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STRENGTH CHARACTERISTICS OF ALCCOFINE BASED LIGHT WEIGHT CONCRETE

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ABSTRACT

Concrete being an important material for construction of various structures has severe demand in the present trend of construction industry. Aggregate occupies the major quantity (70% approx.) of concrete based on which characteristics like compressive strength and porosity are controlled. The present usage of aggregate for construction is resulting in the depletion of the natural resources as well as it is showing a great impact on the environment. The work is to focus on the strength characteristics of concrete using coconut shell as an alternative material obtained from coconut processing units. Based on earlier studies a nominal amount of 30% replacement of natural coarse aggregate with coconut shell has been fixed. 'Alccofine' is used as a mineral admixture by replacing cement at various proportions in order to supplement the loss of strength. Tests have been carried out to find out the dry density, wet density and compressive strength. Comparison of the results show that the 30CS A8 (M4) achieving less density without compromising the strength.

KEY WORDS: Light weight concrete; Coconut shells; Alccofine; Density; Compressive strength;

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1. INTRODUCTION

1.1. General

Concrete has been widely used in the construction industry. It composes of fine aggregate and coarse aggregate along with fluid cementitious composite providing good bond. Lightweight concrete gaining high demand in today's world is all because of its improved thermal properties, reduced self-weight of structural members and its mobility.

Due to the rapid development in the construction sector, the usage of natural sources as aggregates are depleting leading to scarcity. In order to balance the effect, alternative materials need to be found as a replacement of aggregate without any loss in their properties. Experimental investigation was performed to analyze the effects of replacing the conventional coarse aggregate partially by coconut shell to produce light weight concrete [1]. It was found that the strength of coconut shell aggregate concrete is comparatively less than conventional concrete but provides provision for lightweight structures. The addition of steel fibers to coconut shell concrete gave an increase in crack resistance, ductility and impact resistance [2].

Researchers compared the mechanical and bond properties with theoretical values recommended by Indian standards. It has been concluded that the bond strength of coconut shell concrete is higher than the specified standards for lightweight concrete given by BS 8110 and IS 456:2000 [3]. Oil palm shell and palm oil clinkers also have the potential to be manufactured into a structural light weight concrete. The density of this type of concrete is 20-25% lower than conventional concrete [4]. Coconut has granular grains at the bottom of the shell when observed under electron microscope. Hence, it was found that it can be used as a coarse aggregate in concrete [5]. Earlier studies have investigated on the strength characteristics of palm oil shell and coconut shell based light weight concrete. They concluded that coconut based concrete has enhanced characteristics than palm oil shell apart from being cost effective [6]. Researchers found that the durability characteristics like porosity, water absorption were found to be higher for coconut shell mixes than the control mix and the addition of admixtures into coconut shell aggregates have enhanced the properties of coconut shell concrete [7]. Past studies have found out that the replacement of cement with fly ash, micro silica fibres with 10% have resulted in greater strength than in normal coconut shell concrete [8]. It has been found that the addition of supplementary cementitious material (Alccofine) have provided higher strength only at a range of 5-15% [9].

1.2. Research Significance

From the earlier works it has been concluded that the coconut shell concrete has achieved less density having a limitation of reduction in compressive strength. In order to overcome this problem, Alccofine- a supplementary cementitious material having good mechanical properties could be partially replaced for cement. The reduction in strength due to coconut shell as aggregate in concrete could be overcome with the help of the cementitious supplementary material.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Cement

Ordinary Portland cement (Dalmia) cement of grade 53 procured from locally available dealers throughout the investigation. The cement being a binder material helps to bind the fine and coarse aggregate together and also filling the larger voids between aggregates. Cement had a specific gravity of 3.1 with consistency 32% and setting time 33 minutes. The properties of cement are shown in table 1.

2.1.2. Alccofine 1203

ALCCOFINE 1203 is a special admixture having glass content with high reactivity when undergone granulation, and it was procured from the local supplier. The properties of Alccofine are shown in table 2.

2.1.2. Fine Aggregate

River sand has been used throughout the investigation as the fine aggregate conforming to grading zone II as per IS 383:1970 [16]. The fineness modulus and specific gravity are 3.35 and 2.7 respectively.

Table 1 Properties of cement

S.No.	Properties	Observed value
1.	Setting time	30 minutes
2	Specific gravity	3.15
3.	Consistency	30%

Chemical composition

Oxide	*Per cent content*
CaO	60–67
SiO_2	17–25
Al_2O_3	3.0–8.0
Fe_2O_3	0.5–6.0
MgO	0.1–4.0
Alkalies (K_2O, Na_2O)	0.4–1.3
SO_3	1.3–3.0

Table 2 Properties of Alccofine

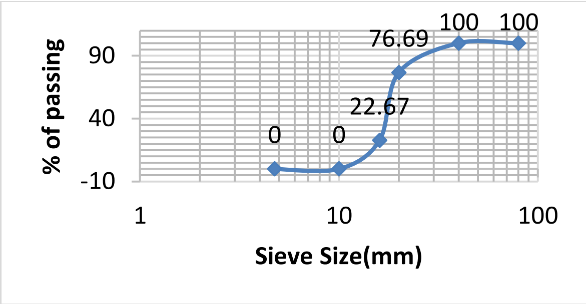
S.No.	Test	Result
1.	Particle size distribution (μm) d10	1.4
2.	d50	4.3
3.	d90	8.9
4.	Bulk Density (Kg/m³)	675
5.	Specific gravity	2.87
6.	Marsh cone flow (with water to ALCCOFINE 1203 ratio as 1.5)	29
	Chemical composition	
7.	SiO_2	35.8%
8.	Al_2O_3	21.6%
9.	Fe_2O_3	1.3%
10.	CaO	33.9%
11.	SO_3	0.12%
12.	MgO	6.3%

2.1.3. Coarse Aggregate

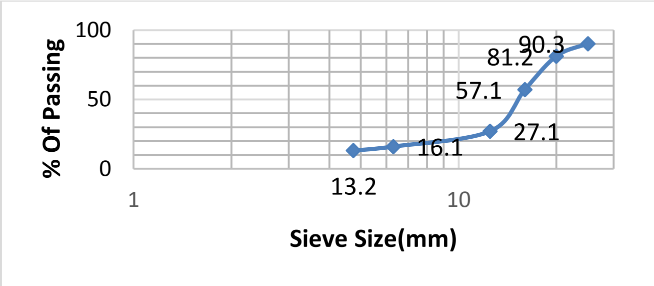
Natural coarse aggregate from local quarries are collected with maximum size of 20mm.

Coconut shell collected from oil mills and hotels were seasoned properly. The seasoned coconut shell are manually crushed using hammer. The crushed aggregate are made to sieve and aggregates passing through 20mm sieve and retained on 12.5mm are picked and are used at Saturated Surface Dry (SSD) condition. The sieve analysis and particle distribution are as shown in figure 1.

(a)



(b)



(c)

Figure 1 (a) Sieve Analysis of Coarse Aggregate; **(b)** Fineness modulus for conventional coarse aggregate; **(c)** Fineness modulus for coconut shell aggregate;

Table 3 Properties of coarse aggregate and coconut shell aggregate [15]

Description	CA	CS
Specific Gravity	2.66	1.314
Water Absorption	0.49%	18.68%
Surface Texture	Rough	Smooth Inner surface and rough outer surface
Shape	Angular	Flaky
Impact Value	20.13%	6.94%
Crushing Value	23.86%	1.93%

2.2. Casting and Testing of specimens

2.2.1. Mix proportion

Mix design is carried out for achieving the required strength. The mix proportion arrived for M40 concrete is 1:1.212:2.179 along with water cement ratio 0.4 and slump 27mm [17]. Fresh concrete properties like workability were observed using slump. The obtained slump was true slump having no shear.

The mix ID provides the various mixes to be used in the whole project. The proportions for different mixes are as shown in table 4.

Table 4 Proportions for Alccofine based lightweight concrete (kg/m^3)

SL.NO	MIX ID	CEMENT	ALCCOFINE	FA	CA	COCONUT SHELL
1	Control Mix M1	492.9	-	597.5	1074.33	-
2	30CS M2	492.9	-	597.5	752.03	157.5
3	30CS 6A M3	492.9	29.574	597.5	752.03	157.5
4	30CS 8A M4	492.9	39.432	597.5	752.03	157.5
5	30CS 10A M5	492.9	49.290	597.5	752.03	157.5
6	30CS 12A M6	492.9	59.148	597.5	752.03	157.5

2.2.2. Casting of specimens

The present work involved in casting of 36 cubical specimens of size (100 mm×100 mm ×100 mm) in total for both conventional and coconut shell concrete. The average compressive strength of 3 specimens were calculated for both 7 and 28 days strength for all the mixes. Workability test and the cast specimens are shown in figure 3.

Figure 2 Fresh concrete slump and cubical specimens after 28day curing

2.2.3. Testing of specimens

After curing, the specimens were surface dried and tested under compressive load in CTM 3000kN capacity [18]. The failure of specimen is as shown in figure.

Figure 3 Compressive testing in CTM

3. RESULTS AND DISCUSSIONS

3.1. Wet and Dry density

After demoulding the weight of the specimens are measured and the dry density is calculated with respect to the volume of the specimen. After curing, the procedure is repeated to calculate the wet densities of specimens. The wet and dry densities of specimens are tabulated in table 5.

Table 5 Dry and wet densities of specimens

Mix ID	Dry Density (Kg/ m³)	% decrease in dry density	Wet Density (Kg/ m³)	% decrease in wet density
Control Mix (M1)	2560	-	2591	-
30CS (M2)	2168	15.3	2279	12.04
30CS 6A (M3)	2180	14.84	2256	12.9
30CS 8A (M4)	2120	17.18	2194	18.09
30CS 10A (M5)	2110	17.57	2200	15.09
30CS 12A (M6)	2210	13.67	2279	12.04

The wet and dry weights of the cubical specimens for all the mixes are noted. The conventional concrete having no addition of coconut shell has not given much variation in the density after curing. The density for mixes having 30% coconut shell has shown an increase of 3.5% after curing. This might be due to the absorbent nature of coconut shell resulting in increase of density.

3.2. Compressive strength

After demoulding, the specimens are surface dried. The ultimate load at which the failure has occurred is noted down and the compressive strength for different specimens are tabulated in table 6.

Table 6 Comparison of Compressive strength of specimens [18]

Type of Mix	7 Day strength (N/mm²)	% decrease in strength	28 Day strength (N/mm²)	% decrease in strength
Control Mix (M1)	17.8	-	44.8	-
30CS (M2)	11.05	37.92	35.49	20.78
30CS 6A (M3)	13.98	21.4	37.94	15.31
30CS 8A (M4)	14.4	19.1	42.41	5.33
30CS 10A (M5)	13.02	26.85	39.12	12.6
30CS 12A (M6)	12.17	31.62	38.18	14.77

It has been observed that the compressive strength has been reduced from 17.8 N/mm^2 **(M1)** to 11.05 N/mm^2 **(M2)** with replacement of 30% of coconut shell as coarse aggregate whereas for **(M4)** the partial replacement of cement with mineral admixture has enhanced the strength properties by 20% compared to (**M2).**

Compared to other mixes, **(M4)** with 8% of Alccofine replacement has given an effective restoration of strength.

4. CONCLUSION

Light weight concrete specimens were cast using coconut shell as partial replacement for conventional aggregate. Both dry and wet densities were checked. The specimens were tested for compressive strength. In order to overcome the reduction in strength of light weight concrete, cement is being partially replaced with Alccofine mineral admixture. The results are compared and following conclusions are arrived.

- Both dry and wet density got reduced in CS based concrete. All the combinations showed an average reduction of about 14.85%, compared to that of control mix concrete.
- The compressive strength after 7 days of moisture curing was comparatively lesser than that of control concrete. Compared to Control Mix (**M1**), the reduction for CS30 (**M2**), CS30 A6 (**M3**), CS30 A8 (**M4**), CS30 A10 (**M5**), CS30 A12 (**M6**) are 37.9%, 21.46%, 19.1%, 26.9%, 31.6% respectively. Among the different combinations, CS30A8 shows less reduction.
- Similar performance were noticed in the specimens which were moist cured for 28 days. Compared to Control Mix **(M1)**, the reduction compressive strength for CS30 (**M2**), CS30 A6 (**M3**), CS30 A8 (**M4**), CS30 A10 (**M5**), CS30 A12 (**M6**) are 20.8%, 15.3%, 5.3%, 12.7%, 14.1% . From the results the optimum mix is found to be CS30 A8 **(M4)**.
- Without replacing cement with Alccofine, for CS30 (**M2**), the reduction in strength was 20.8% compared to control mix. Whereas the percentage reduction is brought to a lesser value of 5.3% for CS30 A8 (**M4**).
- There was a gradual increase in strength up to 7 days, from where the strength has increased exponentially till 28 days.

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