# Evaluation of the Compressive Strength of Concrete Using Bush Gravel as Coarse Aggregates Partially Replaced with Broken Bricks

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***Abstract:***
*Concrete is the most used building material in the construction industry. In recent years, concrete production has become more expensive due to the increase in demand for it, which has led to a rise in the cost of concrete production. This has compelled the construction industry to find alternatives to concrete production. In this study, the compressive strength of concrete is evaluated when bush gravel, as coarse aggregate, is partially replaced with broken bricks which have acceptable properties comparable to a normal concrete. The absolute volume method was used in determining the values of water/cement ratio, aggregate/cement ratio and the relative proportions of aggregates of various sizes. Mix ratio of 1:2:4 and water/cement ratio of 0.45% were used. The compressive strength observed after 7 days was 15.29, 14.39, 14.68, 14.55, 14.22, 13.41 and 10.75N/mm$^2$, while compressive strength after 14 days was 18.46, 16.12, 15.38, 15.23, 14.87, 14.82 and 13.67N/mm$^2$,compressive strength after 21 days was 20.45, 19.94, 19.63, 19.41, 19.26, 17.78, and 14.81N/mm$^2$, and finally after 28 days, the compressive strength was 23.63, 21.85, 20.30, 19.29, 18.26, 18.22 and 16.45N/mm$^2$ all for 0, 10, 20, 30, 40, 50, and 60% replacements of broken bricks respectively. These results clearly shows that the compressive strength of concrete increases as the curing ages increases and both bush gravel and broken bricks can be used as coarse aggregates for structural concrete when structural coarse aggregates are hard to find, and where high strength of concrete is not needed.*

*Keywords: Concrete, Coarse aggregates, Compressive strength, Bush gravel, Broken bricks.*

## 1. Introduction

Concrete is one of the most versatile construction materials in-used; it consists primarily of, cement, aggregates, water and admixtures. Concretes' strength is formed as a result of hydration, and this happens when the water and cement reacts. Its product consists majorly of calcium aluminates, silicates and hydroxides which are relatively insoluble and bind the aggregates in harden mixture. Concrete is said to be stronger in compression than it is in tension and it is used to carry loads in structures of compressive nature. Steel bars are embedded in concrete structures when they are subjected to tensile stresses. Neville (1995).
According to Chong (1981), the required proportions of material for a given concrete grade are normally obtained from mix design. When the constituent's materials are properly batched and mixed thoroughly, this goes through the process of hydration and hardens into a mass of concrete which is capable of resisting compressive and tensile stresses. The compressive strength of concrete determines how well a concrete structure can resist compressive stress applied. This also depends on the quality of such concrete. Concrete constitutes about seventy five percent of aggregates; this makes its quality, types and general properties determine the quality of concrete. Amit Gupta (2004). In construction, coarse aggregates used consist of one or a combination of particles having a size of between 4.76mm and 20mm, they can be natural or machine crushed rock aggregate. Duggal (2008). Natural gravel and sand are usually dug or dredged from a pit, river, lake, or seabed. Crushed stone is produced by crushing quarry rock, boulders, cobbles, or large-size gravel. Close to half of the coarse aggregates used in Portland cement concrete are gravels; most of the remainder are crushed stones. McGennis *et al.* (1995). It is important to note that the use of waste material as aggregates in concrete production is beneficial; this is because it reduces the impact on economic cost of quarrying operations, processing and transport.

In recent times, reusing waste is desirably increased; this is due to rise in tipping fees for disposing these waste materials in landfills. Robinson *et al* (2004). ). Different sustained constructive initiative developed in recent years has made reuse of construction and demolition debris (as aggregates) an alternative in carrying out different design for structures.
Materials that could be used as coarse aggregates in concrete include palm kernel shells, broken bricks, and marbles. Barra *et al* (1998). Brick products usually are made from naturally occurring materials mixed with water and formed into the desired shape, fired in a kiln to give the clay mixture a permanent bond. With the enormous amount of brick produced in the country, the material can possibly provide a unique source of aggregates which can actually be used to produce a more efficient and sustainable concrete. Desai (2004). This, in addition will reduce the waste that is usually land filled (which is detrimental to the environment).Aggregates made up of bricks is lighter than normal weight aggregate and will reduce haul cost. This goes to show that concrete made with brick aggregate is lighter than concrete made with normal aggregates thereby reducing the self weight of the concrete. This study will majorly deal on broken bricks as waste chips which can be utilized as aggregates, in addition with the bush gravel locally called Bida natural stones as the normal coarse aggregates. This research work is aimed at evaluating the strength of concrete when Bida natural stones is used as coarse aggregates and partially replaced with broken bricks at 0, 10, 20, 30, 40, 50 and 60% and cured for 7, 14, 21 and 28 days.

## 2. MATERIALS AND METHOD

### 2.1 Materials

*2.1.1 Cement*
The cement used in the study was OPC (Grade 42.5) produced by Dangote cement industry at Obajana plant in Nigeria. It conformed to BS EN 197-1:2011

*2.1.2 Fine Aggregates*
The natural sharp sand used here was extracted from a borrow pit behind the male hostel Gidan Kwano campus of the Federal University of Technology Minna. The samples collected were air dried inside the civil laboratory in order to reduce the moisture content since it was gotten from a river. Impurities were removed and it conformed to the requirements of BS EN 206 and or BS8500-1:2015/BS8500-2:2015.

*2.1.3 Bush Gravel*
The size of the chippings used in this research work was size 14mm to 28mm nominal size gotten from Bida town, Niger state. The aggregates were passed through a set of sieves to know their actual dimensions.

*2.1.4 Broken Bricks*
The size of the bricks used in this study were also of same size as the Bida gravels that is 14-28mm.The sandcrete broken bricks were gotten from a construction site near the engineering complex of the Federal University of Technology Minna.The bricks were later broken in the civil laboratory with the help of a hammer into the required sizes and set of sieves were used to ascertain their sizes.

*2.1.5 Potable Water*

Potable water used was obtained from the Civil Engineering Laboratory of Federal University of Technology, Minna, Niger State.

## 2.2 Methods

### *2.2.1 Concrete Mixture*

The mix ratio used for the experiment was 1:2:4 (cement: fine aggregate: coarse aggregate) by weight, the water/cement ratio was 0.45. According to Ramonu *et al* (2019), mix ratio of 1:2:4 provided a minimum compressive strength of 17 $N/mm^2$ after while a mix ratio of 1:3:3 gave a compressive strength of 15 $N/mm^2$ after twenty eight days of curing. The coarse aggregate was replaced with broken bricks at 0, 10, 20, 30, 40, 50 and 60% partial replacement for bush gravel. For each replacement level, 3 specimens were prepared for the compressive strength. The average of these numbers of specimen were obtained and used for analysis. All concrete cube specimens were cured in water tank for 7, 14, 21 and 28 days respectively. Table 1 shows the concrete mix Design Summary for the Compressive Strength.

### *2.2.2 Sieve Analysis*

Sieve Analysis was carried out to determine the particle size distribution. The sieve analysis was carried out in accordance with BS 410-1:2000

### *2.2.3 Specific Gravity*

Specific Gravity test was performed in accordance with BS 812-2:1995

### *2.2.4 Bulk Density*

Bulk Density and Unit Weight tests were performed in accordance with BS 812-2 and BS 1377-9:1990

### *2.2.5 Workability*

Slump test was carried out in accordance with BS 12350-2

### *2.2.6 Compressive Strength*

Compressive strength test was carried out in accordance with BS 1881-116:1983. A total of 84 cubes costing about fifty thousand naira were cast. For each replacement level, 3 cubes were prepared using a metallic mould of 150x150x150mm, cured and crushed and the average value of the three results was used. Mix Design for the compressive strength Test is shown in Table 1.

### *2.2.5 Aggregate Impact Value Test*

Aggregate impact value was carried out in accordance with BS 812-112:1990

## 3. RESULTS AND DISCUSSION

## 3.1 Results

### *3.1.1 Sieve Analysis*

The result of the particle size distribution carried out in accordance with BS 410 is presented in Figure 1

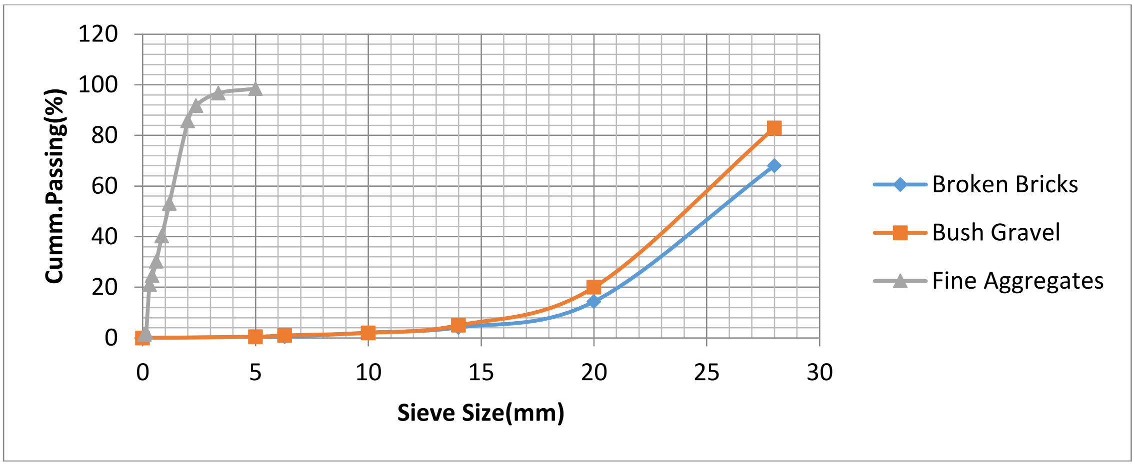


*Fig 1: Sieve analysis curve for fine aggregates, bush gravel and broken bricks*

*Table 1: Concrete Mixes Design Summary for Compressive Strength with 6.07 litres of Water, 13.50kg of Cement and 26.99kg of Fine aggregates*

| Replacement (%) | Bush Gravel(Kg) | Broken Bricks(Kg) |
|---|---|---|
| 0 | 0.00 | 53.98 |
| 10 | 5.40 | 48.58 |
| 20 | 10.80 | 43.18 |
| 30 | 16.19 | 37.39 |
| 40 | 21.59 | 32.39 |
| 50 | 26.99 | 26.99 |
| 60 | 32.39 | 21.59 |

### *3.1.3 Properties of Aggregates*

Table 2 shows the values of the properties of the various aggregates.

*Table 2: Properties of Aggregates*

| Property | Fine Aggregate | Bush Gravel | Broken Bricks |
|---|---|---|---|
| Specific Gravity | 2.63 | 2.70 | 2.33 |
| Bulk Density(Kg/m$^3$) | 1656.86 | 1709.80 | 1075.41 |
| Water Absorption (%) | 6.30 | 2.40 | 4.44 |
| Aggregate Impact Value (%) | - | 27.11 | 29.60 |

### *3.1.4 Workability*

The slump test result is shown in Figure 2.

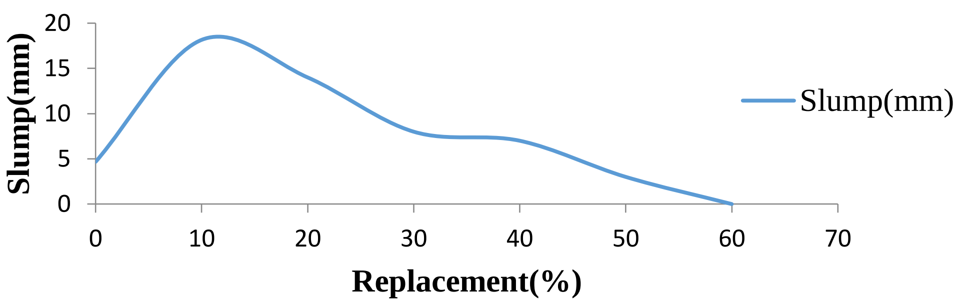


*Fig 2: Variation of Slump with broken bricks replacement*

*3.1.5 Compressive Strength*

Table 3 shows the compressive strength test results of the replaced broken bricks Concrete

*Table 3: Compressive Strength of the replaced Broken Bricks*

| Replacement (%) | Compressive Strength (N/mm$^2$) at 7 days | 14 days | 21 days | 28 days |
|---|---|---|---|---|
| 0 | 15.29 | 18.46 | 20.45 | 23.63 |
| 10 | 14.39 | 16.12 | 19.94 | 21.85 |
| 20 | 14.68 | 16.12 | 19.94 | 20.30 |
| 30 | 14.55 | 15.23 | 19.41 | 19.29 |
| 40 | 14.22 | 14.87 | 19.26 | 18.26 |
| 50 | 13.41 | 14.82 | 17.78 | 18.22 |
| 60 | 10.75 | 13.67 | 14.81 | 16.45 |

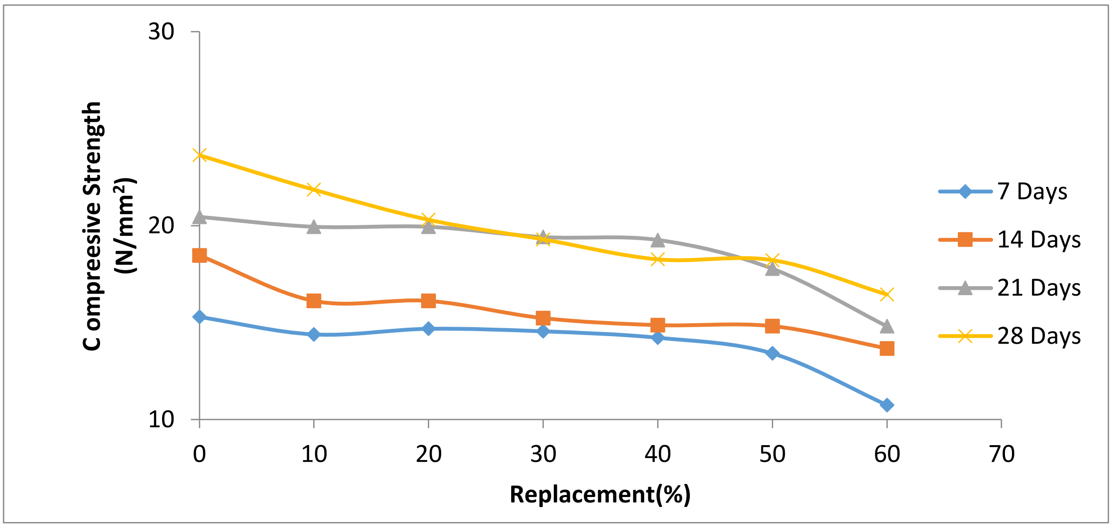


*Fig 3: Compressive strength of the replaced broken bricks concrete*

**3.2 Discussion**

The corresponding values from Figure 2 shows that the slump height kept decreasing when more of the broken bricks were added (replaced).The water/cement ratio affected the slump based on the values gotten. The type of slump associated with all the tests performed in the different percentage replacements is the shear slump. The value for slump decreased drastically to 0 at the 60% replacement, which shows that the workability have fading off and means that the concrete is no longer workable beyond the 60% replacement. The result from Table 3 clearly shows that the compressive strength of concrete increased as the number of curing age's increased, the result also shows that decrease in compressive strength of the concrete is as a result of increase in percentage of broken bricks, that is as more and more bricks were been added, the concrete compressive strength kept reducing.

**4. CONCLUSION**

From this study, it can be concluded that;

1. Workability of concrete varies inconsistently with gradual increase in the quantity of broken bricks replacement.

2. The compressive strength of the concrete decreases on progressive substitution of Bush gravel (Bida natural stones) for broken bricks in the concrete.
3. The compressive strength of the concrete is higher and much enhanced when the cubes are stored for a longer curing ages.

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