# Suitability of Crushed Sandcrete Block (Csb) as Fine Aggregate for Masonry Works

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***Abstract*— *This paper focuses on the prospects of recycled broken sand Crete hollow blocks as fine aggregate for masonry works. Sandcrete hollow blocks were taken from dealers in Zaria and tested for density, water absorption, dimension tolerances, drying shrinkage, wetting expansion and compressive strength as compared to hand moulded blocks which were moulded in the laboratory to NIS 87(2004) specification. Density ranges from 1797.37Kg/m$^3$ – 1974.00Kg/m$^3$, water absorption ranges from 5.38% - 10.38%, drying shrinkage ranges from 0.028% - 0.044%, wetting expansion ranges from 0.042% - 0.059% and the 28$^{th}$ day compressive strength ranges from 0.45N/mm$^2$ - 0.85N/mm$^2$. Results showed that density, water absorption, drying shrinkage, wetting expansion and 28$^{th}$-day compressive strength of block samples manufactured from quarry fine collected from one of the industries was 2070.11Kg/m$^3$, 9.54%, 0.034%, 0.05%, and 1.38N/mm$^2$ respectively. The study confirmed that the quality of sand Crete blocks manufactured in Zaria does not meet the specified standard in respect of strength.*

***Keywords*— Aggregate, Crushed Sandcrete Block, River sand, waste materials.**

## I. INTRODUCTION

In most construction sites today, broken Sandcrete blocks are being disposed of as waste materials**.** The application of recycled aggregates from construction and demolition wastes is viewing the potential presentation in construction as another to primary (natural) aggregates. It saves usual resources and decreases the space essential for landfill removal (Buchner and Scholten, 1992). In Nigeria and many other developing countries, the building construction industry is exploring and still combining materials within its immediate surroundings in search of suitable materials that can combine to facilitate the building of civil engineering structures.

It is a recognised detail that the non-stop generation of solid waste materials gives a serious environmental challenge. For this motive, it is very significant to study and develop any technology, procedure or method that may help to exploit their use efficiently (Bolden, 2013). Due to the high cost of building materials in Nigeria, the average citizen finds it difficult to afford good housing in the country. This trouble has led to the use of local wastes as alternatives to conventional materials in the construction industry**.** One of the main challenges of our current society is to safeguard the environment. The significant features in this respect are the decrease in the consumption of energy and natural raw materials and the consumption of waste materials.

The two main potential markets to utilize recycled waste materials successfully are the transportation and construction industries (Bolden, 2013).

Crushed Sandcrete block (CSB) is a cohesion-less sandy material developed artificially by the mechanical disturbance of Sandcrete block, which is composed largely of particles with a diameter range of 0.05mm to 5mm depending on the mode of crushing (Afolayan et. al. 2008). A research carried out by Seeley (1993), stated that Sandcrete blocks are walling materials that consist of coarse sand or crushed rock dust mixed in proportion with cement and water and compacted to various shapes. Abdullahi, (2005) defined Sandcrete hollow blocks as structural walling units which are dimensionally larger than bricks and have one or more large holes or cavities passing through them. The solid materials range between 50% to 75% of the total volume of the block calculated from the overall dimension.

This makes it attain acceptable strength to be used as walling material. Hollow Sandcrete blocks have featured for a very long time in building construction works in Nigeria. Seeley, (1993) grouped Sandcrete blocks into two key categories:

1. Lightweight block: These are Sandcrete blocks made from lightweight aggregates. These types of blocks are non-load bearing and are not appropriate to be used below ground floor damp proof course. There are intended for use in non-load bearing walls and partitions.
2. Dense Sandcrete: These are Sandcrete blocks made from dense weight aggregates. These types of blocks are load-bearing and are appropriate to be used beneath ground floor damp proof course (DPC) and are resilient even when exposed to extreme climate.

This research aims to find out the suitability of using these crushed Sandcrete blocks as fine aggregate for masonry works, an endeavour is made to link some of the engineering properties of recycled crushed Sandcrete block (CSB) with the natural fine aggregate. Although an enormous quantity of broken Sandcrete block is available for recycling from construction sites and block industries, Sandcrete blocks collected from the four (4) manufacturers in Zaria and tested in the laboratory were used in the present study to produce the recycled aggregates. The broken Sandcrete blocks were crushed into fine aggregates with the use of a hammer.

## II. MATERIALS AND METHODS

### 2.1 Study area

This research started with a general survey of Zaria town locating the block manufacturing sites. The majority of the block manufacturers in Zaria have located along Kwangila - Shika road because of the easy access to the highway. A total of nine hollow Sandcrete block manufacturing industries were visited. Field trips were made to these sites supported by interviews with key individuals within the industry, who were asked to respond to a structured questionnaire. The general questions included:

- Mix ratio
- Type and source of material
- W/C ratio
- Cement type
- Mode of production
- Sizes of blocks produced
- Type of machine used
- Number of workers
- Curing period

The information gathered was analysed to select four (4) block manufacturers based on random sampling and even distribution within Zaria. 15 samples of Sandcrete hollow blocks were randomly collected and paid for from each of the selected block manufacturers. Blocks made from quarry fine was collected from industry A and tested. In addition, hand moulded samples of hollow Sandcrete blocks were manufactured in the laboratory to NIS 87(2004) specification using a cement-aggregate ratio of 1:8 and water-cement ratio of 0.6. Dangote brand of ordinary Portland cement was used. The information got is shown in Table 1.

Industry A: Rahusa Blocks (Zango junction)

Industry B: Aliyu Kwari Blocks (College of Aviation Technology main gate)

Industry C: Hand Moulded Laboratory Samples to NIS 87(2004) specifications

Industry D: Nasara Blocks (opposite ABU North gate)

Industry E: Alheri Blocks (Samaru village, along Basawa road)

**TABLE 1**
**SUMMARY OF THE INFORMATION OBTAINED ON THE FOUR (4) SELECTED BLOCK MANUFACTURERS IN ZARIA.**

| Industry | Mix ratio | Mode of production | W/C Ratio | Type of material | Size of blocks produced |
|---|---|---|---|---|---|
| A | 1:10 | Machine mould | Not defined | River sand & quarry fine | 460x230x230 460x230x150 |
| B | 1:12 | Machine mould | Not defined | River sand | 460x230x230 460x230x150 |
| C | 1:8 | Hand moulded lab samples | 0.6 | River sand | 460x230x230 |
| D | 1:12 | Machine mould | Not defined | River sand | 460x230x230 460x230x150 |
| E | 1:14 | Machine mould | Not defined | River sand | 460x230x230 460x230x150 |

## III. RESULTS AND DISCUSSION

### 3.1 Dry compressive strength test

The compressive strength test was determined on the Sandcrete blocks between two Celotex boards of thickness 10mm using the Universal testing machine in the Department of Civil Engineering laboratory, Ahmadu Bello University, Zaria. The entire test was carried out at the same rate of loading. Each block was weighed and positioned in the testing machine is flanked by the two Celotex boards. Load is applied until failure occurred and the load at failure is verified against each sample. The compressive strength of the blocks is calculated by dividing load at failure and the effective area of the block in square millimetres.

The Sandcrete hollow blocks were tested at the following ages: 7, 14, and 28 days respectively. The average mean value of the compressive strength of five samples is presented in Table. 2. The test was conducted by Appendix C.4.1 of BS 2028 (1985). The results for the selected industries A, B, D and E are presented in Fig. 1 which shows the compressive strength and the age days of the block.

**TABLE 2**
**COMPRESSIVE STRENGTH TEST RESULTS**

| Industry | A | B | C | D | E |
|---|---|---|---|---|---|
| Age(days) | ($N/mm^2$) | ($N/mm^2$) | ($N/mm^2$) | ($N/mm^2$) | ($N/mm^2$) |
| 7 | 0.61 | 0.40 | 1.21 | 0.42 | 0.33 |
| 14 | 0.70 | 0.45 | 1.79 | 0.52 | 0.40 |
| 28 | 0.85 | 0.65 | 2.01 | 0.56 | 0.45 |

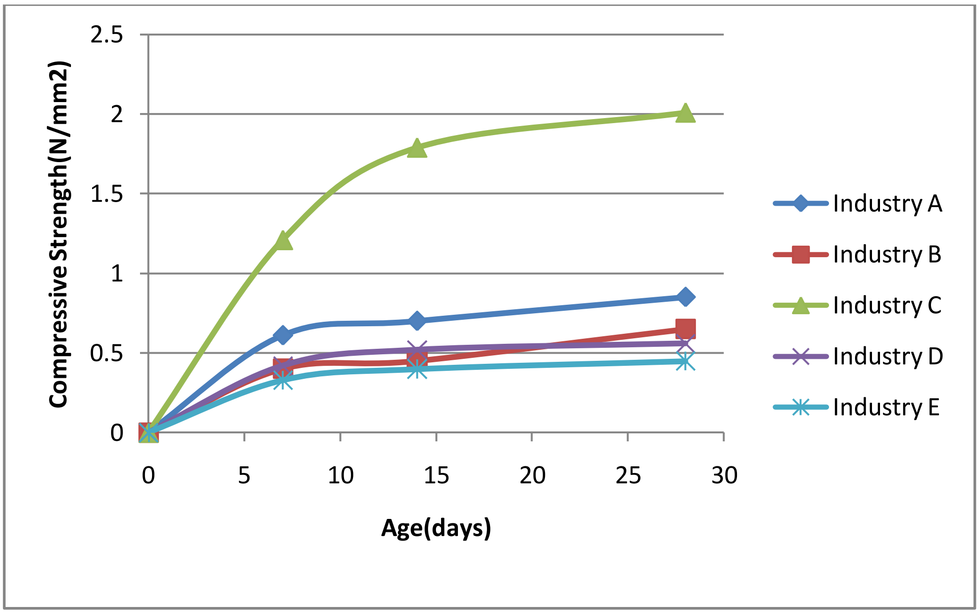


**FIGURE 1: Compressive Strength versus age curve**

Test results show that the average 28$^{th}$-day compressive strength of manufacturers A, B, D and E is 0.85, 0.65, 0.56 and 0.45 N/mm$^2$ respectively. The 28$^{th}$-day compressive strength of blocks made from quarry fine aggregates collected from RAHUSA block manufacturer was 1.38 N/mm$^2$.

The Nigerian Industrial Standard (NIS 87: 2004) stated that the compressive strength of individual load-bearing machine vibrated blocks shall not be less than 2.5 N/mm$^2$ and also, the average compressive strength of five blocks shall not be less than 3.45 N/mm$^2$. Furthermore, the Nigerian Industrial Standard (NIS 87: 2004) indicated that the lowest compressive strength of individual load-bearing hand compacted blocks shall not be less than 2.0 N/mm$^2$ and the average compressive strength of five blocks shall not be less than 2.5 N/mm$^2$. It is perceived that manufacturer A has the highest 28$^{th}$-day compressive strength of 0.85 N/mm$^2$ while manufacturer E has the lowest 28$^{th}$-day compressive strength of 0.45 N/mm$^2$. The high strength of manufacturer A can be documented to the higher cement aggregate ratio related to the other manufacturers.

From Fig.1 it can be observed that the 28$^{th}$-day compressive strength of blocks collected from the four selected producers ranges from 0.45N/mm$^2$ - 0.85N/mm$^2$.

This confirmed earlier work done by Omopariola, (2014) and Satyanarayanaet et.al, (2013) on the standard of Sandcrete hollow blocks manufactured in Kaduna state does not meet the specified standard in respect to strength.

This low strength value can be ascribed to the absence of adequate knowledge, non-adherence to the established standard and poor quality control measures on the part of Sandcrete block manufacturers in Zaria. The cement-sand mix ratio used by the manufacturers is one-part cement to ten or fourteen parts of sand (1:10 to 1:14) compared to one-part cement to six or eight parts of sand (1:6 to 1:8) and is below codes requirements. Mixing water is not measured and is based on eye judgement.

### 3.2 Density determination

This experiment was carried out following the BS 2028 (1985). The test was aimed at determining the density of the Sandcrete hollow blocks at 28days. Results are presented in Table 3 with an average of five readings for each industry.

The British standard BS 2028(1985) described three types of blocks: Types A, B, and C.

1. Type A: These have a density of not less than 1500Kg/m$^3$; they are strong even when exposed to adverse climate.
2. Type B: These are made of lightweight aggregates and are load-bearing. They may be used below ground floor damp proof course. Density is less than 1500Kg/m$^3$ but more than 625Kg/m$^3$
3. Type C: they are similar to type B blocks except they are non-load bearing and are not appropriate to be used below ground floor damp proof course. They are envisioned for use in non-load bearing walls and partitions.

The mean density of blocks made from quarry fine aggregate collected from manufacturer A is 1909.09 kg/m$^3$. These values are greater than 1500kg/m$^3$ therefore they could be classified as type A blocks. They are load-bearing and may be used below damp proof course even when exposed to adverse climate. Sandcrete blocks are obtainable for the construction of load-bearing and non-load-bearing structures. Load bearing blocks must follow building code regard to their crushing and the amount of solid mineral contained in section example the total width of the block. Sandcrete blocks also contribute most to the task of transforming the actual load from the overlaying structural element to the foundation. In this case, the load-bearing wall is those walls acting as supports for the whole structure to transmit the weight to the ground surface underneath it for stability (NIS 87:2004).

**TABLE 3**
**DENSITY TEST RESULTS**

| Industry | A | B | C | D | E |
|---|---|---|---|---|---|
| Mean Density(Kg/m$^3$) | 1909.09 | 1881.28 | 1874.00 | 1863.58 | 1797.37 |

### 3.3 Water absorption test

The test was conducted by BS 2028 (1985). Based on the code requires the water absorption for blocks shall not exceed 12% of the dry weight (BS 2028, 1985). The results of the mean water absorption of five different readings are shown in Table 4.

**TABLE 4**
**WATER ABSORPTION TEST RESULTS**

| Industry | A | B | C | D | E |
|---|---|---|---|---|---|
| Mean water absorption (%) | 5.38 | 9.07 | 5.05 | 9.45 | 10.38 |

The average water absorption for blocks made from quarry fine was 9.54%. This satisfies the 12% value recommended by BS 2028(1985).

### 3.4 Drying shrinkage and wetting expansion

The test was carried out as specified by BS 2028 (1985). Measurements were done with a micrometre screw gauge. Table 5 is the mean of five readings from each industry.

**TABLE 5**
**AVERAGE DRYING SHRINKAGE AND WETTING EXPANSION TEST RESULTS**

| Industry | A | B | C | D | E |
|---|---|---|---|---|---|
| Mean Drying shrinkage (%) | 0.028 | 0.036 | 0.023 | 0.039 | 0.044 |
| Mean Wetting expansion (%) | 0.042 | 0.047 | 0.035 | 0.051 | 0.059 |

BS 2028 (1985) limits the drying shrinkage and wetting expansion of Sandcrete blocks to 0.05%. These values satisfy the requirements of BS 2028 (1985). This indicates that the Sandcrete hollow blocks manufactured in Zaria are of low cement content and as such will exhibit a normal change in dimensional properties when exposed to moisture condition change.

### 3.5 Dimension tolerance

Length, breadth and height of four (4) Sandcrete hollow block specimen were measured up to 1mm accuracy for manufacturers A, B, D and E. Each dimension was measured at three different sections and the mean of the three was taken as the value of the parameter for that specimen. Measurements were done with a micrometre screw gauge. The summary of results of the dimension tolerance measured for the four selected block industries is presented in Table 6.

**TABLE 6**
**DIMENSION TOLERANCE TEST RESULTS**

| Industry | A | B | C | D | E |
|---|---|---|---|---|---|
| **Dimension** | **(%)** | **(%)** | **(%)** | **(%)** | **(%)** |
| Length (L) | 0 | 0 | 0 | 0.2 | 0.4 |
| Breath (B) | 0 | 0 | 0 | 0.4 | 0.4 |
| Height (H) | 0 | 0.4 | 0 | 0.4 | 0.4 |

From Table 6 The British Standard BS 2028(1985) gave the work size of 450x225x225mm for type A and B blocks with a tolerance of ±3.0mm for length and height and ±1.5mm tolerance in width. This represents a tolerance of 0.67%. The actual/normal size of the blocks produced in Nigeria is 460x230x230mm. Therefore, the normal size will be used as the size for tolerance. From Tables 7 and 8, it was observed that all of the dimensions of the sampled Sandcrete hollow blocks from any of the five industries fall within the permissible deviations specified by the BS 2028 (1985).

**TABLE 7**
**DIMENSION TOLERANCE TEST RESULT**

| Industry / Sample Number | A | | | B | | | C | | | D | | | E | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | B | H | L | B | H | L | B | H | L | B | H | L | B | H |
| 1 | 461 | 230 | 230 | 461 | 231 | 230 | 460 | 230 | 231 | 461 | 230 | 229 | 461 | 231 | 230 |
| 2 | 460 | 230 | 231 | 460 | 230 | 231 | 459 | 230 | 230 | 461 | 230 | 230 | 462 | 231 | 229 |
| 3 | 460 | 231 | 230 | 460 | 230 | 231 | 460 | 230 | 229 | 460 | 231 | 229 | 461 | 230 | 231 |
| 4 | 461 | 230 | 231 | 460 | 231 | 230 | 460 | 230 | 230 | 460 | 231 | 230 | 462 | 230 | 230 |
| 5 | 460 | 231 | 230 | 461 | 230 | 231 | 460 | 229 | 230 | 461 | 231 | 229 | 462 | 231 | 229 |
| Average(mm) | 460 | 230 | 230 | 460 | 230 | 231 | 460 | 230 | 230 | 461 | 231 | 229 | 462 | 231 | 229 |
| Difference(mm) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | -1 | 2 | 1 | -1 |
| Tolerance (%) | 0 | 0 | 0 | 0 | 0 | 0.4 | 0 | 0 | 0 | 0.2 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |

**TABLE 8**
**DIMENSION TOLERANCE TEST RESULT (QUARRY FINE)**

| Industry / Sample Number | A | | |
|---|---|---|---|
| | LENGTH | BREATH | HEIGHT |
| A1 | 460 | 230 | 230 |
| A2 | 461 | 229 | 230 |
| A3 | 460 | 230 | 230 |
| A4 | 460 | 231 | 231 |
| A5 | 460 | 230 | 230 |
| Average(mm) | 460 | 230 | 230 |
| Difference(mm) | 0 | 0 | 0 |
| Tolerance (%) | 0 | 0 | 0 |

## IV. CONCLUSION

The suitability of crushed Sandcrete block as fine aggregate for masonry work has been carried out, based on the findings the resulting conclusions can be noted:

1. The lack of adequate knowledge, non-adherence to established standard and poor quality control measures on the part of Sandcrete block manufacturers in Zaria is responsible for the considerable variations and low compressive strength.
2. The cement-sand mix ratio used by the manufacturers in Zaria is one-part cement to ten or fourteen parts of sand (1:10 to 1:14) compared to one-part cement to six or eight parts of sand (1:6 to 1:8) and is below codes requirements.
3. A curing period of 1 to 3 days has been adopted by Sandcrete hollow blocks manufacturers in Zaria instead of a minimum of seven (7) days.
4. The water absorption of Sandcrete hollow blocks in Zaria satisfies the code requirements.
5. The densities of Sandcrete blocks manufactured in Zaria are greater than 1500Kg/m$^3$ which makes them be classified as Type A blocks.
6. The density, water absorption, drying shrinkage, wetting expansion and 28$^{th}$-day compressive strength of block samples manufactured from quarry fine collected from a manufacturer in Zaria is 2070.11Kg/m$^3$, 9.54%, 0.034%, 0.05%, and 1.38N/mm$^2$ respectively.

## RECOMMENDATIONS

From the foregoing, this suggests that crushed Sandcrete blocks (CSB) are a good substitute for river sand in ordinary construction works particularly in dwellings where river sand is in low supply and waste Sandcrete blocks are freely obtainable. This will help in decreasing the danger these broken Sandcrete blocks as to our environment. Because of the above, there is a vital need to take the following measures:

1. An evaluation of a comparative cost-benefit analysis should be measured.
2. Creation of awareness on capacity building towards the use of construction and demolition waste.
3. Execution of techno-legal regime with legislations, guidance, penalties etc. for the dumping of building and construction waste.
4. Designing dumping sites for pre-selection, treatment, and recycling of CSB for construction purposes.

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