TO STUDY THE PROPERTIES OF STEEL FIBER REINFORCED SELF-COMPACTING CONCRETE (SFR-SCC) USING RICE HUSK ASH (RHA)

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***Abstract*:** This study is done to check the properties of steel fiber reinforced self-compacting concrete using Rice husk ash (RHA). Basically the two essential properties has been studied i.e. strength and workability and also on some other properties such as segregation and bleeding. Some of the workability test are performed i.e. Slump flow, J-ring, V- funnel and L-box. From the study it is found that the steel fiber increases the strength of SCC but reduces the workability and increases the segregation and bleeding whereas the RHA reduces the segregation and bleeding but it also reduces the workability of the SCC. The result on an experimental program is done to explore the use of steel fiber and RHA in SCC in addition from through the volume of concrete. SCC mixes were designed and steel fiber and RHA were added in the concrete in different content (steel fiber= 0, 1%, 2%, 3%, 4%, 5% and RHA= 0%, 1%, 1.5%, 2%, 2.5%, 3%).

Keywords: Steel fiber, Rice husk ash (RHA), Self-compacting concrete, Strength, Workability.

INTRODUCTION

The application of Steel Fibre Reinforced Self-compacting Concrete (SFRSC) in the construction of structural elements is seen as an alternative solution to the complication in placing the reinforcement and compaction of normally vibrated concrete but by using steel fibre in self-compacting concrete the bleeding and segregation increases and workability reduces so, we use an alternative called Rice husk ash (RHA) which is used to provide resistance to segregation and bleeding but it also reduces the workability of SCC. This review has been done to study the properties of steel fibre reinforced self-compacting concrete (SFR-SCC) using rice husk ash and to analyse the strength, workability, segregation, viscosity etc. properties of steel fibre reinforced self-compacting concrete using rice husk ash. Large volume of rice husk is thrown in open land in nearby areas and it increases the environmental pollution. So, a considerable factor has made the idea of utilizing rice husk ash in concrete. The rice husk ash has rough surface and abrasive nature.

Self-compacting concrete is a mixture of different materials like cement, coarse aggregate, fine aggregate, water and chemical admixture. Self-compacting concrete is a concrete having high flow-ability, high deformability and good resistance to segregation and bleeding. There is no need of vibrators for the compaction of self-compacting concrete. For good and economical concrete the materials should be selected properly and accurate mix- design should be made. The testing of materials should be done as per IS code.

MATERIALS

1) CEMENT

OPC-43 has been used for this study, physical properties of OPC-43 is given in table 1.

Table 1 Physical properties of OPC-43

Characteristics	Test results	Recommended values (As per IS 8112:1989)[26]
Fineness	95%	>90%
Consistency	30%	
Initial setting time	115 minutes	30 minutes (minimum)
Final setting time	225 minutes	600 minutes (maximum)

2) FINE AGGREGATE

Locally available aggregates passing through 4.75mm sieve and retained on 0.7 mm sieve are used as a fine aggregate. The test procedures are as per IS383:1970[23] is carried out to determine the properties of fine aggregate. The physical properties of fine aggregate is given in table 2.

Table 2 Physical properties of fine aggregate

Characteristics	Test results	Recommended values
Grading zone	Zone II	
Fineness modulus	4.123	
Specific gravity	2.65	2.65-3.0
Silt content	4.41%	5%

3) COARSE AGGREGATE

Locally available aggregate of 10 mm size.

Having specific gravity of 2.67

4) STEEL FIBRE

It is made up of steel which are of different lengths and of different diameter and are of different types i.e. rolling edge steel fiber, hooked end steel fiber, micro steel fiber etc. The length of the steel fiber varies from 1 to 2 inches 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.

5) RICE HUSK ASH (RHA)

Rice husk ash is used in concrete construction as an alternative of cement and also in the addition form. The rice husk ash possesses a chemical composition similar to many of the organic fibres. Rice husk ash consists of the following:

- Cellulose ($C_5H_{10}O_5$)
- Lignin ($C_7H_{10}O_3$)
- Hemicellulose
- SiO_2 (silicon di oxide) silica.
- Holocellulose

6) ADMIXTURE

Super plasticizer (poly carboxylate ether) is a chemical admixture used to increase the workability of the concrete. And it also reduces water-cement ratio without negatively affecting the workability. From the code IS 9103:2007[25]. The properties of super-plasticizer is given in table 3.

Table 3 properties of super plasticizer

Properties	
Specific gravity	1.15
Chlorides	Nil
Nitrates	Nil
Sulphates	0.5%
Appearance	Straw coloured liquid
Freezing point	+5 ^{0}C material can be reconstructed by agitating at 30 ^{0}C
Role in concrete	Improves workability and flow properties of concrete

EXPERIMENTAL PROCEDURE

Six batches of mix is prepared in this study by adding steel fiber and rice husk ash (RHA) in different percentages (0%, 1%, 2%, 3%, 4%, 5%) to the volume of the concrete. To check the strength of concrete the cubes are casted and tested at 7 and 28 days of curing. And to check the workability of SCC different tests i.e. V- funnel, J-ring, Slump flow and L-box is performed.

Table 4 Mix Design

Cement	W/C	Fine aggregate	Coarse aggregate	Super plasticizer
1	0.45	2.43	1.795	0.01

The six batches concrete are shown in the table 5. The quantity of material used are also shown. The amount steel fiber and RHA used are as Mix 1= 1% of steel fiber and 5% of RHA, Mix 2= 2% of steel fiber and 4% of RHA, Mix 3= 3% of steel fiber and 3% of RHA, Mix 4= 4% of steel fiber and 4% of RHA, Mix 5= 5% of steel fiber and 1% of RHA.

Table 5 Mix proportioning

Trial	Cement (kg/m^3)	w/c ratio	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Admixture (kg/m^3)	Steel fiber (%)	RHA (%)
N. Mix	423	0.45	1027.98	759.30	4.23	0	0
Mix 1	423	0.45	1027.98	759.30	4.23	1	1
Mix 2	423	0.45	1027.98	759.30	4.23	2	1.5
Mix 3	423	0.45	1027.98	759.30	4.23	3	2
Mix 4	423	0.45	1027.98	759.30	4.23	4	2.5
Mix 5	423	0.45	1027.98	759.30	4.23	5	3

RESULTS AND DISCUSSION

WORKABILITY

With increase in the percentage of steel fiber and rice husk ash the workability of concrete decreases which is not essential for SCC. To check the workability of SCC different test are performed such as V-funnel, L-box, J-ring, Slump flow. It is seen that on increasing the amount of steel fiber and rice husk ash the workability decreases because both steel fiber and rice husk ash have a rough surface and abrasive in nature. Due to rough surface they generate the friction which affects on the flow of concrete.

Slump flow test shows the decrease in workability with increase of steel fibre and rice husk ash percentage. This test help in determining the concrete is self-compacting concrete or not. It can be seen in table no. 6 and figure 1 that with increase in the percentage of steel fibre and rice husk ash the flow properties of concrete is decreasing at percentage 3% for Mix 1, 7.4% for Mix 2, 10.6% for Mix 3, 14% for Mix 4, 18.5% for Mix 5.

Table No. 6 Slump Flow

	Flow (mm)
Trail Mix	624
Mix 1	604
Mix 2	578
Mix 3	558
Mix 4	538
Mix 5	510

Graphical representation of slump flow values is given below:

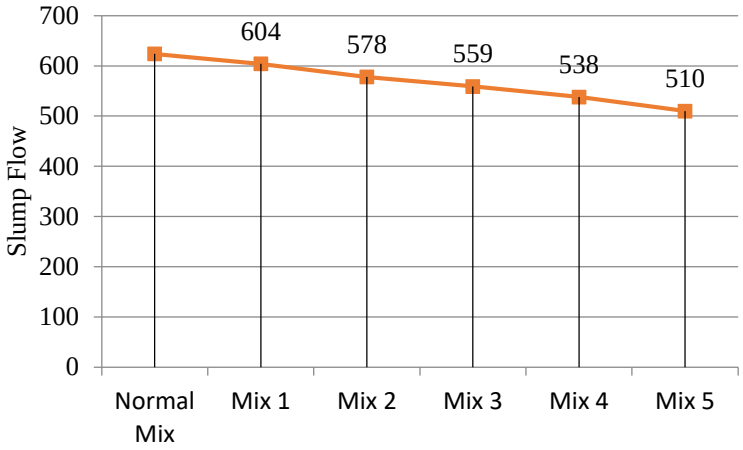

Figure 1. Graphical Representation of slump flow

L Box shows the passing ability of concrete. L Box result shows that passing ability of concrete is decreasing with increase of percentage of steel fibre and rice husk ash. It can be seen in table no. 7 and figure 2 that with increase in the percentage of steel fibre the passing ability of concrete is decreasing at percentage 4% for Mix 1, 6.5% for Mix 2, 8.6% for Mix 3, 13% for Mix 4, 15% for Mix 5.

Table No.7 L-Box

	P_L	B_L
Trail Mix	0.92	0.08
Mix 1	0.88	0.12
Mix 2	0.86	0.14
Mix 3	0.84	0.16
Mix 4	0.80	0.20
Mix 5	0.78	0.22

Graphical representation of L-box result values is given below:

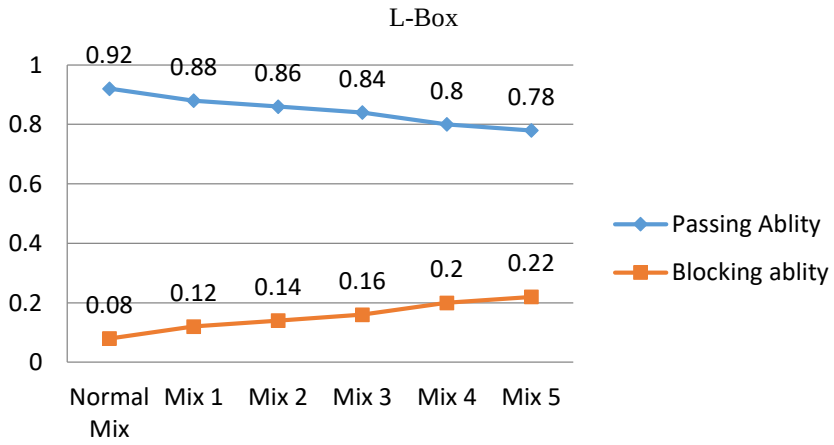

Figure 2. Graphical Representation of L Box

V Funnel shows the flow-ability of concrete. Result shows that increase in the percentage of steel fibre and rice husk ash results in increase in the time. That means flow-ability is decreasing. It can be seen in table no. 8 and figure 3 that with increase in the percentage of steel fibre and rice husk ash the flow time of concrete is increased.

Table No.8 V Funnel

	Time (second)
Trail Mix	7
Mix 1	9
Mix 2	10
Mix 3	12
Mix 4	13
Mix 5	14

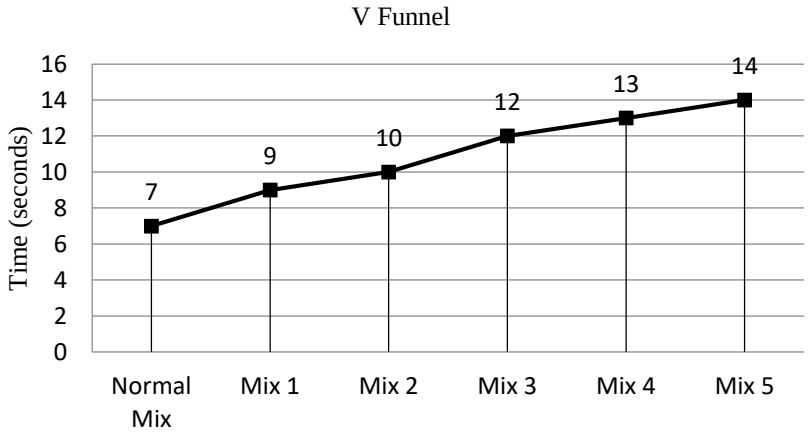

Figure 3. Graphical Representation of V Funnel

J Ring Test is used to determine the passing ability of concrete. Result shows increase in J Ring Value which means decrease in passing ability of concrete. It can be seen in table no. 9 and figure 4 that the J Ring value is increasing with increase in the percentage of steel fibre and rice husk ash thus, the passing ability of concrete is decreasing.

Table No. 9 J Ring

	Slump Flow (mm)	**J Flow (mm)**	**J Ring Result (mm)**
Trial mix	624	612	12
Mix 1	604	590	14
Mix 2	578	562	16
Mix 3	558	538	20
Mix 4	538	512	24
Mix 5	510	478	32

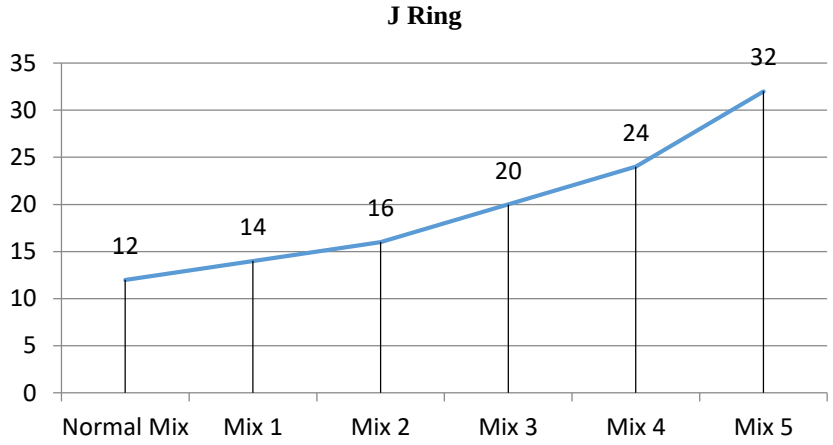

Figure 4. Graphical Representation of J Ring

Due the rough surface of steel fibre and rice husk ash (RHA) the friction in concrete increases which in turns reduces the workability of concrete as result shows that more the amount of steel fibre and RHA is used more will be the friction and results in decrease in the workability of concrete.

Table No.10 Workability of Mixes

S. NO	Cement (kg/m^3)	W/C	F. Agg. (kg/m^3)	C. Agg.(kg/m^3)	C. Adm(kg/m^3)	Steel Fibre (% wt of cement)	RHA(% wt of cement)	L- box	V-funnel	J-ring
N. mix	423	0.45	1027.98	759.30	4.23	0	0	0.08	7	12
MIX 1	423	0.45	1027.98	759.30	4.23	1	1	0.12	9	14
MIX 2	423	0.45	1027.98	759.30	4.23	2	1.5	0.14	10	16
MIX 3	423	0.45	1027.98	759.30	4.23	3	2	0.16	12	20
MIX 4	423	0.45	1027.98	759.30	4.23	4	2.5	0.20	13	24
MIX 5	423	0.45	1027.98	759.30	4.23	5	3	0.22	14	32

COMPRESSIVE STRENGTH

Compressive strength of concrete increases with increase in the amount of steel fibre. At 7 days and 28 days of curing there is an increase of 3%, 8%, 22%, 26%, 36% after 7 days of curing and 3%, 9%, 21%, 28%, 34% after 28 days of curing. The results are shown below in table no 11.

Table No. 11 Compressive strength at 7days and 28 days of curing

S. NO	Cement (kg/m^3)	W/C	F. Agg. (kg/m^3)	C. Agg. (kg/m^3)	C. Adm (kg/m^3)	Steel Fibre (% wt of cement)	RHA (% wt of cement)	Compressive strength at 7 days (MPa)	Compressive strength at 28 days (MPa)
N. mix	423	0.45	1027.98	759.30	4.23	0	0	23.067	34.4
MIX 1	423	0.45	1027.98	759.30	4.23	1	1	23.76	35.56
MIX 2	423	0.45	1027.98	759.30	4.23	2	1.5	24.933	37.43
MIX 3	423	0.45	1027.98	759.30	4.23	3	2	28.26	41.64
MIX 4	423	0.45	1027.98	759.30	4.23	4	2.5	29.033	44.2
MIX 5	423	0.45	1027.98	759.30	4.23	5	3	31.33	46.2

The cubes casted are tested for compressive strength after 7 and 28 days of curing. The machine used for testing compressive strength is shown below in the figure:

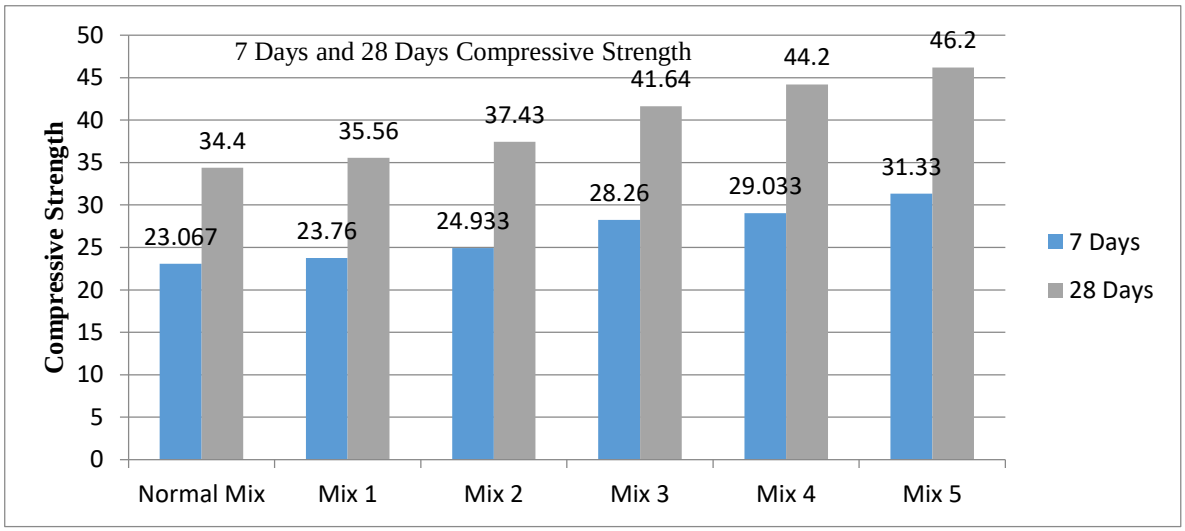

Figure 5. Graphical Representation of Compressive Strength (at 7 days of curing)

CONCLUSIONS

After the study following conclusions are came out as given below:

- On using steel fiber in SCC the compressive strength of concrete increases with increase in the percentage of steel fiber (there is an increase of 3%, 8%, 22%, 26%, 36% after 7 days of curing and 3%, 9%, 21%, 28%, 34% after 28 days of curing).
- The use of steel fiber increases the segregation and bleeding of SCC and also reduces its workability.
- RHA used in the SCC reduces the workability of concrete but it provides resistance to segregation and bleeding of concrete.
- Due to the use of RHA the concrete becomes economical.

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