M30 GRADE CONCRETE MIX USING SOILD WASTE AGGREGATES (COCONUT SHELL CONCRETE)

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Abstract : *The rising cost of construction is a growing concern, primarily driven by the increasing prices of building materials. Concrete, a key component in construction, consists mainly of coarse aggregate, fine aggregate, and cement. Construction companies heavily rely on these materials for concrete production. Recent research has focused on reducing construction costs while improving concrete strength. Various waste materials have been explored as partial replacements for aggregates based on their properties. Among them, fly ash, rice husk ash, and blast furnace slag have been identified as effective substitutes for fine aggregate in concrete. Agriculture plays a crucial role in India's economy, with coconut production being a significant sector. However, coconut shells, a byproduct of this industry, pose disposal challenges and contribute to environmental pollution if not managed properly. Using coconut shells as a partial replacement for coarse aggregate in concrete presents a sustainable and eco-friendly solution. This study investigates the effects of replacing coarse aggregate with coconut shells in varying proportions (0%, 10%,15%, and 20%) for M30 grade concrete. Four different concrete mixes were prepared for each grade, with three specimens cast per mix. The primary goal is to assess the feasibility of utilizing agricultural waste like coconut shells, which are more cost-effective than traditional coarse aggregates, to develop affordable construction solutions. A 28-day short-term analysis was conducted to evaluate the properties of coconut shell aggregate concrete through tests such as compressive strength and workability. The results were compared with those of conventional concrete. To ensure durability, serviceability, and structural integrity, all necessary precautions were taken.*

Key Words: Coconut Shell, Light Weight Concrete, Compressive Strength, Solid Waste

I. INTRODUCTION

Concrete is one of the most widely used construction materials due to its strength, durability, and versatility. It is composed of cement, water, sand, and gravel or crushed stone. Through hydration, these materials harden over time, making concrete essential for structures like buildings, bridges, roads, and tunnels. Its adaptability allows for various types, such as reinforced, precast, and high-performance concrete, to meet structural and environmental needs. Concrete is also used in infrastructure projects, offshore platforms, and harbour structures. Floating concrete platforms are being explored for airports and power plants to reduce land congestion. Despite its benefits, finding a durable and cost-effective alternative remains a challenge. Durability in concrete depends on proper curing, which maintains moisture levels for strength development. However, the growing scarcity of fresh water is a concern, with nearly half the world's population expected to face shortages by 2025. Since billions of litters are used in mixing and curing, sustainable alternatives and water-efficient curing methods are crucial for the future of construction.

a) Objective of the present work

The primary objective of this study is to assess the feasibility and benefits of using coconut shells as an alternative to coarse aggregate in concrete. Before incorporating coconut shells in concrete, their properties must be thoroughly understood. While coconut shells have not been widely explored as aggregates in structural concrete, this study aims to utilize them as structural components.

Developing lightweight structural concrete using coconut shells—an abundant agricultural waste—could be a significant breakthrough for small-scale construction industries. This research seeks to determine the viability of using coconut shells as a sustainable material in lightweight structural concrete.

The key objectives are:

- To evaluate the workability of Coconut Shell Aggregate Concrete (CSAC) for M30 concrete mix.
- To determine the compressive strength of CSAC for M30 grade concrete by conducting compressive strength tests.

II. LITERATURE REVIEW

Utsev,J.T.,Taku, J. K.- The coconut shells which are considered as an environmental pollutant are collected and burnt in order to produce ash of coconut shell. This ash is used as a pozzolana and is replaced partially with cement in the production of concrete. By replacing the cement with coconut shell ash in various percentages of 0, 10, 20 and 30 percentage concrete cubes were prepared. These concrete cubes were cured for 7, 14 and 28 days and the various properties like density, compressive strength and setting time of the concrete are determined. The density of the concrete cube was greater than 2400 Kg/m3 for 15-20 % replacement. The compressive strength of the concrete for 7 days and 28 days is 13.52 N/mm2 and 32.81 N/mm2 respectively and thus meeting the requirements for using it as both heavy weight and light weight concrete. Finally, it is concluded that OPC can be replaced with coconut shell ash up to 10-15 % and at this percentage it can be recommended to use it as light weight and heavy weight concrete.

R. Naga Lakshmi - An attempt has been made to determine the properties of the concrete by replacing 20% of the fly ash obtained from the Vijayawada thermal power station with cement and also replacing the coarse aggregate with coconut shell in various percentages like 10 %, 20 % & 30 % for the M25 grade concrete mix. The strength characteristics of M25 grade concrete are examined by conducting the various tests such as compressive strength test, flexure strength test, split tensile strength test for 14,28,56 days curing period and the obtained test results Arte compared with the nominal concrete mix by following IS code provisions. Various workability tests are conducted in order to maintain water cement ratio. It is concluded that the results obtained are closer to the results obtained from the conventional mix.

Olanipekun- Olanipekun has made an attempt on comparing the strength properties and analysing the cost of concrete which is obtained by replacing coarse aggregate with the crushed coconut granules and palm kernels in the ratio of 0 %, 25 % and 50 % with conventional concrete of grades M20 and M25. A total of about 320 concrete cubes were casted and tested them in order to know their mechanical and physical properties. It is concluded that compressive strength of coconut shell is more than the compressive strength of palm kernel shell. But as the percentage of coconut shell is increasing the compressive strength of concrete is decreasing in both the grades of concrete. When coarse aggregate is replaced by coconut shell and palm kernel shell the cost of the concrete is reduced by 32 % and 44 % respectively.

Saravanan R – The coconut fibre was used in order to verify the mechanical, physical and fracture behaviour of reinforced cement concrete with coconut fibre and also gave a report on how the properties are enhancing for fly ash concrete mixed with natural coconut fibre. M20 grade concrete was prepared with the mix design of 1:1.5:2.8 with the water cement ratio of 0.46 by replacing cement. Finally, it is concluded that there is an increase in the mechanical properties of the concrete by using coconut fibre in the concrete.

Sabarudin Bin Mohd and Siti Aminah Bt Tukiman- In their study they have utilized the naturally available materials like coconut shell and palm kernels. Six different concrete mixes are prepared by partially replacing coarse aggregate with coconut shell and partially replacing fine aggregate with grained palm kernels in various percentages of 0 %, 20 %, 40 %, 60 %, 80 % and 100 %. For each concrete mix three different samples are prepared and various parameters like flexural strength, tensile strength, compressive strength, young's modulus, durability and crack deflection behaviour are determined. The final conclusion given by them is when coconut shell and grained palm kernel shell combined together gives good results and can be effectively used as light weight concrete.

III. METHODOLOGY

a) Materials

- Cement (opc)
- Fine aggregate
- Coconut shell
- Coarse aggregate
- Water

Cement: Portland cement is the most common type of cement which is generally used in construction activities. This cement is made by heating limestone with other materials such as clay to 1450 °C in a kiln by a process known as calcination. This liberates CO2 from the calcium carbonate to form calcium oxide, or quicklime which then chemically combines with the other materials in the mix to form calcium silicates and other cementitious compounds. This result in the formation of harder substances called clinker which is further grounded with a small amount of gypsum into a powder form to make Ordinary Portland cement.

Coarse Aggregate: The particles which retain on the 4.75 mm sieve and can undergo 3 inches screen area are known as coarse aggregate. The course the aggregate the more economical will be the mix. Larger items can offer less area of the particles than constant volume of tiny items. Use of the utmost permissible size of the coarse aggregates permits a discount in cement and water needs.

Fine Aggregate: The particles which are passing through 4.75 mm sieve and retaining on 75 µ sieve those particles are called as fine aggregates. Rounded shape fine aggregates are used in order to increase the workability. The main intention of using fine aggregates is to fill the voids in the concrete that are created by the coarse aggregate and can be effectively used as a workability agent.

Coconut Shell: In order to analyse the properties of coconut shells which are used in this study are collected from locally available oil mills and coconut industries as a half-rounded shell. The coconut shell will be having a thickness range of 3-9 mm. The collected coconut shells were crushed in to smaller pieces having a range of about 3-10 mm in length. These broken pieces of coconut shells are washed with water several times and soak them in water for 1 day. After 1 day remove the coconut shell pieces from water and dry them in the sun in order to saturate the coconut shell pieces. Then the required amount of crushed CS pieces is utilised for casting.

Water: Water in concrete always gets least importance and often ignored by the people at the time of construction. We should not forget that water is an integral part of construction and any kind of compromises in quality of water during construction may ruin all our efforts made at the time of construction.

b) Mix Design

Mix Design is carried out in B.I.S Method (Bureau of Indian Standards) As per IS 10262:2009

MIX DESIGN PROCEDURE FOR THE CONCRETE OF GRADE M30:

1. Target strength:

f'ck = (fck+ks) or (fck+x)

fck = Target mean compressive strength at 28 days

K = 1.65

S = 5 N/mm^2 standard deviation (IS-10262-2019, table-2 P. No:3)

X = factor based on grade of concrete as per table-1

X = 6.5 (IS-10262-209, Table -2 P. No:3)

f'ck1= 30+(1.65×5)

f'ck1= 38.25 N/mm^2

f'ck2= 30+6.5

f'ck= 36.5 N/mm^2

f'ck1 > f'ck2

38.25 > 36.5 N/mm^2

f'ck= 38.25 N/mm^2

2. Water cement ratio:

Using IS-456-2000, table – 3&5, P. No:20

Water cement ratio = 0.45 (sever range)

3. Water content:

Using IS-10262, Table-4, P. No:5

20 mm coarse aggregate= 186 kg (for 50 mm slump)

100 mm slump:

For every 25 mm –add 3% (IS-10262-2019, cl:5.30)

186+6%= 197 kg

4. Calculation of cement content:

Water cement ratio = water content / cement content

Cement = water content / water cement ratio

Cement = 197 kg / 0.45 = 437.78 kg

minimum cement content = 320 kg (IS: 456:2000, P. No:20)

437.78 >320 kg

5. Aggregate proportion (coarse aggregate &fine aggregate):

IS-10262-2019, Table – 5, P. No:6, cl:5.51

Zone-2-0.62 (W/C-0.5)

Every 0.05 decrease increase 0.01

(W/C-0.45) = (0.45-0.45) =0

0.62+0= 0.62kg

Coarse aggregate = 0.620 kg

Volume of fine aggregate = 1-0.620 = 0.380 kg

Fine aggregate = 0.380 kg

6. Mix calculation:

a) Volume of concrete – 1 m^3

b) Volume of cement

(mass / sp. gravity) × (1/1000)

= 437.78/ (3.16*1000) = 0.139 m^3

c) Volume of Water = 197 / (1×1000) =

d) Volume of all in aggregate:

1-(b+c) = 1-(0.139+0.197) = 0.664 kg

e) Mass of coarse aggregate:

Volume of all in aggregate × volume of coarse aggregate × sp. gravity of coarse aggregate ×1000 = 0.664×0.630×2.73×1000 = 1142 kg

f) Mass of fine aggregate:

Volume of all in aggregate × volume of fine aggregate × sp. gravity of fine aggregate × 1000 =

0.664× 0.370×2.46×1000 =604 kg

7. Summary:

Cement = 437.78 kg/m^3

Water =194 kg/m^3

Fine aggregate = 604 kg/m^3

Coarse aggregate = 1142 kg/m^3

M20 grade concrete	% Replacement			
	0%	10%	15%	20%
Cement	437.78	437.78	437.78	437.78
Fine aggregate	604	604	604	604
Coarse aggregate	1142	1027.8	970.7	913.6
Coconut shell	0	114.2	171.3	228.4
Water	194	194	194	194

Quantity of Material in Different Proportions per m3

The ratio of the mix is 1:1.38:2.60 (Cement: fine aggregate: coarse aggregate)

IV. RESULTS AND ANALYSIS

Tests on Concrete (before casting)

• Slump Test:

The most commonly used method for determining the workability of the concrete is slump cone test which can be done either in the field or in the laboratory. This method is not suitable if the concrete is very wet or very dry.

Table: Slump value for different percentage replacements in M30 grade concrete

% Replacement	Slump Value
0%	106
10%	105
15%	105
20%	100

• Compacting Factor Test:

The most commonly used workability test in the laboratory is compaction factor test. The results of the compaction factor test are more accurate than the results obtained from the slump cone test. The main advantage of the compaction factor test is it can be effectively used for the concrete mixes of very low workability.

Table: Compaction factor values for different percentage replacements in M30 grade concrete

% Replacement	Compaction Factor
0%	0.91
10%	0.88
15%	0.85
20%	0.83

Tests on Hardened Concrete

• COMPRESSION TEST

In order to determine the compressive strength of the hardened concrete one of the most commonly used test is compression test. This test is conducted on the hardened concrete blocks by applying the loads gradually.

Table: Compressive strength of M30 grade concrete cubes after 7 days

Coconut shell	grade	Load crushing in (KN)	Compressive strength (N/mm²)
0%	M30	300 KN	13.34 N/mm²
10%	M30	120KN	5.33 N/mm²
15%	M30	133KN	5.92 N/mm²
20%	M30	60KN	2.67 N/mm²

Table: Compressive strength of M30 grade concrete cubes after 14 days

Coconut shell	grade	Load crushing in (KN)	Compressive strength (N/mm²)
0%	M30	650 KN	28.89 N/mm²
10%	M30	488 KN	21.69 N/mm²
15%	M30	496 KN	22.04 N/mm²
20%	M30	288 KN	12.80 N/mm²

Table: Compressive strength of M30 grade concrete cubes after 21 days

Coconut shell	grade	Load crushing in (KN)	Compressive strength (N/mm²)
0%	M30	700 KN	31.11 N/mm²
10%	M30	520 KN	23.11 N/mm²
15%	M30	624 KN	27.73 N/mm²
20%	M30	406 KN	18.04 N/mm²

Table: Compressive strength of M30 grade concrete cubes after 28 days

Coconut shell	grade	Load crushing in (KN)	Compressive strength (N/mm²)
0%	M30	800 KN	35.56 N/mm²
10%	M30	710 KN	31.56 N/mm²
15%	M30	723 KN	32.14 N/mm²
20%	M30	511 KN	22.72 N/mm²

V. CONCLUSION

This study concludes that replacing coarse aggregate with coconut shell results in lightweight concrete with lower strength compared to conventional concrete, while still meeting structural requirements.

Key findings include:

Experimental results on compressive strength and workability for different mix proportions, where coarse aggregate was replaced with coconut shell at varying percentages, were analysed and compared with conventional concrete. The findings indicate that while coconut shell can serve as an alternative aggregate, its performance is slightly lower than that of normal concrete.

An increase in coconut shell content leads to higher void content in concrete. For a 20% replacement, the voids increased by 40% compared to conventional concrete.

The 28-day compressive strength of M30 grade concrete with coconut shell replacement was:

- 35.56 N/mm² (0% replacement)
- 31.56 N/mm² (10% replacement)
- 32.14 N/mm² (15% replacement)
- 22.72 N/mm² (20% replacement)

These values satisfy the requirements for structural lightweight concrete.

In conclusion, coconut shell concrete is a sustainable and economical alternative for lightweight construction, contributing to environmental conservation by utilizing solid waste materials effectively. Further studies should focus on the effects of coconut shell replacement on split tensile strength and flexural strength.

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