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Experimental Study on Concrete by Partial Replacement of Cement with Coconut Shell Ash, Incorporating Steel Fibres: A Review

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Abstract*: Demand for cement continues to grow, and also increase in the cost of conventional building materials; for this objective, the use of industrial waste products and agricultural byproducts are very constructive. These industrial and agricultural byproducts such as Fly Ash, Rice Husk Ash, Coconut shell ash, Silica Fume etc can be used as cementing materials because of their pozzolanic behavior, and fibers like Steel fibre, Jute fiber, Coconut fiber etc. can be used to increase the tensile strength of concrete, which otherwise require large tracts of lands for dumping, thus the concrete industry offers an ideal method to integrate and utilize a number of waste materials, which are easily available, and economically within the buying powers of an ordinary man. Presence of such materials in cement concrete not only reduces the carbon dioxide emission, but also imparts significant improvement in Compressive strength, Split tensile strength, Workability.
Keywords*: Coconut shell ash, Steel fibre, Compressive strength, Tensile strength, Workability

I. INTRODUCTION

Approximately, about 10 billion cubic meters concrete is being produced yearly. Cement is a very important constituent of concrete. In 2014 approximately 4180 million tons of cement were produced globally. Production of one ton of cement releases approximately one ton of CO_2 which makes up 7% of all CO_2 emissions produced globally. It is a pressing need today for the concrete industry to produce concrete with lower environmental impact, these-called green concrete. It can be possible to achieve in three different ways. The first one is by reducing the quantity of cements ; one ton of cement saved will save equal amount of CO_2 to be discharged into atmosphere. By reducing the use of natural aggregates whose resources are limited and are exhausting very fast, is the second way. It is also achieved by utilizing maximum possible waste materials like coconut shell ash, fly ash, Ground Granulated Blast Furnace Slag, Rice husk ash and silica fume are some of the pozzolanic materials in concrete. By this, we can reduce the requirement of landfill area and system can become more sustainable.

The cost of conventional building materials continue to increase as the majority of the population continues to fall below the poverty line. Thus, local materials as alternatives for the construction of functional but low-cost buildings in both the rural and urban areas are required to search & promote.

The researchers are inspired by the concept of environmentally friendly technology to do more in protecting the environment. In most developing countries, it has become the popular way to utilize the waste material as alternative building material to overcome the environmental problem. Waste material such as Coconut shell ash has great potential to be used as building material. The high silica content from Coconut Shell Ash has pozzolanic behaviour which influence the concrete strength.

To produce CSA, coconut shell is sun dried for 48 hours to remove moisture from it. It was then subjected to internal combustion using a furnace, burn it for 24 – 48 hours and allow it to cool for about 12 hours. Collect the ash and sieve it through a BS sieve (75 microns). The resulting coconut shell ash (CSA) which has the required fineness is collected for use.

Coconut shell is one of the most important natural fillers produced in tropical countries. Use of coconut shell ash is a major step towards sustainable development.CSA does not have cementitious property by itself which is responsible for strength generation. It reacts with free lime obtained from cement and form hydrated products (C_2S and C_3S) in presence of water, which contributes in attaining the strength and also improving the durability.

As the CSA is very fine in structure, it fills more voids and provides superior pore structure and thereby improves its strength at later stages due to reduced permeability. So, by partially replacing cement with pozzolanic material such as coconut shell ash, the cement industry can serve both the purposes of meeting the demands of construction industry and at the same time providing a green and clean environment.

With the addition of steel fibres concrete's flexural and tensile strength can also be enhanced as the concrete is weak in tension by nature .The advantage of adding steel fibres is that it prevents crack from proceeding by applying forces at the tips of the crack, thus delaying their advancement across the concrete and helps in attaining a gradual failure. And, thus increasing the tensile and flexural strength to many folds.

II. LITREATURE REVIEW

Vignesh Kumar Nagarajan[1] carried out an Experimental study on partial replacement of cement with coconut shell ash in concrete. Agricultural waste material, in this case, coconut shells, which is an environmental pollutant, are collected and burnt in the open air(uncontrolled combustion) for three hours and that product is incinerated in muffle furnace at 800oC for 6 hrs to produce coconut shell ash (CSA), which in turn was used as pozzolana in partial replacement of cement in concrete production. Author has produced concrete mortar cubes by replacing 0 and 5 percent of OPC with CSA. He has concluded that, the setting time increases with increase in the amount of coconut shell ash. He also noticed that, with increase in percentage replacement of OPC with CSA ,the compressive strength decreases. The optimal 28 days strength for OPC-CSA mix is recorded at 10% replacement.

Utsev[13] carried out research on Coconut shell ash as partial replacement of ordinary portland cement in concrete production. Author has produced concrete cubes using various replacement levels between 0 to 30 percentage of OPC with CSA. He has casted total 54 cubes and cured by immersing them in water for 7, 14 and 28 days respectively. Compressive strength, Density, setting times and pozzolanic activity index were determined. He has concluded that the densities of concrete cubes for 10-15% replacement was above 2400Kg/m3 and the compressive strength increased from 12.45N/mm2 at 7days to 31.78N/mm2 at 28 days curing which meets the requirement for use in both heavy weight and light weight concreting. Thus, 10 -15% replacement of OPC with CSA is recommended for both heavy weight and light weight concrete production.

Oyedepo OJ[2] carried out an experimental research on Performance of coconut shell ash and palm kernel shell ash as partial replacement for cement in concrete. Using a mix design ratio of 1:2:4 and water binder ratio of 0.63, concrete cubes were casted using varying ordinary Portland cement (OPC): palm kernel shell ash (PKSA) and ordinary Portland cement (OPC): coconut shell ash (CSA) ratios of 100:0, 90:10, 80:20, 70:30 , 60:40 and 50:50 respectively. Author has noticed that the partial replacement of cement with 20% PKSA and CSA in concrete gives an average optimum compressive strength of 15.4 N/mm2 and 17.26 N/mm2 respectively at 28 days. While,10% replacement with CSA gives the optimum value of compressive strength which is 20.58 N/mm2 at 28 days. Such strength is suitable for both light weight and heavy weight concrete respectively. Thus, the researcher has concluded that the use of PKSA and CSA as a partial replacement for cement in concrete, at lower volume of replacement, will enhance the reduction of cement usage in concretes, thereby reducing the production cost and the environmental pollution caused by the dumping of the agricultural waste.

Neetesh Kumar[3] carried out research on Utilization of coconut shell in different forms in concrete. Replacement of cement by CSA in concrete showed that the density of concrete cubes for 10-15% replacement was above 2400 Kg/m3. This paper shows that at 30% replacement the average density decreases from 2525.5 Kg/m3 to 2314 Kg/m3. The achieved value of compressive strength meets the requirement for use in both heavy weight and light weight concreting. With the increase in the amount of CSA, the setting time also increases. The initial setting time increases from 1 hr 5 min at 0% replacement to 3 hrs 26 min at 30% replacement while the final setting time increases from 1 hr 26 min at 0% replacement to 4 hrs 22 min at 30% replacement. Author has also noticed that with increasing percentage replacement of OPC with CSA, the pozzolanic activity index decreases & the compressive strength decreases with increasing percentage replacement of OPC with CSA. 10% replacement gives the optimal 28 days strength for OPC-CSA mix which is 31.78 N/mm^2.

Sanjay Sen[14] carried out the study on Effect of coconut fibre ash on strength properties of concrete. Coconut fibres are collected and the fibre are properly dried and burnt in the open air with a temperature range of 600'c to 700'c. Author has collected the ash and made to pass through 150 micron sieve after the fibres turned into the ash. Replacement is done between 0 to 25% & the cubes are tested at 7, 28, 60, & 90 days. Paper shows that the workability of the concrete decreased as the CFA content increased & the compressive strength of CFA concrete increased with curing aging but decrease with increasing the percentage of coconut fibre ash. Author has concluded that the optimum compressive strength of 59.25N/mm^2 was obtained at 5% replacement at 90 days of ages.

L. O. Ettu[15] carried out study on Suitability of Nigerian Agricultural By-Products as Cement Replacement for Concrete Making. This work investigated the strength characteristics of binary blended cement concrete made with Ordinary Portland Cement (OPC) and each of eight agricultural by-products in South Eastern Nigeria, namely Rice Husk Ash (RHA), Saw Dust Ash (SDA), Oil Palm

Bunch Ash (OPBA), Cassava Waste Ash (CWA), Coconut Husk Ash (CHA), Corn Cob Ash (CCA), Plantain Leaf Ash (PLA), and Paw-Paw Leaf Ash (PPLA). 105 concrete cubes of 150mm x 150mm x 150mm were produced at percentage OPC replacement with each of the eight ashes of 5%, 10%, 15%, 20%, and 25%. Author has tested three concrete cubes for each percentage replacement of OPC with each ash & obtained their compressive strengths at 3, 7, 14, 21, 28, 50, and 90 days of curing. Paper shows that the compressive strengths of binary blended cement concrete increased with curing age and decreased with increase in percentage replacement of OPC with pozzolans. Author has noticed that compressive strength values for 3-14 days is much lower than the control values for all percentage replacements of OPC with pozzolan. The 90-days strength at 5-10% replacement of OPC in binary blending with each of the eight pozzolans was higher than that of the control, ranging from 24.50N/mm2 for 10% replacement of OPC with coconut husk ash (CHA) to 30.2N/mm2 for 5% replacement of OPC with RHA compared with the control value of 23.8N/mm2.The author concluded that, all the eight agricultural by-products investigated in this work could be good for binary blending with OPC in making structural concrete. However, since blended cement concrete take a longer time to attain adequate strength than 100% OPC concrete, major structural elements constructed with blended cement concrete should be allowed a longer time before loading, say 28-50 days for 5-15% replacement of OPC with agricultural by-product pozzolans and 50-90 days for 15-25% replacement of OPC.

Amit Rana[4] carried out Some Studies on Steel Fiber Reinforced Concrete. Author found that with increase in steel fibre content in concrete there was a tremendous increase in flexural strength & the flexural strength was observed 6.46 N/mm^2 even at 1% steel fibre content.

E. Mello[5] carried out study on Improving concrete properties with fibers addition. Author has studied about the improvement in concrete properties with addition of cellulose, steel, carbon and PET fibers in this paper. He has added each fibre at four percentages to the fresh concrete, which was moist-cured for 28-days and then tested for compressive, flexural and tensile strengths. Author noticed that addition of cellulose caused a decrease between 9.8% and 16.4% in compressive strength.. Most importantly, he has observed that the compressive strength is increased up to 20% by addition of steel fibres & the increaments were reported 121.5% and 80.7% in tensile and flexural strengths respectively. Where as Carbon fibers increased flexural and tensile strengths by up to 11% and 45%, respectively. In case of PET fibres, concrete strength properties decreased. Author has concluded that the extra cost of steel & carbon fibers is justified due to the improvement in strength.

Ambika Nahak[10] carried out study on Strength of concrete with partial replacement of cement with saw dust ash and steel fibre. A study of mechanical strength of concrete made using Ordinary Portland Cement with a partial replacement of saw dust ash ranging from 5% to 20% and again by incorporating steel fibre of 0.5%, 1%, 1.5% with same SDA percent .The grade of concrete designed here was M25. Slump and compacting factor tests were carried out for fresh concrete and compressive strength, split tensile strength, flexural strength tests for hardened concrete. The compressive strength and split tensile strength tests of normal and SDA concrete was done at the age of 3, 7, 28 and 56 days and SDA concrete containing steel fibre was tested at the age of 3, 7 and 28 days. The flexural strength of saw dust ash concrete with & without steel fibre was tested at the age of 28 days. From the experimental results, it was found that there is a reduction in strength with an increment of saw dust ash. But while adding steel fibre to SDA, it is observed that the fibre reinforced saw dust ash (FRSDA) concrete has an increase in strength twice than that of the SDA concrete at 3rd, 7th and 28th days.

Tarun Sama[11] carried out study on Effect of strength of concrete by partial replacement of cement with flyash and addition of steel fibres. Steel fibres having aspect ratio 50 were used between 0 to 2%.Author has replaced cement by 40% & 60% of Class F fly ash. All the results obtained were compared and examined with respect to the control specimen. Author has noticed that due to the addition of steel fibre in concrete, it enhances its overall strength especially the flexural and split tensile strength. Author has concluded that, the 40% and 2% are the optimum percentages of adding flyash & steel fibres respectively which showed the maximum improvement in tensile and flexural strength.

III. CONCLUSION FROM LITREATURE REVIEW

As the amount of coconut shell ash increases ,setting time also increases.

The use of CSA as a partial replacement for cement in concrete, at lower volume of replacement, will enhance the reduction of cement usage in concretes, thereby reducing the production cost and the environmental pollution caused by the dumping of the agricultural waste.

With the increase in percentage replacement of OPC with CSA,the compressive strength decreases.

The Pozzolanic index decreases with increasing percentage replacement of OPC with CSA.

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Partial replacement of cement with 20% PKSA and CSA in concrete gives an average optimum compressive strength at 28 days. It is suitable for both light weight and heavy weight concrete respectively.

The optimum 28 days strength for OPC-CSA mix is recorded at 10-15% replacement.

Flexural strength can be tremendously increase with increase in steel fibre content in concrete. The extra cost of steel & carbon fibers is justified due to the improvement in strength.

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