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LIGHT WEIGHT CONCRETE USING COCONUT SHELLS

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ABSTRACT

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 paper aims at analyzing flexural and compressive strength characteristic coconut shells of concrete produced using crushed, granular coconut shells as substitutes for conventional coarse aggregate with partial replacement using M30 grade concrete. Beams are casted and 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 expected to serve the purpose of encouraging housing developers in investing these materials in house construction.

Key Words Civil Engineering; Construction Materials; Compressive Strength Coconut Shells; Concrete , Environment; Sustainability.

I INTRODUCTION

There were many experimental work conducted to improve the properties of the concrete by putting new materials, whether it is natural materials or recycle materials or synthetic materials in the concrete mix. The additional material can be replacing the aggregate, cement or just as additive and one form of the additive is natural material. A large amount of agricultural waste was disposed in most of tropical countries especially in Asia for countries like Thailand, Philippine and Malaysia. If the waste cannot be disposed efficiently it will lead to social and environmental problem. The high cost of conventional building materials is a major factor affecting housing delivery in India. This has necessitated research into alternative materials of construction. There is an increasing interest in what happens to products at the end of their useful lives, so natural materials have an advantage in that they can biodegrade or be burnt in a carbon-neutral manner. Natural material like coconut shell and palm kernel shell are not commonly used in the construction industry but still are often dumped as agricultural wastes. However, with the quest for affordable housing system for both the rural and urban population of India and other developing countries, various proposals focusing on cutting down conventional building material costs have been put forward. One of the suggestions in the forefront has been the sourcing, development and use of alternative, non-conventional local construction materials including the possibility of using some agricultural wastes and residues as construction materials. As the natural fibers are agriculture waste, manufacturing natural product is, therefore, an economic and interesting option. Coconuts show a wide diversity in size, weight, shape and color, depending on genetic variety and maturity of the nut at harvest (Ohler, 1999). Adeyemi, 1998 investigated, for one mix ratio (1:2:4) the suitability of coconut shell as substitute for either fine or coarse aggregate in concrete production. (Olanipekun et al., 2006) Investigated the comparative cost analysis and strength characteristic coconut shells of concrete produced using crushed, granular coconut shell as substitutes for conventional coarse aggregate. It was concluded that the coconut shell were suitable as low strength-giving lightweight aggregate when used to replace common coarse aggregate in concrete production.

II LITERATURE REVIEW

2.1 Basri H.B. and Khedari

Normal concrete contains four components, cement, crushed stone, river sand and water. The crushed stone and sand are the components that are usually replaced with lightweight aggregates. Lightweight concrete is typically made by incorporating natural or synthetic lightweight aggregates or by entraining air into a concrete mixture. Some of the lightweight aggregates used for lightweight concrete productions are pumice, perlite, expanded clay or vermiculite, coal slag, sintered fly ash, rice husk, straw, sawdust, cork granules, wheat husk, oil palm shell, and coconut shell. (Basri.H.B et al., 1999, Khedari et al., 2000).

2.2 Asokan Pappu

Presently in India, about 960 million tonnes of solid wastes are being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this 350 million tonnes are organic wastes from agricultural sources; 290 million tonnes are inorganic waste of industrial and mining sectors. However, it is reported that about 600 MT of wastes have been generated in India from agricultural sources alone (Asokan Pappu (2007). The new and alternative building construction materials developed using agro-industrial wastes have ample scope for introducing new building components that will reduce to an extent the costs of building materials. The high cost of conventional building materials is a major factor affecting housing delivery in India. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used as potential material or replacement material in the construction industry.

One such alternative is coconut shell (**CS**), which is a form of agricultural solid waste. It is one of the most promising agro wastes with its possible uses as coarse aggregate in the production of concrete. This has good potential to use in areas where crushed stones are costly. Statistical data of coconut production shows that, India is producing nearly 27% of total world production and the annual production of coconut is reported to be more than 12 million tons. Only few studies have been reported on use of coconut shells as aggregate in concrete This paper discussed the physical properties of crushed coconut shell aggregate and the compressive strength of the concrete made with coconut shell coarse aggregate.

Fig.1 Uncrushed coconut shells

Fig.2 Crushed coconut shells

III EXPERIMENTAL PROGRAMME

The target of the experimental program was to determine the contribution of natural material aggregate type to the development of the strength behavior of the conventional concrete. The experimental program comprises the following:

a. To investigate the best mix proportion of the combination of coconut shell as coarse aggregate in concrete.

b. To investigate the feasibility of the combination of coconut shell as coarse aggregate and in concrete by determining its flexural, compressive strength, tensile strength.

c. To investigate the effect of the combination of coconut shell as coarse aggregate in concrete content and length to the workability as lightweight aggregate in concrete and also the mechanical properties mentioned above.

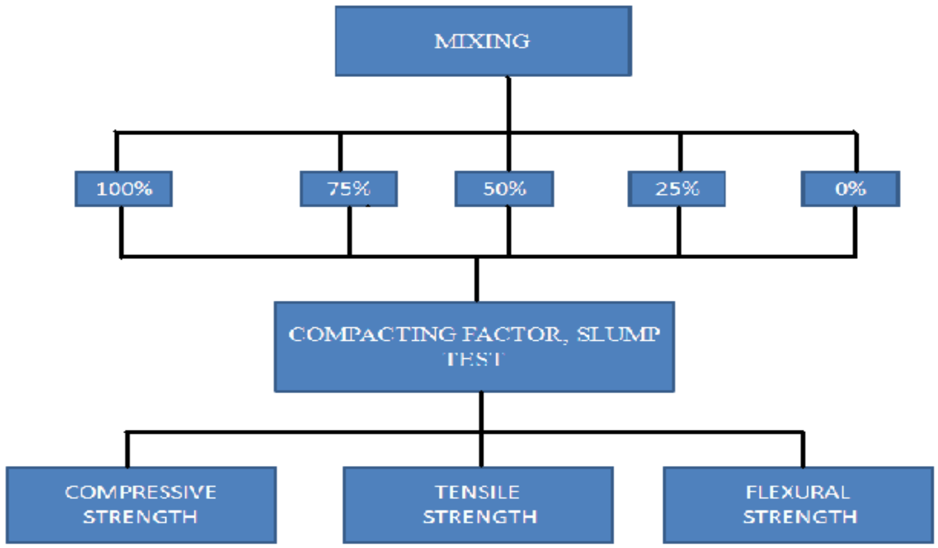


Fig.3 Experimental program conducted

IV MATERIALS AND MIX PROPORTIONS

All raw materials used in this investigation were locally obtained. These includes Pozzolana Portland cement confirming to Indian standard code IS 8112-1995, river sand as fine aggregate and crushed coconut shell as coarse aggregate. The potable water was used for mixing and curing. After crushed the coconut shells, they were sieved and the aggregates passing 12.5mm sieve size was used for this investigation (**Fig.1 and Fig.2**). The physical and mechanical properties of the river sand, coconut shells aggregate and granite aggregates are shown in **Table 1**.

The normal design procedures for ordinary conventional concretes are not applicable to the mix design of lightweight aggregate concrete for two reasons:

-The water content of the cement paste in the fresh lightweight aggregate concrete mix is reduced progressively through absorption by the aggregate and therefore the water-cement ratio will also decrease, and

-The compressive strength of lightweight aggregate concrete is not only influenced by the strength of the mortar but also by the aggregate used.

Hence, it is recommended to go for trial mixes for designing lightweight concrete mix. For lightweight concrete, the cement is recommended in the range of 285–510 kg/m^3. The concrete mix proportion obtained from the trials is 1:1.83:2.63. The mix proportion consists of 480 kg/m3 cement with the water / cement ratio of 0.5 All the ingredients of the mix were weighed and mixed in concrete mixture machine. Steel moulds were used for casting specimens Sides of the moulds and bottom of all the moulds were properly oiled for easy demoulding. The concrete was placed in the mould and proper care was taken for uniform compaction and surface finish.

Sr no.	Physical and mechanical properties		Coconut shells	Crushed granite	River sand
1	Moisture content		4.20 %	-	-
2	Water absorption		24.00 %	0.50 %	-
3	Specific gravity		1.05	2.82	2.57
4	Impact value		8.15 %	12.40%	-
5	Crushing value		2.58 %	6.30 %	-
6	Bulk Density	Tamped	650 kg / m3	1650 kg / m3	-
		Loose	550 kg / m3	1450 kg / m3	-
7	Fineness modulus		6.26	6.94	2.50
8	Shell Thickness		2mm- 7mm	-	-

Table 1. Physical properties of different materials

V SPECIMEN PREPARATION AND TESTING

For each mix, workability (in terms of slump) of the fresh concrete was measured. For each mix, nine 100-mm size cubes were cast to determine the compressive strength at the age of 3, 7, and 28 days. Mixing was performed in a drum type mixer (capacity 50 kg) in the laboratory with an ambient temperature of 28±5ºC and the mixing time was adjusted for each mix type to obtain a uniform and homogenous concrete. All specimens were cast in two layers and compacted on a vibrating table until air bubbles appearing on the surface stopped.

Immediately after casting, the specimens were covered with plastic sheet, left in the mould for one day and then removed from the moulds. After that, they were cured in water at 23 ± 2 ºC until they were tested. The compressive strength was determined by crushing three 100 mm cubes in accordance with BS 1881: Part 116: and averages of the three values were obtained. Table 2 presents the results of compressive strength at 3 days,7 days and 28-day of concrete made with coconut shell aggregate.

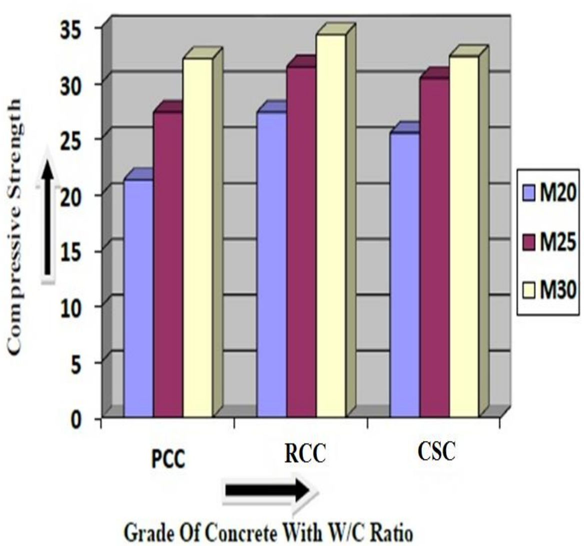
VI RESULTS AND DISCUSSION

The average moisture content and water absorption of the crushed coconut shell was found to be 4.20 % and 24.00 % respectively. Since the coconut shells are basically wood based and organic material and therefore moisture retaining capacity would be more compared with the crushed stone aggregates. Due to the high water absorption of CS, the aggregates were pre-soaked for 24 hours in potable water prior to mixing and were in saturated surface dry

(**SSD**) condition during mixing to prevent absorption of mixing water. The specific gravity under SSD condition of CS and crushed granite was found to be 1.05 and 2.82 respectively. The specific gravity for normal weight aggregate used in concrete ranges from 2.30 to 2.90. The aggregate impact value gives relative measure of the resistance of an aggregate to sudden impact or shock. The aggregate impact value should not be more than 45 % by weight for aggregate used in concrete From **Table 1**, it can be observed that the aggregate impact value (**AIV**) and aggregate crushing value (**ACV**) of CS aggregates are much lower compared to the crushed stone aggregates. The slump obtained for the trial mix was 55 mm, which has showed that CS concrete has a medium degree of workability. The 28-day compressive strength of the concrete using coconut shell aggregate was found to be 29.3 N/mm2 (**Table 2**) under full water curing. The compressive strength of concrete using coconut shell coarse aggregate was more than 27.2 N/ mm^2, which is a requirement for structural lightweight concrete.

Mix type	Compressive strength, N/mm2			
	3-day	7-day	14-days	28-day
CS concrete	11.3	17.8	22.6	29.3

Table 2. Test result of coconut shell concrete



Graph 1. Compressive Test result of coconut shell concrete

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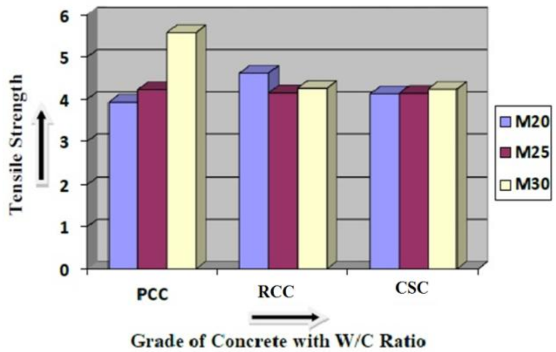
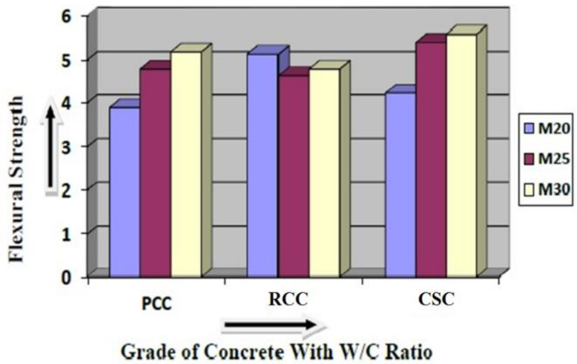


Graph 2. Tensile Test result of coconut shell concrete



Graph 3. Flexural Test result of coconut shell concrete

VII CONCLUSIONS

This paper presents the effective way of utilizing crushed coconut shell aggregate in concrete. Presently, coconut shell is available at a low price in most of the tropical countries. Also the concrete obtained using coconut shell aggregates satisfy the minimum requirements of lightweight concrete. Hence it is possible to made lightweight concrete making use of coconut shells as an aggregate in concrete. Based on the investigation, the following conclusions were made.

i) The average moisture content and water absorption of the crushed coconut shell were found to be 4.20 % and 24.00 % respectively. The CS aggregates have higher water absorption because of higher porosity in its' shell structure.

ii) The aggregate impact value and aggregate crushing value of CS aggregates were much lower compared to the crushed stone aggregate, which indicates that these aggregates have good absorbance to shock.

iii) The specific gravity under SSD condition of CS and crushed granite was found to be 1.05 and 2.82 respectively.

iv) The 28-day compressive strength of the concrete using coconut shell aggregate was found to be 29.3 N/mm^2 under full water curing and it satisfies the requirement for structural lightweight concrete. It should, however, further investigations are required before it can be used as a building material.

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