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Fracture Behaviour Of Concrete With Sawdust Replacementunder Uniaxial Compressive Loading

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Abstract :

The mechanical strength of concrete made from Ordinary Portland Cement with sawdust replacement has been studied in this paper. The percentage replacements of aggregates by sawdust were 0 %, 25 %, 50 %, 75 % and 100 %. The size of the test sample concrete adopted was 400 mm x 200 mm x 100 mm. The concrete was mixed, placed and compacted. The samples were removed from their moulds after 24 hrs and allowed to cure for 7, 14 and 28 days as required. Compressive and Flexural tests were performed on the test samples. Results show that the flexural strength of the concrete increases as the curing days increase but decreases as the percentage of sawdust increases. The compressive strength also decreases as the percentage of sawdust increases. As the number of curing day increases and the percentage of sawdust decreases, the harder and stronger the concrete produced becomes. Optimum replacement of sand with sawdust was found to be 20 % which satisfies the BS 1881 Part 4 (1970) code requirements for strength.

Keywords :*Ordinary Portland cement, mechanical strength, concrete, sawdust, compressive strength, flexural strength, curing day.*

1.Introduction

Egyptians used straw in making mud bricks 1200-1400 BC **(Exodus 5:7)** but cement, granite and sand have been the popular materials for the production of concrete by the construction industry nowadays. Concrete as is well known is a heterogeneous mix of cement, water and aggregates. In its simplest form, concrete is a mixture of paste and aggregates. The presence of crack in structure changes its dynamic characteristics (Akinwonmi and Adzimah, 2012) .The admixtures may be added in concrete in order to enhance some of the properties desired specially. These materials are very expensive and have hindered the development of shelter and other infrastructural facilities in developing countries. There arises the quest for engineering consideration and replacement with cheaper and locally available materials to meet this need in order to reduce construction cost, maximise resources and explore the economic values of these materials for sustainable development. Timber is one of the oldest structural materials used by man. Temples and monuments built several years ago, which still remain in excellent condition show the durability and usefulness of timber (Kullkarni, 2005). And the product from timber conversion is sawdust**.** Sawdust can be defined as loose particles or wood chippings obtained as by-products from sawing of timber into standard useable sizes. Approximately half of the log volume can be converted into timber during a sawing process, the rest of the log volume is converted into chips, sawdust and bark. The quality of sawdust depends on the saw type, method of sawing, type of tree used, and the storage method of logs including temperature, moisture and season. Thus, sawdust from different mills can be very heterogeneous raw materials. (Risto Korpinen, 2010). The quality of sawdust is mainly dependent on the particle size of sawdust. The particle size of sawdust is not uniform and the distribution is usually concentrated on the smallest size fractions. (Korpinen and Fardim 2006; Bergström et al. 2008). Sawdust is one of the major underutilized by-products from sawmilling operations in Ghana. The underlying reasons for the inefficiency and waste in the saw milling industry included the use of inappropriate processing technologies, poor maintenance of sawmill machinery, poor management and lack of proper technical skills by the sawmill operators. Portland cement is commonly used in the manufacture of panel products as a binder. Wood to cement ratio, shape and size of the wood particles affect the strength and suitability of the composites (Sorfa 1984; Wolfe and Gjinolli, 1999). Cement wood particle-boards have been found to be good substitutes for hollow concrete blocks, plywood, particleboard and other resin bonded boards. It is a very versatile material that can be used as eaves, exterior wall, ceiling, partition wall, flooring, cladding and even roofing provided that proper coating is applied and wire meshes imbedded to enhance the interlocking capacity especially for longer spans. (Zziwa1 et al. 2006). The high dimensional stability exhibited in cement bonded boards is because the wood particles are encased in a cement matrix and are restricted in hydro-expansion (Hachmi et al, 1990). To improve the properties of cement, admixtures are added with it and these are either naturally occurring compounds or chemicals produced in industrial process. Most admixtures are pozzolans. A pozzolan is a powdered material, which when added to the cement in a concrete mix reacts with the lime, released by the hydration of the cement, to create compounds which improve the strength or other properties of the concrete (King, 2000; Lohita et al, 1995). The produced saw dust from the milling plants constitutes waste and pollution in our environments. When burnt or used as a fuel, it also contributes to pollution and efforts are being made to overcome this environmental issue by utilizing this material as a supplementary reinforcement in concrete. Finding an appropriate use of sawdust would help to offset production costs and increase the profitability of sawmilling operations in Ghana's plantation forests.

Therefore, the objective of this research is to investigate into the mechanical strength of concrete when sawdust is used as reinforcement in order to solve the disposal problem, ascertain their suitability as replacement for aggregates in production of reinforced concrete and enhance their economic value.

2.Materials And Methods

2.1.Materials

2.1.1.Sawdust

The sawdust was sourced from planks sawmill in Tarkwa, Ghana. The sawdust consisted of chippings from various hardwoods. It was sun dried and kept in waterproof bags.

2.1.2.Cement

Ordinary Portland® Cement (OPC) conforming to ASTM C 150 type I was used for this study, its chemical and physical properties is given in Table 1.

Material	OPC
SiO_2 (%)	20.99
Al_2O_3 (%)	6.19
Fe_2O_3 (%)	3.86
CaO (%)	65.96
MgO (%)	0.22
Na_2O_3 (%)	0.17
K_2O (%)	0.6
Specific Gravity	2.95

Table 1: Chemical Compositions Of The Raw Material Used

2.1.3.Water

Potable water was used for the study and was obtained from a borehole. The water was clean and free from any visible impurities. It conformed to BS3148 (1980) requirements.

2.1.4.Sand

The sand was sourced from University of Mines and technology, Tarkwa in Ghana. It was sieved and thoroughly flushed with water to reduce the level of impurities and organic matter in conformity to the requirements of BS 882(1982) and finally sun dried for about 72 hours.

2.1.5.Materials Mixing

Batching of materials was done by weight. The percentage replacements of aggregates by sawdust were 0 %, 25 %, 50 %, 75 % and 100 %.This was done to determine the proportion that would give the most favourable result. The 0% replacement served as control for other sample.

Sawdust replacement (%)	**Mass of Concrete** (kg)		
	Cement	**Sawdust**	**Sand**
0	7. 200	-	15.32
25	7. 200	4.07	10.25
50	7. 200	6.17	8.15
75	7. 200	10.22	5.10
100	7. 200	15.32	-

Table 2:Masses Of Constitutions For Sawdust Replacement

3.Test Samples

The size of the test sample concrete adopted was 400 mm x 200 mm x 100 mm. The concrete was mixed, placed and compacted. The samples were removed from their moulds after 24 hrs and allowed to cure for 7, 14 and 28 days as required.

3.1.Compressive Test

The compression tests for the concrete cubes were carried out at the University of Mines and technology, Tarkwa in Ghana. Standard test procedures were used for the experiment. Before the commencement of the test, all specimens were weighed and the results recorded and at the time of each respective test. The weight was measured for each sample specimen for each saw dust percentage (0 %, 20 %, 40 %, 60 %, 80 % and 100 %.) and for the number of days for setting of the concrete block cubes (7, 14 and 28). A constant uniform pressure was applied by the testing machine to the cubes of the concrete blocks until failure occurs. Cracks were initially noticed on the specimen and the cracks propagated until failure was finally observed when the cube no longer could resist the force applied to it without breaking apart.

3.2.The Flexural Test

The flexural test on the test samples was carried out with the automatic Techno Test Flexural machine. The samples were weighed before the test being put in the flexural machine. The load was applied and increased until failure. The machine automatically stops when failure occurs, and then displays the load and the flexural strength was evaluated.

4.Results And Discussion

The chemical composition of Ordinary Portland® Cement (OPC) shown in table 1 conforms to ASTM C 150 type. Table 2 presents the masses of constitutions for sawdust replacement(0 %, 25 %, 50 %, 75 % and 100 %).

The results of the Compressive and Flexural experiments performed on the test samples are presented in table 3 with the various percentages of saw dust and different number of days for curing.

% Sawdust	**7 days**		**14 days**		**28 days**		
	Weight (kg)	**Flexural strength** (N/mm^2)	**Weight** (kg)	**Flexural strength** (N/mm^2)	**Weight** (kg)	**Flexural strength** (N/mm^2)	**Comp. strength** (N/mm^2)
0	35.80	1.25	30.10	1.46	28.20	1.75	18.5
20	31.45	1.19	28.90	1.33	26.25	1.60	15.9
40	29.65	0.89	25.16	0.97	23.50	1.12	9.5
60	25.10	0.64	21.85	0.78	19.30	0.81	7.8
80	15.30	0.49	12.40	0.61	10.25	0.75	6.5
100	10.45	0.35	9.60	0.42	8.50	0.60	4.2

Table 3: Flexural And Compressive Strength Of Slabs With Various Percentage Of Sawdust And Days Of Cure

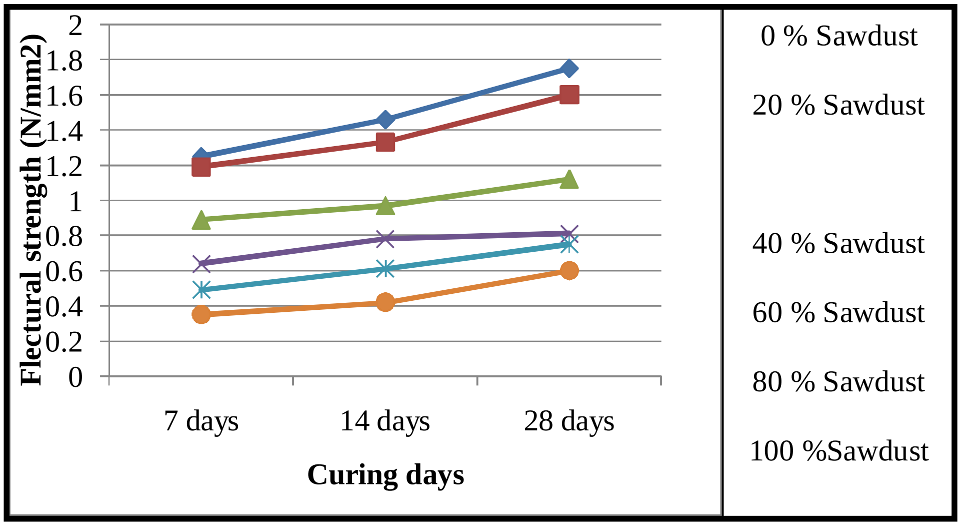

Figure1: Graph Of Flexural Strength Against Curing Days

It is clearly interpreted on table 2 that as the percentage of sawdust increases, the weight of concrete decreases, this may not be far from the density of sand being greater than that of sawdust, the weight also decreases as the number of curing days increases because water is being removed from the concrete as they become drier. The flexural strength of the concrete increases as the curing days increase but decreases as the percentage of sawdust increases as shown on fig.1. The compressive strength decreases as the percentage of sawdust increases. As the number of curing days increases and the percentage of sawdust decreases, the harder and stronger the concrete produced. This means curing days and the percentage of sawdust replacement influence the strength of concrete produced. Optimum replacement of sand with sawdust was found to be 20 % which satisfies the BS 1881 Part 4 (1970) code requirements for strength.

5.Conclusion

The strength of the composite bricks is considerably low therefore cannot be for high strength external construction. They can only be used for non-structural purposes e.g. roadside kerb construction. Their structural rigidity is also affected by damp conditions. Their densities and weights are generally low; this can reduce overall weight of the construction.

6.Recommendations

Further study should be done on other strength properties of sawdust/cement composites such as bending strength, modulus of elasticity, modulus of rigidity, durability and possibilities of reinforcing sawdust.

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