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Use of Rice Husk and Rice Husk Ash as a Replacement for Cement with Use of Additional Steel Fibres in Concrete

Mohini Ashok Khopade[1], Dr. S.V. Desale[2]

Abstract: Concrete is the most versatile building material after water in our construction industry. As the production of cement is not eco-friendly because during the production of cement there is a large amount of production of CO_2 gas which is very harmful. From the previous concrete study, till now many elements are added in the concrete such as fly ash, red ballast, silica fume, agricultural fibres, organic fibres, glass, etc to enhance the properties of concrete or were also added as a partial replacement of cement. India produces abundant quantity of rice annually, for example in 2019-2020, is 117.47 million tonnes. In this research paper, experimentation is done by using rice husk as well as rice husk ash as a partial replacement of flyash along with steel fibres by 1%, 2% and 3% is provided to procure more strength to the concrete. Steel fibre reinforced concrete is increasingly being used day by day as structural material. The compressive and flexural strength of concrete has been analyzed and compared with a controlled specimen for 7 and 28 days and are expressed graphically.
Keywords: Rice husk and rice husk ash, steel fibres, self-compacting concrete, compressive strength, flexural strength, cement replacement.

I. INTRODUCTION

The use of steel fiber reinforced concrete has rapidly increased during the last 20 years. Substantial development has materialized in the sector of steel-fiber reinforced concrete. In today's world, the steel fibre reinforced concrete is mostly used for heavy pavements, slab tracks, shotcrete linings, in precast elements, etc. According to the ACI, this combination of concrete and steel has more potential for many more application, especially in the field of structural engineering. A number of researchers are assessing the probability of using steel-fiber reinforced concrete. In the designing process of seismic resistant reinforced concrete structures, the most important factors to be considered are ductility and strength, where the structure may be subjected to large distortion. Due to the addition of steel fibres in concrete it shows improvement of many engineering properties of concrete. Most impact is seen in the strength and toughness of concrete. Many other properties are also enhanced like flexural strength, fatigue strength, tensile strength and the ability to resist the cracking and spalling. Among of which the use of agricultural waste has tremendously increased in the last decade. It is eco-friendly as well as economical to use these agricultural wastages. There are a lot of agricultural waste of which rice husk and rice husk ash is used in the above work. Rice husk is the hard-protecting covering of grain of rice. Rice husk can be used in the construction industry, as absorbents of oils and chemical, soil ameliorants, a source of silicon, insulation powder in the steel mills, as catalyst support, etc. The annual production of rice husk is approximately 120 million tons around the world which is the reason of its abundance of availability.

Self-compacting concrete is a concrete that has excellent deformability and high resistance and can be filled in heavily reinforced area without applying vibration. An effective method to produce the self-compacting concrete is that to increase the fine material in the concrete mix without increasing the cost. SCC was initially not used much due to its high cost compared to the conventional concrete, but now-a-days number of research institute and construction companies have undertaken the R and D work on SCC. This research aims for high strength concrete attained with economy by the use of rice husk ash as well as steel fibres, which are agricultural and industrial waste which are abundantly available and very low in cost. Due to the replacement of cement also reduces the amount of cement used during concrete

II. LITERATURE REVIEW

All over the globe, the construction activity is increasing with a tremendous boost, in which the most important factor of the structure is concrete, it consists up to the mark satisfactory qualities like durability, strength, economy, etc. Hence, its applications are wide like dams, bridges, culverts, tunnels, industrial, residential as well as commercial buildings, etc. There are lots of types of concrete available in the market for particular use like high performance concrete, low heat concrete, white concrete, etc. From the list of concretes available, the OPC (Ordinary Portland Cement) is widely used amongst all the concrete, but during the production of OPC there is a release of significant amount of CO_2, the hazardous greenhouse gas(GHG). The production of one ton of portland cement leads to the production of one ton of CO_2. The aim of the research is to utilize the rice husk ash as replacement for cement in concrete in order to increase the strength, bonding between the particles and cement paste.

Industrial waste like blast furnace slag, fly ash and silica fume are used as supplementary cement replacement material. When this husk is burned under controlled conditions, it gives ash having amorphous silica, which has pozzolonic properties. Hence, the rice husk ash is used as a replacement of cement to improve the quality and reduce the cost of the construction as well as reducing the environmental pollution.

III. TESTING OF MATEERIALS

Following tests are conducted for the ingredients i.e. cement and sand.

A. Materials Used

1) *Cement*- Portland Pozzolona Cement (PPC) 53 Grade
2) *Sand*- River sand (locally available)
3) *Aggregate*- 10mm and 20mm (locally available)

Tests on Cement

SR NO	DESCRIPTION	VALUE
1	Specific gravity	3.15
2	Fineness (by sieve analysis)	3.2%
3	Consistency	31%
4	Initial setting time	720 minutes Min 30 minutes
5	Final setting time	330 minutes Max 600 minutes
6	Compressive strength (3,9,28)	27,39,55 MPa 27,37,53MPa

Table no 1- Test results of cement (Specifications as per IS 8112-1986)

Test results of Coarse Aggregate

SR NO	DESCRIPTION	VALUE
1	Specific gravity	2.65
2	Fineness modulus	3.3
3	Water absorption	2%
4	Surface moisture	0.08%
5	Aggregate impact value	24.40%
6	Aggregate crushing value	21.40%
7	Bulk density	1642.50 kg/m^3

Table no 2-Test results of coarse aggregate.

Rice husk and rice husk ash- (locally available)

Rice husk consists of approximately 50% of cellulose, 25% of hemi cellulose and 25% of lignin. Each ton of rice husk generate approximately 26% of baggase (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion present a chemical composition dominates by silicon dioxide SiO_2. The detailed chemical composition is shown below and also physical properties of rice husk ash.

Rice husk constitutes about 20% of the weight of rice and its composition is as follows: cellulose (50%), lignin (25%–30%), silica (15%–20%), and moisture (10%–15%). Bulk density of rice husk is low and lies in the range 90–150 kg/m^3.

Below are the chemical and physical composition of rice husk ash.

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CHEMICAL COMPOSITION	RESIDUAL RICE HUSK ASH(%)
SiO_2	86.94
Al_2	0.2
Fe_2O_3	0.1
CaO	0.3-2.2
Na_2O	0.1-0.8
K_2O	2.15-2.30
MnO	0.2-0.6
TiO_2	0.50
BaO	<0.16
P_2O_5	1.07
C	2.25
Others	1.75

Table 3- Chemical composition of Rice husk residual ash

COMPONENT	MASS(%)
Specific gravity	2.05
Blaine surface area(cm^2/gm)	11770 m
Particle size(µm)	25µ mean size
Colour	Grey
Odour	Odourless
Physical state	Solid
Appearance	Very fine powder
Loss of ignition	2.33%
Pozzolonic Activity Index	99%

Table 4- Physical properties of Rice husk ash

B. Steel Fibres

Crimped steel fibres are used. Crimped steel fibres are low carbon, cold drawn steel wire fibers designed to provide concrete with temperature and shrinkage crack control, enhanced flexural reinforcement, improved shear strength and increase the crack resistance of concrete.

With the addition of steel fibres to concrete, its properties are altered from brittle to ductile. Addition of steel fibres to concrete results in better ductility and higher load carrying capacity compared to concrete with normal strength steel fibres. In the absence of the main reinforcement bars. Use of optimum steel fibres weight ratio in high strength concrete produces high performance bending elements having elastic-plastic behavior similar to that of normal strength concrete members.

Sr. No.	Property	Value
1	Fiber type	Crimped type fiber
2	Length	30 mm
3	Diameter	0.5mm
4	Density	7850kg/m^3
5	Tensile strength	940MPa
6	Aspect ratio	60

Table 5- Properties of Crimped steel fiber

CHEMICAL COMPOSITION	PERCENTAGE
C	0.074
Mn	0.36
Si	0.065
P	0.01
S	0.009

Table no 6- Chemical composition of mild steel wire

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IV. EXPERIMENTAL WORK

Fresh concrete test such as slump cone test were carried out according to IS 1199-1959. Also the test on hard concrete like compressive test and flexural strength are carried out for 7 and 28 days.

A. Compressive Strength

Concrete mixture can be produced by hand mixing, then water by considering w/c ratio at 0.4. After mixing the concrete prepared is poured into assembled moulds of block in the 3 layers by giving 25 blows for each layer for better compaction. The dimensions of the blocks are 150x150x150mm. Then after 24 hours the moulds were erected and cured for 7-28 days in the tank. After the completion of the curing process the specimens were undergone for further testing in the laboratory for the compaction testing machine as per norms of IS 516-1959. For each batch of mixture three specimens were tested and the failure values were noted. Then compressive strength of cubes can be determined by using formula that is compressive strength of cubes=load of fracture/ area of cross section. The arranged value can be taken from the 3 specimen of compressive strength test and the results are tabulated in table no.

B. Flexural Strength

Flexural strength is one which measures the tensile strength and also unreinforced concrete which resist failure load in bending. It is also known as modulus of rupture or fracture. To test, the beam specimens of dimension 150x150x700mm were cast. After the casting of beams, curing was done, de-moulded and transferred to the curing tank and were allowed to rest for 28 days. The strength was tested under two-point loading as per I.S.516-1959, the effective span was divided into three equal parts. The beams were rested on a testing machine to check their strength. While testing was done the load was increased gradually and the failure of the beams was noted at which the beam was cracked. For each percentage of mix two beams were tested and the average value was considered.

The flexural strength can be calculated by the below formula

$$\text{Flexure strength (MPa)} = \frac{PxL}{bxd^2}$$

where,
P = Failure load,
L = Distance between the supports from centre to centre
b=Specimen’s width = 150mm,
d =Specimen’s depth = 150mm

Below figure 1 shows the flexural strength of plain cement concrete beam and steel fibre rice husk and rice husk ash beam. The results are shown in the table no and further graphical representation is done.

Figure 1. Flexural strength of plain cement concrete beam after testing

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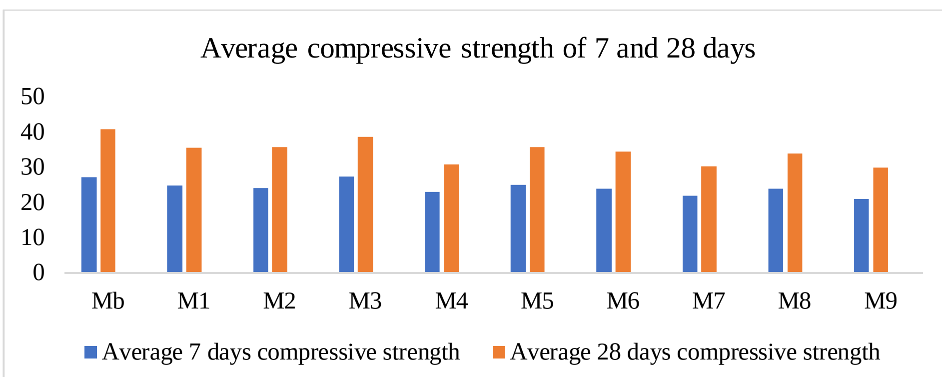
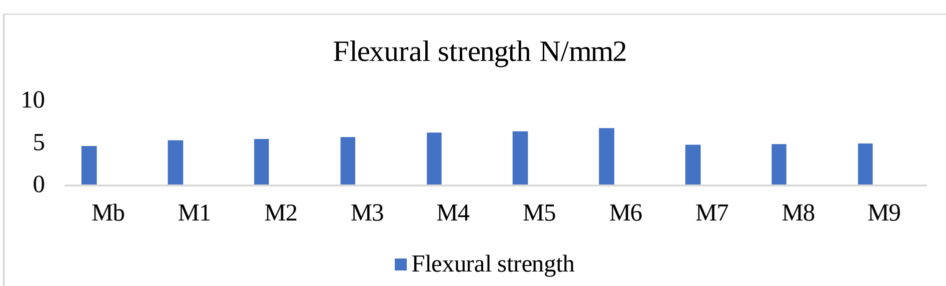
Figure 2 Flexural strength of steel fibre rice husk and rice husk ash beam after testing

Rice husk and rice husk ash	Mix	Steel Fiber	Average 7 days compressive strength N/mm^2	Average 28 days compressive strength	Flexural strength N/mm^2
0%	Mb	0%	27.09	40.69	4.62
10%	M_1	1%	24.85	35.46	5.31
	M_2	2%	24.12	35.75	5.49
	M_3	3%	27.32	38.51	5.66
20%	M_4	1%	22.96	30.51	6.19
	M_5	2%	24.99	35.67	6.36
	M_6	3%	23.90	34.37	6.73
30%	M_7	1%	21.94	30.22	4.74
	M_8	2%	23.83	33.86	4.88
	M_9	3%	21.02	29.93	4.95

Table no 7 Results of the compressive strength testing and flexural testing



Graph 1 Average compressive strength at 7 and 28 days



Graph 2 Flexural strength for various mixes

V. CONCLUSION

A. Rice husk ash increases the workability of fresh concrete and the relative density decreases.
B. 10% and 20% of fine aggregate can effectively be replaced with a rice husk ash without considerable loss of workability.
C. The replacement of cement by rice husk and rice husk ash gives increase in the compressive strength upto 10% after 20% and 30% compressive strength may decrease.
D. The compressive strength results in the specimen at 7 and 28 days. Increase with 10% and 20% rice husk and rice husk ash by fine aggregate.
E. Replacement of rice husk and rice husk ash in cement by 10% and 20% in flexural strength and decrease by increasing upto 30%.
F. When the steel fibres add in concrete then the concrete converts from brittle to ductile, steel fibres improves the ductility of concrete. The compressive strength of concrete is slightly increased with the increase of steel fibres from 35.75 to 38.51 i.e. 2.76 N/m^2.

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