Effect of Treated Coconut Shells on Mechanical Property of Lightweight Concrete

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Abstract— **The overuse of natural aggregates for construction causes many environmental problems. Concrete has a negative impact on the environment as it requires a great quantity of natural resources. To eliminate or reduce the negative impact of concrete, several researches have been undertaken on the use of natural and recyclable materials for construction. However, previous studies show that coconut shell (CS) has a weak adhesion with cement paste, which results in a decrease in the physical and mechanical properties of coconut shell concrete (CSC). One of the solutions for this problem is to carry out a surface treatment on coconut shell before using them in concrete. This study has examined the influence of five treatments on the physical and chemical properties of concrete; treatment with lime (CH), sodium silicate (SS), polyvinyl alcohol l (PVA) and heat treatment.**

***Keywords*-Coconut shell treatment, Lightweight concrete, Mechanical properties of coconut shell aggregate.**

I. INTRODUCTION

Concrete is a composite material composed mainly of water, aggregates and cement. Often, additives are included in the mixture to achieve the desired physical properties of the finished material. The aggregate generally used is gravel or crushed stone with fine aggregates such as sand and water are mixed together, they form a fluid mass that is easily moulded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many used. The objectives of the project are as follows:

- To study the mechanical properties and physical properties of coconut shell aggregate concrete.
- To compare the coconut shell concrete with Lime, Sodium Silicate, PVA and Heat-treated coconut shell concrete.

II. MATERIALS AND TREATMENT METHODS

A. Materials used

Cement is a binding material. Its use is to bind the fine aggregate and coarse aggregate in the concrete. Ordinary Portland cement of grade 53 confirming to IS 8112-1989 [43 grade] is used for experimental work. Laboratory test were conducted on cement to determine specific gravity, consistency, initial and final setting time and fineness. The locally available M-sand conforming to grading zone II of Table 4 of IS 383-1970 has been used as fine aggregate. Aggregate which is passing through 4.75 IS sieve is termed as fine aggregate. Fine aggregate is added to concrete to assist workability and to bring uniformity in mixture. Important thing to be considered is that the fine aggregate should be free from coagulated lumps.

The coarse aggregate used in this project is coconut shell, an agricultural waste. The freshly discarded shells were collected from the local oil mills and they are well seasoned. The seasoned coconut shell is crushed manually. The size of the coconut shell used is 12mm. The surface texture of shell was fairly smooth with concave and convex faces. So, the shells are crushed edges will be rough and spiky that leads to be bonding. Conplast is used as super plasticizers to increase workability and strength of the concrete. The specific gravity of used Conplast is 1.18. Improved cohesion and particle dispersion minimize segregation and bleeding and improves pumpability.

B. Nature and methods of treatment

Five different treatments were studied. Their purpose was to reduce the hydrophilic behavior of CS or to modify the CS surface. A first treatment (CH) consisted of mixing the CS in a solution of lime for 2 hours. 40g of Calcium

Hydroxide in per litre of water. The solution is stirred simultaneously. Authors have observed that lime treatment modifies the surface of the aggregates used and improves the mechanical strength of their composites A second treatment (SS) consisted of mixing the CS in a solution of sodium silicate (SS) for 2 hours. 100g of sodium silicate in per litre of water is dissolved. The solution is stirred simultaneously. A previous study on lightweight concretes containing oil palm shells [2] showed that the presence of amorphous silica on palm shells improves bonding with cement paste. A third treatment (PVA) consisted of mixing the CS in a solution of 5% polyvinyl alcohol (PVA) for 3 minutes. This type of solution was used to make each of the particles water proof [3]. A fourth treatment (TH) consisted of mixing the CS at 60° C for 30 minutes in reference to the work of Yew et al. [4]. Heat treatment of CS can modify its surface roughness, and improves mechanical adhesion between the CS and the cement paste.

C. Properties

Thus, the properties of cement and fine aggregates is shown in table1

TABLE 1 : PROPERTIES OF CEMENT AND FINE AGGREGATE

.

Properties	Materials	
	Cement	M sand
Fineness	6.00	3.28
Specific gravity	3.13	2.57

D. Properties of treated aggregates

Table 2 shows the physical and mechanical properties of aggregates before and after treatment. The percentages of water absorbed after 24 hours are shown in Table 1. It can be absorbed that the PVA treatment has slightly reduced the water absorption of CS as thin layer has formed on the surface of CS.

TABLE 2 : PROPERTIES OF TREATED AGGREGATES

Properties	Treated Coconut shell				
	Ordinary	Calcium Hydroxide	Sodium Silicate	Polyvinyl alcohol	Heated
Water absorption	7.00	5.00	5.00	4.00	8.0
Impact test	6.60	2.20	3.00	2.70	1.85
Crushing test	0.76	0.54	0.48	0.48	0.26

E. Mix Proportion

The normal mix proportion can’t be used for lightweight concrete. Trial and error method suitable for lightweight concrete, because coconut shell aggregate is a natural material which can irregular shape and texture. Hence Gunasekaran (2013) [3] has investigated the mix proportion for lightweight coconut shell concrete. Hence the trial mix proportion of 1:1.58:0.6 with w/c ratio 0.40 is chosen as base mix. The mix proportion is shown in table 3.

TABLE 3. MIX PROPORTION

Mix	Cement (Kg/m^3)	Sand (Kg/m^3)	Coconut shell (Kg/m^3)	W/C Ratio	Superplasticizers (%)
1	510	805.8	306	0.4	1

III. TESTING OF MECHANICAL PROPERTIES OF CONCRETE

A. Compressive strength

The test is carried out on 100 x 100 x 100 mm size cubes, as per IS: 516-19594. The test specimens are marked and removed from the moulds and unless required for test within 24 hours, immediately submerged in clean fresh water and kept there until taken out just prior to test. A 3000 kN capacity Compression Testing Machine (CTM) is used to conduct the test.

Compressive strength (N/mm^2) = Load / Area

B. Split Tensile Strength Test

The Split tensile strength of concrete cylinder was determined based on 516-19594. The load shall be applied nominal rate within the range 1.2 N/m^2/min to 2.4 N/mm^2/min. The test was carried out on diameter of 100 mm and length of 200mm size cylinder. The results of Split Tensile Strength on the mixes at 14 and 28 days are presented in table and figure.

Split Tensile Strength (N/mm^2)=$2P/\pi DL$ [3]

C. Flexural Strength Test

The test is carried out on 100 x 100 x 500 mm size prism, as per IS: 516-19594. The test specimens are marked and removed from the moulds and unless required for test within 24 hours, immediately submerged in clean fresh water and kept there until taken out just prior to test.

Modulus of rupture f_b (N/mm^2) = $(PL)/(bd^2)$

IV. RESULT AND DISCUSSION

A. Compressive strength

The table 4 and Fig 1 show the variation in compressive strength of coconut shell concrete. The compressive strength of untreated CSC at 28 days of curing was 16.33N/mm^2. All of the treatments on CS showed improvement in compressive strength after 28 days of CSC compared to untreated CSC. This increase in the compressive strength after treatment may be due to an improvement in adherence between the treated CS and the cement paste. Heated has average compressive strength of 28.83 N/mm^2 after 28 days of curing. PVA treatment result in real improvement to the compressive strength of CSC as concluded by Mannan et al [6] in their study obtained a 20% increase in compressive strength of PVA. An examination of the failure surfaces showed breakage of the CS aggregate, indicating that the individual shell strength had a strong influence on the resultant concrete strength.

TABLE 4: VARIATION OF COMPRESSIVE STRENGTH

Treatment	Load (KN)	Compressive strength(N/mm^2)	
CSC	150	15	16.33
	160	16	
	180	18	
CSC treated with Calcium Hydroxide	260	26	28.33
	310	31	
	280	28	
CSC treated with Sodium silicate	260	26	27.66
	290	29	
	280	28	
CSC treated with Polyvinyl alcohol	205	20.5	22.66
	220	22	
	255	25.5	
Heated	265	26.5	28.83
	310	31	
	290	29	

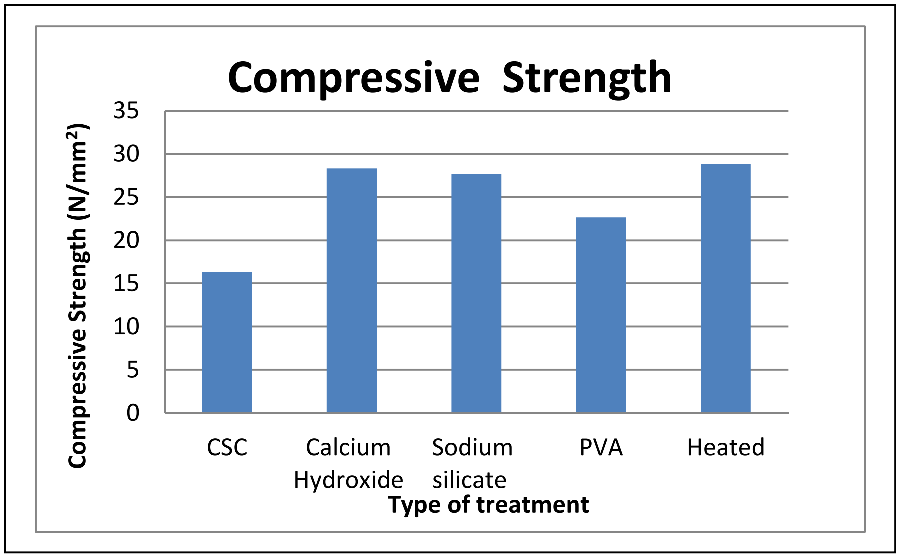

Figure 1. Variation of Compressive Strength

B. Spilt tensile strength

The spilt tensile strength of specimens is in the range of 2 N/mm^2 to 3 N/mm^2. As per ASTM C330 the split tensile strength of lightweight concrete is 2 N/mm^2. Hence the above results are proved that. Thus the table shows the variation in spilt tensile strength of coconut shell concrete. All of the treatments on CS showed improvement in split tensile strength after 28 days of CSC compared to untreated CSC. Sodium silicate has an average split tensile strength of 2.7 N/mm^2 after 28 days of curing. The variation of split tensile strength is shown in table 5 and Fig.2.

TABLE 5 : VARIATION OF SPLIT TENSILE STRENGTH

Treatment	Sample	Load (kN)	Split tensile Strength (N/mm^2)	
Ordinary	1	55	1.75	1.59
	2	45	1.43	
Calcium Hydroxide	1	50	1.69	2.04
	2	75	2.38	
Sodium silicate	1	80	2.54	2.70
	2	90	2.86	
Polyvinyl alcohol	1	75	2.38	2.30
	2	70	2.22	
Heated	1	85	2.70	2.54
	2	75	2.38	

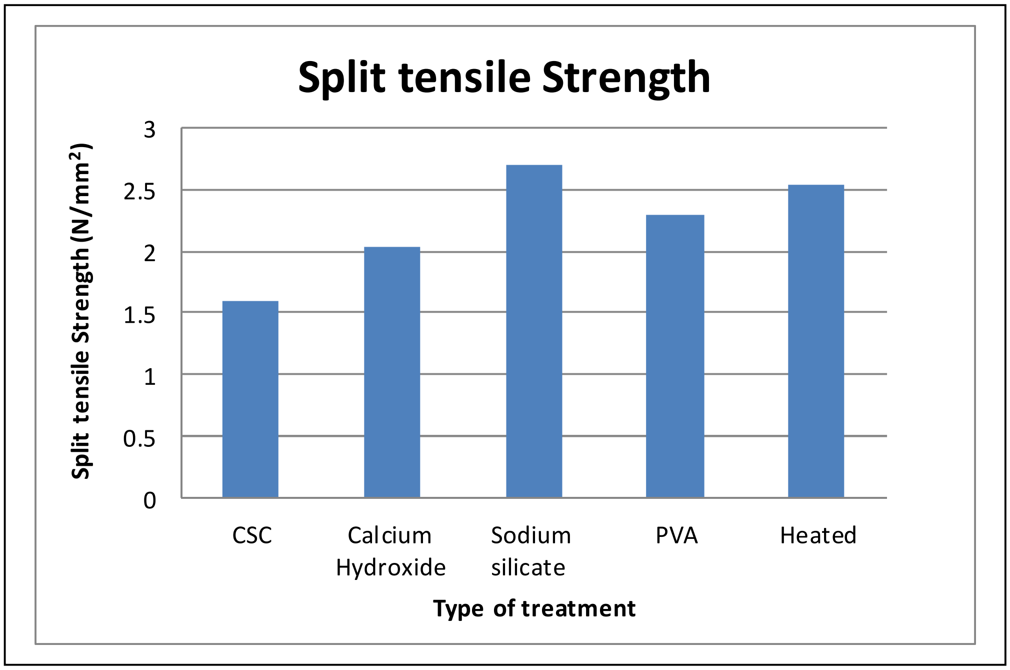

Figure 2 : Variation of Split tensile Strength

C. Flexural strength

The flexural strength of specimens is in the range of 12 to 20% of compressive strength. Hence the above results are proved that. Thus, the table shows the variation in flexural strength of coconut shell concrete. Treated coconut shell has the better flexural strength than non-treated coconut shell. Calcium Hydroxide has an average flexural strength of 3.83 N/mm^2 after 28 days of curing. The variation of flexural strength is shown in table 6 and Fig.3.

TABLE 6. VARIATION OF FLEXURAL STRENGTH

Treatment	Sample	Load (kN)	Breaking point (mm)	Flexural Strength (N/mm^2)	
Ordinary	1	41	246	3.38	3.64
	2	35	212	3.89	
Calcium Hydroxide	1	45	242	3.84	3.83
	2	43	237	3.82	
Sodium silicate	1	40	243	3.38	3.67
	2	50	251	3.96	
Polyvinyl alcohol	1	45	242	3.84	3.57
	2	40	246	3.30	
Heated	1	30	238	2.6	3.01
	2	35	226	3.42	

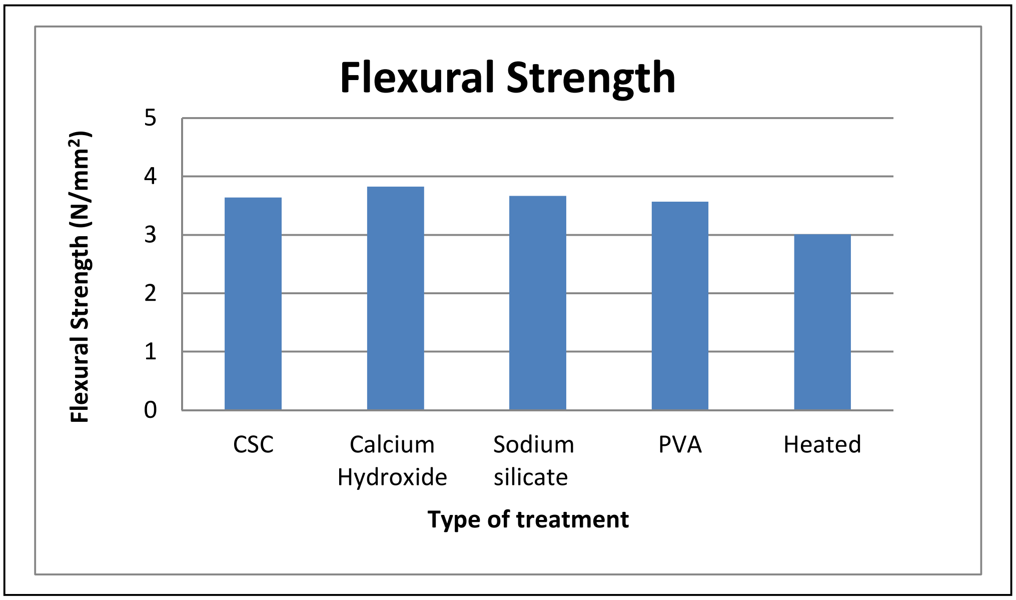

Figure 3. Variation of Flexural Strength

V. CONCLUSION

The purpose of this study was to examine the influence of different treatments on the properties of CSC and the behavior of concrete made with treated CSC aggregates. Five treatments were investigated such as Lime, Sodium silicate, Polyvinyl alcohol and heat treatment.

- Crushed Coconut shell aggregate satisfies the requirements of lightweight aggregate as per the code ASTM C330.
- The mechanical properties of CSC such as compressive strength, flexural and split tensile strength increases with treatment of chemicals in LWC. Strength of CSC satisfies the requirements of LWC as per ASTM C330
- When ordinary CSC compared with treated CSCs, Sodium silicate treated CSC, shows better mechanical properties.

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