Cost and Strength Analysis on Partial Replacement of Coconut Shell in Concrete as Coarse Aggregate

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ABSTRACT

Aggregates provide volume at low cost, comprising 66 percent to 78 percent of the concrete. With increasing concern over the excessive exploitation of natural and quality aggregates, the aggregate produced from industrial wastes and agriculture wastes being viable new source for building material. This study was carried out to determine the possibilities of using coconut shell as aggregate in concrete. Utilizing coconut shell as aggregate in concrete production not only solves the problem of disposing this solid waste but also helps conserve natural resources. In this paper, the physical properties of crushed coconut shell aggregate were presented. The fresh concrete properties such as density and slump and 28-day compressive strength of a lightweight concrete made with coconut shell as coarse aggregate also presented. The findings indicated that water absorption of the coconut shell aggregate was high about 24 % but the crushing value and impact value was comparable to that of other lightweight aggregates. The average fresh concrete density and 28-day cube compressive strength of the concrete using coconut shell aggregate were 1975 kg/m^3 and 19.1 N/mm^2 respectively. It is concluded that crushed coconut shells are suitable when it is used as substitute for conventional aggregates in lightweight concrete production.

Conventional coarse aggregate namely gravel and fine aggregate is sand in concrete will be used as control. While natural material is coconut shell as course aggregate will be investigate to replace the aggregate in concrete. In this studies, three different concrete mixes with different the combination of natural material content namely 0%, 10%, 20%, 30%.Three sample specimen will be prepared for each concrete mixes. The parameters will be tested are flexural strength, compressive strength, tensile strength. The effect of using different length of natural material aggregate will also investigate. The effect of aggregate content to workability will also examine. The expected outcomes of the study, is the combination of coconut shell has potential as lightweight aggregate in concrete. Also, using the combination of coconut shell as aggregate in concrete can reduce the material cost in construction because of the low cost and abundant agricultural waste.

This report presents an investigation on the behavior of concrete specimens produced from coconut shell (CS) aggregates. Utilizing CS in concrete production not only solves the problem of disposing this solid waste but also helps conserve natural resources. A total of 54 specimens with varying percentage of replacement were casted and tested. Data presented include the compressive strength, tensile strength and flexural strength of coconut shell concrete and comparison with conventional concrete. The investigation revealed that the behavior of CS concrete beams was comparable to that of other lightweight concretes and the experimental results compare reasonably well with the current Codes of Practice.

The attempt is made to prove in all respect the serviceability, durability and economy in the experimental study is structurally satisfying and can be implemented in rural areas by considering all technical aspect. The aim behind this is to use low cost material like coconut shell and thus taking close to the concept of low cost housing. All precaution is taken to maintain serviceability, strength and durability of the members. The method adopted is relevant to real social needs that are accessible, affordable and empowering impact as saving of material is achieved ultimately caring for natural resources. Thus it will be helpful for civil engineers and society to adopt this concept to fulfill the basic need of human that is housing.

Keyword:- *Coconut shell, Partial Replacement, Compressive Strength, Control concrete, Strength analysis, Cost analysis.*

INTRODUCTION

Concrete is the widely used number one structural material in the world today. The demand to make this material lighter has been the subject of study that has challenged scientists and engineers alike. The challenge in making a lightweight concrete is decreasing the density while maintaining strength and without adversely affecting cost.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. 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. This will have the double advantage of reduction in the cost of construction material and also as a means of disposal of wastes. It is at this time the above approach is logical, worthy and attributable. Presently in India, about 960 million tons of solid wastes are being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this 350 million tons are organic wastes from agricultural sources; 290 million tons 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.The use of coconut shell as coarse aggregate in concrete has never been a usual practice among the average citizens, particularly in areas where light weight concrete is required for non-load bearing walls, non-structural floors, and strip footings. Although coarse aggregate usually take about 50% of the overall self weight of concrete, thereby determining the quality of reinforcement required to resist forces acting on the structural member. Little or no effort has been made to verify the strength and properties of the concrete made with these materials and the economic benefits derivable.

LITERATURE REVIEW

Ohler (1999), Olanipekun (2006): Coconuts show a wide diversity in size, weight, shape and color, depending on genetic variety and maturity of the nut at harvest (Ohler, 1999) 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 characteristics of concrete produced using crushed, granular coconut and Palm kernel 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.

Asokan Pappu: Presently in India, about 960 million tonnes of solid waste is 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 and 4.5 million tonnes are hazardous in nature. Advances in solid waste management resulted in alternative construction materials as a substitute to traditional materials like bricks, blocks, tiles, aggregates, ceramics, cement, lime, soil, timber and paint. To safeguard the environment, efforts are being made for recycling different wastes and utilise them in value added applications. In this paper, present status on generation and utilization of both non-hazardous and hazardous solid wastes in India, their recycling potentials and environmental implication are reported and discussed in details.

K. Gunasekaran, P.S.Kumar **:** The high cost of conventional building material is a major factor affecting housing delivery in India. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes are can be used as potential material or replacement material in the construction industry. This will have double advantage of reduction of in the cost of construction material and also as a means of disposal of wastes. It is at this time the above approach is logical, worthy and attributable. One such alternative is coconut shell, 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 show as that, India is producing nearly 27% of total world production and the annual production of coconut is reported to be more than 12 million tonnes. Presently the coconut shell waste being used in making mosquito coils, essence sticks, organic fertilizers, etc. Only few studies have been reported on use of coconut shells as aggregate in concrete.

In a research conducted on the use of stone dust as a partial replacement of stone dust in block concluded that the laboratory analysis indicated that there is an improvement in average compressive strength of the blocks with an increasing percentage stabilization of stone dust; same applies also to the increase in age of curing. An

optimum percentage stabilization of 20% was obtained A – 5 laterite soil with 0.15 w/s ratio which gave the highest strength of 1.28 N/mm2, there was also a significant improvement in the properties of the soil with percentage increase in stone dust stabilization, thus concluded that the strength and durability of the blocks are generally improved by stabilization of stone dust.

It is observed from literature survey that the use of coconut shell is more advantageous as they enhance the mechanical properties of concrete. Presently, coconut shells are available at a low price in most of the tropical countries. Also the concrete obtained using coconut shell aggregate satisfies the minimum requirement of light weight concrete. Hence it is possible to make use of lightweight concrete making use of coconut shells as an aggregate in concrete.

METHODOLOGY

- Material Properties
- Mix design of conventional concrete and concrete with coconut shell as partial replacement for coarse aggregate. The replacement is by weight of coarse aggregate used in conventional concrete in range of 10%, 20% and 30%.
- Casting of beams- 3 specimens as control beam and 3 specimens for each replacement.
- Specimen cross section- 230 x 300mm
- Specimen length- 3m
- Testing- 4 point loading.

MIX DESIGN

1. Conventional Concrete

On basis of	Water	Cement	Fine Aggregate	Coarse Aggregate
Mass	191.6 lit	383 kg	546 kg	1187 kg
Ratio	0.5	1.0	1.42	3.09
Per Bag	24.35 lit	50 kg	72.42 kg	153.73 kg

2. 10% replacement

On basis of	Water	Cement	Fine Aggregate	Coarse Aggregate	Coconut shell
Mass	191.6 lit	383 kg	546 kg	937.08 kg	118.7 kg
Ratio	0.5	1.0	1.42	2.44	0.31
Per Bag	24.35 lit	50 kg	72.42 kg	122.33 kg	15.49 kg

3. 20% replacement

On basis of	Water	Cement	Fine Aggregate	Coarse Aggregate	Coconut shell
Mass	191.6 lit	383 kg	546 kg	756.24 kg	237.4 kg
Ratio	0.5	1.0	1.42	1.97	0.61
Per Bag	24.35 lit	50 kg	72.42 kg	98.72 kg	30.99 kg

4. 30% replacement

On basis of	Water	Cement	Fine Aggregate	Coarse Aggregate	Coconut shell
Mass	191.6 lit	383 kg	546 kg	572.112 kg	356.1 kg
Ratio	0.5	1.0	1.42	1.49	0.93
Per Bag	24.35 lit	50 kg	72.42 kg	74.68 kg	46.48 kg

TESTING

The specimens are tested for flexure under a four point test setup using universal testing machine of capacity 1000KN. The loads were placed at a distance of 1m from the supports. The load was increased until the failure took place. The load was measured using the digital display of UTM and Deflection was also measured. Load vs. Deflection graph was plotted.

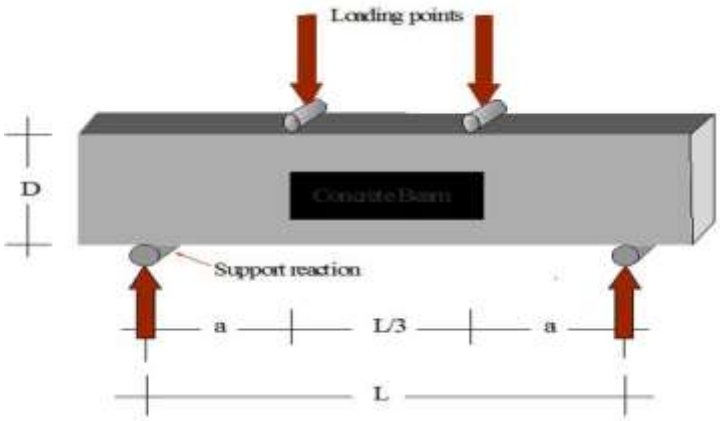

Fig 1- Experimental Setup

Fig 2- Actual Experimental work.

COST ANALYSIS.

For 10% replacement:

1) Coarse aggregate required for Control Beam = 1187 kg / m^3
2) Coarse aggregate required for 10% replacement = 937.08 kg / m^3
3) Coarse aggregate saved = 249.92 kg / m^3

Sample Calculations:

Actual Coarse Aggregate used = 1187 kg
Specific Gravity = G = $\frac{\rho_s}{\rho_w}$
Therefore, 2.75 = $\frac{\rho_s}{1000}$
ρs = 2750 kg/m^3

Therefore, 1 m^3 carries 2750 kg of aggregate
1187 kg = 0.43 m^3
= 0.43 * 0.353 = 0.152 brass

Similarly, Coarse aggregate required for 10% replacement = 937.08 kg / m^3

937.08 kg = 0.339 m^3
= 0.339 * 0.353 = 0.119 brass
Therefore, Coarse Aggregate saved = 0.152 - 0.119 = 0.033 brass

Rate of 1 brass of Coarse Aggregate = Rs. 2200/-
Therefore, Cost of Coarse Aggregate saved = 0.033 * 2200 = Rs. 72.6/-
Cost of crushing 500 kg of Coconut Shell to required size = Rs. 150/-
Therefore for 118.7 kg cost of crushing = Rs. 35.60/-
Therefore Net Saving = 72.6 – 35.60 = 37 Rs./m^3 of concrete
Cost Saved in Percentage = (Net Saving / Cost of aggregate) * 100
= (37/ 0.152*2200) * 100
Cost Saved in Percentage = 11.06 %

Specimen	Cost Saved in Percentage
Control Beam	0%
10% replacement	11.06%
20% replacement	26.19%
30% replacement	41.32%

RESULT AND DISCUSSION

The beams on testing under flexure were loaded up to their failure and then the load vs. deflection graph was plotted. The results are then plotted on the graph. The graphs are as shown below.

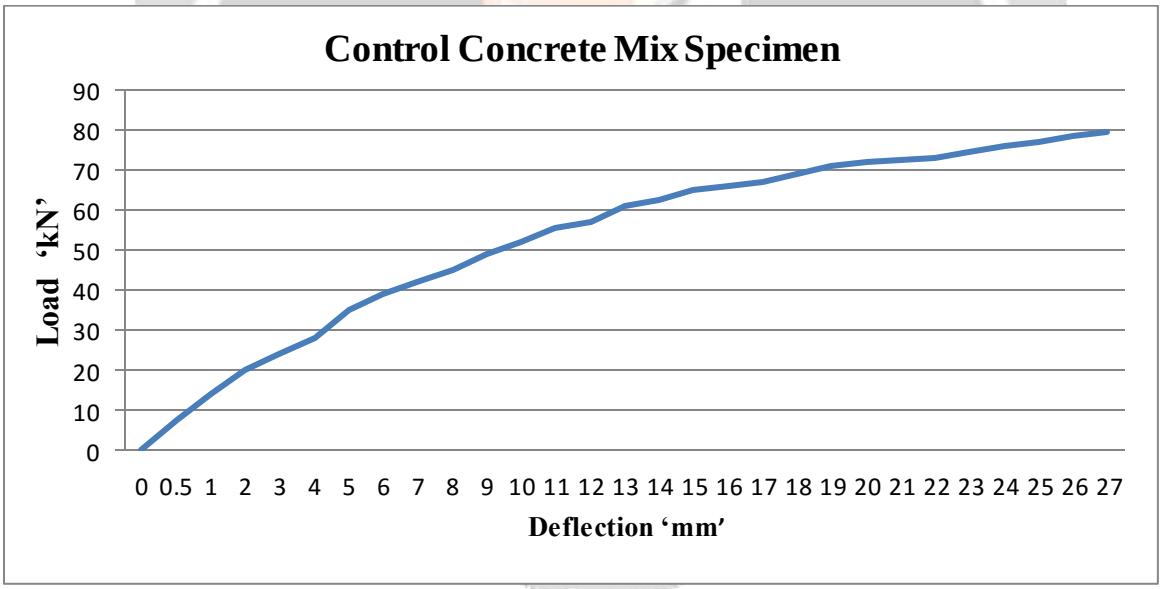

Fig 3- Graph Showing Load vs. Deflection for control beam

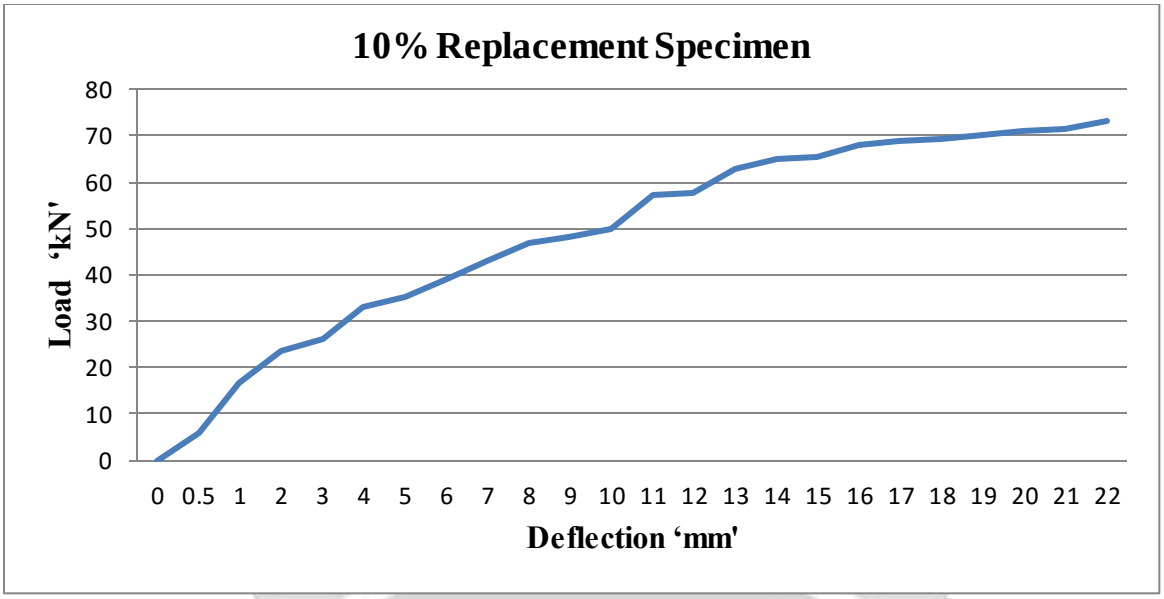

Fig 4- Graph Showing Load vs. Deflection for beam with 10% replacement.

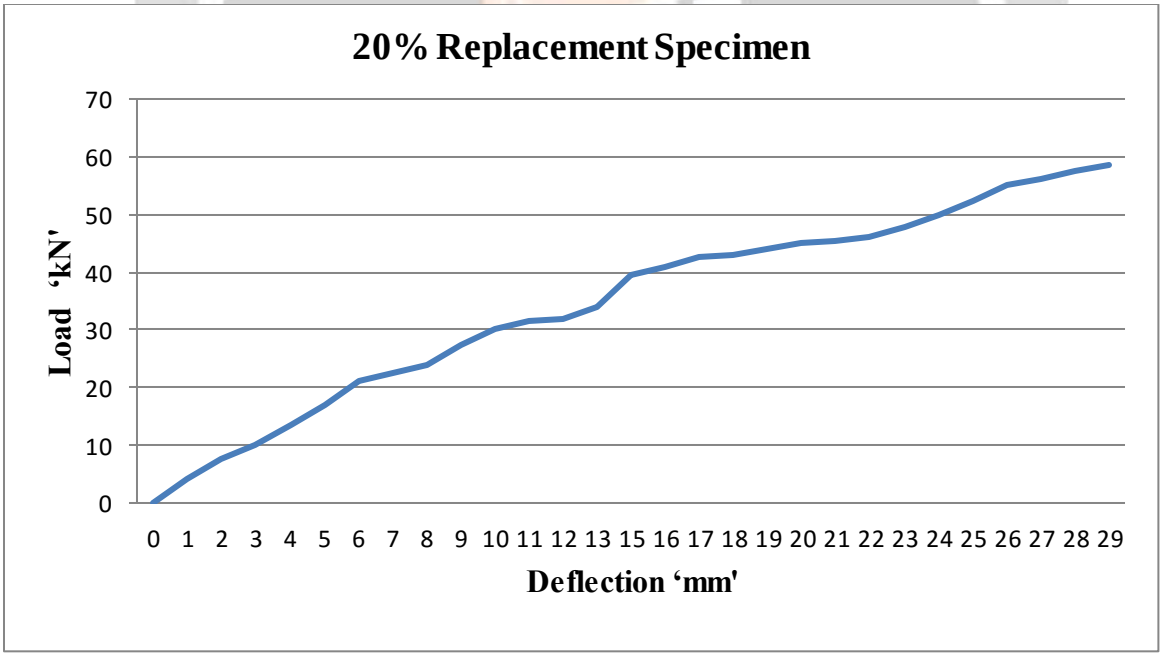

Fig 5 - Graph Showing Load vs. Deflection for beam with 20% replacement.

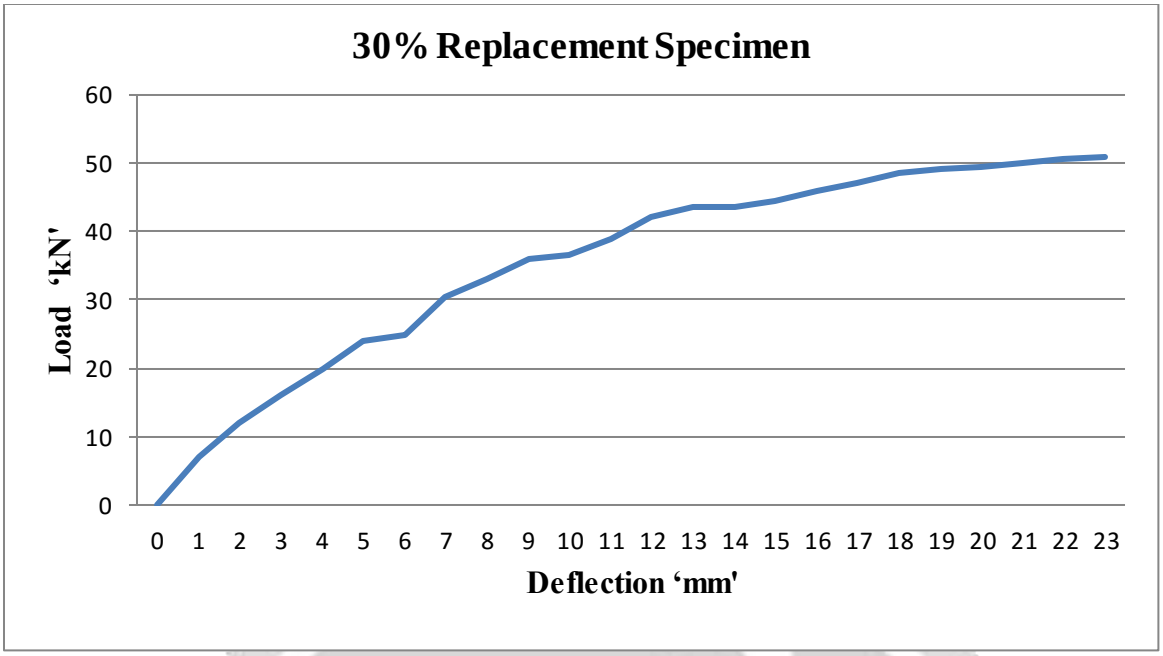

Fig 6 - Graph Showing Load vs. Deflection for beam with 30% replacement.

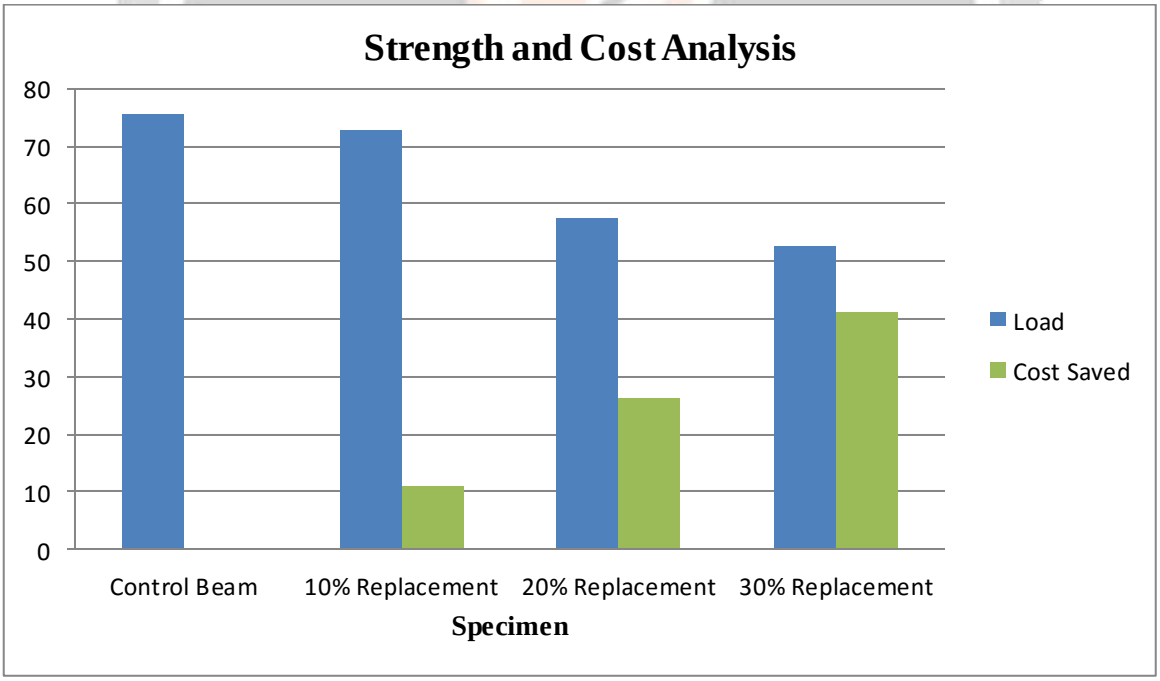

Fig 7- Load and Cost Comparison

1. Beams were casted with 10%, 20% and 30% replacement with a Control Beam as a Bench Mark. Three beams were casted of each specimen. The average load taken by each specimen was 75.66 kN, 72.66 kN, 57.5 kN and 52.5 kN for control, 10%, 20% and 30% replacement each.

2. The Cost saved in 10%, 20% and 30% replacement is 11.06 %, 26.19% and 41.32% resp.

3. The deflection occurred in control, 10%, 20% and 30% replacement beams was 26.67mm, 21.33mm, 28.67mm and 24mm each.

CONCLUSION

Based on the tests following conclusions were made:
1. The use of crushed coconut shell has saved a good quantity of coarse aggregate by replacing it by weight. The 10% replacement shows a good behaviors as the strength of concrete is not much lower than the control concrete and the cost saving is of 11.06% which is promising.

2. The other two mix i.e. the 20% replacement and 30% replacement is also a good cost saving option but it drastically reduces the strength of concrete. This concrete can be used in PCC saving a lot of construction cost.

3. Beams constructed with coconut shell showed good ductility behavior. All beams exhibited considerable amount of deflection, which provided ample warning to the imminence of failure.

4. The specific gravity under SSD condition of coconut shell and crushed granite was found to be 1.05 and 2.82 respectively.

5. The aggregate impact value (AIV) and aggregate crushing value (ACV) of coconut shell aggregates are much lower compared to crushed stone aggregate which indicates that this aggregates have good absorbance to shock.

6. The fresh concrete density and hardened concrete density after 28 days (under SSD condition) using coconut shell was found to be in the range of 1975-2110 kg/m3 and 1880-1930 kg/m3.

7. With CS percentage increase the 7 day strength gain also increased with corresponding 28 day curing strength. However, the overall strength decreased with CS replacement when compared to control concrete.

8. Using coconut shell as aggregate in concrete can reduce the material cost in construction because of the low cost and abundant agricultural waste.

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