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PREPARATION OF LIGHT WEIGHT CONCRETE BRICKS USING COCONUT SHELL FLY ASH

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ABSTRACT

In this project, efforts have been made to study the behaviour of fly ash bricks by taking different proportions of fly ash, cement, lime, gypsum and sand. Three types of fly ash bricks in the different percentage of cement such as 3%, 5% and without cement are designed and then various tests such as compressive strength test, water absorption test, efflorescence, weight test, structural test were performed in order to have comparison with conventional bricks. In the experimental study it is found that the compressive strength of fly ash brick containing 5% cement is 152.1 kg/cm2 which is more than that of class I conventional bricks by 40% approximately. Effort has been made by making different proportions of ingredients having composition of fly ash, coconut charcoal cement, lime, gypsum, and sand.
The need to conserve traditional natural resources that are facing contraction have obliged engineers to look for alternative materials. The production of conventional building materials consumes a lot of thermal and electrical energy and in turn pollutes air, water, and land. Disposal of solid waste generated from agricultural and industrial production activity is the other serious problem in fast developing countries like India. The accumulation of wastes is not only a burden to the industry, but also affects the environment adversely. Therefore, development of new technologies to recycle and convert waste materials into reusable materials is severally important for the protection of the environment and sustainable development of the society. Reuse of such wastes as a sustainable construction material appears to be a workable solution not only to the pollution problem, but also to the problem of the landfill and high cost of building materials. Fast Growth of population, increasing urbanization, and the rising standard of living due to technological innovations have contributed to an increase in the Quantity and variety of solid wastes generated by industrial, mining, domestic, and agricultural activity This work has investigated the potential use of used coconut charcoal as a concrete material. The use coconut charcoal were used as fine concrete aggregate. In the laboratory test, conventional fine aggregate was replaced at 100% replacement level. A total of 18 cubes were cast, cured and tested. The strength development of the concrete mixes containing coconut charcoal and fly ash aggregates was compared to that of conventional concrete with sand as fine aggregate. The result showed a reduction in compressive strength of the concrete but still falls within limits of lightweight concrete. This paper recommends that coconut charcoal can be used for producing concrete where a lighter weight concrete is required and a reduction of dead load of structure is desired.

Keywords: *Internet of Things, Cloud computing, Machine learning, Smart Environments.*

I. INTRODUCTION

The construction industry is revolutionizing in two major ways. One way is the development of construction techniques, such as using automated tools in construction. The other is the advancement in high-performance construction materials, such as the introduction of high strength concrete. Among these high- performance materials, fibre reinforced concrete (FRC) is gradually gaining acceptance from civil engineers. In recent years, research and development of fibres and matrix materials and fabrication process related to construction industry have grown rapidly. Their advantages over other construction materials are their high tensile strength to weight ratio, ability to be moulded into various shapes and potential resistance to environmental conditions, resulting in potentially low maintenance cost. These properties make FRC composite a good alternative for innovative construction. Their application in construction includes both upgrading existing structures and building new ones, which can apply to various types of structure, for example offshore platforms, buildings and bridges (Thou, 2005).

A major roadblock towards development of high performance concrete using steel fibres is the high costs involved, availability and also problem of corrosion. Coconut fibre being the most ductile among all natural fibres (Majid Ali et al.,2012) has the potential to be used as a reinforcement material in concrete. It is biodegradable so the impact on environment will be minimal. This is also a way to dispose off the fibres which are derived as waste materials from coir based manufacturing units to produce high strength materials .They are also non-abrasive in nature ,cheap and easily available. Research work is being carried out to find the possibility of coconut-fibre ropes as a vertical reinforcement in mortar-free interlocking structures. This is believed to be a cost-effective solution to earthquake-resistant housing.

The aim of this study was to identify the improvement in strength characteristics of concrete with the addition of oil coated coconut fibre. In the study, coconut fibre is added to concrete and Plain Cement Concrete (PCC) is used as reference to study its effect on flexural, compressive and tensile strength properties and also drying shrinkage. Fibre is coated with oil so as to decrease the water absorption. Some of the advantages being observed are low-cost, low density, reasonable specific strength, good thermal insulation, reduced wear and ability to be recycled with minimal impact on environment (Majid Ali et al.,2011). Thus in addition to the enhancement in the physical properties of concrete, it turns out to be a sustainable waste management technique.

II. LITERATURE SURVEY

(Bhatia, 2001) studied the usefulness of fibre reinforced concrete in various civil engineering applications. Fibres include steel fibre, natural fibres and synthetic fibres- each of which lends varying properties to the concrete. The study revealed that the fibrous material increases the structural integrity. These studies made us adopt natural fibres which are abundantly available and cheap.

(Chouw et al., 2012) studied the viability of using coconut-fibre ropes as vertical reinforcement in mortar-free low cost housing in earth quake prone regions. The rope anchorage is achieved by embedding it in the foundation and top tie-beams. The bond between the rope and the concrete plays an important role in the stability of the structure and the rope tensile strength is also found to be fairly high. The rope tension generated due to earthquake loading should be less than both the pull out force and the rope tensile load to avoid the structure collapse. The study concluded that the pull out energy increases with an increase in embedment length, rope diameter, cement and fibre content in the matrix.

(Li et al., 2007) studied fibre volume fraction by surface treatment with a wetting agent for coir mesh reinforced mortar using non-woven coir mesh matting. They performed a four-point bending test and concluded that cementitious composites, reinforced by three layers of coir mesh with a low fibre content of 1.8%, resulted in 40% improvement in flexural strength compared to conventional concrete. The composites were found to be 25 times stronger in flexural toughness and about 20 times higher in flexural ductility. To the best knowledge of authors the only research work on static CFRC properties is the test done on concrete reinforced with coir fibre of length 4 cm. With regard to dynamic properties of CFRC, no study has been reported yet. Dynamic tests had been performed only for concrete reinforced by other fibres, e.g. polyolefin fibres or rubber scrap. To reveal the consequence of fibre length for CFRC properties, thorough investigations involving more fibre lengths and other parameters are required in order to arrive at reliable conclusions. The knowledge of static and dynamic properties of CFRC is essential to understand the potential of such concrete in cheap housing in earth quake prone regions. But the scope of which requires stringent investigations CFRC blocks are used as pavement materials in parking areas to avoid shrinkage crack. The high crack resistance offered by coconut fibre made us adopt coconut fibre reinforced concrete.

measured by Japanese Industrial Standard JIS A 5908-1994 and the thermal properties using JIS R 2618. The parameters studied were fibre length, coir pre-treatment and mixture ratio. 5 cm long boiled and washed fibres with the optimum cement: fibre: water weight ratio of 2:1:2 gave the highest modulus of rupture and internal bond amongst the tested specimens. The board also had a thermal conductivity lower than other commercial flake board composite. These paper made us choose 5cm fibre length after proper treatment of the fibre for the removal of the coir dust.

(Liu et al., 2011) studied the influence of 1%, 2%, 3% and 5% at fibre lengths of 2.5, 5 and 7.5 cm on properties of concrete. For a proper analysis the properties of plain cement concrete was used as reference. It was seen that damping of CFRC beams increases with the increase in fibre content. It was observed that CFRC with a fibre length of 5 cm and fibre content of 5% produced the best results. In this study the optimum percent of coconut fibre added was 5%,which made us to adopt addition of 4%,5% and 6% coconut fibre by weight of cement in our research work. (Kelleret al., 2005) investigated the shear behaviour of reinforced concrete beams strengthened by the attachment of different configurations and quantities of carbon fibres. The study revealed that the strengthening by using carbon fibres increased the resistance to shear and also spalling of concrete.

The next chapter is methodology which gives a brief idea about the overall aspects of this research.

III. ANALYSIS

IV. STUDY ON MATERIALS USED

4.1 Overview

Concrete is a freshly mixed material which can be moulded in to any shape. Concrete is a site made material unlike other material of construction such as can vary to a very great extent in its quality, properties and performance owing to the use of natural material except cement. The properties of materials are important to make concrete workable and durable.

The materials used in this study are:

i) Cement	:	PPC
ii) Fine aggregate	:	sand
iii) Coarse aggregate	:	Aggregates passing through
iv) 20mm is sieve		
v) Coconut fibre	:	Washed fibres of length 5cm
Water	:	Potable water

4.2 Cement

IS 1489 1991 Part I defines PPC as “An intimately interground mixture of Portland clinker and pozzolana with the possible addition of gypsum (natural or chemical) or an intimate and uniform blending of Portland cement and fine pozzolana”. Portland- pozzolana cement can be produced either by grinding together Portland cement clinker and pozzolana with addition of gypsum or calcium sulphate, or by intimately and uniformly blending Portland cement and fine pozzolana. The pozzolanic materials generally used for manufacture of PPC are calcined clay or fly ash. Portland- pozzolana cement produces less heat of hydration and offers greater resistance to the attack of aggressive waters than normal Portland cement. Moreover, it reduces the leaching of calcium hydroxide liberated during the

4.4 Coarse Aggregate

IS 383-1970 defines coarse aggregates as Aggregates most of which is retained on mm IS Sieve and containing only so much finer material as is permitted for the various types described in this standardFigure4.2
Coarse aggregates may be described as:

1. Uncrushed gravel or stone which results from natural disintegration of rock,
2. Crushed gravel or stone when it results from crushing of gravel or hard stone, and
3. Partially crushed gravel or stone when it is a product of the blending of uncrushed gravel stone and crushed gravel or stone.

Figure 4.4 : Coarse aggregate

4.5 Water
According to IS 456 : 2000, water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. The pH value of water shall be not less than 6

4.6 Coconut fibre
Coconut fibre both raw and processed are used in this research.

4.6.1 Raw fibre
It is the waste material obtained from mattress manufacturing and possess high degree of tensile strength of 21.5 MPa Figure 4.3. They are properly washed before use. This will remove dust and other residual particles left on the fibre so as to augment the surface of contact between the fibre and mix resulting in better binding between the reinforcement and concrete and ultimately higher strength. The fibres are then cut into square meshes of size 5cm x 5cm

Figure 4.6.1 : Coconut fibre obtained from mattress waste

4.7 Tests on materials– results and discussion

4.7.1 Tests on cement

The various tests done on cement are :

i) Standard Consistency
ii) Initial Setting Time
iii) Final Setting Time
iv) Fineness of Cement
v) Density of Cement
vi) Soundness of Cement

4.7.2 Tests on coarse aggregate

1. Bulk density of coarse aggregates
2. Specific gravity of coarse aggregates
3. Sieve analysis of coarse aggregates

Bulk Density of Coarse Aggregates

The experiment was carried out as per IS code 2386 part-III-1963 and IS 383.

Diameter of the metal measure, d=25cm Height of the metal measure, h=21.5cm
Volume of the metal measure, V= $10.55x10^3 cm^3$ Weight of the empty metal measure, W =5.5kg
Weight of compacted aggregate + metal measure, W_1=19.95 kg Bulk density of compacted coarse aggregate = 1.37 kg/lit

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Weight of loosely packed aggregate + metal measure, W_2= 19.1kg Bulk density of loosely packed aggregate = 1.29 kg/lit

INFERENCE
As per IS code 2386-part III -1963, the obtained value of bulk density of aggregates lies within the range of 1.2-1.8kg/l.

Specific Gravity of Coarse Aggregate
The experiment was carried out as per IS code 2386 part-III-1963 and IS 383.
Weight of saturated aggregate suspended in water with the wire basket,A_1=2800g
Weight of empty wire basket suspended in water,A_2=1550g Weight of saturated aggregate in water=A_1-A_2=2800-1550=1250g Weight of saturated surface dry aggregate in air,B=1992g
Weight of oven dried aggregate in air,C=1985g

Specific gravity= 2.72 Apparent specific gravity=2.75 Water absorption = 0.04685

INFERENCE
As per IS code 2386-part III -1963, Average value of specific gravity should lies between 2.6-2.8

Grain Size Distribution of coarse aggregate
Experiment was done as per IS 2386-Part I-1963,IS:383-1970 and the results are tabulated in Table 4.1. The gradation curve is shown in Figure 4.5.

Weight of sample taken, W=5000g

Table 4.7.2: Results of sieve analysis conducted on Sample

Is sieve size in mm	Weight retained on each sieve(g)	Percentage retained on each sieve	Cumulative % retained on each sieve	% finer
80	0	0	0	100
40	0	0	0	100
20	42	0.84	0.84	99.16
10	4705	94.1	94.94	5.06
4.75	16	0.32	95.26	4.74

Figure 4.7.2 : Gradation curve for Coarse Aggregate

INFERENCE
Value of fineness modulus is **6.9**. As per IS 2386 part-1, 1963 fineness modulus of coarse aggregate is between 6.5 and 8. Obtained value lies within the range. hence it can be used for making satisfactory concrete.

4.7.3 Tests on fine aggregate
Bulk density of fine aggregate
Specific gravity of fine aggregate
Sieve analysis of fine aggregate

Bulk density of fine aggregate
The experiment was carried out as per IS code 2386 part-III-1963 and IS 383. Diameter of the metal measure, d=25cm
Height of the metal measure, h=21.5cm

Volume of the metal measure, V= $10.55 x 10^3 cm^3$

Weight of the empty metal measure, W =5.5 kg

Weight of compacted fine aggregate + metal measure, W_1= 24.3kg Bulk density of compacted coarse aggregate = 1.78 kg/lit
Weight of loosely packed aggregate + metal measure, W_2= 23.5 kg Bulk density of loosely packed aggregate = 1.74 kg/lit

INFERENCE

As per IS code 2386-part III -1963, the value of bulk density of aggregates lies within the range of 1.2-1.8kg/l. The obtained value if bulk density is 1.78 kg/l which is within this range and hence can provide sufficient rigidity to the concrete mix

Specific Gravity of fine aggregate

The experiment was carried out as per IS code 2386 part-III-1963 and IS 383.

Weight of empty pycnometer =636g Weight of pycnometer + Msand A =1136g
Weight of pycnometer + aggregate+ water B =1718g Weight of pycnometer + water C=1395g
Specific gravity=2.706

INFERENCE

As per IS code 2386-Part III -1963 the specific gravity of fine aggregate ranges from 2.65 to 2.68. The obtained value is 2.706 is within the range.

4.7.3.3 Sieve Analysis of Fine Aggregate

Experiment was done as per IS 2386-Part I-1963,IS:383-1970 and the results are tabulated in Table 4.2 and table 4.3 respectively. The gradation curve is shown in Fig 4.6 and Fig 4.7

Sample 1

Weight of sample taken, W = 500g

Table 4.7.3(a) : Results of sieve analysis conducted on Sample 1

I.S sieve size	Weight retained on each sieve(g)	Percentage retained on each sieve	Cumulative % retained on each sieve	% finer
4.75 mm	0.680	0.136	0.136	99.864
2.36 mm	0.9	0.18	0.136	99.684
1.18 mm	0.84	0.168	0.484	99.516
600 micron	2.7	0.54	1.024	98.976
300 micron	130	26	27.024	72.976
150 micron	300	60	87.024	12.976
Pan	64.88	12.98	100	0

Fineness modulus = (/ 100) = (116.008/100) = 1.16

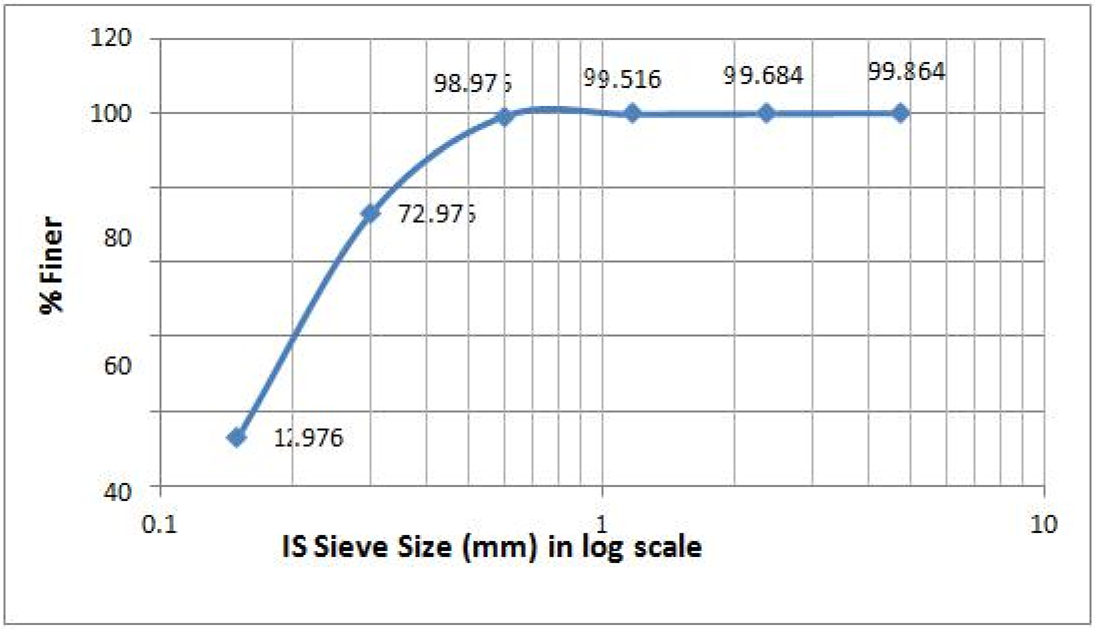

Figure 4.7.3(a) : Gradation Curve for Sample

Sample 2
Weight of sample taken, W = 1000g

Table 4.7.3(b) : Results of sieve analysis conducted on Sample 2

I.S sieve size	Weight retained on each sieve(g)	Percentage retained on each sieve	Cumulative % retained on each sieve	% finer
4.75 mm	23	2.3	2.3	97.7
2.36 mm	205	20.54	22.84	77.16
1.18 mm	185	18.54	41.38	58.62
600 micron	145	14.53	55.91	44.09
300 micron	161	16.13	72.04	27.96
150 micron	149	14.93	86.97	13.03
Pan	130	13.03	100	0

Fineness modulus = (/ 100) = (281.44/100) = 2.814

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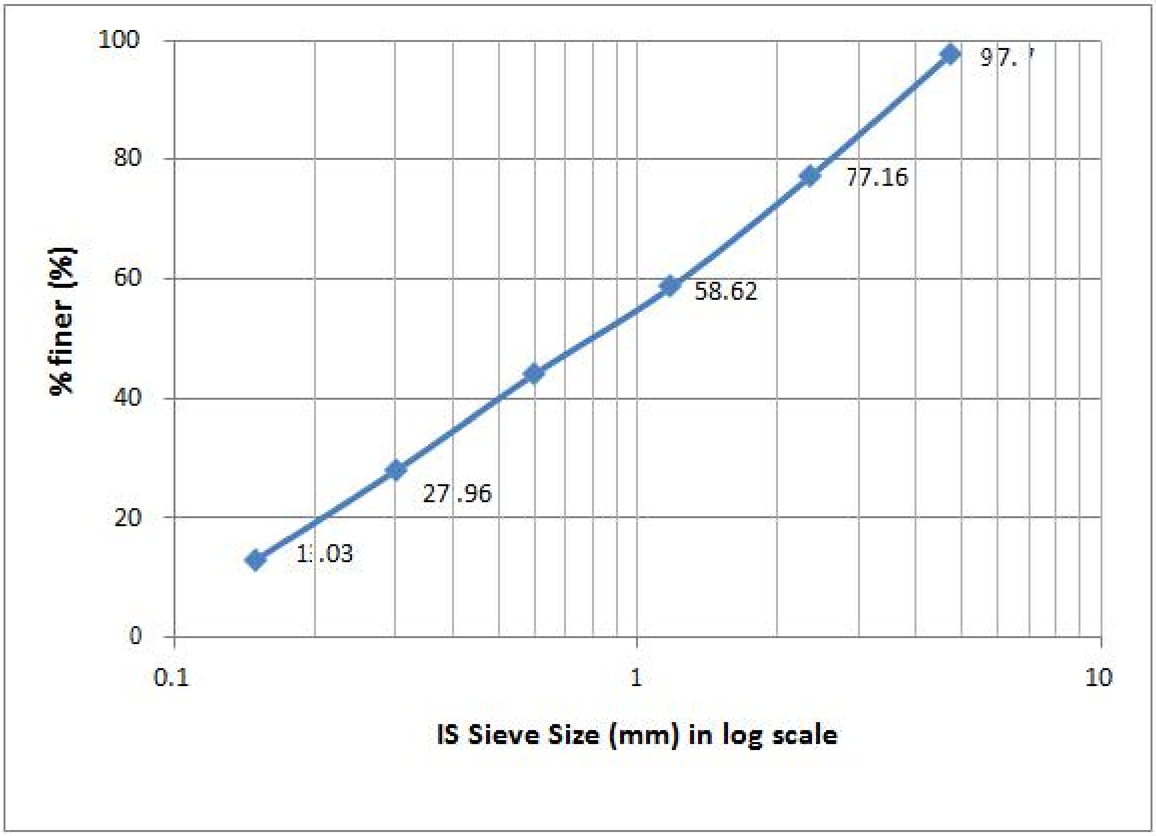

Figure 4.7.3(b) : Gradation Curve for Sample 2

INFERENCE

Aggregates can be grouped in to different zones according to its gradation curve. Zone 1, Zone 2, Zone 3 and Zone 4 are different zones. It is recommended that fine aggregates conforming to Grading zone 4 should not be used in reinforced concrete. Grading of fine aggregates has much greater effect on workability of concrete. According to IS: 2386-Part I-1963, IS: 383-1970, the graph of Sample 2. Hence Sample 2 was selected for the experimental purpose. Properties of Sample 2 are shown in Table 4.3.

V. CASTING AND TESTING OF CONCRETE SPECIMEN

5.1 Tests on fresh concrete

5.1.1 Slump test

Slump test is the most commonly used method of measuring consistency of concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete. Additional information on workability and quality of concrete can be obtained by observing the manner in which concrete slumps. The apparatus for conducting the slump test essentially consists of a metallic mould in the form of frustum of a cone having the internal dimensions of bottom diameter 20 cm, top diameter 10 cm and a height of 30 cm as shown in Figure 5.1.

Figure 5.1 : Slump Testing Apparatus

5.2 Tests on hardened concrete

5.2.1 Compressive strength test

Compressive strength is the capacity of a material or structure to withstand axial loads tending to reduce the size. It is measured using the Universal Testing machine. Concrete can be made to have high compressive strength, e.g. many concrete structures have compressive strengths in excess of 50 MPa. Here the compressive

strength of concrete cubes for the plain concrete and fibre reinforced concrete are found out using Compression testing machine. Three cubes were cast for each percentage of fibres and the average of the two compressive strength values was taken. A Compression testing machine is shown in Figure 5.2.

Figure 5.2.1 : Compression Testing Machine

5.2.2 Split tensile strength test

Tensile strength is the capacity of a material or structure to withstand tension. It is measured on concrete cylinders of standard dimensions using a Universal Testing machine. Both conventional and fibre reinforced specimens were tested at varying percentages of fibre and the average value was obtained

5.3 Experimental procedure

5.3.1 Mix design

Mix design is defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The mix design must consider the environment that the concrete will be in exposure to sea water, trucks, cars, forklifts, foot traffic or extremes of hot and cold. A Mix design was conducted as per IS 10262-1982 to arrive at M 20 mix concrete.

Stipulations for proportioning

Grade designation : M20
Type of cement : PPC
Max nominal size of aggregate : 20mm Min cement content : 300 kg/m^3
Max water cement ratio : 0.55
Workability : 100mm(slump)
Exposure condition : Mild(for reinforced concrete)
Degree of supervision : Good
Type of aggregate : Crushed angular aggregate
Max cement content : 450 kg/m^3
Chemical admixture type : Superplasticizer

Test data for materials

Cement used : PPC
Standard consistency of cement : 34% Initial setting time of cement :70 min Final setting time of cement : 300 min
Specific gravity of cement : 3.09 g/cc
Chemical admixture : Superplasticizer conforming to IS 9103

Specific gravity of

1) Coarse aggregate : 2.72
2) Fine agggregate : 2.706

Water absorption of

1) Coarse aggregate : 0.5%
2) Fine aggregate : 1%

Free surface moisture of

a) Coarse aggregate : Nil
b) Fine aggregate : Nil

Bulk density of

a) Coarse aggregate : 1.37 kg/l

b) Fine aggregate : 1.78 kg/l

Sieve analysis

a) Coarse aggregate : Fineness modulus = 6.91

b) Fine aggregate : Fineness modulus = 2.814 and Conforming to grading zone 2, Table 4 of IS 383

1) Target strength for mix proportioning

$f'_{ck} = f_{ck} + 1.65\ s$

where f'_{ck}= target average compressive strength at 28 days

f_{ck}= characteristic compressive strength at 28 days = 20 N/mm^2

s = standard deviation = 4 N/mm^2 (from Table 1, IS 10262 : 2009) t = statistical value dependent on expected results

According to IS:456-2000 and IS 1343-1980, the characteristic strength is defined as that value below which not more than 5 percent results are expected to fall, in which case the above equation reduces to

Therefore, target strength = 20 + 1.65 * 4 = 26.6 N/mm^2

2) **Selection of water cement ratio**

Various parameters like type of cement, aggregate, maximum size of aggregate, surface texture of aggregate etc are influencing the strength of concrete, when water cement ratio remain constant, hence it is desirable to establish a relation between concrete strength and free water cement ratio with materials and condition to be used actually at site.

From Table 5 of IS 456, maximum water cement ratio for M_{20}mix = 0.55 From the trial mixes, water cement ratio is fixed as 0.50

0.50 <0.55 , hence OK

3) Selection of air content

Air content for 20 mm aggregate = 2% of volume of concrete from Table 4.4 (IS 10262-1982)

Table 5.3.1 : Approximate Entrapped Air Content

Maximum Size of Aggregate(mm)	**Entrapped Air, as Percentage of Volume of Concrete**
10	3
20	2
40	1

1) Selection of water content

The water content and percentage of sand in total aggregate by absolute volume are determined from Table 2 of IS 10262 : 2009

Maximum water content

(for 20 mm aggregate) = 186 litre (for 25 to 50 mm slump range)

Estimated water content for 100mm slump = 186 + (6/100*186) = 197 litres

2) Calculation of cement content

The cement content per unit volume of concrete may be calculated from free water cement ratio and the quantity of water per unit volume of concrete.

Water cement ratio = 0.5
Cement content = 197/0.5 =394 kg/m^3

From Table 5 of IS 456, minimum cement content for severe exposure condition
= 320kg/m^3

394 kg/m^3> 320 kg/m^3, hence OK

3) Proportion of volume of coarse aggregate and fine aggregate

From Table 3 of IS 10262 : 2009, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (zone 2) for water cement ratio of 0.50
= 0.62

Therefore proportion of volume of fine aggregate = 1 – 0.62 = 0.38
MIX CALCULATIONS

The mix calculation per unit volume of concrete shall be as follows

a. Volume of concrete = **1 m^3**
b. Volume of cement = (mass of cement / (specific gravity of cement * 1000))
= (350 / (3.09 * 1000)) = **0.1275 m^3**
c. Volume of water = (mass of water / (specific gravity of water * 1000))
= (197 / (1 * 1000)) = **0.197 m^3**
d. Volume of chemical admixture = **NIL**
e. Volume of all in aggregate = (a - (b + c + d)) = 1 – (0.1275 + 0.197 + 0)
= **0.675 m^3**
f. Mass of coarse aggregate = e * volume of coarse aggregate * specific gravity of coarse aggregate * 1000
= 0.675 * 0.62 *2.72 * 1000 = **1138 kg**
g. Mass of fine aggregate = e * volume of fine aggregate * specific gravity Of fine aggregate * 1000=0.675 * 0.38 * 2.706 * 1000= **687 kg**

Mix proportion

Cement	=	394kg/m^3
Water	=	197 kg/m^3
Coarse aggregate	=	1138 kg/m^3
Fine aggregate	=	687 kg/m^3
Water cement ratio	=	0.5

Table 5.3.1.2 : Quantity of materials required for each mix

Materials	**Mix 1 (Plain Concrete)**	**Mix 2 (4% fibre) processed**	**Mix 3 (5% fibre) Processed**	**Mix 4 (6% fibre) processed**	**Mix 5 (4% fibre) Raw**	**Mix 6 (5% fibre) Raw**	**Mix 7 (6% fibre) Raw**
Cement (Kg)	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Water (Kg)	4.75	4.75	4.75	4.75	4.75	4.75	4.75

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Coarse Aggregate (Kg)	27	27	27	27	27	27	27
Fine Aggregate (Kg)	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Fibre (Kg)	-	0.38	0.475	0.57	0.38	0.475	0.57
Super Plasticizer		0.2%	0.4%	0.6%	0.2%	0.4%	0.6%

5.3.2 Casting procedure

5.3.2.1 Casting of concrete cubes

Concrete is mixed either by hand Fig 5.4. In this casting process is used. Concrete is a mixture of Cement, Water, Coarse and Fine Aggregates and Admixtures. The proportion of each material in the mixture affects the properties of the final hardened concrete. These proportions are best measured by weight. Measurement by volume is not as accurate, but is suitable for minor projects. The dry ingredients are mixed and water is added slowly until the concrete is workable. This mixture may need to be modified depending on the aggregate used to provide a concrete of the right workability. The mix should not be too stiff or too sloppy. It is difficult to form good test specimens if it is too stiff. If it is too sloppy, water may separate (bleed) from the mixture.

Figure 5.3.2.1(a): Mixing of concrete

For casting, all the moulds were cleaned and oiled properly. There were securely tightened to correct dimension before casting. Care was taken that there is no gaps left, where there is any possibility of leakage of slurry. Careful procedure was adopted in the batching, mixing and casting operation. The coarse aggregate and fine aggregate were weighed first. The concrete mixture was prepared by hand mixing on a water tight platform. On the water tight platform cement and fine aggregates are mixed thoroughly until a uniform colour is obtained, to this mixture coarse aggregate was added and mixed thoroughly. Then water is added carefully making sure no water is lost during mixing. While adding water care should be taken to add it in stages so as to prevent bleeding which may affect the strength formation of concrete rising of water required for hydration to the surface. Clean and oiled mould for each category was then placed on the vibrating table respectively and filled in three layers. Vibrations were stopped as soon as the cement slurry appeared on the top surface of the mould. Fig 5.5 shows cube specimen placed on table vibrator.

Figure 5.3.2.1(b) : Cubes Specimen Placed on Table Vibrator

These specimens were allowed to remain in the steel mould for the first 24 hours at ambient condition. After that these were demoulded with care so that no edges were broken and were placed in the tank at the ambient temperature for curing. After demoulding the specimen by loosening the screws of the steel mould, the cubes were placed in the water for 7 days and 28 days.

Figure 5.3.2.1(c) : Finishing of moulds

Figure 5.3.2.1(d) : Finished fibre reinforced concrete cubes

The calculated amount of cement and fine aggregate are mixed together till a uniform mix is obtained. The amounts of fibre adopted are 4%, 5% and 6% of cement. Raw and non uniform coir fibres are cut into square chips of of 5cm x 5cm. They are then washed, oil coated with coconut oil and dried in sunlight for 24 hours and added to the mix until a uniform colour is obtained. Coarse aggregates are then added to the same and mixed followed by addition of water. Care should be taken to add water slowly in stages so as to prevent bleeding which may affect the strength formation of concrete rising of water required for hydration to the surface. Admixture is added towards the last stage of addition of water so as to avail sufficient time for mixing before the concrete hardens It is placed in the mould and compacted. 6 cubes each of the same are prepared and cured. The compressive strength for 7day and 28 day is determined.

5.4.3 Compressive strength of cfrc

Coconut fibre reinforced concrete was cast at a water cement ratio of 0.5 at which desired slump values and compressive strength were obtained for conventional concrete. However, when fibre is added the mix showed very low workability. Hence superplasticizer was added at different proportions of cement to get a concrete mix with suitable workability. The result of compressive strength of fibre reinforced concrete and slump test results are shown in Table 5.4.3.1 and is shown graphical.

Table 5.4.3.1 : Compressive Strength of CFRC Cubes

Specimen	w/c ratio	Percentage of coconut fibre added	Amount of superplasticizer used	Slump Value (mm)	Compressive strength(N/mm^2)	
					7 day	28 day
1	0.5	4 %	0.6 %	108	13.7	23.2
2		5 %	0.8 %	102	12.96	22.1
3		6 %	1 %	100	12.51	21.82

INFERENCE

From the table a decreasing trend in compressive strength is observed with a maximum at 4% fibre addition. On further addition of fibres compressive strength values way below that of conventional concrete is obtained. This is due to formation of zone of transition, which creates a weak zone around the fibre making the entire specimen weak. Moreover the thickness of the fibres can hinder better packing of the constituents of concrete thus making.

VI. CONCLUSION

Coconut fibre is available in abundance at the test site, which makes it quite viable as a reinforcement material in concrete. Further, it acts as a source of income for the coconut producer who gets the benefits of the new demand generated by the construction industry. In addition to this, it is an efficient method for the disposal of coir mattress waste which will reduce the demand for additional waste disposal infrastructure and decrease the load on existing landfills and incinerators. Coconut fibres being natural in origin, is ecologically sustainable and can bring down the global carbon footprint quite effectively.

The objectives of this work were:

1. To find out variation in compressive, tensile and flexural strengths of CFRC using processed fibre strands and raw fibre meshes at varying fibre contents and to compare it with that of conventional concrete

2. To determine the influence of shape of fibres on strength of concrete The scope of this project was limited to rural residential constructions.

The major conclusions from this study are

1. At 5% addition of coconut fibre with a water cement ratio of 0.5, compressive strength tests yielded best results. However, the compressive strength decreased on further fibre addition. This must be due to the fact that when the fibres are initially added to concrete, the finer sized fine aggregates enter into the surface pores in the fibre creating a better bonding between the fibre and mix, however further addition of fibres resulted in formation of bulk fibre in the mix which will lead to decrease in bonding. Hence there is an optimum value of fibre to cement ratio, beyond which the compressive strength decreases. Hence 0.5 was taken as the optimum water cement ratio and optimum fibre content was taken as 5%
2. When the fibre content is increased there is an increase in split tensile strength with a maximum at 5%. However when the fibre content is increased beyond this value a reduction in tensile strength is observed. This is due to the fact that tensile failure occurs due to the dislocation of atoms and molecules present in concrete. However when the fibre is added it acts as a binder holding them together.
3. When fibre content is increased there is an increase in flexural strength with a maximum at 5% of fibre. However when the fibre content is increased beyond this value a downward slope of the graph is observed. This is also due to the binding properties of coconut fibre owing to its high tensile strength of 21.5 MPa.
4. A decreasing trend in compressive strength was observed in concrete with mesh shaped fibres. This is due to formation of weak inter transition zone around these fibres, making the entire specimen weak. Moreover the thickness of the fibres can hinder better packing of the constituents of concrete thereby making it weak. The presence of dust and other impurities on the surface of fibres can also be another reason for this reduction in strength which may interfere with the bonding of mix and subsequent strength formation.
5. The tensile properties and cracking pattern of CFRC shows that it can be particularly useful in construction activities in seismic zones due to its high tensile strength and post peak load behaviour, which offers sufficient warning to the inhabitants before complete collapse of the structure.
6. Due to its relatively higher strength and ductility, It can be a good replacement for asbestos fibres in roofing sheets, which being natural in origin pose zero threat to the environment
7. Since higher strength is attained at a lower design mix. It can be used to manufacture building blocks at relatively lower costs in comparison to plain concrete blocks thus making it suitable for rural residential buildings upto 10m height or as protection walls around buildings.
8. It can also be used as the reinforcement material in cement fibre boards which can act as a good backing to tiles thereby improving its impact resistance and also in faux ceilings. The advantage of cement fibre boards is its ability to survive under moist environments unlike paper based gypsum boards.

VII. FUTURE SCOPE

The effect of coconut fibres on high strength concrete should be studied and thus the use of CFRC can be extended to industrial and commercial buildings. Since the corrosion study is not done, the applicability of CFRC in reinforced constructions could be tested.

Coconut fibre is a good insulator in itself and as such it can improve the thermal properties of concrete. This is particularly useful in a tropical country like India where the mercury levels are quite high for most part of the year, so as to maintain the room temperatures within comfort levels of its inhabitants. It can also reduce the load on air conditioning systems thus reducing the power consumption.

The acoustic properties of concrete reinforced with other natural fibres have been studied in the past using an impedance tube apparatus and the results are fair enough to justify the use of coconut fibres as an alternative which is a good absorbent due to the presence of surface pores.

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