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The Effect Of Hybrid Fibers On High Strength Self Compacting Concrete

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ABSTRACT

Low tensile strength and brittle nature are the basic defects in concrete. These defects are enhanced due to improper compaction due to congested reinforcement in detailing. Concrete is a weak building material in tension. Inherently, micro cracks will be present in concrete. The formation of micro cracks normally due to shrinkage of concrete. Self-compacting concrete is being developed in recent years to avoid these defects. Fibers act as bridge towards crack propagation and increase the energy absorption capacity of the concrete. Moreover, concrete suffers from low tensile strength, limited ductility and little resistance to cracking. In order to improve these properties, an attempt has been made to study the effect of addition of steel, glass fibers in ordinary Portland cement concrete. In this study, the scope of research will be focused on the effect of hybrid fibers on mechanical properties. In present investigation is mainly focused on the effect of mechanical properties on M 70 grade of concrete by providing steel, glass fibers. Two different fibers will be used with different dosage levels by volume of concrete.

1.0 INTRODUCTION:

It is well known that normal concrete reinforced with less than 2% of volume content of steel fibers provides better properties compared to normal concrete, especially the improvement of toughness. Recently, with the rapid development of very tall buildings, larger-sized and long-span concrete structures, the requirements for better concrete performance are higher strength, light weight, higher toughness and others. The research on adding steel fibers in lightweight concrete have been reported. For example, **Odorakopoulos and Swamy** are among the very few who reported on sintered fly ash aggregate high strength concrete with steel-fiber reinforcement. They have presented results on the mechanical properties and have highlighted the benefits of including the fibers, especially the improvement in ductility. Nevertheless, in spite of the advantages that have been reported in this area, much more research is still needed. This is especially so because the variability in the characteristics of the lightweight aggregates used. Added to that is the diversity of the types of fibers and the various choices that are available within each type.

The modern development of steel fiber reinforced concrete may have begun around the early 1960s. Polymeric fibers came into commercial use in the late 1970s, glass fibers experienced widespread use in the 1980s, and the carbon fibers attracted much attention in 1990s. The main applications of steel fiber reinforced concrete (SFRC) are in structures subjected to potentially damaging concentrated and dynamic load. SFRC has been used in several areas of infrastructure and industrial applications such as airport pavements, industrial floors, overlays, and channel lining where laboratory tests and field applications have shown SFRC to be more durable than plain concrete subjected to high velocity water flow. The effect of carbon fiber addition on the properties of concrete increases with fiber volume fraction, unless the carbon fiber volume fraction is so high that the air void content increases with fiber content and air voids tend to have a negative effect on many properties, such as the compressive strength. In addition, the workability of the carbon fiber reinforced concrete (CFRC) mix decreases with fiber content. Short carbon fiber cement matrix composites exhibit attractive tensile and flexural properties, low drying shrinkage, high specific heat, low thermal conductivity, high corrosion resistance and weak thermoelectric behavior. Moreover, they facilitate the cathodic protection of steel reinforcement in concrete, and have the ability to sense their own strain, damage and temperature.

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Concrete is one of the principal materials for structures and it is widely used all over the world. However, the heterogeneous structure of concrete results some undesirable effects. The most spectacular disadvantage of concrete may be thought as its exceedingly complex structure which results many internal stress concentration zones. Thus, some internal micro-cracks mostly occurred in fresh or hardened state in concrete. Such micro-cracks exist at cement paste–aggregate interfaces within concrete even prior to any load and environmental effects.

2.0 LITERATURE REVIEW:

Burcu studied mixture design, workability, fibre dispersion/orientation, mechanical properties and fracture behaviour of hybrid steel fibre reinforced self-compacting concretes (HSFRSCCs) were investigated. Three different types of steel fibres with and/or without hooked-ends were added to the mixtures in two different volume fractions (0.75 and 1.5% of the total volume of concrete). The results of slump flow, Ubox, V-funnel and J-ring tests have shown that increasing the fibre content of the concretes slightly reduced the workability of HSFRSCC, and the main influencing factor on flowability is the geometry of fibres. The addition of fibres, although did not change the final flowability, decreased the rate of flowability. The results from the experimental tests showed that the flexural strengths increased slightly with increasing strength of long fibres, whereas the splitting tensile strength remained unchanged. The concretes with high strength, long steel fibres show behaviour of enhanced toughness and ductility compared to that with normal strength steel fibres. The orientation and distribution of fibres in concrete have been investigated by image analysis and it was observed that fibres dispersed homogeneously in all concrete series without any clumping. With increasing the amount of fibres, the fibres were more vertically orientated relative to the bending loading direction, resulting in enhancement in the mechanical properties of concrete.

Mazaheripour evaluated the LECA Lightweight Self-Compacting Concrete (LLSCC) manufactured by Nan-Su, of which the Packing Factor (PF) of its design mixing method has been modified and improved. The study analyzes the impact of

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polypropylene fibers on LLSCC performance at its fresh condition as well as its mechanical properties at the hardened condition. The evaluation of Fiber Reinforced LLSCC (FR-LLSCC) fluidity has been conducted per the standard of second class rating of JSCE, by three categories of flowability, segregation resistance ability and filling ability of fresh concrete. For the mechanical properties of LLSCC, the study has been conducted as follows: compressive strength with elapsed age, splitting tensile strength, elastic modulus and flexural strength, all of which were measured after the sample being cured for 28 days. When self-compacting concretes were lightened to 75% of their normal weight, their fresh properties are affected immensely. Applying 0.3% volume fractions of polypropylene fiber to the LLSCC resulted in 40% reduction in the slump flow (from 720 mm to 430 mm). In general, the rate of slump flow over Super Plasticizer (SP) volume percentage reduced with the use of polypropylene fibers in the FR-LLSC. Polypropylene fibers did not influence the compressive strength and elastic modulus of LLSCC, however applying these fibers at their maximum percentage volume determined through this study, increased the tensile strength by 14.4% in the splitting tensile strength test, and 10.7% in the flexural strength.

3.0 MATERIALS

3.1 Cement:

Ordinary Portland cement of 53 grade, conforming to IS: 12269-1999 with particle size of 90μ has been used in the present investigation. The specific gravity, standard consistency were 3.12 and 32% respectively.

3.2 Fine Aggregates:

Locally available river sand conforming to Zone-II as per IS: 383-1999 has been used. The bulk density, specific gravity, and fineness modulus of the sand were 1.41g/cc, 2.68, and 2.9.

3.3 Coarse Aggregates:

Crushed granite aggregate of maximum 16 mm size conforming to IS: 383-1999 has been used. The bulk density, specific gravity and fineness modulus of the coarse aggregate were 1.46g/cc, 2.7 and 7.1.

3.4 Fly ash:

Fly ash of Class F conforming to IS: 3812: Part-II-2003 obtained from Ramagundam thermal power plant (India) with a specific gravity of 2.18 and fineness of 6422 cm2/gm was used.

3.5 Glass Fibers:

Glass fiber of 6 mm length and tensile strength 1700 MPa were used. Aspect ratio of glass fibers was 428.57.

3.6 Steel Fibers:

Tensile strength of steel fibers were 250 N/mm^2, with an aspect ratio of 54 of hooked end shape.

3.7 Water:

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers.

3.8 Chemical Admixture:

Modified polycarboxylate based superplasticizer confirming to IS 9103-1999 was used. The product name is Chryso Fluid optima S-815. Optimum dosage is confirmed by various trail mixes.

4.0 EXPERIMENTAL PROGRAM:

The investigation was aimed at studying the effect of glass fibers and steel fibers on the standard specimens. Compressive strength and split tensile will be evaluated in this study on M70 concrete. Mix proportioning of concrete will be done based on guidelines of NanSu method of mix design. To study effect on strength of concrete the specimens will be tested for 28 days of curing. Standard cubes (150x150x150 mm) will be cast to investigate the behaviour on mechanical properties. Tests on fresh properties will be done according to EFNARC specifications. The inclusion of glass fibers will be varied from 0 to 0.09% with an increment of 0.03% i.e 0, 0.03%, 0.06%, 0.09% by volume of concrete. The inclusion of steel fibers will be varied from 0 to 1% with an variation of 0, 0.25%, 0.5%, 0.75% and 1% by volume of concrete.

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Table 1 - Mix Proportions of mixes M 70 grade in kg/m^3

Cement	Fly ash	Silica Fume	Fine Aggregate	Coarse Aggregate	SP	Water
425	130	22	830	790	6.12	174

5. RESULTS AND DISCUSSION

5.1 Workability:

Workability tests were performed on the fresh concrete of SCC by various tests. The results of workability tests for M70 grade of concrete with polypropylene fibers and Lime sludge is shown in table 2.

Table 2: Fresh Properties of SCC with GF and SF

Mix Designation	Slump Flow (mm)	T_{500} mm (sec)	J- ring (mm)	V- funnel (sec)	V- funnel T_5 min (sec)
EFNARC Limits	**550-850**	**2-5**	**0-10**	**6-12**	**6-15**
SCC Plain	785	2.3	6	7	9
SCC GF (0.03)+SF (0.25)	765	2.6	7	8	12
SCC GF (0.03)+SF (0.5)	740	2.8	8	10	14
SCC GF (0.03)+SF (0.75)	725	3.1	10	11	15
SCC GF (0.03)+SF (0.1)	680	3.4	10	12	15
SCC GF (0.06)+SF (0.25)	755	2.4	8	9	13
SCC GF (0.06)+SF (0.5)	735	2.8	9	11	14
SCC GF (0.06)+SF (0.75)	710	3.2	10	12	16
SCC GF (0.06)+SF (0.1)	690	3.5	12	13	15
SCC GF (0.09)+SF (0.25)	745	2.6	9	11	14
SCC GF (0.09)+SF (0.5)	715	2.9	10	12	15
SCC GF (0.09)+SF (0.75)	685	3.4	11	15	18
SCC GF (0.09)+SF (0.1)	665	3.9	13	16	19

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Figure 1: Effect of hybrid fibers on slump flow of SCC

5.2 Mechanical Properties:

Compression testing machine of 2000 kN has been used for the test of compressive strength. The results of compressive strength are given in the Table 3.

Table 3: Mechanical properties of SCC with GF and SF

Mix Designation	Compressive strength (MPa)	Spl stren
SCC Plain	78.1	
SCC GF (0.03)+SF (0.25)	80.1	
SCC GF (0.03)+SF (0.5)	81.2	
SCC GF (0.03)+SF (0.75)	82.5	
SCC GF (0.03)+SF (0.1)	83.1	
SCC GF (0.06)+SF (0.25)	81.1	
SCC GF (0.06)+SF (0.5)	83.2	
SCC GF (0.06)+SF (0.75)	84.5	
SCC GF (0.06)+SF (0.1)	82.5	
SCC GF (0.09)+SF (0.25)	84.5	
SCC GF (0.09)+SF (0.5)	86.5	
SCC GF (0.09)+SF (0.75)	83.2	
SCC GF (0.09)+SF (0.1)	82.2	

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Figure 3: Effect of hybrid fibers on split tensile strength of SCC

Figure 2: Effect of hybrid fibers on compressive strength of SCC

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Figure 4: Effect of hybrid fibers on flexural strength of SCC

CONCLUSIONS:

1. Fresh properties of SCC were effected with the addition of hybrid fibers, but all the properties were satisfying EFNARC specimens. The combination of highest dosages (glass (0.09%) and polypropylene (0.1%)) has shown adverse effects on fresh properties.
2. Compressive strength of concrete increased with the increase in percentage of glass and steel fibers.
3. The effect of hybrid fibers is seen significantly in tensile properties (Split tensile and Flexural strength) of concrete.
4. The optimum combination of glass and steel fibers were 0.09% and 0.5% dosages respectively based on fresh and hardened properties.
5. The failure pattern of has been changed from brittle nature to ductile with the addition of hybrid fibers.

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