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COCONUT SHELL AND ALCCOFINE IN CONSTRUCTION INDUSTRY AS A PARTIAL REPLACEMENT MATERIAL - A REVIEW

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Abstract - *Concrete is the most widely used construction material around the world and is used in all types of construction works, including infrastructure, domestic developments and low and high-rise buildings. Concrete consist of a mixture of cement, aggregates, water and admixture. The major part of the aggregates are Sand, crushed stone or gravel. The continuous extensive extraction of aggregates from natural resources causes depletion of conventional aggregates. Because of this, the non-availability of natural resources to future generations has also been realized. Different alternative waste materials and industrial by products such as recycled aggregates, foundry sand, palm kernel shell, china clay sand, glass were replaced with natural aggregate and has evaluated the properties of the concretes. Apart from above mentioned waste materials and industrial by products, few studies have identified that agricultural by product can also be used as aggregate in concrete. Coconut shell is one of the agricultural by product that can be used as a partial replacement for coarse aggregate. Addition of Coconut shell will develop a light weight concrete as the density of concrete is reduced. The introduction of Coconut shell aggregate in concrete will decrease the compressive strength of concrete, some additional material should be added to compensate it. Alccofine is an ultrafine material of particle sizes much finer that other SCM. It can be used as a partial replacement material for cement to improve workability and strength. In this paper an overview on the literature on mechanical properties of concrete with Coconut shell aggregate and Alccofine is carried out based on recent research studies.*

Key Words: Coconut shell aggregate, Alccofine, Ultrafine material, Light weight concrete, Mechanical properties

1. INTRODUCTION

Sustainable development is a challenge that civil engineers have an opportunity to present. It is essential to look for sustainable solutions for concrete constructions in future. Sustainable concrete can be developed by utilizing eco friendly materials having less energy consumption and which could be recycled and replenished. Concrete is a heterogeneous material which consist of cement, aggregates, water and admixtures. In early days, aggregates were available at reasonable prices and with good qualities. But, the continued extraction of aggregates from nature has caused its depletion and thus the cost increases. Due to this demand in finding an alternative building materials that can be used as aggregates in producing concrete is growing. One such alternate material is agricultural by-products. Coconut shell is one of the agricultural by product that can be used as a partial replacement for coarse aggregate. As the introduction of Coconut shell aggregate in concrete will decrease the compressive strength of concrete, some additional material should be added to compensate it. Alccofine is an ultrafine material of particle sizes much finer that other SCM. It can be used as a partial replacement material for cement to improve workability and strength. As both the materials are low in cost, it will reduce the overall cost of concrete.

1.1 Coconut shell aggregate

Coconuts are considered as "king of the tropical flora", man's most useful trees" and "tree of life". Coconut is grown in more than 93 countries all over the world and India is the third largest country having cultivation of about 1.78 million hectares for coconut production. The yearly output is nearly 7562 million nuts with an average of 4248 nuts per hectare. The coconut industry in India accounts for one fourth of the world's total coconut oil output and thus it grows further with the global increase in demand. Due to this, disposal problem is a serious issue for local environment as it is an abundantly available agricultural waste from local coconut industries. Coconut shell being a difficult and not easily degrade material, if it is crushed to the size of coarse aggregate can be a used as a material to substitute coarse aggregate. The chemical composition of the coconut shell is similar to wood. It contains 34% cellulose, 36% lignin, 29% pentosan and 1% ash. In developing countries, where a large quantity of coconut shell waste is discharged, these wastes can be used as replacement material in the construction industry. This will have an advantage of reduction in the value of construction material and a resolution to disposal of wastes.

Properties of Coconut Shell:

- Due to the presence of high lignin content, the composites become more weather resistant.
- Coconut shell absorbs less moisture as compare to other agricultural waste as it contain low cellulose content
- Coconuts are being naturally available in nature abundantly and thus its shells are non-biodegradable, so they can be used in concrete after treated for water absorption.
- Coconut shell possess high strength, durability characteristics, high toughness & abrasion resistant properties

Fig. 1 : Waste coconut shell

1.2 Alccofine

Alccofine Micro Materials are range of innovative products of Count Micro fine Products Pvt. Ltd (CMPPL) – a joint venture between Ambuja Cements Limited (ACL) and the Goa-based Alcon Group, launched in the year 2013. The production facility is at Pissurlem Industrial Estate, Goa. Alccofine is a micro fine material of particle size much finer than other hydraulic materials like cement, fly ash, silica etc. being manufactured in India. Alccofine has unique characteristics to enhance performance of concrete in both fresh as well as hardened stages due to its optimized particle size distribution Cementitious materials for concrete are fine mineral powders. When this material is mixed with water, they react chemically to form a strong rigid mass that binds aggregate particles together to make concrete. Alccofine material is pozzolanic material which is becoming popular in the construction industry and has brought many developments in the field of Civil Engineering.

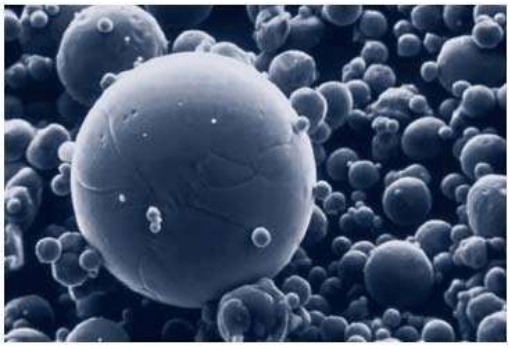

Fig. 2 : Nano particle form of Alccofine

For high strength, Alccofine is a new generation micro fine concrete material and which is important in respect of workability as well as strength. It can be added directly with cement and are easy to handle. The ultrafine particle of Alccofine provides smooth surface finish. As well as cost is concerned, for high strength concrete the cost of concrete mix prepared with Alccofine is less than the concrete without Alccofine. The most important advantages of Alccofine is its strength improvement and lower the water/binder ratio. Compression and flexure can be increased to a large extent with the addition of Alccofine. Alccofine also consumes by product calcium hydroxide from the hydration of cement to from additional C-S-H gel which is similar to pozzolans.

$C_3S + H_2O \rightarrow C\text{-}S\text{-}H + CaOH_2$

$SiO_2 + CaOH_2 \rightarrow C\text{-}S\text{-}H$

2. LITERATURE REVIEW

In recent years, many studies were conducted by various researchers on environmental friendly concrete materials. Coconut shell and Alccofine are two such materials that can be used in the construction industry. The goal which is expected from the paper is to study the properties of concrete with Coconut shell and Alccofine to make a strong and durable low cost and eco friendly concrete.

2.1 Studies on coconut shell aggregate in concrete

Apeksha Kanojia and Sarvesh K. Jain (2017) evaluated the performance of coconut shell as a partial replacement of coarse aggregate in concrete. This study was conducted because of the problems faced due to the disposal of large quantity of waste coconut shell and scarcity of conventional coarse aggregate used in concrete. The present research was divided into two parts. The first part was to determine the compressive strength and density of concrete with coconut shell and the second was to evaluate the additional quantity of cement in order to compensate the reduction in strength of concrete due to replacement. Through their experimental investigation they concluded that the compressive strength reduction is about 22% in 28 day strength when coarse aggregate is replaced with coconut shell by 40 %. As the percentage of coconut shell increases, strength decreases. But it makes the concrete lighter. Also there is an increase in cost as additional cement content is required to improve the strength of concrete.

K. Gunashekaran et al. (2011) investigated the properties of concrete with coconut shell as a partial replacement for coarse aggregate through an experimental study. They compared compressive strength, tensile strength, flexural strength, impact resistance and bond strength with those values recommended in standards. Coconut shell concrete can be considered as light weight concrete, but as the amount of coconut shell increases, strength gradually decreases. The length of coconut shell aggregate used in the study was restricted to a maximum of 12 mm and were in saturated surface dry condition. Through their experimental investigation they found that coconut shell concrete has better workability due to its size and smooth surface on one side of the shell. The impact resistance of coconut shell is greater as compared with conventional concrete. Experimental bond strength is also greater than the theoretical bond strength as per standards.

K. Gunashekaran et al. (2012) studied the effect of three types of curing on coconut shell aggregate concrete to observe the long term performance. Intermittent curing shows the highest strength which is followed by full water and air dry curing. Scanning Electron Microscopic analysis was done to study the pore structure of the coconut shell.

SEM analysis shows that there is better bonding between cement paste and coconut shell. The bonding between cement paste and coconut shell was observed by measuring fissures between them. Before using coconut shell as an aggregate it should be treated for water absorption. Coconut shell aggregate concrete was also tested for compressive strength, bond strength, workability and ultrasonic pulse velocity. They stated that coconut shell aggregate concrete continue gaining strength even after 365 days and this shows that if once the coconut shell aggregates are encapsulated into the concrete mix, it does not get deteriorated.

Abdullah Anwar et al. (2016) discussed about the compressive strength of M20 grade concrete with waste coconut shell as partial replacement for coarse aggregate. The percentage replacement of coarse aggregate with coconut shell varies from 0% to 50%. Cubes were casted and tested at 7, 14 and 28 days strength. They stated that coconut shell concrete can be used as light weight concrete. Through their experimental investigation, 10% replacement of coarse aggregate with coconut shell shows the optimum value and the compressive strength at 28 day was 20.75 N/mm^2. As coconut shell is cost effective and eco friendly, it can be used as a partial replacement material for coarse aggregate in concrete which is a resolution for the problems related to shortage of conventional material and waste material disposal.

Vijay Kumar Shukla et al. (2017) evaluated the compressive strength of M20 grade concrete with coconut shell as a partial replacement for coarse aggregate and compared it with conventional concrete. The percentage replacement of coarse aggregate with coconut shell varies from 5% to 30%. From their study it was clear that as the percentage of coconut shell increases, compressive strength decreases and density of the concrete decreases, which makes the concrete light weight.

Kalyanapu Venkateswara Rao et al. (2015) studied on the strength properties of coconut shell concrete. From their experimental investigation, the following conclusions were found:

- Workability decreases with the addition of coconut shell which can be compensated by adding fly ash as a partial replacement for cement
- Compressive strength decreases with increase in coconut shell. But with the addition of fly ash as partial replacement of cement, an improvement in compressive strength was observed.
- Replacement of coarse aggregate with 10% of coconut shell and cement with 10% of cement has decreased the marginal value of 0.205% in compression and increased 2.7% in tension.

2.2 Studies on Alccofine in concrete

Malavika Gautam and Hemant Sood (2017) stated that the addition of Alccofine in concrete has gradually increased the strength of concrete at all stages. Alccofine has a unique characteristic to enhance the performance of concrete in both fresh and hardend state because of its optimized particle size distribution. Through their experimental study. The optimum percentage replacement of cement with Alccofine to increase the strength was found to be 10 %.The seven day strength showed an increment when compared with the control mix. The ultrafine Alccofine partical provides smooth surface workability and lower water / binder ratio.

Mahim Mathur and Ashish Mathur (2018) studied about the performance of concrete with Alccofine 1203. They stated that the addition of Alccofine 1203 in OPC will initially increase a slump of 10% when compared to M20 grade concrete mix. The optimum value of Alccofine found was 10%. The compressive strength at 10% replacement of cement with Alccofine in M20 grade concrete is $41.11N/mm^2$. Which is greater than the target compressive strength of M30 grade concrete. From this it is proved that the addition of Alccofine will increase the strength properties of concrete.

Devinder Sharma et al. (2016) discussed about the strength development of concrete with Foundry Slag and Alccofine as a partial replacement for fine aggregate and cement respectively. In their study M100 grade concrete samples were casted and tested for compressive strength, tensile strength and flexural strength with varying percentage of Foundry Slag (0% - 50%) and optimum of Alccofine (15%) at the age of 7, 14, 28, 56 and 90 days. Carbonation as alkalinity test and rapid chloride permeability test were also studies. From the experimental investigation they concluded that reasonably high strength concrete mix can be developed by substituting fine aggregate with 10% to 45% of Foundry Slag and cement with 15% of Alccofine. Foundry Slag was found to be safe from carbonation as the pH of concrete was increasing slightly with increase in Foundry Slag content which reduced corrosion and permeability of concrete decrease with increase in Foundry Slag content. Also the study was done to reduce the impact on environment by saving the natural resources.

Siddharth P Upadhyay and M. A. Jamnu (2014) studied the effect of Alccofine and Fly ash as a Supplementary Cementitious Material on the strength of concrete. Alccofine and Fly ash are pozzolanic material that can be utilized for the development of highly durable concrete. From their experimental investigation, addition of Alccofine results in early strength gain where as Fly ash show long term strength. By using 10% of Alccofine and 30 % of fly ash maximum compressive strength of concrete can be achieved. Addition of Alccofine increase the filling ability, pass ability, flow ability, pump ability and reduced the segregation and bleeding due to its optimized particle size distribution. It is also an economical solution for higher grade concrete as the relative cost of Alccofine is cheap when compared to cement.

3. CONCLUSION

This paper presents a review on the effect of Coconut shell and Alccofine on the properties of concrete. It was found that

addition of Coconut shell reduces the strength of concrete, but with the addition of SCM as a partial replacement for cement, the strength reduction can be compensated. Alccofine is a pozzolanic material that can be used to replace cement to increase the strength of concrete. From the literature review, the optimum replacement of coarse aggregate with coconut shell was 10% and cement with alccofine was 10% to develop a durable concrete with comparable strength. If the percentage level of alccofine is increased beyond optimum level, it acts as a filler material and yields good workability to the concrete.

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