Available Online http://www.ijncse.com

ISSN Online: 2395-7018

Special issue ,March,(2016),30-37

INTERNATIONAL JOURNAL OF NANO CORROSION SCIENCE AND ENGINEERING

EXPERIMENTAL INVESTIGATION ON STRENGTH CHARACTERISTICS OF NATURAL FIBER CONCRETE BEAMS

M. Gowtham Raj*, M.P.Karthik*, Dr. V. Sree Vidya** and Dr. R. Robert Ravi*

* Department of Civil Engineering, SSM Institute of Engineering & Technology, Dindigul.

** Sri Krishna College of Technology, Dindigul.

ABSTRACT

From the investigation this paper express that the strength and durability characteristics of M40 grade concrete in which cement is partially replaced by rice husk ash and coir. Coconut fibers are reported as most ductile and energy absorbent material. It is concluded that coconut fibers have the potential to be used in composites for different purposes. Rice husk ash is obtained by burning rice husk in a controlled manner without causing environmental pollution. There is a good potential to make use of RHA as a valuable pozzolanic material to give almost the same properties as that of micro silica. In this study, the strength related properties such as compressive strength, splitting tensile strength, flexural strength were calculated and better durability characteristics when compared to other replacement levels.

Key Words: *Rice Husk Ash, Coir, Environmental Pollution, Compressive Strength, Splitting Tensile Strength, Flexural Strength and Durability.*

INTRODUCTION

Concrete is one of the crucial materials for infrastructure development due to its versatile application, globally its usage is second to water. Due to increase in the cost of conventional building materials and environmental hazard, the designers and developers are looking for 'alternative materials' to reduce the use of cement in civil engineering constructions. For this objective, the researchers are trying to use various waste products in concrete technology. The objective of this investigation is to study the effect of partial replacement of cement by Rice husk Ash as a Mineral admixture in concrete and also adding Natural fiber (Coir) to increase the tensile strength of concrete.

MATERIALS USED AND METHODOLOGY

CEMENT

The Ordinary Portland Cement of 53 Grade conforming to IS 12269 – 1987 was used in this study. The specific gravity, initial and final setting of OPC 53 grade were 3.15, 30 and 600 minutes respectively.

FINE AGGREGATE

Locally available river sand conforming to grading zone II of IS 383 –1970. Sand passing through IS 4.75mm Sieve will be used with the specific gravity of 2.65. The sieve analysis of fine aggregate is shown in Table 1

COARSE AGGREGATE

Locally available blue metal was used. Crushed granite stones of size passing through 20mm sieve and retained on 4.75 mm sieve as per IS: 383-1970 was used for experimental purpose. The sieve analysis of natural coarse aggregate is shown in Table 2

Table 1 Sieve Analysis of River Sand

Sieve size	% passing
4.75mm	98
2.36mm	96
1.18mm	78
600µm	51
300 µm	26
150 µm	7

Table2 Sieve Analysis of Natural Coarse Aggregate

Sieve Size	% Passing
25	100
20	100
16	100
12.5	100
10	33
6.3	3
4.75	0

WATER

Casting and curing of specimens were done with the potable water that is available in the college premises.

RICE HUSK ASH

RHA, produced after burning of Rice husks (RH) has high reactivity and pozzolanic property. Indian Standard code of practice for plain and reinforced concrete, IS 456- 2000, recommends use of RHA in concrete but does not specify quantities. The physical and chemical properties of RHA are shown in Table 3 and Table 4.

Table 3 Physical Properties of Rice Husk Ash

Physical properties	Value
Specific gravity	2.19
Fineness passing through 45µm sieve in (%)	99.5
Colour	Grey

Table 4 Chemical Properties of Rice Husk Ash

Chemical properties	Value
Silicon dioxide(SiO2)	88.32
Silicon dioxide(SiO2)	0.46
Ferric oxide(Fe2O3)	0.67
Calcium oxide(CaO)	0.51
Magnesium oxide(MgO)	0.44
Sodium oxide(Na2O3)	0.12
Potassium oxide(K2O)	2.91

Table 5 Properties of Coconut Fibre

Properties	Value
Fiber length (mm)	50-110
Fiber diameter (mm)	0.1-0.406
Average tensile strength(N/mm2)	150
Specific gravity	1.12-1.15
Elongation (%)	10-25

COIR

Coconut fibre is one of the natural fibres abundantly available in tropical regions, and is extracted from the husk of coconut fruit. The aim of this review is to spread awareness of coconut fibres as a construction material in civil engineering.

The versatility and applications of coconut fibres in different fields is discussed in detail. Coconut fibres are reported as most ductile and energy absorbent material. It is concluded that coconut fibres have the potential to be used in composites for different purposes.

In civil engineering, coconut fibres have been used as reinforcement in composites for non-structural components. There is a need of investigating the behaviour of coconut fibre reinforced concrete to be used in main structural components like beams and columns.

EXPERIMENTAL INVESTIGATION

MIX DESIGN

Mix design is the process of selecting suitable ingredients of concrete and determines their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The first object is to achieve the stipulated minimum strength. The second object is to make the concrete in the most economical manner.

Table 6 Design of Concrete Mix for M40 Grade

CEMENT (Kg/m3)	F.A (Kg/m3)	C.A (Kg/m3)	WATER (Kg/m3)
492.5	755	968	197
1	1.53	1.96	0.4

TEST PROCEDURE

The experimental investigations carried out on the test specimens to study the strength-related properties of concrete using Rice husk ash and coir. Here, an attempt was made to study the strength development at different replacement levels at different ages with Rice husk ash and coir the results were compared.

Concrete were produced with 10, 12.5 and 15% of the RHA as cement replacement (in mass) and coir is replaced with 1, 2, and 3% (by mass). Totally thirteen different proportions of concrete mixes are used. Ratio for M40 Grade as per IS 10262:2009.

The strength-related properties such as compressive strength, splitting tensile strength, flexural strength were studied. Minimum three specimens were tested for each mix for each test. The entire tests were conducted as per specifications required.

CASTING AND TESTING OF SPECIMENS

All the ingredients were first mixed in dry condition in the concrete mixer. The concrete mix proportion is already shown in table. The calculated amount of water added to the dry mix and mixed thoroughly to get uniform mix. Before casting machine oil was smeared on the inner surface of the mould and the concrete was poured in to the mould. After 24 hours of casting, the specimens were demoulded and cured for 28 days using water tank. After the curing period was over, the specimens were white washed and kept ready for testing. For each mix, six cube specimens, three cylinder specimens and three beam specimens of size 100 x 150 x 1000 mm. Cube and specimens were tested on 7 days and 28 days.

DURABILITY CHARACTERISTICS

To trace the history of concrete, more attention has been given to the aspect of its strength. Concrete performance has been specified and evaluated in terms of its compressive strength. The higher the compressive strength, the better the expected performance. However, experience has shown that considerations of durability become more important for structures, especially, those exposed to hostile environments. Hence, in this research, experimental study was carried out on the test specimens to ascertain the durability- related property such as acid resistance of the designed M40 grade. The acid resistance tests were carried out on 150 mm size cube specimens at the age of 28 days curing. The cube specimens were weighed and immersed in water diluted with one percent by weight of sulphuric acid for 28 days continuously. Then the specimens were taken out from the acid water and the surfaces of the cubes were cleaned. Then, the weight of the specimens was found out and the average percentage of loss of weight was calculated.

TEST SPECIMEN

CUBE COMPRESSIVE STRENGTH

For cube compression testing of concrete, 150 mm cubes were used. All the cubes were tested in saturated condition, after wiping out the surface moisture. For each trial mix combination, three cubes were tested at the age of 7 days and 28 days of curing using AIMIL compression testing machine of 3000 KN capacity as per BIS : 516- 1959.

CYLINDER SPLIT TENSILE STRENGTH

This is an indirect test to determine the tensile strength of cylindrical specimens. Splitting tensile strength tests were carried out on cylinder specimens of size 150 mm diameter and 300 mm length at the age of 28 days curing, using AIMIL compression testing machine of 3000 KN capacity as per BIS : 5816 - 1970 . To avoid the direct load on the specimen, the cylindrical specimens were kept below the wooden strips. The load was applied gradually till the specimens split and readings were noted. Patterns of typical splitting tensile failure mode shapes of HPC cylinder specimens are shown in Figure 2 The splitting tensile strength has been calculated using the following formula:

$$ft = 2P/\pi DL$$

Where

ft = splitting tensile strength of the specimen in Mpa
P = maximum load in N applied to the specimen
D = measured diameter of the specimen in mm, and
L = measured length of the specimen in mm.

FLEXURAL STRENGTH TEST

The size of beam used was 100 x 150 x 1000 mm. Three cubes of size 150 x 150 x150 mm were cast as control specimens. M40 grade is attempted, with different replacement levels of cement with of RHA .To start with specimens having a span of 1000 mm were tested under two-point loading. The effective span was 800mm. Hence the point load was applied at one third point from the end supports.

The size of the beam was 100 x 150 x 1000 mm. The reinforcement used were high yield strength deformed (HYSD) bars 2 No's of 10mm diameter in the tension side and 2 No's of 8 mm diameter in compression zone and three specimens for each parameter. The shear reinforcement is designed in such a way that, the shear capacity of the specimen is higher than the flexural strength. This is done to ensure flexural failure. For shear span 2 legged 6mm diameter stirrups at 120mm center to center is provided as shown in Fig 3.



Fig: 1 Compressive Strength **Fig. 2 Testing of cylinder** **Fig: 3 Reinforcement Details**

Table 7 Specimen Details

SL.NO	Beam designation	RHA	COIR	No of Specimens
1	NM+10%+1%	10	1	1
2	NM+10%+2%	10	2	1
3	NM+10%+3%	10	3	1
4	NM+12.5%+1%	12.5	1	1
5	NM+12.5%+2%	12.5	2	1
6	NM+12.5%+3%	12.5	3	1
7	NM+15%+1%	15	1	1
8	NM+15%+2%	15	2	1
9	NM+15%+3%	15	3	1

RESULT AND DISCUSSION

STRENGTH CHARACTERISTICS

Cube Compressive Strength

The test results was observed that the maximum compressive strength is obtained for mix with 12.5% RHA and 1% COIR was observed that the maximum compressive strength at the water-binder ratio of 0.40. The compressive strength development is due to the pozzolanic reaction of RHA. The rapid rate of strength development is due to the fact that for lower water-binder ratio, the cement particles are held at closer interval than for higher water-binder ratios. Also due to the action of silica fume on calcium hydroxide, more gel is formed. These two factors enhance the formation of a continuous system of gel, which provides better development of strength at early ages since, silica fume starts react with calcium hydroxide and produces C-S-H gel immediately.

Cylinder Split Tensile Strength

The split tensile strength results of mixes at the age of 28 days for different replacement levels such as 10%, 12.5%, and 15% of Cement with Rice husk ash and 1%, 2% and 3 % replacement of coir are presented in Tables 6.3 and 6.4. The development of Compressive Strength with ages for the above different mixes was plotted in the form of graphs as shown in Fig 6.3 and Fig 6.4.

From the test results it was observed that the maximum split tensile strength is obtained for mix with 12.5% RHA. In the replacement of RHA the mix with 12.5% RHA and 2% COIR was observed that the maximum split tensile strength at the water-binder ratio of 0.40.

Flexure Strength

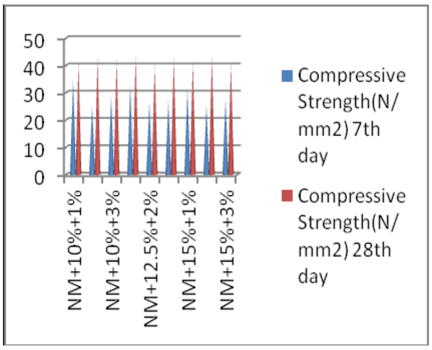
The size of beam used was 100 x 150 x 1000 mm. Three cubes of size 150 x 150 x150 mm were cast as control specimens. To start with trial specimens having a span of 1000 mm were tested under two-point loading. The effective span was 800 mm. Hence the point load was applied at one third point from the end supports.

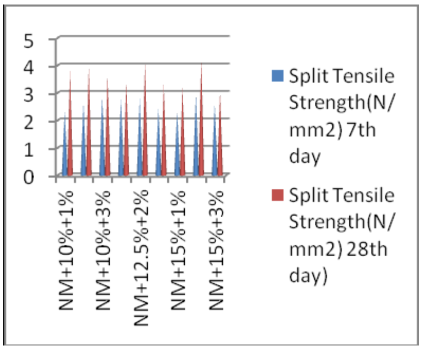
Table 8 Results of Cube Test

Mix	RHA (%)	COIR (%)	Compressive Strength (N/mm2) 7th day	Compressive Strength (N/mm2) 28th day
NM+10%+1%	10	1	34.82	40.88
NM+10%+2%	10	2	25.48	42.65
NM+10%+3%	10	3	28.42	42.18
NM+12.5%+1%	12.5	1	33	43.23
NM+12.5%+2%	12.5	2	26.55	40.11
NM+12.5%+3%	12.5	3	27.11	42.65
NM+15%+1%	15	1	31.25	41.32
NM+15%+2%	15	2	25.3	42.89
NM+15%+3%	15	3	27.62	40.56

Table.9 Results of Cylinder Test (7th day)

Mix	RHA (%)	COIR (%)	Split Tensile Strength(N/mm2) 7th day	Split Tensile Strength(N/mm2) 28th day)
NM+10%+1%	10	1	2.33	3.81
NM+10%+2%	10	2	2.65	3.95
NM+10%+3%	10	3	2.88	3.65
NM+12.5%+1%	12.5	1	2.78	3.42
NM+12.5%+2%	12.5	2	2.8	4.12
NM+12.5%+3%	12.5	3	2.44	3.29
NM+15%+1%	15	1	2.32	3.21
NM+15%+2%	15	2	2.95	4.2
NM+15%+3%	15	3	2.6	3.02





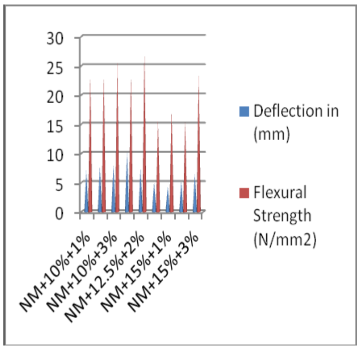


Fig. 4 Compression test 7 & 28 days Fig. 5 Split Tensile test 7 & 28 days Fig. 6Comparison of Flexural & Deflection Results

Table 10 Flexural Strength Result of Beams

Mix	RHA (%)	COIR (%)	Ultimate Load(N/mm2)	Deflection in (mm)	Flexural Strength (N/mm2)
NM+10%+1%	10	1	52.8	7.05	23.47
NM+10%+2%	10	2	52.8	7.88	23.47
NM+10%+3%	10	3	57.2	8.03	25.42
NM+12.5%+1%	12.5	1	52.8	10.2	23.47
NM+12.5%+2%	12.5	2	61.6	7.52	27.38
NM+12.5%+3%	12.5	3	35.2	5.02	15.65
NM+15%+1%	15	1	39.6	4.36	17.6
NM+15%+2%	15	2	35.2	5.28	15.65
NM+15%+3%	15	3	52.8	6.54	23.47

DURABILITY CHARACTERISTICS

ACID RESISTANCE

The acid resistance tests were carried out on 150 mm size cube specimens at the age of 28 days curing. The cube specimens were weighed and immersed in water diluted with one percent by weight of sulphuric acid for 28 days continuously. Then the specimens were taken out from the acid water and the surfaces of the cubes were cleaned. Then, the weight of the specimens was found out and the average percentage of loss of weight was calculated.

SPECIMENS UNDER ACID RESISTANCE TEST


Fig.8 View of Acid Resistance Test Fig.9 View of Specimen after Acid resistance Test

Table 13 Acid Resistance Test Results

Mix	Reduction in weight (%)
NM+10%+1%	1.18
NM+10%+2%	1
NM+10%+3%	0.89
NM+12.5%+1%	0.82

NM+12.5%+2%	0.8
NM+12.5%+3%	0.75

CONCLUSION

Cube Compressive Strength

- At the age of 28days the compressive strength of mix 12.5%RHA + 1%COIR shows the highest strength when compared to other replacement levels of RHA with Cement. This indicates that the optimum percentage of replacement of Rice husk ash with cement is 12.5 percent.
- The Rice husk ash used in this investigation exhibits good pozzolanic properties. Therefore, it is strongly recommended for the production of concrete.

Split Tensile Strength

- In the replacement levels of Rice husk ash with cement, the optimum replacement of Rice husk ash with cement for M40 grade of concrete was found to be 12.5% for achieving maximum split tensile strength at the age of 28 days.
- The tensile strength increases along with increase in compressive strength .The tensile strength of concrete is 6 to 9 percent of cube compressive strength.

Experimental Investigations on Flexural Behaviour of Concrete

- At the age of 28days the flexural strength of mix 12.5% RHA + 2% COIR shows the highest strength when compared to other replacement levels of Rice husk ash with cement. The ultimate load and first crack load for the above mix shows the highest value and this indicates that the optimum percentage of replacement of Rice husk ash with cement is 12.5 percent.

Experimental Investigations on Durability Characteristics of Concrete

Based on the experimental investigations carried out on the durability characteristics of concrete mixes, the following conclusions are arrived at:

Acid Resistance

- The acid resistance of concrete mixes containing Rice husk ash was higher when compared with that of the concrete mixes without Rice husk ash at the age of 28 days.
- In the replacement levels of Rice husk ash with cement mix 12.5% RHA+ 3% coir shows the optimum weight reduction when compared to other replacement levels. This indicates that the optimum percentage of replacement of Rice husk ash with cement is 12.5 percent. When the replacement levels increase the effect of acid is more.

REFERENCE

1) IS 456-2000, “Plain and Reinforced Concrete-Code of Practice”, Bureau of Indian Standards,(BIS 2000). Fifth Reprint, 2002.

2) IS 516-1959, “Methods of tests for strength of concrete”, Bureau of Indian Standards, 1992.

3) IS 10262-2009, “Concrete Mix Proportioning-Guidelines”, Bureau of Indian Standards,(BIS 2009), First Revision, 2009.

4) Maged S. Sobhy and M. T. Tammam (2010), “The Influence of Fiber Length and Concentration on the Physical Properties of Wheat Husk Fibers Rubber Composites”, ID 528173, pp. 583-591.

5) A. Muthadhi, R. Anita and Dr. S.Kothandaraman (2007), “Rice Husk Ash – Properties and its Uses: A Review”, Journal of the Institution of Engineers. India. Civil Engineering Division, vol. 88, pp. 50-56.

6) Pravin V Domke, Sandesh D Deshmukh, Satish D kene and R.S.Deotale (2009), “Study of Various characteristic of concrete with Rice Husk Ash as a partial replacement of cement with natural fibers (Coir)”, International Journal of Engineering, Vol. 1, Issue 3, pp.554-562.

7) Rahmat madandoust, Malec Mohammed Ranjibar, Hamed Ahmadi Moghadam and Syed Yasin Mousari (2011), “Mechanical properties and durability assesement of rice husk ash concrete”, Biosystem, Elsevier Journals Ltd., Vol.30, pp. 1589-1598.

8) R. Sathish Kumar (2012), “Experimental study on the properties of concrete made with alternate construction materials”, International Journal of Modern Engineering Research, Vol. 2, pp-3006-3012.

9) Utsev, J. T. and Taku, J. K. (2012), “Coconut Shell Ash As Partial Replacement of Ordinary Portland Cement In Concrete Production”, International Journal of Scientific & Technology Research Vol.1, pp. 86-89.

10) Vanchai seta, Chai jaturapitakkul and Kraiwood Kittikomol (2007), "Influence of pozzolan from various by-product materials on mechanical properties of high strength concrete", Construction and Building Materials, Elsevier Journals Ltd., Vol.30, pp. 1589-1598.

11) Weerachart Tangchiapat, Rak Buranasing. Chai Jaturapitakul and Prinya Chindaprasirt (2008), "Influence of rice husk ash – bark ash on mechanical properties of concrete containing high amount of recycled aggregate", Construction and Building Materials, Elsevier Journals Ltd., Vol.3