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Study On The Mechanical Properties Of Concrete Using Scba And Coir Fibres

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Abstract

Construction industry is one of the rapidly growing industries in the world. In this industry, concrete plays an inherent role and is the most widely used man made construction material. Concrete consumes large quantities of natural resources. As per the present scenario, it is known that natural resources are depleting worldwide while at the same time the generated wastes from the industry are increasing substantially. So for the sustainable development of construction industry, methods like use of non-conventional innovative materials and recycling of waste materials should be adopted. Eco-friendly cement may be obtained by partial replacement of cement with certain low cost waste materials such as Bagasse ash. Sugarcane bagasse is the waste produced after juice extraction from sugarcane and the Sugarcane bagasse ash is obtained as by product of control burning of sugarcane bagasse. These composites have high impact strength and they can be regarded as an environment friendly material[1]**.** Fibre-reinforced polymer composites have played a dominant role due to their high specific strength and modulus. For the present study the concrete mixes used for are designed for a characteristic strength of 30 N/mm2. This concrete is further modified by adding 10% Sugarcane bagasse ash as a partial replacement to cement and coir fibre in different dosage such as 0%, 0.5%, 1.0%, 1.5%, 2% of the volume of cement. These concrete mixes are tested to assess the effect of SCBA and Coir fibre on workability and strength characteristics of concrete.

Keywords: *sugarcane bagasse ash, coir fibre, mechanical properties of concrete*

1. Introduction

Construction industry is one of the rapidly growing industries in the world. In this industry, concrete plays an inherent role and is the most widely used man made construction material. Concrete consumes large quantities of natural resources. As per the present scenario, it is known that natural resources are depleting worldwide while at the same time the generated wastes from the industry are increasing substantially. So for the sustainable development of construction industry, methods like use of non-conventional innovative materials, and recycling of waste materials should be adopted[6]. Eco-friendly cement may be obtained by partial replacement of cement with certain low cost waste materials. Bagasse is a byproduct of the sugar industry. Juice is extracted from sugar cane then ash produced by burning bagasse is in controlled condition and at very high temperature. The disposal of this material is already causing serious environmental impacts[4]. The recycling of bagasse ash as a partial cement replacement in concrete provides a satisfactory solution to environmental concerns associated with waste management[3].

Concrete is acknowledged to be a relatively brittle material when subjected to normal stresses and impact loads, where tensile strength is approximately just one tenth of its compressive strength. Fibre-reinforced polymer composites have played a dominant role for a longtime in a variety of applications for their high specific strength and modulus[2]. The fibre which serves as a reinforcement in reinforced plastics may be synthetic or natural. Past studies show that natural fibres can provide desired strength. Although glass and other synthetic fibre-reinforced plastics possess high specific strength, their fields of application are very limited because of their inherent higher cost of production. In this connection, an investigation has been carried out to make use of coir, a natural fibre abundantly available in India. Natural fibres are not only strong and lightweight but also relatively very cheap. The present work describes the development and characterization of a new set of natural fibre based composites consisting of coconut coir as reinforcement. Fibres are most generally discontinuous, randomly distributed throughout the cement matrices. The addition of fibres reduces the workability of fresh concrete, marginal improvements in the mechanical strength properties are observed which ranges from 10% to 20%[6].

The following objectives were formulated for the present experimental investigation:

- To evaluate the effect of SCBA as a partial replacement for Cement on strength and workability of concrete.
- To study the effect of coir fibre on the mechanical properties of concrete.
- To find out the best percentages of SCBA and coir fibre for good results.

2. Materials and Their Properties

2.1 Cement

Cement is the most important constituent in a concrete mixture. The function of cement is first, to bind the sand and the coarse aggregates together and second, to fill the voids in between sand and coarse aggregates particles to form a compact mass. For the present work, Ordinary Portland cement (OPC) of 53 Grade confirming to IS 12269 was used. The use of high grade cement offers 10 to 20% savings in cement consumption in addition to high strength. Laboratory tests were conducted on cement to determine its standard consistency, initial setting time, final setting time

Table 1: Properties of Cement

SL NO	PROPERTIES	TEST RESULT
1	Grade	53
2	Specific Gravity	3.13
3	Standard Consistency (%)	31
4	Fineness (%)	4
5	Initial setting time(min)	57

2.2 Coarse Aggregate and Fine Aggregate

Manufactured sand having specific gravity 2.6 was used as fine aggregate. Sieve analysis of fine aggregate was also conducted as per IS 383 (Part III)-1970 to determine its grading pattern. Crushed natural stone of maximum size 20 mm was used as coarse aggregate Table-2 gives the physical properties of the coarse and fine aggregates.

Table 2: Properties of Fine Aggregate and Coarse Aggregate

Sl No	Properties	Fine Aggregate	Coarse Aggregate
1	Specific Gravity	2.6	2.62
2	Fineness Modulus	2.78	2.3

2. 3 Water

Water is the most important and least expensive ingredient of concrete. It actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Potable water is generally considered satisfactory for mixing concrete. For the present study, clean drinking water available in the college water supply system was used for the casting as well as the curing of the test specimens.

2. 4. Super Plasticizer

To keep the water-cement ratio as low as possible and hence to obtain a given degree of workability, chemical admixtures such as super plasticizer was used. Super plasticizers help to reduce the water content, thereby effectively controlling the water-cement ratio to achieve the design strength. The super plasticizer used in this study was Master Rheobuild 1125. It is a high-range, retarding, super plasticizing admixture for concrete. It is a sulphonated naphthalene polymer based super plasticizer having slump retaining capabilities. It shall comply with IS: 9103 and shall be of type G when tested to ASTM C-494. The optimum dosage of super plasticizer has been fixed based on a number of trials wherein the dosage was increased from 0.5% to 1.2% by weight of cement. Based on the results, it has been decided to use a constant super plasticizer dosage of 1% by weight of cement for casting the various specimens. The properties are listed below[10].

Table 3: Physical Properties of Super plasticizer

Appearance	Dark Brown free flowing liquid
Density	1.24±0.02 at 25^{0}C
pH	≥6
Chloride ion content	<0.2%
Dosage limit	0.5 – 1.2% by weight of cement

2.5 Bagasse Ash

Sugarcane bagasse (SCB) is the waste produced after juice extraction from sugarcane. The Sugarcane bagasse ash (SCBA) is obtained as by product of control burning of sugar cane bagasse[3]. The nature of ash can be altered by controlling the parameters such as temperature and rate of heating[7]. The Bagasse Ash which is passing through 90mm sieve is used. And fineness of this material is about 4%. In this investigation the concrete mix in part are replaced with 10%, 20% and 30% of bagasse ash respectively. The compressive strength, the porocity, the coefficient of water absorption, the rapid chloride penetration and the chloride diffusion of concrete are determined. The test results indicate that the incorperation of bagasse ash up to 30% replacement increases the resistance to chloride penetration. Besides the use of 10% bagasse ash produce concrete with good strength and low porocity. Reasonably the substition of 30% bagasse ash is acceptable for producing high strength concrete[9].

Sugarcane bagasse ash is one of the main byproduct that can be used as mineral admixture due to its high content in silica (SiO_2)[10]. Sugarcane bagasse ash has been chemically and physically characterized and it is partially replaced in the ratio of 0%, 10%, 15%, 20%, 25% and 30% by weight of cement in concrete. The properties of fresh concrete are tested like slump cone test and for hardened concrete compressive strength at the age of 7, 28, 56 and 90 days. The result indicates that strength of concrete increases up to15%sugarcane bagasse ash replacement with cement[10].

2.6 Coir Fibre

Coir is an abundant, versatile, renewable, cheap, and biodegradable lignocelluloses fibre used for making a wide variety of products. Coir has also been tested as a filler or reinforcement in different composite materials. Among the various natural fibres sisal fibres, bamboo fibres, coir fibres and jute fibres are of particular interest. These composites have high impact strength besides having moderate tensile and flexural properties and it can be regarded as an environment friendly material[5]. Concrete with coir fibre were experimentally investigated and found to improve shear strength. It also increases the modulus of elasticity and modulus of rupture[2].

In the experimental study of 28 days the compressive strength and split tensile strength are carried out using different coir fibre length of 20mm, 25mm and 30mm respectively of different percentage as0.5%, 0.75% and 1%[5]. Coir fibre used in cement improves the resistance of concrete from sulphate attack[5]. Compressive strength is also improved up to certain percentage. Addition of coir fibre also arrests the micro cracks present in the concrete[5]. Coconut coir is the most interesting products as it has the lowest thermal conductivity and bulk density. The addition of coconut coir reduced the thermal conductivity of the composite specimens and yielded a lightweight product. Development of composite materials for buildings using natural fibre as coconut coir with low thermal conductivity is an interesting alternative which would solve environment and energy concern[8]. Coir fibre of 5cm length is used for the experiment and aspect ratio is about 80.The following are major properties of coir fibre[6] [5].

Table 4: Properties Of Coir Fibre

Properties	Values
Colour	Brown
Specific gravity	1177Kg/m^3
Water Absorption	93%
Tensile strength	95-118 MPa

3. Experimental Work and Tests

3.1 Mix Design:

Concrete mix design is the step by step procedure to work out various proportions of the ingredients required to make concrete. The proportioning of concrete mix consists of determination of the quantities of respective ingredients necessary to produce concrete having adequate, but not excessive, workability and strength for a particular loading and durability for the exposure to which it is subjected. The assumption made in mix design is that the compressive strength of workable concrete is governed by the water-cement ratio. Another most convenient relationship applicable to normal concrete is that for a given type, size and gradation of aggregates, the amount of water determines its workability.

Concrete mix of grade M 30 was designed using IS 10262 code procedure[9]. The aggregates used in the mix design were under saturated surface dry conditions. The quantity of materials needed listed below.

Table 5 : mix proportions for 1 m^3

Component	Quantity
Coarse aggregate	1252 kg
Fine aggregate	647 kg
Cement	360 kg
Water	144 kg
Superplasticizer	1% of cement weight

Table 6: Mix Designation

Mix Designation	SCBA (%)	Coir Fibre(%)
NC	0	0
CF1	10	0.5
CF2	10	1
CF3	10	1.5
CF4	10	2

3.2 Physical Tests on Concrete

3.2.1 Slump Test

This test is intended for measuring workability of concrete. The apparatus for conducting the slump test essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as 200 mm bottom diameter, 100 mm top diameter and a height of 300 mm. The mould is placed on a smooth, horizontal, rigid and non-absorbent surface. The mould is filled with concrete in four layers, each approximately ¼ of the height of the mould. Each layer is tamped with 25 times by a tamping rod taking care to distribute the strokes evenly over the cross sections. Tamping rod is a steel rod

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of 16mm diameter and 0.6 m long with bullet end. After the top layer has been compacted, the concrete is struck off level with a trowel or rod. Then the mould is removed from the concrete immediately by raising it slowly and carefully in vertical direction. This allows the concrete to subside. This subsidence is referred as SLUMP of concrete. The slump shall be measured immediately by determining the difference in level between the height of the mould and that of the highest point of the subsided concrete[8].

3.2.2 Compression Test

The bearing surface of the testing machine shall be wiped clean and any loose sand or other material shall be removed from the surfaces of the specimen which are to be in contact with the compression platens. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen. The load shall be applied without shock and increased continuously at a rate of approximately 14 N/mm2/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted[8]. Compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen by cross sectional area of the specimen.

3.2.3 Cylinder Split Tensile Strength

The tensile strength on concrete is one of the basic and important properties. The concrete is very weak in tension due to its brittle nature and is not expected to take direct tension. The concrete develops cracks when subjected to tensile forces. Thus it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. The split tensile strength was conducted on the compression testing machine using cylinders of 300 mm height and 150 mm diameter.

3.2.4. Flexure Test

The testing machine employed in testing was universal testing machine. The flexural strength was determined according to IS: 516-1975. The bed of the testing machine was provided with two steel rollers on which the specimen was supported. The rollers were so mounted that the distance from centre-to-centre was 400 mm. The load was applied through two similar rollers mounted at the third points of the supporting span. The load was equally divided between the two loading rollers and the rollers were mounted in such a manner that the load was applied axially and without subjecting the specimen to any torsional stresses. The load shall be applied without any shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 0.7 N/mm2/min, that is at a rate of 1800 N/min for the 100 mm specimens. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded. The flexural strength was conducted on the universal testing machine using beams of 100mm x 100mm x 500mm[8].

4. Results and Discussions

4.1 Fresh Properties

4.4.1 Workability

The property of concrete which determines the amount of useful internal work necessary to produce full compaction is known as workability. The workability of fresh concrete depends mainly on the material, mix proportion and environmental conditions. Generally workability of concrete decreases on addition of SCBA and increases on addition of Coir fibre. The workability of concrete is measured using slump test. The results show that compared to the normal concrete, all investigated coir fibre mixtures had high slump values and acceptable workability.

Table 7: Workability

Mix Designation	SCBA	Coir fibre	Slump (mm)
NC	0	0	80
BAC0.5	10	0.5	80
BAC 1	10	1	100
BAC 1.5	10	1.5	105
BAC 2	10	2	105

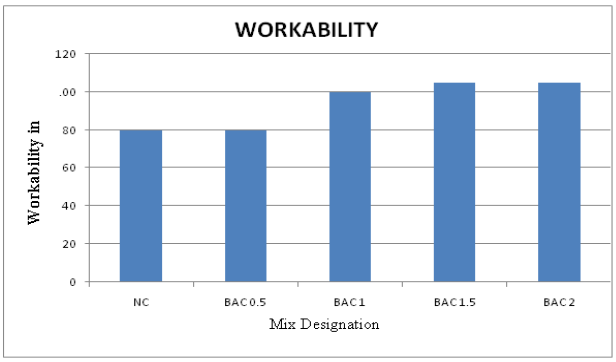

Figure 2: Workability

4.2 Hardened Properties of Concrete

4.2.1 Compressive Strength

The compressive strength tests were conducted on concrete cube specimens of size 150mm. The cubes were tested after curing periods of 7 and 28 days. The results obtained for cube compressive strengths for the different mixes at 7 day and 28 day are shown in Table.

Table 8: 7th And 28th Day Compression Test Results

Mix designation	SCBA	Coir fibre	Cube compressive strength in N/mm2 (7 days)	Cube compressive strength in N/mm2 (28days)
NC	0	0	22	33.8
CF1	10	.5	24.3	39.3
CF2	10	1	26.8	41.6
CF3	10	1.5	29	43.4
CF4	10	2	28.2	39.92

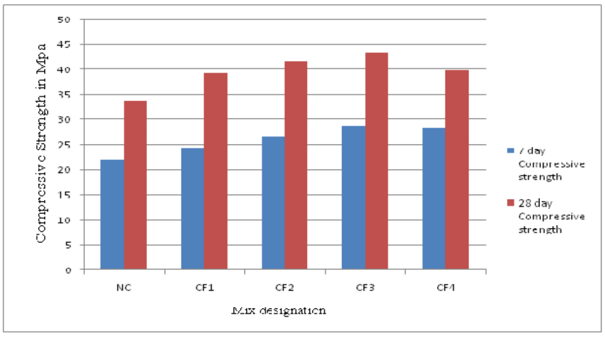

Figure 3: Comparison Of 7 & 28 Day Compressive Strength

The silica content of pozzolans reacts with free lime released during the hydration of cement and forms additional calcium silicate hydrate (CSH) as new hydration products, which improved the compressive strength of concrete. When quantity of coir fibre and SCBA Sin mix is higher than the amount required to combine with the liberated lime during the process of hydration, leading to excess silica leaching out, causes a reduction in strength as it replaces part of the cementitious material but does not contribute to strength.

4.2.2 Cylinder Split Tensile Strength

The variation in flexural strength is similar to that observed in case of compressive strength. At 28 days, flexural strength increases as % of fibre content increases upto coir 0.3%. Further increment of fibre content the strength reduces. Optimum flexural strength is obtained at coir fibre 1.5% and 10% SCBA replacement.

Table 9: Split Tensile Strength

Mix designation	SCBA	COIR	Split Tensile Strength. N/mm2
NC	0	0	2.73
CF1	10	0.5	3.1
CF2	10	1	3.3
CF3	10	1.5	4.6
CF4	10	2	4.1

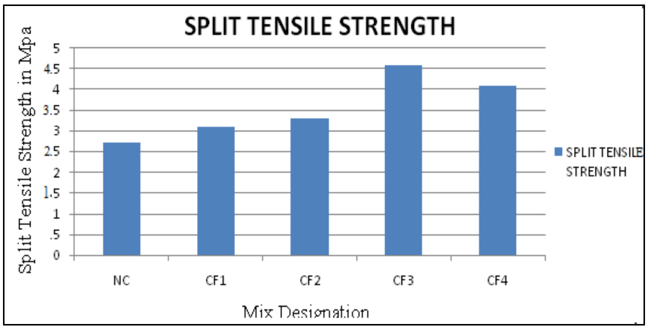

Figure 4: Split Tensile Strength

4.2.3 Flexural Strength

The flexural strength was conducted on the universal testing machine using beams of 100mm x 100mm x 500mm. Flexural strength increased upto 1.5% coir and for further increment of fibre content the strength reduces.

Table.10. Flexural strength

Mix Designation	SCBA	COIR	Flexural strength N/mm2
NC	0	0	4.07
CF1	10	0.5	4.2
CF2	10	1	4.4
CF3	10	1.5	4.6
CF4	10	2	4.1

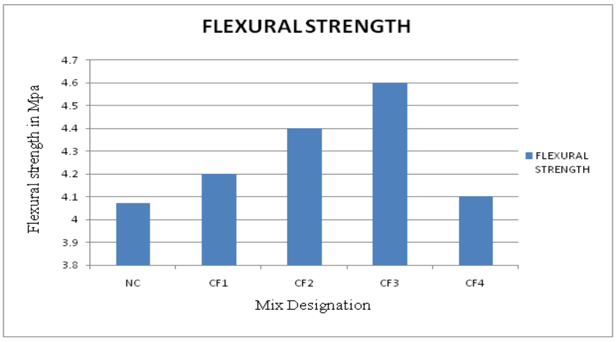

Figure 5: Variation In Flexural Strength

5. Conclusions

Based on the present study the following conclusions can be drawn:-

1. The workability of the modified concrete increases with increase in coir fibre, when SCBA percentage is kept constant. Compared to the normal concrete, all coir fibre mixtures have high slump values and acceptable workability.

2. It has been noticed that for 10% SCBA and 1.5% coir fibre, the Compressive Strength increases to 131.81% at the end of 7days and increases to 128.40% at the end of 28 days

3. For the modified concrete with 10% SCBA and 1.5% coir fibre it is found that the splitting tensile strength increases to 168.49% and the flexural strength increases to 113.02% compared to normal concrete.

4. Maximum compressive strength, flexural strength and splitting tensile strength occur at 10% of SCBA and 1.5% of Coir fibre.

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