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# EFFECT OF SUGARCANE AND NEEM LEAVES ASHES ON THE COMPRESSIVE STRENGTH OF CONCRETE

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**Abstract**: This paper presented the properties of sugarcane Leaves Ash (SCLA) combined with Neem Leave Ash (NLA) as alternative binders to cement and this could reduce the cost of concrete production and the effect of the products as wastes in environs. Sugarcane is among the principal agricultural crops cultivated in tropical country and its annual world production is 1.6 billion tons which generates about 279 million metric tons (MMT) of biomass residues, particularly sugarcane bagasse and leaves. Also, the neem products from neem tree generate large quantity of wastes annually. The sugarcane and neem leaves obtained were dried, burnt at 600$^{o}$C to ashes, grinded into finer particles while the oxide composition on $Al_2O_3$; $SiO_2$; CaO and $Fe_2O_3$ were determined. The mix ratio of 1:2:4 on 0.5 water-cement was adopted and the experiments on chemical composition, slump, setting time and compressive strength test on concrete partially replaced with SCLA/NLA by 0%, 5%, 10%, 15%, 20% and 25% are presented. The casted concrete cubes were cured for 28 days at the intervals of 7 days while the maximum compressive strength at 28 days of curing by 5% is 22.81 N/mm$^2$ and 10% is 20.85 N/mm$^2$ on the percentage replacement of SCLA/NLA. This has significant effect on the strength of concrete and can be use in the production of light weight concrete. The strength logically increases with respect to curing age and decreases with percentage replacement of SCLA/NLA.

## 1. 0 INTRODUCTION

Concrete is the most widely used man-made construction material in the world and is second only to water as the most utilized substance on the planet. It is obtained by mixing cementitious materials, water, aggregates and sometime sad mixtures in required proportions (Gambhir, 2007).

Sugarcane is an important cash crop which isused for sugar production, molasses for livestock, food and alcohol production. Bagasse is used as fuel for cooking, trash form ulching and also serves as fertilizer. It is readily vailable for usage as forage particularly in the dry season to prevent overgrazing of pasture in Brazil (Gana, 2010).

Neem is a fast growing tree that usually reaches a height of 15-20 m, and under favourable conditions up to approximately 30-35 m. It is an evergreen tree but under extreme circumstances such as extended dry periods may shed most of nearly all of its leaves (Schmatterer, 1997).

The production of bottom ashes as pozzolan material from combustion of sugarcane leaves (SCL) for partial replacement of ordinary portland cement (OPC) was investigated and the combustion ashes obtained qualify as a pozzolan material and are suitable to be used as partial replacement of OPC up to a value of 20% (Silva, 2017).

Neem seed huskisa by-product obtained during industrial processing of Neem seed to extract oil and produce fertilizer. Compressive strength, flexural strength and splitting tensile strength tests were carried out on concrete partially replaced with 5% to 25% NSHA (Nurudden, 2013).

Supplementary cementitious materials also called mineral additives contributes to the properties of hardened concrete through hydraulic or pozzolanic activities. Typical examples are natural pozzolans, fly ash, granulated blast-furnanceslag and silica fume (Gambhir, 2007).

In statements of using Sugarcane leaves (SCL) and Neem Seed Husk Ash (NSHA) as agro-wastes in substitute to ordinary Portland cement (opc), Sugarcane and Neem leaves in combination can also be use as pozzolanhence the oxide compositions ($CaO+SiO_2+Al_2O_3+Fe_2O_3$) of the materials combined exceeded 70% by weight for pozzolan (ASTM, 2005).

The history of Pozzolanic materials goes back to roman time. It is a natural or artificial material containing sillies in a reactive form. As Per Astin specifications, a Pozzolana is a Silicious or Silicious and aluminiuons material which itself possesses little or no cementations properties, but in finely divided form and in the presence of moisture, it chemically reacts with calcium hydroxide at possessing cementations properties (Gupta, 2012).

## 2. MATERIALS AND METHOD

The sugarcane and neem leaves obtained were dried, burnt at 600$^{o}$C to ashes, grinded into a finer particles and the oxide composition was conducted at chemistry laboratory ABU-Zaria, Nigeria. The percentage chemical compositions of the following Oxides were determined; $Al_2O_3$ $SiO_2$, CaO and $Fe_2O_3$ on both sugar cane and neem leave ashes.

### *2.1 Particle Size Analysis*

The particle size analysis of the fine and coarse aggregates was carried out in accordance to BS812-103.1 part 1, 1985. In carrying out the tests, a complete set of eleven (5 mm to 0.075 µm) sieves were ranged from biggest to the lowest size for fine aggregates. On the other hand a four set of sieve was ranged for the coarse aggregates (i.e. 28mm, 20 mm,14 mm, and 10 mm sieve sizes).

### *2.2 The Specific Gravity*

The specific gravity tests on Sugarcane Leave Ash (SCLA), Neem Leaves Ash (NLA), Sand and Coarse aggregate were carried out in accordance to BS1377, 1990. The apparatus in used include weighing balance, measuring cylinder and water sprayer. The cylinder was dried and weighed, while 50g of

SCLA/NLA, Sand or Coarse aggregate samples was introduced into the cylinder A. The air dried samples plus the cylinder were weighed and about 500 ml of water was added to each of the SCLA, NLA, Sand and coarse aggregates.

### *2.3 Initial and Final Setting Time*

The initial and final setting times of cement and SCLA/NLA replacements show the differences in the initial and final setting on 0% to 25%. The initial time was found to increase from 55 minutes to 105 minutes and the final setting time increased from 135 minutes to 235 minutes. The increased in replacement of SCLA/NLA content slows down the hydration process causing setting time to increase and resulting into low rate of heat development in process of concrete production.

### *2.4 Mix Design*

Mix design is the process of selecting suitable ingredients for concrete mix and to determining their relative quantities with the purpose of producing an economical concrete which has certain minimum properties notably; workability, strength and durability.

### *2.5 Concrete Production*

In the production of concrete cubes, the mould size of 150x150x150 (mm) in accordance to BS1881; part 102; 1983 was used for casting the concrete cubes on the design mix of 1:2:4 by 0.5 water cement ratio. The cement on 0%, 5%, 10%, 15%, 20% and blended SCLA/NLA was used to replace ordinary Portland 25%.

### *2.6 Slump Test*

The slump test is the measure of resistance of concrete. Flow under its own weight for the determination of workability. It was conducted in accordance with BS 1881 part 102 and 103: 1983. The difference between the height of the concrete before and after removing the cone is taken to be the measure of workability.

### *2.7 Compressive Strength Test*

The compressive strength of concrete cubes was determined in accordance to BS1881; part116; 1983. The weight of the samples was taken before the compressive strength test was conducted and the cubes were removed from the curing tank after 7, 14, 21and 28 days of curing. Consequently, on the designated days of crushing each of the cubes were allowed to drain and weighed before placing in compressive testing machine.

## 3. RESULTS AND DISCUSSION

The oxide compositions of SCLA and NLA in table 1 below shows the combination of Lime ($CaO_2$), Silica ($SiO_2$), Alumina ($Al_2O_3$) and Iron ($Fe_2O_2$) summed up to **56.9%** (SCLA) and **42.9%** (NLA) respectively which isabove70%for pozzolan. This shows that the SCLA and NLA posses some characteristics of cementitious material.

In a well burnt modern clinker the amount of tricalcium silicate ($C_3S$) is about 40% and that of dicalcium silicate ($C_2S$) is 25%. The sum total of $C_3S$ and $C_2S$ in most cement varies from 70 – 74% (Gupta, 2012).

Table1: CHEMICAL COMPOSITION OF SCLA/NLA

| Oxide | Oxide Concentration by weight (SCLA) % | Oxide Concentration by weight (NLA) % |
|---|---|---|
| Na2O | 1.111 | 1.431 |
| MgO | 2.747 | 8.185 |
| **$Al_2O_3$** | **2.180** | **2.945** |
| **$SiO_2$** | **43.384** | **10.081** |
| $P_2O_5$ | 12.751 | 5.813 |
| $SO_3$ | 3.400 | 5.585 |
| Cl | 2.366 | 2.497 |
| $K_2O$ | 19.921 | 32.929 |
| **CaO** | **10.181** | **28.456** |
| $TiO_2$ | 0.289 | 0.325 |
| $Cr_2O_3$ | 0.000 | 0.000 |
| $Mn_2O_3$ | 0.359 | 0.082 |
| **$Fe_2O_3$** | **1.112** | **1.427** |
| ZnO | 0.128 | 0.127 |
| SrO | 0.071 | 0.117 |
| **Total** | **56.9** | **42.9** |

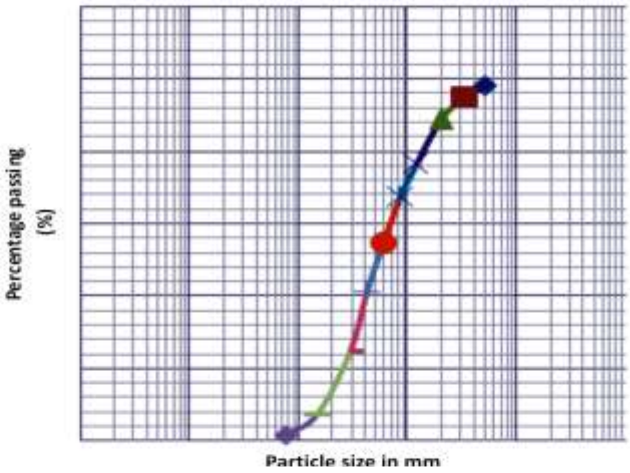


Figure 1: The particle size distribution curve of fine aggregate

The figure above shows the grading and with 98.27% passing and 1.73% retained hence more than 50% passed through the 5mm sieve which classified the aggregates as fine grained soil. The grain size corresponding to 60% (D60), 10% (D10) and 30% (D30) passing the sieve is 0.70 mm, 0.1 mm and 0.38 mm respectively. Hence, the aggregate is well graded and the result conforms with the United Soil Classification System (USCS) on well graded sand with less than 5% fine has Cu= 6 and 1<Cu<3 as stated by (Arora, 2010).

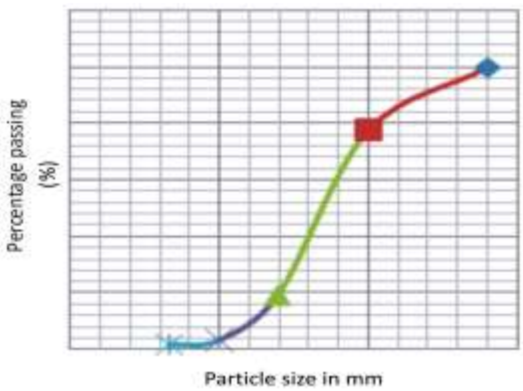


Figure 2: The distribution Figure curve of coarse aggregates

The figure above shows the grading with 77.27 passing and 22.73 retained on 20mm sieve, the grain size corresponding to 60% ($D_{60}$). The distribution curve corresponding to 60% ($D_{60}$), 10% ($D_{10}$) and 30% ($D_{30}$) passing the sieve is 18 mm. 15.2

mm and 12.5mm respectively. Hence, the aggregate is well graded sand, this result agrees with the United Soil Classification System (USCS) well graded sand with less than 5% fine has Cu= 6 and 1<Cu<3 as stated by (Arora, 2010).

Table 2: SPECIFIC GRAVITY ON SCLA, NLA, FINE AND COARSE AGGREGATES

| Sample | SCLA | NLA | Fine Aggregate | Coarse Aggregate |
|---|---|---|---|---|
| $M_1$ (g) | 358.8 | 347.9 | 335.1 | 335.3 |
| $M_2$ (g) | 408.8 | 397.9 | 435.2 | 436.5 |
| $M_3$ (g) | 874.4 | 862.7 | 783.9 | 785.9 |
| $M_4$ (g) | 848.9 | 837.3 | 722.1 | 722.4 |
| $M_2$-$M_1$ | 50.0 | 50.0 | 100.1 | 101.2 |
| $M_4$-$M_1$ | 490.1 | 489.4 | 387.0 | 387.1 |
| $M_3$-$M_2$ | 465.6 | 464.8 | 348.7 | 349.4 |
| $(M_4-M_1)-(M_3-M_2)$ | 24.5 | 24.6 | 38.3 | 37.7 |
| **Gs** | **2.04** | **2.0** | **2.61** | **2.68** |

The table above shows the specific gravities of SCLA as 2.04; NLA was 2.0; Fine aggregate was 2.61; and coarse aggregates as 2.68 which are less than the specific gravity of cement (3.15). The range of specific gravity of rocks is between 2.54 for flint and 2.80 for basalt which shows that the results are in line with standard.

### 3.1 Workability

The results of the slump and compacting factors' tests on percentage replacements of SCLA/NLA to Ordinary Portland Cement(OPC) indicates that the rate of the slump goes higher and the compacting factors goes down on percentage replacement of SCLA/NLA.

Table 3: SLUMP AND COMPACTING FACTORS

| Variation on SCLA/NLA | Slump (mm) | Compacting Factors' |
|---|---|---|
| 0% | 50 (True) | 0.84 |
| 5% | 50 (True) | 0.83 |
| 10% | 60 (True) | 0.82 |
| 15% | 70 (Shear) | 0.82 |
| 20% | 75 (Collapse) | 0.81 |
| 25% | 75 (Collapse) | 0.81 |

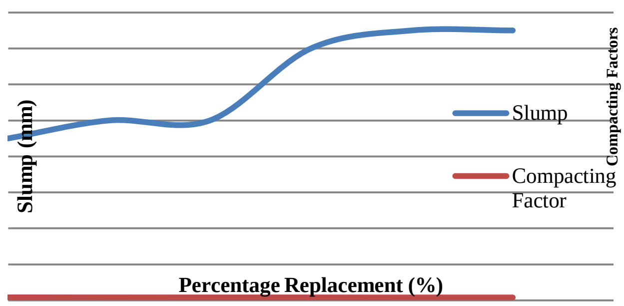


Figure 3: The workability on percentage replacement of SCLA/NLA.

The figure above shows that the concrete becomes less workable as the percentage replacement of SCLA/NLA increases while the range of slump for low workability is between 15 mm and 30 mm and the workability on medium falls between 35 mm and 75 mm.

Therefore, the mixes concrete fall within the standard range of workability.

Table 4: COMPRESSIVE STRENGTH ON REPLACEMENT OF SCLA/NLA

| Variation on SCLA/NLA | Strength at 7days $N/mm^2$ | Strength at 14 days $N/mm^2$ | Strength at 21 days $N/mm^2$ | Strength at 28 days $N/mm^2$ |
|---|---|---|---|---|
| 0% | 20.88 | 21.0 | 23.01 | 24.79 |
| 5% | 19.96 | 20.3 | 21.11 | 22.81 |
| 10% | 18.79 | 19.5 | 19.58 | 20.85 |
| 15% | 18.59 | 18.01 | 19.01 | 19.04 |
| 20% | 9.53 | 10.89 | 11.1 | 11.23 |
| 25% | 9.11 | 9.72 | 9.84 | 10.91 |

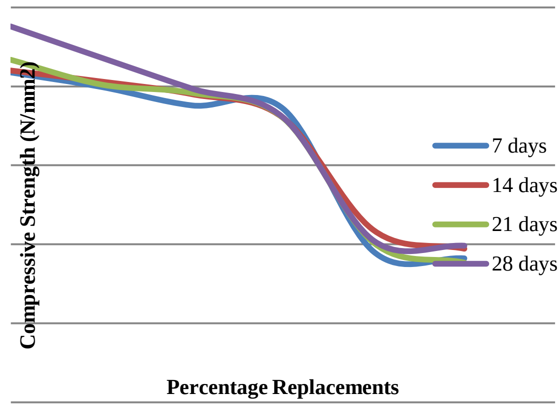


Figure 4: The compressive strength of SCLA/NLA on percentage replacement.

The compressive strength results at 7days of curing was 20.88 $N/mm^2$ on control (0%) and at 5% replacement was 19.96 $N/mm^2$ which declined logically to 9.11 $N/mm^2$ on 10%, 15%, 20% and 25% replacements. The compressive strength at 14days was 21.00 $N/mm^2$ which also decreases to 9.72 $N/mm^2$ also at 21days and 28 days. It was observed that the strength similarly decrease in accordance to percentage replacement of SCLA/NLA from 5%, 10%, 15%, 20% and 25%.

But at 28 days of curing, 5% and 10% replacements show potential of having all most 25 $N/mm^2$ or more, if the curing ages can be improve. This is similar to (Ejeh, 2014); it says that 5% of NSHA replacement satisfied the target compressive strength and can be used for non-structural and mass concrete application. Also, (Silva, 2017); concluded that SCL combustion ashes are good pozzolan and suitable for partial replacement of OPC up to a value of 20% replacement.

Generally, the compressive strength on percentage replacement of SCLA/NLA indicates that 5% and 10% can be adopted on mass concrete production.

## CONCLUSION

The oxide compositions of SCLA ($Al_2O_3$ +$SiO_2$ + CaO+$Fe_2O_3$= **56.9)** and NLA ($Al_2O_3$+$SiO_2$+CaO+$Fe_2O_3$= **42.9)** when summed together resulted into 99.9% which is above 70% and this satisfied the requirements for pozzolana. The compressive strength at 0% replacement (i.e control) on 28 day is 24.79 $N/mm^2$ which almost satisfied the target compressive strength of 25 N/mm$^2$ and that of 5%, 10%, 15%, 20% and 25% also increases with respect to curingage and decreases accordingly on percentage re placement of SCLA/NLA. Itwas observed that the concrete performed fairly betterat 5% and 10% replacements and which results into the following conclusion:

1. The replacement of SCLA/NLA can be used in the production of mass concrete since the compressive strength of the cubes at 28 days of curing indicates that 5% and 10% meet up the requirements for light weight concrete. The application of this could reduce the cost of cement in concrete production as well as effects of the leaves as wastes in environment.
2. Long term curing of the concrete should be encourage as the compressive strength increases logically with respect to curingage.
3. Due to increased in the content of SCLA/NLA, the workability was low and therefore the water cement ratio of 0.65 can be adopted against 0.5 w/c.

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