A Study on Mechanical Properties of Chopped Fiber Reinforced Self-Compacting Concrete

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Abstract— The objective of present research is to design of SCC and to investigate the effect of inclusion of chopped basalt fiber, glass fiber & carbon fiber on fresh properties and hardened properties of SCC. Fresh properties comprise flow ability, passing ability, and viscosity related segregation resistance. Hardened properties to be studied are compressive strength, splitting tensile strength, flexural strength. Fiber reinforced concrete (FRC) is widely practiced with high ductility and sufficient durability. Fiber-reinforced self-compacting concrete uses the flow ability of concrete in fresh state to improve fiber orientation and in due course enhancing toughness and energy absorption capacity. In the past few years there has been a boost in the development of concretes with different types of fibers added to it. In the present work the mechanical properties of a self-compacting concrete with chopped Basalt, glass & Carbon fiber of length 12mm, added in various proportions will be studied in fresh and hardened state.

Key words: Self–Compacting Concrete (SCC), Carbon Fiber, Mechanical Properties

I. INTRODUCTION

The growth of Self Compacting Concrete has caused a significant impact on the construction industry by overcoming some of the difficulties related to freshly prepared concrete. The SCC in fresh form reports numerous difficulties related to the skill of workers, density of reinforcement, type and configuration of a structural section, pump-ability, segregation resistance and, mostly compaction. The Self Consolidating Concrete, which is rich in fines content, is shown to be more lasting. Addition of more fines content and high water reducing admixtures make SCC more sensitive with reduced toughness and it designed and designated by concrete society that is why the use of SCC in a considerable way in making of pre-cast products, bridges, wall panels etc. also in some countries. Carbon fibers have low density, high thermal conductivity, good chemical stability and exceptional abrasion resistance, and can be used to decrease or reduce cracking and shrinkage. These fibers increase some structural properties like tensile and flexural strengths, flexural toughness and impact resistance.

The Self Consolidating Concrete, which is rich in fines content, is shown to be more lasting. Bureau of Indian Standards (BIS) has not taken out a standard mix method while number of construction systems and researchers carried out a widespread research to find proper mix design trials and self-compact ability testing approaches. The work of Self Compacting Concrete is like to that of conventional concrete, comprising, binder, fine aggregate and coarse aggregates, water, fines and admixtures. To adjust the rheological properties of SCC from conventional concrete which is a remarkable difference, SCC should have more fines content, super plasticizers with viscosity modifying agents to some extent.

II. LITERATURE REVIEW

A. *Self-Compacting Concrete*

Self-compacting concrete (SCC) was originally developed in Japan and Europe. It is a concrete that is able to flow and fill every part of the corner of the formwork, even in the presence of dense reinforcement, purely by means of own weight and without the need of for any vibration or other type of compaction. Considering it, researchers have focused on studied the strength and durability aspects of fiber reinforced SCC which are:

1) Glass fibers
2) Carbon fibers
3) Basalt fibers
4) Polypropylene fibers etc.

Glass fibers are formed in a process in which molten glass is drawn in the form of filaments. Basalt Fibers are made by melting the quarried basalt rock at about 1400^0C and extrude through small nozzles to create continuous filaments of basalt fibers. Carbon fibers have low density, high thermal conductivity, good chemical stability and exceptional abrasion resistance, and can be used to decrease or reduce cracking and shrinkage.

Fiber reinforced SCC is currently being studied and applied around the world as given under:

M. Sonebi, et al. (2002) it shows results of fresh properties of self-compacting concrete, like, filling ability measured by slump flow apparatus and flow time measured by apparatus and plastic fresh properties measured by column apparatus. The fresh properties were affected by water/binder ratio, nature of sand, slump were estimated. The fresh tests and hardened test results like compressive strength and splitting tensile strength were compared to a control mix. The properties of fresh SCC improved by increasing in water/binder ratio and nature of sand but the volume of coarse aggregate and dosage of chemical admixture kept constant.

Hajime Okamura et al. (2003) The authors differentiate that when self-compacting concrete becomes so widely used that it should be seen as the "Standard Concrete" rather than a "Special Concrete", it will be successful in constructing durable and reliable concrete structures that need very little repairs work.

T. SeshadriSekhar, et al. (2005) the authors established SCC mixes of grades M30, M40, M50 & M60. Again as compared to the lower grade of SCC mixes, cast 100 mm dia. cylinders so as to test the permeability characteristics by loading in the cells duly applying constant air pressure of 15 kg/mm2 along with water pressure of 2Kg/ mm^2 for a definite period of time and found coefficient

of permeability to determine that the higher the grade of SCC mixes.

Mustapha Abdulhadi, et al. (2012) the author prepared M30 grade concrete and added polypropylene fiber 0% to 1.2% volume fraction by weight of cement and tested the compressive and split tensile strength and obtained the relation between them.

Chihuahua Jiang, et al (2014) in this field, the effects of the volume fraction and length of basalt fiber (BF) on the mechanical properties of FRC were Analyzed. The outcomes indicate that adding BF significantly improves the tensile strength, flexural strength and toughness index, whereas the compressive strength shows no obvious gain. Furthermore, the length of BF presents an influence on the mechanical properties.

M.G. Alberti. Et al (2014) in this paper the mechanical attributes of a self-compacting concrete with low, medium and high-fiber contents of macro polyolefin fibers are considered. Their fracture behavior is compared with a manifest self-compacting concrete and also with a steel fiber-reinforced self-compacting concrete.

III. MATERIALS AND LABORATORY TESTING

A. *Materials*

1) Cement

Portland slag cement of Konark brand available in the local market was used in the present studies. The physical properties of PSC obtained from the experimental investigation were confirmed to IS: 455-1989.

2) Coarse Aggregate

The coarse aggregate used were 20 mm and 10 mm down size and collected from Quarry nearRourkela.

3) Fine Aggregate

Natural river sand has been collected from Koel River, Rourkela, Orissa and conforming to the Zone-III as per IS-383-1970.

4) Silica Fume

Elkem Micro Silica 920D is used as Silica fume. Silica fume is among one of the most recent pozzolanic materials currently used in concrete whose addition to concrete mixtures results in lower porosity, permeability and bleeding because its fineness and pozzolanic reaction

5) Admixture

The SikaViscoCrete Premier from Sika is super plasticizer and viscosity modifying admixture, used in the present study.

6) Water

Potable water conforming to IS: 3025-1986 part 22 &23 and IS 456-2000 was employed in the investigations.

7) Glass Fiber

Alkali resistant glass fiber having a modulus of elasticity of 72 GPA and 12mm length was used.

8) Basalt Fiber

Basalt fiber of 12mm length was used in the investigations.

9) Carbon Fiber

Carbon fiber of length 12mm was used in the investigations.

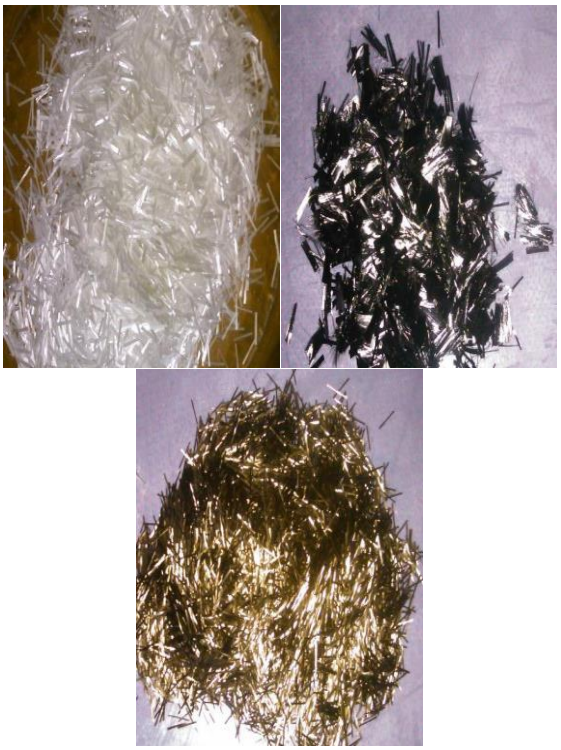

Fig. 1(A): Glass Fiber (B): Carbon Fiber (C): Basalt Fiber

B. *Laboratory Testing*

1) Tests on Fresh Concrete

To determine the fresh properties of SCC, different methods were developed.

- Slump flow
- V-Funnel: This test is performed to determine the filling ability (flow-ability) of self-compacting concrete.
- L-Box: Test has been proposed for determining the segregation resistance.

2) Tests on Hardened Concrete

A proper time schedule for testing of hardened SCC specimens was maintained in order to ensure proper testing on the due date. The specimens were tested using standard testing procedures as per IS: 516-1959.

a) Compression Test

For mix cube of (150×150×150) mm were cast to determine the compressive strength, after the required curing period of the specimen and was casted to measure the compressive strength after 7-days and 28-days. The size of the cube is as per the IS code 10086-1982.

b) Split Tension Test

For mix cylinder of (150×300) mm were cast to determine the split tensile strength, after the required curing period of the specimen and cylinder was casted to measure the split tensile strength after 28-days.

The split tensile strength = $2P / \pi LD$

Where P = Compressive load applied on the cylinder

L = Length of the specimen D = diameter of the cylinder.

c) Flexural Strength

The flexural strength test was carried out on a prism specimen of dimension 100mm×100mm×500mm as per IS specification. prisms were cast to measure the flexural strength after 28-days. The flexural strength of specimen shall be calculated as:

The flexural strength $=PL / BD^2$

Where P = load applied on the prism (KN), L = length of the specimen from supports (mm)

B = measured width of the specimen (mm), D = measured depth of the specimen (mm).

IV. CONCLUSION

- Addition of fibers to self-compacting concrete improve mechanical properties like compressive strength ,split tensile strength, flexural strength etc. of the mix.
- Addition of fibers to self-compacting concrete causes loss of basic characteristics of SCC measured in terms of slump flow, etc.
- Reduction in slump flow was observed maximum with carbon fiber, then basalt and glass fiber respectively. This is because carbon fibers absorbed more water than others and glass absorbed less.
- There was an optimum percentage of each type of fiber, provided maximum improvement in mechanical properties of SCC.
- Mix having 0.15% carbon fiber, 0.2% of glass fiber and 0.25% of basalt fiber were observed to increase the mechanical properties to maximum.
- Carbon fiber addition more than 2% made mix harsh which did not satisfy the aspects like slump value test etc. required for self-compacting concrete.
- The performance of carbon fiber reinforced SCC mixes was better than basalt FRSCC and glass FRSCC mixes. Then carbon fiber FRSCC exhibited best mechanical properties with comparatively lower volume fraction but its effect on SCC fresh properties was just reverse. Its inclusion reduced flow-ability, deformability because it absorbs more water. Other drawback is that it is costliest than other two types of fibers.

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