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MECHANICAL PROPERTIES OF COCONUT FIBER REINFORCED LIGHT WEIGHT CONCRETE WITH COCONUT SHELL AGGREGATE

*Engr. Muhammad Kashif[1], Fawad Ahmad[2], Masaud Ahmad Khan[3]

[1]*Student, Dept. of Civil Engineering, CECOS University of IT and Emerging Sciences, Peshawar, Khyber Pakhtunkhwa, Pakistan.*

[2]*Lecturer, Dept. of Civil Engineering, Iqra National University, Peshawar, Khyber Pakhtunkhwa, Pakistan.*

[3]*Student, Dept. of Civil Engineering, CECOS University of IT and Emerging Sciences, Peshawar, Khyber Pakhtunkhwa, Pakistan.*

Abstract:- *The use of concrete is increasing day by day due to which the sources of the aggregates are reducing. Coconut shell and coconut fibers are the natural materials which is abundantly available in tropical regions. Wastes generated by industrial and agricultural processes have created disposal and management problems which pose serious challenges to efforts towards environmental conservation. A considerable amount of coconut shells and fibers remain in the environment as waste, so utilization of these materials for construction will be an important step to improve sustainability and eco-friendly construction. In addition to that it will help to produce light weight and economically profitable materials in construction field. In this research the entire program is carried out to find mechanical properties i.e compressive, split tensile, flexure, and pull out strength of concrete samples having partial replacement of coarse aggregate by coconut shell with partial addition of coconut fiber. Concrete mix ratio was 1:2:4 with water cement ratio 0.55. Concrete cylindrical and beam samples having partial replacement of coarse aggregate by 10% of coconut shell and addition of 1%, 2%, and 3% of coconut fiber by weight of cement were casted and then cured for 28 days. After completion of 28 days of curing period the concrete specimens were tested and then compared to control concrete specimens. Results concluded that incorporation of coconut shell as a partial replacement of coarse aggregate improves workability of concrete while coconut fibers reduce the workability. It is also concluded that on 10% replacement of coarse aggregate by coconut shell gives approximately same compressive and pull out strength as for control concrete. While Split tensile and flexure strength increase with 10% replacement of coarse aggregate by coconut shell and addition of 2% coconut fiber. Hence it is recommended that coconut shell is replaceable up to 10% in concrete mix also coconut fiber can be added up to 2% in concrete with 10% coconut shell for improvement of split tensile and flexure strength.*

Key words*: Coconut shell, Coconut fiber, fiber reinforcement, Concrete mechanical properties.*

1 Introduction

Modern concrete is a combination of cement, fine aggregate, coarse aggregate, water and in some cases, admixtures. Admixtures are materials that although not an essential part of concrete and is occasionally added to advance or modify certain physical properties like strength or workability. Concrete is frequently looked upon as “man-made rock”. Its long life and relatively low maintenance requirements add to its popularity (Neville, 1995).

Use of natural aggregate in such a rate leads to a question about the preservation of natural aggregates sources. In addition, operations associated with aggregate extraction and processing are the principal causes of environmental concerns. In light of this, in the contemporary civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete as sustainable and environmentally friendly construction material (Yerramala and Ramachandrudu, 2012).

In developed countries, many natural materials like Pumice, Scoria and Volcanic debris and manmade materials like expanded blast-furnace slag, vermiculite and clinker are used in construction works as substitutes for natural stone aggregates. In India, commercial use of non-conventional aggregates in concrete construction has not yet started (Alengaram et al., 2008).

Coconut trees are widely cultivated in the southern states of India, especially Kerala. Kerala got its name itself derived from a word, ’kera’ meaning coconut tree. Coconut shells thus get accumulated in the mainland without being degraded for around 100 to 120 years. Disposal of these coconut shells is therefore a serious environmental issue. In this juncture, the study on use of coconut shells as a substitute or replacement for coarse aggregates in concrete is gaining importance in terms of possible reduction of waste products in the environment and finding a sustainable alternative for nonrenewable natural stone aggregates (Gummadi and Srikanth, 2012).
India is a country in South Asia and it is the seventh-largest country by area, the second-most populous country, and the most populous democracy in the world. Talking about India’s coconut field, it plays an important role in national

economy of India. According to the various survey India is the world's third largest producer of coconuts. Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Goa, Orissa, West Bengal, Puducherry and Maharashtra are the states those produce maximum coconuts and it includes the island territories of Lakshadweep and Andaman. They produced 11,930,000 metric tons of coconuts and that will become 23.3% of world's total (Singh, 2014).

Lightweight concrete has strengths comparable to normal concrete; yet is typically 25–35% lighter. A recent study showed that Lightweight concrete using coconut shell as coarse aggregate is able to produce concretes with compressive strengths of more than 25 N/mm2. Coconut shell is lighter than the conventional coarse aggregate. Hence the resulting concrete will be light in weight. The compressive strength of lightweight concrete used for structural applications should not be less than 17 N/mm2. An attempt has been made in the present work to develop Structural Lightweight Concrete in accordance with Indian Standards IS 10262 (2009) with coconut shell as a partial replacement to coarse aggregate (Wyman et al., 2005).

Experimental analysis was done on coconut fibers and rope reinforced concrete beam under dynamic loading. In order to acquire knowledge for designing low-cost but safe housing in earthquake prone regions, the dynamic properties of coconut fiber reinforced concrete (CFRC) structural members is investigated. The outcome of the research will be used in the analysis of CFRC buildings under earthquake loading in the future. Natural coconut fibers having a length of 7.5 cm and a fibers content of 3% by weight of cement are used to prepare CFRC beams. Coir having a diameter of 1cm and tensile strength of 7.8 MPa is added as the reinforcement. Compressive strength, splitting tensile strength, modulus of elasticity and rupture for CFRC are investigated. The workability of CFRC is a major problem because of the presence of fibers (Ealias et al., 2014).

2 Methodology

The experimental program is carried out to find compressive, split tensile, flexure, and pull out strength of concrete samples having partial replacement of coarse aggregate by coconut shell with partial addition of coconut fiber.

2.1. Material Used

The material used in the research work were Ordinary Portland cement, Coconut shell, Coconut fiber, Fine aggregate (sand), Course aggregate (crushed stones)

2.2. Cement

ASTM Type I cement was used in this research.

2.3. Coconut Shell

Coconut shell is an agricultural waste product of coconut trees. Coconut trees generate residues in the form of wood, fronds, husks and shells.

Coconut shell being a hard and not easily degrade material if crushed to size of sand can be a potential material to substitute sand.

Coconut shell has also been burnt to produce charcoal and activated carbon for food and carbonated drink and filtering mineral water use.

Figure 1: Crushed coconut shell

2.4. Sand

Fine aggregate used in this research investigation have the Fineness Modulus of 2.67.

2.5. Coarse Aggregate

Coarse aggregate used in this research investigation have the Fineness Modulus of 2.89.

2.6. Coconut Fiber

Coconut fiber is an abundant, versatile, renewable, cheap, lingo cellulosic fiber and more resistant to thermal conductivity.

2.7. Mixing Proportion

For different test purposes we mix the samples according to the ratio as usually used 1:2:4 with water to cement ratio 0.55. By proper calculation we find the quantity of samples (cement, sand, coarse aggregates, coconut shell and fiber).

2.8. Casting

Concrete different mix were prepared and cylindrical and beam samples having partial replacement of coarse aggregate by 10% of coconut shell and addition 1%, 2%, and 3% of coconut fiber were casted and then cured for 28 days. After completion of 28 days of curing period the concrete specimens were tested and then compared to control concrete specimens.

3 Experimental Procedure

The four main tests carried out were workability, Compression test, Flexural test and Pull out test.

3.1. Slump Cone Test

To check the workability of concrete having coconut shell and fiber, slump test was carried out as per ASTM C143 as shown in Figure 3

Figure 2: Slump Test

3.2. Compression Test

The compression test for the coconut shell and fiber reinforcing concrete cylinder specimen was carried out per ASTM C-39 requirements as shown in Figure 3. Before testing of specimens, it was properly capped both on the top and bottom surface per ASTM C-617 requirements to overcome the unevenness of the surface of samples.

Figure 3: Compressive Strength Test

3.3. Flexure Test

To find modulus of rupture concrete beam specimen were test for flexural strength as per ASTM C-1609 requirements as shown in Figure 4.

Figure 4: Flexural Test

3.4. Pull out Test

The dimensions of the pull-out specimens were 6 inch diameter and 12 inches height with a single deformed or ribbed bar of 4/8" diameter embedded in the middle of the concrete cylinder. Preceding to casting, the reinforcement bars were cleaned using a wire brush to eradicate any corrosion on the steel surface. The bond length for the steel bar was selected to be 21 times that of the steel bar diameter. The steel rebars were placed at the middle of the concrete cylinder with a definite entrenched length (i.e. 12"). Figure 5 shows details of the sample used for the pull-out test.

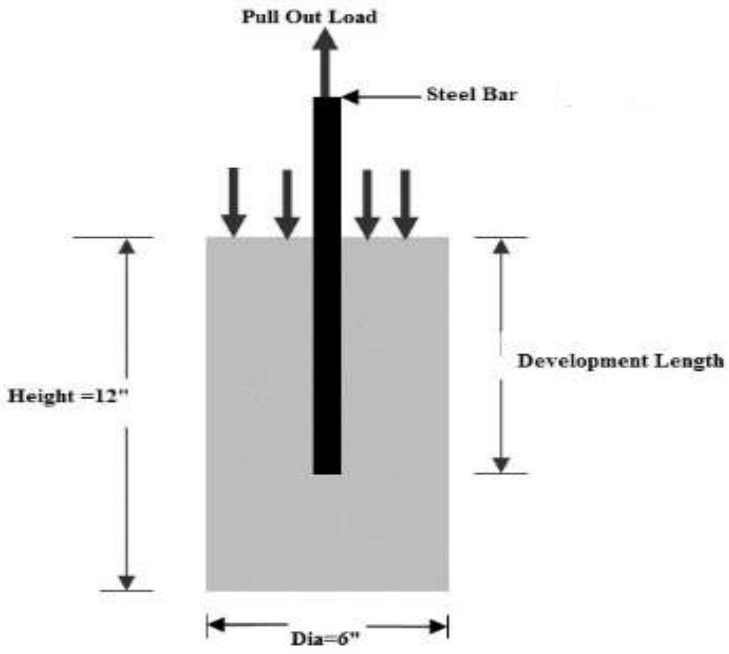

Figure 5: Pull out test

4 Analysis and Results

The graphical test results are briefly discussed in the below section.

4.1. Slump Test

To check the workability of fresh concrete slump test was conducted. Slump test was conducted for each batch of concrete. Each batch of concrete was having percent replacement of coarse aggregate by coconut shell and addition of 0%, 1%, 2% and 3% of coconut fiber. Slump test was also performed for control concrete.

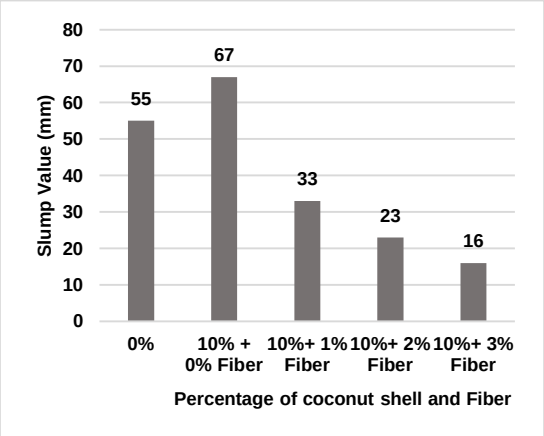

Figure 6: Comparison of workability of Normal Concrete with concrete having 10% coconut shell and 1%, 2%, 3% fiber.

In Figure 6 results shows that the control/ordinary concrete give slump upto 55mm, while on , 10% coconut shell with 0% fiber, 10% coconut shell with 1% fiber, 10% coconut shell with 2% fiber and 10% coconut shell with 3% fiber gives slump value upto 67mm, 33mm, 23mm and 16mm respectively.

By results discussed above it can be concluded that by replacing coconut shell and addition of coconut fiber in concrete, slump value increases with addition of coconut shell while decreases on addition of coconut fiber.

4.2. Compression Strength Test

The compressive test was conducted on concrete cylindrical samples having partial replacement of coarse aggregate by coconut shell with partial addition of coconut fiber.

Concrete cylindrical samples having partial replacement of coarse aggregate by 10% of coconut shell and addition 1%, 2%, and 3% of coconut fiber were casted and then cured for 28 days. First three control concrete samples were casted having no coconut shell and fiber, then 12 concrete cylindrical samples having only 10% replacement of coconut shell with 0%, 1%, 2% and 3% addition of coconut fibers respectively. After completion of 28 days of curing period the concrete cylindrical specimens were tested, the compressive test result for 28 days of curing period is shown in Figure 7

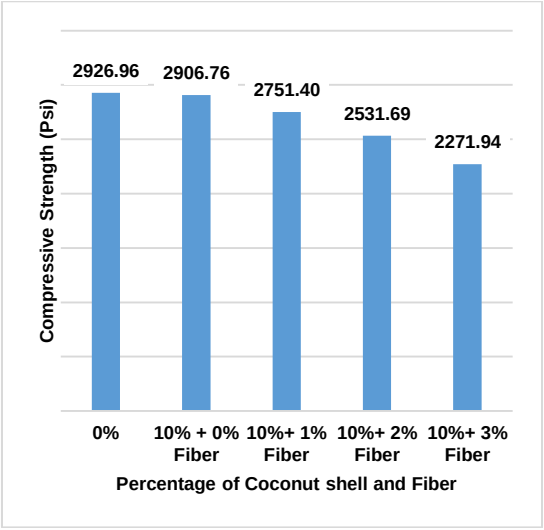

Figure 7: Comparison of compressive strength of Normal Concrete with concrete having 10% coconut shell and 1%, 2%, 3% fiber.

The compressive test was conducted on concrete cylindrical samples having partial replacement of coarse aggregate by coconut shell and addition of fiber then compared with control concrete having no coconut shell and fiber.

Test results indicates that when coarse aggregate was replaced by coconut shell to 10% (with 0% coconut fiber) it gives compressive strength approximately equal to control concrete.

While on further addition of coconut fiber decreases the compressive strength gradually.

4.3. Flexural test

The flexure test was conducted on concrete beam samples having partial replacement of coarse aggregate by coconut shell with partial addition of coconut fiber.

Concrete beam samples having partial replacement of coarse aggregate by 10% of coconut shell and addition 1%, 2%, and 3% of coconut fiber were casted and then cured for 28 days. First three control concrete samples were casted having no coconut shell and fiber, then 12 concrete beam samples having only 10% replacement of coconut shell with 0%, 1%, 2% and 3% addition of coconut fibers respectively. After completion of 28 days of curing period the concrete beam specimens were tested, the flexural test result for 28 days of curing period is shown in Figure 8

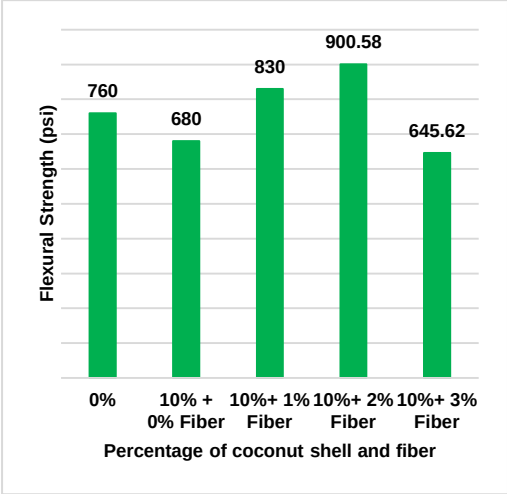

Figure 8: Comparison of Average Flexure Strength of Normal Concrete with concrete having 10% coconut shell and 1%, 2%, 3% fiber.

The flexure test was conducted on concrete beam samples having partial replacement of coarse aggregate by coconut shell and addition of fiber then compared with control concrete having no coconut shell and fiber.

Test results indicates that when coarse aggregate was replaced by coconut shell to 10% (with 2% addition of coconut fiber) it gives optimum flexure strength. While on further addition of coconut fiber decreases the flexure strength gradually.

4.4. Pull Out Test

The pull out test was conducted on concrete cylindrical samples having partial replacement of coarse aggregate by coconut shell and addition of fiber then compared with control concrete having no coconut shell and fiber.

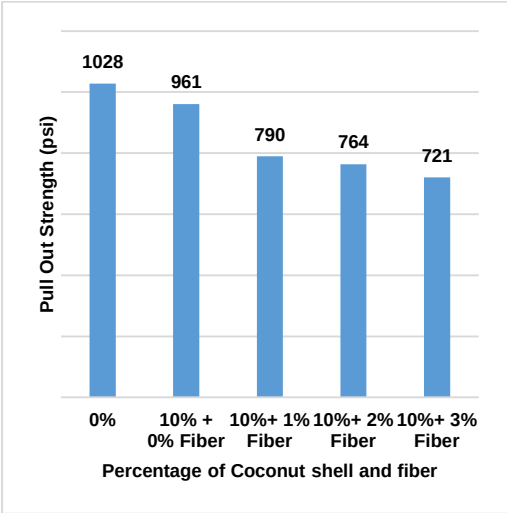

Figure 9: Comparison of Pull out strength of Normal Concrete with concrete having 10% coconut shell and 1%, 2%, 3% fiber.

Test results indicates that when coarse aggregate was replaced by coconut shell up to 10% pull out strength decrease but decrease is very less so it may concluded that give approximately equal strength as that of control concrete. Also on further addition of coconut fiber decreases the strength gradually.

5 Conclusions and Recommendations

The following conclusions are drawn out from this research study
Incorporation of coconut shell as a partial replacement coarse aggregate improves workability of concrete.
Coconut fiber can reduce the workability.
Incorporation of the 10% replacement of coarse aggregate by coconut shell gives the approximately same compressive strength as for control concrete.
Flexure strength increase with 10% replacement of coarse aggregate by coconut shell and addition of 2% coconut fiber.

It is recommended that:
Coconut shell may use as workability improving agent.
Coconut shell is replaceable up to 10% in concrete mix.
Coconut Fiber can be used up to 2% in concrete with 10% coconut shell for improvement of split tensile and flexure strength.

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