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SUITABILITY OF AGRICULTURAL WASTE PRODUCT (PALM KERNEL SHELL) AS COARSE AGGREGATE IN CONCRETE: A REVIEW

[*]Asuzu C. C.[a] , C. D. Okereke[b], S. N. Asoegwu[c], P. I. Nwachukwu[d]

[a,b,c] Department of Agricultural/Bio resources Engineering, Federal University of Technology, Owerri, Imo State, Nigeria

[d] Department of Agricultural/Bioenvironmental Engineering, Imo State Polytechnic, Umuagwo-Ohaji, Imo State, Nigeria

phone: +2348038762461

ABSTRACT

In the construction industry, the rising cost of building construction materials is a factor of great concern. The prices of building materials are rising as the days go by. The coarse aggregates are the main ingredients of concrete. In this paper, the suitability of agricultural waste product (palm kernel shell) as a coarse aggregate has been discussed based on the results got from comprehensive review of literature. The aim of every builder is that the buildings must be strong and should be built with the construction material of reasonable rates. Every construction industry totally relies on cement, sand and aggregates for the production of concrete. These days, most of the researchers are researching on the material which can reduce the cost of construction as well as increase the strength. Some of the waste materials are used in concrete according to their properties. For instance fly ash, rice husk, slag and sludge from the treatment of industrial and domestic waste water have been found suitable as partial replacement for cement in concrete. The palm kernel shell is a material which can be a substitute for aggregates. The palm kernel shell is mostly used as a source of activated carbon. The use of palm kernel shells can also help in the prevention of the environment and also help economically. It also contributes to sustainable construction. The aim of this paper is to create awareness about the usefulness of palm kernel shell as a construction material in the construction environment.

Keywords: Concrete; Agricultural Waste; Palm kernel Shells; Usefulness;

1. Introduction

The construction industry relies heavily on conventional materials such as cement, granite and sand for the production of concrete. The high and increasing cost of these materials has greatly

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hindered the development of shelter and other infrastructural facilities in developing countries. There arises the need for engineering consideration of the use of cheaper and locally available materials to reduce the construction cost for sustainable development (Usman *et al.*, 2012).

Historically, agricultural and industrial wastes have created waste management and pollution problems. However, the use of agricultural and industrial wastes to complement other traditional materials in construction provides both practical and economic advantages. The wastes generally have no commercial value and being locally available, transportation cost is minimal (Chandra and Berntsson, 2002). Agricultural wastes have advantages over conventional materials in low cost construction (Abdullah, 1997). The use of waste materials in construction contributes to conservation of natural resources and the protection of the environment (Osei and Jackson, 2012).

The palm oil industry and rice mills produce wastes such as palm kernel shells, palm oil fibres and rice husk respectively which are usually dumped in the open thereby impacting the environment negatively with no economic benefits.

2. Definitions of concrete

Concrete is an artificial material similar in appearance and properties to some natural lime stone rock. It is a man made composite, the major constituent being natural aggregate such as gravel, or crushed rock, sand and fine particles of cement powder all mixed with water. The concrete as time goes on through a process of hydration of the cement paste, producing a required strength to withstand the load (Maninder and Manpreet, 2012). Concrete is defined in student Encarta as a mixture of sand, cement, aggregate and water in specific proportions that hardens to a strong stony consistency over varying length of time. The aggregate in this context refers to rock particles of size above $5mm^2$.

American concrete institute also sees concrete as an engineering material made from a mixture of Portland cement, water, fine and coarse aggregate and small amount of air.

Olanipekun (2006) defines concrete as a composite material consisting of a binding medium within which the particles are embedded.

Other scholars also define concrete as a combination of aggregates and a paste composed of a Portland cement and water. The aggregate refer to sand and gravels or crushed stones (Mannan and Ganapathy, 2002).Concrete is a widely used construction material in civil engineering projects throughout the world for the following reasons: It has excellent resistance to water, structural concrete elements can be formed into a variety of shapes and sizes and it is usually the cheapest and most readily available material for the job (Olanipekun, 2006).

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3. RESEARCH FINDINGS

Attempts have been made by various researchers to reduce the cost of concrete constituents and hence total construction cost by investigating and ascertaining the usefulness of materials which could be classified as agricultural or industrial waste. Some of these wastes include sawdust, pulverized fuel ash, palm kernel shells, rice husk and ash, slag, fly ash which is produced from milling stations, thermal power station and waste treatment plants (Usman *et al.*, 2012, Kumar *et al.*,2012).

The market inflationary trend and the constituent materials used for concrete have led to high cost of construction (Ndoke, 2006).

The market inflationary trend and the constituent materials used for concrete have led to high cost of construction (Ndoke, 2006). In the same write up, an assessment was carried out on the performance of palm kernel shells as a partial replacement for coarse aggregate in asphalt concrete. It was concluded that palm kernel shells could be used up to 30% in asphalt concrete production. Falade (1992) also investigated into the sustainability of palm kernel shells as aggregate in light and dense concrete for structural and non-structural purposes. He concluded that, palm kernel shell could be used as an aggregate up to 45% in the production of light and dense concrete. As palm kernel shells perform creditably when partially replaced in concrete production, it is anticipated that it could be fully used as lightweight coarse aggregate in concrete production.

Olutoge (1995) in his investigations into the physical properties of rice husk ash, sawdust and palm kernel shell found their bulk densities to be 530kg/m^3, 614kg/m^3 and 740kg/m^3 respectively. He concluded that these materials had properties which resembled those of lightweight concrete materials. In his findings, it is clearly indicated that palm kernel shells could be used as lightweight coarse aggregate as its bulk density affirms its viability.

Sisman *et al.* (2011) investigated the effects of organic waste (rice husk) on the concrete properties for farm buildings and found that the unit weight of the concrete samples produced varied between 1797 and 2268 Kg/m^3, when the rice husk amount in the mixture was greater than 15%, concrete could be classified as lightweight concrete with respect to their unit weights, the compressive strengths of the samples at days 7 and 28 ranged from 15.2-31.3 Mpa and 18.1-37.5 Mpa, respectively and the water absorption of the samples on day 28 varied between 3.02 and 5.48%, and the use of rice husk as an aggregate replacement increased the water absorption.

Olanipekun (2006) investigated the properties of coconut shells and palm kernel shells as coarse aggregates in concrete. The coconut shells were crushed and substituted for conventional coarse aggregates in gradations of 0%, 25%, 50%, 75% and 100%. Two mix ratios (1:1:2) and (1:2:4) were used respectively. He noted that the compressive strength of the concrete decreased as the

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percentage of the shells increased in the two mix ratios. However, concrete obtained from coconut shells exhibited a higher compressive strength than palm kernel shell concrete in the two proportions. His results also indicated a 30% and 42% cost reduction for concrete produced from coconut shells and palm kernel shells respectively. He concluded that coconut shells were more suitable than palm kernel shells when used as substitute for conventional aggregates in concrete production.

In Nigeria, Okafor (1988) conducted further study on using Palm kernel shell as coarse aggregate and found out that, the weight of the concrete produced with palm kernel shells is similar to normal weight concrete. Water cement ratio affects the mechanical properties of palm kernel shell-aggregate concrete. The 28-day compressive strength of Palm kernel shell concrete varied between 5 and 25 Mega Pascal (MPa) based on mix design. Subsequently, other researchers (Okpala, 1990a; Olanipekun, 2006; Mannan and Ganapathy, 2002; Alengaram *et al.*, 2008; Jumaat *et al.*, 2009) investigated physical, mechanical and structural properties of Palm kernel shell and have shown its behaviour similar to that of normal weight concrete.

From the previous studies done by the other researches, it has been found that, the air-dry density of the Palm Kernel Shell Concrete was in the range of 1725 to 1900 kg/m3 (Okafor, 1988; Mannan and Ganapathy, 2002; Olanipekun, 2006; Alengaram *et al.*, 2008; Jumaat *et al.*, 2009). However, the compressive strength was found between 5 and 25 MPa. Though the compressive strength of Palm Kernel Shell Concrete fulfils the requirement for lightweight concretes, higher strength of about 30 MPa is preferred for medium strength structural members. The smooth surfaces of Palm Kernel Shell resulted in weaker bond, which in turn affected the mechanical properties. Thus, Palm Kernel Shell Concrete produced compressive strength of about 20 to 25 MPa (Mannan and Ganapathy, 2002; Olanipekun, 2006).

Osei and Jackson (2012) in their experimental study on palm kernel shells as coarse aggregates in concrete used crushed granite of size 20mm. The shells were flushed with hot water to remove dust and other impurities that could be detrimental to concrete and then sun-dried before being packed in plastic sheets to prevent contact with water. The two mix ratios 1:2:4 batched by volume and 1:2:4 batched by weight. The percentage replacements of the aggregates by palm kernel shells were 0%, 25%, 50%, 75% and 100% by volume and by weight respectively. They found that there exists a high potential for the use of palm kernel shells as aggregates in the manufacture of lightly reinforced concrete. Palm kernel shell concrete batched by volume replacement or weight replacement of coarse aggregate with palm kernel shells show similar trends in the variation of density, workability and strength with increase in percentage replacement. Also palm kernel shell concrete batched by volume performed better than that batched by weight and replacement of 8% crushed granite by palm kernel shells in volume-

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batched concrete can be used in reinforced concrete construction whereas replacement of 13% if crushed granite in weight-batched concrete can be used in reinforced concrete construction.

Williams *et al.* (2014) in their work titled "Sustainability of palm kernel shell as concrete aggregate in lightweight concrete production found that properties of palm kernel shells fresh concrete are excellent, workable, consistent and easily placed. And that hardened palm kernel shell concrete developed sufficient strength that will help make it suitable for a wide range of uses. However, the flexural and compressive strength values of the normal weight concrete is about twice that of the palm kernel shells which is normal as palm kernel shell is lighter. They concluded that palm kernel shell concrete is useful as coarse aggregate where they are abundant in order to reduce the cost of building construction.

4. DISCUSSION

Use of palm kernel 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. The construction industries have identified many artificial and natural lightweight aggregates that have replaced conventional aggregates thereby reducing the size of structural members. This has brought immense change in the development of high rise structures using Light weight concrete. Palm kernel shells are not commonly used in the construction industry but are often dumped as agricultural wastes. Palm kernel shells Concrete can be used in rural areas and places where palm kernel is abundant and may also be used where the conventional aggregates are costly. Palm kernel shells concrete is also classified as structural lightweight concrete. It is concluded that the palm kernel Shells are more suitable as low strength-giving lightweight aggregate when used to replace common coarse aggregate in concrete production.

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