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The Experimental Investigation On Performance Of Waste Coconut Shell As Partial Replacement Of Natural Coarse Aggregate In Concrete

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Abstract— A large amount of waste coconut shell is generated in India from temples and industries of coconut product and its disposal need to be addressed. Researchers have proposed to utilize it as ingredient of concrete. This experimental investigation was aimed to quantify the effects of replacing partially the conventional coarse aggregate by coconut shell to produce concrete. Concrete has become basic material in day to day life of humans. Low tensile strength and brittle nature are the basic defects in concrete. The present investigation is mainly focused on the effect of mechanical properties of concrete with coconut shell replacing coarse aggregate. In this investigation concrete having compressive strength M60 is used. Coconut shell is replaced in concrete from 0 to 40 % by weight.

1.0 INTRODUCTION

Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way. With advent of high-rise buildings and pre-stressed concrete, use of higher grades of concrete is becoming more common. Even the revised IS 456–2000 advocates use of higher grade of concrete for more severe conditions of exposure, for durability considerations. Since structural concrete is used extensively in the construction of various kinds of buildings, consumed at a rate of approximately one ton for every living human being and aggregate contributes significantly to the structural performance of concrete, the high demand for concrete using normal weight aggregates such as gravel and granite drastically reduces the natural stone resources and this damages the environment thereby causing ecological imbalance. Therefore, there is a need to explore and to find suitable replacement material to substitute the natural stone aggregate. Some of the lightweight aggregates used for lightweight concrete production are pumice, perlite, expanded clay or vermiculite, coal slag, sintered fly ash, rice husk, straw, sawdust, cork granules, wheat husk, no fines, foamed type concrete, oil palm shell, and coconut shell.

Coconut shell concrete (CSC) is one of the special concrete under lightweight concrete which is recently developed in the concrete world. Though the basic properties of CSC, mechanical properties of CSC, bond properties of CSC and long term performance of CSC are in acceptable range, for structural applications, knowledge of the behaviour of structures is essential for design so that an economical structure can be obtained consistent with safety and serviceability. Since, behaviours of reinforced lightweight CSC beam under flexure and shear had been already studied and published in the earlier publication, this study investigated and presented the experimental

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evaluation of reinforced lightweight CSC beam under torsion.

In the construction industry, due to the depletion of natural resources and increasing cost of construction materials, using alternative construction materials is gaining importance. Using waste materials in concrete has become a necessity to provide a sustainable environment. Light weight concrete using waste is preferred due to its low density, good acoustic and thermal insulation. Coconut shell (CS) is an agricultural waste which is available in abundant in the tropical regions like Asia, America and Africa is being used successfully as low strength giving light weight aggregate.

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2.0 LITERATURE REVIEW

A. Jaya Prithika has performed an experimental investigation on mechanical properties and fracture toughness of Eco-friendly concrete produced, using coconut shell as coarse aggregate, blast furnace slag as a partial replacement for cement and manufactured sand as fine aggregate. Three mixes were selected and three types of curing like water curing, steam curing and conceal curing of concrete were adopted. Mechanical properties like compressive strength, flexural strength, static modulus of elasticity, Poisson's ratio and fracture toughness were investigated. The results proved that the mechanical properties and fracture toughness of coconut shell concrete are on par with other light weight concrete. **Gunasekaran** investigated and evaluates the results of coconut shell concrete beams subjected to torsion and compared with conventional concrete beams. Eight beams, four with coconut shell concrete and four with conventional concrete were fabricated and tested. Study includes the general cracking characteristics, pre cracking behaviour and analysis, post cracking behaviour and analysis, minimum torsional reinforcement, torsional reinforcement, ductility, crack width and stiffness. It was observed that the torsional behaviour of coconut shell concrete is comparable to that of conventional concrete. Compared to conventional concrete specimens, coconut shell concrete specimens have more ductility. Crack width at initial cracking torque for both conventional and coconut shell concrete with corresponding reinforcement ratios is almost similar. **Laksmipathy** investigated the properties of concrete using coconut shell as coarse aggregate in concrete. Compressive, flexural, splitting tensile strengths, impact resistance and bond strength were measured and compared with the theoretical values as recommended by the standards. For the selected mix, two different water–cement ratios have been considered to study the effect on the flexural and splitting tensile strengths and impact resistance of coconut shell concrete. The results showed that the

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experimental bond strength of coconut shell concrete is much higher than the bond strength as estimated by BS 8110 and IS 456:2000 for the mix selected. **Aruna Devi** investigated the Coconut Shell ash is used for the partial replacement of cement. Further, use of coconut shell ash as a value added material as in the case of binary blended cement concrete, reduces the consumption of cement. Reduction of cement usage will reduce the production of cement which in turn cut the CO_2 emissions. The time has come for the review of progress made in the field of development of binary blended cement concrete.

A. 3.0 MATERIALS

1) 3.1 Cement:

Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being effected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS: 4032-1988.

2) 3.2 FINE AGGREGATES

River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963. The sand was surface dried before use.

3) 3.3 Coarse Aggregates:

Crushed aggregates of less than 10mm size produced from local crushing plants were used. The aggregate exclusively passing through 10mm sieve size and retained on 6.5mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963.

4) 3.4 Water:

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers.

. 4. EXPERIMENTAL PROCEDURE

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The investigation was aimed at studying the effect of replacement of coarse aggregate with coconut shell on compressive strength, split tensile strength, flexural strength of M60 grade of concrete. Mix proportioning of concrete will be done based on IS 10262:2009. To study on strength of concrete the specimens will be tested for 28 days of curing. Standard cubes (150 x 150 x 150 mm), cylinders (150 mm diameter, 300 mm height), prisms (100 x 100 x 500 mm) will be cast to investigate the behaviour on mechanical properties. The replacement of coconut shell will be varied from 0 to 40% with an increment of 10% i.e 0, 10%, 20%, 30% and 40% replacement to coarse aggregate.

Table 1 - Mix Proportions of mixes M60 grade in kg/m^3

Cement	Fine Aggregate	Coarse Aggregate	Water
386	589	836	165

5. RESULTS AND DISCUSSION

5.1 Workability:

Workability test is performed on the fresh concrete by slump cone and compaction factor test. Slump cone test and compaction factor were conducted as per Indian standards as explained in previous chapter. The results of slump cone and compaction factor test for M60 grade of concrete with coconut shell replacement to natural coarse aggregate is shown in table 2.

Table 2: Effect of coconut on workability of M60 concrete

Coconut Shell	Slump	Compaction

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Replacement (%)	Cone (mm)	Factor
0	85	0.92
10	76	0.90
20	68	0.88
30	61	0.87
40	55	0.85

Figure 3: Variation slump cone with coconut shell replacement

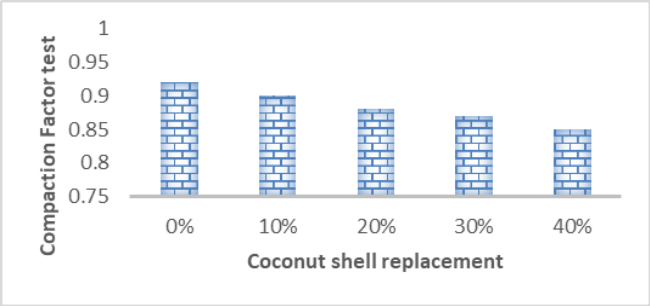

Figure 4: Variation compaction factor with coconut shell replacement

5.2 Mechanical Properties:

Fresh properties of concrete like workability has performed using slump test. Slump is decreasing as the percentage of coconut shell increases. Compression testing machine of 2000 kN used for the compression test and 600 kN UTM has been used for the split tensile test and flexural test. The results of compressive strength, split tensile strength and flexural strength are given in the Table 3 and 5 respectively

Table 3: Effect of coconut shell on mechanical properties of M60 concrete

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Coconut Shell Replacement (%)	Compressive strength (MPa)	Split tensile strength (MPa)	Flexural Strength (MPa)
0	68.5	3.81	5.96
10	66.8	3.72	5.88
20	65.7	3.64	5.84
30	60.2	3.48	5.59
40	55.4	3.33	5.36

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Figure 5: Variation compressive strength with coconut shell replacement

Figure 6: Variation split tensile strength with coconut shell replacement

Figure 6: Variation flexural strength with coconut shell replacement

Table 3: Percentage decrease in mechanical properties of M60 due to coconut shell

Coconut Shell Replacement (%)	Compressive strength (MPa)	Split tensile strength (MPa)	Flexural Strength (MPa)
10	2.54	2.52	1.26
20	4.26	4.77	2.11
30	13.79	9.59	6.67
40	23.65	14.53	11.20

6.0 CONCLUSIONS

1. The workability of concrete is effected with the coconut shell replacement to natural coarse aggregate.
2. The decrease in slump and compaction factor is observed with the increase in replacement levels of coconut shell.
3. Coconut shell replacement into concrete has effected the mechanical properties of concrete.
4. Upto 20% replacement levels of coconut shell is effect in decrease in mechanical properties is limited to 5% only.
5. Similarly, the adverse decrease in mechanical properties is observed with the increase in replacement of coconut shell to 30% and 40%.
6. It is concluded that coconut shell can be used as replacement to natural coarse aggregate to produce efficient light weight concrete.

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7. Finally, optimum replacement of coconut shell was observed to be 10% without much loss in fresh and hardened properties.

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