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Application of Coconut Shell as Coarse Aggregate in Concrete: A Technical Review

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ABSTRACT
Oil palm shell (OPS) is a waste from the agricultural sector and is available in large quantities in the tropical regions. The high cost of conventional building materials is a major factor affecting housing delivery in world. This has necessitated research into alternative materials of construction. The project paper aims at analysing compressive strength characteristics of concrete produced using crushed, granular coconut as substitutes for conventional coarse aggregate with partial replacement. The main objective is to encourage the use of these 'seemingly' waste products as construction materials in low-cost housing. It is also expected to serve the purpose of encouraging housing developers in investing these materials in house construction.
Keywords - Coarse aggregates, Coconut shell, Compressive strength, Concrete cube specimens, Grade 53 Birla cement, M20, M35, M40, CTM, etc.

I. Introduction

Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal.

1.1 Concrete:

Far more concrete is produced than any other man-made material. Annual production represents one ton for every person on the planet. It is incredibly versatile, and is used in almost all major construction projects. Aggregates are used in concrete for very specific purposes. Aggregates typically make up about 60 % to 75 % of the volume of a concrete mixture, and as they are the least expensive of the materials used in concrete, the economic impact is significant. 80 % of buildings CO_2 emissions are generated not by the production of the materials used in its construction, but in the electric utilities of the building over its life-cycle. Compared to other comparable building materials, concrete is less costly to produce and remains extremely affordable.

1.2 Use of waste in concrete:

A research effort has been done to match society's need for safe and economic disposal of waste materials. The use of waste materials saves natural resources and dumping spaces, and helps to maintain a clean environment. The current concrete construction practice is thought unsustainable because, not only it is consuming enormous quantities of stone, sand and drinking water, but also two billion tons a year of Portland cement, which releases green-house gases leading to global warming. Experiments has been conducted for waste materials like- rubber tyre, e-waste, coconut shell, blast furnace slag, waste plastic, demolished concrete constituents, waste water etc. Construction waste recycle plants are now installed in various countries but they are partly solution to the waste problems.

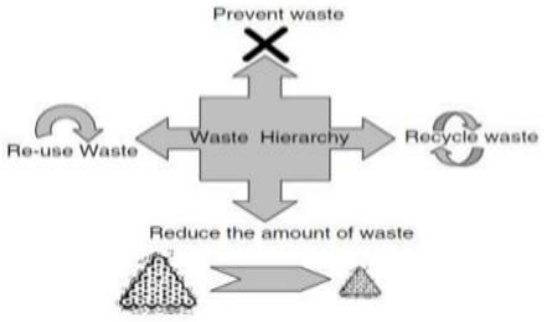

Figure 1: Waste Hierarchy

II. Coconut shell as aggregate

Coconut shell particles are used as reinforcing material for investigation. Shell particles

of size between 20 mm – 600 μ are prepared in grinding machine. Coconut shell aggregates are potential candidates for the development of new composites because of their high strength and modulus properties. An approximate value of coconut shell density is 1.60 g/cm^3.

Figure 2: Coconut Shell

Figure 3: Coconut shell as aggregates

III. Experimental programme

The target of the experimental program was to determine the contribution of natural material aggregate type to the development of the strength behaviour of the confined concrete. The experimental program comprises the following:

a. To investigate the best mix proportion of the combination of coconut shell as coarse aggregate in concrete by the value of strength per weight ratio of sample specimen.
b. To investigate the feasibility of the combination of coconut shell as coarse aggregate in concrete by determining its compressive strength and durability.
c. To investigate the effect of the combination of coconut shell as coarse aggregate in concrete content and length to the workability as lightweight aggregate in concrete and also the mechanical properties mentioned above.
d. To determine the optimum content of the combination of coconut shell as coarse aggregate in concrete to improve the ductility and does not cause reduction in the compressive strength.

IV. Research finding

Based on the literature review and research planning, the expected outcomes for the Research are:

a. Olanipekun et al. (2006) were 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. The main objective is to encourage the use of these 'seemingly' waste products as construction materials in low-cost housing. It is also expected to serve the purpose of encouraging housing developers in investing in house construction incorporating these materials. The conclusions for the research are the compressive strength of the concrete decreased as the percentage shell substitution increased. In all cases, the Coconut shell concrete exhibited a higher compressive strength than Palm kernel shell concrete in the two mix proportion tested. Both types of concrete performed fairly equally well in terms of their water absorption capacities. In terms of cost, the Palm kernel shell concrete appears to be cheaper. However, considering the strength per economy ratio and expecting further studies on the durability performance of both types of shell concrete, it could reasonably be concluded that Coconut shell would be more suitable than Palm kernel shell when used as substitute for conventional aggregates in concrete production.
b. In the paper Coconut Shell as Coarse Aggregate by Gopal Charan Behera, Ranjan Kumar Behera were investigated the comparative cost analysis and strength characteristics of concrete produced using crushed coconut shell as substitutes for conventional coarse aggregate. The main objective is to encourage the use of these 'seemingly' waste products as construction materials in low-cost housing.

Design grade – M40
Trial 1- For M40
Comp. Strength – 40.34 Mpa,
Trial 2 – For 5% CS replace
Comp. Strength – 30.67 Mpa,
Trial 3 – For 10% CS replace
Comp. Strength – 23.17 Mpa

c. In the paper Properties of Concrete with Coconut Shells as Aggregate Replacement by Amarnath Yerramala Ramachandrudu C were investigated on the Design grade – M20. They replaces the coconut shell in the % 10, 15, 20 as follows

Trial 1- For M20
Comp. Strength – 22.33 Mpa,
Trial 2 – For 10% CS replace
Comp. Strength – 13.56 Mpa,
Trial 3 – For 15% CS replace
Comp. Strength – 12.56 Mpa,
Trial 4 – For 20% CS replace
Comp. Strength – 9.33 Mpa,
Trial 5 – For 20% CS + 25% Fly ash replace
Comp. Strength – 7.22 Mpa,
Trial 6 – For 20% CS + 5% Fly ash replace
Comp. Strength – 9.67 Mpa

d. In the paper Exploratory Study of Coconut Shell as Coarse Aggregate in Concrete by Abdulfatah Abubakar and Muhammed Saleh Abubakar, Department of Civil Engineering, Kaduna Polytechnic, Kaduna were investigated on the Design grade – M10, M15 & M20.

Aggregate Crushing Value -
For Coarse Aggregate – 21.84
For CS Aggregate – 4.71
Aggregate Impact Value -
For Coarse Aggregate – 7.25
For CS Aggregate – 4.26
Elongation index –
For gravels – 58.54
For CS Aggregate – 50.56
Flakiness index –
For gravels – 15.69
For CS Aggregate – 97.19

Grade	**7 days**	**14 days**	**21 days**	**28 days**
M10	9.6	10.4	12.9	15
M10 CS replace	6.4	8.7	10.7	11
M15	19.1	22.5	26.7	28
M15 CS replace	8.6	9.6	13.6	15.1
M20	18.5	23	24.9	30
M20 CS replace	8.9	11.2	13.1	16.5

e. In the paper Experimental assessment on coconut shells as aggregate in concrete by Daniel Yaw Osei Department of Civil Engineering Cape Coast Polytechnic, Cape Coast, Ghana were investigated on the Design grade – M20. They replaces the Coconut shell in the % 20, 30, 40, 50 & 100 respectively and the results are

Trial	**7 days**	**14 days**	**21 days**	**28 days**
M20	15.75	18.88	20.17	20.94
20 % CS Replace	15.18	17.06	18.33	19.7
30 % CS Replace	14.56	16.38	17.04	18.58
40 % CS Replace	12.76	15.75	16.5	17.57
50 % CS Replace	12.17	15.17	15.86	16.65
100 % CS Replace	3.91	5.40	8.11	9.29

f. In the paper Review On Utilization Of Coconut Shell As Coarse Aggregates in Mass Concrete by Maninder Kaur & Manpreet Kaur, Department of Civil Engineering, PEC, Chandigarh were investigated on the Use of coconut shells in cement concrete can help in waste reduction and pollution reduction. The need of the hour is to encourage the use of the waste products as construction materials in low-cost housing. It is also expected to serve the purpose of encouraging housing developers in investing these materials in house construction.

V. Conclusion

From the experimental results and discussion, the coconut shell has potential as lightweight aggregate in concrete. Also, using the coconut shell as aggregate in concrete can reduce the material cost in construction because of the low cost and abundant agricultural waste. Coconut Shell Concrete can be used in rural areas and places where coconut is abundant and may also be used where the conventional aggregates are costly. Coconut shell concrete is also classified as structural lightweight concrete. It is concluded that the Coconut Shells are more suitable as low strength-giving lightweight aggregate when used to replace common coarse aggregate in concrete production.

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