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A DETAILED ANALYSIS TO FIND THE CHARACTERISTICS OF CONCRETE BY USING THE COCONUT SHELL AS AGGREGATE

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ABSTRACT

Coconut aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the construction and demolition debris. One of the major challenges of our present society is the protection of environment. The use of aggregates from construction and demolition debris (wastes) is showing prospective application in construction as alternative to primary (natural) aggregates. It conserves natural resources and reduces the space required for the landfill disposal. Although there is a critical shortage of natural aggregate, the availability of demolished concrete for use as COCONUT CONCRETE AGGREGATE (RCA) is increasing. Using the waste concrete as RCA can provide cost savings. Coconut aggregates are the materials for the future.

The aim of this project is to determine the strength characteristic of Coconut aggregates for application in high strength structural concrete, which will give a better understanding on the properties of concrete with Coconut aggregates, as an alternative material to coarse aggregate in structural concrete. Further, this work is to determine and compare the workability, compression strength, indirect tensile strength, flexural strength and modulus of elasticity properties of Coconut aggregate concrete with that of natural aggregate concrete.

The development of compressive and tensile strengths of Coconut aggregate concrete at the age of 7and 28 days; the development of flexural strength and static modulus of elasticity at the age of 28 days are investigated. The parameters which were investigated for Coconut aggregate concrete and compared with natural aggregate concrete as per BIS specifications found to be decreasing gradually as the percentage of Coconut aggregate are increased.

1.0 INTRODUCTION

1.1 General Introduction:

CONCRETE has been proved to be a leading construction material for more than a century. It is estimated that the global production of concrete is at an annual rate of $1m^3$ (approximately 2.5 tones) per capita

Fig 1.1 Coconut aggregates

In the past, almost all materials which are used in the construction industry were entirely natural and all waste from demolished buildings was disposed of in landfills and partially in unauthorized places. The utilization of the Coconut aggregates created from processing C&DW in new construction has become more important over the last two decades. There are many factors contributing to this, from the availability of new material and the damage caused by the quarrying of NA and the increased disposal of costs of waste materials. C&DW are generated mainly from demolished concrete and masonry structures. Due to advances in manufacturing of crushing industry, machinery and recycling process, it became possible to scale or crush down large masses of C&DW into smaller particles to produce Coconut aggregate (RA) at acceptable cost.

The quality of the Coconut aggregates has been improved significantly during the last decade as a result of good deconstruction practice and advances in stationary or transportable crushing machinery, as well as the recycling process itself *i.e* .screening and separation. As a result, improved quality aggregates are available now-a-days, at prices competitive to NA. However, despite the enhanced quality of the Coconut aggregates, the uptake of this alternative is still in fact too low(Dhir 2001; Wrap 2007).this limited use is largely due to the past experience formed when low strength cements and low quality Coconut aggregates were used as well as the restrictions imposed by standards.

Concrete debris was once routinely shipped to landfills for disposal, but recycling is increasing due to improved environmental awareness, governmental laws and economic benefits.

Aims and Objectives:

The main objective of project is as follows:

1. To obtain the fresh concrete properties of Natural Aggregate and various proportions Coconut Aggregate (slump, compaction factor, stability and air content tests)
2. To evaluate the mechanical properties of Coconut Aggregate Concrete.
3. To determine strengths of the Coconut Aggregate Concrete with different proportions (0%, 25%, 50%, 75%, 100%).
4. To compare the strength characteristics of Natural Aggregate Concrete and Coconut Aggregate Concrete.

Scope of the Present Work:

The scope of this project:

The project is proposed to cast the specimens of natural and Coconut aggregate concrete, of (0%, 25%, 50%, 75%, and 100%) proportions. Cubes (150mm x 150mm x 150mm), Cylinders (150mmdia*300mmheight), Beams (150mm*150mm*700mm) by using natural and Coconut aggregate, which will give a better understanding on the properties of concrete with RAC.

- Each proportion of concrete consists of 6 cubes, 4 cylinders and 2 prisms by using natural and Coconut aggregate concrete. Total number of specimens prepared using natural and Coconut aggregate is 110 specimens.
- Investigation and laboratory testing on high strength concrete with Coconut aggregate.
- Analyse the results and recommendation for further research area.

2.0 LITERATURE REVIEW

The main target of the sustainable development is to address the consumption and management of natural mineral resources, whilst minimizing the effects that our working environment has on these resources. The sustainable development strategy gives advice on

Review of Coconut Aggregate:

Tavakoli (1996), the strength characteristics of Coconut aggregate concrete were influenced by the strength of the original concrete, the ratio of coarse aggregate to fine aggregate in the original concrete, and the ratio of top size of the aggregate in the original concrete in the Coconut aggregate. He also mentioned that water absorption and Los Angeles abrasion loss will influence the water cement ratio and top size ratio for the strength characteristic of Coconut aggregate.

According to **Ramamurthy and Gumaster (1998),** the compressive strength of Coconut aggregate concrete was relatively lower and variation was depended on the strength of parent concrete from the obtained aggregate.

Sawamoto and Takehino (2000) found that the strength of the Coconut aggregate concrete can be increased by using Pozzolanic material that can absorb the water.

Limbachiya and Leelawat (2000) found that Coconut concrete aggregate had 7 to 9% lower relative density and 2 times higher water absorption than natural aggregate. According to their test results, it shown that there was no effect with the replacement of 30% coarse Coconut concrete aggregate used on the ceiling strength of concrete. It also mentioned that Coconut concrete aggregate could be used in high strength concrete mixes with the Coconut concrete aggregate content in the concrete.

Mandal (2002) stated that adjusted the water/cement ratio when using Coconut concrete aggregate during the concrete mixing can improved the strength of the Coconut aggregate concrete specimens. From the obtained result, Coconut aggregate concrete specimens had the same engineering and durability performance when compared to the concrete specimens made by natural aggregate within 28days design strength.

Sagoe, Brown and Taylor (2002) stated that the difference between the characteristic of fresh and hardened Coconut aggregate concrete and natural aggregate concrete is relatively narrower than reported for laboratory crush Coconut aggregate concrete mixes. There was no difference at the 5% significance level in concrete compressive and tensile strength of Coconut concrete and control normal concrete made from natural aggregate.

Bodin and Zaharieva (2002) stated that decreasing of the strength of Coconut concrete specimen was due to the increase of water/cement ratio that required by the preservation of workability.

Poon (2002) reported that there were not much effect of the compressive strength of brick specimens with the replacement of 25% and 50% of Coconut aggregate. But when the percentage of Coconut aggregate replacement increased, the compressive strength of the specimens was reducing.

Mandal, Chakarborty and Gupta (2002) also found that there will no effects on the concrete strength with the replacement of 30% of Coconut aggregate. But the compressive strength was gradually decreasing when the amount replacement of Coconut increased. They concluded that the properties and the strength characteristic of Coconut aggregate concrete were deficiency when compared to the specimens that made by the natural aggregate.

Chen and Kuan (2003) found that the strength of the concrete specimens was affected by the unwashed Coconut aggregate in the concrete. The effect will more strange at the low water cement ratio. These effects can be improved by using the washed Coconut aggregate.

3.0 TEST ON MATERIALS

Cement: cement is a binding material invented by Joseph Aspdin in 1824. It is manufactured from calcareous materials, such as limestone or chalk, and argillaceous material such as shale and clay.

Coarse Aggregate: If the size of aggregate is bigger than 4.75 mm, then the aggregate is considered as coarse aggregate.

Eg: Stone, ballast, gravel, brick ballast.

Fine Aggregate: According to IS 383, most of the aggregate which will pass through 4.75 mm IS sieve and entirely retained on 75 µ sieve is considered as fine aggregate.

Eg: Sand crushed stone, ash or cinder and surkhi.

Water: water is the main ingredient used to mix all the contents. Potable water is used as usage of any other water may contain salts and cause decrease in strength of concrete.

Normal Consistency of Cement

The main objective of this test is to determine the quantity of water required to produce a cement paste of standard consistency. The standard consistency of a cement paste is defined as percentage water which will permit the vicat plunger having 10mm diameter and 50mm long to penetrate to a depth of 5 to 7 mm from the bottom of the vicat mould or 33-35mm from the top of the mould.

For finding out initial setting time, final setting time, soundness of cement and compressive strength of cement, it is necessary to fix the quantity of water to be mixed in cement in each case. This experiment is intended to find out the quantity of water to be mixed for a given cement to give a cement paste of normal consistency and can be done with the help of vicat apparatus.

Figure shows standard consistency

Apparatus

The apparatus used in this test are Vicat's apparatus, Plunger (10mm dia, 50mm long), Mould (980mm dia, 40 mm high), Glass plate, Non-porous tray and weighing balance.

Test procedure

a. Take 300gms of weighted quantity of cement.
b. Add calculated quantity of water (24% by weight of cement) to cement and prepare a paste.
c. The paste must be prepared in a standard manner and filled in to the vicat's mould within 3-5 minutes after completing filling the mould, shake the mould to expel air.
d. A standard plunger is attached and brought down to touch the surface of the paste by its own weight.
e. Note down the depth of penetration of the plunger with the help of graduations provided to the vicat's apparatus.
f. Conduct a second trail by increasing percentage of water (26% and find out the depth of penetration of plunger.
g. Similarly conduct number of trails with higher percentage of water quantity up to plunger penetrates a depth of 33mm to 35mm from the top or 5mm to 7mm from the bottom of the mould.

Result: Normal consistency of the cement sample used in this study is 32%

Initial and Final Setting Times of Cement

The objective of this test is to determine the initial and final setting times of the cement. Initial setting time is regarded as the time elapsed between the moments that the water is added to the cement to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain pressure.The constituents and fineness of cement is maintained in such a way that the concrete remains in plastic condition for certain minimum time. This time should not be more than 10 hours which is referred to as final setting time. Initial setting time should not be less than 30 minutes. The procedure adopted for finding out initial and final setting times of cement is as follows.

Apparatus

The apparatus used in this test are Vicat's apparatus with needles for initial and final setting time, Measuring jar, Weighing balance, Stop watch and Glass plates.

Test Procedure for Initial Setting Time

a. Take 300gms of cement and prepare a cement paste of 0.85 times of water required for normal consistency.
b. Place the vicat's mould on a non-porous plate and place the cement paste in the mould and level the surface.

c. For determining the initial setting time, the needle of $1mm^2$ or (1.13mm diameter) is fitted to the vicat's apparatus. Place the mould filled with cement paste under the needle. Lower the needle gently to touch the surface at the cement and allows it to penetrate in to the paste.
d. Repeat the procedure at regular intervals till the needle stops penetrating 5 to 7 mm from the bottom or 33 to 35 mm from the top of the mould.
e. The time period elapsed, is known as "initial setting time".

Test Procedure for Final setting time

a. For determining the final setting time needle (a needle with angular ring) to the mould rod, release the needle gently and note down the time when the needle gently makes an impression on the mould surface and the angular ring fails to do so. In other words paste has attained such hardness that centre needle does not penetrate through the paste not more than 0.5mm.
b. The final setting time is the time elapsed between the time of addition of water to the cement and the time at which needle makes an impression on the surface of the sample and the angular ring fails to do so.

4.0 EXPERIMENTAL METHODOLOGY

Tests on Fresh Concrete

Workability tests

Slump test: Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete.

The mould is then filled in four layers, each approximately1/4 of the height of the mould. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section. After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside. This subsidence is referred as SLUMP of concrete.

The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured and is taken as the slump of concrete. ASTM measures the center of the slumped concrete as the difference in height.

If the concrete slumps evenly, it is called true slump. If one half of the cone slides down, it is called shear slump. IS 456-2000 suggests that in the very low category of workability where strict control is necessary, measurement of workability by determination of compaction factor will be more appropriate than slump.

Figure shows Apparatus to determine the workability of concrete (slump test)

Compaction factor test

Principle: To determine the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. Compaction factor is the ratio of the density actually achieved in the test to density of same concrete fully compacted.

The apparatus consists of upper hopper, lower hopper and cylinder. Upper and lower hoppers having, top internal diameter 25.4 cm, bottom internal diameter 12.7 cm, internal height 27.9 cm. dimensions of cylinder are internal diameter 15.2 cm, internal height 30.5 cm. the sample of concrete to be tested is placed in the upper hopper up to the brim. The trap door is opened so that the concrete falls in to the lower hopper. The cylinder is emptied and then refilled with the same sample in 5 layers each layer is given 25 blows with a tamping rod for the sake of fully compaction. It is taken as the Weight of Fully Compacted Concrete.

Compaction Factor = weight of partially compacted concrete/weight of fully compacted concrete.

Figure shows Apparatus for compaction factor test

Figure shows Setup for Compression Test

Flexural strength

Flexural strength is the measure of modulus of rupture. The systems of loading used in finding out the flexural strength are central point loading and third point loading. In the central point loading, maximum fiber stress will come below the point of loading where bending moment is maximum. In case of symmetrical two point loading, the critical crack may appear at any section, not strong enough to resist the stress within the middle third, where the bending moment is maximum. It can be expected that the two point loading will yield a lower value of modulus of rupture than the center point loading.

Figure shows Setup for flexural strength test

Figure shows Arranging the bearings on uppermost surface

5.0 Test Result and Analysis

Series of test was carried out on the concrete cylinder to obtain the strength characteristics of Coconut aggregate for potential application in high strength structural Concrete. This chapter discuss on the result that obtained from the testing. The results are such as slump test, compacting factor test, compression test, indirect tensile test and modulus of elasticity.

Slump Test Result and Analysis

The slump test indicates a decreasing trend of workability when the percentage of Coconut aggregate increased. Table shows the average slump recorded during the test. Figure 5.1 below shows a graphical representation of slump height. According to the result, the highest slump obtained was 110mm and the lowest slump was 82mm. the average slum for each batch of mix was 96mm. therefore, target slump had been achieved, where the range is from 50mm to 120mm.The workability was good and can be satisfactorily handle for 0% Coconut aggregate to 100% Coconut aggregate. The slump from 0% Coconut aggregate to 100% Coconut aggregate were considered moderate due to the drop in the range of 5mm to 9mm.The average slump that obtained for 100% Coconut aggregate (with 0.47 water cement ratio) was 82mm.

Fig 5.1 slump results at R0, R25, R50, R75, R100

Table 5.1 slump values

	RAC 0%	RAC 25%	RAC 50%	RAC 75%	RAC100%
Slump @ 0Min	110mm	104mm	100mm	90mm	82mm
Slump @ 30Min	98mm	98mm	94mm	88mm	75mm

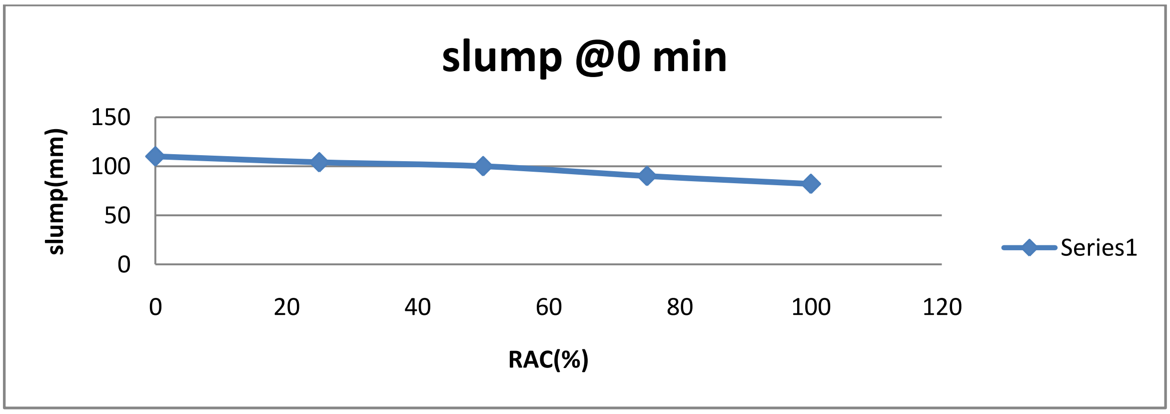
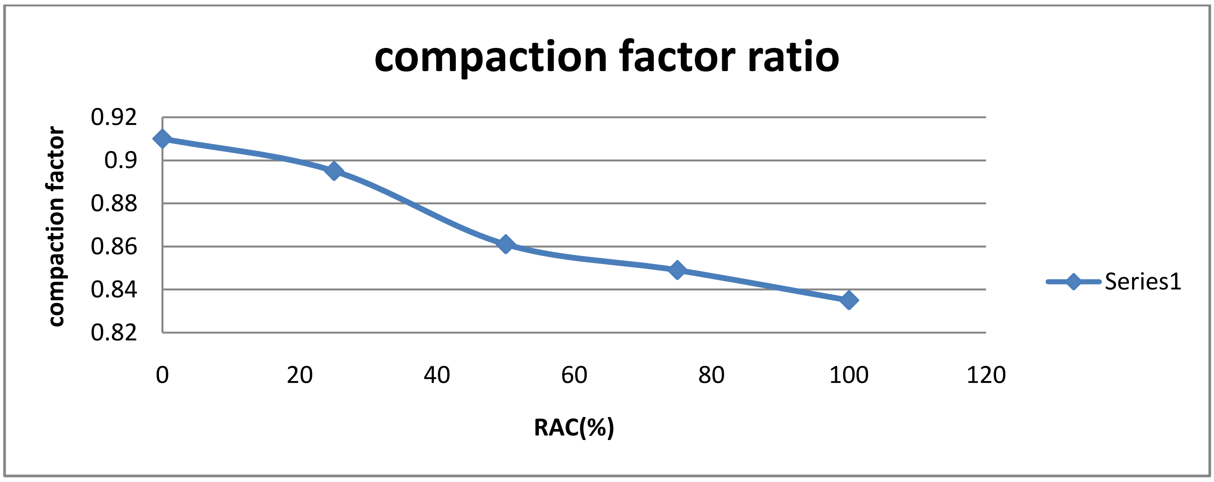


Table 5.2: The Compacting Factor Ratio for Each Of Mix Concrete

RAC	0%	25%	50%	75%	100%
Compaction factor	0.91	0.895	0.861	0.849	0.835



6.0 CONCLUSION AND RECOMMENDATIONS

This chapter was set out to represent the conclusion of this project. Before the conclusion is list, the achievement of objectives set in beginning of the project was also discussed and achieved. Lastly, some testing, investigations and studies were also recommended after the conclusion, to further the strength characteristics of Coconut aggregates for the application in high strength concrete.

Achievement of Objectives

The project achievements are as follows:

• In this project, the review and research of current usage to the use of Coconut aggregate in the concrete was discussed into different sectors, such as constructions, industries, applications, recycling process, previous research and investigation..

• All the result for the tests was recorded in an appropriate manner. Moreover, result of each test was analysed in detail. All of this was discussed in chapter 5.

Conclusion

Research on the usage of waste construction materials is very important due to the materials waste is gradually increasing with the increased of population and increasing of urban development. The reasons that many investigations and analysis had been made on Coconut aggregate are because Coconut aggregate is easy to obtain and the cost is cheaper than virgin aggregate.

Virgin aggregate need to mine but Coconut aggregate can ignore this process. This on-going research project is to determine the strength characteristics of Coconut aggregate for potential application in the high concrete structural concrete. This type of concrete can only be used under the condition that does not involve a lot of handling works.

6.3 Recommendations for Further Studies

Further testing and studies on the Coconut aggregate concrete is highly recommended to indicate the strength characteristics of Coconut aggregates for application in high strength concrete.

Below are some of the recommendations for further studies:

1. Although by decreasing the water/cement ratio, Coconut aggregate can achieve high strength concrete. But the workability will be very low. Therefore, it is recommended that adding admixtures such as super plasticizer and silica fume into the mixing so that the workability will be improved.
2. More investigations and laboratory tests should be done on the strength characteristics of Coconut aggregate. It is recommended that testing can be done on concrete slabs, beams and walls. Some mechanical properties such as creeping and abrasion were also recommended.
3. More trials with different particle sizes of Coconut aggregate and percentage of replacement of Coconut aggregate are recommended to get different outcomes and higher strength characteristics in the Coconut aggregate concrete.

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