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Influence of Addition of Micro Silica on Strength Properties of Basalt Fiber Reinforced Multi Blended Concrete

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Abstract*: In recent years, the development of multi blended mix concrete has gained attention due to its multiple advantages and environmental friendliness. This paper has attempted to examine mechanical properties of Multi blended concrete of M30 grade made with micro silica and basalt fibers. To reduce the deleterious effects of the production of cement on the environment, concrete is being developed by substituting admixtures like GGBS and Fly Ash in place of cement. Multi blended concrete developed with Fly ash and GGBS showed depletion in the mechanical properties. Micro silica & Basalt fibers were added to this mix additionally to overcome this deficiency. Initially four series of mixes of multi blended concrete were developed with a composition of Fly ash 20% and GGBS 30%, 40%, 50% & 60% as replacement of cement. For better performance, micro silica at 5% by weight of cement and Basalt fibers at 0.2% by volume of concrete were added. The mechanical properties such as Split tensile & Compressive strengths were studied at the age of 7 & 28 days. The results showed that M30 grade multi blended concrete can be achieved with 30% GGBS, 20% fly ash, 5% micro silica, 0.2% basalt fibers.

Keywords: Multi blended concrete, Fly ash, GGBS, Micro silica, Basalt fibers, Split tensile & compressive strengths.

I. INTRODUCTION

Concrete made with cement was commonly used material for construction purpose. In development of cement, bulk amount of CO2 is emitted into the atmosphere, causes environmental pollution. The viable solution to this problem is substituting cement with Ground Granulated Blast Furnace Slag (GGBS), Fly Ash (F), Micro silica (S) & Meta kaolin. The fibres are used for concrete to overcome certain deficiencies. The most common fibers are steel, glass, polypropylene, basalt and carbon fibers.

The workability of ternary mixes with Fly ash & GGBS was greater than that of parent concrete and it increased by increasing the percentage of mineral admixtures. The workability of binary mixes containing higher percentage substitution with Fly Ash & GGBS was lower and higher respectively. Improvement of properties can be observed for mixes designed appropriately [1]. Long term compressive strength of both F and GGBS mixes can be improved by addition of 7.5% of Silica Fume(SF), however the mix with SF & F show more recovery in compressive strength than GGBS and SF mix [2]. Addition of 0.1% of basalt fibers (by volume of concrete) showed increment in compressive strength [3]. Addition of varied percentage of fibres made with steel to the optimum percentage of SF showed the extreme augmentation of compressive & split tensile strengths as 13.4% & 30% respectively [4]. The nano silica with 1.2% as replacement of cement and 3 kg/m3 basalt fibers dosages in concrete developed the better compactness of concrete microstructure, showed Compressive and Split tensile strengths approximately 10% and 18% higher [5]. Increase in the percentage replacement of cement with Fly Ash & GGBS lead to separation of materials. A small increase in compressive strength was shown in concrete with Fly ash at 20% and in SCC mixes with 15% of SF [6].

Application of 10% wt. of SF with FA at 20 % showed the increase in the compressive strength at early ages when compared with concrete made with F [7]. Addition of basalt fibers to concrete made with Fly ash showed the significant increase in compressive strength at early and later ages with maximum increase at 0.15% volume fraction of basalt fiber [8].Incorporation of Basalt fibers to high strength concrete resulted in improved properties compared to the Glass fibers [9].Mechanical performance of concrete prepared with Basalt Fiber showed improvement than that of Polypropylene fiber concrete. Concrete reinforced with Basalt Fiber exhibited high flexural and tensile strength. The compressive strength of Basalt fiber concrete increased at initial age decreased at the long term age [10]. Incorporation of slag up to 60% in concrete increases compressive and splitting tensile strengths at long term curing ages [11]. The SF & F based multi blended concrete mixes show substantial development in strength compared with binary blends and parent concrete [12].

The usage of mineral admixtures (GGBS, F, S) into concrete mix contributes to sustainable development. To date very few studies have been taken up on the usage of the combination of F, GGBS & S. Hence in this paper the authors inspected the mechanical properties of Basalt fiber reinforced concrete (BFRC) with partial replacement of cement by Fly Ash (20%), GGBS (30-60%) and the addition of micro silica.

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II. TEST PROGRAMME

A. Materials

OPC 53 Grade Cement confirming to IS: 12269-1987 was used. The cementitious materials such as Fly Ash, GGBS & Micro silica were used. Physical properties and chemical compositions for OPC and the cementitious materials were presented in Tables 1 and 2. Sand confirming to Zone- II, obtained from river Godavari and gravel obtained locally from Visakhapatnam were used as fine & coarse aggregates. Properties of both Fine & Coarse aggregates were tabulated in Table 3. 12mm long, 13 microns diameter of Basalt fibers and Conplast SP 430 super plasticizer were used. Basalt fibers properties were tabulated in Table 4.

Table-1 Physical Properties of OPC & Cementitious Materials

Physical properties	OPC	Fly ash (F)	GGBS (G)	Micro Silica(S)
Specific Gravity	3.14	2.32	2.92	2.352
Fineness Modulus (% retained on 45 µm sieve)	7% (90µm)	33.7	23.5	5

Table-2 Chemical Composition of OPC & Mineral Admixtures

Materials (%)	SiO	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3
OPC	21.04	6.02	3.77	62.93	2.49	1.72
Fly ash	58.8	31.3	3.9	4.3	0.2	0.27
GGBS	34.5	21.5	0.2	33.2	9.5	0.66
Micro silica	90	0.4	0.4	1.6	0.1	0.2

Table-3 Physical Properties of Fine & Coarse aggregate

Aggregate type		Density kg/m^3	Fineness Modulus	Water Absorption (%)	Specific gravity
Fine aggregate		1567	2.58	0.783	2.73
Coarse aggregate	20mm	1537	6.71	0.46	2.98
	12.5mm	1568	6.28	0.226	2.52

Table 4 Properties of Basalt Fibers

Properties	Values
Density(g/cm^3)	2.75
Filament diameter (microns)	15
Tensile strength (MPa)	4800
Elastic modulus (GPa)	94
Elongation at break (%)	3.1

B. Experimental program

Methodology

The Conventional concrete of M30 grade was designed by using IS: 10262 2000 (34) with water binder ratio of 0.4. A set with four multi blended concrete mixes were prepared by substituting cement with Fly ash (20%) and GGBS (30%, 40%, 50% & 60%) in the above conventional concrete. Another set of four multi blended concrete mixes were prepared by adding combination of micro silica at 5% and 0.2% of basalt fibers .The Composition of multi blended BFRC mixes were presented in table-5.

Test program

The Conplast SP 430 of sufficient dosage was added for maintaining the essential workability ranged from 50-75 mm for all mixes. A total of 108 samples were prepared to test compressive & split tensile strength of multi blended BFRC mixes at 7 and 28 days as per IS: 516-1959 (22) and IS: 5816-1999 (23) respectively.

III. RESULTS AND DISCUSSIONS

A. Compressive Strength

Figs- 1 & 2 depicts the variation of 7 & 28 day compressive strength of Fly Ash & GGBS based multi blended concrete mixes without and with Micro silica & Basalt fibers.

Compressive strength of Fly ash & GGBS based multi blended concrete mixes without and with Micro silica & Basalt fibers was reduced with the increase in percentage of GGBS at 7day. None of the multi blended concrete mixes exhibited compressive strength equal to conventional concrete. The 7 days compressive strength of conventional concrete was 26.69 N/mm2, whereas it was ranged from 20.96 - 12.35 N/mm2 and 24.19 - 13.67 N/mm2 for multi blended concrete mixes with out and with micro silica and basalt fiber respectively. The incomplete pozzolanic reaction of cementitious materials causes the delay in the strength development. Multi blended concrete with micro silica & basalt fiber at 30% GGBS exhibited the least reduction in compressive strength compared to conventional concrete.

It can be observed from Fig-2 that the compressive strength of Fly ash & GGBS based multi blended concrete mixes without and with Micro silica & Basalt fibers reduced with the increase in percentage of GGBS at 28 days except with slight increase at 30% of GGBS. The multi blended concrete with micro silica & basalt fiber exhibited the target strength of 30 grade at 30% of GGBS. This enhancement in compressive strength may be attributed to the addition of 5% Micro silica.

Table- 5: Composition of BFRC mixes - C –OPC, F- Fly ash, G - GGBS, S – Micro silica, B- Basalt fibers

Mix designation	Cement kg/m^3	Fly ash kg/m^3	GGBS kg/m^3	Micro silica kg/m^3	Basalt fiber % by vol.	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Water kg/m	W/ b ratio
C100	380	-	-	-	-	712	1275	152	0.4
C50F20G30 S5B0.2	190	76	114	19	0.2	712	1275	152	0.4
C40F20G40 S5B0.2	152	76	152	19	0.2	712	1275	152	0.4
C30F20G50 S5B0.2	114	76	190	19	0.2	712	1275	152	0.4
C20F20G60 S5B0.2	76	76	228	19	0.2	712	1275	152	0.4

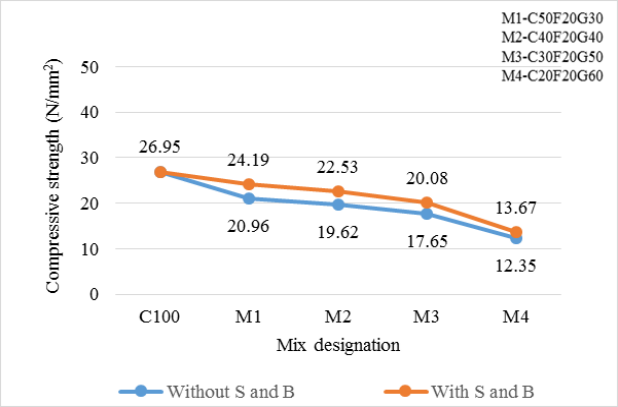

Fig-1: 7 day Compressive strength of multi blended concrete without and with micro silica & basalt fibers.

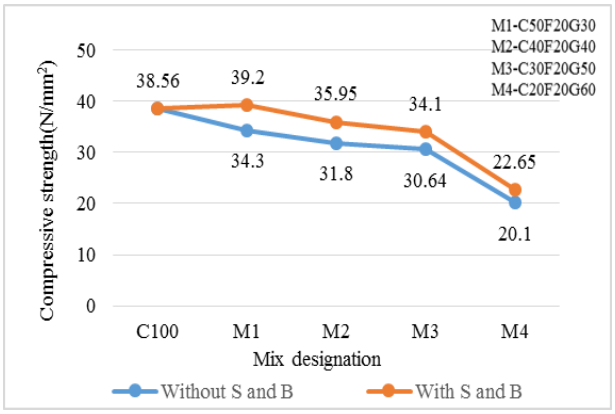

Fig-2: 28 day Compressive strength of multi blended concrete without and with micro silica & basalt fibers.

B. Split Tensile Strength

Fig-3 & 4 showed the variation in Split tensile strength of Fly Ash & GGBS based multi blended concrete mixes without and with Micro silica & Basalt fibers at 7 and 28days.

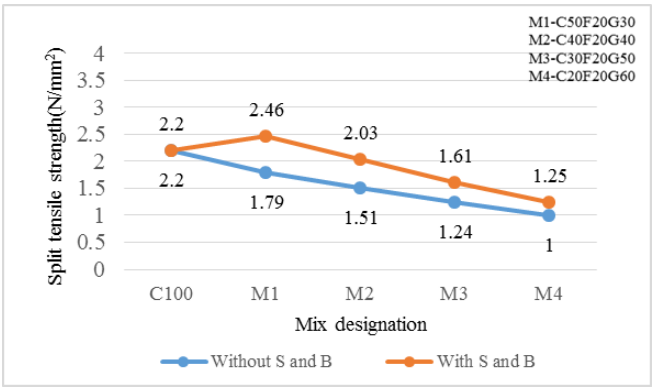

Fig-3: 7 day Split Tensile Strength of multi blended concrete without and with micro silica & basalt fibers

The 7 day split tensile strength of Fly ash & GGBS based multi blended concrete mixes without and with Micro silica & Basalt fibers reduced with increase in percentage of GGBS except at 30% . The Split tensile strength of conventional concrete was found to be 2.2 N/mm2, whereas it was ranged from 1.79 - 1.0 N/mm2 and 2.46 - 1.25 N/mm2 for multi blended concrete mixes with out and with micro silica and basalt fiber respectively. The multi blended concrete without micro silica & basalt fiber at 30% GGBS showed the least reduction in split tensile strength and enhanced to 12% by addition of micro silica and basalt fibers compared to conventional concrete.

It was observed from Fig.4 that the 28 days split tensile strength of Fly ash & GGBS based multi blended concrete mixes without and with Micro silica & Basalt fibers exhibited the similar trend as that of 7 days split tensile strength. The increase in percentage of GGBS decreased the strength except at 30%. The multi blended

BFRC showed a better performance than that of multi blended concrete without fibers. An increase in the split tensile strength was observed at 30% GGBS in BFRC with silica. This enhanced split tensile strength may be

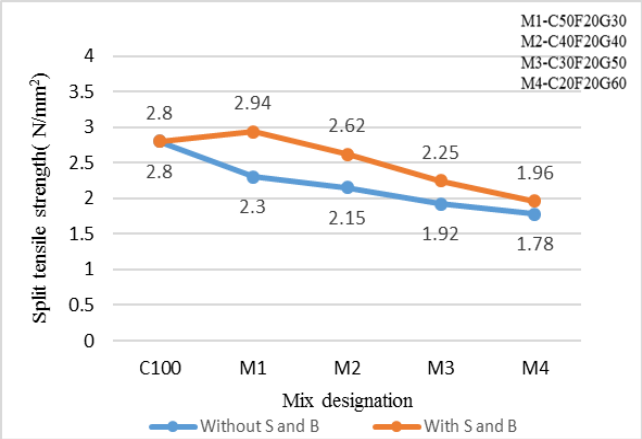

Fig-4: 28 day Split Tensile Strength of multi blended concrete without and with micro silica, basalt fibers

attributed to the presence of basalt fibers. Multi blended concrete with micro silica & basalt fiber exhibited almost the same strength as that of conventional concrete at 30% of GGBS.

IV. CONCLUSIONS

- This paper is aimed to study the influence of addition of Micro silica on strength properties of basalt fiber reinforced concrete mixes. Based on the discussions of the experimental results, it can be summarized that
- The split tensile & compressive strengths of Fly Ash & GGBS based multi blended concrete with micro silica and basalt fibers were improved when compared with multi blended concrete without micro silica and basalt fibers.
- Compressive strength of Fly ash & GGBS based multi blended concrete with and without micro silica and basalt fibers decreased with the increase in percentage of GGBS at 7 days. It followed the similar trend at 28 days except at 30% GGBS with Micro silica and basalt fibers.
- The addition of 5% micro silica helped in attaining target strength of 30 grade at 30% of GGBS.
- Split tensile strength of Fly ash & GGBS based multi blended concrete mixes without and with Micro silica & Basalt fibers exhibited the similar trend with reduction with the increase in percentage of GGBS except at 30% of GGBS.
- The Basalt Fiber reinforced multi blended concrete almost the same split strength as that of conventional concrete at 30% of GGBS.
- Impact of addition of cementitious materials on mechanical properties is significant. Concrete with required grade can be achieved with the judicial use of these materials in suitable proportions. The 30 grade concrete can be developed with the use of 20% Fly ash, 30% GGBS as replacement, 5% Micro silica as addition and 0.2% of basalt fibers.

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