ANALYZING THE ENGINEERING PROPERTIES OF CONCRETE CEMENT WITH RHA & STEEL FIBER

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Abstract - *Concrete has basic naturally, cheaply and easily available ingredients as cement, sand, aggregate and water. After the water, cement is second most used material in the world. But this rapid production of cement creates two big environmental problems for which we have to find out civil engineering solutions. In addition, Due to increasing environmental awareness as well as stricter policy on managing industrial waste, the world is progressively more spinning to researching properties of industrial waste and judgment of solutions on using its valuable component so that those might be used as secondary raw material in other industrial branches. The present experimental investigation is done to study the effect of partial replacement of cement by Rice husk ash (RHA) with using Steel fibre in concrete. The experimental investigation carried out on steel and concret soil uses have fibre up to entire fibre volume portion of 0.5%, 1%, 1.5% and 2.0 % and cement was partially replaced with 10%, 20%, 30% and 40% of RHA on the basis of previous research results. The engineering properties like compressive strength, splitting tensile and flexural strength were studied for concrete prepared. All results were determined at the age of 7, 14 and 28 days of curing. The laboratory results showed that addition of steel fibres reinforced RHA into concrete increases the mechanical properties.*

***Key Words*: Cement Concrete, Rice Husk, Steel Fibres, Environment, Engineering Properties, Durability.**

1. INTRODUCTION

Concrete is the most significant constituent for the growth of infrastructure, buildings, industrialized structures, flyovers and highways etc. In today's circumstances concrete needs extraordinary combinations of appearance and uniformity necessities that cannot be always achieved by using conventional constituents and normal and the one of the important mixing. Construction industry is one of the highest increasing sectors in India. Rapid construction action and rising requirement of houses has guide to the short fall of conservative building supplies like bricks, cement, sand and wood. Requirement of good features of building supplies to replace the conservative materials and the requirement for cost effective and durable materials for low cost construction has necessitated the researchers to expand variety of new and inventive construction materials. As we know Concrete is a versatile construction material. Firstly it was innovated as protective cover of steel members, after that it was revised and now a day's concrete is worn as a structural member and steel is provided to adapt its properties and give better strength to the concrete. Concrete has benefits like fire resistance, excellent resistance to water, has ability to mould into various shapes and sizes easily as per requirement, economic and readily available material on the work site. It was observed that the normal concrete have many inadequacy such as low value of strength to weight ratio since compared to steel. So because to overcome this inadequacy resulted in the growth of high strength concrete.

Rice milling generates a byproduct known as husk and this husk is converted in to ash is known as rice husk ash. This RHA contains approximately 85-90% silica. Silica is the basic component of sand which is used with cement for plastering and concreting. Rice husk is afarming deposit which accounts for 20% of the 649.7 million tons of rice formed per annum global. Flaming the husk under prohibited temperature below 800°C can manufacture ash with silica mainly in amorphous form.

Today and the have parts enthused from the antique application of techniques artificial fibers are commonly used now a day in arrange to progress the mechanical properties of concrete. It is essential to find out substitute materials for pavements to meet the necessities of bitumen for the forthcoming years, to afford sufficient serviceability at lowest amount, to make the eco-friendly pavements with security, and speed for the run of traffic.

RICE HUSK ASH (RHA)

Rice husk is an agricultural dump consisting of non-crystalline silicon dioxide with high face area and high pozzolanic reactivity; therefore due to growing environmental apprehension and the requirement to defend energy and resources, consumption of industrial and biogenic waste as supplement material has become an necessary part of concrete construction. Pozzolonas progress strength because they are small in size while compared to the cement particles, and can set in between the cement particles and provide a greater pore structure. RHA has two parts in concrete production, as as will they a alternate for Portland cement, dropping the cost of concrete in the manufacturing of low priced building blocks, and as an admixture in the manufacture of high strength concrete.

STEEL FIBRE REINFORCED CONCRETE (SFRC)

Steel Fibers are of wire, distorted and cut to lengths, for a reinforcement of concrete, mortar and extra composite material. The occurrence of micro cracks in the mortar-aggregate boundary is responsible for the intrinsic weakness of plain concrete. The limitation can be disinterested by enclosure of fiber in the mixture. Dissimilar types of fibers, such as individuals used in conventional composite materials can be introduced addicted to the concrete mix to enlarge its robustness, or capability to oppose crack growth. The fiber assists to convey loads at the internal micro cracks.

1.1 LITERATURE REVIEW

Mehta and Pirth 2000, investigated the use of RHA (Rice Husk Ash) to reduce temperature in high strength mass concrete and concluded that RHA is very effective in reducing temperature of mass concrete compared to OPC concrete. RHA which is an agricultural by-product has been reported to be a good pozzolanic material by numerous researchers.RHA is obtained after burning of rice husk at a very high temperature

Malhotra and Mehta 2004, reported that ground RHA with fine particle size than OPC improves concrete properties, including higher substitution amounts in lower water absorption value sand the addition of RHA caused an increment in the compressive strength.

Adewuyi and Ola 2005, have carried out research on the binary blends of OPC with different pozzolanic material in making cement composites. Supplementary cementious materials have been proven to be effective in meeting most of the requirements of durable concrete so the important.

Batson and Romualdi 2000, presented that the first crack strength of concrete improves by mixing closely continuous steel fibers in it. These steel wires act as crack arresters preventing the advancing micro cracks by applying pinching forces at the crack tips and thus delaying the propagation of cracks. The existence of crack arrest mechanism in closely spaced wire reinforced concrete also suggests that the increase in strength of concrete is inversely proportional to the square root of the wire spacing.

Elsaigh et al. 2005,carried out investigation on steel fibre reinforced concrete for road pavement applications. In this paper, they established that the use of SFRC for road pavements and compare its execution with plain concrete under traffic loading. The determining of SFRC properties on performance and design aspects of concrete roads are discussed. Results coming out from road trial sections, tested under in-service traffic, are used to validate the use of the material in roads.

Khan et al. 2013,performed on steel fibres to increase the load carrying capacity of concrete members. Fibres substantially reduce the brittleness of concrete and improve its engineering properties, such as tensile, flexural, impact resistance, fatigue, load bearing capacity after cracking and toughness. It shows a review of research performed on Steel Fibre reinforced concrete. The performance of the Steel Fibre Reinforced Concrete (SFRC) has shown a significant improvement in flexural strength and overall toughness compared against Conventional Reinforced Concrete.

1.2 SUMMARY OF MIX DESIGN OF CONCRETE

Material – Cement-A.C.C. (OPC 43 Grade), Sand – Narmada Sand, Coarse Aggregate- 20 mm & 10 mm.

Design Stipulations -

- Characteristic compressive strength necessary – 30 mpa. In field at 28 Days.
- Maximum size of aggregates – 20 mm (Angular)
- Degree of Workability – medium
- Degree of Quality Control – Good
- Types of expose – Moderate

Test Data for material –

- Type of cement – Cement - Ultra Tech (OPC 43 Grade)
- Specific gravity of cement - 3.15
- Specific gravity of coarse Aggregate - 2.70
- Specific gravity of Fine Aggregates - 2.60
- Water absorption for

  Coarse Aggregate - 0.50%

  Fine Aggregate - 1.50%
- Free surface Moisture

  Coarse Aggregate - 1%

  Fine Aggregate - 2%
- Sieve Analysis

S.No	Sieve Size	C.A(% Passing)	F.A(% Passing)
1	40 mm	100	
2	20 mm	53.6	
3	10 mm	12.8	
4	4.75 mm	01.0	98.8
5	2.00 mm		86.9
6	1.00 mm	-	50.9
7	600 mm	-	36.9
8	425 mm	-	30.4

9	300 mm	-	21.4
10	150 mm	-	16.4
11	75 mm	-	14.2

(Coarse Aggregate and Fine Aggregate sieve analysis tests are practiced as per IS Code – 4031 – 1968 and IS -383 -1970 respectively).The proportion between (20mm & 10 mm) is 50%:50%

Target Lab Strength - 28 days 30 + 1.65 × 6.0 = 39.9Mpa

Mix Proportion – The designed mix proportion on the basis of properties of the supplied ingredients material are as follows:

Water: Cement: F.A: C.A

180.6Litre: 430.00kg: 542.91kg: 1226.36kg

1.00: 1.26: 2.85

Quantities required- the mix per bag of cement

1. Cement
2. Fine Aggregate
3. Coarse Aggregate

   Fraction - I (20 mm) 50%- 71.25 kg

   Fraction – II (10 mm) 50%- 71.250 kg

Water

1. For w/c ratio 0.42 quantity = 21.0 liter
2. Additional quantity of water to be added for absorption in case of coarse Aggregate at 0.50% by mass = 0.7125 liters
3. Quantity of water to be reduced for moisture present in Fine Aggregate at 1.5 % by = 0.945 liter
4. Actual quantity of water mass required to be added= 21.0+ 0.7125–0.945= 20.7670 liters

Actual quantity - fine aggregate required after allowing for mass of free moisture= 63.0 + 0.945 = 63.945 kg

Actual quantity - coarse Aggregate Required

Fraction - I (20 mm)--71.25 kg – 0.356 = 70.894 kg

Fraction – II (10 mm)--71.25 kg – 0.356 = 70.894 kg

The actual quantities- different constituents required for one bag mix are

1. Water - 20.767 litre
2. Cement - 50 kg
3. Sand - 63.945 kg
4. Coarse Aggregate

   Fraction - I - 70.894 kg

   Fraction - II - 70.894 kg

Actual mix proportion- per cubic meter quantities are qty :

Water : Cement : F.A : C.A

178.60 Liter 430.00 kg 549.92 kg 1219.37 kg

1.00 1.27 2.83

7 days Lab Strength of (3 cubes) are:

1. 30.00Mpa
2. 30.00Mpa
3. 30.00Mpa

   Average- 30.00Mpa.

28 days Lab Strength of (3 Cubes) are:

1. 42.00Mpa
2. 42.00Mpa
3. 43.00Mpa

Average- 42.33Mpa

Water	Cement	Fine Aggregate	Coarse Aggregate
178.60 Liter	430.00 kg	549.92 kg	1219.37 kg
0.42	1	1.270	2.830

2. RESULTS AND DISCUSSION

SLUMP TEST (WORKABILITY): Slump cone test was conducted on all samples. Concrete mix with 30% RHA gave the highest slump with 38 mm while steel fiber addition showed a slump measurement of 36 mm to 31 mm. Graph shows the reduction in slump measurement when fiber was added. This result shows that concrete mix with higher fiber content of a constant w/c ratio will give a lower workability as the stability of concrete mix with support cement and the soil of fibers.

Table1: Workability Test results of cement replaced with RHA

S.No	RHA(%)	Weight of RHA in Mix(Kg)	Slump Value (mm)
1	0	00	40
2	10	43	37
3	20	86	35
4	30	129	32
5	40	172	28

Table2: Workability test of concrete with 30% RHA and Different % of steel fiber

S.No	RHA (30%) + Steel Fiber %	Weight of RHA in Mix (Kg/cum)	Weight of Steel Fiber in Mix (Kg/cum)	Slump Value (mm)
1	0	129	00	38
2	0.5		40	36
3	1.0		80	35
4	1.5		120	32
5	2.0		160	31

COMPRESSIVE STRENGTH TEST:

In this study, the mix was done by manually. The cement and fine aggregate were first assorted dry to uniform color and then coarse aggregate was additional and mixed with the combination of cement and fine aggregates. Water was then added and the whole mass mixed. The fibres were added just before adding water and mixed dry thoroughly. Same in the case of RHA, cement in different percentages was replaced with RHA and added before adding water. The internal surface of the specimen moulds and the bottom plate were oiled before concrete was placed. After 24 hours the specimens were detached from the moulds and placed in dirt free clean water at a temperature of $27^0 \pm 2^0$C for 28 days curing. For testing in firmness, no cushioning material was placed among the specimen and the plates of the machine. The load was applied axially with a uniform rate of 140 kg/min without shock till the specimen was crushed. Test results of compressive strength test at the age of 28 days are given in the Table 4.2. The cube strength results of concrete mix are also shown graphically.

Test specimens of size 150×150×150 mm were casted for testing the compressive strength of both controlled as well as RHA-steel fiber reinforced concrete. The modified concrete mixtures with varying percentages of steel fibers and fractional replacement of cement with RHA were prepared and cast into cubes.

Table 3: Details of Compressive Strength test with various % of RHA

Mix	Average Compressive Strength (N/mm^2)		
	7 days	14 days	28 days
0 %(Control)	28.23	34.4	39.15
10%	29.14	36.23	40.27
20%	29.75	36.95	41.15
30%	31.27	38.15	44.360
40%	28.15	33.25	38.800

Table 4:Test results of compressive strength of dissimilar mix with different percentage of 30 % RHA & Steel fiber

S.No	RHA (30%) + Steel Fiber %	Average Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
1	0 %(Control)	31.27	38.15	44.36
2	0.5%	31.50	38.60	44.68
3	1.0%	32.43	39.85	46.76
4	1.5%	31.25	38.00	43.50
5	2.0%	30.10	37.250	43.150

SPLIT TENSILE STRENGTH:

The split tensile strength of all the mixes was determined at the ages 28 days for various replacement levels of RHA and variable percentages of steel fibers in concrete mix. The 150mm × 300 mm size cylinders were casted and tested in the compression testing machine with a uniform rate of 180 kg/min. The results of split tensile strength of concrete are reported in Table 4.3 shows the gain in split tensile strength for different levels of RHA replacement with concrete and addition of steel fiber at different time. The split tensile strength results of individual concrete mix are also shown graphically. From the results, it is observed that the optimum value of split tensile strength is achieved with addition of 1% of steel fiber in controlled concrete mix.

Table 5: Details of Split Tensile Strength test with different % of RHA

Mix	Average Split Tensile Strength (N/mm^2)		
	7 days	14 days	28 days
CM	2.46	2.77	3.18
10%	2.58	2.92	3.300
20%	2.65	3.05	3.420
30%	2.82	3.23	3.63
40%	2.40	2.65	3.100

Table 6: Split tensile strength of different mix with 30% of RHA & Steel fiber

S.No	RHA (30%) + Steel Fiber %	Average Split Tensile Strength (N/mm²)		
		7 days	14 days	28 days
1	0 %(Control)	2.82	3.23	3.63
2	0.5%	2.85	3.31	3.72
3	1.0%	3.05	3.52	3.95
4	1.5%	2.75	3.15	3.50
5	2.0%	2.700	3.10	3.450

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FLEXURAL STRENGTH

Test specimens of beam size 100 mm×100 mm×500 mm were prepared for determining the flexural strength of steel fiber reinforced concrete and substitute of cement with RHA. The beam moulds containing the test specimens were placed in moist air (at least 90% relative humidity) and a temperature of 27° ± 2 °C for 24 hours /hour from the time of accumulation of water to the dry ingredients. After this the specimens were detached from the moulds and placed in clean new water at a temperature of 27°±2° C for the remaining curing period. After 28 days of curing the specimens were observed for bending on a flexure Testing Machine. Loads were applied at the one third points at a constant rate of 180 kg/minute. The distance between the centers of two rollers was kept 20 cm.

Table 7: Details of Flexural Strength test with different % of RHA

S.No	RHA %	7 Days strength, N/mm²	28 Days strength(N/mm²
		Average of 3 samples	
1	0	5.30	6.75
2	10	5.41	6.82
3	20	5.63	7.03
4	30	5.85	7.32
5	40	5.27	6.66

Table 7: Flexural strength test results of each mix with 30 % of RHA & Steel fibre

S.No	RHA(30%)+ SteelFiber %	7Days strengthN/mm²	28Days strength,N/mm²
		Average of 3 Samples	
1	0 %(Control)	5.85	7.32
2	0.5%	5.92	7.43
3	1.0%	6.25	7.85
4	1.5%	5.75	7.25
5	2.0%	5.660	7.200

CALCULATION OF OPTIMUM FIBRE CONTENT:

From the test outcome conducted in different days with the dissimilar percentage of RHA-Steel fibre, it is observed that the optimum content of fibre in concrete mixes is 1%. The variation of compressive, split tensile and flexural strength with the different percentage of RHA-Steel fibre can be concluded from the curve shown in graph 4.2, 4.3 and 4.4. However at the same percentage of RHA-Steel fibre in the mix the percentage increase difference in between compressive, split tensile and flexural strength, the flexural strength development is comparatively more. The 28 days percentage increase variation is described below:

Table 8: 28 Days percentage increase of strength with dissimilar percentage of RHA & Steel fiber

S.No	RHA(30%)+ SteelFiber%	Average		
		Compressive Strength, %	Split Tensile Strength, %	Flexural Strength,%
1	0.5%	0.71	2.41	1.48
2	1.0%	5.13	8.10	6.75
3	1.5%	-1.97	-3.71	-0.96
4	2.0%	-2.80	-5.21	-1.66

3. CONCLUSIONS

- Concrete mixes when reinforced by steel fiber 1% shows an increased compressive strength when compared to nominal mix.
- The split tensile strength also tends to increase with 1% increase percentages of steel fibers in the mix.
- The flexure strength also tends to increase through the increase percentages of steel fibers, a trend similar to enhance in split tensile strength and compressive strength.
- Maximum strength (compressive, split tensile as well as flexure) of concrete incorporating RHA and steel fibers, both, is achieved for 30% RHA replacement and 1% steel fibers. Though, if the steel fiber content is increased, the increase is not very significant.
- From the percentage increase graph, it can be concluded that due to the addition of Steel fiber concrete resist more tensile stresses when the cement and compared to compressive stresses.
- Although testing the specimens, the plain cement concrete specimens have shown a characteristic crack dissemination outline which tends into splitting of beam in two piece geometry. But due to addition of steel fibers in concrete cracks gets ceased which results into the ductile behavior of steel fibers inclusion.

ACKNOWLEDGEMENT

The authors can acknowledge any person/authorities in this section. This is not mandatory.

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