Study on Steel Fiber Reinforced Self-Compacting Concrete using Fly Ash and Rice Husk Ash

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Abstract – *Currently, many researches have been going on to modify and improve the concrete properties by adding different types of materials. One of them is self-compacting concrete. Self-compacting concrete is a highly flowable, deformable, non-segregating concrete that spreads and fills in the formwork under its own weight. The aim of this research is to study the steel fiber reinforced self-compacted concrete (SFRSCC) with partial replacement of cement by fly ash and rice husk ash. In the present study, cement is partially replaced by rice husk ash & fly ash. A total of 5 mixes with 0.36 W/C ratio were cast for 7- and 28-days water curing. Superplasticizer is added at the dosage of 1% by weight of binder. The percentage of steel fibers was considered as 0%, 0.5%, 1%, 1.5%, and 2% by weight of binder. Basically, the two essential properties have been studied in this investigation i.e. strength and workability. Workability tests performed were slump flow, V- funnel and L-box. Compressive and Split Tensile strength test has been studied for determining strength. Superior strength was observed at optimum dosage of steel fibers at 1.5% by weight of binder.*

***Key Words*: Self-compacting concrete, Steel fibers, Rice husk ash, Fly ash, SFRSCC**

1.INTRODUCTION

Self-Compacting Concrete (SCC) is a special type of concrete that can flow and compact under its own weight. SCC is suitable for placing in structures with congested reinforcement without vibration due to its excellent deformability and it also helps in achieving higher quality of surface finishes. SCC possesses enhanced qualities and improves productivity and working conditions due to elimination of compaction. Fibers are added to enhance its ductility, toughness and to reduce drying shrinkage [1]. Steel fibers acts as a bridge to retard their cracks propagation, and improve several characteristics and properties of the concrete [2]. Steel fiber is a metal reinforcement. A certain amount of steel fiber in concrete can cause qualitative changes in concrete's physical properties. Steel fibers are well known to improve the resistance to crack growth thereby improves the mechanical properties. But the problem with steel fibers reduces the workability [3]. Ordinary Portland Cement (OPC) is becoming an energy exhaustive and pricey constituent in the production of concrete. Although the requirement is vast, the raw materials required for the cement production is relatively less. One of the efficient methods to conserve the natural resources and reduce the impact on the environment is to go for SCMs, wherein the quantity of OPC can be saved. Since most of the SCMs are waste materials, blending of them in concrete becomes a safe and effective disposal method. Some of the waste materials which improve the properties of concrete are fly ash, Ground Granulated Blast Furnace Slag, silica fume, rice husk ash, copper slag and so on [4]. Fly ash is a byproduct of burned coal from power station and rice husk ash is the byproduct of burned rice husk at higher temperature from paper plant artificial fibers are commonly used nowadays in order to improve the mechanical properties of concrete [5].

2. MATERIALS AND METHODOLOGY

This chapter deals with the experimental program particulars that is the materials used, mix details, casting procedure, curing and testing procedures are explained.

2.1 Materials:

Cement: Cement is a grey color fine powder, which is a mixture of calcareous and argillaceous material used for binding between the materials of concrete. Ordinary Portland Cement of 53 grade confirming to be IS 12269:1987 is used. Specific gravity being 3.12 gm/cc.

Fine aggregate: Locally available river sand passing through 4.75mm sieve and retaining on 0.125mm sieve, confirming to IS 2386-1975 are used as a fine aggregate.

Coarse aggregate: Coarse aggregate used for the preparation of SCC was 12mm in size obtained from the local crushing plant confirming to IS: 2386-1975 is used in the present study.

Fly ash: Class F grade dry Fly Ash of specific gravity 2.15 confirming to IS 3812-2003 is used.

Rice husk ash: Rice Husk Ash is collected from Vijay Mamra factory, Gondal which was obtained from burning of puffed rice and rice flakes at almost 900^{o}C. Ignition loss is found to be 5% and the Specific gravity of RHA is determined as 1.82.

Steel Fibers: Steel fibers are made up of steel which are of different lengths and diameters. They are of different types i.e. hooked end steel fiber, rolling edge steel fiber, crimped steel fiber, micro steel fiber etc. The length of the steel fiber varies from 20mm to 60mm and diameter sizes varies from 0.55mm, 0.75mm and 0.9mm respectively. It is used in the concrete to increase the strength of the concrete. The fibers used are hooked end steel fibers of 40mm length and 0.75mm diameter (aspect ratio being 53) which are randomly oriented and uniformly distributed.

Superplasticizer: Superplasticizer is a chemical admixture used to increase the workability of the concrete. It also reduces water-cement ratio without negatively affecting the workability of concrete. The superplasticizer used in this study is Poly-carboxylate ether.

Water: Portable water free from impurities, oils, acids and salts is generally considered for mixing concrete.

2.2 Mix design:

Mix design is a term used for determining quantities of different constituents. The target mean strength was 48.25 MPa (M40) for the Ordinary Portland Cement control mixture. The quantities of cement, coarse aggregate, fine aggregate, fly ash and rice husk ash were found out.

Table 1: Mix Proportion for Self-compacting Concrete

Cementi tious material (kg/m³)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)	W/C Rati o	Super-plasticizer (%)
470	930	816	0.36	0.01

2.3 Experimental programme:

Initially, a test was conducted for 28 days of compressive strength to know the optimum percentage replacement of rice husk ash with four different mix proportions 5%, 10%, 15% and 20% whereas fly ash percentage was kept constant at 15% of Binder. For this, 3 cubes for each mix were prepared, the results of which are given in Table 2.

Table 2: Compressive strength of 28 days

Rice Husk Ash %	28 days compressive strength (N/mm²)
5%	44.9
10%	46.1
15%	48.3
20%	46.8

From the above results, it is observed that 15% replacement of rice husk ash is giving more strength whereas further increase in RHA% decreases the strength. Therefore 15% rice husk ash is taken as the optimum replacement percentage and further experiments with different proportions of steel fibers are determined.

Afterwards, five mixes with 0%, 0.5%, 1.0%, 1.5% and 2.0% of fibers by weight of binder is considered and remaining materials are kept constant. They are designated as M-1, M-2, M-3, M-4 & M-5 where M-1 is considered a conventional mix when comparing mechanical properties of SCC.

2.3 Tests on concrete:

Tests on concrete are performed as a part of quality control of concrete structures. The basic tests to be conducted in the lab as well as in the field based on the state of concrete are given below:

1. Tests on fresh SCC
2. Tests on hardened SCC

2.3.1 Tests on fresh concrete

For determining the self-compatibility properties, following tests were performed on all mixtures:

1. Slump flow test
2. V-Funnel test
3. L-Box test

2.3.2 Tests on hardened concrete:

For studying the mechanical properties of concrete, following tests were performed on all the mixtures.

1. Compressive strength test
2. Split tensile strength test

3. RESULTS AND DISCUSSION

Each mix is tested for fresh concrete properties and hardened properties. Fresh properties of self-compacting concrete are tested as per EFNARC Guidelines. The results of which are as shown in Table 3.

Table 3: Fresh properties of concrete

Property	M-1	M-2	M-3	M-4	M-5
Slump (mm)	650	635	622	610	644

L-Box (ratio)	0.90	0.87	0.84	0.80	0.79
V-funnel (sec)	9	11	12	14	19

The strength test on concrete is conducted as per IS 516-1959. Compressive and Split Tensile Strengths are shown in the tables below.

3.1 Compressive strength:

Compressive strength of concrete is considered with the strength of 150mm cube. Total 30 cubes are cast and cured for 7 days and 28 days. Compressive strength results are shown in Table 4.

Table 4: Compressive strength results

Mix	7 days	28 days
M-1	28	47.5
M-2	29.5	48
M-3	30	49
M-4	32	51
M-5	31	49.5

3.2 Split tensile strength:

Split tensile strength is done by using 150mm diameter and 300mm height cylinders. Totally 30 cylinders are cast to 5 mixes for 7, 28 and 56 days. Split tensile strength results are shown in Table 5.

Table 5: Split tensile strength results

Mix	7 days	28 days
M-1	2.46	3.05
M-2	2.55	3.32
M-3	2.96	3.54
M-4	3.52	3.80
M-5	3.12	3.53

4. CONCLUSIONS

Based on the present investigation, the following conclusions are drawn:

1. The increase in the percentage of fibers decreases the workability of self-compacting concrete.

2. Compressive strength for 28 days was optimum when 15% of cement is replaced by rice husk ash. Therefore 15% RHA and 15% FA can be considered as the optimum replacement.

3. It is also observed that the compressive strength and split tensile strength increases with the increase in Steel fibers up to 1.5% whereas further increase in steel fibers decreases the strength.

ACKNOWLEDGEMENT

It's a great pleasure to submit the research paper titled "Study on steel fiber reinforced self-compacting concrete using fly ash and rice husk ash". I wish to express my gratitude and sincere regards to my guide, Dr. P. O. Modani, for his valuable guidance, encouragement and motivation. His valuable suggestion and friendly discussions helped me a lot in selecting this topic and in preparation and completion of project report. I would also like to extend my gratitude to the principal sir, Dr. P. M. Jawandhiya for providing me with all the facility that was required. Also, I would like to thank all those who directly and indirectly helped me during my project work.

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