EFFECT OF NEEM SEED HUSK ASH ON THE WORKABILITY OF CONCRETE

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Abstract

The production of neem products from neem tree generates large quantity of waste annually. This paper is aimed to examine the effect of Neem Seed Husk Ash (NSHA) on workability of concrete. Neem seed husk was obtained from Bishop Smith Memorial College, Ilorin, sun – dried for 3 days and then calcinated at 650^o C. The calcinated neem seed husk was ground and sieved using 200 μm sieve to obtain NSHA. Pozzolanicity test was conducted on NSHA to determine its chemical composition. Concrete was produced with 5, 10, 15, 20 and 25% by weight of NSHA substitution for cement. Workability tests (slump and compacting factor) were performed for each percentage replacement. Compressive and tensile strength tests were conducted on 150 mm cubes and 150 x 150 x 760 mm beams, respectively at ages 3, 7, 14, 21, 28, 56, 90 and 180 days. All tests carried out were in accordance with British Standard codes. The chemical composition of NSHA showed that the combination of Al_2O_3, SiO_2 and Fe_2O_3 was 75.35%. The slump and compacting factors of NSHA concrete ranged from 5.50 mm to 10.00 mm and 0.91 to 0.95, respectively.

Key words: Neem, Pozzolanicity, Workability, Slump, Compacting factor.

1. Introduction

The present society has shown increasing interest in the use of new materials in place of traditional products. This is aimed at reducing the latter's environmental impact. The search for alternative binders or cement replacement materials has continued in the last three decades. From the economical, technological and ecological points of view, cement replacement materials play an undisputed role in the construction industry. Small amounts of inert fillers have always been acceptable as cement replacement. If the fillers have pozzolanic properties, they impart not only technical advantages to the resulting concrete but also enable larger quantities of cement replacement to be achieved (Khandaker and Anwar 2003).

According to Day (1990) the use of pozzolanic materials, some of which are industrial by-products, reduces natural resources that are used in the production of cement, mortar and concrete. About half of the amount of Portland cement consumed in building construction is used in masonry and plastering. Illston and Domone (2001) reported that in those products i.e. silica fume, fly ash, rice husk, palm oil fuel ash e.t.c, the maximum potential strength developed by the cement is never fully utilized.

Olusola and Adesanya (2004) in their report stated that it is of great importance to make provision for affordable building materials and adequate housing for the teaming populace of the world, especially those in developing nations of the world. It is evident that the cost of building materials is getting outside the reach of the teeming populace who are below the poverty line. Hence, the need to find alternative local materials that can serve the same purpose in the provision of low cost buildings in both the rural and urban areas. Astronomical hike in price of conventional building materials is one of the constraints to the delivery of the much desired housing for all in Nigeria. This study focuses on Portland cement, which is one of the most widely used building materials.

Neem Seed Husk is a by-product obtained during industrial processing of Neem Seed to extract oil and produce fertiliser. In producing Neem based fertilizer, extraction of neem oil is done first, and the resultant cake (which consists of grinded seed and husk) is used in making organic based fertilizer. Little quantity of Neem seed husk is crushed and grinded into fertilizer formulation while the remaining large quantity usually lay as waste. Neem Seed husk ash is obtained by burning the Neem seed husk which comes from the Neem tree (*Azadirachta indica*).

2. Methodology

Pozzolanicity test**:** Pozzolanas are materials containing reactive silica and / or alumina which on their own have little or no binding property but, when mixed with lime in the presence of water, will set and harden like cement. They are an important ingredient in the production of an alternative cementing material to Ordinary Portland Cement (OPC). Pozzolanas, by their diverse and varied nature, tend to have widely varying characteristics. The chemical composition of pozzolanas varies considerably, depending on the source and the preparation technique. Generally, a pozzolana will contain silica, alumina, iron oxide and a variety of oxides and alkalis, each in varying degrees. The pozzolanicity test of NSHA is to determine the presence and percentage composition of chemical compounds such as SiO_2, Al_2O_3, Fe_2O_3, SO_3, MgO and CaO using the X-Ray Flourescent Analyser (X.R.F.).

Sieve analysis**:** According to Khandaker and Anwar (2003) the process of dividing a sample of aggregate into fractions of the same particle size is known as sieve analysis, and its purpose is to determine the grading or size distribution of the aggregate. A sample of air dried aggregate is graded by shaking or vibrating a nest of stacked sieves, with the largest sieve at the top, for a specified time so that the material retained on each sieve represents the fraction coarser than the sieve in question but finer than the sieve above, thus concrete is a true composite material. The grading of aggregates (fine and coarse) as well as NSHA was done according to specifications (BSI, 1975).

Workability tests**:** According to Gupta and Gupta (2004) workability of concrete is the amount of useful internal work necessary to produce complete full compaction. The useful internal work is a physical property of concrete alone and is the work of energy required to overcome the internal friction between the individual particles in the concrete. Factors affecting the workability of concrete are: the water content of the concrete, grading of aggregate, size of aggregate, the consistence of the concrete mix, and weather conditions (Vazirani and Chandola, 2010).

Concrete slump test: Neville (2003) described concrete slump test as an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed in accordance with the requirements of BSI 1970 to check the consistency of freshly made concrete. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete. It refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It is also used to determine consistency between individual batches (Theodore 2005). The test is popular due to the simplicity of apparatus used and simple procedure. Unfortunately, the simplicity of the test often allows a wide variability in the manner that the test is performed. The slump test is used to ensure uniformity for different batches of similar concrete under field conditions and to ascertain the effects of plasticizers on their introduction. The test is carried out using a mould known as a slump cone

Compacting factor test: According to Theodore (2005), compacting factor of fresh concrete is done to determine the workability of fresh concrete. The degree of compaction called the compacting factor is measured by the density ratio i.e. the ratio of the actual achieved in the test to the density of the same concrete fully compacted done in accordance with BSI (1975). The apparatus used is the compacting factor apparatus. Compacting factor is calculated using equation

$$CF = \frac{W_p}{W_f}$$

Where CF = Compacting Factor, W_p = Weight of partially compacted concrete (Kg), W_f = Weight of fully compacted concrete (Kg)

3. Experimentation

Mix Proportion and Concrete Specimen Preparation: The concrete mix ratio of 1:2:4 (cement and Neem seed husk ash: sand: granite) with water/binder ratio of 0.70 was used in the production of concrete. The cement replacement with Neem seed husk ash was at 5%, 10%, 15%, 20% and 25% by weight of cement. Concrete without NSHA serves as the control. Batching of the concrete was by weight.

Specific Gravity test: This test was performed to determine the specific gravity of cement and NSHA by using a pycnometer.

Water absorption test: The pore structure of concrete is known to be of high importance for the durability of the material. A characterization of this pore structure by means of a simple test otherwise referred to as the Permeability test is often investigated in order to find a very simple compliance criterion.

Vazirani and Chandola, (2010) reflected that, just as the porosity of a soil affects how much water it can hold; it also affects how quickly water can flow through the soil. The ability of water to follow through a soil is referred to as the soil's permeability. The permeability of gravel is higher than that of clay. Permeability is defined as the coefficient representing the rate at which water is transmitted through a saturated specimen of concrete under an externally maintained hydraulic gradient which is inversely linked to durability in that the lower the permeability, the higher the durability of concrete.

Constituent	Sample 1	Sample 2	Sample 3	Average
SiO_2	69.14	69.13	69.16	69.15
Al_2O_3	2.94	2.96	2.94	2.95
Fe_2O_3	3.25	3.24	3.27	3.25
CaO	2.75	2.77	2.76	2.76
MgO	0.54	0.56	0.55	0.55
SO_3	0.42	0.43	0.41	0.42
Na_2O	0.15	0.14	0.17	0.15
K_2O	15.01	15.02	15.04	15.02
TiO_2	0.24	0.26	0.24	0.25
P_2O_5	1.01	1.01	1.01	1.01
Mn_2O_3	0.04	0.04	0.05	0.04

Table 1: Chemical Properties of Neem Seed Husk Ash (NSHA)

Pozzolanicity test: Table 1 showed the result of the pozzolanicity test carried out on Neem Seed Husk Ash (NSHA) indicating the average percentage composition of each element. The chemical constituents include Aluminium Oxide (Al_2O_3), Silica Oxide (SiO_2) and Iron Oxide (Fe_2O_3) amongst others. The combination of these three elements makes NSHA useful as a pozzolan since it summed up to 75.35% above 70%. Hence the specification of ASTM C618 for a combined Al_2O_3 + SiO2 + Fe_2O_3 of 70% or above is satisfied.

Sieve Analysis requires

$\frac{D_{60}}{D_{10}} = \frac{0.80}{0.10} = 8.0$; Coefficient of curvature $C_c = \frac{{D_{30}}^2}{D_{60}} * D_{10} = \frac{0.35^2}{0.80} * 1.0 = 1.53$

The grading curve for fine aggregate shown in Figure 1 has a regular slope. The soil is also a well graded soil since

$C_u = 8.0$, $\frac{D_{60}}{D_{10}} = \frac{13.45}{4.0} = 3.37$; Coefficient of curvature $C_c = \frac{{D_{30}}^2}{D_{60}} * D_{10} = \frac{10.20^2}{13.50} * 4.0 = 1.92$

Figure 2 shows the grading curve of the coarse aggregate and that the aggregate used is uniformly graded since the uniformity coefficient C_u is 3.37

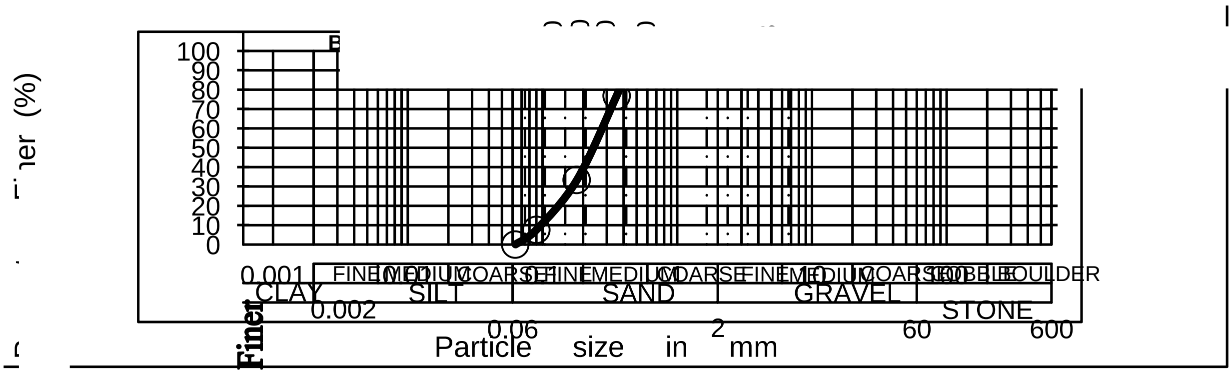

Figure 1: Grading Curve of NSHA

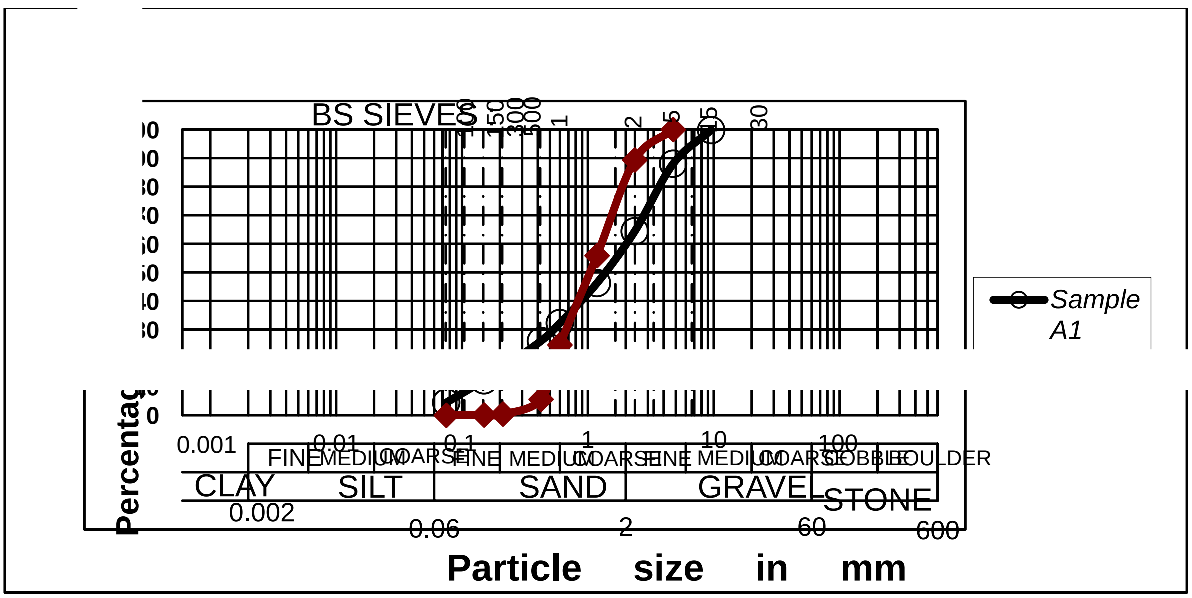

Figure 2: Grading Curves of Fine and Coarse Aggregate

Workability result of the slump and compacting factor tests are as shown in Table 2 and 3 respectively.

Table 2: Slump Result for NSHA - Concrete

% NSHA	Slump (mm)

0	10.0
5	9.82
10	9.40
15	8.20
20	6.20
25	5.50

Table 3: Compacting Factor for NSHA – Concrete

% NSHA	Mass of Cylinder (Partial Concrete (g)	Mass of Cylinder full concrete (g)	Compacting factor
0	18233	19003	0.96
5	17734	18621	0.95
10	16831	18340	0.92
15	16340	18020	0.91
20	16225	17831	0.91
25	16203	17421	0.93

Table 4 and 5 showed the Specific Gravity of Cement and NSHA respectively. The specific gravity of NSHA compared to that of cement shows that it (NSHA) is lighter in density than that of cement because of its composition. Unlike cement, it does not contain lime and other calcareous materials in its production.

Table 4: Specific Gravity of Cement

Specimen number	1	2
Pycnometer bottle number	001	002
WP = Mass of empty, clean pycnometer (grams)	79	79
WPS = Mass of empty pycnometer + dry cement (grams)	182	182
WB = Mass of pycnometer + dry cement + water (grams)	407	405
WA = Mass of pycnometer + water (grams)	335	335
Specific gravity (GS)	3.32	3.12
Average Specific Gravity	3.22	

Table 5: Specific Gravity of NSHA

Specimen number	1	2
Pycnometer bottle number	001	002
WP = Mass of empty, clean pycnometer (grams)	79	79
WPS = Mass of empty pycnometer + dry NSHA (grams)	205	206
WB = Mass of pycnometer + dry NSHA + water (grams)	385	387
WA = Mass of pycnometer + water (grams)	335	335
Specific gravity (GS)	1.66	1.69
Average Specific Gravity	1.68	

Permeability

The results of water absorption of NSH

A concrete for various percentage replacements of NSHA are presented in Table 6. It was observed that for every increment in the NSHA substitute, there is an increase in the weight of water absorbed. This may be as a result of the insufficient quantity of calcium hydroxide to react with the excess NSHA, thus creating pores in the mixture and consequently increasing the water absorption capacity of concrete.

Table 6: Permeability Result of NSHA Concrete

	Weight before immersion (kg)				**Weight after immersion (kg)**					
Percentage NSHA Substitution	Sample 1	Sample 2	Sample 3	Average	Sample 1	Sample 2	Sample 3	Average	Weight absorbed (kg)	Percentage absorbed (%)
0	2.539	2.535	2.538	2.537	2.674	2.672	2.678	2.675	0.138	5.44
5	2.546	2.538	2.544	2.543	2.670	2.665	2.710	2.682	0.139	5.47
10	2.559	2.601	2.584	2.581	2.710	2.740	2.726	2.725	0.144	5.58
15	2.564	2.625	2.597	2.595	2.731	2.768	2.753	2.751	0.156	6.01
20	2.586	2.640	2.617	2.614	2.749	2.812	2.787	2.783	0.169	6.47
25	2.590	2.670	2.636	2.632	2.793	2.870	2.832	2.832	0.20	7.60

The result of the pozzolanicity test carried out on Neem Seed Husk Ash (NSHA) indicating the average percentage composition of each element. The chemical constituents include Aluminium Oxide (Al_2O_3), Silica Oxide (SiO_2) and Iron Oxide (Fe_2O_3) amongst others. The combination of these three elements makes NSHA useful as a pozzolan since it summed up to 75.35% above 70%. Hence the specification of ASTM C618 for a combined Al_2O_3 + SiO2 + Fe_2O_3 of 70% or above is satisfied.

The grading curve of the fine and coarse aggregate used is uniformly graded.

4. Summary of Findings

It was observed from Table 4 that as the percentage of NSHA increased from 0 to 25%, the slump decreased from 10mm to 5.5mm. Similarly, the compacting factor decreased from 0.96 to 0.93 as the percentage replacement increased from 0 to 25% shown in Table 5. This decrease is as a result of increase in the stiffness of the concrete as the percentage of NSHA substitution increased. This implies that more water is required to make the concrete more workable as the percentage NSHA substitution increases (Adesanya and Raheem 2009).

The high demand for water as NSHA substitution increases is as a result of the increasing silica concentration as the NSHA in the concrete increases. Nevertheless, water-binder ratio of 0.70 was adequate to produce workable mix with true slump for all the percentages of NSHA used for the mixes. Generally, most pozzolan cement concrete has this attribute, since the silica lime reaction requires more water in addition to the water required during hydration of cement.

5. Conclusion

From the results of various tests performed, it could be concluded that:

(i). Neem Seed Husk Ash (NSHA) is a suitable material for use as a pozzolan, since it satisfied the requirement for such a material by having a combined SiO_2, Fe_2O_3 and Al_2O_3 of more than 70%.

(ii). The slump and compacting factor decreased as the NSHA content in the mixture increased for constant water cement ratio. This implies that the concrete becomes less workable (stiff) as the NSHA percentage increases.

(iii). The addition of NSHA increased the water absorption of concrete specimen.

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