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A thesis on dissertation work

"STRENGTH OF CORRUGATED ROOFING ELEMENTS REINFORCED WITH SILK FIBRE AND RICE HUSK ASH"

Submitted in partial fulfilment of the requirement for the award of the degree of

MASTER OF TECHNOLOGY in STRUCTURAL ENGINEERING

by

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Certificate

It is certified that the Project Work entitled "**Strength of corrugated roofing elements reinforced with silk fibre and RHA**" is a bonafide work carried out by **Mahesh K.P. (1OX11CSE03), 4th semester M.Tech, Structural Engineering** in partial fulfillment for the award of Degree of Master of Technology in Civil Engineering of the Visvesvaraya Technological University, Belgaum during the year 2012-2013. It is certified that all suggestion/correction indicated for Internal Assessment have been incorporated in the report. The Project report has been approved as it satisfies the academic requirements in respect of Project prescribed for the Master of Technology degree.

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DECLARATION

I hereby declare that the work submitted which is prescribed in project thesis entitled **"STRENGTH OF CORRUGATED ROOFING ELEMENTS REINFORCED WITH SILK FIBRE AND RICE HUSK ASH"** in partial fulfillment of the requirement for the award of Degree of Master of Technology in Structural Engineering from VISVESVARAYA TECHNOLOGICAL UNIVERSITY, Belgaum carried out during the year 2012-2013 under the guidance of **ARUNKUMAR B.N,** Asst. Prof, Department of Civil engineering, The Oxford college of engineering, Bangalore.

Further I declare that the work is original and I have not submitted this work to any other university to get any degree or diploma.

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ABSTRACT

Most of the corrugated roofing sheets have damaged due to tearing out at its corrugations by high wind loads and impact loads. The strength of these corrugations can be improved with fibre reinforcement, as the fibres are the crack arresters and absorbs energy. In this paper natural fibre namely silk fibres are used as reinforcement in cement matrices for producing corrugated roofing sheets has been investigated and reported. Rice husk ash-based silk fibre roofing sheets were cast manually and the strength of the corrugations of the above composite sheets in terms of splitting, due to direct and impact loads, were experimentally evaluated. It is found that the strength towards splitting of corrugations of the RHA based silk fibre corrugated roofing sheets due to direct and impact loads was improved as compared to the corrugated sheets without silk fibres. Also it is observed that RHA based silk fibre reinforced sheets are comparable to the splitting of corrugations due to direct and impact loads of a commercial roofing sheet, available in India. The result of the study revealed that rice husk can be used to replace asbestos, in the production of corrugated roofing sheets. Also the usage of industrial wastes still needs study on their better usage toxicity. These materials if studied and developed properly hold the key to address the current housing needs. The roofing tiles can be adapted particularly for hot climate due to its high insulation properties and therefore suitable to provide shelter for livestock by using the locally available agricultural waste materials for its production.

Chapter1. INTRODUCTION

1.1 General Introduction:

Concrete is characterized by quasi-brittle failure and weak in tension, the nearly complete loss of loading capacity, once failure is initiated. This characteristic, which limits the application of the material, can be overcome by the inclusion of a small amount of short randomly distributed fibers (natural, glass, synthetic and steel) and can be practiced among others that remedy weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc. Fiber reinforced concrete (FRC) is a fiber reinforcing cementitious concrete composite, and by adding discrete short fibers randomly in concrete it exihibits many sustantially improved engineering properties in compressive strength, tensile strength, flexural strength etc. The fibers are able to prevent surface cracking through bridging action leading to an increased impact resistance of the concrete.

Rice husk ash, Fly ash, Ground Granulated Blast furnace Slag, High Reactive Metakaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement. A number of studies are going on in India as well as abroad to study the impact of use of these pozzolanic materials as cement replacements and the results are encouraging. The strength, durability and other characteristic of concrete depends on the properties of its ingredients, proportion of mix, method of compaction and other controls during placing and curing.

So far, there are many types of natural fiber used in civil engineering. Silk fiber's diameter is small. A fiber with diameters larger than 0.1 mm is also defined as macro-fiber. So for Natural fiber, contain macro-fiber and micro-fiber. The micro-fiber often is used to control early plastic shrinkage cracking, the macro-fiber is not only used to restrain early plastic crack, but also to improve the properties of hard concrete.

To study the preparation and properties of the hardened concrete prepared with and without silk fibers, tests were conducted on cubes. They are compression test, flexural strength test, water absorption test and impact test for 28 days.

The locally available materials used for the preparation of concrete. The test were conducted on the materials, such as cement, fine aggregate, and water. Tests on Fine aggregate such as fineness modulus test, specific gravity test and water absorption test, tests on cement such as specific gravity test, initial and final setting time, and standard consistency tests. The drinking water standard is used for the preparation and curing of concrete.

GENERAL PRINCIPLE OF F.R.C

Fibre may be introduced in a particular manner and direction at random.

Thus we have

- 1-D fibre reinforced (Uni-dimensional)
- 2-D fibre reinforced (Two-dimensional)
- 3-D fibre reinforced (Three-dimensional)

I-D Uniaxial Fibre:

It is possible to align steel fibre in a particular direction by using a magnetic field. In 1-D or Uni-dimensional alignment may be achieved by proper vibration technique to get fibre in only one direction. However a random mix is obtained by introducing the fibre to the cement matrix in a special machine designed for the purpose and then this matrix are pumped into the desired site.

The ratio of length of fibre L/D is known as aspect ratio and this is one of the parameter in F.R.C.

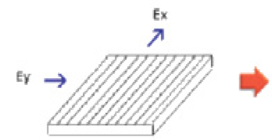

Fig 10. Uniaxial

II-D Two-dimensional:

The major advantage of F.R.C lies in the fact that cracked resistance is considerably increased and fibre alignment may be achieved accidently or intentionally in a various tabular surface vibration tend to align in two directions.

III-D Three-dimensional:

In 3-D or three-dimensional alignment may be achieved by proper vibration technique to get fibre in only one direction. However a random mix is obtained by introducing the fibre to the cement matrix in a special machine the mode of casting in Horizontal or vertical directions also influence the flexural strength.

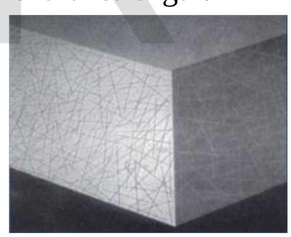

Fig 11. Three dimensional

3.3.1 Functions:

1. Reinforcement against shrinkage and intrinsic cracking.
2. Replaces welded wires mesh/ secondary cracks control steel used for crack prevention of concrete flooring.
3. Reduces bleeding and dust formation in concrete.
4. Improves impact resistance 3-4 times.

5. Improves abrasion resistance by 30-40%.
6. Gives residual strength to concrete.
7. Improves residual strength of concrete- thus avoids sudden failures and make the concrete earth-quake resistant.
8. Reduce permeability, thus protects rebar from corrosion.
9. Makes the concrete more durable.
10. Makes hardened concrete more tough.

DosageRate

Dosage: Optimized as per test results (0.3% silk fibre)

Recommended dosages are as follows:

170gm / 50 kg bag of cement

5 gm / cubic meter of concrete

Chapter 2.

2.REVIEW OF LITERATURE

2.1 General:

The purpose of this literature review is to provide background information on the issues to be considered in this thesis and to emphasize the relevance of the present study. The purpose of this chapter is also to provide a broad understanding of using different pozzolanic materials with the replacement of cement using fibres and rice husk ash mortar.

2.2 Earlier Researches:

2.2.1 Researches on rice husk ash:

[1] Kartini. K Assoc. Prof. Universiti Teknologi MARA, Selangor Malaysia (2011) carried out work on "Rice husk ash – pozzolanic material for sustainability". In this paper, a brief review is presented an intensive study on RHA was conducted to determine its suitability. From the various grade of concrete (Grade M30, M40, M50) studied, it shows that up to 30% replacement of OPC with RHA has the potential to be used as partial cement replacement (PCR), having good compressive strength performance and durability, thus have the potential of using RHA as PCR material and this can contribute to sustainable construction.

[2] S. D. Nagrale, Dr. Hemant Hajare, Pankaj R. Modak (2012) studied "Utilization Of Rice Husk Ash". RHA is used as a replacement for concrete (15 to 25%). This paper evaluates different contents of Rice Husk Ash added to concrete may influence its physical and mechanical properties. Sample Cubes were tested with different percentage of RHA and different w/c ratio, replacing in mass the cement. By the studies it was concluded that with the addition of RHA weight density of concrete reduces by 72-75%. The cost of 1 m^3 of OPC concrete works out to Rs. 1157 while that of RHA concrete works out to Rs. 959. Thus, the use of RHA in concrete leads to around 8-12% saving in material cost. The Compressive Strength will increase with the addition of RHA. The use of RHA considerably reduces the water absorption of concrete. RHA has the potential to act as an admixture, which increases the strength, workability & pozzolanic properties of concrete.

[3] Mauro M. Tashima, Carlos A. R. Da Silva, Jorge L. Akasaki, Michele Beniti Barbosa, Brazil (2003) reported that results of an experimental investigation dealing with the “Possibility of adding the rice husk ash” (RHA) to the concrete. The use of RHA in civil construction, may bring several improvements for the concrete characteristics. Adding RHA to concrete, a decreasing in water absorption was verified. A reducing of 38.7% was observed when compared to control sample. An increment of 25% was obtained when 5% of RHA was added. Moreover, a reducing on waste Portland cement was verified, obtaining the same resistance of control sample. According to the results of splitting tensile test, all the replacement degrees of RHA researched, achieve similar results. Then, may be realized that there is no interference of adding RHA in the splitting tensile strength. All the samples studied have a similar results in elasticity module. A decreasing in the module is realized when the levels of RHA are increasing.

[4] Nilantha B.G.P., Jiffry I., Kumara Y.S. and Subashi G.H.M.J. University of Ruhuna, Galle (2010) carried out work on **“**Structural and thermal performances of Rice husk ash (RHA) based sand cement block”. The sand cement blocks have been used in many countries of the world over a long period and it plays a major role in the building and construction industry. However, in order to make the indoor environment of the building as thermally comfortable as well as for achieving high structural performances, it is useful to use an alternative material to make blocks and bricks.

Strength characteristics of the blocks were investigated by conducting laboratory experiments. Thermal behavior of the block was investigated by comparing the variation of indoor temperatures in two model houses constructed with the sand cement blocks and Rice husk Ash (RHA) based sand cement blocks. It was found that the optimum compressive strength of RHA based cement sand block is achieved at 5% replacement level. The RHA based sand cement block make indoor environment more thermally comfortable than the sand cement block.

[5] E. B. Oyetola and M.Abdullahi Federal University of Technology (2006) The Use of Rice Husk Ash in Low - Cost Sandcrete Block Production Rice Husk Ash (RHA) was prepared using Charcoal from burning firewood. Preliminary analysis of the Constituent materials of the ordinary Portland Cement (OPC) / Rice Husk Ash (RHA) hollow sandcrete blocks were conducted to confirm their suitability for block making. Physical test of the freshly prepared mix was also carried out. 150mm×450mm hollow sandcrete blocks were cast cured and crushed for 1, 3, 7, 14, 21, and 28 days at 0, 10, 20, 30, 40 and 50 percent replacement levels. Test results indicate that most commercial sandcrete blocks in Minna town are below standard. The compressive strength of the OPC/RHA sandcrete blocks increases with age at curing and decreases as the percentage of RHA content increases. The study arrived at an optimum replacement level of 20%.

2.2.2 Researches on corrugated roofing sheets:

[1] G. Ramakrishna, T. Sundararajan and S.Kothandaraman (2011) carried out work on “Strength of corrugations of roofing sheets reinforced with sisal fibres”.

Most of the corrugated roofing sheets have damaged due to tearing out at its corrugations by high wind loads and impact loads. The strength of these corrugations can be improved with fibre reinforcement, as the fibres are the crack arresters and absorbs energy. In this paper natural fibre namely sisal fibres are used as reinforcement in cement matrices for producing corrugated roofing sheets has been investigated and reported. Fly ash based sisal fibre roofing sheets were cast manually and the strength of the corrugations of the above composite sheets in terms of splitting; due to direct and impact loads, were experimentally evaluated. It is found that the strength towards splitting of corrugations of the fly ash based sisal fibre corrugated roofing sheets due to direct and impact loads was improved as compared to the corrugated sheets without sisal fibres. Also it is observed that fly ash based sisal fibre reinforced sheets are comparable to the splitting of corrugations due to direct and impact loads of a commercial roofing sheet, available in India.

[2] Dr. S. Narayana and Dr. M.S. Mathews (2004) carried out an experiment on "Behaviour of Roofing Sheet Systems under Static Uplift Loads".

According to the study, it was found that, the roofing sheets of industrial sheds have been observed to fail in uplift under extreme wind conditions as in a cyclone. This paper presents the research carried out to study the behaviour under static uplift loads of asbestos cement and galvanised iron corrugated roofing sheet systems used in India .Small-scale models were also used to model the uplift behaviour of the roofing sheet systems at the connections and study the effect of dimensions of washers and types of bolts on the behaviour of roofing sheet system.

[3] Md. Koushic Uddin, Ms. Sonia Hossain, University of Science and Technology carried out work on "A comparitive study on silk dyeing with acid dye and relative dye". This research paper shows a comparative analysis of silk dyeing with acid dye, which is commonly used and reactive dye, which is more commonly applied on cotton. The study focuses on the dye uptake, different types of fastness properties and the strength of the dyed samples. It was found that reactive dyes showed better dye uptake and color fastness on silk than acid dyes but comparatively the strength of the fibre was decreased.

[4] C.M.R. Dias, M.A. Cincotto, H. Savastano, V.M. John (2008) carried out work on **"**Long-term aging of fiber-cement corrugated sheets- the effect of carbonation, leaching and acid rain"**.**

This paper studies the performance of fiber-cement corrugated sheets exposed to long-term weathering, exploring the effect of different environments on fiber-cement degradation. Fiber-cement corrugated sheets that had been exposed to weathering, and in place for more than 30-years, were collected. Mechanical properties like fracture toughness was tested on samples removed from the corrugated sheets.

[5] Krunoslov vidovic, Milan Ambrozic, Kristopher Kernel, Tomaz Kosmac and Stephen Akers (2010) carried out work on "The Fracture strength of Fibre cement corrugated sheets".

The breaking load and the breaking moment during transversal and longitudinal loading of fiber-cement profiled (corrugated) sheets were measured on products manufactured on an industrial Hatschek machine, and the corresponding bending strengths were calculated. The influence of two processing parameters, i.e., the pressure applied to the green sheet directly during the manufacture and the content of the reinforcing organic fibers within the Portland cement matrix, on the fracture strength of the products was studied and statistically analyzed assuming Weibull statistics. The Weibull parameters were compared for different fabrication conditions.

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Chapter 3. MATERIALS AND METHODOLOGY

3.1 General:

For the purpose of this work is to study strength characteristics of mortar with replacement of cement by rice husk ash and incorporation of silk fibers. The materials used for casting samples are described as under.

3.2 Materials used:


Fig 19. Cement
Fig 20. Sand


Fig 21. Rice husk ash
Fig 22. Silk fibre

3.2.1 Cement:

Cement is a fine, grey powder. It is mixed with water and materials such as sand, pozzolanas to make mortar and concrete. The cement and water forms a paste that binds the other materials together. The ordinary cement contains two basic ingredients namely argillaceous and calcareous. In argillaceous materials clay predominates and in calcareous materials calcium carbonate predominates. In the present work, 43 grade ordinary Portland cement was used for casting cubes, cylinders and tiles.

Table 3.1 Chemical Composition (%) of OPC:

Oxide	Percentage
CaO	60-67
SiO_2	17-25
Al_2O_3	3.0-8.0
Fe_2O_3	0.5-0.6
MgO	0.1-4.0
Alkalies (K_2O, Na_2O)	0.4-1.3
SO_3	1.3-3.0

Table 3.2 Tabulation of Specific gravity of cement:

1.	Weight of empty bottle, W_1 gm	33	33	33
2.	Weight of bottle+ water, W_2 gm	78	80	76
3.	Weight of bottle+ kerosene, W_3 gm	72	74	71
4.	Weight of bottle+ cement+ kerosene, W_4 gm	90	92	89
5.	Wt of cement, W_5 gm	25	25	25
6.	Sp. gravity of kerosene, $S=(W_3-W_1)/(W_2-W_1)$	0.86	0.87	0.88
7.	Sp. Gravity of cement, $S=W_5 (W_3-W_1)/((W_5+W_3-W_4)(W_2-W_1))$	3.10	3.12	3.15

Result: Specific gravity of cement = 3.12

Table 3.2 Tabulation of Normal consistency of cement:

Trails	1	2	3	4	5
% of Water added	28	30	31	32	33
Initial Reading 'mm'	0	0	0	0	0
Final Reading 'mm'	36	33	26	18	7
Difference (un penetrated depth) 'mm'	39	33	26	15	16

Result: Normal consistency of cement = 33%

Table 3.3 Observation calculation and Tabulation of initial setting time of cement:

Weight of cement = 400gm.

(Size of cement particle passing 800µ size)

Needle dimension = 1mm² area of 50mm long.

Gauging time = 2-3min

Quantity of water = 0.85P x weight of cement = 0.85 x 32 x 400g = 109ml.

Trails	1	2	3	4	5	6	7	8	9	10	11	12	13
Time in min.	0	5	10	15	20	25	30	35	40	45	50	55	60
Initial Reading 'mm'	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Reading 'mm'	0	0	0	0	0	0	0	0	0	0	0	2	5
Difference (mightnot penetrated) 'mm'	0	0	0	0	0	0	0	0	0	0	0	2	5

Result: Initial setting time of cement = 60min.

Final setting time of cement = 5 Hrs.

Table 3.5 Properties of Cement:

Sl. No.	Properties	Values obtained	Standard values
1.	Specific gravity	3.12	3.15
2.	Normal consistency	33%	30%
3.	Initial and Final setting time	60 min and 5 Hrs	Not be less than 30 minutes

3.2.2 Fine Aggregates:

Table 3.6 Tabulation of Specific gravity of fine aggregate:

Specific gravity:	Trail 1	Trail 2	Trail 3
Weight of empty pycnometer (W_1)	558	558	558
Weight of pycnometer + water (W_2)	1557	1560	1566
Weight of saturated surface dry (W_3)	500	500	500
Weight of pycnometer + water + Fine agg(W_4)	1865	1872	1878
Bulk specific gravity	2.60	2.65	2.66

Table 3.7 Tabulation of moisture content of fine aggregates:

Water Absorption:	Trail 1	Trail 2	Trail 3
Weight of tray + saturated surface dry fine agg(W_5)	950	951	940

Weight of tray + oven dry Fine Aggregate (W_6)	947	947	934
Weight of empty try (W_7)	450	447	440
Percentage of water absorption	0.6	0.8	1.21

Bulk specific gravity = $W_3/(W_3-(W_4-W_2))$ = Average value= 2.60.

Percentage of water absorption = (W_5-W_6/W_6-W_7) X100 = Average value = 0.87%.

Result: specific gravity of fine aggregate is 2.60 and percentage of water absorption is 0.87%.

Table 3.8 Tabulation of Sieve Analysis of fine aggregates:

Observation and Calculations:

Weight of fine aggregate (W) = 1000gms.

Weight of fine aggregate retained on sieve (Wi).

Percentage of fine aggregate retained on sieve = (Wi/W) X100

Percentage of passing = 100- (cumulative percentage of retained)

Sieve No.	Weight of FA retained (Wi)	% of retained (Wi/W) X100	Cumulative % of retained (f)	% of passing F = 100-f
4.75mm	18	1.8	1.8	98.2
2.36mm	65	6.5	8.3	91.7
1.18mm	97	9.7	18.0	82.0
600µ	145	14.5	32.5	67.5
300µ	287	28.7	61.2	38.8
150µ	319	31.9	93.1	6.9
PAN	69	6.9	100.00	0.0

Result: Fineness Modulus = $\sum f$ /100 = 314.9/100 = 3.149.

Table 3.9 Properties of Fine aggregates:

Type	Natural sand
Specific gravity	2.600
Fineness Modulus	3.140
Moisture content	0.87%

3.2.3 Water:

Water is one of the ingredients of concrete. It is usually least expensive and testing it tends to be ignored. Water is required for the process of hydration and for getting proper workability. Water is available from many sources, viz., ground, river, lakes, sea, etc. Not all waters are suitable for making of concrete. Water used for concrete should be clear, clean and free from injurious amount of deleterious materials like, salts, oils, acids, alkalis, sugar and organic materials. Potable water (water fit for drinking) is generally considered fit for concrete. The PH value of water shall not be less than 6. In the present work tap water was used for both mixing and curing purposes.

3.2.4 Rice husk ash:

Rice Husk Ash (RHA) is a by-product obtained from the combustion of rice husk which consists of noncrystalline silicon dioxide RHA having pozzolanic properties would reduce the demand of Portland cement The reasons behind the use of RH in the construction industry are its high availability, low bulk density (90-150kg/m3), toughness, abrasive in nature, resistance to weathering and unique composition. The main components in RH are silica, cellulose and lignin. RH density is less than 500kg/m3. RH can be utilised in the manufacture of particleboards, ceiling boards and insulation boards. The use of biodegradable adhesives could reduce the use of synthetic adhesives based on petroleum resources and its ill effects. These materials could provide competitive composite boards for construction and, at the same time, be environmentally friendly.

Table 3.10 Specification of Rice-Husk Ash:

Silica	90% minimum
Humidity	2% maximum
Mean Particle Size	25 microns
Color	Grey
Loss on Ignition at 800 °C	4% maximum

Table 3.11 Physical Properties of Rice-Husk Ash:

Physical Properties	**Values**
Physical State	Solid – Non Hazardous
Appearance	Very fine powder
Specific gravity	2.13
Particle Size	25 microns – mean
Odour	Odourless
Fineness – median particle size, mm	8.3
Nitrogen absorption, m^2/g	20.6
Water requirement, %	104
Pozzolanic activity index, %	99

Table 3.12 Chemical properties of Rice-Husk Ash:

Chemical Properties	Values(%)
Silicon dioxide (SiO_2)	90.7
Aluminium oxide (Al_2O_3)	0.4
Ferric oxide (Fe_2O_3)	0.4
Calcium oxide (CaO)	0.4
Magnesium oxide (MgO)	0.5
Sodium oxide (Na_2O)	0.1
Potassium oxide (K_2O)	2.2
Equivalent alkali (Na_2O+0.658K_2O)	1.5
Phosphorous oxide (P_2O_5)	0.4
Titanium oxide (TiO_2)	0.03
Sulphur trioxide (SO_3)	0.1
Loss of ignition (Loi)	4.8

3.2.5 Advantages of using Rice-Husk Ash:

1) Reduced heat of hydration – leading to minimal crack formation in higher grades of concrete.
2) Reduced permeability at higher dosages.
3) Increased chloride and sulphate resistance/mild acids.
4) Rice husk ash has been effectively used as simple cementitious coatings for concrete surfaces to act as a waterproofing barrier coupled with higher chemical resistance.
5) Rice husk ash has also been extensively used as an effective repair mortar without the use of SBR latex /Acrylic polymer bonding agents.
6) It not only reduces the consumption of cement due to blending but also solves the waste disposal problem.
7) RHA when blended with cement makes it the most eco-friendly versatile supplementary cementing material to concrete.

Other uses:

There are other uses for RHA which are still in the research stages:

1) In the manufacture of roof tiles.
2) As a free running agent for fire extinguishing powder.
3) Abrasive filler for tooth paste.
4) A component of fire proof material and insulation.
5) As a beer clarifier.
6) Extender filler for paint.
7) Production of sodium silicate films.

3.2.6 Application of Natural fibre:

Silk Fibre

India stand second place in the world for producing silk. There are several potential applications for silk cement products, particularly in low cost housing, for example for cladding mud brick walls, Roofing slates and corrugated roofing sheets. The high toughness may also be particularly useful in earthquake zone.

a. Roofing Sheets

There are not many feasible alternatives for roofing materials in many developing countries, especially in the rural areas where modern housing has to rely almost exclusively on the use of corrugated aluminium or asbestos sheets. Due to the high prices of these items, this makes roofing to be the single most expensive item in rural housing schemes. Current research shows that roofing sheets made from silk fibre reinforced concrete can provide a cheap alternative to the conventional corrugated aluminium sheets. silk fibre reinforced concrete sheets are fire resistant and durable. They also have good thermal and sound insulating properties. Silk fibre reinforced concrete roofing sheets can be produced in small scale industries, thereby offering opportunities for improving the quality of life in rural areas.

b. Light Walling and Cladding

Sun screens and cladding for multistory building can be manufactured from silk fibre reinforced concrete, while hallow silk fibre reinforced concrete, blocks can be used for making light load bearing wall elements.

c. Plastering

Silk fibre reinforced concrete surfacing can protect mud brick walls and mud-and-pole construction from destruction by rain.

d. Paving slabs

Silk fibre reinforced concrete can also be used for the manufacture of paving slabs and as surfacing for concrete bridge decks. There are also wide possibilities for semi-structural applications of silk fibre reinforced concrete in the form of light beams, frames and trusses and as permanent work for cast-in-situ concrete.

Thus, when fully developed and tested, silk - cement could become a very useful building material for developing countries.

3.2.7 EFFECT OF SILK FIBERS ON CONCRETE

Constant slump versus fiber content and length, increasing the fiber content and aspect ratio are observed to increase the water cement required for maintaining constant workability. Fibers when incorporated in concrete even at low volume fractions provide a relatively high, fiber surface area that needs to be coated with the paste for effective bonding to concrete. Consumption of wet paste for coating fiber reduces paste content for lubrication of aggregates thus reducing the workability.

Table 3.13 Physical Properties of Silk fibre:

Color	Yellow, brown, green or grey.
Tensile strength	Strength is greatly affected by moisture. Wet strength is 75 – 85%, which is higher than dry strength.
Tenacity	2.4 – 5.1 gms/denier.
Density	1320 – 1400 kg/m^3
Elongation at break (Normal)	20 – 25% at break.
Elongation at break (Extension)	33%
Elastic Recovery	Not so good.
Specific gravity	1.25 – 1.34
Diameter	Negligible (Due to wear and Tear)
Application	Concrete
Moisture regain	Standard moisture regain is 11%, but can absorb up to 35%.
Effect of heat	Silk can withstand at higher temperature than wool. It will remain unaffected for prolonged periods at 140°C. Silk decomposition at 175°C.
Effect of sunlight	Sunlight tends to encourage the decomposition of silk by atmospheric oxygen.
Luster	Bright.
Solubility in water	Not soluble in water

Table 3.14 Chemical properties of Silk fibre:

Effect of acids	Decompsed by strong acids. Dilute acids do not attack silk under mild conditions.
Effect of Alkalis	Silk is a less readily damaged by alkalis than wool. Silk dissolves in solutions of concentrated caustic alkalis.
Effect of organic solvent	Silk is insoluble in the dry-cleaning solvents in common use.

3.3 Methodology:

Manufacturing of Silk - RHA and Cement Composite Roofing Sheets

3.3.1 Casting procedure

Composites were manufactured by manual mix of silk fiber, ordinary portland cement, sand and potable water in a head pan using pre-determined cement, sand and water ratios as shown in the experimental set up. For the control sample, the fiber and pozollona content were both 0%. The cement-water ratio was 1:0.5 while the cement-sand ratio was 1:3. For other test samples, silk fibers were added at the rate of 0.1%, 0.2%, 0.3% and 0.4%. Rice Hush Ash (RHA) was also added at the rate of 10%, 20%, and 30% as partial replacement for cement. The added dosages of the fiber and pozollona were based on the mass of cement. The mixtures were thoroughly mixed until homogenous slurry was formed. Three replicate samples each of dimension 500x320x6 mm samples in replicates of three were prepared for strength test, water absorption test and impact test. The sample with the desirable properties was chosen and used in the production of silk - RHA and cement composite roofing sheets. Each mixture was spread uniformly to a thickness of 6mm. It was then tamped for 60 seconds to reduce and eliminate voids in the composite produced. The slurry was carefully transferred on a corrugated mould as shown in figure, the mixture was smoothened with the aid of a hand trowel as seen in figure and covered with polythene. It was allowed to dry for 24 hours, then it was removed from the sheet.

3.3.2 Casting procedure figures:

Fig 23. Mixing of fibre with aggregate

Fig 24. Spreading and Smoothening with hand trowel

Fig 25. Dragging and allowed to dry

Chapter 4.
EXPERIMENTAL SET UP

4.1 Preparation of specimens for testing:

Cubes of size 75x75x75 mm were used to prepare the mortar specimen for the determination of compressive strength of 1:3 rice husk ash mortar and cylinders of size 100 x 200 mm diameter were used to determine the split tensile strength of the specimen. All specimens were prepared in accordance with Indian Standard specifications IS: 456-2001. All the specimens were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there are no gaps from where there is any possibility of leakage out of slurry.

4.3 Compressive strength:

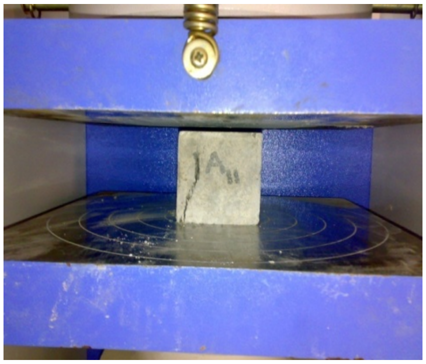

Fig 4.3. Compression testing machine

4.4 Split Tensile Strength:

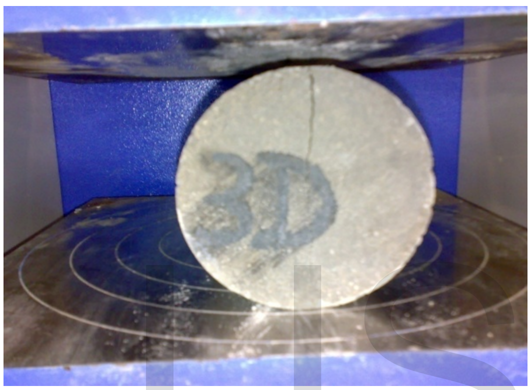

Fig 4.4. Split tensile test

4.5 Flexural strength of Tiles:

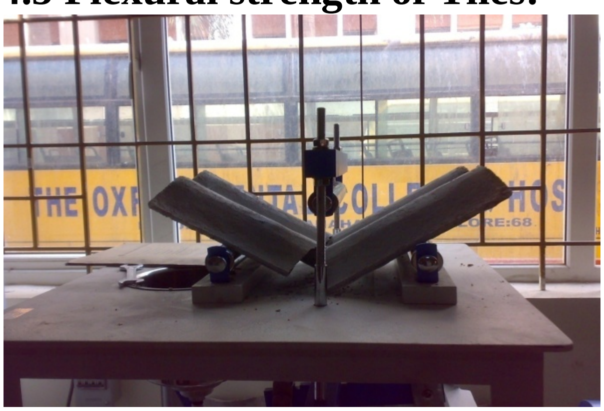

Fig 4.5. Tile testing machine

Calculation:

i) Breaking load= (Total weight – Bucket weight) x 12 .... (4.3)

ii) Breaking strength (N):

$$S = \frac{FL}{b}$$

.... (4.4)

Where,
S= Breaking strength (N),
F= Breaking load in N,
L= length of roofing sheet (mm),
b= breadth of roofing sheet (mm),

iii) Bending strength ($\frac{N}{mm^2}$):

$$R = \frac{3FL}{2bh^2} = \frac{3S}{2h^2}$$

.... (4.5)

Where,
R= Bending strength or modulus of rupture ($\frac{N}{mm^2}$)
h= thickness of roofing sheet (mm)

4.6 Impact test of Tiles:

Calculation:

Residual impact strength ratio (I_{rs}) = ... (4.6)

$$\left\{ \frac{\text{Energy absorbed upto ultimate failure}}{\text{Energy absorbed at initiation of first crack}} \right\}$$

Fig 4.6. Impact test set up

4.7 Water Absorption Test:

Tiles are dried in an oven at constant 60^0C and then put in water for 24 hours. The difference in weight is measured and given as percentage tiles dry weight.

The tiles should absorb at most 6 % after 24 hours in water.

Calculation:

Water Absorption (%) = (B – A) / A x100 .... (4.7)

Where,

B = Weight of specimen after 24 hour immersion

A = Weight of dry specimen

Fig 4.7. Curing (Water Absorption Test)

Chapter 5. RESULTS AND OBSERVATIONS

Table 5.1: Compressive strength of 1:3 cement mortar cubes with 0%, 10%, 20% and 30% replacement of rice husk ash

Mix ratio	Fibre (%)	Numbering	Compressive Strength at 28 days(MPa)	Average Compressive Strength(MPa)	Mean Moisture Absorbed(%)
100% OPC, 0% RHA	0	$1A_1$	26.8	30.00	1.33
		$1A_{11}$	32.5		
		$1A_{111}$	30.7		
	0.1	$1B_1$	27.5	29.80	1.32
		$1B_{11}$	28.4		
		$1B_{111}$	33.5		
	0.2	$1C_1$	31.9	29.97	1.30
		$1C_{11}$	25.9		
		$1C_{111}$	32.1		
	0.3	$1D_1$	23.5	26.8	1.10
		$1D_{11}$	28.3		
		$1D_{111}$	28.6		
	0.4	$1E_1$	24.2	27.8	1.55
		$1E_{11}$	29.5		
		$1E_{111}$	29.7		

Mix ratio	Fibre (%)	Numbering	Compressive Strength at 28 days(MPa)	Average Compressive Strength(MPa)	Mean Moisture Absorbed(%)
90% OPC, 10% RHA	0	$2A_1$	26.9	26.3	2.04
		$2A_{11}$	24.9		
		$2A_{111}$	27.1		
	0.1	$2B_1$	23.3	23.77	2.98
		$2B_{11}$	23.9		
		$2B_{111}$	24.1		
	0.2	$2C_1$	21.0	21.77	3.40
		$2C_{11}$	22.0		
		$2C_{111}$	22.3		

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	0.3	$2D_1$	24.7	25.00	3.44
		$2D_{11}$	25.1		
		$2D_{111}$	25.0		
	0.4	$2E_1$	24.2	27.8	4.86
		$2E_{11}$	29.5		
		$2E_{111}$	29.7		

Mix ratio	Fibre (%)	Numbering	Compressive Strength at 28 days(MPa)	Average Compressive Strength(MPa)	Mean Moisture Absorbed(%)
80% OPC, 20% RHA	0	$3A_1$	21.4	21.33	3.20
		$3A_{11}$	21.0		
		$3A_{111}$	21.6		
	0.1	$3B_1$	21.9	20.83	3.78
		$3B_{11}$	18.5		
		$3B_{111}$	22.1		
	0.2	$3C_1$	17.6	19.33	2.77
		$3C_{11}$	20.1		
		$3C_{111}$	20.3		
	0.3	$3D_1$	20.2	20.20	3.08
		$3D_{11}$	20.0		
		$3D_{111}$	20.4		
	0.4	$3E_1$	20.1	19.13	3.81
		$3E_{11}$	17.0		
		$3E_{111}$	20.3		

Mix ratio	Fibre (%)	Numbering	Compressive Strength at 28 days(MPa)	Average Compressive Strength(MPa)	Mean Moisture Absorbed(%)
70% OPC, 30% RHA	0	$4A_1$	12.9	12.53	5.20
		$4A_{11}$	11.2		
		$4A_{111}$	13.5		
	0.1	$4B_1$	9.8	9.73	4.91
		$4B_{11}$	9.4		
		$4B_{111}$	10.0		
	0.2	$4C_1$	9.8	10.17	5.11
		$4C_{11}$	10.2		

		$4C_{111}$	10.5		
	0.3	$4D_{1}$	15.7	15.90	4.44
		$4D_{11}$	15.9		
		$4D_{111}$	16.1		
	0.4	$4E_{1}$	13.1	13.00	4.41
		$4E_{11}$	12.4		
		$4E_{111}$	13.4		

Table 5.2: Split tensile strength of 1:3 cement mortar cubes with 0%, 10%, 20% and 30% replacement of rice husk ash

Mix ratio	Fibre (%)	Numbering	Split Tensile Strength at 28 days(MPa)	Mean Moisture Absorbed(%)
100% OPC, 0% RHA	0	1A	3.14	2.62
	0.1	1B	2.57	2.36
	0.2	1C	2.24	2.86
	0.3	1D	2.73	2.91
	0.4	1E	2.01	1.62

Mix ratio	Fibre (%)	Numbering	Split Tensile Strength at 28 days(MPa)	Mean Moisture Absorbed(%)
90% OPC, 10% RHA	0	2A	2.25	3.50
	0.1	2B	2.37	1.88
	0.2	2C	2.24	2.20
	0.3	2D	2.77	2.48
	0.4	2E	2.20	2.91

Mix ratio	Fibre (%)	Numbering	Split Tensile Strength at 28 days(MPa)	Mean Moisture Absorbed(%)
80% OPC, 20% RHA	0	3A	3.30	1.50
	0.1	3B	2.46	1.85
	0.2	3C	2.65	1.98
	0.3	3D	2.38	1.97
	0.4	3E	2.10	2.30

Mix ratio	Fibre (%)	Numbering	Split Tensile Strength at 28 days(MPa)	Mean Moisture Absorbed(%)
70% OPC, 30% RHA	0	4A	1.97	5.55
	0.1	4B	1.75	5.07
	0.2	4C	1.55	4.24
	0.3	4D	1.74	5.11
	0.4	4E	2.45	4.35

Table 5.3: Bending Strength of tiles 1:3 cement mortar cylinders with 0%, 10%, 20% and 30% replacement of rice husk ash

Sl. No.	Mix ratio	Fiber %	Flexural load (F) in kg	Breaking strength (S=FL/B) in N	Bending strength ($R=3S/2h^2$) in N
1.	100% OPC, 0% RHA	0	140.34	2151.15	89.63
		0.1	152.82	2342.44	97.60
		0.2	214.14	3282.36	136.77
		0.3	151.14	2316.70	96.53
		0.4	207.00	3172.92	132.20

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2.	90% OPC, 10% RHA	0	117.66	1803.51	75.15
		0.1	164.64	2523.62	105.15
		0.2	173.34	2657.00	110.71
		0.3	126.36	1936.86	80.70
		0.4	167.10	2561.33	106.72
3.	80% OPC, 20% RHA	0	127.38	1952.50	81.35
		0.1	138.54	2123.56	88.48
		0.2	140.34	2151.15	89.63
		0.3	143.70	2202.65	91.78
		0.4	89.46	1371.25	57.13
4.	70% OPC, 30% RHA	0	81.90	1255.37	52.31
		0.1	80.52	1234.22	51.42
		0.2	69.00	1057.64	44.10
		0.3	76.02	1165.24	48.55
		0.4	86.04	1318.83	55.00

Table 5.4: Water absorption of tiles 1:3 cement mortar cylinders with 0%, 10%, 20% and 30% replacement of rice husk ash

Sl. No.	Mix ratio	Fiber (%)	Water absorption (%)	Reference %
1.	100% OPC, 0% RHA	0	2.7	6
		0.1	2.1	6
		0.2	2.1	6
		0.3	3.0	6
		0.4	1.1	6

2.	90% OPC, 10% RHA	0	2.0	6
		0.1	1.5	6
		0.2	0.8	6
		0.3	2.5	6
		0.4	1.5	6
3.	80% OPC, 20% RHA	0	0.9	6
		0.1	2.8	6
		0.2	2.7	6
		0.3	1.3	6
		0.4	2.6	6
4.	70% OPC, 30% RHA	0	0.3	6
		0.1	0.5	6
		0.2	2.6	6
		0.3	1.2	6
		0.4	0.5	6

Table 5.5: Number of blows for tiles 1:3 cement mortar cylinders with 0%, 10%, 20% and 30% replacement of rice husk ash

Sl. No.	Mix ratio	Fibre %	Impact strength (no. of blows)	
			Crack appearing	breaking
1.	100% OPC, 0% RHA	0	2	3
		0.1	2	3
		0.2	2	3
		0.3	1	2
		0.4	1	2
		0	1	2

2.	90% OPC, 10% RHA	0.1	2	3
		0.2	2	3
		0.3	2	3
		0.4	1	2
3.	80% OPC, 20% RHA	0	2	3
		0.1	1	2
		0.2	3	4
		0.3	2	3
		0.4	1	2
4.	70% OPC, 30% RHA	0	1	2
		0.1	1	2
		0.2	2	3
		0.3	1	2
		0.4	1	2

Height of fall= 1mt, Weight of ball= 0.44 kg, Energy= 4.32 J

Table 5.6: Residual impact strength ratio of tiles with 0%, 10%, 20% and 30% replacement of rice husk ash

Sl. No.	Fibers %	Energy absorbed (Joules) for rice husk ash contents of											
		0%			10%			20%			30%		
		A	B	Ratio B/A	A	B	Ratio B/A	A	B	Ratio B/A	A	B	Ratio B/A
1.	0	8.64	12.96	1.5	4.32	8.64	2	8.64	12.96	1.5	4.32	8.64	2
2.	0.1	8.64	12.96	1.5	8.64	12.96	1.5	4.32	8.64	2	4.32	8.64	2
3.	0.2	8.64	12.96	1.5	8.64	12.96	1.5	12.96	17.28	1.33	8.64	12.96	1.5

4.	0.3	4.32	8.64	2	8.64	12.96	1.5	8.64	12.96	1.5	4.32	8.64	2
5.	0.4	4.32	8.64	2	4.32	8.64	2	4.32	8.64	2	4.32	8.64	2
A = Energy absorbed for initiation of crack, B =Energy absorbed for Breaking													

Residual impact strength ratio = B/A

5.7 TESTS ON ROOFING ELEMENT:

The test consists of placing Roofing sheet over a support made of temporary brick wall and load is applied above roofing sheet. The load is introduced by means of sand bags of 10 kg each. The load is increased till the ultimate crack was observed, that load is considered as the load capacity of roofing sheet

Result: The load capacity of SFRC obtained is **87 kg/m^2**

Recommended values:

Residential buildings = **75kg/m^2.**

5.7.1 RATE ANALYSIS

Material calculation for each sheet:

Volume of mortar = 1x2x0.006m

= 0.012 m^3

Weight of mortar = Vol. of mortar x Density of mortar

= 0.012 x 2162

= 26.00 Kg/m^3

Add 10% extra = 26.00+(0.1 x 26.00)

= 28.60 Kg.

Total proportion = 1 + 3

= 4

Weight of cement = (28.60 /4) x 1

= 7.15 Kg.

Weight of sand = (28.60 /4) x 3

= 21.45 Kg

Weight of water = 7150 x 0.5

= 3575 ml

For 10 sheets

Running Cost of 20% RHA for 10 sheets

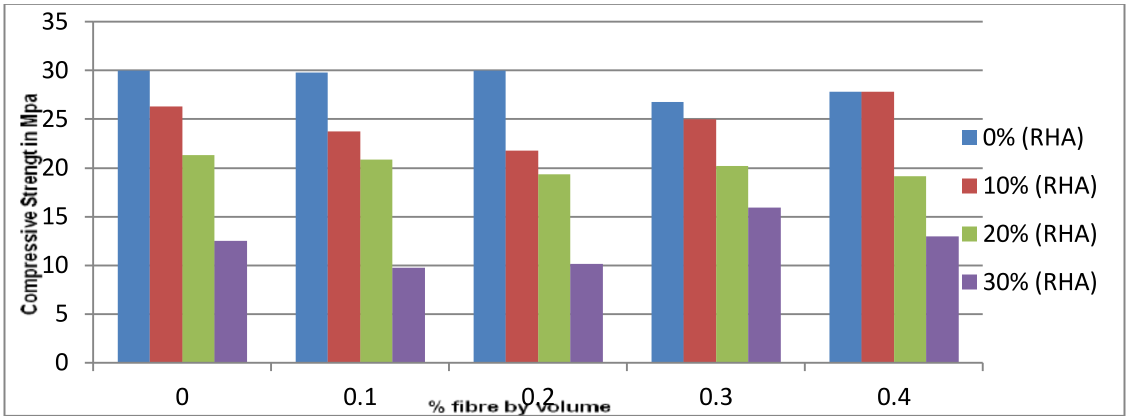
Contents	Quantity	Rate Rs...
Cement	56.5 kg	350
Sand	170 kg	100
RHA	15	40
Fibre	150 gm	25
Labour	2 Persons	500
Total		1015

Cost per sheet = 1085 /10 = Rs.101.5

Rate of Asbestos Sheet of Size lm^2= Rs. 180/-

Chapter 6. ANALYSIS OF RESULTS

6.1 Graphs of Compressive strength for 1:3 cement mortar cubes with 0%, 10%, 20% and 30% replacement of rice husk ash:

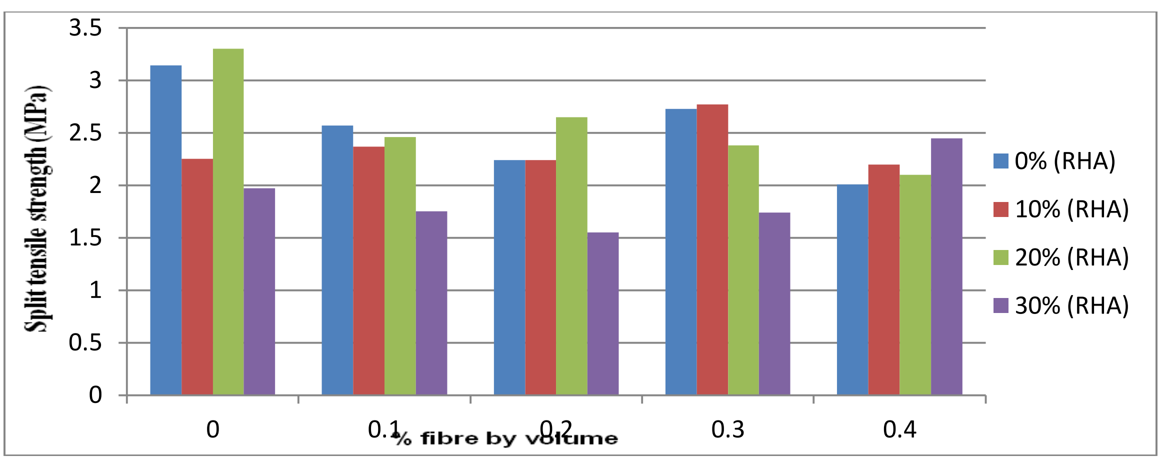


Analysis: The specimen with 0% replacement is showing a higher strength at 0% and 0.2% fibres. As the fibre content increases, there is reduction and gradual increase in the strength at certain % fibres and the strength is slightly increasing at 0.4% fibres by volume.

The compressive strength of specimen with 10% RHA is highest among the other replacement levels of 20% and 30%.

The mortar specimens with 10% and 20% replacement of RHA have higher initial strength at 0.1% and 0.3% fibres but as the fibre content keeps increasing there is reduction in load taking capacity. This can be attributed to the lower rate of strength gain caused by addition of RHA.

6.2 Graphs of Split tensile strength for 1:3 cement mortar cubes with 0%, 10%, 20% and 30% replacement of rice husk ash:

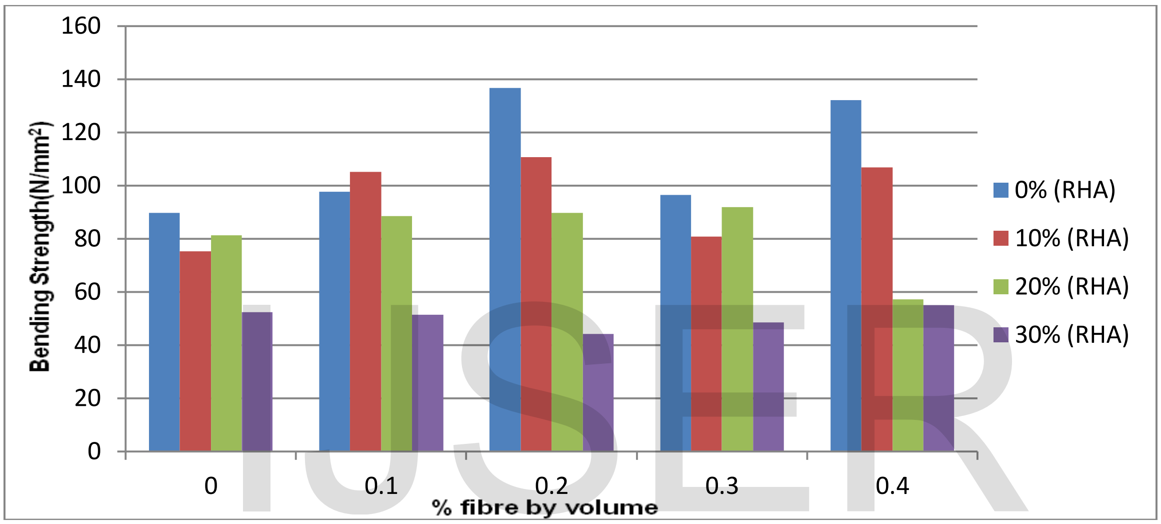


Analysis: Cement mortar cylinders with 20% replacement of RHA is showing better tensile strength than 10% and 30% replacements at 0%, and 0.2% fibre addition by volume. Later on as the fibre % increases there is a reduction in strength, but also observed that 10% RHA beyond 0.3% there is an increase in tensile strength.

Also 30% RHA decreased at 0.2% fibre and gradually increases 0.3% and 0.4%.

As the fibre volume is increased beyond 0.4%, there is reduction in split tensile strength of all 20% RHA specimens.

6.3 Graphs of Bending Strength for tiles 1:3 cement mortar cubes with 0%, 10%, 20% and 30% replacement of rice husk ash:



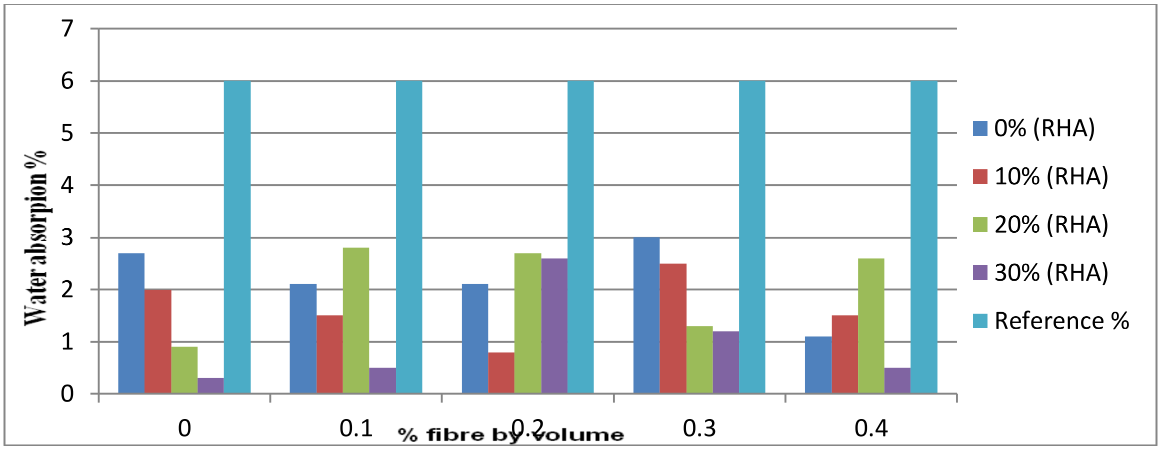
Analysis:

The results of the Bending strength test on corrugations of silk fibre corrugated sheets in CM 1:3 are shown in the graph 6.3

The specimens with 10% RHA replacement are showing better strength than other replacement levels.

The reference mix is showing a consistent improvement in bending strength from 110.71 MPa to 136.77 MPa as fibre volume increases to 0.2%. This strength has been observed for specimens with different RHA replacement up to 30%.

6.4 Graphs of Water absorption for tiles of 1:3 cement mortar cubes with 0%, 10%, 20% and 30% replacement of rice husk ash:

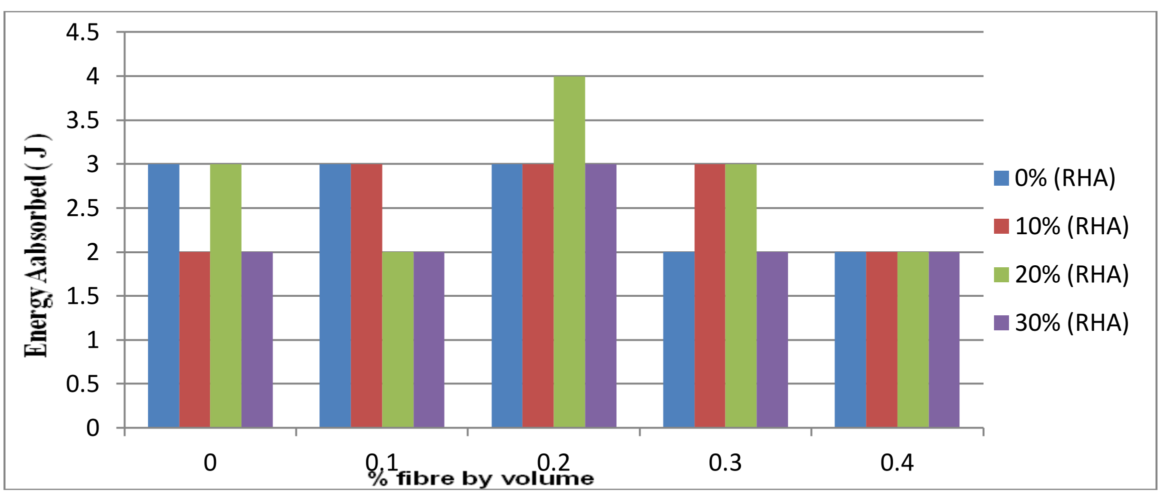


Analysis: The graph 6.4 shows the water absorption for tile specimens cast using different percentage of fibres and RHA.

It is observed that 6% water absorption is highest among other replacement levels. It is less than or equal to the standard specifications which states that tile should not absorb more than 6% of water.

As the graph shows that of 30% RHA having least water absorption among all.

6.5 Graphs of Residual Impact Strength ratio for tiles of 1:3 cement mortar cubes with 0%, 10%, 20% and 30% replacement of rice husk ash:



Analysis: The results of the Impact strength test on corrugation of silk fibre corrugated sheets with CM 1:3 shown in the graph 6.5

At 0.2% fibre volume specimen with 20% RHA has shown to have highest residual impact strength ratio than specimens with other replacement levels.

Chapter7. CONCLUSION

- Rice husk is available in significant quantities as a waste and can be utilized for making roofing sheets. This will go a long way to reduce the quantity of waste in our environment.
- The optimum replacement level of OPC with RHA is 20%.
- The setting times of OPC/RHA paste increases as the ash content increases.
- The rice husk ash wasted from brick burning place is pozzolonic and therefore is suitable for use in manufacturing masonry blocks. Also the RHA based sand cement blocks can make indoor environments more thermally comfortable than the sand cement blocks with the satisfactory level of strength and the RHA with 20% based sand cement block is most suitable for internal wall as it has considerable water absorbent behavior.
- The roofing tiles can be adapted particularly for hot climate due to its high insulation properties and therefore suitable to provide shelter for livestock by using the locally available agricultural waste materials for its production.

1. Compressive Strength:

- In obtaining compressive loading, all the specimens irrespective of the percentage RHA as replacement are observed to be similar.
- The compressive strength of the cubes for all mix increases with age at curing and decreases as the RHA content increases.
- The specimens with 0% fibres by volume are found to be reasonably sound in taking the compressive loading.
- The specimens with 10% RHA, having the highest compressive strength among all other replacements are seem to be efficient.

2. Split tensile strength:

- In taking tensile strength, specimens are having much higher value than reference mix as long as fibre volume is up to 0.4%.
- As the fibre volume is increased beyond 0.4%, there is reduction in split tensile strength of all specimens. This might be attributed to interruption of fibres during formation of CSH gel and hence the bonding will be weak resulting in lower strength.

3. Bending Strength:

- Normal concrete has shown to be much superior in having bending strength than fly ash replaced specimens at 0.2%, 0.3% and 0.4% fibres by volume.

- But specimens with 10% RHA replacement are better than other replacement levels.
- Fibre reinforced corrugated sheets with 10% RHA replacement is showing higher bending strength other replacement levels 0.2% fibres by volume.
- Other than 30% RHA, 0.2% fibres by volume seem to be optimum for all replacement levels giving more than 90 MPa as strength.

4. Residual Impact Strength:

- In having residual impact strength, 20% RHA 0.2% fibre mix is having higher value when compared to all specimens with RHA replacement.
- 0.4% fibres by volume is observed to give same residual impact strength ratio as that of other replacement levels as well as reference mix.

5. Water absorption:

- The water absorption of tiles is within the standard value of 6%.
- For a given mix, the water requirement decreases as the rice husk ash content increases.

Chapter 8. SCOPE FOR FUTURE WORK

1) By restricting fibre volume to 0.2% by volume, thickness of sheet element can be increased and its properties can be tested.
2) The corrugated roofing elements can be tested for their resistance against temperature and chemical atmosphere.
3) The resistance of these roofing elements for different fire loadings can be analysed and understood.

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