing which shows the higher strength at M7 mix with strength as 5.51Mpa and glass fiber content 1%, steel slag content 30% and ground granulated blast furnace slag content 30% when compared with conventional concrete. At the mix M3 the strength values is 5.25Mpa with glass fiber content 0.5% and steel slag content 30%. After 30% of slag replacement the strength values were decreased. The optimum percentage of concrete is observed in design Mix 7 when compared to other mixes,

4.5 FLEXURE STRENGTH

The test was performed as per IS: 516-2018. The flexure strength test results are shown in table 11

Table 11: Flexure strength test results for 0.5% and 1% glass fiber

Mix Design	3 Days (Mpa)	7 Days (Mpa)	28 Days (Mpa)
CC	2.81	3.85	4.32
M1	3.32	4.28	4.72
M2	3.74	4.51	5.07
M3	4.12	4.82	5.45
M4	3.61	4.38	4.90
M5	3.61	4.43	4.95
M6	4.08	4.86	5.41
M7	4.51	5.06	5.86
M8	4.16	4.75	5.38

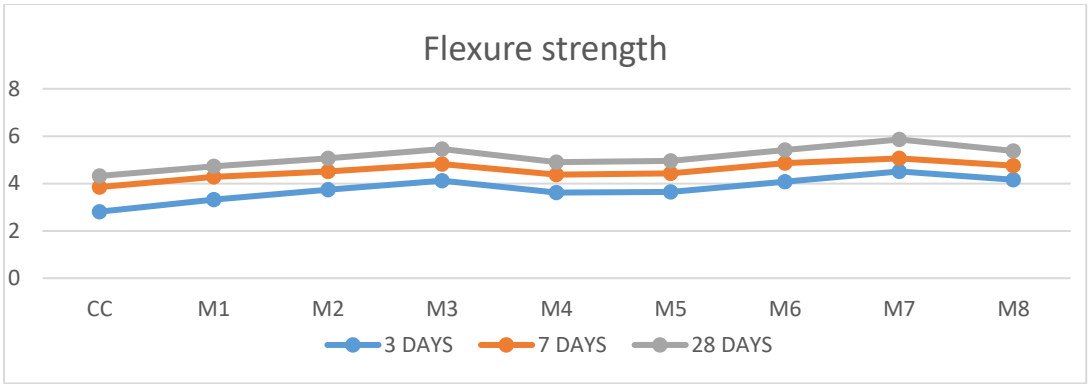

Figure 3. Flexure strength for 3, 7, 28 days

From table 11 and fig.3, Flexure strength of 28 days of M1, M2, M3, M4, M5, M6, M7 and M8 were 4.72Mpa, 4.07Mpa, 5.45Mpa, 4.90Mpa, 4.95Mpa, 5.41Mpa, 5.86Mpa and 5.38Mpa, It is observed that all the trail mixes whose flexure strength is tested after 3, 7, 28 days of curing which shows the higher strength at M7 mix with strength as 5.86Mpa and glass fiber content 1%, steel slag content 30% and ground granulated blast furnace slag content 30% when compared with conventional concrete. At the mix M3 the strength values is 5.45Mpa with glass fiber content 0.75% and steel slag content 30%. After 30% of slag replacement the strength values were gradually decreased. The optimum percentage is Mix M7 mix with glass fiber content 1% when compared to the other mixes.

5. CONCLUSIONS

From the experimental results, the following conclusions were made.

1. The workability is decreased when steel slag and glass fibre percentage increases into the concrete.
2. It is observed that all the trail mixes whose flexure strength is tested after 3, 7, 28 days of curing which shows the higher strength at M7 mix with strength as 5.86Mpa and glass fiber content 1%, steel slag content 30% and ground granulated blast furnace slag content 30% when compared with conventional concrete.
3. It is observed that all the trail mixes whose split tensile strength is tested after 3, 7, 28 days of curing which shows the higher strength at M7 mix with strength as 5.51Mpa and glass fiber content 1%, steel slag content 30% and ground granulated blast furnace slag content 30% when compared with conventional concrete.
4. Beyond 30% of slag replacement the strength values were gradually decreased.
5. Among all mixes, the optimum percentage was at 30% steel slag and 1% of glass fiber.

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