TO INVESTIGATE THE MECHANICAL PROPERTIESOF CONCRETE USING COCONUTSHELL ASH AND SUGARCANE FIBRE

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ABSTRACT:- *Concrete is the most widely used man made construction material in the world. It is obtained by mixing cement materials, water and aggregates, and sometimes admixtures in required proportions. The mixture when placed in forms and allowed to cure hardens into a rock – like mass known as concrete. The hardening is caused by chemical reaction between water and cement and continues for a long time, and consequently the concrete grows stronger with age. Coconut Shell is an agricultural waste and is available in very large quantities throughout the tropical countries of the world. Moreover, coconut is becoming an important agricultural product for tropical countries around the world as a new source of energy biofuel. Previously, coconut shell was burnet as a means of solid waste disposal which contributed significantly to* CO_2 *and methane emission. Sugar cane is a natural Plant Fibre, which is collected from Sugarcane Plant. Mainly Sugarcane Fibre is called "Bagasse". Bagasse is a fibrous material that's remains after sugarcane is crushed to exact their juice from sugarcane. It is dry pulp residue left after the extraction of juice from sugarcane. Certain materials of mineral origin are also added to concrete to enhance their strength and durability properties of concrete materials such as Coconut Shell Ash and other by product like Sugarcane Fiber. Coconut Shell Ash and Sugarcane Fiber can be used in a combination as supplementary cementitious material as partial replacement of cement and Fine aggregate. 3% Sugarcane Fiber with 15% Coconut Shell Ash (G3) gives 32% increase in compressive strength which is 55N/mm*^{2} *of this newly modified concrete in comparison with conventional concrete of M25 grade which is optimum amongst other combinations within 28 Days. 3% Sugarcane Fibre with 15% Coconut Shell Ash (G3) gives increases in Tensile strength which is 5.45N/mm*^{2} *within 28 Days alternatively. 3% Sugarcane Fiber with 15% Coconut Shell Ash (G3) gives increases in Flexural strength which is 6.44N/mm*^{2} *within 28 Days alternatively. Percentage increase in Coconut Shell Ash results in decrease of strength parameters i.e. combination having 5%, 10%, 15%, 20%and 25% of Coconut Shell Ash gives less increase in results for this mix proportion.*

Index Terms: *— Coconut Shell Ash, Sugarcane Fiber, Compressive strength, Tensile Strength, Flexural Strength, Specific gravity, Concrete, Cement.*

INTRODUCTION

Concrete is the most widely used man made construction material in the world. It is obtained by mixing cement materials, water and aggregates, and sometimes admixtures in required proportions. The mixture when placed in forms and allowed to cure hardens into a rock – like mass known as concrete. The hardening is caused by chemical reaction between water and cement and continues for a long time, and consequently the concrete grows stronger with age. Concrete is generally classified as a normal strength concrete, high strength concrete and ultra- high strength concrete etc. As per Indian standard a recommended method of mix design denotes the boundary of 35Mpa between Normal strength concrete and high strength concrete but as per international forum, the high strength concrete label was applied to concrete having strength above 40MPa. Now it have been rose to 55MPa as per IS 456-2000. The strength, durability and other characteristics of a concrete depend upon the properties of its ingredients, on the proportion of mix, the method of compaction and other controls during placing, compaction and curing. The key to producing a strong, durable and uniform concrete i.e. high performance concrete lies in careful control of its basic and process components i.e. cement, aggregate, water, chemical admixtures and other supplementary cementing materials. Certain materials of mineral origin are also added to concrete to enhance their strength and durability properties of concrete materials such as Coconut Shell ash and Sugarcane fiber.

MATERIALS USED

Following materials are used for studying the mechanical properties of Concrete for this study use agricultural waste, eco-friendly material. Materials to be used are as follows:

Coconut Shell Ash

Coconut Shell is an agricultural waste and is available in very large quantities throughout the tropical countries of the world. Moreover, coconut is becoming an important agricultural product for tropical countries around the world as a new source of energy biofuel [1]. Previously, coconut shell was burnet as a means of solid waste disposal which contributed significantly to CO_2 and methane emission [1]. However as the cost of fuel oil, natural gas and electricity supply has increased and become erratic, coconut shell has come to be regarded as source of fuel rather than refuse. Presently, the Nigeria coconut shell is used as a source of fuel for the boilers, and residual coconut shell is disposed of as gravel for Plantation roads maintenance. Black smiths also buy the coconut shellmaterial in their casting and forging operation [1].

Figure 1.1 Coconut Shell

The coconut shell was grinded to form coconut shell powder; the powder was packed in graphite crucible and fired in electric resistance furnace at temperature of 1300^{o}C to form coconut shell ash.

Sugar cane is a natural Plant Fibre, which is collected from Sugarcane Plant. Mainly Sugarcane Fibre is called “Bagasse”. Bagasse is a fibrous material that’s remains after sugarcane is crushed to exact their juice from sugarcane. It is dry pulp residue left after the extraction of juice from sugarcane. About 30 to 32% of bagasse is produced from 1 ton of sugarcane. Since bagasse is a by-product of the cane sugar industry, the quantity of production is in line with the quantity of sugarcane produced. Bagasse is the fibrous residue of the cane stalk left after crushing and extraction of juice. It consists of fibre, water and relatively small quantities of soluble solids mostly sugar. Sugarcane Fiber is a fiber of natural origin obtained from the fiber-rich parts of the plant. Sugarcane Fibers come in a variety of grades and have a wide range of applications in the food industry. Sugarcane Fiber has a high fiber content of at least 99.0%. Bagasse also is used to produce composites of natural fibers. Composite is a mixture of dispersed particles held together by a bonding agent of inorganic or organic or organic origin. Some composites of natural fibers are used by the automobile industry, for textile, for construction materials, with inorganic and organic matrices and more recently, recycled composites made of natural fibres are bonded with thermoplastic polymers.

Figure 2 Sugarcane Fibers

METHODOLOGY

- M25 grade concrete mix design as proposed for controlled concrete based on "Indian standard concrete mix proportioning (IS 10262: 2009)" shall be designed using available natural aggregates.
- Material selection and testing of cement, coarse aggregates, and fine aggregates.
- The varying percentage of Coconut Shell Ash and Sugarcane Fibre added to develop thefibre reinforced concrete.
- Testing of rheological properties of concrete with slump test.
- Preparation of test samples to govern hardened properties Fibre reinforced tested concrete.
- 100×100×100mm cubes (set of 3 for control mix as well as for various additions of fibers) for compressive strength determination are casted. So total no. of 126 cubes were casted for
- 100×200mm cylinders (set of 3 for each) are casted for testing split tensile strength. So total no. of 126 cylinders were casted for tested.
- Pond Curing of all samples is done after 24 hours of cast and testing of all samples is done at 28 days.
- Testing of specimen's for compressive strength, flexural strength as per Indian standard guidelines.
- Analysis and conclusion of results shown by various experiments.

RESULTS

Workability

The consistency of Sugarcane fibre reinforced concrete for each mix group has been determined using the slump test in accordance to **IS: 1199-1959**. The test results for workability of fibre mix at addition percentage of 3% of polypropylene and 5% to 25% of steel fibre.

Table No. 1 Slump Values of Concrete Mix

Mix Group	Addition percentage of Sugarcane (%)	Replacement of coconut shell ash	Slump (mm)
R	0	0	75
G_1	3	5	65
G2	3	10	65
G_3	3	15	62
G_4	3	20	57
G_5	3	25	55

Compressive Strength (Optimization of Fibre Content)

The compressive strength of concrete is of greater importance as compared to other strength properties, as concrete can be considered as one of the strongest building material that is used more often in compression. The compressive strength testing was carried out for different mix group of fibre reinforced concrete at 7 days, 14 days and 28 days as per **IS: 516-1959**. Mix R represents the reference mix. Mix G_1 is the concrete reinforced with 3% SCF and 5% CSA, mix G_2 contains 3% SCF and 10 % CSA, mix G_3 contains 3% SCF and 15% CSA, mix G_4 contains 3% SCF and 20% CSA and mix G_5 contains 3% SCF and 25% CSA.

Table 2: Compressive Strength of Concrete Mix for 7 days, 14 days and 28 days

Mix groups	Sugarcane fibre (%)	Coconut Shell Ash (%)	Compressive strength at 7days (N/mm^2)	Compressive strength at 14days (N/mm^2)	Compressive strength at 28days (N/mm^2)
R	0	0	32.5	45	50
G_1	3	5	32.5	45	50
G_2	3	10	33.8	46.8	52
G_3	3	15	35.75	49.5	55
G_4	3	20	32.5	45	50
G_5	3	25	29.25	40.5	45

Split Tensile Strength

The split tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder specimen (100×200mm) is a method to determine thetensile strength of concrete. Concrete being a weak material in tension due to its brittle nature does not resist the direct tension. Test results of split tensile strength test at the age of 7 days, 14 days and 28 days as per **IS: 5816-1999**. Concrete made with 3% SAF and15% CSA (i.e. mix G_3) showed maximum split tensile strength among all other concrete samples.

Table 3: Split Tensile Strength

Mix groups	Polypropylene fibre (%)	Steel fibre (%)	Split tensile strength (N/mm²) for 7 days	Split tensile strength (N/mm²) for 14 days	Split tensile strength (N/mm²) for 28 days
R	0	0	2.71	3.7	4.93
G_1	3	5	2.695	3.67	4.90
G_2	3	10	2.887	3.94	5.25
G_3	3	15	2.997	4.09	5.45
G_4	3	20	2.19	2.98	3.98
G_5	3	25	2.01	2.75	3.66

Flexural Strength

The Flexural strength of concrete is one of the basic and important properties. Flexural strength test on concrete specimen (150×150mm) is a method to determine the Flexural strength of concrete. Concrete being a weak material in tension due to its brittle nature does not resist the direct tension. Test results of split tensile strength test at the age of 28 days as per **IS: 5816-1999** is given in the Table 4.4. These values are graphically presented in Fig 4.4, which shows the variation in Flexural strength of plain concrete and fibre reinforced concrete. Concrete made with 3% SAF and 15% CSA (i.e. mix G_3) showed maximum split tensile strength amongall other concrete samples.

Table 4 Flexural Strength

Mix groups	Polypropylene fibre (%)	Steel fibre (%)	Flexural strength of concrete for 7 days (N/mm²)	Flexural strength of concrete for 14 days (N/mm²)	Flexural strengthof concrete for 28 days (N/mm²)
R	0	0	4.88	5.49	6.1
G_1	3	5	4.9	5.51	6.12
G_2	3	10	4.98	5.61	6.23
G_3	3	15	5.15	5.79	6.44
G_4	3	20	5.05	5.69	6.32
G_5	3	25	4.82	5.42	6.02

CONCLUSIONS

Workability

- Test result shows that as the fibre content increases slump decreases, addition of Sugarcane fibre slightly increases internal particle friction which results in reductionof slump value. Rather the decrease of slump still lies in the range of 50-75 mm.

- It can be concluded that Concrete Mix requires slightly more quantity of chemical admixture to make it workable enough.

Compressive Strength

- As the percentage of fibre content increases, the compressive strength of specimens alsoincreases upto some extent. Mix reinforced with 3% SCF and 15% CSA has the optimum value of compressive strength. Afterward the compressive strength decreases gradually.

Split Tensile Strength

- As the percentage of fibre content increases the split tensile strength of specimens also increases up to some extent. Mix reinforced with 3% SCF and 15% CSA has theoptimum value of split tensile strength. Afterward the Split tensile strength decreases gradually.

Flexural Strength

- As the percentage of fibre content increases the Flexural strength of specimens also increases up to some extent. Mix reinforced with 3% SCF and 15% CSA has the optimum value of Flexural strength. Afterward the Flexural strength decreases gradually.

Residual Compressive Strength

For Heating Period of 30 Minutes

- As the temperature level increases the residual compressive strength decreases.

- Addition of fibre has the positive effect on residual compressive strength. MixG_3reinforced with (3% SCF+ 15% CSA) shows the optimum value.

- There is no significant difference between the residual compressive strength of tespecimens heated in the temperature range of 400˚C and 600˚C.

- Explosive spelling doesn't occur in any specimen at any temperature level.

For The Heating Period of 1 Hour

- Heating duration of 1 hour also reflects almost similar results as comparedto 30minutes heating.

- Some hair line cracks and edge spelling were observed when the specimens areheated at maximum temperature level of 600˚C for 1 hour.

Residual Split Tensile Strength

- As the temperature increases the residual compressive strength decreases for boththe heating period of 30 minutes and 1 hour.

- Concrete mix G_3 reinforced with 3% SCF and 15% CSA shows the maximumvalue of residual split tensile strength.

Non Destructive Testing

- UPV measurements carried out on heated concrete cubes show reduction of velocity from 4.54 km/s to 3.44 km/s with the increase in temperature from 0˚C to600˚C.

- The reduction in the pulse velocity in Concrete mixes that contained SCF and CSA was significantly higher than normal concrete mix for all additional ratios.

Weight Analysis

- As per the prediction, the total percentage of weight loss of the specimen increases as the exposure temperature increases.
- The average range of variation is 0.3% to 4.3% for the temperature range from 200 to 600˚C when the specimens are heated for 30 minutes and 2.1% to 5% when the specimens are heated for 1 hour.
- From the figure 31 and 32 it is clear that duration of heating has a significant impact onweight of concrete.

Surface Characteristics

- The visual inspection of the surface of specimens after subjecting to high temperature and thermally shocked cooling regime show no visible cracking or spalling on the samples in the 200-400˚C temperature range. Only a small amount of spalling and hair line cracks at 600˚C were observed on some specimens.
- A light pinkish color was observed when the specimens were heated at 600˚C at its maximum temperature level for 30 minutes and 1 hour.

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