INVESTIGATION OF PARTIAL REPLACEMENT OF CEMENT WITH NEEM LEAF ASH IN CONCRETE

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ABSTRACT

The economic crisis around the world, in Nigeria in particular, has led to the escalating rise in prices of building materials of which cement is inclusive. Therefore, this study aims at using Neem Leave Ash (NLA) in concrete in place of some of the cement to mitigate the impact on cement prices. Its pozzolanic properties were obtained using X-Ray Fluorescence (XRF) technique and Fourier-Transform Infrared Spectroscopy (FTIR). The Ordinary Portland cement was partially replaced by NLA at 0 %, 5 %, 10 %, 15 %, and 20% by weight. The workability, consistency and compressive strength of NLA in concrete was evaluated in the laboratory. Concrete mix design of grade C15 was adopted. Cubes of each mix design were crushed on 7 days, 14 days and 28 days to get the compressive strength. The oxide composition of Neem Leave Ash 13.53 % silicon oxide, 49.58 % calcium oxide and 4.32 % aluminum oxide. The FTRI shows OH groups of Si and Al are indicated by the bands at 3641.6 and 3391.9 cm^{-1}. Inner layer water molecules are represented by the band at 1,640.16 cm^{-1}. The outcome demonstrates that as NLA increases, the workability of the NLA concrete declines. As the percentage of cement replaced by NLA increases, the compressive strength falls. Nevertheless, after 28 days of curing, the target value of 15 N/mm^2 was reached at replacement value up to 10% NLA. Therefore, a partial replacement of 10% NLA by weight of concrete is recommended in use of neem leaf in concrete.

Keywords: Neem Leaf Ash, X-Ray Fluorescence, Fourier-Transform Infrared Spectroscopy (FTIR), Compressive Strength

1 INTRODUCTION

Using Ordinary Portland cement as a binder is very important in the construction industry. It uses a lot of energy and is created at a very high temperature [1]. In addition to consuming enormous amounts of energy, it releases toxic chemicals into the atmosphere. Wastes and by-products that would often wind up in landfills are now being used in an effort to lessen the negative environmental effects of industrial and agricultural operations [2, 3]. One of the primary building materials that is frequently utilized, particularly in developing nations, is cement, which is an element in concrete. However, the growing need for cement has made it necessary to look for substitute materials that may either completely or partially replace cement [4]. According to earlier studies, Portland cement contributes to global CO_2 emissions as well [5]. Therefore, using waste products like this will economical and have impact on environmental pollution. Concrete's high compressive strength and durability make it the most used building material. More than any other man-made substance on the planet, it is utilized in construction. The amount of cement used and the mix's water/cement ratio are the primary factors that affect concrete's strength. Concrete is made by mixing cement, fine aggregate, coarse aggregate, and water in precise amounts, depending on the type of construction. For concrete to properly hydrate and reach the required strength, it requires an appropriate environment that provides moisture for at least 28 days [6]. In concrete work, the curing phase of hydration is crucial. Inadequate or incorrect curing will negatively impact the durability and strength. Neem is a medicinal plant get oxygen fresh. Neem leave is obtained from Neem tree (Azadirachtaindica) popularly known in Hausa as "Dogonyaro" [7, 8]. Neem is easily available materials which has good chemical properties, it has high calcium content which is very important for binding property [9]. FTIR Analysis or FTIR Spectroscopy are other names for Fourier Transform Infrared Spectroscopy. Infrared light is used in the FTIR analysis procedure to scan test materials and examine their chemical characteristics. When assessing agricultural and industrially created materials [10], FTIR spectroscopy is a well-established method for quality control that is frequently used as the initial stage of the material examination procedure. It is obvious that a change in the material's composition or the presence of contamination is indicated by a change in the distinctive pattern of absorption bands. If visual inspection reveals product issues, FTIR microanalysis is usually used to identify the source. Both bigger regions on the surface and smaller particles, usually 10–50 microns, can benefit from this technique's ability to analyze their chemical makeup. The elemental composition of materials can be ascertained using this non-destructive analytical method. By detecting the fluorescence (or secondary) x-ray that a sample emits when activated by a main x-ray source, an XRF analyzer can determine the chemistry of a sample [11]. According to [12], the XRF approach may be applied generally in industrial laboratories to determine the amount of ash produced by burning biomass. By using XRF to characterize biomass, ash-forming substances and corrosive substances that can damage the machinery used in thermal conversion processes can be found. This research reviews the effect of utilizing neem leaf ash/powder as partial replacement of cement in concrete. The findings will reveal how this waste product will positively influence the strength properties of concrete.

2 METHODOLOGY

2.1 Material

The fine aggregate from a river sand free from silt and debris passing through 4.75 sieve and retained 0n 75 mi-cron (0.075 mm) was used. Coarse aggregate was finely crushed and it is not less than 20 mm. While the water was one adhering to the requirements of water for concreting and curing. The Neem leaf used was obtained from Federal polytechnic Kaura namoda environment. The cement used was Ordinary Portland of Grade 42.5 which conforms to specification for Portland cement [13].

2.2 Sample Preparation

These leaves were sun dried for a period of 2 weeks and open-air burning was carried out. The NLA was then sieved through a BS No. 200 sieve (75 µ mm) to get it in fine powdered form. The replacement of NLA with cement was partially done in a proportion of 5%, 10%, 15% and 20%. In a mixed ratio of 1:2:4 which is the mixed grade of M15.

2.3 Micro analysis and Oxide composition

The X-Ray Fluorescence (XRF) of Neem Leaf Ash passing the 75-micron sieve was carried out at the department of Chemical Engineering Ahmadu Bello University Zaria using the Thermo Fisher Model ARL 9900.

2.4 Preliminary Test carried out on the Samples

Silt and Clay Content Test was performed par Clause 7.2.5 of BS 812 -1 [14]. Consistency Test were determined using the Vicat Apparatus according to [15] standard for OPC Grade 42.5 with Neem Leaf Ash.

2.5 Workability (Slump Test)

In compliance with [16], the slump test was conducted on the freshly mixed concrete.

2.6 Compressive Strength Test

The test was conducted at the laboratory of Civil Engineering Department A.B.U Zaria in accordance with [17]. The concrete cube slated for a compressive strength test is depicted in Plate 1. The cube samples were taken out of the curing tank Plate 1 after the conclusion of the seventh, fourteenth, and twenty-eighth days of curing and left in the laboratory until the surface dried. Cube specimens were put through a compression testing machine to determine their compressive strength. The specimens were positioned perpendicular to the direction of casting under the compression testing apparatus. The loading rate is kept at 400 kg/sq. cm/min. Compressive strength is calculated as the average of three cubes.

Plate 1. concrete curing and crushing

3 RESULTS AND DISCUSSION

3.1 Oxide Composition of Cement and Neem Leave Ash

The oxide composition derived from the Neem Leave Ash Chemical Analysis is given in Table 1. The oxide composition of Neem Leaves Ash (NLA) shows that it has high calcium content [18] which is very important for binding property contains 13.53% silicon oxide, 49.58% calcium oxide and 4.32% aluminum oxide which for cement and this is an important ingredient as it imparts strength to the cement due to the formation of silicates which are responsible for the cement's mechanical properties. And since it is above 70% it is considered good pozzoloan according to ASTM C618 [19] requirements (Class N).

Table 1. Physical properties and chemical composition for Neem Leave Ash

Chemical composition oxides	Neem Leave Ash Values (%)
SiO_2	**13.53**
Al_2O_3	**4.32**
Fe_2O_3	**2.66**
K_2O	20.71
P_2O_5	0.67
SO_3	2.72
CaO	**49.58**
Cl	1.44
MgO	1.10
TiO_2	0.47

3.2 Fourier-Transform Infrared Spectroscopy (FTIR)

Spectral peak analysis is used to validate the presence of silicon hydroxides, iron oxides, and aluminum oxides [20]. Figure 1 displays the Neem leaf ash's FT-IR spectra. The OH groups of Si and Al are indicated by the bands at 3641.6 and 3391.9 cm^{-1}. Inner layer water molecules are represented by the band at 1,640.16 cm^{-1}. Hematite is indicated by the bands at 711.9 cm^{-1} (Fe–O bond stretching) [20, 21, 22]. A shift in the distinctive absorption band pattern unmistakably signifies a modification in the material's composition or the existence of contamination.

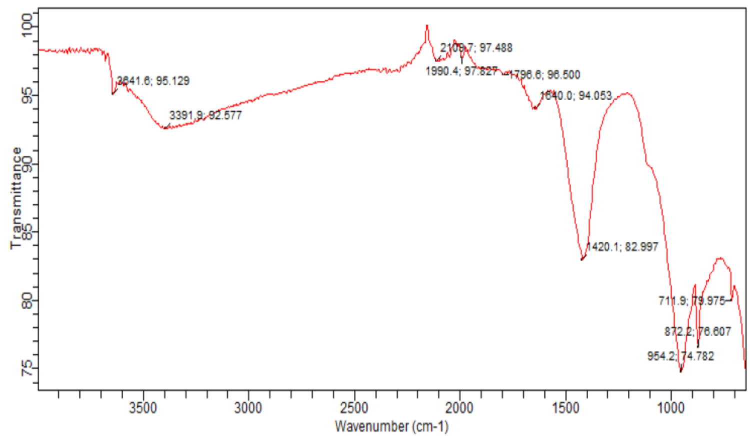

Figure 1. FTIR test result of Neem Leave Ash

3.3 Preliminary Test of the Concrete Composition

The specific gravity of the coarse and fine aggregates 2.86 and 2.27 respectively. The average ACV value obtained was 22%. This according [23] is excellent (0-30%). Therefore, the coarse aggregate has a lower crushing value and it will give a longer service life and has a more economical performance. Aggregate Impact Value of the Coarse Aggregate (AIV) obtained was 17.82%. This is exceptionally strong according [23]. Therefore, the coarse aggregate has an average impact value and can resist any sudden impact or shock which it may be subjected to. The result of the silt/clay content test on the fine aggregate obtained was 3% and the permissible silt content should not be greater than 6% which is satisfactory and can be used for any engineering works. The soundness test obtained was 2 mm this compared to [24] standards requirements of not more than 10 mm. All cement samples are within limits stated by EN. Table 2.

Table 2. Preliminary Test of the Concrete Composition

Description (Test)	Result
Specific Gravity (coarse Aggregate) kg	2.86
Specific Gravity (Fine Aggregate) kg	2.27
aggregate crushing value (ACV) %	22%
Aggregate Impact Value (AIV) %	17.82
Percentage silt	3

3.4 Slump test of the freshly made Concrete

Displayed in Table 3, is the results of the concrete's slump test and the cement's NLA replacement. It exhibits a real decline. Furthermore, the data below indicates that the droop grows steadily as the percentage of Neem leaf ash (NLA) increases. This indicates NLA causes higher demand of water and lower workability at 15% and 20% replacements. The NLA introduced into the cement increases the carbon content due to its high loss of ignition (LOI) [25] and this increases the water required to achieve a reasonable workability.

Table 3. Slump test of the freshly made Concrete

Percentage replacement of cement with Ash	Height of sample cone (cm)	Measured slump	height of Slump	Remark
0	30	0.90	29.10	True Slump
5	30	1.10	28.90	True Slump
10	30	1.00	29.00	True Slump
15	30	0.09	29.91	True Slump
20	30	0.00	30.00	True Slump

3.5 Consistency Results of Cement with Varying Replacement by NLA

The consistency of OPC Grade 42.5 for 0%, 5%, 10% and 15% NLA replacement was 32.0%, 42.5%, 42.5% and 42.5% respectively. From the results, it can be concluded that there was difference in the workability of the OPC and the replacement with the NLA. The ratio of the water used for the consistency of the OPC Grade 42.5 was 32.5% this is in accordance to [15] and for replacement with NLA was 42.5%. The requirement of water increases with the increasing percentage levels of NLA due to its very high fineness. Shown in Table 4, is the recorded setting time for cement with varying NLA percentages. Based on the findings, it can be reported that replacing cement with 5%, 10%, 15%, and 20% NLA improved the starting settings and final time. The samples take 140 to 195 minutes to set initially, and 195 to 200 minutes to set completely. Both [24] standards stipulate that the initial setting time must be more than sixty minutes. Final setting times should be fewer than 600 minutes. Nevertheless, none of the standards provide a value for the final setting time.

Table 4. Results and Setting Time of Varying Percentage by Replacement of Cement with NLA

Sample (%)		initial setting		Final setting	
	consistency %	time (minutes)	depth of penetration (mm)	time (minutes)	depth of penetration (mm)
0	32.0	140	6	195	7
5	42.5	155	6	195	7
10	42.5	170	6	195.5	7
15	42.5	180	6	195.5	7
20	42.5	190	6	198	7

3.6 Compressive Strength of the NLA and Cement Concrete mix

Illustrated in Figure 2 is the varying of compressive strength of concrete with NLA at different curing times. The overall trend is that when the percentage of cement replaced by NLA in concrete rises above 10%, compressive strength gradually declines. It is widely known that concrete rapidly loses some of its mechanical properties when neem leaf ash is added [21]. Additionally, according to [26] this can be explained from the reduction of the quantity of cement and by implication CaO in the mix. However, using the BS-8500-2 C15 concrete grade mix ratio, the target value of about 15 N/mm^2 was reached at replacement value up to 10% NLA for a 28-day curing period.

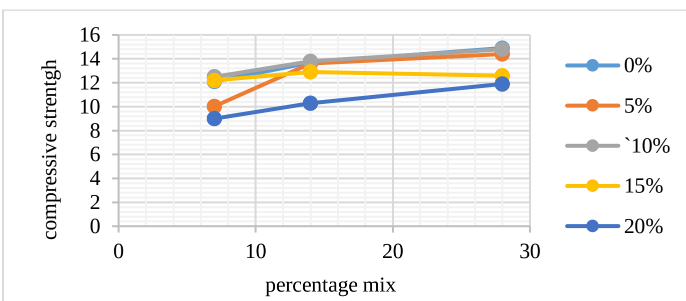

Figure 2. Average compressive strength of NLA and cement concrete mix of varying percentages

4 CONCLUSIONS

The following conclusion can be drawn: Neem leave Ash contain oxide composition of NLA shows that it contains 69.21% silicon oxide, 2.75% calcium oxide and 2.94% aluminum oxide which according to BS standard of pozzolans passes the CLASS N which makes it pozzolanic. These compounds increase its pozzolanic activity. From the results above it can be deduced that workability declines with increase in replacement of neem leave ash. Compressive strength of partially replaced cement tends to increase up to 10% (optimum) and then starts to decrease. The optimum percentage of Neem leave Ash that can replace cement in the BS-8500-2 C-15 is 10% and still achieve a desirable strength of 15N/mm^2. In concrete mix, NLA can be replaced up to 10% mix in concrete considering the current economic situation of Nigeria and still achieve a desirable target strength.

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