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EXPERIMENTAL INVESTIGATION ON PROPERTIES OF LIGHT WEIGHT FOAMED CONCRETE WITH NATURAL FIBRE

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Abstract - *Light weight foamed concrete(LWFC) is an emerging construction material which is used as fungible one for normal clay bricks, concrete blocks etc., This paper explains the evaluation of properties of light weight foamed concrete with inclusion of natural fiber on strength properties includes compressive strength, split tensile strength and flexural strength. The foamed concrete mix was prepared for a target density of 1000 kg/m³ with a tolerance level of 50 kg/m³. The cement, fly ash and water is mixed in ratio 1:1.5:0.55 with different percentages of kenaf fibers (0.35%, 0.4%, 0.45%, 0.5%, 0.55%) which is added individually and in combination with coir fiber (0.4%) by volume of fraction of concrete. The study on strength parameters of light weight foamed concrete with natural fibers paved a way to determine the adaptability of this composite for various construction products in term of life span and functionality. The supreme properties such as low in density and light in weight can reduce the self-weight of the structure, by all means, lowering the project cost and time. The results showed that the light weight foamed concrete with natural fibers shows higher strength characteristics at 0.45% volume fraction of kenaf individually than control mix of normal light weight foamed concrete. When kenaf fiber and coir fiber is combined as kenaf-coir hybrid produces higher strength characteristics than individual natural fiber mix.*

Key Words: Light-weight foamed concrete, natural fiber, kenaf, coir

1. INTRODUCTION

Concrete is the second most widely consumed substance on earth, after water. In high-rise construction, self-weight contributes to a very large proportion of the total load on the structure, hence there is an advantage in reducing the density of concrete by using Light Weight Concrete (LWC). LWC also gives better thermal insulation than ordinary concrete. The practical range of densities of lightweight concrete is between 3.00 and 18.50 KN/m³. One such LWC is foamed concrete. **Light weight foamed concrete (LWFC)** is either a cement paste or mortar, referred as lightweight concrete, foamcrete or cellular light weight concrete in which air voids are entrapped in mortar by suitable foaming agent. The mechanical properties of foamed concrete is weak compared to normal concrete. Numerous studies have been done to overcome this issue and it has been demonstrated that foamed concrete can still be used as a building component. Foamed concrete has so far been utilized principally as a filler material in structural building works.

A Current scenario of addition of natural fibre in light weight foamed concrete improves the strength of lightweight foamed concrete to some extent. The utilization of natural fibres in LWFC has been explored in numerous countries. The production of construction materials involving natural fibre such as kenaf, coir, sisal, bamboo etc., are in research now-a-days. The natural fibre which are easily accessible in large quantity, very cheap and eco-friendly in nature. Among these natural fibre kenaf and coconut fibre (coir) can be possibly used as a fibre reinforcement in light weight foamed concrete. The inclusion of fibre into LWFC is one approach to enhance its strength properties and durability properties.

Kenaf fibre is a benninal herbaceous species belongs to Malvaceae family. It poses the scientific name hibiscus cannabinus. It is a similar plant as deccan hemp, java jute, cotton and okra grows in tropical and temperate climates. Kenaf also absorbs 21-89 tonnes CO_2/ha/year depending on the agronomic management, showing the ability to mitigate the greenhouse gases effectively. Addition of kenaf in concrete increases its tensile strength.

Fig 1. Kenaf fibre

Fig 2 .Coconut fibre

Coconut fibre or coir is natural fibre extracted outer shell of coconut. It's scientific name cocos nucifera. Coconut fibre is the hard stony endocarp but lightweight, naturally sized, very tough and stiff due to volume of lignin when compare with other natural fibre. The addition of coconut fibre significantly improves toughness, compressive strength of foamed concrete, tensile strength, modulus of elasticity and minimum the crack pattern of foamed concrete containing coconut fibre. This paper emphasized a systematic study on the influence of the inclusion of natural fibre in different proportions on the strength parameters of light weight concrete made using pre-formed foam method.The specific objectives of the study are:

- To examine the properties of fibre such as density, tensile strength, water absorption, elongation % and young's modulus.

- To arrive mix ratio for foamed concrete through literature review.
- To cast five different mixes of kenaf fibre. (0.35%, 0.4%, 0.45%, 0.5%, 0.55% by volume fraction of concrete).
- To carry out the experimental study on the mechanical behaviour with various kenaf mix percentages.

Kenaf (Hibiscus cannabinus L.) is a valuable fibre and medicinal plant from the Malvaceae family. **(Ayadi et al., 2017)**.Investigation of the mechanical strength of fibre reinforced lightweight foamed concrete results in increase of flexural capacity to considerable manner by polymer fibres of 2-5 **(Falliano, De Domenico, Ricciardi, & Gugliandolo, 2019)**. The influence of treatment of fibre on the durability properties includes drying shrinkage test, water absorption test, initial surface aborption test (ISAT) and the accelerated weathering test (wet/dry cycling). Low in density and light in weight can reduce the self-weight of the structure, by all means reducing the cost and time of the project. **(Mahzabin, Hock, Hossain, & Kang, 2018).**The normal-incidence sound absorption coefficient and the random-incidence sound absorption co-efficient measurement was conducted using the impedance tube method and reverberation chamber. **(Lim, Putra, Nor, & Yaakob, 2018)**.The mechanical properties of lightweight foamed composite (LFC) with the inclusion of kenaf fibres and superplasticizer influence that water absorption and density of the composite mortar increased as the volume of fibre increased from 0.4% to 0.5% **(Mahzabin, Hock, Kang, & Jarghouyeh, 2017)**.

Coir fibre of 0.4% reached highest strength in 180 days without allowing other additives to overcome its overall flexural strength. It should be pointed out that, the more the addition of fibres in the base mix, the higher the strength obtained due to its low cellulose content **(Othuman Mydin, 2016)**. The treated kenaf fibre Light Weight Concrete specimen showed higher toughness loss when compared to untreated kenaf fibre Light Weight Concrete specimen thereby making the untreated kenaf fibre Light Weight Concrete specimen to be unfit for being as a structural support. Due to the reduced ductility of treated kenaf fibres they tend to break out before pull out test. **(Sadia Mahzabin et al 2018)**.Low self-weight (800 to 1600 kg/m3), high workability (flowing and self-compacting) and excellent thermal insulating properties (, 0.50 W/mK)**(Jones & McCarthy, 2005).**

2. MATERIALS AND MIX PROPORTION

S.NO	Materials	Properties	Values
1	Ordinary Portland cement	Specific gravity	3.13
		Standard consistency	29.5%
		Fineness	6%
		Initial Setting Time	70 minutes
		Final setting Time	600 minutes
2	Flyash (class F)	Specific gravity	2.23
3	M-Sand	Specific gravity	2.61
		Grading	Zone II
4	Coarse aggregate	Specific gravity	2.67
		Water Absorption	0.4%
5	Kenaf fibre	Diameter	0.35mm
		Unit weight	1000 Kg/m^3
		Water Absorption	411.82%
		Tensile strength	1241.22MPa
		Aspect ratio	131.5
6	Coir fibre	Diameter	0.38mm
		Unit weight	1250 Kg/m^3
		Water Absorption	68.6%
		Tensile strength	1000 MPa
		Aspect ratio	133.3

Mix design of foamed concrete doesn't possess any codal provisions. Dry density and strength are two very important performance parameters of foamed concrete. The density of a foam can be determined, quite simply, through weighing a known volume of foam - for example using a glass measuring cylinder. Foam stability can be quantified by measuring the volume of foam which has collapsed into solution at regular time intervals.

MIX RATIO FOR FOAMED CONCRETE:

Cement: Flyash: Foam agent: Water

333.33: 500: 865.8638: 183.3315

1: 1.5: 2.5: 0.55

Table -1: Mix proportions of kenaf fibre

S.No	Mix Id	Mix Proportions		
		Cement (%)	Flyash (%)	Kenaf (%)
1	CM	40	60	-
1	KNFC1	40	60	0.25
2	KNFC2	40	60	0.4
3	KNFC3	40	60	0.45
4	KNFC4	40	60	0.5
5	KNFC5	40	60	0.55

From the literature, Coir fibre with light weight foamed concrete is done with 0.4% variation shows the highest strength when compared with 0.2% percentage mix.

4. EXPERIMENTAL INVESTIGATION

For each mix three cubes of dimension 150X150X150 mm, three cylinders of diameter 150 mm and height 300 mm, three prisms of 100X100X500 mm were casted. The specimens were in the moulds undisturbed at room temperature for about 48 hours after casting. The specimens after removing from the moulds were immediately

transferred to curing ponds containing clean and portable water. The mechanical properties of the fibre reinforced concrete specimen such as compressive strength, split tensile and flexural strength was conducted as specified in test method of IS 516:1959.

3. RESULTS AND DISCUSSION

3.1 Plastic density

The plastic density of fresh LWFC mix before adding fibre was **906 kg/m³.**

3.2 Strength Test

Mechanical strength properties were tested after 28 days of curing. Compressive strength, Split tensile strength and Flexural strength are respresented in below chart 1, chart 2 and chart 3 respectively**.**

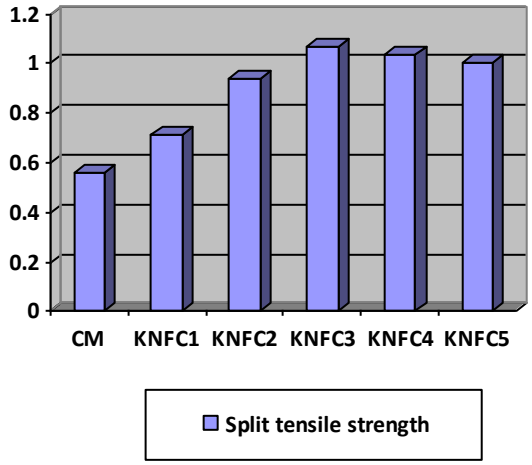

Chart 1. Average Compressive Strength Results of KNFC Cube at 28 days

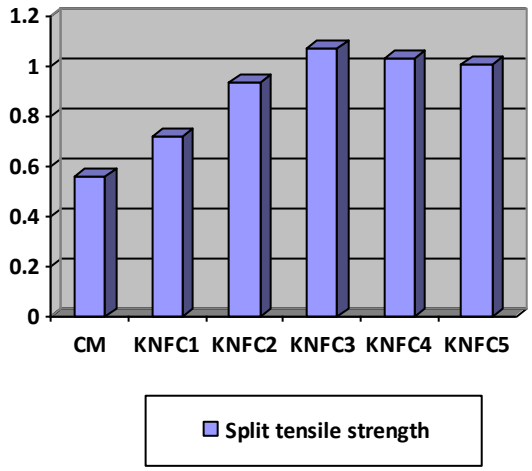

Chart 2. Average Split tensile Strength Results of KNFC Cube at 28 days

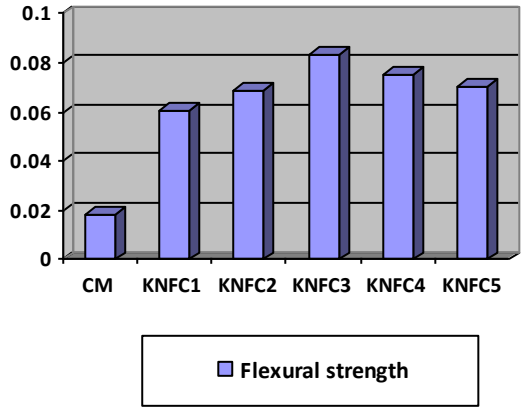

Chart 3. Average Flexural Strength Results of KNFC Cube at 28 days

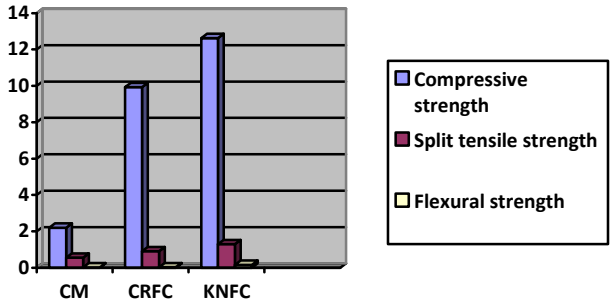

Chart 4. Average Mechanical Strength Results of CRFC and KNCRFC Cube at 28 days

KNFC – Kenaf reinforced foamed concrete

CRFC – Coir reinforced foamed concrete

KNCRFC- Kenaf –coir hybrid foamed concrete

4. CONCLUSIONS

The conclusions of light weight foamed concrete with fibre inclusion as follows,

1. The mix ratio for LWFC with natural fibre used 1:1.5:0.55 . The percentage increase in compressive strength between control mix, KNFC1, KNFC 2, KNFC 3, KNFC 4 and KNFC 5 are 185%, 220.86%, 428.15%, 351.36% and 293.63% respectively. The percentage increase in split tensile between control mix, KNFC1, KNFC 2, KNFC 3, KNFC 4 and KNFC 5 are 28.51%, 68.07%, 91.4%, 85.012% and 80.459% respectively. The percentage increase in flexural strength between control mix, KNFC1, KNFC 2, KNFC 3, KNFC 4 and KNFC 5 are 235.537%, 280.165%, 357.85%, 313.223% and 285.67% respectively. It is noted that the concrete having 0.45% fibre having greater strength.

2. Normal light weight foamed concrete have the compressive strength upto 3 N/mm^2. In LWFC with kenaf fibre shows additional compressive strength upto
3. Even though the weight of prism was maximum upto 5 kg its remains floating for more than 15 days of curing. Density plays a vital role in strength characteristics. When density of the LWFC increases it sustain load upto 18 Mpa but it is not light weighted
4. When is load is applied to the foamed concrete it sustains the load only by the air voids present inside the concrete. These air voids are strengthend by fibres. In compression test, the cube sustain load even after failure to greater extent. The concrete profile after testing remains slightly damaged. In split tensile test, the cylinder didn't break into halves because the fibre inside the concrete takes load after cracks are formed.
5. When observing the failure, it is to noted that the fibre inside the concrete specimen after 28 days curing remains unrotten because the air voids inside the LWFC provides airtight environment for fibres.

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