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DEVELOPMENT AND EXPERIMENTAL STUDY OF COIR FIBER AND RICE HUSK ASH BASED SUSTAINABLE MATERIALS

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Abstract
Present investigation describes the behavioral aspect of coir fiber and rice husk based Concrete, Bricks, Insulation panel and Tiles. Various tests were performed for finding the performance of samples such as compressive, flexural and split tensile strength. The specimens were tested by using guarded heat flow meter. Before, the manufacture of the brick, the exact proportioning of the bricks have to be done in order to have a engineered quality of production and to maintain the quality and to know the quantity of the materials needed for an exact number of bricks. Totally, 6 count of bricks were moulded, the quantity of bricks is counted on the basis of that each proportion of brick has three days of compressive strength test, for each test three bricks are needed. So, totally single proportion will hold one bricks. Totally, five proportions were made, that each one proportion holds one bricks which lead to a count of 5 bricks for the test. After selecting suitable materials like cement, sand and coir fibers, material properties were determined. In order to replace cement with coir fiber, initial studies were conducted to finalize the % replacement of cement with fibers. After finalizing the same, tile specimens were prepared using specially prepared mould. Accelerated curing was given to the specimens using oven. Tests were conducted as per Indian Standard specification for tiles. Finally we can say that coir fiber and rice husk based Concrete, Bricks, Insulation panel and Tiles are suitable for sustainable construction.

Keywords Cement Concrete, flexural strength, Strength parameters, water absorption, Workability.

1 Introduction

Rice husks are the hard protective coverings of rice grains which are separated from the grains during milling process. Rice husk is an abundantly available waste material in all rice producing countries, and it contains about 30%–50% of organic carbon. Rice husk ash is a very fine material having average particle size of 3–10 μm. RHA is grayish-black in color due to unburned carbon. At burning temperatures of 550–800 °C, amorphous silica is formed, while crystalline silica is produced at higher temperatures. The specific gravity of RHA varies from 2.11 to 2.27
The properties of mature coir fibers are as follows: - 100% naturally originated fiber - Coir fibers are strong and light - Coir fibers easily withstand saline water - Coir fibers easily withstand heat exposure - Plastic shrinkage is delayed in coir-based materials by controlling the cracks developed at the initial stage - The usage of coir in composite materials enhances thermal conductivity - Biodegradability and renewability - Higher water retention - Rot-resistant - Moth-resistant - Heat insulator - Have acoustic properties Coir fibers can be of three types as shown in Fig., namely, curled, bristol, and mat fibers.

2 literature review

Several investigations have been described on the various aspects of Sustainable foam concrete. This section deals with the literature review to fill the need for alternative building materials in construction structures and presents. Some of the research work conducted by earlier researchers on the above has been described in this section.

- **Pranay et.al. (2025)** This project presents the experimental investigation of partial replacement of coconut shells as coarse aggregate and fly ash as replacement of cement in the preparation of concrete

bricks. In this study M10 grade of concrete was made for concrete bricks. Concrete mix of 5%, 10%, 15%, 20% and 25% replacement of coconut shell as coarse aggregate and constant replacement of 25% of fly ash were made. The brick specimen was Casted a size of 190mm x 90mm x 90mm and the Shape and size test, Compression test, water absorption test, fire ignition, Soundness test, drop test, Efflorescence test, Colour test and Structure test were conducted to analyze their suitability as a construction material. Up to 10% of aggregate replaced by coconut shell and 25% of cement replaced by flyash is good according to strength and cost wise. Up to 10% of aggregate replaced by coconut shell and 25% of cement replaced by flyash gives higher compressive strength compare to control mix.

- **Vikramjeet and Gagandeep (2024)** This paper shows the experimental study of concrete done on geopolymer concrete with polypropylene fiber which gives 10% more compressive strength than the conventional concrete. The polypropylene fiber gives avg increment of 33% in tensile forces when compared to geopolymer concrete and 24% increment when compared to nominal concrete. The rate of geopolymer concrete is 35% more than the nominal concrete when the polypropylene fiber is used.
- **K.S Chamberlin, M. Rama Rao and K. Suresh (2023)** To take a look at the overall performance of RHA on Expansive soils, diverse chances of RHA become introduced to the dry mass of soil mass and examined for Geotechnical Characteristics consisting of Compaction, Differential FSI and unconfined Compressive energy and swell pressure. Black Cotton soil become amassed from APCRAD Undavalli Villages, Guntur and RHA become amassed from Tadepalli, Guntur district, Andhra Pradesh, India. Tests such as plasticity, compaction, swell, and CBR were also conducted with different water contents of OMCs (such as OMC + 2% water content and OMC + 5% water content). From the test findings, it can be concluded that adding lime reduces flexibility and increases strength. With the addition of RHA and lime, expansive soil gets higher CBR values at varied water contents more than 50% for dosages of 10% lime + 20% RHA and 10% lime + 30% RHA. The expansive soil becomes non-plastic, non-swelling, and has increased strengths, making it suitable for use as a building material for roads.
- **Mondloe et al. (2022)** In the current research, banan-coir epoxy composite based on five different sets of banana and coir fibers has been synthesized by volume fraction. This study helps to determine the most suitable banana-coir epoxy hybrid composite for tribological applications. The results demonstrate that BBCC (20% coir, 20% banana, and 60% epoxy) provides the lowest specific wear rate, while BBBB (0% coir, 40% banana, and 60% epoxy) delivers the highest mechanical strength. Since mechanical elements should have a low specific wear rate while also providing strength to withstand loads, BBCC (20% coir, 20% banana, and 60% epoxy), which shows the same properties, can be recommended for tribological application.
- **Irma Aswani Ahmad , Fildzah Atika and Ahmad Rifqi Asrib (2022)** This research aims to discover the process of making concrete brick using husk rice ash as additives and the difference in quality between ordinary brick and brick made from added rice husk ash. Adding rice husk ash is to utilize the husk waste, which is available in huge quantities. This research is experimental in a laboratory. The specimen is concrete bricks with the addition of an RHA percentage of 0.5%, 1%, and 1.5% of the cement weight.
- **D V Sheng et al. (2022)** Studied Groundnut shell and coir reinforced hybrid bio composites as alternative to gypsum ceiling tiles . Groundnut shells and coir fibers provide the desired features for developing environmentally friendly and sustainable false ceiling tiles. The hybrid composite tiles had highest flexural strength of 3.6 MPa and modulus of 234 MPa higher than pure gypsum and satisfied the requirement for gypsum based insulation materials. More importantly, the hybrid composites can withstand high humidity of up to 90% without major loss in flexural properties unlike the gypsum tiles which become soggy and weak.
- **Shcherban et.al.(2022)** This work aims to investigate the experimental base for the strength properties of dispersed fiber-reinforced concrete with coconut fibers, as well as the influence of the fiber percentage on the mechanical, physical, and deformation characteristics. The samples were made of concrete with a compressive strength at 28 days from 40 to 50 MPa. The main mechanical

characteristics such as strength in compression (cubic and prismatic) and tension (axial and bending), as well as the material's compressive and tensile strains, were investigated.

- **Peter Gyorgy Horv and Tibor Alp (2021)** performed the impact strength characterization by using a Charpy impact tester (MT3116) as per ASTM D 6110-97. The same study has further claimed that with the increased fiber loading, more force is required for pulling-out the fibers, hence the impact strength increases.
- **Faridul et al. (2021)** This study investigated about the developments of insulation panels from multilayered coir long and short fiber reinforced phenol formaldehyde polymeric (PF) resin. The lengths of coir long fibers (CLF) were within 3 mm, whereas the short fibers (CSF) ranged from 0.1 mm to 1.25 mm. Four composite panels of 360, 680, 800, and 1000 kg/m3 densities were developed by employing hot pressing technology.
- **Kochova Gauvin and Brouwers. (2020)** proposed an evaluation framework for cement-fibre composites using alternative waste coir fibres as a reinforcement. In this study, CEM I 52.5 R white is used as a binder and is provided by ENCI, the Netherlands. Untreated and treated coir fibres are used with a length of 40–50 cm. Spruce wood is provided by Knauf Insulation, the Netherlands and coir fibres are provided by Wageningen Food & Biobased Research, the Netherlands. Calcium hydroxide (min. 96% Ca(OH)2) provided by Merck, is used for the pretreatment of coir.
- **Arul Surya, Aravinth and Akshai Raj (2019)** In this study a concern to increase compression strength using coconut fibre is carried out, with this another proportion of replacement to the fly ash is done with rice husk ash. By varying the proportion of fibre and rice husk ash of 5% and 10%, with coconut fibre's aspect ratio of 150, is mixed separately and also in the combined proportion of 5% and 10% of coconut fibre and rice husk ash.

3 Objectives

Following are the objectives of this work

- To manufacture Coconut coir fiber and rice husk has based concrete.
- To manufacture brick using Coconut coir fiber and rice husk ash.
- To manufacture Insulation panel made from coir fiber reinforcement and rice husk.
- To manufacture Coir-fiber and rice husk based cement tiles.
- To compare the engineering properties of the above with traditional construction materials.
- To compare the above parameters for paver blocks prepared having different concrete mixes.
- To find out water absorption and abrasion values of paver blocks with geopolymer concrete.

4 Methodology Adopted

The present work focuses on bringing out the contribution of sustainable material for application in the building sector. The aim of this work is to spread awareness of energy-efficient materialsas a sustainable material in construction industry. Materials are as follows:

1. Coconut coir fiber and rice husk has based concrete
2. Coconut coir fiber and rice husk has based bricks
3. Insulation panel made from coir fiber reinforcement and rice husk
4. Coir-fiber and rice husk based cement tiles

For finalizing the confined number of mixes no. of trail mixes were done. Based on the results ofall the trail mixes the behavior of the concrete with addition of RHA and coir fiber was studied. Finally five mixes were concluded for the further experimental study and the name of the finalized mixes are CCCF0RHA0, CF0.5RHA5, CF1RHA10, CF1.5RHA15 and CF2RHA20 includes conventional mix too. Mix design is made for M30 grade concrete according to IS 10262-2019. For preparing all the mixes RHA and Coir fibre was used. The amount of water, coarse aggregate and fine aggregate were calculated for all the mixes and are reported in the table 3.6 shown below.

Table 1: Mixture proportions of concrete

Sample	Cement (Kg/m^3)	oir fibre(%)	RHA(%)	Coarse Aggregate (Kg/m^3)	Fine Aggregate (Kg/m^3)
CCCF0RHA0	359	0	0	1113	798
CF0.5RHA5	341.05	0.5	5	1113	794.01
CF1RHA10	323.10	1.0	10	1113	790.02
CF1.5RHA15	305.10	1.5	15	1113	786.03
CF2RHA20	287.20	2.0	20	1113	782.04

Cement & Aggregate content is at maximum level

Table 2: Mixture proportions of bricks (190*90*90cm)

Sample	RHA %	Cement	FA	Coir fibre	Q.D
Standard	-	10	80	-	10
S1	10	10	60	10	10
S2	20	10	50	10	10
S3	30	10	40	10	10
S4	40	10	30	10	10
S5	50	10	20	10	10

Table 3: Mixture proportions of cement tile (300 x 300 x 10 mm)

Sample	Cement (Kg/m^3)	oir fibre(%)	RHA(%)	Fine Aggregate (Kg/m^3)
CCCF0RHA0	380	0	0	192
S1	323	5	10	192
S2	304	10	10	192
S3	285	15	10	192
S4	266	20	10	192
S5	247	25	10	192

5 Conclusion

On the basis of experimental investigation of the present research study, the following conclusions have been drawn.

- When the replacement of cement is increased up to RHA up to 10% with RHA in concrete mix, the compressive strength of based RHA concrete have been increased as compared to conventional concrete the strength increase gradually when we increase the percentage of fiber.
- It'sbeen clearly observed that by adding coir fibre and rice husk ash in a regular manner the split tensile strength of coir fiber reinforced based RHA concrete get increased as compared to conventional

concrete.

- The maximum flexural strength of M30 grade of coir fibre and RHA based concrete is 5.25 N/mm2 . The Flexural strength of concrete increases gradually with the percentage of fiber and RHA adding in a regular interval basis.
- The addition of percentage level of coir fibre and RHA will increase the compressive strength of bricks.
- Water absorption increases with increase with coir fibre and rice husk ash content due to presence of pores. With the addition of RHA up to 20 %, the percentageof water absorption is up to 20% as specified in IS 1077-1976.
- Ringing sound of brick goes on decreasing with increase in the amount of RHA content. Ringing sound is excellent for conventional bricks with 0% coir fibre and RHA. Ringing sound for sample S5 found least.
- The result of thermal conductivity for various weight fraction of coir fiber and RHA indicates that Insulation panel made from coir fiber reinforcement and rice husk has thermal Insulation properties.
- Water absorption of coir-fibre and rice husk based tiles was 6.25%. IS specifications for MP tiles advocates that its water absorption should not be more than 18% (for class AA) and 20% (for class A) of its weight. Finally we can say that coir fiber and rice husk based Concrete, Bricks, Insulation panel and Tiles are suitable for sustainable construction.

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