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Experimental Study of Polypropylene Fiber and Coconut Fiber in Cement Concrete to increase Compressive Strength

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ABSTRACT

This experimental study reveals the effect of coconut fibre and polypropylene fibre's on the strength of concrete. Coconut fibre is a biodegradable waste and hence its proper decomposition is of paramount importance. Proper utilization of coconut fibre can minimizes their adverse impact on the nature. On the other hand polypropylene fiber is widely used in concrete to resist the brittle behavior of concrete.

The capability of a structure to resist various types of degradation processes like weathering action, chemical attack, abrasion, contraction and expansion is equally important as the capability of a structure to resist the loads applied on it. Use of polypropylene fibres help to achieve this goal. It helps to make a concrete durable and also provide it some flexibility. Coconut fiber is very strong in tension and hence it can very well be used as a fibre reinforcement material. Cubes and beams of conventional concrete and fibre reinforced concrete which consists of coconut and polypropylene as fibres we casted, tested and their results were compared. As per the previous work and according to various journals and international papers "Addition of coconut fibre and plastic fibre up to certain limit increases the strength of conventional concrete".

In this project work seprate propotion of 0.4 % of coconut and of polypropylene fibres were used. Coconut and Polypropylene fibres are replaced to cement (by volume). Fibres used in this project work is 0.4 The proportion of coconut fibre was kept constant. The strength between the two types of concrete was then compared and a conclusion was derived

Keywords- Fiber Reinforced Concrete, Polypropylene and Coconut Fibres Fibers, Concrete,Compressive strenght, Mechanical Properties, Durability.

I INTRODUCTION

Concrete is the most versatile building material. Concrete has a relatively low tensile strength (compared to other Building materials) and low ductility. And also it is susceptible to cracking. The production of concrete lead to a lot of Environmental issues associated with the significant release of CO_2 and other greenhouse gases.

There is currently a great Deal of interest in developing the technology for using Natural fiber material in cement. Natural Fiber's exist in reasonably large quantities all over the world and natural vegetable fiber's are produced in most developing countries. Natural Fiber's have been used to reinforce inorganic materials for thousands of years. E.g. include straw or bricks, mud and poles, plaster and reeds. During the century other fiber's such as coconut, bamboo, wood cellulose fiber's, wool or chips, bast fiber's, leaf fiber's, seed and fruit fiber's have been used in cement sand based products.

Fiber's may be either classified as man-made or natural Fiber's, further divided into different groups. The use of natural fiber's as reinforcement in concrete (cement-sand matrix) has been comprehensively investigated in many countries. The natural fiber's reinforced material which can be used in production of building materials are presently mainly those based on coconut, bamboo, cane, henequen and sisal fiber's. The main reasons for the use of natural fiber's are abundantly available, comparatively cheap and biodegradable materials.

Natural fiber's are also claimed to offer environmental advantages such as reduced dependence on non-renewable energy materials Sources, lower pollutant emissions, lower green house gases mission, enhance energy recovery and energy end of life biodegradability of components. Appropriate method for manufacturing roof sheets of natural fiber's concrete was rapidly developed widespread to countries in Central America, Africa and Asia through IT building materials workshop in Great Britain and Others. The method which involves reinforcing cement or concrete products with natural fiber's such as coir, sisal and jute has been applied in at least 128 countries. When combining these fiber's with the cement matrix the fiber's are utilized in two ways. On one hand the fiber in the fresh concrete makes it possible to mould product in a simple manner.

On the other the fiber increases toughness of the material so that the product can withstand handling and structural load Coconut fiber is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fiber are coir, cocosnucifera and arecaceae (Palm), respectively. There are two types of coconut fibers: brown fibers extracted from matured coconuts and white fibers extracted from immature coconuts. Brown fibers are thick, strong and have high abrasion resistance, while white fibers are smoother and finer, but also weaker. Coconut fibers are commercially available in three forms, namely bristle (long fibers), mattress (relatively short) and decorticated (mixed fibers). These different types of fibers have different uses depending upon the requirement. In engineering, brown fibers are mostly used (Gu, 2009). Of the 55 billion coconuts harvested every year in the world, only 15% of the coconut fibers are recovered for use (Wei and Gu, 2009).

According to the official website of International Year for Natural Fibers 2009, approximately 500,000 tonnes of coconut fibers are produced annually worldwide, with an approximate value of $100 million. India and Sri Lanka are 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. The general advantages of coconut fibers are that they are moth-proof, resistant to fungi and rot, provide excellent insulation against temperature and sound, flame-retardant, unaffected by moisture and dampness, tough and durable, resilient, and spring back to shape even after constant use (Hemsri et al.2012). Coconut fiber is agricultural waste products obtained in the

processing of coconut oil and is available in large quantities in the tropical regions of the Most World. especially in Africa, Asia, America.

Coconut Fiber are not commonly used in. construction industry but are often dumped as a agricultural waste. However, with the quest for affordable housing system for both the rural and urban population in the developing countries various schemes focusing on cutting down conventional building materials costs have been put forward. One of these suggestions in the forefront has been resourcing development in the use of alternative, non-conventional local construction materials including the possibility of using some agricultural wastes and residue as a partial or full replacement of conventional constructional materials.

Natural fibers as reinforcement in composites (such as cement paste, cement sand mortar and/or concrete) have been studied by many researchers, but only for non- structural members (Cook et al., 1978; Ramakrishna and Sundararajan, 2005a; Asasutjarit et al.,2007). These composites have been tested for plastering and as roofing materials, corrugated slabs and boards in different parts of the world. Significant improvement in the properties of these composites has been obtained by the insertion of fibers. Their potential as an earthquake- resistant structural material needs to be considered. In countries where abundant agricultural wastes are discharged, this waste can be used as potential material or replacement material in construction industry.

One such alternative coconut fiber, produced in abundance has the potential to be used as substitute coarse aggregate in concrete. The huge amount of coconut fiber waste that are produced in the factories. The current waste disposal practice of incineration within the industry is normally done in uncontrolled manner and contributes significantly to atmospheric pollution. Thus these residues are becoming expensive to dispose by satisfying the requirements of environmental regulation. In such situation, efforts are going on to improve the use of these by products. Through the development of value added products. One of the ways of disposing this wastage would be the utilization of coconut fiber in to constructive building material A certain quantity of fibers can be beneficial for enhancing the properties of plain concrete, but it may be noted that all properties may not be improved.

The addition of fibers may improve certain properties while, at the same time, there may be some compromise on other properties. Therefore, fibers in an appropriate quantity should be selected. An effort to diversify and encourage the use of natural fibers for construction is made in this research. Natural fibers (e.g. coconut/coir, sisal, bamboo, flax and hemp) are cheaper than conventional steel fibers and are locally available in many countries. The use of natural fibers costs little, and the resulting product is also much cheaper and has equal or even better properties than the locally available commercial products (Cook et al., 1978). Therefore, their use is increasing day by day.

II PROBLEM STATEMENT

Concrete is very strong in compression but it is weak in tension. Hence we generally provide steel reinforcement to compensate that. If somehow the concrete can be made strong in tension also (up to some extent) then the amount of steel reinforcement will be less. Also it will be an added advantage if compressive strength too increases. In this project one method is suggested which will help to address the above problem by adding coconut and polypropylene fibers in conventional concrete.

III OBJECTIVES

The main objective of this project work is to check the feasibility of coconut and polypropylene fibers in conventional concrete and hence to accomplish that the following steps are Planned.

1. To perform tests on aggregates and cement
2. To design and test M30 grade conventional and fiber-reinforced concrete with varying percentage of fibers
3. To compare the results obtained for fiber-reinforced concrete and ordinary concrete

IV DETAILED METHODOLOGY

1. The very first step behind every successful project is to know each and every aspect associated with it. For this it is vital to collect the information such as the technical parameters, previous work done on that project and its future scope. To achieve our target first of all we collected various national, international journals and papers related to our work. All those papers (mentioned in literature review) gave an overall idea that how we should approach our work and also various technical and non-technical information related to our work
2. Once the plan and approach was decided, the very next step was the collection of materials like- cement, coarse aggregate and fine aggregate. Before using these materials directly in preparation of concrete, it was essential to test the properties of these materials so that we came to know about the properties of aggregate and cement. Tests like- standard consistency of cement, initial and final setting time and fineness of cement were performed once mentto know
3. The mix design was performed according to I.S code method. Several I.S codes were referred like I.S-456, I.S-10262 etc. for mix design calculations. From this calculation we came to know about the exact quantity of materials and their proportions required to cast the desired amount of specimens namely cubes. So mix design was performed for fiber reinforced concrete and specimens were casted. 9 cubes of each fiber, of fiber reinforced concrete were casted. Coconut Fiber and polypropylene were used as fibers in fiber reinforced concrete in 0.4% of total cement content
4. In this project based on literature review we are adopting an optimum fiber as mentioned below to find out its effect on various properties of concrete.
5. Once the specimens were casted compressive strength tests was performed on cubes, CTM was used to perform compressive Test Once the result was obtained, it was recorded carefully
6. Similarly compression test was performed on these specimens on the same machine and the result obtained was recorded carefully
7. Finally the results were compared in a tabular format and final report was prepared.

V EXPERIMENTAL SETUP

This chapter describes the experimental program, which consisted of various laboratory experiments to quantify the plastic properties, mechanical properties and cracking performance of FRC concrete consisting of two

concrete mixtures. Additionally, the mixing procedure, concrete mixture proportions, and the preparation and storage of specimens are also described in this section. The plastic properties were determined by the unit weight and the time of flow test. Visual observation was also carried out to inspect for any clumps and balls caused by the fiber clinging together. The compressive strength, modulus of rupture, flexural toughness, and residual strength tests were used to evaluate the concrete mechanical properties, while the restrained shrinkage test was used to evaluate the cracking performance in concrete A total of two concrete mixtures were investigated in this study.

One mixture consisted of Coconut Fibre that is used in this project. The other Mixture was made by Polyropylene fiber. The materials used for this project was obtained from sources that are Reliable sources to the construction Industry Both concrete mixtures developed for this project were made with the consideration of I.S. 10262(2009 In order to achieve the strength in concrete, the mixtures had high cement content, low water-cement ratio, fibers and super plasticizer

VI MATERIAL PROPERTIES

The raw materials used in this project were obtained from sources and suppliers that are approved by various Bodies in India. Portland cement from a single source was used to eliminate discrepancies and variations in material properties. The fine and coarse aggregates were also obtained from a single supplier and obtained in one batch. The chemical admixtures were obtained from two suppliers. However, for consistency only the admixtures from one supplier were used in preparing the specimens. The fibers were obtained from a verified source.

Figure. shows Coconut fiber and Polypropylene fiber

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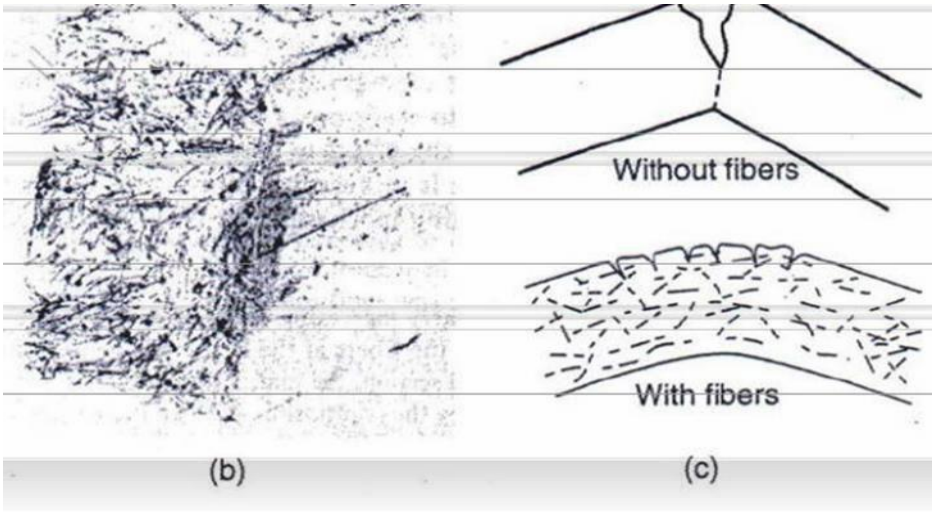

Figure. Shows The effect of fibers on failure mechanism

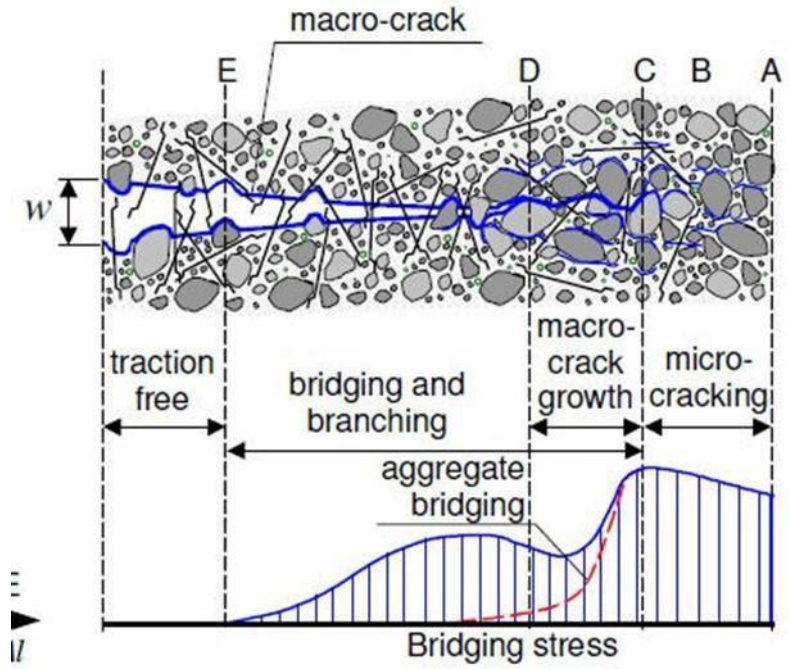

Figure. Shows Schematic description of the effect of fibers on the fracture process in uniaxial tension

MIXTURE PROPORTIONS

Specimens were prepared of M 30 grade concrete with ordinary Portland cement manufactured by Vasavadutta Cement - a unit of Birla Shakti Cement in Sedam, Gulbarga, Karnataka. Crushed sand with a fineness modulus of 2.48 and 10mm 20mm coarse aggregates were used. All mixtures were proportioned to comply with the I.S code provisions for minimum required workability and strength. Water- reducing admixtures were used to achieve the desired level of strength &workability.ASingledoseoffiberswereused,whileitwasfurthervariedin proportions in this project.

A dosage of 0.4 % by weight of cement was used for mixtures. Mixture M30 was a control mixture with added fiber content. The general mixture proportion is given in Table 3.3. The proportions are being taken from the being taken from the concrete mix design on page number (23).

MIXING PROCEDURE

The coarse and fine aggregates were first added to the mixer. After the coarse and fine aggregates were thoroughly mixed, one-third (1/3) of the mixing water was added. The cement and the remainder of the mixing water were added to the mixer after a minute. All ingredients were mixed together in the mixer for another minute before the fiber was added. The mixing continued for two more minutes before allowing the mixture to rest for two minutes. After the mixture was allowed to hydrate and absorb some water, the mixer was started again and the water-reducing admixtures were added to it. Finally the whole mixture was mixed for two more minutes The total mixing time including the resting time was ten minutes. A 0.3 m^3 rotary mixer was used to mix the concrete. The mixer used

Figure. shows Concrete Mix

METHOD OF CONSOLIDATION

Unlike ordinary concrete, external vibration is recommended for FRC to prevent damage to the fibers. In this study, manual method (by using tamping rod) was used

SPECIMENS FABRICATION

A set of three specimens per testing sequence was prepared for all tests and mixtures. A 150 x 150 x 150 mm specimen Cubical in shape complying with I.S Code 10086:1982 was used for measuring the compressiv strength.

CURING AND STORAGE

The test specimen were stored in a place, free from vibration, in moist air (covered with jute bags) at a temperature of 27° ± 2° for 24 hours ± l hour from the time of addition of water to the dry ingredients. After this period, the specimens were marked and removed from the moulds and immediately submerged in clean, fresh water and kept there until taken out just prior to test.

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DATA COLLECTION AND ANALYSIS

Data collection was done with the help of a Micro Data Acquisition system. A Harris and Tarriss data acquisition system was used to collect and process the load and deflection data from the universal testing machine. Software was used to interface the instruments with the data acquisition system.

Figure. shows the data acquisition system

VII OBSERVATIONS

Symbol	Fiber type	7 days	14 days	28 days
A	Polypropylene Fiber	24.7	31.2	44.45
B	Coconut Fiber	21.7 7	29.65	39.57

VIII SUMMARY

Coconut fibers have the highest toughness amongst natural fibers. They have potential to be used as reinforcement in low-cost concrete structures, especially in tropical earthquake regions. Based on the observation workable mixes of coconut fiber can be achieved which also imparts higher strength to the concrete. For minor works where concrete is not generally exposed to liquid, FRC using coconut fiber can be an economical as well as a good solution to increase the strength of concrete. However, one area that needs further

investigation is the test method for evaluating the workability of FRC. Currently, there is no standard, for evaluating the workability of FRC. Another area that needs further investigation is the use of FRC with Coconut fiber as a secondary reinforcement in concrete in building elements. If any such admixtures are developed to use natural fibers in concrete for pavements etc, then it would prove beneficial.

Reinforcement of concrete is necessary to enhance its engineering properties. For this study, coconut fibers were used as they are freely available in large quantities. The study comprises of comparative statement of properties of coconut fiber reinforced concrete with conventional concrete based on experiments performed in the laboratory. The use of coconut fibers will also lead to better management of these waste fibers. The addition of coconut fibers improved the flexural strength of concrete by about 12%, they also formed good bonding in the concrete. The study found the optimum fiber content to be 0.4 % (by weight of cement). Further work is required by changing the fiber content and aspect ratio to determine the optimum range of fiber content so that fiber reinforced concrete can be used where high flexural strength is required.

IX FUTURE SCOPE

1. The workability of the concrete with fibers was found to be very less. Hence, it can be improved to have a better slump value
2. Experiments can be conducted by using hybrid (mixing two fibers)
3. for obtaining economical mixes with improved characteristics
4. Further investigations can be carried out to obtain an economical mix by changing the % of fibers
5. Hand mixing becomes very tedious and leads to formation of a non-homogeneous mix. Certain chemicals can be added so as to replace hand mixing by machine mixing
6. Admixtures can also be used to reduce the number of voids which are formed to the present of fiber in the concrete. It may help improve the strength characteristics of concrete.
7. The experiments can be extended by adding other potential natural fibers, by changing the fiber orientation and fiber content and their mechanical characteristics may be analyzed
8. Investigation on the flexural and shear crack pattern of fiber reinforced concrete
9. Comparative study on blended type micro and macro length polypropylene fibers

X CONCLUSIONS

We have tested Concrete cubes of Polyropylene fiber and Coconnut fiber separately to compare their potential use in helping concrete improve its strength. In general, adding fibers to a concrete mixture was found to be beneficial in increasing the stress at cracking and reducing the crack width. As the diameter of Polypropylene fiber is very minute it dint add up for strength in the mixes while coconut fiber was the main part of interest in this. It helped concrete achieve better compressive strength, it holds up the concrete better against crushing/shattering. It being a relatively cheap option to other fibers has its drawback being a natural fiber. Coconut fibers can be used to restrain early age cracking, however, care must be taken when mixing as fiber balling was encountered. These fibers tend to get wet and once wet form fiber balls and prevent proper consolidation of the concrete especially around corners. Some other conclusion includes

1. It can also be concluded that there will not be significant influence on workability and unit weight due to low volume fraction fiber addition to concrete.
2. Coconut fiber being low in density reduces the overall weight of the fiber reinforced concrete thus it can be used as a structural light weight concrete\
3. By reinforcing the concrete with coconut fibers which are cheaply available if a source of the same is obtained in the nearby vicinity/area which is a common thing in most of the Indian Regions, which will also help to reduce the environmental waste
4. Adding a fiber to concrete can increase the early age compressive strength by up to 48%. Coconut fibers are found to provide high compressive strength, however they are also prone to deterioration due to corrosion
5. For coconut fiber as it can be susceptible to decay/decompose if water seeps through it, it was not seen during the 28 days test after the specimens were removed from water that coconut fiber has been deteriorated or decomposed. But from safety point of view it must be used for less important works.
6. The compressive strength of the fiber mixed concrete has a higher value than that of the conventional mix
7. The flexural strength of the fiber mixed concrete is comparatively very high than that of the conventional mix
8. When viewed holistically the use of fiber reinforced concrete has an advantage of controlling early age cracking and increasing early age strength. Moreover the choice of fiber should be given due consideration as different types of fibers perform differently. A fiber with high tensile strength, higher pull out strength and lower flexural strength will be the best candidate to control early age shrinkage cracking. The ultimate choice of fiber type and volume fraction would depend on the desired effect or property. As far as controlling early age shrinkage cracking is concerned a mix with a combined effect of higher early age compressive strength, longer age at cracking and smallest crack width would be an ideal candidate

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