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EXPERIMENTAL STUDIES ON GLASS FIBRE REINFORCED CONCRETE WITH PARTIAL REPLACEMENT OF FINE AGGREGATE BY FOUNDRY SAND

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ABSTRACT

Fibre reinforced concrete used widely for its better performance in aggressive environment. Addition of Glass fibre is increasing confinement and arresting cracks in plain and reinforced concrete. In this work presents experimental studies on Glass fibre reinforced concrete made with used foundry sand as partial replacement of fine aggregate. Specimens were prepared for various replacement proportions of foundry sand of 10% to 30%. To evaluate the mechanical properties of the concrete mixes, Specimens were tested by Compression, spilt-tensile and flexural strength. Test results were indicated a marginal increase in the mechanical properties of plain and Glass fibre reinforced concrete by the inclusion of foundry sand as a partial replacement of fine aggregate. Utilisation of foundry sand in various engineering applications can solve the waste management problem in disposal of foundry sand and other issues.

Keywords: *Glass fibre reinforced concrete, used foundry sand, Partial replacement, Compressive strength, spilt-tensile strength, flexural strength*

I. INTRODUCTION

Concrete is most widely used construction material in the world. Now a days the world is witnessing the construction of more and more challenging and difficult Engineering structures. So, the concrete need to possess very high strength and sufficient workability. Researchers all over the world are developing high performance concrete by adding various fibres, admixtures in different proportions. Various fibres like glass, carbon, Poly propylene and aramid fibres provide improvement in concrete properties like tensile strength, fatigue characteristic, durability, shrinkage, impact, corrosion resistance and serviceability of concrete. Because of such characteristics fibre Reinforced Concrete has found many applications in civil engineering field. The inclusion of fibers in concrete slabs has showed satisfactory performance with improved mechanical properties and reduced early age micro cracking.

Classifications of foundry sand mainly depend upon the type of binder and binder system used in metal casting. Some of the foundry sand which is use for metal casting is green sand and chemically bonded sand. Resin coated sand, cold box sand, hot box sand; CO_2 sands are some common type of chemically bonded sand. (Mould and core test handbook, American Foundry Society ISBN-087433-228-1). Indian foundries deliver roughly 1.71MT of waste foundry sand (WFS) in every year. Foundry sand is high quality silica sand with uniform physical characteristics. It is a by-product of ferrous and nonferrous metal casting industries, where sand has been used for centuries as a moulding material because of its thermal conductivity. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed foundry sand. The physical and chemical characteristics of foundry sand depend on the type of casting process and the industry sector from which it originates. In modern foundry practice, sand is typically recycled and reused through many production cycles.

II. LITERATURE SURVEY

G. Ganesh Prabhu et al (2014) investigated the properties like including density, slump cone, split tensile strength, flexural strength; ultrasonic pulse velocity (UPV) and compressive strength tests were performed to understand the effects of FS on the behavior of concrete. And concluded that a substitution rate of up to 20% can be effectively used in good concrete production without affecting the concrete standards, and a substitution rate beyond 20% is not beneficial.

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Gurdeep Kaur et al. (2013) investigated the micro-structural and metal analysis of fungal treated leachate obtained from concrete made with various percentages of WFS (0%, 10%, 15% and 20%). Results show the reduction in the metal concentration in leachate obtained from fungal treated concrete. In fungus treated WFS (10%) containing concrete, the metal con-centration in Cd, Cr, Fe, Mo, Mn, Ni and Pb were reduced to significant levels. Microstructural analysis confirms the improvement of concrete by inclusion of fungal treated WFS in concrete due to the formation of calcium rich bio mineral in the pores of concrete.

Navarro-Blasco et al. (2013) investigated the effect of the incorporation of a polymeric admixture – a chitosan derivative – was also explored. Leaching studies on hardened mortars of three tar-get pollutants of the WFS (toxic metals Pb, Cr and Zn) were also done to evaluate their immobilization. By comparison with OPC mortars, the use of CAC showed several advantages, improving the compressive strength and the toxic metal retention.

Deshmukh S.H et al (2012) observed from the experimental results and its analysis, that the compressive strength of concrete, flexural strength of concrete, splitting tensile of concrete increases with addition of percentage of glass fibres. The 0.1% addition of glass fibres into the concrete shows better results in mechanical properties and durability.

H. MerveBasar et al. (2012) investigated the potential re-use of waste foundry sand (WFS) in ready-mixed concrete (RMC) production. Regular sand was replaced with five percentages (0%, 10%, 20% , 30% ,40%) of WFS by weight and solidification/stabilization(S/S) process was applied to all concrete mixtures. Nevertheless, the concrete having 20% WFS exhibited almost similar results with the control one. Leach-ability characteristics of the entire concrete specimens at different pH conditions representing variant natural cases were also observed.

The main aim of this present investigation is to study the effect of used foundry sand as replacement of fine aggregates in various percentages and adding Glass fibres in concrete. Fresh concrete properties and hard concrete properties are investigated such as Compressive strength, Split-tensile and strength Flexural strength at 28 days.

III. METHOD & MATERIAL

A) MATERIALS

The cement used was Ordinary Portland Cement 53 grade. It was tested as per the Indian Standard Specifications BIS: 12269-1987. Properties of the cement are tested according to IS given in Table 1. Waste foundry sand was obtained from a Metal casting industry, Madurai. Fine aggregate was natural sand having a 4.75 mm nominal size and confirming zone II. The coarse aggregate used in this investigation was 12.5 mm nominal size. Both aggregates and waste foundry sand were tested according to BIS: 383-1970. A thin and short fibre will only be effective the first hours after pouring the concrete. Their physical properties are given in Tables 3.

Table 1: Properties of Cement

S.NO	Properties of Cement	
1	Compressive strength	53 Mpa
2	Specific gravity	3.15
3	Standard consistency	31%
4	Initial setting time	30 Minutes

Table 2: Properties of Fine and Coarse Aggregate

S.No	Properties	FA	UFS	CA
1.	Size	4.75	4.75	12.5
2.	Bulk density	1721	1524	1650
3.	Fineness modulus	2.8	2.21	6.8
4.	Specific gravity	2.55	1.85	2.70

Table 3: Properties of Glass Fibre

S.No	Properties	
1	Type	E Glass fibre
2	Length (mm)	6

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3	Tensile strength	3.5
4	Modulus (Gpa)	73.5
5	Density (kg/m^3)	2720

B) MIXTURE PROPORTIONS

Four concrete mixture proportions were made. First was the control mix (without UFS) and the other three mixtures contained UFS. Fine aggregate (regular sand) was replaced with UFS by weight. The FS used in this study was washed by fresh water more than four times to remove ash and clay particles. The proportions of fine aggregate replaced were 10%, 20% and 30%. Mixture proportions are given in Table 4. The control mixture without UFS was proportioned as per the Indian Standard 10262-2007 to have a 28 day cube compressive strength of 37.53 MPa. Concrete mixes were made in power driven revolving-type drum mixers of capacity 1 m^3.

Table 4: Mixture proportions in kg/m^3

Mix designation/ Materials	M1	M2	M3	M4
Cement	413	413	413	413
Fine aggregate	706	635	493	423
Coarse aggregate	1117	1117	1117	1117
Foundry sand	0	71	142	212
Water	186	186	186	186
W/C	0.45	0.45	0.45	0.45

IV. RESULTS & DISCUSSIONS

4.1 COMPRESSIVE STRENGTH

150 mm concrete cubes were cast using 1:1.5:2.61 mix proportion with w/c ratio of 0.45. Specimens were prepared with OPC (control) and fine aggregate replaced by foundry sand at various percentages like 10%, 20% and 30% and also adding 0.5% of glass fibre. During moulding, the cubes were mechanically vibrated. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28 days. After curing, the specimens were tested for compressive strength using a compression testing machine (CTM) having capacity 2000 KN. The concrete cubes were tested accordance with the IS standards at the 7, 14 and 28 days. Concrete mixtures containing Glass fibre and Foundry sand shows higher strength than control mix. Compressive strength results are shown in the fig 1 and Table 5. At the age of 28 days strength was increased up to 7.36%, 16.28% and 27.15% when compared to control mix. In Fig 1, it is found that increasing replacement percentage of UFS shows gradual increasing of compressive strength when compared to control mix.

Table 5: Average Compressive and Splitting tensile Strength in MPa at various ages

Mix Designation	Compressive Strength			Splitting tensile Strength		
	7 Days	14 Days	28 Days	7 Days	14 Days	28 Days
M1	28.31	34.74	37.53	1.93	2.43	2.82
M2	31.34	37.32	40.28	2.02	2.64	3.13
M3	34.65	39.44	43.64	2.37	2.61	3.35
M4	36.24	40.53	47.72	2.63	3.14	3.52

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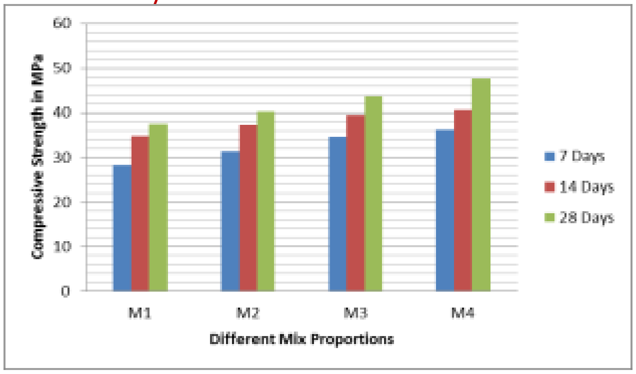

Fig 1: Compressive Strength of Concrete at 28 Days

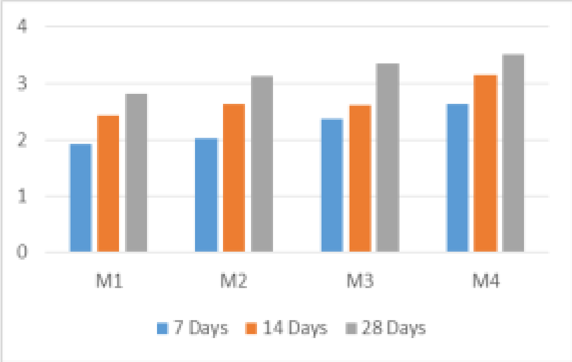

Fig 2: Split tensile Strength of Concrete at 28 Days

4.2 SPLIT TENSILE STRENGTH

Standard cylinder moulds of size (100mm x 300mm) were cast for spilt tensile strength. In this test compressive line loads were applied along a vertical symmetrical plane, which causes splitting of specimen. The tests were carried out on three specimens and average spilt-tensile strength values were obtained as per BIS: 5816-1999. The splitting tensile strength of concrete mixtures was found out at the age of 28 days. The results of splitting tensile strength are shown in Table 5 and Fig. 2. Increase in UFS content led to an increase in splitting tensile strength when compared to Control Mix. The percentage increase in strength at 28 days compared to Control Mix was 10.99%, 16.24% and 24.82% respectively. In this test showed better results when compared with Control Concrete mix.

4.3 FLEXURAL STRENGTH TEST FOR PCC AND RCC BEAMS

4.3.1 FLEXURAL STRENGTH FOR PCC BEAMS

The specimens were tested under two point loading. Standard beam moulds of size 100 mm x 100 mm x 500 mm were cast for the preparation of concrete specimens for flexural strength. A table vibrator was used for compaction of hand filled concrete beams. The specimens were demoulded after 24 hours and subsequently immersed in water for 28 days. For each age three specimens were used for the determination of average flexural strength. The Flexural strength of the concrete measured at the age of 28 days and the strength values are listed in Table 6 and Fig 5. Flexural strength of concrete mixtures increased with the increase in foundry sand content by adding glass fibre. The flexural strength was increased up to 12.1%, 21.65% and 34.39% when compared to Concrete mix.

4.3.2 TWO POINT LOAD SETUP FOR RCC BEAMS

Two point loading system was adopted for the tests. The beams were mounted over two pedestals and the concentrated loads were applied by means of 40 Tonnes Universal Testing machine (UTM). Deflections measured by using linear voltage displacement transducers (LVDTs) and were kept at mid-span as well under the loading points. The load at which the concrete has started to rupture, the failure load of the specimens and also the nature of failure modes were noted for each beam. The experimental setup and reinforcement details for a RCC Beams are shown in Fig 3 and Fig 4.

Fig 3: Two point loading for RC beams

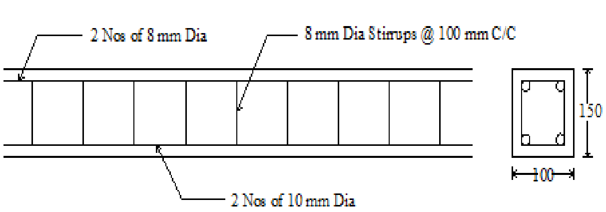

Fig 4: Reinforcement details for a RCC Beam

The ultimate load carrying capacity of the R.C.C beams under flexural loading is relatively increased with increasing the various percentages of R.C.C members. The flexural strength of beam is calculated by the equation,
Flexural strength (N/mm^2 or MPa) = (P x L) / (b x d^2),
Where, P = Failure load, L = Centre to center distance between the support = 1500 mm
b = width of specimen=100 mm d = depth of specimen= 150 mm

Figure 5 shows the comparison of the load deflection behavior of various percentages of foundry sand in R.C.C R.C.C beams. It can be understand that the ultimate load was increased by replacing various percentages of foundry sand. The flexural strength of RCC beams was increased up to 15.3%, 24.94% and 33.17% when compared to Concrete mix. Their results of flexural strength for RCC and PCC beams are shown in Table 6 and Fig. 5.

Table 6: Average flexural strength (N/mm^2) at 28 days

Mix designation	PCC	RCC
M1	3.14	8.5
M2	3.52	9.8
M3	3.82	10.62
M4	4.22	11.73

4.3.3 Load-Deflection Behaviour

Fig 6 shows the Load deflection behaviour of control specimen and other mixtures in which the sand content is replaced by 30% foundry sand and also addition fibres improves the ductile mode of the beam. It controls the mid-span deflection and also increasing the load carrying capacity compared to that of control beam.

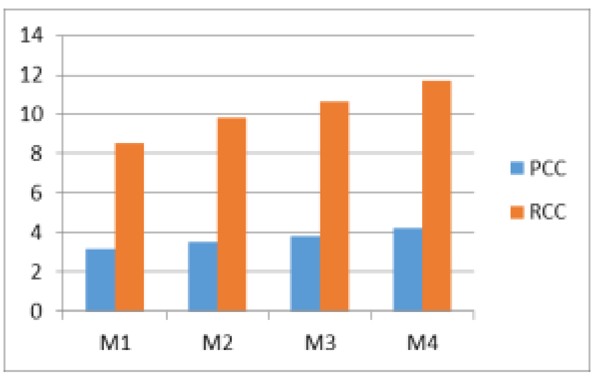

Figure 5: Flexural strength for R.C.C beams

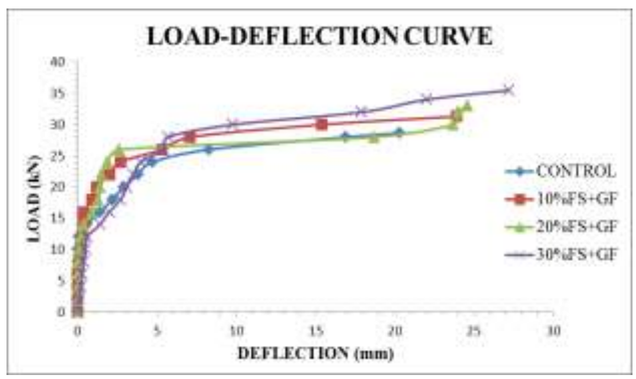

Figure 6: Comparative load-deflection curve

V. CONCLUSION

From this study the following conclusions can be drawn:

1. Compressive strength, splitting-tensile strength and flexural strength test results of concrete mixtures was increased with foundry sand and glass fibre.
2. At the age of 28 days sand content is replaced by 30% foundry sand and addition fibres shows compressive, spilt tensile, flexural strength was increased up to 27.15%, 24.82%, and 33.17% when compared to the control mix.
3. Waste foundry sand can be successfully used in making great quality ready-mix concrete as partial supplanting of fine aggregate
4. Environmental effects from wastes and disposal problems of waste can be reduced through this research.
5. A better measure by an innovative Construction Material is formed through this research.

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