Experimental Study of Natural and Artificial Waste as a Partial Replacement of Coarse Aggregate in Concrete

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Abstract— The properties of concrete using coconut shell and crushed glass as a partial replacement of coarse aggregate were investigated in an experimental study. Compressive strength, split tensile strength and flexural strength were measured and compared it with conventional concrete properties as recommended by the standards. Two concrete grades such as M20 and M30 were used. Coarse aggregate was replaced by coconut shell and crushed glass in four different percentages namely 0%, 10%, 20%, 30% and 40%. In this study 36 cubes, 36 cylinder and 36 beams were casted with constant water cement ratio of 0.45. super plasticizers conplast SP 430 DIS were used to reduce the water content in the concrete. As per the result it is concluded that coconut shell and crushed glass offers as a potential building material and simultaneously solving the environmental problem of reduction in natural and artificial waste.

Keywords: Natural and Artificial Waste, Coarse Aggregate, Concrete

I. INTRODUCTION

In the construction industry, the cost of construction increased day by day. That's why the importance of alternate construction material increased. The aggregates used for constructions such as gravel and granite drastically reduce the natural resources which is harmful to environment. So, it causes ecological imbalance. It is necessary to find the replacement of these material. In developing countries large amount of natural and artificial wastes are discharged. The use of rice husk ash, straw, expanded clay, fly ash, oil palm shell, coconut shell, waste glass, tires, sand papers, metals are some example of waste used in construction industry. These materials can be used as replacement of construction materials. There are two benefits of replacement of these materials first is it reduce the cost of construction and second is it will dispose the waste materials.

The aim of these study is that to replace the waste material as a coarse aggregate. In this study we are partially replacing the coconut shell and crushed glass as a coarse aggregate by finding out its compressive strength, split tensile strength and flexural strength. When the coconut shell dried it contains 34% cellulose, 36% lignin, 29% pentosans and 1% ash. Although the cellulose contains the lower and lignin contain higher, coconut shells are similar in chemical composition to hard wood. Glass has a bright surface, resistance to abrasion, safety and durability. Glass cannot be used as a coarse aggregate without taking into account its alkali silica reaction properties. This expansion reaction can may cause problems of cracking. In waste glass active silica is present and the Portland cement which has a high amount of alkali oxide so it is called alkali silica reaction. It can be extremely deleterious for the durability of concrete. In this study fly ash-based cement was used in the concrete to supress the alkali silica reaction. So many researchers are finding the material which will reduce the cost of construction and increase the strength of building

II. EXPERIMENTAL PROGRAM

A. Materials

1) Cement

Portland pozzolana cement (PPC) were used as the binding agent. It was conforming to IS 1489[1] 1991. Different test of cement was carried out. Fineness of cement was obtained 3%, initial and final setting time of cement is 30min and 600min and specific gravity 2.9 respectively.

2) Coarse Aggregate

Crushed coarse aggregate with two different percentage were used. 70% of aggregate which was passed through the 16 mm sieve and retain through the 12.5 mm sieve were used and 30% of aggregate which was passed through the 10 mm sieve and retain through the 6.5 mm sieve were used. Different test of coarse aggregate was carried out. Specific gravity of coarse aggregate is 2.73, water absorption 0.31%, bulk density 1650 kg/m^3 and fineness modulus of coarse aggregate is 2.73 respectively.

3) Fine Aggregate

In this study River sand conforming to zone2 as per IS 383-1970[10] was used as the fine aggregate. The specific gravity of fine aggregate is 2.6, fineness modulus is 2.57 and bulk density is 1600kg/m^3 respectively.

4) Coconut Shell

The freshly discarded coconut shells were collected from local temples. The coconut shells were crushed using hammers to a size such that it was passes through a 16mm sieve and retained on 10 mm sieve. Properties of coconut shells are shown in table number 1.

5) Crushed Glass

Crushed glass (toughened glass) collected from building, furniture etc. were used as a replacement of coarse aggregate. The crushed glass was washed to remove the dust on it and broke by using hammer such that it was passes through a 16mm sieve and retained on 10mm sieve. Properties of crushed glass are shown in the table number 1.

Properties	Coconut Shell	Crushed Glass
Maximum Size(mm)	16	16
Specific Gravity	1.16	2.4-2.8
Fineness Modulus	6.26	4.25
Bulk Density(kg/m^3)	650	1360
Shell Thickness(mm)	2-8	2-12

Table 1: Properties of Coconut Shell and Crushed Glass

6) Admixture

In this study Conplast SP 430 DIS super plasticizers were used. It improves the effectiveness of the water content of concrete mix. Superplasticizers allows the reduction in water content by 30% and more. It also allows the reduction of

water cement ratio without negatively affecting the workability of the mixture. In this study 0.02 litres of super plasticizers per 1kg of cement were used.

Sr.no.	Physical Property	Test Result
1.	Appearance	Brown liquid
2.	Specific gravity	1.20
3.	CL content	No Cl
4.	Ph	5.6
5.	Density (g/cm3)	1.8

Table 2: Properties of Plasticizer

7) Water

Concrete is made by mixing binding materials and inert materials with water. Thus, the water and its quality play an important role in evaluating the quality of concrete. Potable water which is fit for drinking was used for mixing and curing of concrete.

Fig. 1: Coconut Shells

Fig. 2: crushed glass culets

B. Coconut Shell and Crushed Glass as a Coarse Aggregate in Concrete

Crushed coconut shells were washed to remove the fibers, mud etc. the washed shell was dried in sunlight for 5 days. Before using the coconut shell in concrete they were soaked into the water for 24 hours. Replacement of coconut shell as a coarse aggregate makes the concrete lighter. Because the density of coconut shell is less as compared to conventional aggregate.

Glass cannot be used as a coarse aggregate without taking into account its alkali silica reaction properties. This expansion reaction can may cause problems of cracking. It can be extremely deleterious for the durability of concrete. This expansion reaction causes cracking of concrete and its progressive deterioration. Therefore, the alkali silica reaction test was conducted on mortar bar specimen according to ASTM C 1260. The drying shrinkage of the crushed glass mixes decreases with an increase in the crushed glass aggregate content because crushed glass aggregates are fails to absorb water and therefore prevents a lot of the release of energy during hydration reaction.

C. Mix Proportion

Coconut shell and crushed glass were used as a partial replacement of coarse aggregate. Two different concrete grades such as M20 & M30 were used. The selected mix ratio for coconut shell concrete and crushed glass was 1:1.5:3. The production of concrete mix of M30 grade of concrete was done by using IS 10262-2009 having mix ratio 1:2.22:3.63. coconut shell aggregate and crushed glass aggregate was produced by adding coconut shell and crushed glass in different percentage (0%, 10%, 20%, 30%, 40%). A total of 36 cubes, 36 cylinders and 36 beams were casted for compressive strength test, split tensile strength test and flexural strength test. Mixing was done manually with water cement ratio 0.45. compaction was done by using tamping rod and table vibrator. Concrete cubes, cylinder and beam were left for 24 hours to set. After 24 hours cubes, cylinders and beams were demoulded and placed in curing tank. It was being cured in potable water at room temperature for a period of 56 days. After 56 days, cubes, cylinder and beam were removed from curing tank and were ready to be tested for compression test, split tensile strength and flexural strength test.

III. RESULTS AND DISCUSSION

A. Compressive Strength Test

There is no requirement to argue that compressive strength is the most important property of concrete. Compressive strength is a lifeline property used in concrete technology. Compressive strength depends on the particle strength of aggregate, cement content, strength of matrix and water cement ratio. The compressive strength test on concrete were conducted on universal testing machine. 56 days of test were conducted by using Cubes having size of 150*150*150mm^3. average compressive strength of two cubes was taken.

Sr.no.	% of replacement	Average Compressive strength (N/mm²)			
		Coconut shell		Crushed glass	
		M20	M30	M20	M30
1	0%	27.610	36.630	27.610	36.630
2	10%	25.677	34.902	27.530	36.325
3	20%	25.925	35.273	28.615	37.975
4	30%	19.879	25.991	25.430	34.360
5	40%	17.946	24.134	22.515	32.865

Table 3: Compressive Strength

B. Split Tensile Strength

Split tensile strength test on concrete cylinder is a method to find the tensile strength of concrete. The split tensile strength is one of the basic and important property. The concrete is not usually expected to resist the direct tension because of its low tensile strength and also brittle nature. Split tensile test were conducted for concrete cylinder with dimension of 300 mm of length and 150 mm of diameter. Split tensile test on

cylinder was also carried out at the age 56 days by placing the cylinder horizontally on a universal testing machine.

Sr. no.	% of replacement	Average Split tensile strength(N/mm²)			
		Coconut shell		Crushed glass	
		M20	M30	M20	M30
1	0%	2.105	3.160	2.105	3.160
2	10%	1.745	2.622	2.080	2.236
3	20%	1.749	2.651	2.440	2.735
4	30%	1.604	2.370	1.585	1.906
5	40%	1.454	2.126	1.385	1.557

Table 4: Split Tensile Strength

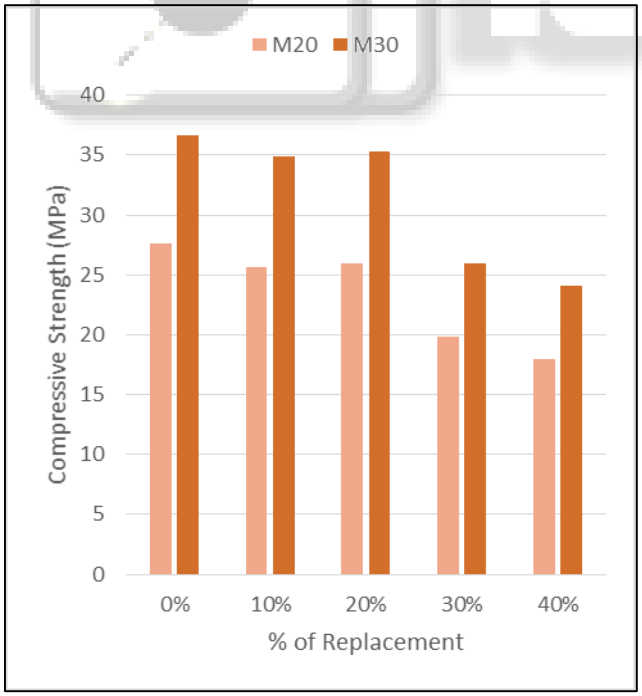
C. Flexural Strength Test

A flexural strength test was performed at 56 days after casting. A centre line was marked at the top of the 100*100*500mm prism specimens using a white chalk perpendicular to its length. Universal testing machine were used for the flexural strength. Length and depth of the crack of each specimen was measured.

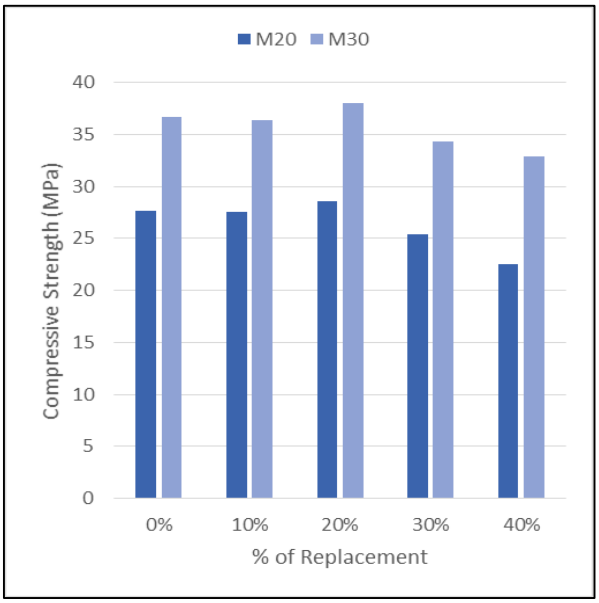
Sr. no.	% Of replacement	Average Flexural Strength (MPa)			
		Coconut shell		Crushed glass	
		M20	M30	M20	M30
1	0%	3.790	4.425	3.790	4.425
2	10%	3.145	3.721	4.605	5.104
3	20%	3.164	3.730	4.887	5.861
4	30%	2.842	3.094	3.922	4.447
5	40%	2.615	2.864	3.070	3.512

Table 5: Flexural Strength

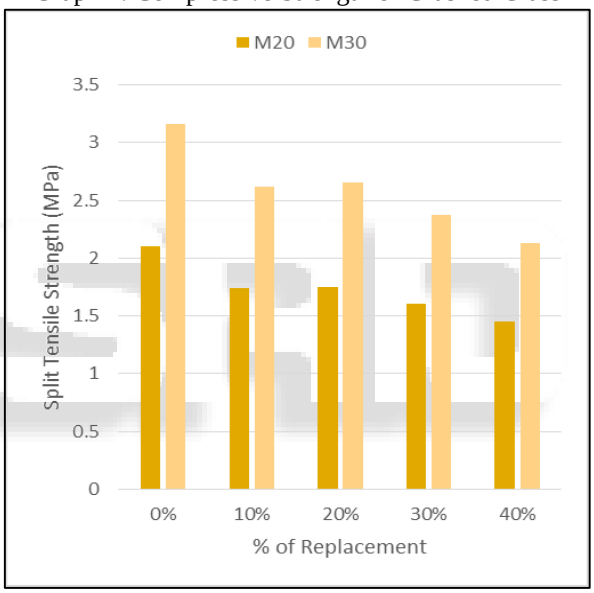
D. Graphs



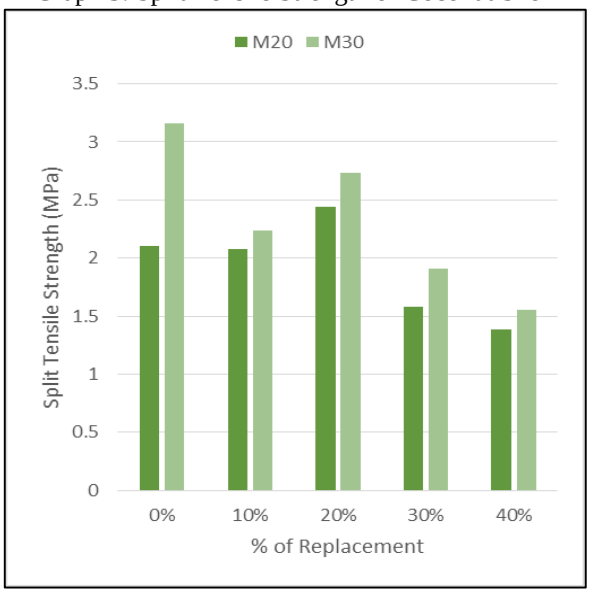
Graph 1: Compressive Strength of Coconut Shell



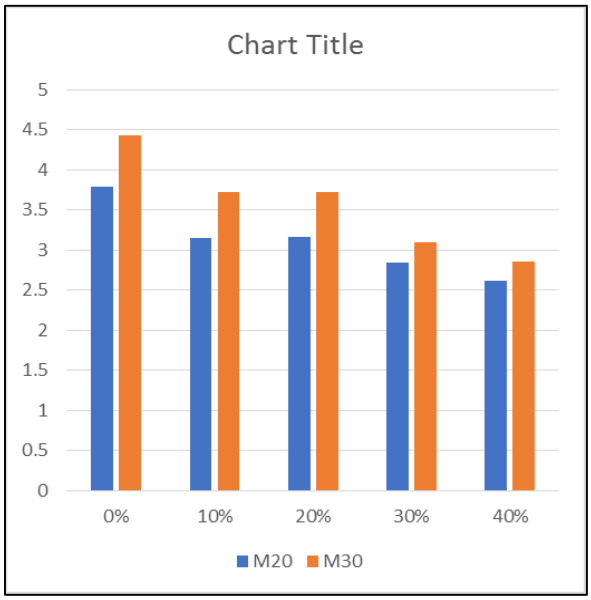
Graph 2: Compressive Strength of Crushed Glass



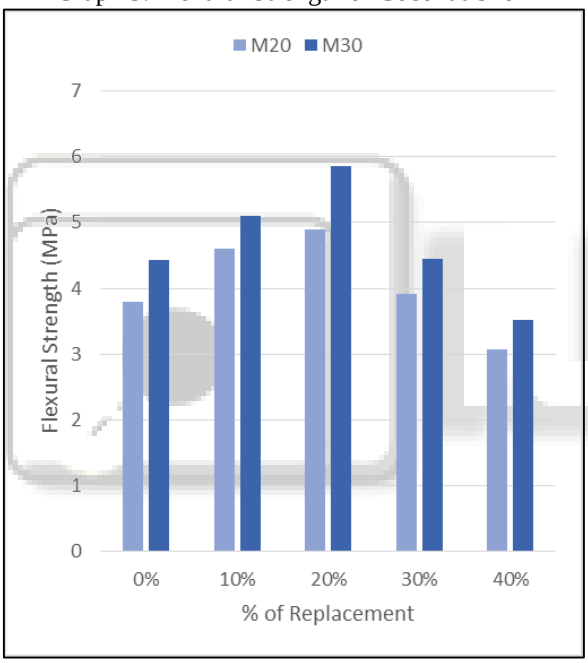
Graph 3: Split Tensile Strength of Coconut Shell



Graph 4: Split Tensile Strength of Crushed Glass



Graph 5: Flexural Strength of Coconut Shell



Graph 6: Flexural Strength of Crushed Glass

IV. CONCLUSION

1) Large amount production of non-decaying waste such as coconut shell and crushed glass leads to disposal problem. The properties of coconut shells and crushed glass makes it suitable ingredients for concrete production and also its use for concrete may help in its disposal.
2) The result shows that the compressive, split tensile and flexural strength of M20 and M30 grade of coconut shell concrete is nearly same for 10% and 20% of replacement and it is decreased for 30% and 40% of replacement.
3) The compressive, split tensile and flexural strength of crushed glass concrete is increased for the replacement of 20% and decreased for 10%, 20% and 30% of replacement
4) The alkali-silica expansion of all the specimen significantly decreased by the use of fly ash-based cement.
5) The drying shrinkage of the crushed glass mixes decreased with an increase in the crushed glass aggregate content because crushed glass aggregates are fails to absorb water and therefore prevents a lot of the release of energy during the hydration reaction
6) Coconut shell concrete can be used in places where coconut is abundant and may also be used where the conventional aggregates are costly.
7) It is concluded that 10% and 20% replacement of coconut shell aggregate and crushed glass aggregate allowable in normal construction work and 30% and 40% replacement of aggregate is cannot be useful for any construction work. It is mainly used for small house, watchman cabin, compound wall construction etc.

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