Sawdust Types Effective as Partial Replacements of Fine Aggregate in Concrete

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Abstract

The paper examined the types of sawdust suitable as partial replacements of fine aggregate in concrete. Two different types of sawdust sourced from Afara and Doka wood species were used for the experiment. DoE Method was used to design and produce three sets of concrete cube samples, i.e. Control concrete, Doka sawdust concrete and Afara sawdust concrete, each of grade 20. The cubes were subjected to compressive strength and water absorption tests. The result showed that, the control concrete, Doka and Afara sawdust concretes gained a compressive strength of 22.6 N/mm^2, 19.6 N/mm^2 and 17.6 N/mm^2, respectively. The control and Doka sawdust concretes exhibited low water absorption when compared with Afara sawdust concrete. This revealed Doka sawdust as more suitable than Afara sawdust for partial replacement of fine aggregate in concrete.

***Key Words**: Concrete, Sawdust, waste recycling.*

Introduction

Overall relevance of concrete in virtually all civil engineering practice and construction work cannot be over emphasized (Adewuyi & Adegoke, 2008). Concrete is a combination of cement, fine and coarse aggregates and water (Agbede & Menessh, 2009). The construction industry relies heavily on these materials for the production of concrete. The availability of river sand for the preparation of concrete is becoming scarce due to non-scientific method of mining the river beds (Mageswari & Vidivelli, 2010).

The consumption of sand as fine aggregate in concrete production is very high and several developing countries have encountered some challenges in the supply of sand in order to meet the increasing need of infrastructural development in recent years (Divakar, Manjunath & Aswath 2012). Therefore, the depletion of fine aggregate is a challenge to engineers and researchers to seek and develop new material relying on renewable resources or locally available materials (Murali & Ramkumar, 2012). Some of these local materials are industrial or agricultural wastes which include sawdust, coconut and palm kernel shells among others.

Sawdust is an industrial waste in the timber industry which constitute nuisance to both health and environment when not properly managed (Elinwa & Abdulkadir, 2011). The use of sawdust as substitution for natural sand might be the right choice as an aggregate in concrete. It can considerably reduce dumping problem and simultaneously helps in the preservation of natural aggregate. In Nigeria, some of the common wood species that are used for various construction works from which sawdust is generated are Afara *(Terminalia Superba)* and Doka *(Melicia Excelsa)* (Kayode & Ogunwole, 2011). This paper assessed the influence of Doka and Afara sawdust as partial replacement of fine aggregate in concrete

Materials and Methods

The binder used for this research was ordinary Portland cement (Dangote brand). Natural river sand of 2.36 mm maximum size and crushed granite stone of 20 mm maximum size were used as fine and coarse aggregates respectively. Clean tap water fit for drinking was used for mixing the materials. The two different types of sawdust (Doka and Afara Sawdust) were obtained from local timber cutting shed in Zaria. The sawdust was sieved, washed and dried under sun before use. Cement, sand, coarse aggregate and water used were in conformity with BS EN 197-1 (2011), BS EN 12620 (2013) and BS EN 1008 (2002), respectively.

Mix Proportion

DoE method of mix design was used to determine the mix proportions that were used for the production of concrete samples. The mix proportions are presented in Table 1.

Table 1: Mix Proportion of Concrete Samples

Concrete Samples	Cement Kg/m^3	Sand Kg/m^3	Doka wood Sawdust Kg/m^3	Afara wood Sawdust Kg/m^3	Coarse aggregate	Water content Kg/m^3	W/C ratio
Control	383	766	-	-	1390	191.5	0.5
Doka Sawdust Concrete	383	612.8	153.2	-	1390	191.5	0.5
Afara Sawdust Concrete	383	612.8	-	153.2	1390	191.5	0.5

Samples Preparation

Three sets of grade 20 concrete (Control; 20% Afara sawdust; and 20% Doka Sawdust) were produced. The 20% Doka and 20% Afara Concrete samples were produced by replacing 20% of fine aggregate. Cube molds of 100 x 100 x 100 mm were used to produce the concrete samples. After curing up to 28 days, the samples were tested for compressive strength and water absorption.

Results and Discussion

Physical Properties of Aggregates

Table 2: Physical Properties of Aggregates

Property	Fine Aggregate	Coarse Aggregate	Doka Sawdust	Afara Sawdust
Specific Gravity	2.7	2.55	1.2	1.25
Bulk Density	1585 kg/m^3	1540 kg/m^3	640 kg/m^3	365 kg/m^3
Water Absorption	2.5%	1.67%	2.7%	2.85%

Table 2 present the physical properties of fine and coarse aggregates; and Doka and Afara sawdust. It can be seen that, the fine and coarse aggregates have densities of

1585 kg/m^3 and 1540 kg/m^3 respectively, which fall within the range of normal aggregate (1520-1680 kg/m^3) as classified by Mehta and Monteiro (2014). The Doka and Afara Sawdust have densities of 640 kg/m^3 and 365 kg/m^3 which fall within the category of light weight aggregate (< 1120).

In terms of water absorption, fine aggregate, coarse aggregate, Doka and Afara sawdust have water absorptions of 2.5%, 1.67%, 2.7% and 2.85% respectively. This means that, Doka and Afara sawdust have higher water absorption than fine and coarse aggregates.

Compressive Strength

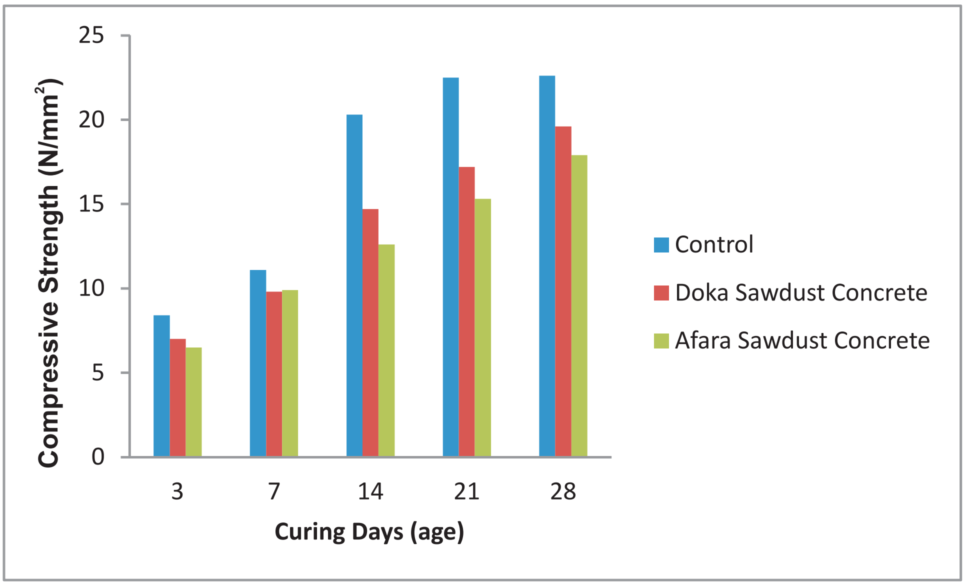

Figure 1. Compressive strength of the Concrete Samples

Figure 1 shows the compressive strength of the concrete samples. It is clear hat, the compressive strength of the concrete samples increased with age. However, the control concrete shows higher strength than Doka and Afara sawdust concrete samples. But the Doka sawdust concrete compares with that of control concrete. At 28 days the control concrete has a compressive strength of 22.6 N/mm^2 while the Doka and Afara sawdust concrete samples have compressive strengths of 19.6 N/mm^2 and 17.9 N/mm^2 respectively. This means that, the control concrete has higher compressive strength than Doka and Afara sawdust by 13.3% and 20.8% respectively. The variation in compressive strength could be attributed to the density of the sawdust as presented in Table 2.

Water Absorption

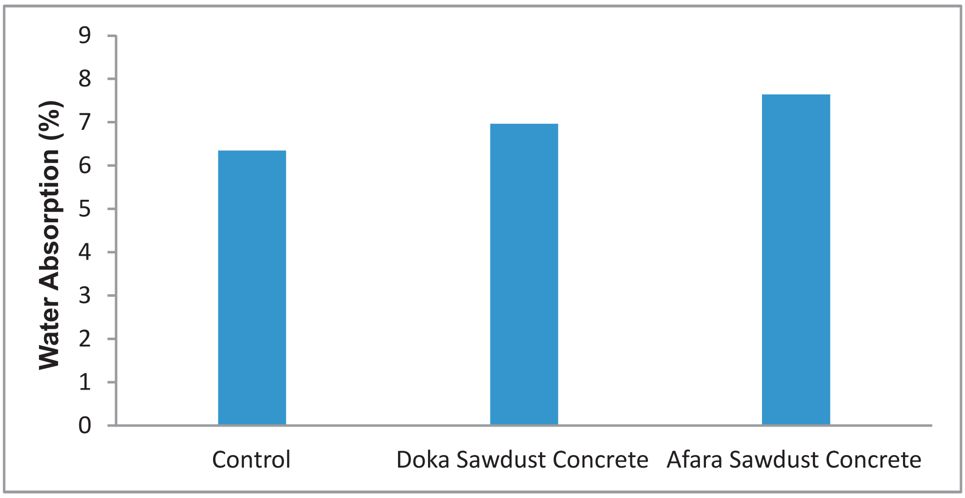

Figure 2. Water Absorption of Concrete Samples

Figure 2 present the water absorption of the concrete samples. The control concrete, Doka and Afara sawdust concrete samples have water absorption of 6.35%, 6.97% and 7.61% respectively. Afara Sawdust concrete samples have higher water absorption than the control concrete and Doka sawdust concretes by 17.42% and 9.36% respectively. This could be attributed to high water absorption capacity of the Afara Sawdust.

Conclusion

Experimental confirmation of sawdust types suitable as partial replacements for fine aggregate in concrete was done by subjecting concrete cubes to compressive strength and water absorption tests. The optimum level of fine aggregate replacement by sawdust in concrete was 20%. Doka sawdust was more suitable than Afara sawdust as partial replacement of fine aggregate in concrete as it showed higher strength and low water absorption when compared with Afara sawdust concrete.

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