Experimental study of compressive and split tensile strength of concrete containing rice-husk ash and coir fibers.

Chirag.D.Magnani[1], Hirak.S.Shah[2], Jay.J.Lad[3], Darshan.M.Mali[4], Vatsal. N. Patel[5]

[1-4]*B.E.Student in Civil Engg.,Department of Civil Engineering, A. D. Patel Institute of Technology, New Vidyanagar, Anand,Gujarat, India*

[5]*Associate professor,Department of Civil Engineering, A. D. Patel Institute of Technology, New Vidyanagar, Anand, Gujarat, India*

Abstract— The present study is carried out for evaluating the influence of Rice-Husk Ash and COIR Fibers in M20 grade concrete. This paper presents the results of compression test and split tensile teston concrete which were casted with various percentage of COIR fibers ranging from 0% to 4% at a regular interval of 1% and Rice-Husk Ash ranging from 0% to 20% at regular interval of 5%. Total 3 cubes and 3 cylinders were casted for each mix design, there were total 17 mix designs, averageresult of 3 cubes and 3 cylinders was taken as final compressive strength and tensile strength of that mix design. Out of 51 cubes and 51 cylinders,3 cubes and 3 cylinders were casted as control mix (M_{20} grade concrete without Rice-husk ash and COIR fibers), remaining 48 cubes and 48 cylinders were casted with different percentages of Rice-Husk Ash and COIR fibers. Results clearly indicated that with increase in % of Rice-Husk Ash and COIR fibers the compressive strength and tensile strength of concrete increases, it can be clearly seen that cement can be replaced up to 20% with Rice-Husk Ash and COIR fibers without compromising the compressive and tensile strength. As a result the concrete becomes economical and also impact on environment decreases due to agricultural waste, industrial waste and also due to emission of CO_2 gas in environment while manufacturing of cement.

Index Terms — Rice-Husk Ash, COIR Fibers, Compressive strength, Tensile strength, Global warming, CO2 gas, Green house gas.

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1 INTRODUCTION

Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and burning of fossil fuels. The global warming is caused by the emission of green house gases, such as CO2, to the atmosphere. Among the greenhouse gases, CO2 contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete. Consequently extensive research is on going into the use of cement replacements, using many waste materials and industrial by products. To reduce the impact on the environment due to industrial and agricultural waste products such as Rice Husk Ash (RHA) and coconut fibers (COIR) which are the waste products of paddy and agricultural industry. Use of these materials in concrete not only improves the strength of concrete but also leads to the proper disposal of these materials, resulting in reducing the impact of these materials on environment. Due to fast growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. The environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy shown in Fig.1. The aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal [1].

Fig-1: Waste Hierarchy

Considerable efforts has been taken Worldwide to utilize the industrial and agricultural waste and its by-products materials having high silica content as supplementary cementing-materials to improve the properties of cement concrete as well as the use of these materials leads to the proper disposal of waste resulting in the less impact on environment.Concrete is a widely used construction material for various types of structures due to its structural stability and strength. All the materials required producing such huge quantities of concrete come from the earth's crust. Thus, it depletes itsresources every year creating ecological strains. On the other hand, human activities on the Earth produce solid waste in considerable quantities of over 2500 MT per year, including industrial wastes, agricultural wastes and wastes from rural and urban societies. Recent technological development has shown that these materials are valuable as inorganic and organicresources and can produce various useful products.Amongst the solid wastes, the most prominent ones are Fly Ash, Blast Furnace Slag, Rice Husk, Rice-husk ash, Coir Fiber and demolished construction materials. The use of byproducts is an environmental friendly method ofdisposal of large quantities of materials that wouldotherwise pollute land, water and air. Most of the increase in cement demand will be met by the use of supplementary cementing materials.Rice milling generates a by-product known as husk as shown in Fig.2. This surrounds the paddy grain. During the milling of paddy about 78 % of weight is received as rice, broken rice and bran. The rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75 % organic volatile matter which burns up and the balance 25 % of the weight of this husk is converted into ash during the firing process, which is known as Rice-Husk Ash (RHA).The burning temperature is within the range of 600 to 850 degrees. The ash obtained is ground in a ball mill for 30 minutes. This RHA in turn contains around 85%-90% amorphous silica. So for every 1000 kg of paddy milled, about 220 kg (22%) of husk is produced, and when this husk is burnt in the boilers, about 55 kg (25%) of RHA is generated. India is a major rice producing country, and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy, producing energy through direct combustion or by gasification. About 20 million tons of RHA is produced annually. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought of for disposing it by makingCommercial use of this RHA.[3] Coconut fiber (COIR) shown in Fig.3 is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fiber is Coir, Cocos nucifera and Arecaceae (Palm), respectively. There are two types of coconut fibers, brown fiber extracted from matured coconuts and white fibers extracted from immature coconuts. Brown fibers are thick, strong and have high abrasion resistance. White fibers are smoother and finer, but also weaker. Coconut fibers are commercial available in three forms, namely bristle (long fibers), mattress (relatively short) and decorticated (mixed fibers). These different types offibers have different uses depending upon the requirement. In engineering, brown fibers are mostly used According to official website of International Year for Natural Fibers 2009, approximately, 500 000 tones of coconut fibers are produced annually worldwide, mainly in India and Sri Lanka. Its total value is estimated at $100 million. India and Sri Lanka are also the main exporters, followed by Thailand, Vietnam, the Philippines and Indonesia. Around half of the coconut fibers produced is exported in the form of raw fiber [4].Fig-4 shows the mixture of cement,Rice-Husk Ash and COIR Fiber.

Fig-2: Rice-husk, Rice-husk Ash.

Fig-3: Coconut tree, coconut, coconut fiber

Fig-4: Cement mixed with Rice-husk ash and COIR fiber

The aim of this study is to spread the awareness of coconut fibers and Rice-husk ash as a construction material in civil engineering. 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. Since the use of coconut fibers has given some marvelous products, there is still possibility of the invention of new products containing coconut fibers with improved results. In civil engineering, coconut fibers have been used as reinforcement in composites for non-structural components. There is a need of investigating the behavior of coconut fiber reinforced concrete to be used in main structural components like beams and columns.Rice-Husk Ash has been categorized under pozzolana, with about 85-90% silica and about 4.9% and 0.95% Alumina and iron oxides, respectively. The silica is substantially contained in amorphous form, which can react with the CaOH librated during the hardening of cement to further form cementations compounds.

2 LITERATURE REVIEW

P.V.Domke [2], In his experimental work replaced cement by 15% RHA and added 3% Coir in M20 grade concrete and got Tensile strength = 7.8N/mm2Compared to 4.2 N/mm2of ordinary mix concrete.Further adding 17.5% RHA and 4% Coir Fiber he got optimum compressive strength as 24.5N/mm2compared to 23.55N/mm2of normal concrete at 7thday. He also in his experimental work replaced cement by only 3% Coir fiber in M20grade concrete and got tensile strength 7.5N/mm2and compressive strength 41.1N/mm2,46.6 N/mm2at 7thand 28thday. Compared to 4.2

N/mm2tensile strength and 23.55 N/mm2, 40 N/mm2compressive strength of ordinary mix concrete.

Majid Ali, [4] In his experimental work replaced cement by 2% Coir fibre and got tensile strength 3.54 N/mm2and compressive strength 24.35 N/mm2compared to normal concrete with tensile strength 2.88 N/mm2and compressive strength 21.42 N/mm2.

S.D.Kene, et.al [5] in their experimental work replaced cement by 30% rice husk ash and got tensile strength 2.26 N/mm2and compressive strength 18.33 N/mm2at 7thday as compared to 6.5 N/mm2 tensile strength and 24.56 N/mm2compressive strength of normal concrete of M25 grade.

M. Sivaraja, et.al [6], in their experimentalwork replaced cement by 1.5% Rice Husk and got tensile strength 3.48 N/mm2and compressive strength 27.98N/mm2compared to 2.86 N/mm2tensile strength and 27N/mm2compressive strength of normal concrete.

Chagas.D, et.al [7], In theirexperimental work replaced cement by 10%,15%,20% rice husk ash got tensile strength 5.9 N/mm2,5.7N/mm2, 5.8 N/mm2compared to 5.5N/mm2of normal concrete.

Anju Mary Ealias, et.al, [11], In their experimental work replaced cement by 3% coir fiber and adding 10% coconut shell by weight of aggregate in M30grade concrete gave tensile strength 1.23N/mm2,1.91 N/mm2, & 2.1 N/mm2and compressive strength 11.34 N/mm2,18.38 N/mm2,20.47 N/mm2at 7th,14th,& 28thday compared to 1.93 N/mm2,2.51N/mm2, & 3.71 N/mm2tensile strength and 28.45N/mm2,31.62 N/mm2,36.06 N/mm2compressive strength at 7th,14th, & 28thday normal concrete.

3 OBJECTIVES OF STUDY

- To partially replace cement with agricultural waste and industrial waste which is easily available and in huge quantity.
- To make concrete more economical as price of cement is increasing rapidly.
- To attain greater compressive strength than that obtained for concrete without cement replacement.
- To achieve better tensile strength of concrete using coir fiber, as concrete is weak in tension.
- Use of waste in a useful manner, so that emission of co2 is decreased.
- To make concrete light in weight.

4 EXPERIMENTAL STUDY

4.1. *Material Used.*

4.1.1. Cement

Ordinary Portland cement (Sanghi-53 Grade)Confirming IS 12269:1987 [8] was used in presentstudy with properties listed in Table 1

Table-1: Properties of OPC 53 grade SANGHI cement

Sr. No.	Properties	Results
1	Loss of Ignition	1.56
2	%SiO_2	19.70
3	% CaO	63.44
4	Specific Gravity	3.15
5	% Normal Consistency	29.5
6	Specific Surface(m^2/kg)	306
7	Initial Setting Time (minutes)	145
8	Final Setting Time (minutes)	185
9	Compressive Strength(MPa)	
	3days	37.5
	7days	48.5
	28days	63

4.1.2. Coarse aggregate

Crushed angular aggregates confirming IS 383:1987 [9] with maximum size of 20mm and 10mm was used having bulk density of 1600 kg/m^3.The specific gravity was found to be 2.87.

4.1.3. Fine aggregate

River sand from local source confirming IS 383:1987 [9] was used as fine aggregate. The fineness modulus and specific gravity were found to be 2.64 and 2.84.

4.1.4. Water

Fresh potable water free from acid and organic substances was used for mixing and curing the concrete.

4.1.5. COIR (Coconut Fibers)

Table-2: Mechanical properties of coconut fiber (As per ACI 544.1R-96) Manual of concrete practice

PROPERTIES	VALUES
Fiber length(mm)	50-110
Fiber diameter(mm)	0.1-0.406
Specific Gravity	1.12-1.15
Elongation (%)	10-25strength
Modulus of elasticity(ksi)150	2750-3770
Average tensile strength(N/mm²)	150

Coir fibers have higher tensile strength as compared to other natural fibers, as the coir does not break easily with hand. Coir has a high resistance against salt water. It also has good resistance against corrosion.

4.1.6. Rice-husk Ash

Rice-husk ash was collected from “Mahalakshmi poha mill, Godhra.”, where it was prepared by burning of rice husk over 700 ° c temperatures in furnace.

Table-3: Physical properties of Rice-husk Ash

Physical state	Solid Non-Hazardous
Appearance	Very fine powder
Colour	Grey
Odour	Odourless
Particle size	2.3
Specific gravity	25 micron – mean

Table-4: Chemical properties of Rice-husk Ash

SiO2	93.8 %
AL_2O_3	0.74 %
Fe_2O_3	0.30 %
TiO_2	0.10 %
CaO	0.89 %
MgO	0.32 %
Na_2O	0.28 %
K_2O	0.12 %
Loi	3.37 %

4.2. *Mix Proportion*

The Mix Proportion was made for a concrete with a compaction factor of 0.96 and M_{20} grade as per method given by IS 10262-1982 [12].

(a) Design stipulations

(I) Characteristic compressive strength required in the field at 28 days. 20 MPa
(II) Maximum size of aggregate 20 mm (angular)
(III) Degree of workability 0.90 compacting factor
(IV) Degree of quality control Good
(V) Type of Exposure Mild

(b) Test data for Materials

1. Specific gravity of cement 3.15
2. Specific gravity of coarse aggregates 2.60
3. Specific gravity of fine aggregates 2.60

(I) Water absorption:
1. Coarse aggregate 0.50%
2. Fine aggregate 1.0%

(II) Free (surface) moisture:
1. Coarse aggregate Nil
2. Fine aggregate 2.0%

(III) Sieve analysis is shown below:

Table-5: Sieve analysis of coarse aggregate

Sieve size(mm)	**Analysis of Coarse aggregate (% passing) Fractions**		**Percentage of different fractions**			**Remark**
	I	II	I (60 %)	II (40 %)	Combined (100%)	Conforming to Table 2, IS: 383—1970
20	100	100	60	40	10	
10	0	71.2	0	28.5	28.5	
4.75	-	9.4	-	3.7	3.7	
2.36	-	-	-	-	-	

Table-6: Sieve analysis of fine aggregates

Sieve size	**Fine aggregate passing (%)**	**Remarks**
4.75 mm	100	Conforming to grading zone III of table 4, IS: 383—1970
2.36 mm	100	
1.18 mm	93	
600 micron	60	
300 micron	12	
150 micron	2	

(c) Target mean strength of concrete

The target mean strength for specified characteristic cube strength is
20 + (1.65) x 4 = 26.6 MPa

(d) Selection of water-cement ratio

The water-cement ratio required for the target mean strength of 26.6 MPa is 0.50. This is lower than the maximum value of 0.55 prescribed for 'Mild' exposure. Adopt W/C ratio of 0.50.

(e) Selection of water and sand content

For 20 mm maximum size aggregate, sand conforming to grading Zone II, water content per cubic metre of concrete = 186 kg and sand content as percentage of total aggregate by absolute volume = 35 %

For change in value in water-cement ratio, compacting factor, for sand belonging to Zone III, adjustment is required.

Therefore, required sand content as percentage of total aggregate by absolute volume = 35 – 3.5 = 31.5%

Required water content = 186 + 5.58 = 191.6 $1/m^3$

(f) Determination of cement content

Water-cement ratio = 0.50
water = 191.6 litre
∴cement = 191.6 / 0.50 = 383 kg/m^3
This cement content is adequate for 'mild' exposure condition.

(g) Determination of coarse and fine aggregate contents

1. Fine aggregate

For the specified maximum size of aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2 per cent
$0.98 = [191.6 + (383/3.15) + \{(1/0.315) \times (F_a/260)\}] (1/1000)$
$F_a = 546\ kg/m^3$.

2.Coarse aggregate :-

$C_a = \{(1-0.315)/ 0.315\} \times 546 = 1188\ kg/m^3$.

(h) Mix proportion

Water: Cement: Fine aggregate: Coarse Aggregate

191.6	383 kg	546 kg	1188 kg
0.50	1	1.425	3.10

4.3. ***Casting and Curing***

Mixing of ingredients was done according to specifications given in IS 516:1959[11] by machine mixing. The concrete was filled into the moulds in layers approximately 5cm deep and compacted by vibrator. The specimens were removed from mould after 24 hours and were kept submerged in curing tank. After curing for a period of 28 days, specimens were taken out and dried before testing.

5 TESTS ON CONCRETE

5.1 Slump measurement test:

The concrete slump test is an empirical test that measures the workability of fresh concrete.Metal mould, in the shape of the frustum of a cone, open at both ends, and provided with the handle, top internal diameter 10 cm, and bottom internal diameter 20 cm with a height of 30 cm was used to measure the slump of fresh concrete. Fig 5 and Fig 6 shows the step wise procedure of slump test and measured slump of fresh concrete. Table 5 and Chart 1 show slump test results measured.

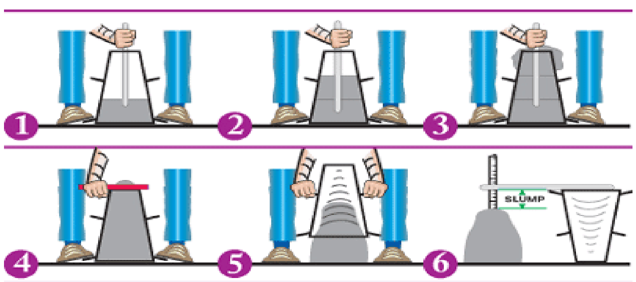

Fig-5: Procedure of measuring slump of fresh concrete.

Fig-6: Slump of fresh concrete measured.

Table-7: Slump test result of fresh concrete with different percentage of Rice-Husk Ash and COIR fibers.

SR NO.	MIX	Slump measured (mm)
1	M 20 (control mix)	50
2	5% RHA and 1% COIR	50
3	5% RHA and 2% COIR	48
4	5% RHA and 3% COIR	37
5	5% RHA and 4% COIR	35
6	10% RHA and 1% COIR	42
7	10% RHA and 2% COIR	39
8	10% RHA and 3% COIR	33
9	10% RHA and 4% COIR	28
10	15% RHA and 1% COIR	40
11	15% RHA and 2% COIR	35
12	15% RHA and 3% COIR	28
13	15% RHA and 4% COIR	25
14	20% RHA and 1% COIR	35
15	20% RHA and 2% COIR	30
16	20% RHA and 3% COIR	22
17	20% RHA and 4% COIR	18

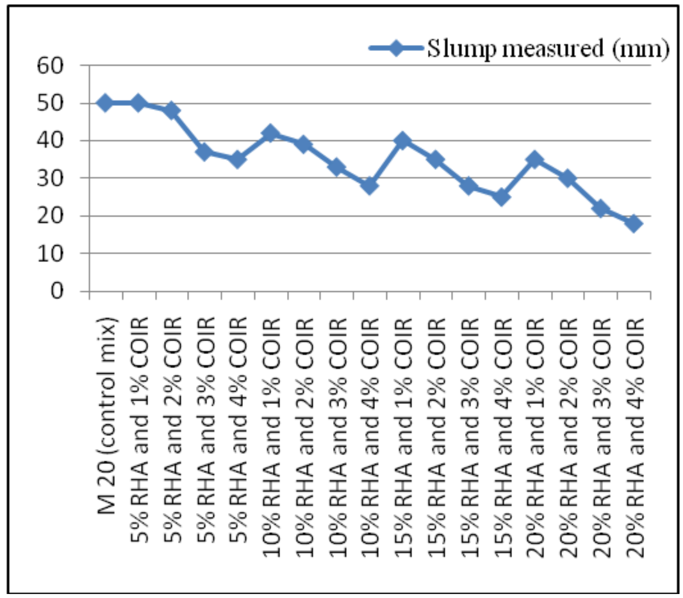

Chart-1: Slump test result of fresh concrete.

5.2 Compressive strength test:

Compression Test on cubes of size 150 mm was conducted on the compression testing machine (Aimil, 2000kN capacity). The load on cube was applied at a rate 5.2kN/s upto the failure of specimen. Average compressive strength of three cubes was taken after 28 days curing.Three cube specimensfor each mix are casted with different percentages of RHA and COIR fibers. Fig 7.Shows the compression test done on concrete cube containing 15% Rice-Husk Ash and 1% COIR Fiber. Table 6 and Chart 2 show the compressive strength result of concrete cubes containing various percentage of Rice-Husk Ash and COIR fiber.

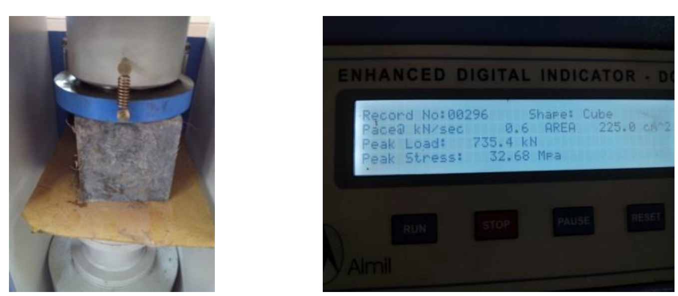

Fig-7: Compressive strength on cube and its result.

Table-8: Compressive strength of concrete with different percentages of Rice-husk Ash and COIR fibers.

SR NO.	MIX	COMPRESSIVE STRENGTH (N/mm^2)
1	M 20 (control mix)	22
2	5% RHA and 1% COIR	23.05
3	5% RHA and 2% COIR	22.75
4	5% RHA and 3% COIR	20.75
5	5% RHA and 4% COIR	19.55
6	10% RHA and 1% COIR	31.85
7	10% RHA and 2% COIR	22.64
8	10% RHA and 3% COIR	21.85
9	10% RHA and 4% COIR	18.70
10	15% RHA and 1% COIR	32.68
11	15% RHA and 2% COIR	29.32
12	15% RHA and 3% COIR	27.00
13	15% RHA and 4% COIR	11.00
14	20% RHA and 1% COIR	31.00
15	20% RHA and 2% COIR	16.90
16	20% RHA and 3% COIR	15.00
17	20% RHA and 4% COIR	13.11

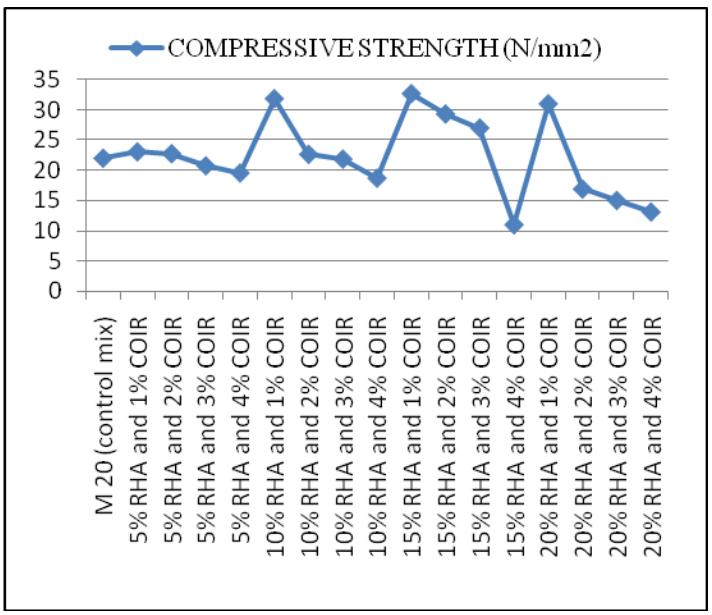

Chart-2: Compressive strength test result.

5.3 Split tensile strength test:

Split tensile test on cylinders of size 150mm diameter and 300mm height was conducted on the compressive testing machine (Aimil,2000kN) as per specifications given in IS 5816:1999[13].The load was applied at a rate of 1.8kN/s upto failure of specimen. Average Split Tensile Strength was taken after 28 days. It is observed that at failure load the cylinders of the control specimens is split or crush very easily but the cylinders of the mix containing fibers still kept intact even after failure. Fig 8. Shows the split tensile test on concrete containing Rice-husk Ash and COIR fiber, and its failure pattern after testing.Table 7 and Chart3 show the Tensile strength result of concrete containing various percentage of Rice-husk Ash and COIR fiber.

Fig-8: Tensile strength of concrete cylinder and failure pattern

Table-9: Tensile strength of concrete with different percentages of Rice-Husk Ash and COIR fibers.

SR NO.	MIX	TENSILE STRENGTH (N/mm^2)
1	M 20 (control mix)	2.2
2	5% RHA and 1% COIR	2.27
3	5% RHA and 2% COIR	2.22
4	5% RHA and 3% COIR	1.98
5	5% RHA and 4% COIR	1.77
6	10% RHA and 1% COIR	4.22
7	10% RHA and 2% COIR	3.33
8	10% RHA and 3% COIR	2.88
9	10% RHA and 4% COIR	2.24
10	15% RHA and 1% COIR	3.40
11	15% RHA and 2% COIR	4.00
12	15% RHA and 3% COIR	4.15
13	15% RHA and 4% COIR	2.70
14	20% RHA and 1% COIR	3.85
15	20% RHA and 2% COIR	2.70
16	20% RHA and 3% COIR	2.50
17	20% RHA and 4% COIR	2.19

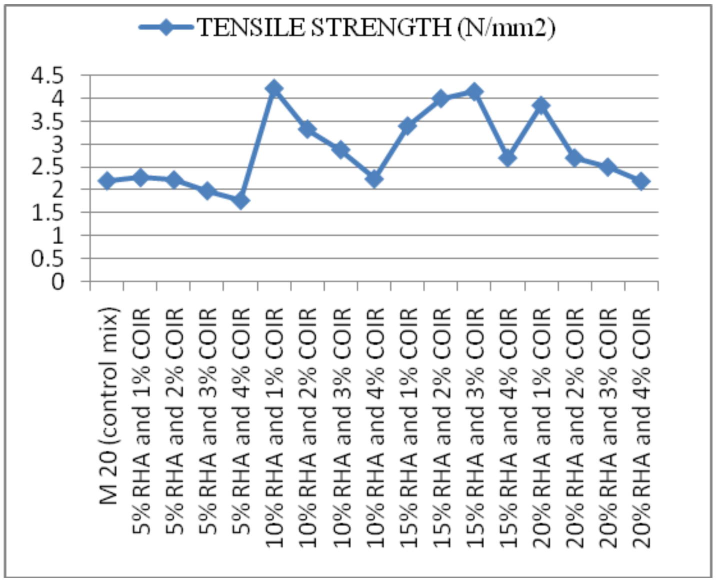

Chart-3: Tensile strength test result

5.4 Reduction in weight of the concrete:

It is observed that the RHA and COIR fibers have some property by which after adding it in the concrete it will reduce the weight of the concrete.RHA when added in the concrete reduces the weight of the concrete, as well as the addition of COIR fibers further reduces the weight of the concrete. Up to 25%reduction in weight is observed during experiment.

6. RESULTS AND DISCUSSIONS

- It is observed that replacing cement by 10%RHA and 1% Coir fiber gives maximum tensile strength.
- Maximum compressive strength is obtained at cement replacement of 15% RHA + 1% Coir fiber.
- Rate analysis shows that as the percentage of RHA and Coir increases the cost of concrete decreases.
- Weight reduction upto 25% is observed.
- Compressive and Tensile strength also increase at various other percentages.
- Cement can be replaced up to 20% by RHA and COIR fiber without compromising compressive and tensile strength.
- It is observed that as the percentage of Rice Husk Ash increase in concrete the compressive strength and tensile strength increases.
- It is observed that as the percentage of Coir fiber in concrete increase the tensile strength of concrete increases, but there is a reduction seen in compressive strength due to it.
- It is observed that as the percentage of Rice-Husk Ash and Coir Fiber in concrete increase the slump of concrete decreases, i.e. the concrete becomes less workable on higher percentage of cement replacement by Rice-Husk Ash and Coir Fibers.

7. CONCLUSSIONS

- Compressive strength increases upto 1.5 times compared to normal concrete at 15% RHA and 1% COIR replacement.
- Tensile strength increases upto 2.1 times at 10% RHA and 1% COIR fiber replacement.
- Concrete requires increase in water cement ratio due to increase in percentage of RHA and COIR fiber, because RHA is highly porous material and COIR fiber absorbs more water.
- The workability of RHA and COIR fiber concrete has been found to decrease with increase in RHA and COIR replacement.
- It is found that rice husk when burned produced approximately 80% amount of silica. For this reason it provides excellent thermal insulation.
- Rice husk ash contains more silica, and hence we prefer rice husk ash use in concrete to increase the strength.
- Rice-husk Ash and COIR fiber are available free of cost, so it's economical to use in concrete.
- Cost of concrete decreases by the use of Rice-Husk Ash and Coir fibers.

REFERENCES

[1] Kartini K, Mahmud HB, Hamidah MS; Strength Properties of Grade 30 Rice Husk Ash Concrete. 31st Conference on Our World in Concrete & Structures: 16 - 17 August 2006, Singapore.
[2] Domke PV; Improvement In The Strength Of Concrete By Using Industrial And Agricultural Waste. IOSR Journal of Engineering Apr, 2012; 2(4):755-759.
[3] Rao PP, Kumar AP, Singh BB; A Study on Use OfRice Husk Ash In Concrete. International Journalof education and applied research, 2014; 4(2):75-81.
[4] Ali M, Coconut Fibre – A Versatile Material andIts Applications in Engineering. Journal of CivilEngineering and Construction Technology, 2011;2(9):189-197.
[5] Kene SD, Domke PV, Deshmukh SD, Deotale RS;Assessment Of Concrete Strength Using FlyashAnd Rice Husk Ash. International Journal OfEngineering Research And Applications, 2011;1(3):524-534.
[6] Sivaraja M, Kandasamy S; Potential Reuse ofWaste Rice Husk as Fibre Composites inConcrete. Asian Journal of Civil Engineering(Building and Housing), 2011; 12(2):205-217.
[7] Chagas G, Dias CR, Filho T, De E, Fairbairn MR;Use of Ultrafine Rice Husk Ash with High-Carbon Content as Pozzolan in High Performance Concrete. Materials and Structures, 2009; 42:983–992.
[8] IS 12269:1987, "Specification for 53 grade ordinary Portland cement", Bureau of Indian Standards, New Delhi.
[9] IS 383:1987, "Specification for coarse and fine aggregate from natural sources for concrete", Bureau of Indian Standards, New Delhi.

[10] . ACI 544.1R-96,"State-of-the-Art Report on Fiber Reinforced Concrete", American Concrete Institute,(Reapproved 2002)
[11] Ealias AN, Rajeena AP, Sivadutt S , John L, PaulA; Improvement Of Strength Of Concrete WithPartial Replacement Of Course Aggregate WithCoconut Shell And Coir Fibres", IOSR Journal OfMechanical And Civil Engineering, 2014;11(3):16-24.
[12] IS 10262:1982, Indian Standard Recommended Guidelines for Concrete Mix Design, Bureau of Indian Standards, New Delhi.
[13] IS 5816:1999, "Splitting tensile strength of concretemethodof test", *Bureau of Indian Standards*, NewDelhi.
[14] IS 456:2000,Indian Standard Code of Practice for Plain and reinforced Concrete, *Bureau of Indian Standards*,New Delhi.
[15] IS 516 (1959),"Method of Tests
for Strength of Concrete", Bureau of Indian Standards, New Delhi.