Comparative Study of the Compressive Strength of concrete by Partially Replacing Coarse Aggregate with Coconut Shell Aggregate

Asadullah[1], Fahad Ali Shaikh[1], Asif Raza[1], Muhammad Awais[1] and Muhammad Abubakar[1]

[1]*Civil Engineering Department, Mehran UET Jamshoro, Sindh, Pakistan*

***Abstract*: This study examined the structural behavior of lightweight concrete made with crushed coconut shell aggregate (CCSA) and normal weight concrete with aim to investigate the effect of partial replacement at 5%, 10% and 15% with coarse aggregate. Coconut Shell is an Agricultural waste available in adequate quantity in the coastal regions of Sindh, Pakistan. This paper is focused on performance parameters such as workability, compressive strength and unit weight. The experimental results showed that workability decreased with increase in percentages of CCSA. The compressive strength also decreased with increasing percentage but at acceptable values. Compressive strength of plain concrete (M25) at 28 days was found to be 34.850 MPa, whereas compressive strength of 5%, 10% and 15% CCSA Concrete at 28 days were found to be 23.894, 22.765 and 21.740 MPa respectively. The density of CCSA concrete produced at above mentioned percentages lies in the range of medium lightweight concrete, which is 2100-2250kg/m^3, whereas, density of normal concrete is about 2400 kg/m^3. This shows that coconut shell aggregate can be used when there is a light structure and high strength is not needed.**

***Keywords*: Crushed Coconut Shell Aggregate (CCSA), Slump, Compressive Strength, Light weight Concrete.**

I. INTRODUCTION

Mix design is done to produce a qualitative concrete of required strength besides it, considering the most economical proportion of cement, fine aggregate and coarse aggregate of various sizes and water. Replacement in coarse aggregate with appropriate percentages converts the concrete in lightweight material because of its dead load intensity reduces, the mix design of lightweight concrete is complicated. Large amounts of many industrial wastes, domestic wastes and agricultural wastes are being recycled as a substitute of cement or aggregates in concrete [1,2]. More than 86 countries are producing with a total production of billion nuts per annual and In Pakistan, the coconut is grown widely about 10,168 tons in lower parts of Sindh like; Karachi,Thatta, Gharo and some parts of Hyderabad [3,4].The sizable quantity of this discarded CS resource is yet unutilized commercially as a building material, particularly in concrete mix. The utilization of Coconut Shell that is agricultural byproduct as a partial replacement on varying proportions of *0%, 5%,10% and 15%*in conventional concrete. The Cement, crushed stones, sand and water are contained in normal concrete, for the lightweight concrete basically change is occurred in the proportion of crushed stone and sand. Previous publications have listed mechanical properties namely compressive, flexural, splitting tensile strengths and impact resistance of CS concrete [5]. It was concluded that the behavior of CS concrete is like conventional concrete and results of mechanical properties were in the acceptable range[6,7].

A. Coconut shell aggregate

The concrete work all over the world is increasing because of it, natural resources of coarse aggregates are depleting and scarcity increasing, and waste CS can be used as an alternative of natural coarse aggregate by crushing it to the required size in mix design [8]. Numbers of 36 concrete cubes were casted for the compressive strength. Mix design M25 was made at varying proportion of CA and CS. Four ratios of CA and CS were considered (100:0), (95:05), (90:10) and (85:15) respectively.

II. MATERIALS & METHODS

A. Materials

List of materials which are used in this study are listed below with a brief detail.

*i Cemen*t

Ordinary Portland cement is manufactured by *Lucky Cement Company, Sindh, Pakistan.* Following tests were performed;

Table 1: Tests result

No.	Tests	Standards	Results
a)	Consistency Test(w/c)	(ASTM C187)	0.34
b)	Initial Setting time Final Setting time	(ASTM C403)	1 hour and 45min 7 hours and 45min
c)	Fineness of Cement (%)	(ASTM C786)	1.65

ii Fine Aggregate

The Bolari Uncrushed Aggregate was used in the concrete work that is brought from the place situated in Thatta, Sindh, Pakistan.

iii Coarse Aggregate

The Coarse Aggregate was brought from a quarry situated in Jamshoro District of Sindh, Pakistan.

iv Crushed Coconut Shell Aggregate

It was obtained from the locally available merchant of Thatta, Sindh, Pakistan.

v Water

Tap water was used in concrete production and following tests were conducted to check the properties of water.

Table 2: Properties of Tap or Portable water

No.	Different properties	Tap water
a)	Turbidity	22mg/L
b)	PH	7.8
c)	Chloride Concentration	230mg/L

B. Methods

Considering the properties of the concrete ingredient for the better performance in compressive strength, Specific gravity, Water absorption, Flakiness index, Elongation index and Fineness modulus were performed to assess the individual constituents of concrete for concrete samples. Test results are as under:

Table 3: Properties of CS aggregate

No.	Different properties	Standards	CS aggregate
a)	Specific gravity	ASTM C-127	1.3
b)	Water absorption (%)	ASTM C-127	17.75
c)	Flakiness index (%)	ASTM C-1252	43
d)	Elongation index (%)	ASTM C-1252	41
e)	Fineness modulus	ASTM C-786	7.96

C. Concrete production mix design M25

Mix design has been done according to ACI method and found the following proportion of cement, fine aggregate and coarse aggregate.

Table 4: Mix design M25 concrete

Water	Cement	FA	CA
205	372.727	769.554	1062.720
0.55	1	2.064	2.850

It has characteristic strength of *25MPa at 28 days of curing period,* Total number of concrete cube specimens were 36, casted to determine the compressive strength at 7,14 and 28 days of curing. CS aggregate was soaked 24 hours before the use [9]. The results of compressive strength of control concrete were compared with different proportion of replacement of CS at the interval of 0%, 5%,10% and 15% respectively by keeping water cement w/c ratio 0.55 constant.

Table 5: Ingredients of concrete

Ingredients of Concrete	Percentage replacement of CS with natural coarse aggregate			
	0%	5%	10%	15%
Water	205	205	205	205s
w/c ratio	0.55	0.55	0.55	0.55

Cement	372.72	372.72	372.72	372.72
Fine aggregate	769.55	769.55	769.55	769.55
Coarse aggregate	1062.72	1009.58	956.44	903.31
Crushed Coconut shell	---	53.13	106.27	159.40

D. Tests on concrete

The Compressive strength of concrete cubes having dimension (4"x4"x4"in^3) were conducted at 7, 14 and 28 days of curing, for each replacement 0%,5%,10% and 15% the number of specimens were 9 cubes. Dry weight of the specimens was taken to find the dry unit weight of concrete. Workability was measured at each replacement to know the effect of CS on concrete mix.

III. RESULTS

A. Workability of concrete

The following results of workability show that the slump decreases with increase in the percentage of coconut shell.

Table 6: Decrease in slump percentage

No.	Type	Percentage Replaced	Slump (mm)	Percentage Decrease in Slump
a)	Plain Concrete	0	69	---
b)	CS Concrete	5%	62	10.14%
c)	CS Concrete	10%	58	15.94%
d)	CS Concrete	15%	56	18.84%

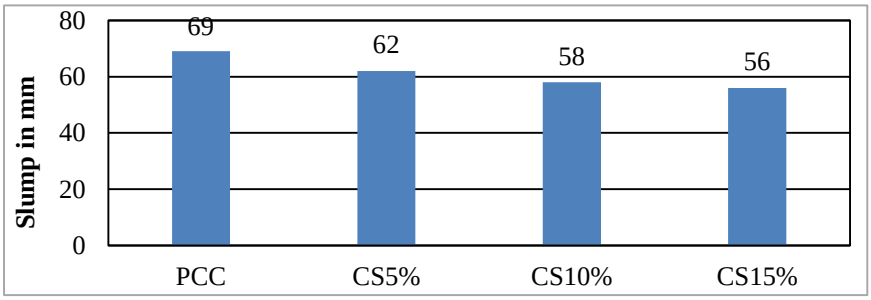

Fig. 2: Slump value vs Replacement

B. Compressive Strength

Compressive strength of concrete cube at different replacement of 0%, 5%, 10% and 15%, For each replacement 9 cubes were casted and every 3 of them were tested for 7, 14 and 28 days of curing. Following are the results of compressive strength of replaced concrete aggregate.

Table 7: Compressive Strength of Cubes

Concrete Mix	7 DAYS		14 DAYS		28 DAYS	
	Strength (MPa)	% Dec	Strength (MPa)	%Dec	Strength (MPa)	% Dec
Plain Concrete	25.04	-	31.17	-	34.850	-
5% CS	19.10	23.56	22.74	27.04	23.894	31.45
10% CS	17.12	31.52	19.16	38.53	22.765	34.66
15% CS	15.80	36.80	17.83	42.80	21.740	37.62

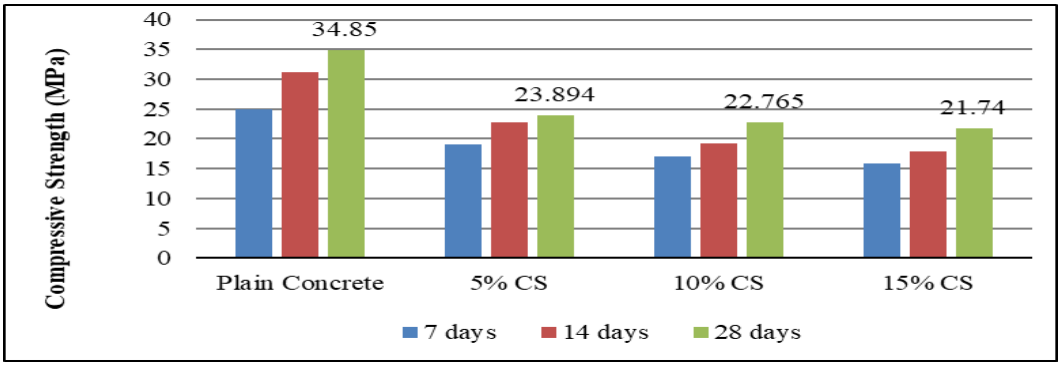

Fig. 3: Compression Strength vs. Coconut Shell (CS) Replacement

C. Dry unit weight

Dry unit weight of concrete cubes was measured when it got fully dried at sunlight, it can be defined as the ratio between weight and volume of cube by dimensions of 4"x4"x4"in^3.

Table 8: Dry Unit Weight

No.	Concrete Type	Percentage Replaced	Unit Weight (kg/m^3)	Percentage Decreased
a)	Plain	0%	2410	-
b)	CS	5%	2320	3.73%
c)	CS	10%	2270	5.80%
d)	CS	15%	2237.5	7.15%

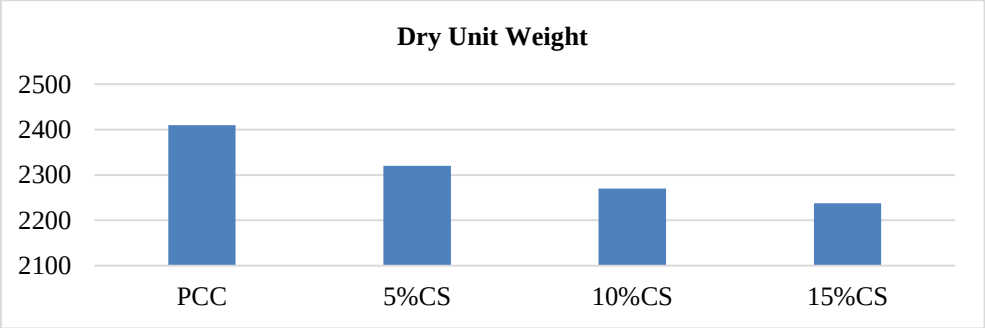

Fig. 4: Unit Weights vs. Replacements

IV. CONCLUSIONS

The data have been collected from the test of compressive strength, unit weight and workability of control concrete and partially replaced concrete with coconut shell, following conclusions can be made:

1. It was found that replacement of CS increases in concrete the compressive strength decreases.
2. It has affected the unit weight of concrete when CS increases; increase in percentage replacement decreases its unit weight.
3. Absorption characteristics show that as the days increase with absorption decreases, however CS replacement increases water absorption increases.
4. Workability of concrete decreases due to increase in CS percentage replacement.

V. RECOMMENDATIONS

Based on the experimental results, the following recommendations can be made:

1. The specimens tested for the compressive strength were dried at sunlight; it should be checked for the oven-dried Specimens at a particular temperature.
2. The results were made for *mix design M25 at constant w/c ratio 0.55*; it is suggested to use different mix design.
3. The results were made for the percentage replacement of 5%, 10% and 15% with the difference of 5%; It should be tested for the interval of 10%.
4. Continues decrease in workability, Admixtures should be used to maintain the workability.

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