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Evaluation of Flexural and Torsional Strength of Self-Compacting Composite Concrete

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***Abstract*:-- In the percent work, attempt has been made to improve the performance of self-compacting composite concrete by using recycled coarse aggregate, fly ash and steel fibers. The study is carried out by replacing of natural course aggregate with recycled coarse aggregate in self-compacted concrete (SCC) at different percentages like 10%, 20%, and 30%. It is observed that maximum of 30% recycled aggregate can be effectively used in production of SCC without any significant reduction in strength and durability. The present study also aims at improving the shear, flexural and torsional strength of the concrete by addition of fly ash (FA) and steel fibers (SF). In this research work, 20% of fly ash (class-C) is added as a replacement of binder to its weight and 1.5% steel fibers by weight of concrete. Based on the experimental results, it can be seen that the load carrying capacity of composite concrete increased by 40 to 50% than the plain beam along with energy absorption and ductility.**

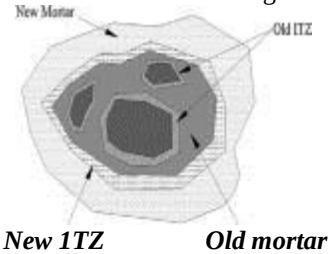
Keywords: **Self-compacting concrete, recycled coarse aggregate, fly ash, steel fibers.**

I. INTRODUCTION

Concrete is most widely used construction material all over the world in the view of its compressive strength, high strength, durability, structural stability and economic considerations.

Self-compacting concrete (SCC) is aqueous mixture, which is suitable for placing difficult conditions and also in congested reinforcement, without vibrators. SCC poured in the same way as conventional concrete but without vibration. It is very fluidic and can pass around obstacles.

India has established itself as one of the world's fast growing economies. Currently construction sector in India is growing at the rate of 10% per annum. Presently construction and demolition waste generation in India accounts up to 23.76 million tons annually and these figures are likely to double fold up to 2017[1]. According to an estimate the concrete industry consumes approximately 40% of the total worldwide construction aggregate production. The use of recycle course aggregate (RCA) for concrete production is not simply applied because the properties of RCA are different from natural aggregates. Furthermore, the quality of RCA fluctuates when collected from different sources. In physical terms, characteristic differences are observed between the properties of RCA since it not only consist of original aggregates, but also comprise of the remains of mortar (cement paste) adhering to the aggregate surfaces. The presence of mortars remain in the RCA is a main reason for deteriorated RCA quality as 'compared to natural aggregates because adhered mortar characterized as porous and presents numerous micro cracks. As a result, RCA are characterized as having lower density, higher water absorption, and lower mechanical strength than the natural aggregates. Consequently, when using RCA in production of new concrete, these characteristics of the aggregate may have adverse effect on interfacial bond between RCA and cement paste. But considering the use of recycled aggregates could reduce the dependence of the construction industry on natural aggregates, and thus, maintain aggregate security and still ensure sustainable development their use in concrete is negotiable.



New 1TZ ***Old mortar***

Figure 1: Structure of recycled aggregate

II. LITERATURE REVIEW

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In this study of high performance self-compacting concrete researcher give the brief discussion on self-compacting concrete.

Durability aspects of steel fibre-reinforced SCC by Ganesan et al [2015].They studied the effect of steel fibres on the durability parameters of self-compacting concrete (SCC). Based on the experimental investigation, it is concluded that addition of steel fibres improved the durability aspects of self-compacting concrete. The optimum dosage of fibres for better performance is found to be 1.5 percent.

A Study on the Properties of Self Compacting Concrete using Recycled Aggregate in Fresh and Hardened State by Nischay T G et.al. [2015].

Self-compacting concrete of M20 grade is mixed with recycled aggregate at different percentage. Replacement levels of Recycled aggregate-0%, 25%, 50%, 75%, 100%.

Effect of fly-ash on long term strength in High Strength Self Compacting Concrete (HSSCC) is studied by Jagadish Vengala et. al. [2016].

Based on fresh and hardened properties of SCC mixes they concluded that inclusion of fly ash as part replacement of cement has increased the paste content and hence enhances the self-compacting properties. The optimum dosage of Fly ash for better performance was found to be 20% percent.

III. OBJECTIVES

- To verify index properties like compressive strength, split tensile strength and flexural strength, torsion.
- To Improve performance of SCC using recycled aggregate.
- To find strength of concrete using fly ash, steel fiber.

IV. MATERIALS

The mix design is for M40 grade of concrete. The concrete mix proportion is 1:1.5:1.85 and water cement ratio of 0.45. The material used as follows:

Cement: Ordinary Portland Cement (OPC) of 53 grade conform to IS12269:1987. The compressive strength of cement obtained at 28 days is 59.2MPa. . Fitness of cement = 5 %< 10 % (IS: 12269-1976). Specific gravity of cement = 3.15 (IS: 2720-part3). Standard consistency test=29.25% <30% (IS: 4031-1968). Initial setting time = 115 minutes > 30 minutes (minimum) (IS: 12269-1976). Final setting time = 250 minutes <600 minutes (maximum) (IS: 12269-1976). Coarse aggregate: The natural coarse aggregate, obtained from the locally available quarries with size in between 10mm to 12mm satisfy the grading requirements of BIS. The specific gravity of 2.65 and fineness modulus 6.2 is used. The aggregate are tested as per IS 383:1970.

Fine aggregate: The natural fine an aggregate, obtained from the local river is passed through 4.75 IS sieve. Fine aggregates shall be such that not more than 5 percent shall exceed 5mm in size and having a fineness modulus of 2.90 (Zone II).

Recycled aggregate: The recycled coarse aggregates are obtained from the demolished building of 25 years old. It is not exposed to any chemicals. The large pieces of slab [free from impurities] are transported to the laboratory and broken into pieces smaller than 20mm and sieved through 12mm. The pieces greater than 20mm are crushed through a crusher to the maximum of 12mm sieve and then both the materials are mixed and sieved again. The density and absorption, the most important properties of recycled aggregates are directly related to the quantity of adhered mortar. The procedure adopted for the production of recycled aggregates in the present study may not truly represent the field conditions. But by adopting the combinations of both manual as well as crusher, the quantity of adhered mortar can be minimized up to certain extent. Therefore this process will improve the quality of recycled aggregates.

Fly ash: In this study Class C fly ash is used. Chemical composition and physical composition are as per IS3812 Part I– 2003. It is replacing to cement of 20% by its weight.

Chemical admixture: Chemical admixture is a substance which imparts very high workability with a large decrease in water content (at least 20%) for a given workability. A water-reducing admixture, constitute of a Poly Carboxylic Ether (PCE). Admixture {Super plasticizer- Muraplast FK 61 viscosity modifying agent (VMA) - Centrament Stabi 510} is used in this experimental study. It is having quantity of 1.32% of the cement.

Steel fibers: Steel fibers manufactured by Bekaert-Dramix® are used having a ‘trough’ shape with hooks at both ends. Fibers had a length of 60 mm, a diameter of 0.75 mm (aspect ratio of 80).

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V. MIX DESIGN

For the purpose of the experiment four types of concrete mixes are made. In each mix natural course

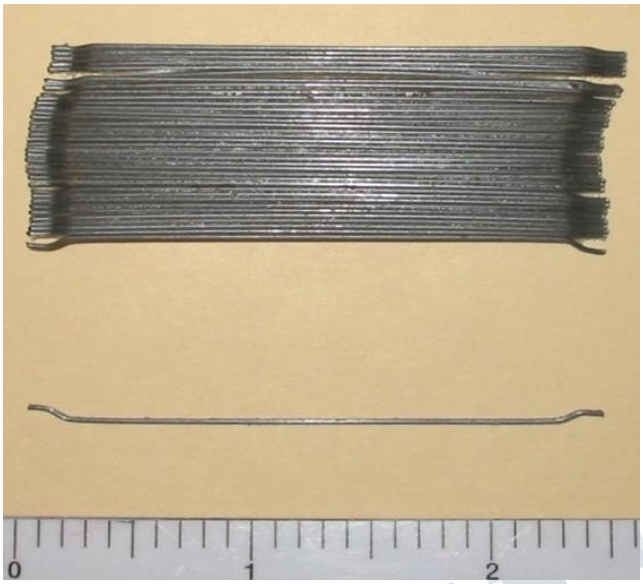

Figure 2: Hook type Bekaert-Dramix® steel fibers

aggregate is replaced by recycled coarse aggregate in the ratio of 0%, 10%, 20%, and 30% by volume.

The preliminary mix design is carried out as per IS:10262-2009 for target strength of 40 MPa. After the initial mix design, the trial mixes are prepared and tested for the fresh properties of SCC as per the European Federation of Specialist Construction Chemicals and Construction Systems (EFNARC) guidelines. The quantity of components required for making 1 cubic meter of concrete is constant, with the exception of small variations in the quantity of super plasticizer for the purpose of achieving equal consistency for all the mixes and due to slightly higher water absorption by the recycled aggregate.

VI. METHODOLOGY

The study has been divided into various parts:

In the first part, the material characterization of the recycled aggregates as per Indian standards is conducted. In the second part, the suitability of RCA in M-40 self-compacting concrete mix is investigated. The hardened concrete wastes from demolished building are brought to the laboratory and it is crushed and sieved. The aggregates characterization are done by conducting the following tests as per IS 2386 Part III: 1990 and IS 2386 Part IV: 1990 and the properties of the crushed unprocessed aggregates are found.

The mix with OPC and fly ash are considered. Four batches of M-40 mix are prepared:

Batch-1 (40SCC0) mixes has Ordinary Portland Cement (OPC) 80%, fly ash 20% replacing to cement to its weight and natural coarse aggregates (NCA) 100% as determined in the mix design.

Batch-2 (40SCC10) mixes has OPC 80%, fly ash 20% and natural fine aggregates are taken as per mix design. However the coarse aggregates are substituted with RCA in the range of 10% replacement to natural coarse aggregates.

Table 1 Summary of properties of the recycled course aggregate

Mix Type	Slump Flow(mm)	T500 Slump Flow(sec)	J-RING (mm)
40SCC0	693	2.6	3.76
40SCC10	711	3.09	3.86
40SCC20	685	2.74	4.3
40SCC30	660	2.5	6.3

Batch-3 (40SCC20) mixes has OPC 80% , fly ash 20% and natural fine aggregates are taken as per mix design. However the coarse aggregates are substituted with RCA in the range of 20% replacement to natural coarse aggregates**.**

Batch-4 (40SCC30) OPC 80%, fly ash 20% and natural fine aggregates are taken as per mix design. However the coarse aggregates are substituted with RCA in the range of 30% replacement to natural coarse aggregates.

VII. RESULTS

The test program is divided into two parts. Testing of fresh properties of SCC and strength investigations on hard concrete.

A. Fresh state of concrete

SCC differs from conventional concrete in that its fresh properties are vital in determining whether or not it can be placed satisfactorily. The various aspects of workability which control its filling ability, its passing ability and its Segregation resistance all need to be carefully controlled to ensure that its ability to be placed

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Vol 1, Issue 8, December 2016

remains acceptable. Different methods have been developed to characterize the properties of SCC.

In this investigation the fresh state properties of SCC are tested by following methods as suggested by EFNARC. Slump flow test and T50 slump flow for flowing ability and viscosity, j-ring test for passing ability.

Table 1 provides a summary of the properties of the recycled coarse aggregate self-compacting concrete mixes in the fresh state

B. Hard State Concrete

1. Compressive strength

The variation of compressive strength of concrete with respect to age of concrete for different percentages of recycled aggregate is shown in Figure 1. It is observed that all the mixes achieved the target strength of 40 MPa. All four mixtures quickly gain strength, and after 7 days they achieve more than 90% of the strength they have at the age of 28 days. Use of recycled coarse aggregate self-compacting concrete, there is a small variation in the strength and the same is reported.

The increase in compressive strength of recycled coarse aggregate self-compacting concrete. The tests are carried at 7, 14 & 28 days. It is found that the compressive strength at 28 days has decreased up to 7.45% with 30% of recycled aggregate.

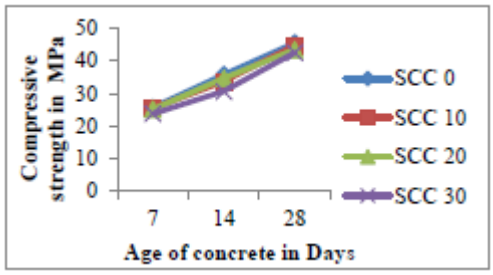

Figure 1 Compressive strength of SCC with different percentage of RCA

2. Split tensile strength

In this investigation, the Split tensile strength test of self-compacting concrete is carried out with 0%,10%, 20%, 30% replacement of recycled aggregate with coarse aggregate. The tests are carried out after 28 days of curing. All three mixtures quickly gain strength, and after 7 days they achieve more than 90% of the strength at the age of 28 days. Split tensile strength value is gradually increased to the percentage of recycled coarse aggregate replaced in the concrete. It is found that the split tensile strength at 28 days has decreased up to 5.5% with 30% of recycled aggregate. Percentage increases in split tensile strength of recycled coarse aggregate.

Table 2 Split tensile strength of concrete

Mix	% of RCA	Split tensile Strength in MPa
40SCC0	0	5.47
40SCC10	10	5.40
40SCC20	20	5.33
40SCC30	30	5.20

3. Flexural strength

In this investigation, the flexural strength test of self compacting concrete is carried out without steel fibers and with 1.5% steel fibers keeping 30% replacement of recycled aggregate. The tests are carried after 28 days of curing. The decreased in flexural strength at 28 days was recorded to be increase by using steel fibers and recycled aggregate.

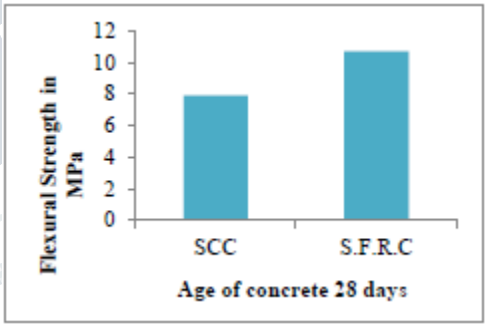

Figure 2 Flexural strength of SCC and SFRC

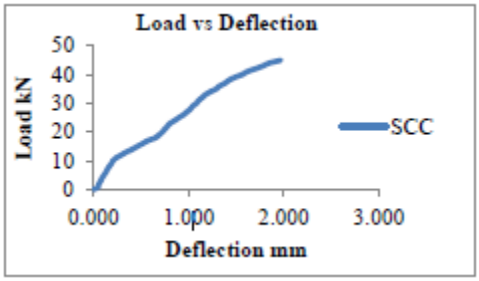

Figure 3 Load Vs deflection for loading of SCC

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Vol 1, Issue 8, December 2016

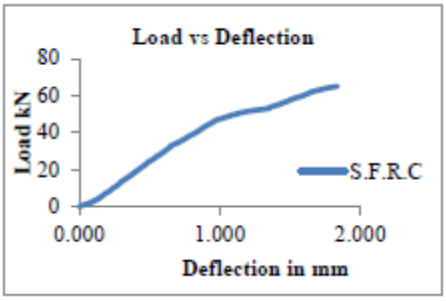

Figure 4 Load Vs deflection for loading of SFRC

4. Torsional strength

In this investigation, the torsional strength test of self-compacting concrete is carried out without steel fibers and with 1.5% steel fibers keeping 30% replacement of recycled aggregate. The tests are carried after 28 days of curing. The torsional strength at 28 days was recorded to be increase by using steel fibers and recycled aggregate.

Table 3 Split tensile strength of concrete

Sample identification	Torsion Nm	Angle of Rotation in radians
SCC	241.91	0.05767
S.F.R.C	340.148	0.06494

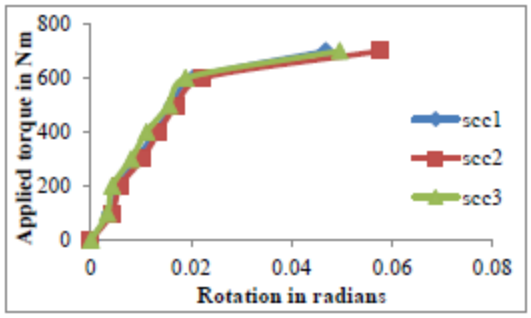

Figure 5 Pure torsional strength results for SCC

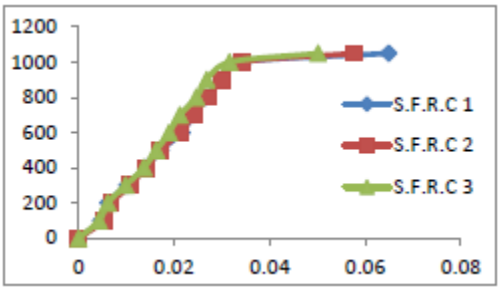

Figure 6 Pure torsional strength results for S.F.R.C

VIII. CONCLUSION

Based on the results obtained the following conclusion are drawn from the study:

- The surface texture of recycled coarse aggregate is more porous and rough due to the adherence of old porous mortar. This may increase the water demand and reduce the workability.
- The compressive strength at 28days has decreased 7.45% increase with 30% replacement of recycled aggregates.
- Split tensile strength at 28 days has decreased up to 5.5% with 30% of recycled aggregate but from adding steel fiber in same proportion it increases up to natural coarse aggregate concrete.
- Flexural strength at 28 days has increased with using recycled aggregate and steel fiber.
- Overall 30% recycled aggregate gives considerable strength mixture for self-compacting concrete.

REFERENCES

[1] Sudhir P. Patil, Keshav K. Sangle (2016), "Shear and flexural behaviour of prestressed and non-prestressed plain and SFRC concrete beams", King Saud University Journal of King Saud University – Engineering Sciences, Vol. 4 Issue 01, May-2016, pages 110-117.

[2] Ganeshram, Gopalan (2015), "An Experimental Study on Impact Strength of Self Compacting Concrete", International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181Vol. 4 Issue 06, June-2015, pages-1184-1189.

[3] M.Seethapathi, S.R.R.Senthilkumar, K.Chinnaraju (2015),"Experimental Study on High Performance Self compacting Concrete using Recycled Aggregate", Journal of Theoretical and Applied Information Technology, Vol. 67 No.1, 2005, ISSN: 1992-8645,pages-84-90.

[4] Zhi Shan, Zhiwu Yu, Jianjun Shi (2015),"Experimental investigation of flow of fresh self-compacting concrete in improved L-box", Construction and Building Materials, Elsvier publication, vol.84 (2015), pages-30–38.

[5] Nischay T G , S Vijaya and B Shiva Kumaraswamy (2015), "A Study on the Properties of Self Compacted Concrete using Recycled Aggregate in Fresh and Hardened State", International Journal of Engineering Research & Technology (IJERT),ISSN: 2278-0181,Vol. 4 Issue 06, June-2015, pages 822-826.

[6] Prashant O. Modani, Vinod M. Mohitkar (2015), "Recycled Aggregate Self Compacting Concrete:A Sustainable Concrete for Structural use", International Journal of Engineering Research & Technology (IJERT),ISSN: 2278-0181,Vol. 4 Issue 01,January-2015, pages 116-120.

[7] Sija K Sam, Deepthy Varkey , Elson John (2014), "Self-Compacting Concrete with Recycled Coarse Aggregates", International Journal of Engineering Research & Technology (IJERT),ISSN: 2278-0181,Vol. 3 Issue 9, September- 2014,pages-105-107.

[8] Jagadish Vengala (2014), "Effect of Fly Ash on Long term Strength in High Strength Self Compacting Concrete" International Journal of Science and Research (IJSR) Volume 2 Issue 4,pages-135-140.

[9] Sudhir P.Patil, Ganesh S.Ingle, Prashant D.Sathe (2013) ,"Recycled Coarse Aggregates", International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-2, Issue-1, 2013,pages-27-33.

[10] Eric P. Koehler (2007), "Aggregate in Self Consolidating Concrete", ICAR Project 108, pp 141-152.

[11] KHALEEL, O.R. (2011), "The Effect of Coarse Aggregate on Fresh and Hardened Properties of Self-Compacting Concrete (SCC)", Elsevier, pp 805-813.

[12] OKAMURA H., MAEKAWA K. and OZAWA K., (1993) "High-Performance Concrete" ,Gihodo Publishing volume 3, pp 231-240.

[13] Padmanapan.M, N.Sakthieswaran (2015), "Mechanical Properties Of Self Compacting Concrete Containing Silica Fume And Steatite Powder", (IJ0SER) Volume 3 Issue 6, pp 172-181.

[14] Rahul Sikka and Arvind Dewangan, (2014), "Determination of compressive strength difference between conventional concrete and recycled aggregate concrete", (ISSN) Volume 2, pp 124-132.

[15] SK Singh (2009), "Self Compacting Concrete - A Paradigm Shift", Journal of New Building Materials & Construction World, Vol. 15, No. 3, pp 164-180.

[16] ASTM C 78 – 02, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).

[17] ASTM C 1018 – 97, Standard Test Method for Flexural Toughness and First-Crack Strength of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading).

[18] EFNARC (2002), "Specification and Guidelines for Self Compacting Concrete".

[19] IS: 456:2000, "Indian Standard plain and reinforced concrete- Code of Practice", Bureau of Indian Standards, New Delhi, 2000.

[20] IS: 650-1966, (Reaffirmed 1980), "Standard Sand for Testing of cement', Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi -110 002.

[21] IS: 8142-1976, "Method of Test for Determining Setting Time of concrete by Penetration Resistance", Bureau of Indian Standards, Delhi.

[22] IS: 2386 (Part-I) -1963, "Methods of Test for Aggregate for Concrete", Bureau of Indian Standards, Delhi.

[23] IS: 383-1970 (Second Revision), "Specification for Coarse and Fine Aggregate from Natural Source for Concrete", Bureau of Indian Standards, Delhi.

[24] IS: 1786-1985, "Specification for High Strength deformed Steel Bars and Wires for Concrete Reinforcement", Bureau of Indian Standards, Delhi.

[25] IS: 10262-1982, "Recommended Guidelines for Concrete Mix Design",Bureau of Indian Standards, Delhi.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 1, Issue 8, December 2016

[26] IS: 516-1959, "Methods of Test for Strength of Concrete", Bureau of Indian Standards, Delhi.