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BEHAVIOUR OF REINFORCED CONCRETE BEAMS WITH COCONUT SHELLS AS COARSE AGGREGATES

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ABSTRACT

Lightweight aggregate concrete (LWAC) is an important and versatile material in modern construction. Many architects, engineers, and contractors recognize the inherent economies and advantages offered by this material, as evidenced by the many impressive lightweight concrete (LWC) structures found throughout the world. Use of mineral admixture in conventional concrete and light weight concrete mix has made a remarkable achievement in development and design of high strength in conventional concrete (HSC) and light weight concrete (HSLWAC). The use of high strength concrete (HSC) has many advantages such as a reduction in beam and column sizes, increased building height, greater span-depth ratio for beams in prestressed concrete construction and improved durability of marine concrete structures. It can be said that HSLWACs have a significant advantage over normal weight HSC because of the reduction of dead load and construction cost. Among many mineral admixtures available, Ground granulated blast furnace slag (GGBS), Silica fume (SF) and Alccofine(AF) are added to gain the high strength properties. Mineral Admixtures are added to Portland cement concrete to improve its properties, in particular its compressive strength, bond strength, and abrasion resistance. GGBS 50% and Silica fume or Alccofine 15% are added additive to cement and find the Mechanical properties such as compressive strength, flexural strength, split tensile strength and impact resistance can be studied.

The high cost of conventional building materials is a major factor affecting housing delivery in world. This has necessitated research into alternative materials of construction. The project paper aims at analyzing flexural and compressive strength characteristics of concrete produced using crushed, granular coconut as substitutes for conventional coarse aggregate with partial replacement using M30 grade concrete. Beams are casted, tested and their physical and mechanical properties are determined. The main objective is to encourage the use of these

'seemingly' waste products as construction materials in low-cost housing. It is also expected to serve the purpose of encouraging housing developers in investing these materials in house construction.

KEY WORDS :- Lightweight, low-cost housing, compressive strength, bond strength, abrasion resistance.

1. INTRODUCTION

Concrete is the widely used number one structural material in the world today. The challenge in making a light weight concrete is decreasing the density while maintaining strength and without adversely affecting cost. Light weight concrete is typically made by incorporating natural or synthetic light weight aggregate or by entraining air into a concrete mixture. Although, coarse aggregate usually take about 50% of the overall self-weight concrete. And also, the cost of construction material is increasing day by day because of high demand, scarcity of raw material and high price of energy, from the stand point of energy saving and conservation of natural resources, the use of alternative constituents which should be light in weight to reduce the self-weight of concrete in construction materials is now a global concern. From the studies, the use of coconut shell as a coarse aggregate is effective and having the double advantage of reduction in the cost of construction material and also as a means of disposal of wastes. Hence coconut shell is used as a replacement for coarse aggregate.

2. MATERIAL USED

In this project, the material used are Cement, Fine aggregate, Coarse aggregate and Mineral admixtures like GGBS, SF or AF for manufacturing the concrete. Cement Ordinary Portland Cement (OPC) is a most commonly used cement for wide range of application. 53 grade OPC is a higher strength cement to meet the needs of the for higher strength concrete. Fine aggregate -The material, which is passed through IS test sieve No. 4.75 mm is termed as a fine aggregate. Fine aggregate is of angular grains, clean and free from dust, dirt and organic matters. Coarse aggregate- The material which is retained on IS test sieve No. 12.5 mm -10 mm is termed as a coarse aggregate. The coarse aggregate used in pavement block generally hard, durable and of acceptable shape, free from flaxy elongated particles. Ground granulated blast furnace slag (GGBS) GGBS is used to make durable concrete structures in combination with ordinary Portland cement. Concrete made with GGBS cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of GGBS in the cementitious material, but also continues to gain strength over a longer period in production conditions. Alccofine (AF) Alccofine performs in superior manner than all other mineral admixtures used in concrete within India. Alccofine also consumes by product calcium hydroxide from the hydration of cement to form additional C-S-H gel, similar to pozzolans. The computed blain value based on PSD is around 12000 cm2 /g and is truly ultrafine. Micro silica fume (SF) Silica fume (SF) is a mineral admixture, ultrafine material with spherical particles less than 1 µm in diameter. The bulk density of silica fume depends on the degree of densification in the silo and varies from 130 (undensified) to 600 kg/m3. When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete. A high performance concrete super plasticiser, based on polycarboxylic technology. Structure 203 is a high performance super plasticiser intended for applications where increased early and ultimate compressive strengths are required. Coconut shell -The collected coconut shells were stacked in the SRM University premises. The coconut shells were well seasoned and free from vegetative matter. After crushing the CS, they were sieved and the aggregate passing 12.50 mm sieve size was used for CS concrete. The aggregate used were in saturated surface dry (SSD) condition to prevent absorption taking place during.

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3. MODELLING AND ANALYSIS/EXPERIMENTAL METHODOLOGY

. Slump Cone Test

Slump test is the most commonly used method of measuring workability of concrete which can be employed either in laboratory or at site of work. This test method provides a technique to monitor the consistency of unhardened concrete as shown in Figure 2. In this test, each layer of concrete was compacted 25 times with the help of steel rod 0.6m long and 16mm in diameter in accordance with ASTM C143. The main objective of the present investigation was to study the performance of CS concretes in terms of strength and physical properties with normal water curing. Performance of the concretes was assessed through some physical and mechanical properties such as compressive strength, splitting tensile strength. The concrete mix for every specimen was based on the volume of materials. The weight proportion of the concrete mixture was 1 (cement): 1.5 (fine aggregate): 3 (coarse aggregate) with a constant water to cement ratio of 0.5. Locally available materials (fine and coarse aggregate) are used in this research. In this study, concrete produced by stone chips based coarse aggregate were replaced volumetrically by 0%, 10%, 25% and 50% with crushed coconut shells. Each cylinder has been prepared with a dimension of 100 mm and 200 mm in accordance with ASTM C39. Figure 1 shows some specimens after casting of the cylinder. The specimens were demoulded after 24 hours and immersed in normal water for curing until the test age. Each test was conducted on three replicate specimens and the average crushing loads were reported.

Fig 1: Slump Test for Workability

. Compressive strength test

This test was used for both the normal weight concrete and concrete replacement with coconut shell. The compressive loading tests on concretes were conducted on a compression testing machine (shown in Figure 3). Total 36 samples were casted for compression testing. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per ASTM C39. Load was applied until failure of the specimens and record the ultimate load.

Fig 2: Compressive Test of block.

. Splitting Tensile Strength

Lightweight structural concrete members to evaluate the shear resistance, bond strength, torsion, anchorage, crack resistance and development length of reinforcement. This test has been performed in accordance with ASTM Splitting tensile strength on concrete cylinder is used in the design of C496. Specimens were positioned into the compression testing machine (shown in Figure 4). Load was applied until failure of the specimens. Tensile strength is calculated by using the following equation T=2P/πDL.

Fig 3: Split Cylinder Test.

4. RESULTS AND DISCUSSION

. Physical properties of coconut shell

The density of concrete is primarily affected by some properties of aggregate (for instance, unit weight), which varies by geographical location and increases with concrete compressive strength depending on the added pozzolans. Therefore, it is essential to determine the important physical properties to observe the behavior of concrete. The unit weight, specific gravity, moisture content and water absorption properties of both coarse aggregate (stone chips and coconut shells) and fine aggregate (Sylhet sand) were determined and presented in Table 1. Portland composite cement was used as binder. Specific gravity, initial setting time and final setting time of Portland cement were found 3.02, 120 minute and 200 minutes, respectively. Grain size analysis for coarse aggregates were performed at the materials laboratory of the department of Civil Engineering, Khulna

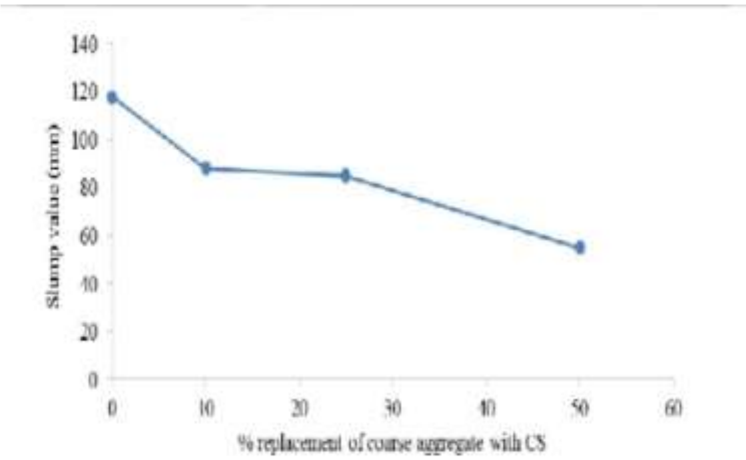
University of Engineering & Technology, Bangladesh. Figure 5 shows the grain size curves of crushed coconut shell aggregates which were used as normal weight aggregates in replacement of stone chips.

Table 1: Determination of physical properties of coarse and fine aggregates.

Properties	Test results		
	Stone chips	Sand	Coconut shell
Unit weight (kg/m^3)	1508	1627	545
Specific gravity	2.61	2.43	1.23
Water content (%)	3	0.75	11.3
Absorption (%)	3.3	4	26.4

. **WORKABILITY**

Slump test was employed to measure the workability of concrete. Figure 6 shows the workability test results from slump test for both normal weight concrete and % replacement of coarse aggregate with CS. It has been observed that the slump value decrease with the increase of percentage replacement of stone chips with CS. All the measured slumps in this research were true slumps.



Variation of slump values due to % replacement of stone chips with CS

. **Compressive Strength**

Compression testing has been performed for 0%, 10%, 25% and 50% replacement of stone chips with CS. It has been observed that the compressive strength of the concrete decreases as the percentage of the coconut shells increase in the concrete mixer as presented in Table 2. It is also observed that the concrete compressive strength of the cylinder specimens increases with the increasing curing days. According to ACI, a concrete is considered structural lightweight aggregate concrete when made with lightweight aggregates conforming to ASTM C 330 and has a compressive strength in excess of 2,500 psi (17.25 MPa) at 28 days of age. From Figure 7 it can be observed that the compressive strength (at 28 days and 90 days) of concrete produced with 10% and 25% replacement of stone chips with coconut shells is approximately 90% and 65% of the concrete produced with

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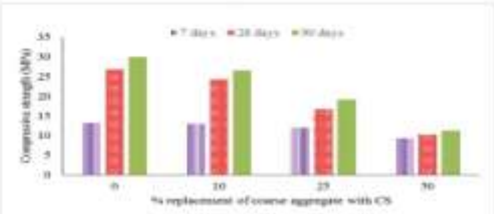
100% stone chips coarse aggregate and therefore, satisfies the strength requirements for lightweight concrete. A compression testing has been performed for 0%, 10%, 25% and 50% replacement of stone chips with CS. It has been observed that the compressive strength of the concrete decreases as the percentage of the coconut shells increase in the concrete mixer as presented in Table 2. It is also observed that the concrete compressive strength of the cylinder specimens increases with the increasing curing days. According to ACI, a concrete is considered structural lightweight aggregate concrete when made with lightweight aggregates conforming to ASTM C 330 and has a compressive strength in excess of 2,500 psi (17.25 MPa) at 28 days of age. From Figure 7 it can be observed that the compressive strength (at 28 days and 90 days) of concrete produced with 10% and 25% replacement of stone chips with coconut shells is approximately 90% and 65% of the concrete produced with 100% stone chips coarse aggregate and therefore, satisfies the strength requirements for lightweight concrete.

Curing (days)	% replacement of CS	Crushing load (kN)	Compressive strength (MPa)
7	0	103.60	13.19
	10	101.40	12.91
	25	93.80	11.94
	50	72.92	9.28
28	0	210.72	26.83
	10	190.72	24.28
	25	131.04	16.68
	50	80.72	10.28
90	0	235.32	29.96
	10	208.40	26.53
	25	150.40	19.15
	50	88.40	11.26



Test results of compressive strength. Compressive strength for different percentage of coconut shell concrete in different curing day.

. Splitting Tensile Strength

Test results of splitting tensile strength has been performed at 28 days for 0%, 10%, 25% and 50% replacement of stone chips with CS and presented in Table 3. From Figure 8 it has been observed that the splitting tensile strength of the concrete decreases with the increase of % replacement of stone chips through coconut shells. It is also observed that the splitting tensile strength is about 9% of its compressive strength. According to ACI 301-05, the minimum splitting tensile strength of concrete is 290 psi (2.0 MPa) for structural grade lightweight aggregates conforming to the requirements of ASTM C330. Therefore, concrete produced with 10% and 25% replacement of stone chips with coconut shells almost satisfies the strength requirements for lightweight concrete.

Test result of splitting tensile strength at 28 days

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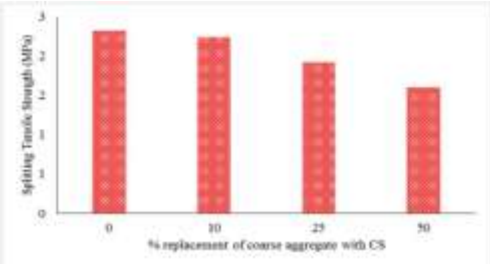
% replacement of CS	Crushing load (kN)	Splitting tensile strength (MPa)
0	72.92	2.32
10	70.48	2.24
25	60.40	1.92
50	50.20	1.60



Variation of Splitting Tensile Test.

5. CONCLUSIONS

Using mixing proportions of 1:1.5:3, results of experiments on the physical and mechanical properties of concrete replaced coarse aggregates with coconut shells have been presented in this research. Based on the experimental results of this study the following conclusions can be drawn:

- Coconut shells can be used as partial replacement for the conventional stone aggregates in concrete production.
- In terms of strength, 20% crushed stone chips can be replaced with coconut shells to produce structural lightweight concrete as per the requirements provided by American Concrete Institute.
- From the experimental work it is clear that the with CS percentage increase the 7 days strength gain also increased with the corresponding 28 days curing strength. Workability of concrete is increases as the replacement increases.
- Specific gravity of the concrete reduces as the replacement of coarse aggregate increases. The density of concrete is decreases as the replacement increases. Density of concrete should not be less than 2000 kg/cum.

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