# Assessment of Pozzolanic behavior of Saw Dust Ash in Load Bearing Hollow Sandcrete Blocks

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***Abstract*-The use of waste materials or by products of industrial process as alternative cementatious materials in concrete and mortar is essential for the sustainability of our environment. It contributes in utilization of cheaper construction materials and save environmental degradation with better waste disposal processes. This paper presents an assessment of pozzolanic behaviour of Saw dust/Wood ash in load bearing blocks. The possibility of using Saw Dust Ash (SDA) as a construction material was experimentally investigated. Saw dust, a waste product of wood processing was burnt to 554$^0$C for 14 hours in incinerator to produce the ash which was sieved using 90 $\mu m$. SDA was replaced with Ordinary Portland Cement OPC at 0%, 5%, 10%, 15% and 20%, in the production of load bearing sandcrete blocks. Compressive strength test results of 2.95 N/mm$^2$, 2.87 N/mm$^2$, 2.77 N/mm$^2$, 2.70 N/mm$^2$ and 1.74N/mm$^2$ were obtained for 0% 5%, 10% and 15% and 20% replacement respectively. This result showed that SDA is a good pozzolan for up to 15% replacement of OPC with it in load bearing sandcrete blocks whose minimum strength is 3.5N/mm$^2$. Therefore, the study suggest the use of SDA as a partial replacement of OPC fora maximum of 15% in load bearing hollow sandcrete blocks.**

***Key Words*-- Saw Dust Ash, Hollow Sandcrete Blocks, Load bearing, Pozzolan, Compressive Strength**

## I. INTRODUCTION

Several research efforts are employed on the use of alternative cementations materials in concrete and mortar to bring down the expenditure on building materials and to reduce the environmental problem of production wastes disposal from factories. Industrial pozzolans like Pulvanized Fuel Ash (PFA), Granulated Blast Furnace Slag, Microsilica, Metakaoline and Saw Dust Ash (SDA) are by-products of manufacturing process and are widely used to form cementitious compounds to improve the performance of concrete [123]. Experimentations on pozzolans like Saw Dust Ash (SDA) Rice Husk Ash (RHA), Fly Ash, Cassava Peel Ash (CPA) as partial replacement of Ordinary Portland Cement (OPC) in concrete production has revealed encouraging results. SDA is waste product of wood work operations made of fine particles of wood; its Ash has pozzolanic properties and is therefore used as partial replacement of Ordinary Portland Cement (OPC) in concrete and mortar. The use of SDA as partial replacement for OPC in concrete production has achieved good result for 1-10 % replacement [4]. There was no adequate study on performance of load bearing sandcrete blocks produced with partial replacement of OPC with SDA. This study therefore investigates the desirable replacement of OPC with SDA for optimum performance of load bearing hollow sandcrete blocks. A 0-20% replacement of OPC with SDA is considered in this study.

## II. PROPERTIES OF SAW DUST ASH

Saw Dust Ash is produced through burning of wood at temperature range of 350 $^0$C to 11000 $^0$C for 360 – 540 minutes [5]. It has specific gravity of 2.13-2.60, Particle finess 45-75 and bulk density of 490 kg/m$^3$ - 827 kg/m$^3$ [6,7,8,9,10]. Other properties like PH value 10.48, specific gravity 2.43, moisture content 1.81% and Loss on ignition 10.46 were obtained when wood was burnt to 1000 $^0$C [10]. The elements found in the ash particles produced from incineration of waste wood include, Sodium (0.2–0.5%), Manganese (0.3–1.3%), Phosphorus (0.3–1.4%), Magnesium (1–2%), Potassium (3–4%), and Calcium (7–33%) [5]. Apart from the above mentioned chemicals several other elements are formed, some of them are boron, copper, molybdenum, zinc. Finally important component, Carbon mass varies between 4 – 34 % in formed SDA. Studies on the thermal conductivity of SDA blended cement mortar and revealed that the thermal conductivity decreased as the SDA percentage increased [11].

## III. MATERIALS AND METHODS

The materials used in the production of sandcrete blocks samples were locally sourced and they include fine aggregate, cement (OPC), water (free from acid concentration and organic substances) and saw dust. The saw dust was burnt to a temperature of 554 $^0$C for 14 hours in incinerator (Figure 1) and a thermocouple thermometer was used to measure the temperature. The main physical properties of SDA that influence its binder properties is it fineness, SDA is expected to have similar fineness with OPC therefore SDA was sieved with sieve size of 90 microns. Mix ratio for the sandcrete blocks is1:4 (1 part of cement to 4 parts of fine aggregate) and water cement ratio of 0.5-1 (according to BS 1881, 1983) was used. Nine specimens of sandcrete blocks were produced in each percentage replacement of SDA with OPC (0%, 5%, 10%,15% and 20%) and are used for compressive strength tests at 3, 14 and 28 days curing ages. Physical properties tests like sieve analysis, specific gravity, bulk density were carried out in line with Indian Standard [12] to properly identify the fine aggregate. Compressive strength test was conducted on three specimen of sandcrete blocks at 7, 14, and 28 days curing periods. The test was conducted on hollow sandcrete blocks (Figure 2) produced with 0%, 5%, 10%, 15% and 20% replacement of OPC with SDA as shown in Table 1.

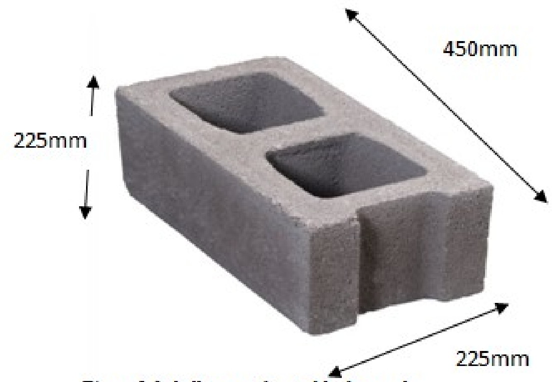


Figure 2.0: hallow sandcrete block sample

Fig. 1 Incinerator used for the research.

## IV. RESULT AND DISCUSSION

Sieve analysis for fine aggregate was carried out using sieve size of 2mm, 1.18mm, 0.6mm, 0.425mm, 0.3mm, 0.212mm, 0.15mm, 0.063mm. The result shows that much of the sample is retained on 63 $\mu m$ sieve size (Table 2). Table 3 shows results of bulk density test and specific gravity test. Sprinkling of water continuously on the blocks surface provides efficient curing. The blocks were allowed to set sufficiently before sprinkling is started using perforated plastic box. Sprinkling of water continuously on the blocks surface provides efficient curing. The blocks were allowed to set sufficiently before sprinkling is started using perforated plastic box.

Table 1: Schedule of compressive strength tests on sandcrete blocks

| Percentage SDA Replacement | Crushing Period (days) | | |
|---|---|---|---|
| | 7 | 14 | 28 |
| | Number of specimens | | |
| 0% | 3 | 3 | 3 |
| 5% | 3 | 3 | 3 |
| 10% | 3 | 3 | 3 |
| 15% | 3 | 3 | 3 |
| 20% | 3 | 3 | 3 |
| Total number of blocks = 45 | | | |

Table 2: Sieve analysis result for fine aggregate

| S/No | Sieve Size (mm) | Mass Retained (kg) | % of Mass Retained | Cumulative % of Mass Retained | Total % of Mass Passing |
|---|---|---|---|---|---|
| 1 | 2.00 | 7.5 | 0.75 | 0.75 | 100 |
| 2 | 1.180 | 2.3 | 0.23 | 0.98 | 99.25 |
| 3 | 0.600 | 33.2 | 3.32 | 3.20 | 96.70 |
| 4 | 0.425 | 71.15 | 7.15 | 10.45 | 89.55 |
| 5 | 0.300 | 111.8 | 11.18 | 21.63 | 78.37 |
| 6 | 0.212 | 238.2 | 23.82 | 44.45 | 55.55 |
| 7 | 0.150 | 145 | 1.45 | 45.90 | 54.10 |
| 8 | 0.063 | 250.2 | 25.02 | 70.92 | 29.08 |
| 9 | Pan | 140.2 | 14.02 | 84.94 | 15.06 |

Table 3: Sieve analysis result for Coarse aggregate

| No | Sieve Size (mm) | Mass Retained | % of Mass Retained | Cumulative % of Mass Retained | Total % of Mass Passing |
|---|---|---|---|---|---|
| 1 | 2.00 | 7.5 | 0.75 | 0.75 | 100 |
| 2 | 1.180 | 2.3 | 0.23 | 0.98 | 99.25 |
| 3 | 0.600 | 33.2 | 3.32 | 3.20 | 96.70 |
| 4 | 0.425 | 71.15 | 7.15 | 10.45 | 89.55 |
| 5 | 0.300 | 111.8 | 11.18 | 21.63 | 78.37 |
| 6 | 0.212 | 238.2 | 23.82 | 44.45 | 55.55 |
| 7 | 0.150 | 145 | 1.45 | 45.90 | 54.10 |
| 8 | 0.063 | 250.2 | 25.02 | 70.92 | 29.08 |
| 9 | Pan | 140.2 | 14.02 | 84.94 | 15.06 |

Table 4: Showing the compressive strength of Sandcrete Blocks at 7 days

| % replacement | Days | Weight of Block (kg) | Crushing Load (kg) | Compressive Strength N/mm$^2$ | Average Compressive Strength N/mm$^2$ |
|---|---|---|---|---|---|
| 0 | 7 days | 19.04 | 90 | 1.42 | 1.26 |
| | 7 days | 17.84 | 60 | 1.02 | |
| | 7 days | 19.03 | 80 | 1.26 | |
| 5 | 7 days | 17.80 | 75 | 1.18 | 1.02 |
| | 7 days | 16.63 | 85 | 1.34 | |
| | 7 days | 17.59 | 55 | 0.86 | |
| 10 | 7 days | 16.01 | 65 | 1.10 | 1.1 |
| | 7 days | 17.77 | 85 | 1.34 | |
| | 7 days | 17.26 | 55 | 0.86 | |
| 15 | 7 days | 15.29 | 40 | 0.63 | 0.65 |
| | 7 days | 17.10 | 50 | 0.75 | |
| | 7 days | 15.60 | 35 | 0.55 | |
| 20 | 7 days | 16.95 | 35 | 0.55 | 0.47 |
| | 7 days | 15.79 | 30 | 0.47 | |
| | 7 days | 16.30 | 25 | 0.39 | |

Table 5: Showing the compressive strength of Sandcrete Blocks at 14 days

| % replacement | Days | Weight of Block (kg) | Crushing Load (kg) | Compressive Strength N/mm$^2$ | Average Compressive Strength N/mm$^2$ |
|---|---|---|---|---|---|
| 0 | 14 days | 18.62 | 85 | 1.34 | 1.76 |
| | 14 days | 18.41 | 155 | 2.44 | |
| | 14 days | 18.83 | 95 | 1.50 | |
| 5 | 14 days | 16.85 | 95 | 1.50 | 1.74 |
| | 14 days | 16.96 | 90 | 1.42 | |
| | 14 days | 16.30 | 145 | 2.29 | |
| 10 | 14 days | 17.28 | 85 | 1.35 | 1.45 |
| | 14 days | 17.83 | 90 | 1.42 | |
| | 14 days | 15.88 | 100 | 1.58 | |
| 15 | 14 days | 18.05 | 95 | 1.50 | 1.32 |
| | 14 days | 17.77 | 75 | 1.18 | |
| | 14 days | 17.12 | 80 | 1.26 | |
| 20 | 14 days | 17.51 | 75 | 1.18 | 1.08 |
| | 14 days | 17.54 | 65 | 1.02 | |
| | 14 days | 16.41 | 45 | 0.71 | |

Table 6: Showing the compressive strength of Sandcrete Blocks at 28 days

| % replacement | Days | Weight of Block (kg) | Crushing Load (kg) | Compressive Strength ( N/mm$^2$) | Average Compressive Strength (N/mm$^2$) |
|---|---|---|---|---|---|
| 0 | 28 days | 17.06 | 185 | 2.92 | 2.95 |
| | 28 days | 18.07 | 180 | 2.84 | |
| | 28 days | 18.85 | 195 | 3.08 | |
| 5 | 28 days | 18.74 | 185 | 2.92 | 2.87 |
| | 28 days | 18.99 | 190 | 3.00 | |
| | 28 days | 18.85 | 170 | 2.69 | |
| 10 | 28 days | 16.95 | 195 | 3.08 | 2.77 |
| | 28 days | 18.83 | 170 | 2.69 | |
| | 28 days | 15.30 | 160 | 2.53 | |
| 15 | 28 days | 16.75 | 185 | 2.92 | 2.70 |
| | 28 days | 17.05 | 155 | 2.44 | |
| | 28 days | 16.66 | 175 | 2.76 | |
| 20 | 28 days | 15.85 | 95 | 1.50 | 1.74 |
| | 28 days | 15.65 | 145 | 2.29 | |
| | 28 days | 16.36 | 90 | 1.42 | |

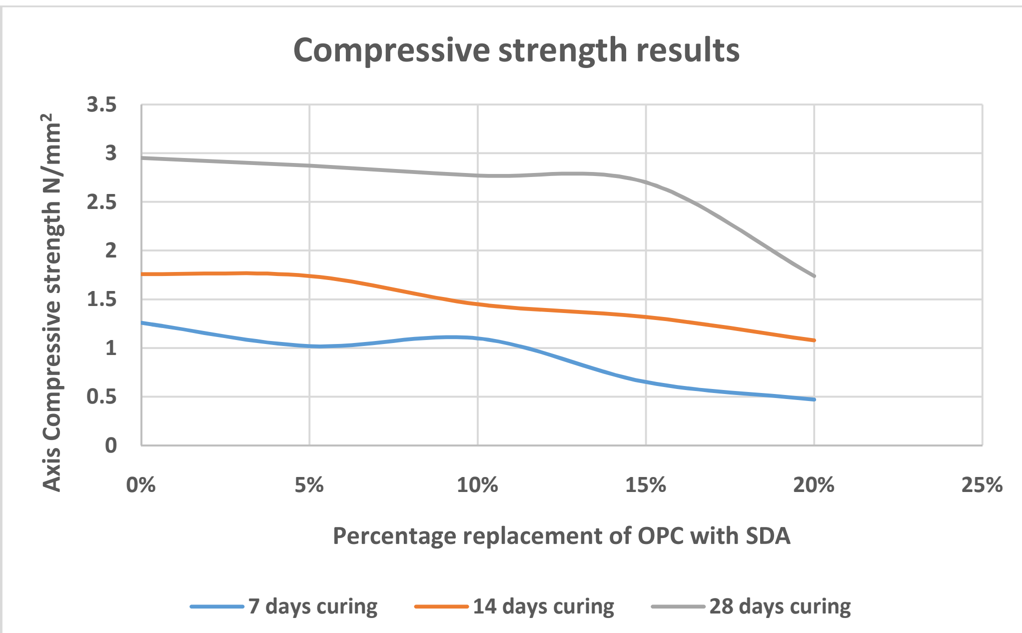


Figure 3: Compressive Strength Results of sandcrete blocks for various curing ages

Table 4, Table 5 and Table 6 shows compressive strength tests results were carried out on sandcrete blocks at 7, 14 and 28 days respectively in line with B S 1881: Part 116 [13]. The blocks were crushed and their corresponding failure loads were recorded. The crushing force was divided by the cross sectional area of the block to give the compressive strength. The strength value was the average of tests conducted on three specimens. From Table 4, a maximum strength of 1.26 N/mm$^2$ was recorded for 0 % replacement followed by 1.02 N/mm$^2$ for 5 % replacement and 1.1 N/mm$^2$ for 10 % replacement. This indicates a 14.5 % difference between 10 % replacement and control. From Table 5, a maximum strength of 1.76 N/mm$^2$ was recorded for 0% replacement followed by 1.74N/mm$^2$ for 5% replacement and 1.45N/mm$^2$ for 10% replacement and 1.32N/mm$^2$ for 15% replacement. This indicates a 31 % difference between 15 % replacement and control. From Table 6, a maximum strength of 2.95 N/mm$^2$ was recorded for 0% replacement followed by 2.87 N/mm$^2$ for 5% replacement and 2.77 N/mm$^2$ for 10% replacement and 2.70 N/mm$^2$ for 15% replacement. This indicates a minimal 9.2 % difference between 15 % replacement and control. This is an encouraging result.

Figure 3 shows compressive strength test results for hollow sandcrete blocks with 0 %, 5 %, 10 %, 15 % and 20 % replacements of OPC with SDA. The compressive strength of blocks made with 0 % SDA replacement of OPC and cured for 28 days has the highest strength result of 2.95 N/mm$^2$ which is close to 3.5 N/mm$^2$ strength obtained for load bearing blocks [12]. The difference in the result can be as a result of manual method of block moulding employed in the research leading to lower compaction of blocks in comparison to machine moulding. At 15 % replacement a desirable strength of 2.7 N/mm$^2$ was obtained which is close to the 2.95N/mm$^2$ obtained from 0 % replacement. The lowest compressive strength of 1.74 N/mm$^2$ for 28 days curing was at 20% OPC replacement with SDA. It is observed that there is compressive strength decrease of sandcrete blocks as the percentage replacement of OPC with SDA is increased at all curing ages.

## V. CONCLUSION AND RECOMMENDATION

The research has shown that SDA is a good pozzolan and can be used to produce cementitious compounds that will improve the performance of sandcrete blocks. The percentage replacement of SDA with OPC should be limited to 15% for optimum result. Further study should be conducted on microstructure properties of SDA to further understand its pozzolanic behavior in concrete and mortar.

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