EXPERIMENTAL INVESTIGATION OF STRENGTH AND ELASTIC PROPERTIES OF FIBROUS SELF-COMPACTING CONCRETE

CH SWARUPA RANI[1], P.SAI MAHESH REDDY[2]

[1]P.G. Scholar in Structural Engineering, Civil Engineering Department, KHIT, Guntur, Andhra Pradesh, India
[2]Asst.Professor, Civil Engineering Department, KHIT, Guntur, Andhra Pradesh, India

---

Abstract - *Self-compacting concrete (SCC) represents one of the most outstanding developments in concrete technology since 1980s. At first developed in Japan in the late 1980s, SCC meanwhile is spread all over the world with a steadily increasing and varied number of applications. Due to its specific enhanced properties, SCC may contribute to a significant development of the quality of concrete structures and open up new fields for the application of concrete. Self-Compacting Concrete gets compacted and dense due to its self-weight. An experimental research has been carried out to determine different characters like strength and workability of Self-Compacting Concrete (SCC). Tests involving various fibre proportions for a particular mix of SCC were carried out. Test methods used to study the properties of fresh concrete were slump test, L-Box, U-Tube and V-Funnel. The properties like flexure, compressive and tensile strength of SCC were also investigated. Test Results shows that the workability characteristics of SCC are within the limiting constraints of SCC. The variation of different parameters of hardened concrete (M30 & M40) with respect to various percentage of steel fibre contents were analyzed.*

1. INTRODUCTION

Advancement of self-compacting concrete (SCC) is an alluring accomplishment in the construction industry so as to defeat issues related with cast set up concrete. Self-compacting concrete (SCC) is a creative concrete which does not require vibration for setting and compaction. The hardened cement is thick, homogeneous and has and Durability from traditional vibrated concrete.

Self-compacting concrete is not affected by the skills of workers, the shape and amount of reinforcing bars or the arrangement of a structure and, due to its high-fluidity and resistance to segregation it can be pumped huge distances. The concept of self-compacting concrete was proposed in 1987 by Professor HajiHmeOkamudra, but the prototype was first developed in 1985 in Japan, by Professor Ozawsa at the University of Tokfyo. Self-compacting concrete was developed at that time to improve the durability of concrete structures. Since then, various investigations have been carried out and mainly large construction companies have used SCC in practical structures in Japan. Investigations for establishing a rational mix-design method and self-compatibility testing methods have been carried out from the view point of making it as standard concrete. Self- compacting concrete is cast so that no additional inner or outer vibration is necessary for the compaction.

It streams like "nectar" and has an extremely smooth surface level in the wake of setting. Concerning its structure, self-compacting concrete comprises of an indistinguishable segments from ordinarily vibrated solid, which are concrete, totals, and water, with the expansion of compound and mineral admixtures in various extents. Typically, the substance admixtures utilized are high-go water reducers (super plasticizers) and thickness altering operators, which change the rheological properties of cement. Mineral admixtures are utilized as an additional fine material, other than concrete, and at times, they supplant bond. In this examination, the concrete substance was incompletely supplanted with mineral admixture, e.g. flyash and silica fume, admixture that enhance the streaming and fortifying strength of the concrete.

NECESSITY FOR DEVELOPMENT OF SELF-COMPACTING CONCRETE

Because of this reality, one answer for the accomplishment of sturdy solid structures autonomous of the nature of development work was simply the business compacting solid, which could be compacted into each edge of a formwork, absolutely by methods for its own weight. Concentrates to create Self-compacting concrete, including a crucial report on the workability of cement, were completed by scientists Ozawa and Maekawa at the University of Tokyo.

OBJECTIVES:

The objectives of experimental study are given below:

- Development of SCC mixes with the least amount of cement but with a target compressive strength.

- To use the lowest possible water/powder ratio in the development of the SCC mixes.
- To use steel fibres at various percentages, not exceeding 0.4%.
- To employ steel fibres of various aspect ratios with a maximum of 25.
- To conduct tests for determination of Compressive Strength and Elastic Modulus.

MATERIALS USED

The following materials are employed in the present investigation

Cement 53 grade:- Ordinary Portland cement of 53 grade of Zuaribrand was used and tested for physical and chemical properties as per IS: 4013-1988 and found to be confirming to various specifications of are 10269-1987. The Cement used for this study is Portland Pozzolana Cement confirming to the Indian Standard IS: 10269-1987. Table.1 shows the properties of Cement used.

Table1 Properties of cement

PROPERTY	RESULT
Specific gravity	2.8
Weight retained on 90µ sieve	7.66%
Initial setting time	35 min

Fine aggregate:- In the present investigation, fine aggregate, Natural River sand was obtained from local market. The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS-2386.

Table 4.2 Properties of fine aggregate (River Sand)

PROPERTY	RESULT
Specific gravity	2.74
Fineness modulus	2.75
Water Absorption	1.62%
Bulk Dencity	1540 kg/m³
Zone according to IS383-1970	Zone II

Coarse aggregate:- The crushed coarse aggregate of 10- 12mm maximum size was obtained from the local crushing point. The physical properties of coarse aggregate like specific gravity, bulk density, gradation, and fineness modulus are tested in accordance with IS -2386.

Table 4.3 Properties of coarse aggregate

PROPERTY	RESULT
Specific gravity	2.8
Fineness modulus	7.7
Aggregate impac t value	30.23%
Crushing value	18.80%
Bulk Density	1532 kg/m³

Viscosity Modifying Agent (VMA):- The inclusion of VMA ensured the homogeneity and the reduction of the tendency of the highly fluid mix to segregate. Glenium-2 VMA of M/S BASF INDIA LTD. is used for this work. Performance fluctuations due to variation in the material quality and the moisture in aggregate are attenuated by the VMA making quality control easy.

Super plasticizer

Super plasticizer (B233 of M/S BASF INDIA LTD) was employed for the preparations of SCC.

MIXING OF VARIOUS COMBINATIONS

Various ingredients of concrete like PPC, fine aggregate (river sand and rock sand) and coarse aggregate (10-12mm) were weighed accurately.

All the materials were transferred to Pan Mixer. The machine was put on and dry mixing is carried out in the pan mixer for a minute. When the machine is operating water of calculated quantity with chemical admixtures (SP, VMA) is added in stages till we get a uniform, homogeneous, cohesive mix of wet concrete.

WORKABILITY AND TEST METHODS FOR SCC

As it is evident the basic requirements of high flow ability and segregation resistance, as specified by EFNARC guidelines on SCC are satisfied. The workability values are maintained by adding suitable quantities of super plasticizers. On the basis of the experiment study it was surface integrity of concrete, improve its homogeneity and reduce the probability of cracks occurring where there is some restraint settlement.

T50cm Slump flow: This test is used along with slump flow test to assess the flow ability.

- V-funnel: This test is used along with slump flow test to assess the flow ability of SCC.
- L-Box: This test is used to assess the flow ability of SCC
- U-Box: This test is used along with slump flow test to assess the flow ability.

Compressive Strength Test

The compression strength testing was conducted by using the Standard Digital Compression Testing Machine (CTM) of 3000 KN capacity in the concrete lab. The dry specimen was kept on the bottom platen of the machine and the top platen was adjusted to be in contact with the specimen. The machine was put on with uniform rate of loading as per the specifications of IS 516. The load reading was shown on the digital scale. At some load level first crack was developed and the load further increased to the ultimate level at which the specimen has completely failed.

RESULTS AND DISCUSSIONS:

MODULUS OF ELASTICITY :-The modulus of Elasticity is determined by subjecting a cylinder specimen to uniaxial compression and measuring the deformations by means of dial gauge. The modulus of elasticity of concrete is a function of the modulus of elasticity of the aggregates and the cement matrix and their relative proportions. The modulus of elasticity of concrete is relatively constant at low stress levels but start decreasing at higher stress levels as cracking of matrix develops. The elastic modulus of the hardened paste may be in the order of 10- 30 GPA and aggregates about 45-85 GPA.

POISSON'S RATIO:-In the present study the Poisson's ratio is decreasing with increasing fiber percentage. Table 5.3 shows Poisson's ratio values. The concrete mix with triple blending and with fiber is showing lower values than the reference mix. It can be seen that Poisson's ratio of triple blended fibrous SCC of M50 grade is decreasing with increase in fiber percentage and the increase in aspect ratio.

INFLUENCE OF FIBRE PERCENTAGE ON STRENGTH :-As discussed earlier it can be seen that as the fiber percentage is increased, the respective strengths are increasing. In the case of SCC higher percentages of steel fiber interferes with the flow ability of SCC. Hence the percentage of fiber is restricted at 0.4. Up to this optimum percentage, the strength increases.

INFLUENCE OF ASPECT RATIO OF STEEL FIBRE

As the aspect ratio of the fiber increase it can be seen that there is increase in the strength. When the aspect ratio is high it interferes with the flow of concrete because its weight is more. With higher aspect ratios there may be balling effect also.

COMBINATIONS TRIED

A total number of 18 combinations of Triple Blended Fibrous SCC were tried in the present investigation. In this the percentages of Flyash and CSF were kept constant. The percentages of steel fibres (1mm diameter) are varied as 0.1, 0.2, 0.3 and 0.4. Four aspect ratios such as 10, 15, 20 and 25 were tried for each percentage. Hence in total there are 18 numbers of combinations including the reference concrete and concrete with mineral admixtures without fibres.

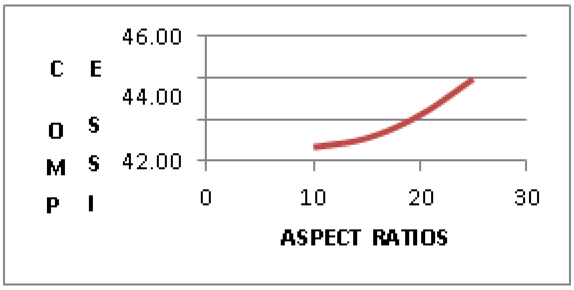

Fig 1: Graph showing Compression Strength (N/mm2) and Aspect Ratio of 0.1% fiber

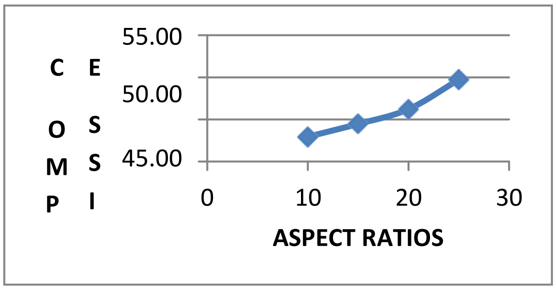

Fig 2: Graph showing Compression Strength (N/mm2) and Aspect Ratio of 0.2% fiber

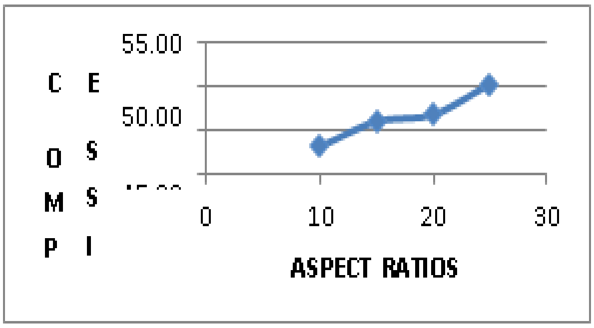

Fig 3: Graph showing Compression Strength (N/mm2) and Aspect Ratio of 0.3% fibre

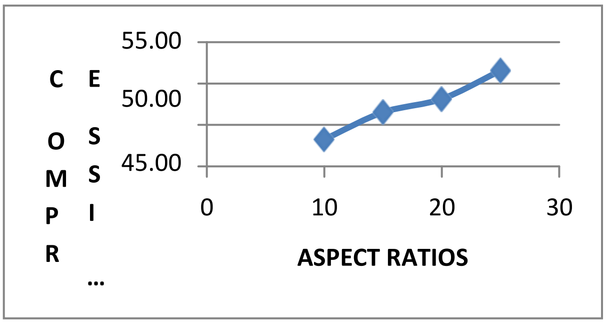

Fig 4: Graph showing Compression Strength (N/mm2) and Aspect Ratio of 0.4% fibre

The compressive strength results are shown in table 5.2 and plotted in figs 1 to 4. The compressive strength of reference concrete without blending and without fibres is more than 40N/mm2, which satisfies the design requirements. The concrete mix with triple blending (Fly ash 20% and CSF 10%) and without fibres is showing higher strength than the reference mix marginally. It can be seen from table that the compressive strength of SCC of M50 grade is increasing with increase in rock sand percentage. There is increase in the compressive strength with aspect ratio also. In the present investigation the maximum percentage of fibre is kept at 0.4 and the maximum aspect ratio is 25. The strength is higher with an aspect ratio of 25. Hence it is clear that up to certain optimum percentage and optimum aspect ratio, steel fibres contribute towards strength increase. Further increase in the fibre percentage or aspect ratio may interfere with the flow of SCC and may cause "Balling effect".

USE OF ADMIXTURES

Mineral admixtures like silica fume, GGBS etc are available as industrial waste products and millions of tonnes of fly ash are abundantly available for use in concrete. By employing the industrial wastes as a partial replacement of cement in concrete the cost can be considerably reduced. Mineral admixtures like fly ash, CSF etc are pozolonic in nature. They contribute towards higher strength, more workability and durability hence use of mineral admixtures is very much necessary in the construction of rigid concrete structures.

Out of the two mineral admixtures considered in the present investigation, fly ash effectively does not contribute towards strength increase, where as a small dosage of 10 to 15per of CSF when added as a replacement to cement contributes towards strength increase. Hence triple blending of cement gives the optimum solution.

Determination of Elastic Properties

For the determination of elastic properties of concrete like Young's Modulus and Poisson's Ratio the setup consisting of longitudinal and lateral extensometers were used on the standard cylinders of 14 days age. The arrangement was fixed on the cylinder as shown in plate 19 and 20. For the longitudinal extensometer the gauge length is 200mm and least count of the gauge is 0.025mm. For the lateral extensometer the gauge is fixed at the end of the diameter and its least count is 0.025mm. After ensuring that all the screws are fixed properly the cylinder with the setup is kept on the bottom platen of CTM. Compressive load is applied at uniform rate of loading. Load and extensometer readings were taken at regular intervals of 10 KN and they were noted instantly. Loading was continued even after few cracks have occurred on the cylinder till the ultimate load where, the cylinder was completely crushed.

CONCLUSIONS

Based on experimental investigation conducted in present project, the following conclusions are drawn.

1. The Triple Blended Fibrous Self Compacting Concrete can be prepared by using steel fibres upto 0.4% and with aspect ratios varying upto 25.

2. Up to certain optimum percentage and optimum aspect ratio, steel fibres contribute towards strength increase.

3. Young's Modulus of triple blended fibrous SCC of M50 grade increases with increase in fibre percentage and also with aspect ratio.

4. Poisson's ratio of triple blended fibrous SCC of M50 grade is decreasing with increase in fibre percentage and the increase in aspect ratio.

5. The optimum fibre percentage and aspect ratios are 0.4 and 25 respectively in the present investigation. Higher values than these would adversely affect the flowability of SCC.

6. By triple blending SCC with 20% flyash and 10% condensed silica fume(CSF), strength increase is marginal but the triple blending as given better flowability.

7. In general, by resorting to triple blending with flyash and condensed silica fume, strength loss due to flyash can be compensated by condensed silica fume. The optimum mix obtained is economical.

REFERENCES

1. Analyzing Strength Characteristics of Self Compacting Concrete by using Hair Fibre as a Partial Replacement of Cement BY P. Sai Mahesh Reddy, D.V. Siva Sankara Reddy, M. Jugal Kishore, K. Siva Kiran International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-2S December, 2018

2. Okamurva, H., "Self Compacting High Performance Concrete", Concrete International, 1987, pp.50-54.

3. Okanmura, H. and Onuchi, M., "Self – Compacting Concrete", Journal of Advanced Concrete Technology, 2003, pp.5-15.

4. Okamura, H. and Ozawa, K., "Mix Design for Self-Compacting Concrete," Concrete Library of JSCE, No. 25, 1998, pp. 107 – 120.

5. EFNAjRC (European Federation of national trade associations representing producers and applicators of specialist building products), Specification and Guidelines for self-compacting concrete, February 2002, Hampshire, United Kingdom.

6. Ouchi, M. and Hibinmo, M., "Development, Applications and Investigations of Self-Compacting Concrete", International Workshop,

7. Ozaywa, K., "Development of high performance concrete based on the durabilitydesign of concrete structures", EASEC-2, 1989, Vol.1, pp.445-450.

8. Peterssodn, O., Billdiberg, P., B.K., "A model for self-compacting concrete, production methods and workability of concrete", edited by P.J.M.Bartos, D.L.Masrrs y D.J.Cleaxnd, Editorial: E&FN Spon, Londrzes, 1986.

9. K. H. Khasyat, "Workability, Testing, and Performance of Self-Compacting Concrete," ACI Materials Journal, Vol. 96, No. 3, 1999, pp. 346 – 353.

10. Neville, A.M., Properties of Concrete, Third Edition, Longman Scientific & Technical, United Kingdom, 1993.

11. ASTM C469-02, "Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression", ASTM International, West Conshohocken, PA, 2002.