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AN EXPERIMENTAL ANALYSIS OF CEMENT CONCRETE PREPARED WITH RICE HUSK ASH & STEEL FIBRE

Mr. Kanhiya Kumar[1], Prof. Kapil Soni[2]
[1]Scholar M.Tech (CTM) Department of Civil Engineering, RNTU, Bhopal (M.P).
[2]HOD, Department of Civil Engineering, RNTU, Bhopal (M.P).

ABSTRACT: The application of flexibility enhancing mineral admixtures or additional cementing materials has gained considerable importance from the last decade as akey to long service life of concrete structures. In today's condition concrete needs special combinations of performance and uniformity requirements that cannot be always achieved by using traditional constituents and normal mixing. Concrete is poor in tension, has limited ductility and little resistance to cracking. 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 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.

Keywords: Cement Concrete, Rice Husk, Steel Fibres, Environment, Mechanical Properties, Durability.

I. INTRODUCTION

Concrete is the most important constituent for the development of infrastructure, buildings, industrialized structures, flyovers and highways etc. In today's situation concrete needs special combinations of presentation and uniformity necessities that cannot be always achieved by using conventional constituents and normal mixing. Construction industry is one of the fastest growing sectors in India. Rapid construction activity and growing requirement of houses has lead to the short fall of conventional building materials like bricks, cement, sand and wood. Demand of good features of building supplies to replace the conventional materials and the need for cost effective and durable materials for low cost construction has necessitated the researchers to develop variety of new and innovative construction materials.

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 an agricultural residue which accounts for 20% of the 649.7 million tons of rice produced per annum worldwide. Flaming the husk under controlled temperature below 800°C can produce ash with silica mainly in amorphous form.

Today inspired from the ancient application of techniques artificial fibres are commonly used now a day in order to improve the mechanical properties of concrete. It is necessary to find out substitute materials for pavements to meet the requirements 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 deposit consisting of non-crystalline silicon dioxide with high face area and high pozzolanic reactivity; therefore due to growing environmental apprehension and the need 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 when compared to the cement particles, and can set in between the cement particles and provide a greater pore structure. RHA has two roles in concrete production, as a alternate for Portland cement, reducing 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 Fibres are filaments of wire, distorted and cut to lengths, for a reinforcement of concrete, mortar and additional composite material. The occurrence of micro cracks in the mortar-aggregate boundary is responsible for the inherent weakness of plain concrete. The weakness can be disinterested by enclosure of fibre in the mixture. Dissimilar types of fibres, such as those used in conventional composite materials can be introduced into the concrete mix to increase its robustness, or ability to resist crack growth. The fibre assist to convey loads at the internal micro cracks.

ADVANTAGES OF SFRC

- Fast and ideal mixable fibres and High performance and crack opposition
- Optimize expenses with lesser fibre dosages
- Steel fibres reinforce concrete against brunt forces, thereby improving the robustness distinctiveness of hardened concrete.

- Steel fibres decrease the permeability and water immigration in concrete, which ensures fortification of concrete due to the ill possessions of moisture.
- Enhanced pavement physical properties by amendment of existing aggregate gradation, and blacktop binder properties

II. CONCRETE WITH RICE HUSK ASH & STEEL FIBRES

The durability improvement properties of rice husk ash when mixed with cement makes it the most eco-friendly resourceful supplementary cementing material to concrete. The following properties of concrete are significantly altered when mixed with RHA:
1. Concentrated heat of hydration – leading to negligible crack configuration in higher grades of concrete.
2. Reduced permeability at superior dosages.
3. Amplified chloride and sulphate conflict/mild acids.

Therefore RHA can be used as an successful and Green additional cementing material. RHA can be used for a broad variety of applications starting from a simple water proof coating to an admixture for cement to resist a wide variety of chemicals together with mild acids like lactic acid (milk) alkalies, etc. in restroom floors, swimming pools, Industrial plant floorings, foundation concreting when concrete is uncovered to both chlorides and sulphate attack and as an successful repair mortar to resist chlorides.

EXPERIMENTAL PROGRAMME

MATERIALS

Materials used for this dissertation mix cement, coarse aggregates, fine aggregates, water, RHA and Steel Fibre. The concrete mix uses a single group of cement supply to minimize variation of results. Aggregates are selected through gradation test which are free from impurities were checked and certain standards were complied in the course of this study.

CEMENT

Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravel, and crushed gravels to make concrete. The cement and water form a paste that binds the other materials together as the concrete hardens. The ordinary Portland cement contains two basic ingredients namely argillaceous and calcareous. In the present work 43 grade Ultra Tech cement was used for casting cubes, cylinders and Beams for all concrete mixes. The cement was in uniform color i.e. grey with a light greenish shade and was free from any stiff lumps. Ordinary Portland Cement (OPC) of 43 Grade (Ultra tech) from a single lot was used throughout the course of the investigation.

Sr. No.	Characteristics	Values Obtained Experimentally	Values Prescribed By IS 8112:1989
1.	Specific Gravity	3.12	-
2.	Standard Consistency, percent	29	-
3.	Initial Setting Time, minutes	147	30 (minimum)
4.	Final Setting Time, minutes	305	600 (maximum)
5.	Compressive Strength 3 days 7 days 28 days	24.7 N/mm^2 37.4 N/mm^2 47.5 N/mm^2	23 N/mm^2(minimum) 33 N/mm^2(minimum) 43 N/mm^2(minimum)

*It can be observed from tables that all the results satisfy the standard criteria.

Table 1 Properties of OPC 43 Grade Cement

AGGREGATE

Aggregates comprise the bulk of a concrete mixture and give dimensional firmness to concrete. To enlarge the density of resulting mix, the aggregates are normally used in two or more sizes. The most significant function of the fine aggregate is to help in producing workability and regularity in mixture.

a) COARSE AGGREGATES

The aggregate which is retained over IS Sieve 4.75 mm is coined as coarse aggregate. The coarse aggregates may be of subsequent types:-
i) Crushed stone obtained by crushing of rock or hard stone.
ii) Uncrushed gravel or stone resulting from the usual disintegration of rocks.
iii) Partially crushed gravel or stone obtained as product of blending of over two types.

Characteristics	Value
Colour	Grey
Shape	Angular
Maximum Size	20 mm/10mm
Specific Gravity	2.73/2.72
Water Absorption	0.20%/0.35%

Table 2: Properties of Coarse Aggregates

b) FINE AGGREGATES

The aggregates most of which get ahead of through 4.75 mm IS sieve are termed as fine aggregates. The fine aggregate may be of subsequent types:
i) Natural sand, i.e. the fine aggregate resulting from natural disintegration of rocks.
ii) Crushed stone sand, i.e. the fine aggregate formed by crushing hard stone.
iii) Crushed gravel sand, i.e. the fine aggregate manufactured by crushing natural gravel.

RICE HUSK ASH

Rice husk ash is obtained by burning rice husk in a controlled manner with no environmental pollution. When it is appropriately brunt it has high SiO2 content and can be used as a concrete admixture. Following Table shows Physical properties of RHA.

S.No	Particulars	Proportion

1	Color	Gray
2	Shape texture	Irregular
3	Mineralogy	Non crystalline
4	Particle size	>45 micron
5	Specific gravity	2.3
6	Odour	Odourless

Table 3: Physical properties of RHA

Following Table Chemical properties of RHA.

No	Particulars	Proportion
1	Silicon dioxide	86.94%
2	Aluminum oxide	0.2%
3	Iron oxide	0.1%
4	Calcium oxide	0.3-2.2%
5	Magnesium oxide	0.2-0.6%
6	Sodium oxide	0.1-0.8%
7	Potassium oxide	2.15-2.30%

TABLE 4: Chemical properties of RHA

STEEL FIBRE

Steel Fibres are filaments of wire, deformed and cut to lengths, for a reinforcement of concrete, mortar and other composite material. The presence of micro cracks in the mortar-aggregate interface is responsible for the intrinsic weakness of plain concrete. The limitation can be removed by inclusion of fibres in the mixture. Three different proportions of fibres i.e. 0%, 0.5%, 1%, 1.50% and 2% have been used. Properties of steel fibre used are tabulated in 3.4.

S.No	Parameters Evaluated	Obtained Values
1	Average Thickness	1.2 mm
2	Length	60 mm
3	Density	7850 kg/m3
4	Tensile Strength	8500 kg/m3
5	Shape	Crimped steel fibre

Table 5: Properties of Steel Fibres

WATER

The drinkable water is generally considered satisfactory for mixing and curing of concrete. Consequently potable water was used for making concrete available in Material Testing laboratory. This was free from any detrimental contaminants and was good potable quality.

DETAILS OF SPECIMENS PREPARED:

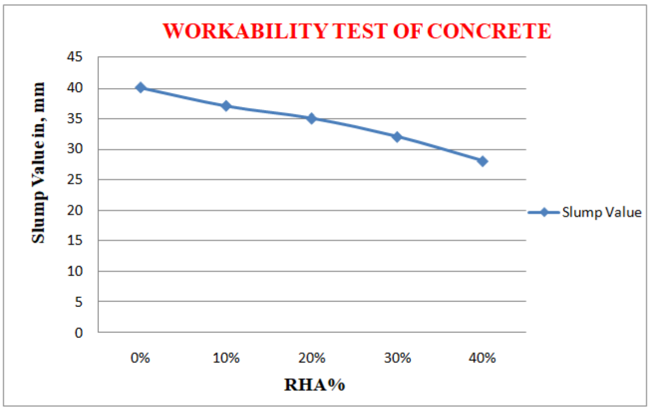
- 150mm x 150mm x 150mm Cube specimens for Compressive strength.
- 150 mm x 300 mm Cylindrical specimen for Split tensile strength.
- 100 mm x 100mm x 500 mm Beam specimen of Flexural Testing.

II. RESULTS & DISCUSSION

WORKABILITY TEST OF CONCRETE (SLUMP CONE METHOD)

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

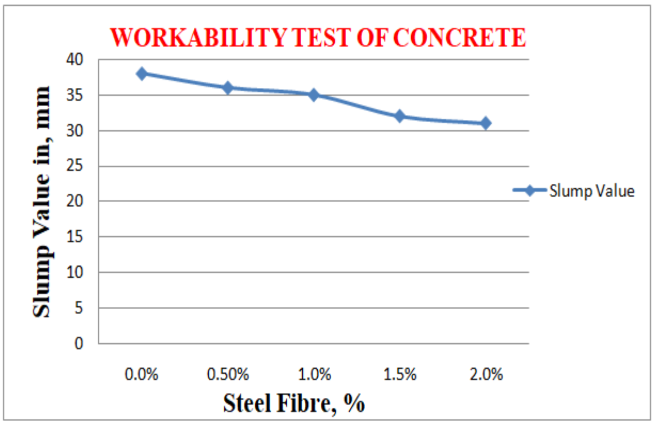
Table 6: Workability Test results of cement replaced with RHA.



Graph 1: Workability testing of concrete Mix with RHA.

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

Table 7: Workability test of concrete with 30% RHA and Different % of steel fibre.

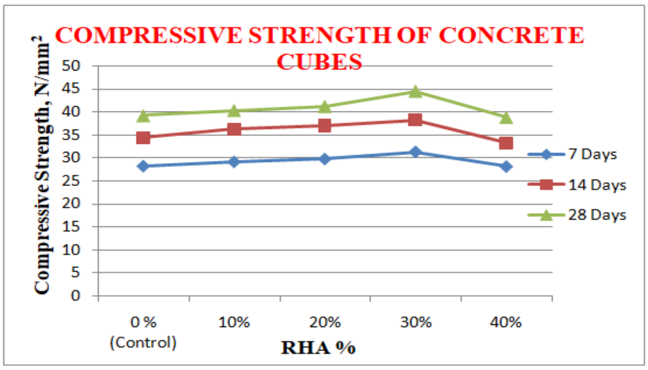


Graph 2: Workability test of concrete by slump cone method with 30% RHA and different percentage of steel fibre.

III. COMPRESSIVE STRENGTH

Mix	Average Compressive Strength (N/mm²)		
	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	44.36
40%	28.15	33.25	38.80

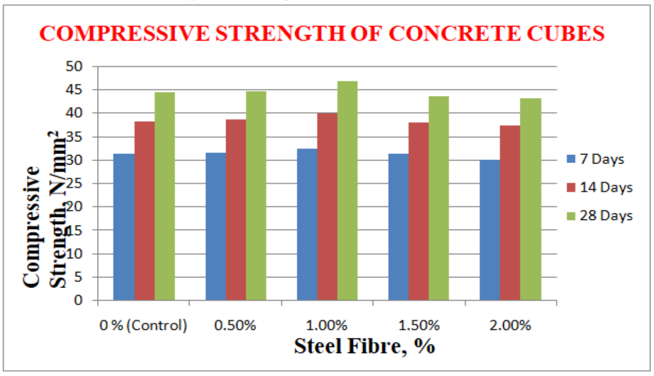
Table 8: Details of Compressive Strength test with various % of RHA.



Graph 3: Compressive Strength testing of concrete cubes with various % RHA.

S.No	RHA (30%) + Steel Fiber %	Average Compressive Strength (N/mm²)		
		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	37.25	43.15

Table 9: Test results of compressive strength of different mix with different percentage of 30 % RHA & Steel fibre.

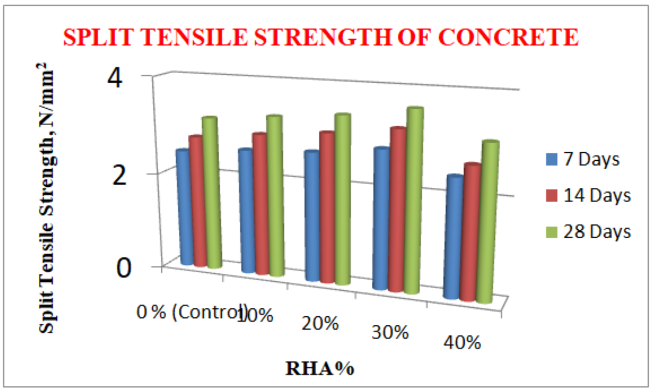


Graph 4: Compressive Strength variation of each mix with different percentage of RHA & Steel fibre.

SPLIT TENSILE STRENGTH

Mix	Average Split Tensile Strength (N/mm²)		
	7 days	14 days	28 days
CM	2.46	2.77	3.18
10%	2.58	2.92	3.30
20%	2.65	3.05	3.42
30%	2.82	3.23	3.63
40%	2.40	2.65	3.10

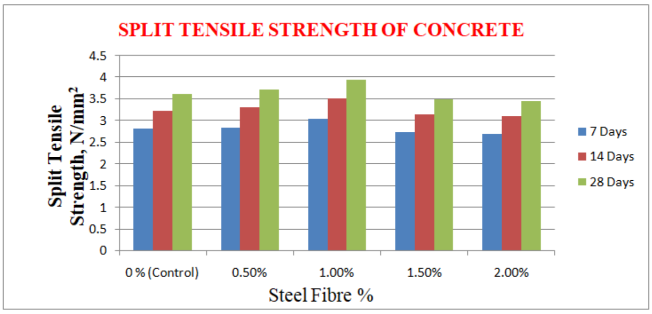
Table 10: Details of Split Tensile Strength test with different % of RHA.



Graph 5: Split Tensile Strength testing of concrete cylinders with various RHA%.

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%	2.70	3.10	3.45

Table 11: Split tensile strength of different mix with 30% of RHA & Steel fibre.

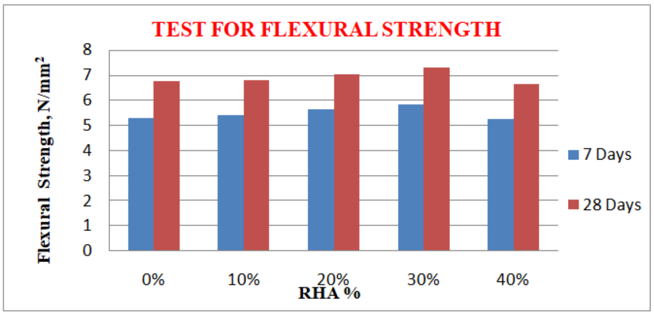


Graph 6: Test results of split tensile strength of different mix with 30% of RHA & Steel fibre.

FLEXURAL STRENGTH

S.No	RHA %	7 Days strength, N/mm^2	28 Days strength, N/mm^2
		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

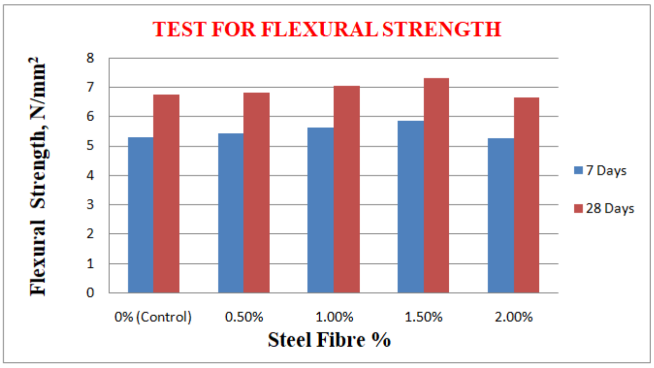
Table 12: Details of Flexural Strength test with different % of RHA.



Graph 7: Flexural Strength testing of concrete Beam with RHA%.

S.No	RHA (30%) + Steel Fiber %	7 Days strength, N/mm^2	28 Days strength, N/mm^2
		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%	5.66	7.20

Table 13: Flexural strength test results of each mix with 30 % of RHA & Steel fibre.



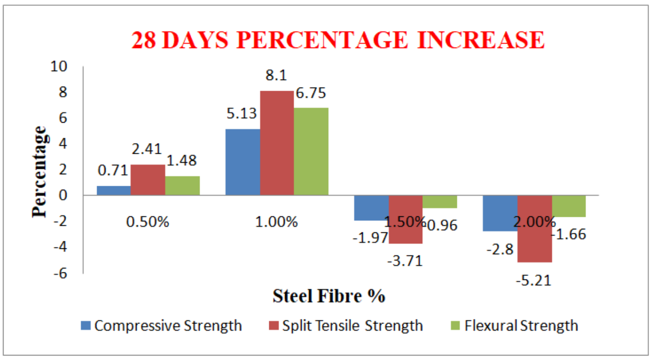
Graph 8: Flexural Strength variation of each mix with 30 % RHA & Steel fibre.

IV. 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:

S.No	RHA (30%) + Steel Fiber %	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

Table 9: 28 Days percentage increase of strength with dissimilar percentage of RHA & Steel fibre.



Graph 10: 28 Days percentage increase of strength with 30% of RHA & dissimilar % of Steel fibre.

V. CONCLUSIONS

The current study was undertaken to investigate the compressive strength, split tensile and flexure strength, of concrete with substitute of cement with RHA and addition of steel fibre in concrete mix. Cement was moderately replaced by RHA and steel fibre is added in concrete mix at different percentage i.e. 0%, 0.5%, 1%, 1.5% and 2.0%. On the origin of this experimental work done in the laboratory, following conclusion can be drawn.

WORKABILITY

- It is observed that the workability of reinforced concrete with steel fibre gets concentrated at constat water cement ratio as the proportion of steel fibres increases.
- Addition of binding wire or a steel fibre into the concrete considerably increases the workability due to the reinforcing effects of steel fibres.

STRENGTH CHARACTERISTICS

- The satisfactory development in various strengths is determined with the insertion of RHA and Steel fibres in the plain concrete. However, greatest gain in strength of concrete is originated to depend up on the amount of fibre content.
- Concrete mixes when reinforced by steel fibre 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 fibres in the mix.
- The flexure strength also tends to increase through the increase percentages of steel fibres, 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 fibres, both, is achieved for 30% RHA replacement and 1% steel fibres. Though, if the steel fibre 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 concreteresist more tensile stresses when compared tocompressive 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 fibres in concrete cracks gets ceased which results into the ductile behavior of steel fibres inclusion.
- The results represents that 30 % of RHA and 1.0 % of steel fibre shows a greater combination for preparing a durable concrete which may help to solve environmental problems and gives long lasting economical concrete. By this enhancement of strength results in reduction of pavement thickness.

This experiment was performed on the origin of previous results obtained by adding dissimilar percentage of RHA with substitution of cement. So due to those results optimum RHA was selected for this study is 30%. The reason for selecting the RHA content 30% is as follows:

- The enhance in strength up to 30 % replacement is due to the pozzolanic response of the available silica from RHA and the amount of C-H available from the hydration progression and also due to the microfiller consequence when fine RHA is used.
- The reduction in the strength by increasing RHA more than 30% replacement level is due to the decrease in the cement amount and as a effect of that, the unconfined amount of C-H due to the hydration process is not sufficient to react with all the available silica from RHA and thus, the silica will act as inert material and will not contribute to the strength development excluding for the fine RHA where it can be measured as a microfiller.

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