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Experimental Study on Strength and Durability Properties of Natural Fibre-Reinforced Concrete Beam

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ABSTRACT –

In the present scenario, natural fibres including jute, coir, and sisal fibres are often employed as natural reinforcing materials to enhance the mechanical qualities of concrete and mortar. It involves the preparation of NFRC specimens with varying fibre types, lengths, and dosages, followed by comprehensive testing to evaluate their compressive strength, tensile strength, flexural strength, and durability characteristics. The addition of these fibres can enhance the mechanical properties of concrete, including tensile strength, ductility, and crack resistance. This paper goes into detail regarding textile-reinforced concrete's characteristics. The use of these fibres will aid in reducing steel bar-related corrosion. Regarding mechanical performance, environmental impact, and sustainability, natural fibre-reinforced concrete (NFRC) has become a popular substitute for traditional concrete that is both sustainable and environmentally friendly. An overview of the main conclusions and revelations from the most current research on non-fungible reinforced concrete (NFRC) beams is given in this abstract, with particular attention to the material's mechanical characteristics, benefits for the environment, and potential uses. Research has thoroughly examined the mechanical qualities of non-fibrous reinforced concrete (NFRC) beams, including elements like durability, toughness, flexural strength, and bond properties. The experimental results are then compared to analytical results (ANSYS software)

Keywords: Natural Fibres Reinforced Concrete, Sustainability, Mechanical Properties, Durability, Flexural Behaviour, ANSYS software.

1. INTRODUCTION

Fibres are often used in the manufacture of other materials. The strongest engineering materials often incorporate fibres. Fibres are a class of hair-like materials that are continuous filaments or are in discrete elongated pieces, like pieces of thread. Natural fibres are increasingly being explored as reinforcement materials in concrete due to their eco-friendly and sustainable properties. Compared to synthetic fibres, natural fibres are more environmentally beneficial because they are renewable and biodegradable. They are easy to dispose of without harming the environment and require little energy during production. Furthermore, using natural fibres in construction methods lowers carbon emissions and promotes sustainability.

Natural fibres can enhance the tensile strength, ductility, impact resistance, and crack resistance of concrete. They serve as reinforcing components that improve the overall durability of concrete constructions and aid in the management of cracking.

1.1 Objective

- To find the physical and chemical properties of natural fibres such as coir, jute, sisal, and sugarcane.
- To determine the fresh concrete test.
- To determine the mechanical and durability properties.
- To cast and test the reinforced concrete (RC) beams using a control mix, as well as optimum natural fibres. (Coir, Jute, Sisal and Sugarcane)
- To test the flexural behaviour of the RC beam.
- To analyze the specimen using ANSYS software and compare the results with the experimental results.

1.2 Scope

- To improve mechanical properties of the concrete.
- To minimize the crack control and reduction of shrinkage.

- To encompasses environmental sustainability and improve mechanical properties.

2. LITERATURE REVIEW

i)Nithin Sam et.al., Durability properties of fibre reinforced concrete (2016) The document discusses the durability properties of concrete reinforced with coir fibre. The study concludes that concrete reinforced with coir fibres shows improved durability compared to concrete without fibre content. The document also provides information on the materials used for the study, such as fine aggregate, coarse aggregate, coir fibre, and PPC cement. The properties of these materials are discussed, including grain size analysis and cement properties.

ii)Babar Ali., Coir Fibre Reinforced Concrete (2018) Fibre-reinforced concrete (FRC) developed with recycled aggregates (RA) and waste coconut fibres (CF) can lead to the production of a cheap and eco-friendly FRC. The addition of CF improved the shear strength of plain concrete by 40% and 60% with and without the use of a superplasticizer (SP), respectively. The combined use of CF and SP provided recycled aggregate concrete (RAC) with higher mechanical performance compared to plain natural aggregate concrete (NAC). The permeability of CF-reinforced mixes was controlled by the addition of SP, reducing chloride permeability and water absorption.

iii)Adewumi John Babafem et.al "Experimental Study on Self-Compacting Concrete with Natural Fibres",2019

The inclusion of 0.5% and 1% coir fibre in concrete did not affect its density. Coir fibre slightly improved the compressive strength of concrete, especially at 0.5% content. The tensile strength of concrete was only slightly improved at an early age. The resistance to sulphate attack was improved at 1% coir fibre content. Fibres in concrete generally enhance its toughness, ductility, shear strength, energy absorption capacity, damage tolerance, stress distribution, and volume changes.

iv)Ali Raza et.al, "Experimental study on jute fibre reinforced concrete",2020 The findings demonstrate that when the fibre concentrations varied from 6.5%–17.4% for the coconut and 5.8%–17.1% for the basalt fibres RC samples, the thermal insulation improved the most. 10% to 2.5%. The proportion of natural fibres rises. The TGA of the plain concrete samples and the natural fibres RC samples. The test's temperature (°C) range, which is 30 °C to 250 °C, indicates that it is the lowest. In the case of a simple concrete sample, heat deterioration is present 2.79 of the (100% mass), the coconut fibre RC samples show the most degradation (around 8.87% of total mass) and the RC samples of jute, sugarcane, and sisal show a moderate degree of heat deterioration, whereas the RC samples' basalt fibres.

3. PRELIMINARY TESTS AND MIX DESIGN

The materials used to perform the above study are initially tested for their basic properties. Cement, m-sand, foundry sand Coarse aggregate, are performed with Specific gravity test, water absorption test, Sieve analysis, Bulk density test, Impact test, Crushing test are performed and test values are used to obtain the required mix design.

Table -1: Mix Proportion in kg/m^3

CEMENT	FA	CA	WATER
370	665	1285	148

4. EXPERIMENTAL INVESTIGATION

Fresh concrete or plastic concrete is a freshly mixed material which can be moulded into any shape. The relative quantities of cement, aggregates and water mixed, control the properties of concrete in the wet state as well as in the hardened state.

Slump cone test, to be conducted in order to determine the workability of the self-compacting concrete.

One of the purposes of testing hardened concrete is to confirm that the concrete used at site has developed the required strength. The test methods should be simple, direct and convenient to apply. The controlled concrete is cast and cured for 28 days and the tests for hardened concrete such as compressive strength, split tensile strength tests are done.

The number of specimens casted and their test values are listed in the table below.

TABLE 2: Description of Specimen

Percentage of replacement	No. of specimens
NOMINAL MIX	3 CUBES 3 CYLINDERS
MIX-1	
MIX-2	
MIX-3	

5. FRESH AND HARDENED CONCRETE TEST

The workability of the concrete is determined using the slump cone at the fresh stage of concrete as per IS code provisions

TABLE 3: Fresh Concrete Properties

COMBINATIONS	**SLUMP VALUE in (mm)**	**WORKABILITY**
NOMINAL	94	MEDIUM
MIX-1	92	
MIX-2	88	
MIX-3	82	

Compressive strength tests are carried out on cubes of size 150 mm x 150 mm x 150mm. The results obtained are compared with the results of a control mix specimens. Effect on compressive strength of M30 Grade concrete mixes MIX-1 (1.5%), MIX-2(2%) MIX3(2.5%), NOMINAL MIX at the age of 7, 28days are tabulated below.

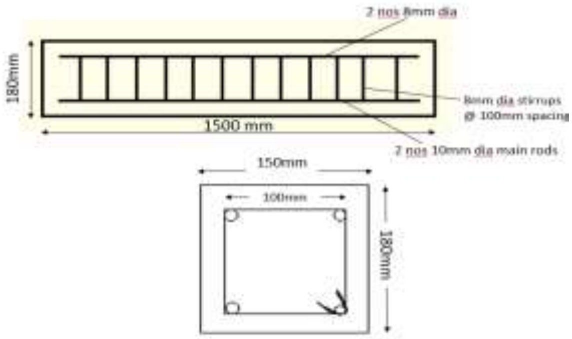
RESULTS OBTAINED FROM FRESH AND HARDENED CONCRETE TEST

- In this experimental study on natural fibre-reinforced concrete (NFRC), the focus was on investigating the strength and durability properties of concrete mixes incorporating natural fibres.
- Various natural fibres, such as sisal, coconut, or jute, were added to the concrete mix to assess their impact on concrete performance.
- The compressive strength results revealed variations based on the type and percentage of natural fibres incorporated.
- Similarly, flexural strength exhibited changes, showcasing the influence of fibre reinforcement on the material's ability to withstand bending stresses.
- In comparison by addition of natural fibres in the concrete mix, it improves the flexural properties and toughness of the cement concrete.
- By addition of 2% of natural fibres shows good results.
- The percentage variation of the compressive strength for 28^{th} day of M0, M1, M2 and M3 are 3.43, 1.30 and -2.43.
- In comparison to the control mixes, the concrete mixes containing natural fibres exhibited a greater splitting tensile strength.
- By taking the optimum percentage of 2%, the structural component (beam) is then casted.
- A conventional beam is also then casted to compare the results in the experimental tests.

6.DESIGN OF BEAM

The design of a beam involves determining its dimensions and structural properties to ensure that it can safely support the loads it will be subjected to during its intended use.

Fig 3: Reinforcement Details



7.EXPERIMENTAL INVESTIGATION OF BEAM

In this chapter, the test on two-point loading is followed up mainly by the determination of the flexural strength of test specimens of hardened concrete by moment in the centre zone using two-point loading.

Fig 4: Test setup

Fig 5: Graph results of conventional beam

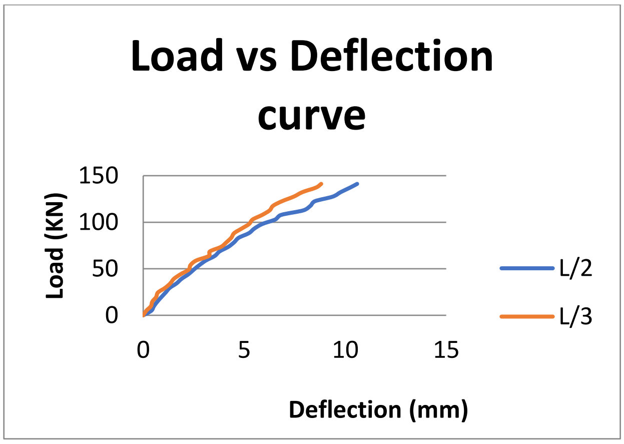
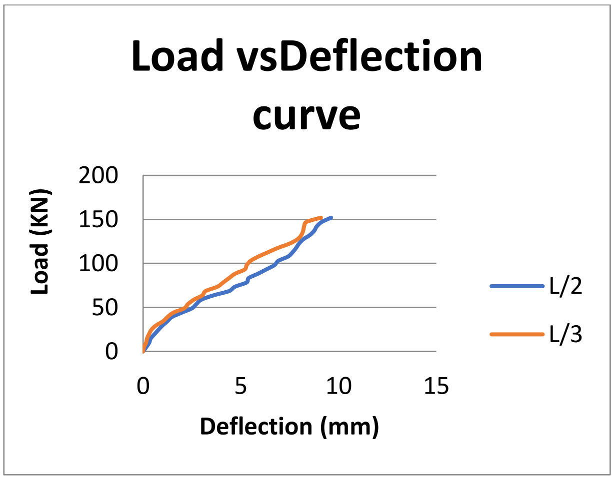


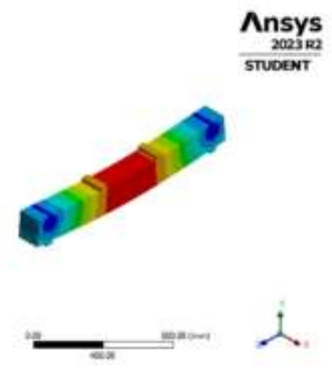
Fig 6: Graph results of NFRC beam



8. ANALYTICAL INVESTIGATION

An analytical inquiry for a beam entail examining the beam's structural behaviour under various scenarios. Determining the beam's geometry, material characteristics, boundary conditions, and loads inside the ANSYS environment are usually steps in this process.

Fig 7: Total deformation of the NFRC beam



9.CONCLUSION

- In conclusion, a thorough comparison of conventional concrete beams with natural fibre-reinforced concrete (NFRC) beams has provided important new information about the structural performance of each material.
- In comparison to conventional beams, NFRC beams have a significantly larger ultimate load capacity and better deflection characteristics, according to experimental testing conducted under 2-point loading.
- This result emphasizes how natural fibre reinforcement can improve the mechanical qualities of concrete constructions.
- Through the simulation of beam behaviour under various loading circumstances, the ANSYS analytical research further validated these conclusions.
- The accuracy of the analytical model in forecasting the structural response of NFRC and conventional beams was validated by the near alignment of the ANSYS results with the experimental data.
- Lower stress and more uniform stress transfer were shown by the ANSYS stress distribution analysis.
- The testing findings comparing the mechanical behaviour of fresh and hardened concrete demonstrated how the curing and hydration processes affect the material.
- When compared to traditional concrete, NFRC outperformed it in both fresh and hardened states, exhibiting greater modulus of elasticity, flexural strength, and compressive strength.

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