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STRENGTH AND DURAILITY STUDIES ON HYBRID FIBRE REINFORCED CONCRETE USING FOUNDRY SAND

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ABSTRACT:

Self-compacting concrete, also referred to as Self-consolidating concrete can flow and consolidate under its own self weight and de-aerated almost completely while flowing in the formwork. SCC was first introduced in the late 1980's by Japanese researchers and its highly workable concrete that can flow under its own weight through restricted sections without segregation and bleeding. Such concrete should have a relatively low yield value to ensure high flow ability, a moderate viscosity to resist segregation and bleeding and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long term durability. Foundry sand is high quality uniform silica sand that is used to make moulds and cores for ferrous and non ferrous metal castings. Foundry sand is a by product of the castings industry typically comprising uniformly sized sands with various additives and metals associated with the specific casting process. The hybrid combination of metallic and non-metallic fibres can offer potential advantages in improving concrete properties as well as reducing the overall cost of concrete production.

1.1 INTRODUCTION

Self-compacting concrete can save manpower, eliminate consolidation noise and lead to innovative construction methods. It has been used in Japan for the construction of bridge girders, towers, piers, LNG tanks, culverts and building structures. Precast concrete plants are using self-compacting concrete in manufacturing, where it elimin ates the need for vibrating machines and their associated noise. Since self-compatibility is largely affected by the characteristics of materials and the mix proportions, it becomes necessary to evolve a procedure for mix design of SCC. In this system, the coarse aggregate and fine aggregate contents are fixed and self-compatibility is to be achieved by adjusting the water/powder ratio and super plasticizer dosage. The coarse aggregate content in concrete is generally fixed at 40% of the total solid volume, the fine aggregate content is fixed at 60% of the mortar volume and the water/powder ratio is assumed to be 0.9 to 1 by volume depending on the properties of the powder and the super plasticizer dosage. Foundry sand is high quality uniform silica sand that is used to make moulds and cores for ferrous and non ferrous metal castings. Foundry sand is a by product of the castings industry typically comprising uniformly sized sands with various additives and metals associated with the specific casting process. A composite is termed as hybrid, if two or more types of fibers are rationally combined to produce a composite that derives benefits from each of the individual fibres and exhibits a synergetic response. Reinforcement of concrete with a single type of fibre may improve the properties to a limited level. However by using the concept of hybridization with two or more different types of fibers incorporated in a common

cement matrix, the hybrid composite can offer more attractive engineering properties because the presence of one fibre enables the more efficient utilization of the potential properties of the other fibre. The hybrid combination of metallic and non- metallic fibres can offer potential advantages in improving concrete properties as well as reducing the overall cost of concrete production.

1.2 OBJECTIVE

- The aim of this study is to investigate the effect of replacing of fine aggregate by foundry sand and adding hybrid fibres in various proportions to evaluate the performance of these replacement materials on the strength of specimens.

- To develop a Hybrid fibre Reinforced Concrete with the addition of polypropylene (PP) and glass fiber (GF).

- Comparison of result on various percentages using bar chart.

2 MATERIALS

2.1 CEMENT

Cement is the most important ingredient in concrete. Ordinary Portland cement (53 grade) conforming to IS: 1489 (Part 1) 1991 was used for casting all the specimens. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strength at early ages can be considerably influenced by the particular cement used.

FIG. 2.1 ORDINARY PORTLAND CEMENT 53 GRADE

2.2 FINE AGGREGATE

Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm sieve will be used for casting all the specimens.

2.2.1 FOUNDRY SAND

Foundry sand is high quality uniform silica sand that is used to make moulds and cores for ferrous and non-ferrous metals castings. Foundry sand is a bi-product of the casting industry typically comprising uniformly sized sands with various additives and metals associated with the specific casting process. Sand passing through IS 4.75 mm sieve was used for casting all the specimens. Fine aggregate used are confirming to IS 383-1970.

2.3 COARSE AGGREGATE

For making SCC maximum size of aggregate is 12.5mm. The aggregate used is sound free from deleterious materials and hacking crushing strength, at least 1.5 times that of concrete. Crushed stone angular shaped aggregate is used. Ordinary blue granite crushed stone aggregate confirming to IS: 383-1970 was used as a coarse aggregate in concrete.

2.4 WATER

Water is an important ingredient of concrete as it actively participates in chemical reactions with cement to form the hydration products, calcium-silicate-hydrate (C-S-H) gel. The strength of the cement concrete depends mainly from the binding action of the hydrate cement paste gel. Water confirming to the requirements of IS: 456-2000, is found to be suitable for making concrete. It is generally stated that the water used for drinking is fit for making concrete. In this present study, casting and curing of specimens were done with the potable water, i.e., available in the college premises.

2.5 SUPER PLASTICIZERS GLENIUM B233

The hyper plasticizer shall be Glenium B233, high range water reducing, super plasticizer based on polycarboxylic ether formulation. The product shall have specific gravity of 1.09 and solid contents not less than 30% by weight. Optimum dosage of Glenium B233 should be determined with trial mixes. As a guide, a dosage range of 500ml to 1500ml per 100kg of cementitious material is normally recommended.

Fig : 2.2 Glenium B233

3. PROPERTIES OF MATERIALS

Table 3.1 Chemical constituents of cement

S. No.	CONSTITUENTS	SYMBOL	PERCENTAGE
1	Tricalcium aluminate (CaO)3 · Al2O3	C3A	0 – 13%
2	Tricalcium silicate (CaO)3 · SiO2	C3S	45 – 75%
3	Dicalcium silicate (CaO)2 · SiO2	C2S	7 – 32%
4	Tetracalciumaluminoferrite (CaO)4 · Al2O3 · Fe2O3	C4AF	0 – 18%

Table 3.2 Physical Properties of Cement

S.No	PROPERTIES	VALUES
1	Specific Gravity	3.15
2	Bulk Density	1440 Kg/m^3
3	Surface area	225 m^2/Kg
4	Initial setting time	30 min
5	Final setting time	600 min

TABLE 3.3 CHEMICAL PROPERTIES OF FOUNDARY SAND

NAME OF THE COMPOUND	COMPOSITION LEVEL
Silica (SiO_2)	87.91%
Alumina (Al_2O_3)	4.7%
Potassium (K_2O)	0.25%
Calcium (Cao)	0.14%
Iron (Fe_2O_3)	0.94%
Sodium (Na_2O)	0.19%
Magnesium (MgO)	0.30%
Loss on Ignition (H_2O)	5.15%

TABLE 3.3 TYPICAL RANGE OF SCC CONSTITUENTS SUGGESTED BY EFNARC

CONSTITUENT	TYPICAL RANGE BY MASS (kg/m^3)	TYPICAL RANGE BY VOLUME (lit/m^3)
Powder	380-600	
Paste		300-380
Water	150-210	150-210
Coarse aggregate	750-1000	270-360
Fine aggregate (sand)	Content balances the volume of the other constituents, typically 48%-55% of total aggregate weight.	
Water/powder ratio by volume		0.85-1.10

4 MIX PROPORTIONS

TABLE 4.1 DETAILED MIX PROPORTION

CEMENT (kg/m^3)	F.A (kg/m^3)	SAND RE-PLACEMENT (kg/m^3)	C.A (kg/m^3)	w/b (lit/m^3)	SP (% by weight of concrete)
500	900	0	600	0.4	2
500	765	135	600	0.4	2
500	765	135	600	0.4	2
500	765	135	600	0.4	2
500	765	135	600	0.4	2

FA- Fine Aggregate; CA- Coarse Aggregate; SP- Superplasticizer

5 .RESULTS AND DISCUSSIONS

5.1 GENERAL

In this chapter the test results of Marsh cone test, workability and strength studies are discussed and its influence on various constituents of SCC. And deals with the result and discussions of the experimental investigation carried out to study the mechanical properties of hybrid concrete. The basic strength properties namely compressive strength, split tensile strength and flexural strength were studied

5.1.1 COMPRESSIVE STRENGTH TEST

TABLE 5.1 MARSH CONE TEST RESULTS WITH DIFFERENT SUPER PLASTICIZER

SP% BY CEMENT	TIME IN SEC (T) SP1	TIME IN SEC (T) SP2
0.1	168	175
0.3	77.30	83
0.5	50.38	58.23
0.7	38.54	47.12
0.8	38.57	41.03
0.9	38.61	40.67
1	39.31	**39.96**

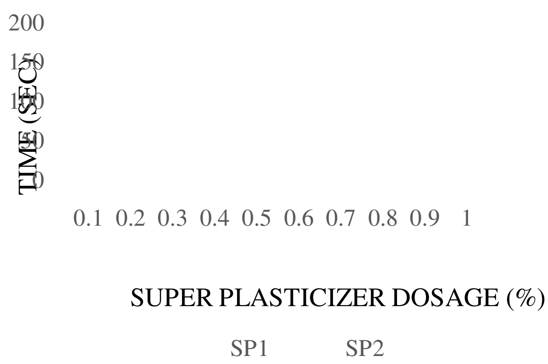


FIG. 5.1 TIME vs SUPER PLASTICIZER DOSAGE

6.1 WORKABILITY STUDIES

6.1.1 V-FUNNEL TEST

TABLE 6.1 V-FUNNEL VALUES FOR MIXES

SL. NO.	MIX PROPORTIONS	TIMINGS IN SEC
1	SCC-0	12
2	SCC-1	11
3	SCC-2	10.5
4	SCC-3	11.5

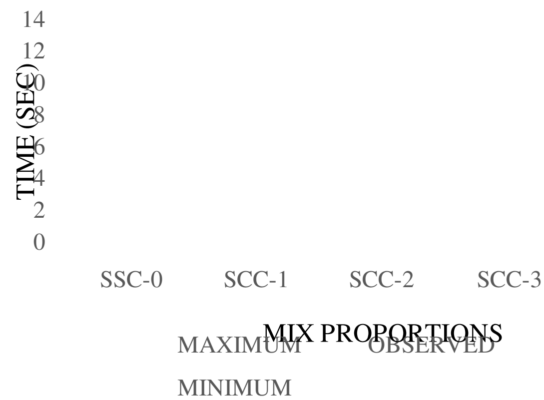
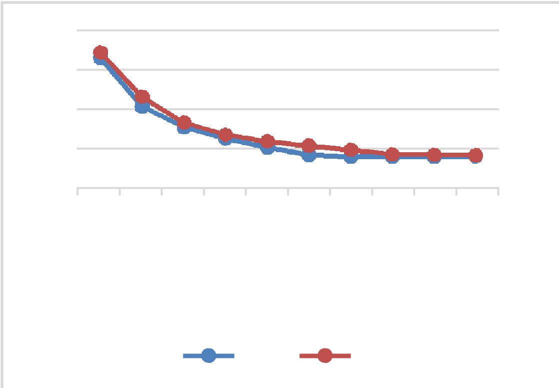


FIG. 6.1 V-FUNNEL VALUES vs MIX PROPORTIONS

6.1.2 L-BOX TEST

TABLE 6.2 L-BOX HEIGHT RATIO (H_2/H_1) FOR MIX PROPORTIONS

SL. NO.	MIX PROPORTION	H_2/H_1
1	SSC-0	0.920
2	SCC-1	0.900
3	SCC-2	0.950
4	SCC-3	0.939



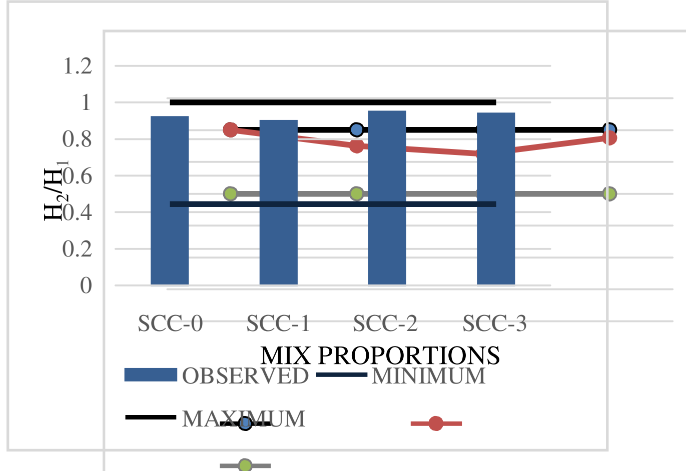


FIG. 6.2 L-BOX HEIGHT RATIO (H_2/H_1) FOR MIX PROPORTIONS

6.1.3 U-BOX TEST

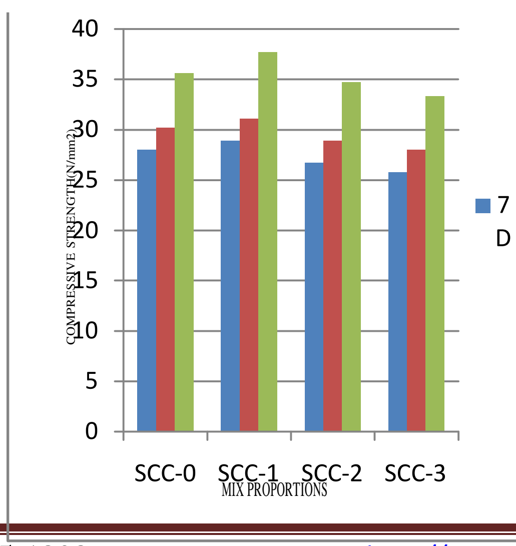
TABLE 6.3 U-BOX DIFFERENCE (H_2/H_1) FOR MIX PROPORTIONS

SL. NO.	MIX PROPORTIONS	H_2/H_1
1	SCC-0	28
2	SCC-1	21
3	SCC-2	20
4	SCC-3	22

6.2 COMPRESSIVE STRENGTH TEST

TABLE 6.4 COMPRESSIVE STRENGTH RESULTS

SL. NO.	MIX PROPORTIONS	COMPRESSIVE STRENGTH		
		7-DAYS	14-DAYS	28-DAYS
1	SCC-0	28	30.2	35.6
2	SCC-1	28.9	31.1	37.8
3	SCC-2	26.7	28.9	34.7
4	SCC-3	25.8	28	33.3



6.3SPLIT TENSILE TEST

TABLE 6.5 SPLIT TENSILE STRENGTH RESULTS

SL. NO.	MIX PROPORTIONS	SPLIT TENSILE STRENGTH		
		7-DAYS	14-DAYS	28-DAYS
1	SCC-0	2.33	3.18	4.6
2	SCC-1	2.55	3.61	4.8
3	SCC-2	2.02	2.9	4.35
4	SCC-3	1.91	2.86	4.14

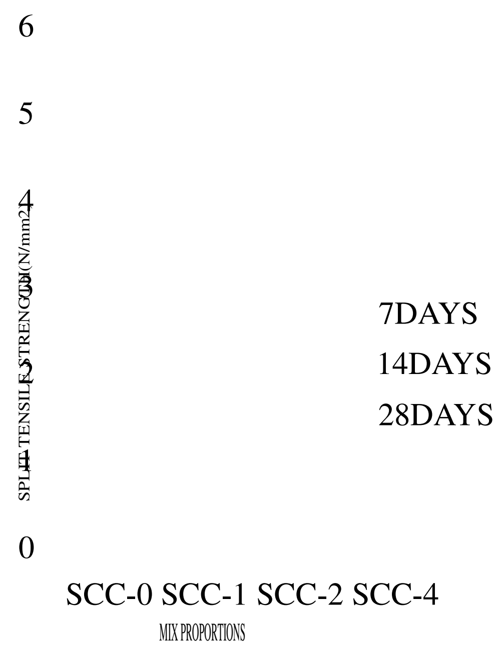
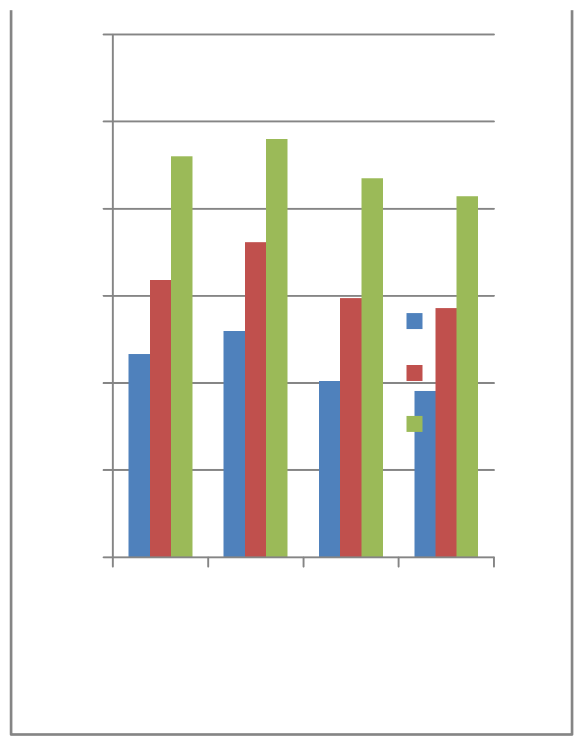


FIG. 6.5 MIX PROPORTIONS vs SPLIT TENSILE STRENGTH

FIG. 6.4 MIX PROPORTIONS vs COMPRESSIVE STRENGTH



7.1 DISCUSSION

From studies it is found out that interaction between two fibres causes increase in 28 day compressive strength, flexural strength and split tensile strength. Single fibre reinforced concrete has lesser values of the same. Use of fibres cause reduction in workability. In order to maintain a constant slump, super plasticizer dosage has to be increased. Increase in synthetic fiber percentage causes formation of lumps in concrete which in turn reduces the strength of concrete.

CONCLUSION

8.1 GENERAL

This chapter deals with the conclusion arrived from experimental investigation on hybrid fibre reinforced concrete and future investigation works.

8.2 CONCLUSION

Based on the experiment the following conclusion is drawn within the limitation of test results.

- From the above experiment work, it's concluded that when the coarse aggregate content is reduced better flow in SCC can be achieved due to the less blocking effect.
- In this study it has been found that with increase in super plasticizer dosage the workability is increased. So that the required slump value can be obtained thus full filling the criteria of EFNARC.
- The split tensile strength improved with increasing fibre percentage. Fibre combination with MIX 3 showed higher split tensile strength than other combinations.
- From this study work, it's concluded that foundry sand both show higher strength values compared to normal mix.
- From this study work, it's concluded that foundry sand can be used as a partial replacement in concrete.
- Comparison of predicted and experimental values for compressive strength split tensile strength and flexural strength were done. Only marginal variations were found.
- This helps to reduce the cost of construction and also reduce the dumping of waste materials from industries.
- It also reduces the pollution of environment, land to an extent.
- This type of SCC can be used for shortcrete works in concreting vertical walls of tanks.

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