STUDY ON PROPERTIES OF NATURAL FIBER REINFORCED CONCRETE MADE WITH COCONUT SHELL

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ABSTRACT:

Utilization of agricultural waste material in concrete enhances the properties of concrete. To study this phenomenon concrete made of fly ash, coconut fibre and coir fibre for M40 was done and evaluated. Cement is substituted with fly ash by 10%, 20%, and 30%.Coir fibres is include by weight of the binder in the proportions about 0%, 1%, 1.5%, 2%, 2.5%, 3%. Coconut shells are replaced in the place of coarse aggregate. The breadth of coconut fibre will vary from 0.25 to 1.0 cm. The present study has illustrated that addition of coconut fibre and coir fibre to concrete enhances the properties of concrete.

Key words: coconut shells, stone dust, concrete.

1. INTRODUCTION

1.1 COCONUT SHELL

a) Coconut shell has high strength and modulus properties.

b) It has added advantage of the high lignin content. High lignin content makes the composites more weather resistant.

c) It has low cellulose content due to which it absorbs less moisture as compare to other agricultural waste.

d) Coconuts are being naturally available in nature and since its shells are no biodegradable; they can be used readily in concrete, which may fulfill almost all the qualities of the original form of concrete

1.2. METHODOLOGY

The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete was produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore, these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are compared with the other LWA used in concrete.

2. OBJECTIVES AND SCOPE

If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to 8 determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC.

The research objectives are briefly summarized below.

- To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28-day compressive strength more than 20 N/mm2.
- To study the strength properties of concrete in replacement of coarse aggregate.
- To study the behavior of compressive strength and workability.

3. MATERIALS USED

3.1. Here mainly three materials were used, namely

1. Coconut shells

2. Stone dust

3.1.1. STONE DUST

A finely crushed material used tofill in the spaces between gravel or paving stones. Once in place and moistened, it is heavy enough to stay in place. Also called road base in some areas.

Fig 3.1.1 stone dust

3.1.2 COCONUT SHELL

- Coconut shell has high strength and modulus properties.
- It has added advantage of the high lignin content. High lignin content makes the composites more weather resistant.
- It has low cellulose content due to which it absorbs less moisture as compare to other agricultural waste.
- Coconuts are being naturally available in nature and since its shells are no biodegradable; they can be used readily in concrete, which may fulfill almost all the qualities of the original form of concrete.

In this work coconut shell was used as partial replacement of coarse aggregate which is crushed granite. Coconut shells were unruffled from the local temple after that it was cleaned, sun dried, removed fibers to evaluate its properties. Coconut shell needs no pre treatment, except for water absorption. Coconut shell has very high water absorption. Due to this property, before use coconut shells were soaked in potable water for 24 hours.

Fig 3.1.2 Coconut shell

MIX DESIGN OF CONCRETE

- M30 mix design as per 10262
- Ordinary Portland cement grade 53 confirming to IS 12269-1987.
- Maximum nominal aggregate size 20mm.
- Minimum cement content 400 kg per cubic meters.
- Specific gravity of cement 3.15.
- Specific gravity of coarse aggregate 2.8
- Specific gravity of water 1.00
- Specific gravity of fine aggregate 2.6

Target strength for mix proportioning:

f'm = fck + 1.65 s

f'm= target average compressive strength at 28 days,

f'ck = characteristics compressive strength at 28 days, and

s = standard deviation.

From table 1 IS 10262 : 2009 standard deviation = 5 n/sq.mm.

target strength = 40+1.65(5)=48.25n/sq.mm

WATER-CEMENT RATIO

Adopted maximum water-cement ratio = 0.44. From the Table 5 of IS 456 for Very severe Exposure maximum Water Cement Ratio is 0.45 0.44 < 0.45 .

PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

- From Table 3 of (IS 10262:2009) Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.50 =0.62 .
- In the present case water-cement ratio is 0.44. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.06. The proportion of volume of coarse aggregate is increased by 0.02 (at the rate of -/+ 0.01 for every ± 0.05 change in water-cement ratio).
- Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.44 = 0.64

The mix calculations per unit volume of concrete shall be as follows:

A) Volume of concrete = 0.15x0.15x0.15=0.003375 m3 by adding 10% extra we get 0.0037125 cubic meters = 0.0037125*2400 = 8.91 kgs

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

MIX PROPORTION

Materials	Mix 1 (plain concrete)&stone dust	Mix 2 (5% coconut shell) &stone dust	Mix 3 (10% coconut shell) &stone dust	Mix 4 (15% coconut shell) &stone dust
Cement Kg	2.4	2.4	2.4	2.4
Water Kg	0.6	0.6	0.586	0.586
Coarse aggregate (kg)	4	3.8	3.6	3.4
Fine aggregate (kg)	2	1.9	1.8	1.7

TABLE-1 Quantity of materials required for concrete mixing

4. METHODOLOGY

4.1. Mix design

Mix design is a process of selecting suitable ingredients and determining their relative proportions with the objective of producing concrete of having certain minimum workability, strength and durability as economically as possible

It is a performance based mix where choice of ingredients and proportioning are left to the designer to be decided. The user has to specify only the requirements of concrete in fresh as well as hardened state. The requirements in fresh concrete are workability and finishing characteristics, whereas in hardened concrete these are mainly the compressive strength and durability a mix design was conducted as per

IS 10262-1982 to arrive at M40 mix concrete

Procedure for concrete mix design calculation as per IS 10262-2009 based on strength and durability, workability, economy is discussed in this article.

To produce concrete of required strength and properties, selection of ingredients and their quantity is to be found which is called concrete mix design. Proper mix design will solve every problem arises in concrete while placing or curing etc.. The mix design also helps to produce economical concrete.

Generally, cement is more costly than other ingredients of concrete. So, quantity and quality of cement is designed by proper mix design concept. In this article we are going to discuss about the concrete mix design concept as per IS 10262-2009.

Concrete mix design concept is majorly depending upon the following

- Strength and durability
- Workability
- Economy
- specifications

Concrete Mix Design Procedure as per is 10262 – 2009

Procedure for concrete mix design requires following step by step process:

1. Calculation of target strength of concrete
2. Selection of water-cement ratio
3. Determination of aggregate air content
4. Selection of water content for concrete
5. Selection of cement content for concrete
6. Calculation of aggregate ratio
7. Calculation of aggregate content for concrete

8. Trial mixes for testing concrete mix design strength

Step 1: Calculation of Target Strength of Concrete

Target strength is denoted by f_t which is obtained by characteristic compressive strength of concrete at 28 days (f_{ck}) and value of standard deviation (s)

Step 2: Selection of Water-Cement Ratio

Ratio of the weight of water to weight of cement in the concrete mix is watercement ratio. It is the important consideration in concrete mix design to make the concrete workable. Water cement ratio is selected from the below curve for 28 days characteristic compressive strength of concrete.

Similarly, we can determine the water-cement ration from the 7-day concrete strength, the curves are divided on the basis of strength from water cement ratio is decided. Which is observed from above graph.

Fig: Concrete Compressive Strength vs. Water Cement Ratio

Step 3: Determination of Aggregate Air content

Air content in the concrete mix is determined by the nominal maximum size of aggregate used. Below table will give the entrapped air content in percentage of volume of concrete.

Step4: Selection of Water Content for Concrete

Select the water content which is useful to get required workability with the help of nominal maximum size of aggregate as given in below table. The table given below is used when only angular shaped aggregates are used in concrete as well as the slump should be 25 to 50mm.

Cement Content for Reinforced Concrete

For the given nominal maximum size of aggregate, we can calculate the ratio of volumes of coarse aggregate and volume of total aggregates for different Step 7: Calculation of Aggregate Content for ConcreteWe already determine the coarse aggregate volume ratio in the total aggregate volume. So, it is very easy that, 1 – volume of coarse aggregate will give the volume of fine aggregate. Alternatively, there are some formulae to find the volume of fine and coarse aggregates as follows.

Mass of fine aggregate is calculated from below formula

$$V = \left[W + \frac{C}{GC} + \left(\frac{1}{1-P} * \frac{F.A}{Gf}\right)\right] * \frac{1}{1000}$$

Similarly, mass of coarse aggregate is calculated from below formula.

$$V = \left[W + \frac{C}{GC} + \left(\frac{1}{P} * \frac{C.A}{Gca}\right)\right] * \frac{1}{1000}$$

Where, V = volume of concrete

W = water content

C = cement content

Gc = sp. Gravity of cement

P = aggregate ration obtained in step6

F.A & C.A = masses of fine and coarse aggregates

Gf & Gca = sp. Gravities of fine and coarse aggregates.

STEP 8: Trial Mixes for Testing Concrete Mix Design Strength

Based on the values obtained above, conduct a trail test by making at least 3 cubes of 150mm size as per above standards. Test that cubes and verify whether the required strength is gained or not. If not, redesign the mix with proper adjustments until required strength of cube occurs.

STIPULATIONS FOR PROPORTIONING

Grade designation : M40

Type of cement : OPC

Max nominal size of aggregtae : 20mm and 10mm

Minimum cement content : 400kg/m^3

Manimum water cement ratio : 0.4

Workability : 100mm slump

Exposure condition : mild

Degree of supervision : good

Type of aggregate : crushed angular aggregate

Maximum cement content : 450kg/m^3

5.0 RESULTS AND DISCUSSION

R.C.C. concrete. In this study the density and strength characteristics of concrete produced by volume replacement of 5%, 10%, 15% replacement of crushed granite with coconut shells were investigated. The conclusions for the research are the compressive strength of the concrete decreased as the percentage shell substitution increased. Also increased in percentage replacement by coconut shell increase workability of concrete. Coconut shell can be used as partial replacement of coarse aggregate in

The following recommendations are made at the end of the study.

- Further studies should be carried out to ascertain the possibility of using coconut shell concrete as a structural material.
- Durability studies on coconut shell concrete should be carried out its.
- Developing countries like Ghana should encourage the use of agricultural wastes in construction as an environmental protection and cost reduction measure
- Our study had many limitations, of which the time was a major concern. The strength properties of CSC depends on the aggregate properties of coconut shells and its individual strength characteristics.
- Experiments on impact value, crushing value etc can be done in order to analyze the strength properties of coconut shells. When CSC is used along with reinforcement, the surface bonding between coconut shell aggregates and steel come

Following Values Are The Compressive Strength Of Cubes After 7,14,28 Dyas Of Curing

%0f coconut shell and stone dust	Compressive strength at 7 days (mpa)	Compressive strength at 14 days (mpa)	Compressive at strength 28 Days (mpa)
0 %	35	36.11	37.28
5%	31.2	32.7	33.6
10%	32.8	33.9	34.7
15%	33.5	34.8	35.67

TABLE 2.

CUBE STRENGTH

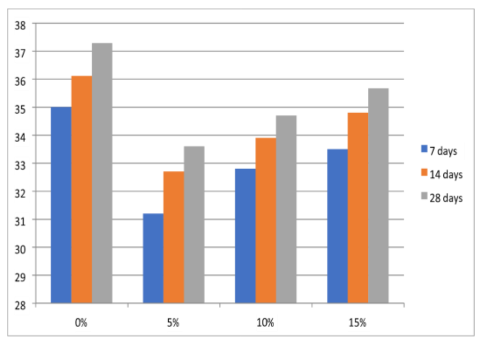

Chart.1: STRENGTH OF CUBES FOR 7, 14, 28 DAYS

ltrasonic pulse velocity results

- Pulse velocity with 0% replacement is 4.5km/sec.
- Pulse velocity with 5 % replacement is 4.0 km/sec.
- Pulse velocity with 10% replacement is 3.8 km/sec.
- Pulse velocity with 15% replacement is 3.5km/sec.

Chart.2: Ultrasonic pulse velocity graph

6.0 CONCLUSION

The major conclusions are of the following:

- To increase the speed of construction, enhance green construction environment we can use lightweight concrete.
- The possibility exists for the partial replacement of coarse aggregate with coconut shell to produce lightweight concrete.
- Coconut shell exhibits more resistance against crushing, impact and abrasion, compared to crushed granite aggregate.
- Coconut shell can be grouped under lightweight aggregate. There is no need to treat the coconut shell before use as an aggregate except for water absorption.
- Coconut shell is compatible with the cement.

The 28-day air-dry densities of coconut shell aggregate concrete are less than 2000 kg/m3 and these are 184 within the range of structural lightweight concrete.

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