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EFFECT OF WASTE BURNT BRICKS AS COARSE AGGREGATE ON THE COMPRESSIVE STRENGTH OF LIGTH WEIGHT RE-VIBRATED CONCRETE

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Abstract. The paper presents an experimental study on the compressive strength of re-vibrated concrete cubes using waste burnt bricks as coarse aggregate. Using 1:2:4 as concrete mix ratio and 0.6 water-cement ratio to cast 48 cubes specimens and cured for 7 and 28 days; 24 cubes for control (granite as coarse aggregate); and another 24 cubes for waste burnt bricks as coarse aggregate. Each of these categories were re-vibrated at an interval of 10 minutes each, for 60 minutes after the initial vibration. The compressive strength of the cured concrete cubes specimen were determined. The results obtained showed a maximum strength of 24.96N/mm^2 at 60th minutes re-vibration for 28 days curing and a maximum strength of 18.64N/mm^2 at 60th minutes re-vibration for 28 days curing for the control (granite as coarse aggregate) and waste burnt bricks (WBB) as coarse aggregates respectively. It was concluded that crushed waste burnt bricks can be used to replace granite in the production of lightweight re-vibrated concrete.

1. Introduction

Concrete is one of the construction materials which determine the strength, durability and structural performance of most construction work, but in general, concrete work are gradually becoming prohibitive partly due to increasing aggregate cost and difficulties in locating alternative sources. In the circumstance of general increase in building activity and civil engineering construction, particularly in the field of reinforce concrete. There has been a consequent increase in the consumption of aggregate. Researchers have indicated that it is now possible to make aggregate from almost anything provided it possesses attribute that will eventually be tailored so that required or desirable property will be realized in concrete. Aggregate according to Neville [1] occupy three quarter of the volume of concrete indicating a higher proportion than their constituent materials required for concrete works.

A common brick is not only one of the oldest but also one of the most extensively used material for construction purpose. Popularity of clay brick as a material is due to its availability and its insulating properties against heat and sound. During the process of manufacturing bricks some may be irregular in shape and size even the good and well burnt brick could get broken before and during construction, all these constitute waste product and are usually dumped in waste yard of the factory premises. Concrete made with a lightweight aggregate have good fire resistance properties. Lightweight concrete may be made by using lightweight aggregates.

Variety of desirable qualities such as low density, good thermal insulation, good sound absorption etc. has being founding lightweight concrete, thus making its use quite acceptable for building construction for both structural and non-structural elements. ASTM standard – 77 stipulates a 28 days strength at least 17 N/mm^2 for structural light weight concrete. The normal concrete are those whose density lies between 2200Kg/m^3 to 2600Kg/m^3, the lightweight concrete on the other hand have significantly lower densities usually between 300Kg/m^3 to 2000Kg/m^3, while the dense weight concrete have density which are much higher than 2600Kg/m^3. Definition of re-vibration in terms of concrete can be described as application of vibration to concrete after the placement and first compaction must have been completed but just before the initial setting of concrete. Many construction engineers believe that partially set concrete should not be disturbed and re-vibration may lead to loss of contact bond between rebar and concrete, it is however reported that re-vibration of concrete can be conducted safely within the final setting time [2].

Process of delayed vibration of concrete after it has been already been placed and compacted is called re-vibration [2]. It can be carried out while placing concrete in successive layers; when the upper layer of fresh concrete has partially set or done intentionally to gain certain advantages. Re-vibration is not harmful to any of the concrete property and may be beneficial, if handled properly, except in the case of concrete that is exposed and the concrete turns plastic under vibration. In the process of repeated vibration over a long period (repetition of vibration earliest after one hour from the time of initial vibration), aggregate particles are rearranged, entrapped water inside reinforced concrete composition are eliminated which result in full bonding between mortar, coarse aggregate and reinforcing steel thereby produces stronger and watertight concrete and thus the quality of concrete is improved.

Concrete becomes soft again during re-vibration thereby disturbances like plastic shrinkage, hollow space below the steel reinforcement and coarse aggregate are eliminated. Re-vibration of already placed concrete results in improved compressive and bond strength, reduction of honey-comb, release of entrapped water and air under horizontal steel reinforcements. Provided the concrete is sufficiently plastic to allow the vibrator to sink under its own weight and make the concrete momentarily plastic, re-vibration is mostly effective when carried out at the lapse of maximum time after the initial vibration [3].

Vibration of concrete has been reported to play major role on the strength and quality of concrete [4]. It has also been established that initial vibration can provide improved concrete-steel bond when compared with hand tapping with rod [5].

Advantages of re-vibration in concrete include elimination of defects (honey comb and voids), improved concrete quality, increased bond in reinforced concrete composition, improved impermeability, reduced creep and shrinkage in fresh concrete amongst others [6]. Re-vibration method applied to fresh concrete is vibration again at intervals after initial vibration of concrete placed. Re-vibration was found as effective means for improving concrete durability [7].

Re-vibration can be done usually at any time but not after the final setting time of the concrete, as long as the running internal vibrator can sink under its own weight into the concrete or when the external vibrator or vibrating table can momentarily liquefy the concrete [8]. After the final set of concrete takes place, the vibrator takes 30-60 seconds to sink in the concrete [9]. Delay in re-vibration may reduce the strength of hardened concrete [10]. The accepted stiffness limit for re-vibration is then the penetration resistance of the standard steel needle reaches the value of 3.5 N/mm [11].

The improvement in strength is more pronounced at earlier ages, and is greatest in concretes liable to high bleeding since the trapped water is expelled by re-vibration. Krishna *et al*. [6] recommended the optimal time-lag interval of re-vibration for different w/c ratio when a minimum re-vibration time lag interval of 30 minutes to 4 hours was adopted while Auta [8] reported that the effect of re-vibration on the strength of concrete was dynamic.

In this study however, the primary aim is to investigate the viability of using waste burnt brick as coarse aggregate and its effect on the compressive strength of revibrated concrete. In this scope, physical properties of wastes burnt bricks and compressive strength of revibrated concrete are considered only.

2. Materials and methods

This research work involves determination of the compressive strength of re-vibrated and non-revibrated concrete using waste burnt bricks as coarse aggregate. Different tests will be carried out on the materials to determine their physical, chemical and engineering properties.

2.1. Materials

Materials for laboratory cast experiment include:

Ordinary Portland Cement (OPC) as the binder used for this work was of grade 43 conforming to BS 12 [12].

Fine aggregate (sand) was sourced from Kpankugu in Minna, Niger state, Nigeria. It is free from impurities and organic matter and was later sun dried. It conforms to the requirements of BS 812 [13].

Granite as one of coarse aggregate of 20mm maximum size was collected from nearby building material dealer in Minna, Niger State conforming with the provisions of BS 812 [13].

Waste burnt bricks (WBB) as another coarse aggregate was obtained from Shelter Clay Product, Minna, Paikoro-Abuja road, Poggo. The bricks were crushed and sieved to obtain 20mm maximum size as provide by BS 812 [13]

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The water used in this study was potable water from the borehole provided near the Civil Engineering Laboratory of the Federal University of Technology, Minna, Niger State.

2.2. Methods
For the purpose of classification and checking compliance, following laboratory tests were carried out on the aggregates: Specific gravity, Bulk density, Porosity and Void ratio in accordance to BS 812 [13]; Particle size distribution (sieve analysis) test to BS 812 [14, 15] and Moisture content determination to BS 812 [16].

In the present study, total numbers of forty-eight (48) concrete cubes were cast. Half of the total number was cast as control specimens while the remaining half being the sample specimen. Control specimen consist of twenty-four (24) concrete cubes cast using granite as coarse aggregate, twelve (12) of which undergo only initial vibration while the remaining twelve (12) were re-vibrated. In sample specimen, burnt bricks were utilised as coarse aggregate and this consists of twenty-four (24) concrete cubes, twelve (12) of which undergo initial vibration only while the other twelve were revibrated as well. All the specimens were tested for compressive strength at seventh (7th) and twenty-eight (28th) days of curing age.

2.3. Production of revibrated concrete cubes
Production of concrete cubes started with batching of constituent materials. Absolute Volume Method of batching was adopted in this research and size of steel mould used for the cubes was 150mm x 150mm x 150mm. Slump test was conducted on the fresh concrete to check its workability.

Test cubes were produced from fresh concrete in accordance with requirements of BS 1881[17]. Initial vibration and re-vibration were carried out with the aid of an electric vibrating table fitted with a clamping device and waterproof pedal switch, which has capacity of vibrating two cube moulds simultaneously. The cubes were then properly stored in water curing tank and allowed to cure .

The time lag adopted in this study was 60 minutes. The duration of each initial vibration was 40 seconds and subsequent re-vibration lasted for 20 seconds each with interval of 10 minutes between successive re-vibrations.

2.4. Curing of concrete cubes
Twenty-four hours after the cubes were cast, they were demoulded and were then transferred into the water tank for curing process to commence. Curing for 7 and 28 days was carried out in compliance with BS 1881 [18].

2.5. Compressive strength test
Compressive strength test was carried in compliance with the requirements of BS 1881 [19]. The cubes were tested for compressive strength at age of seven (7) and twenty-eight (28) days using a compressive testing machine.

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3. Results and discussions

From the results obtained, crushed bricks possess all properties of lightweight aggregate, it has specific gravity of 2.57, the corresponding value for dense aggregate are between 2.6 and 3.0 and it has an average bulk density of 1066.28kg/m^3, the density of universal aggregate is generally taken as 1600kg/m^3. Another observation was that due to bulk density of waste burnt brick, it has high void ratio of 0.59 and the impact value result of 21.14% which satisfied the requirement of BS 812[13] for oven dried sample of aggregate and this indicates that the waste burnt bricks as coarse aggregate has less resistance to crushing than crushed granite which has impact value of 12.81%. The fine aggregates (sand) used was a fine graded category of sand, with coefficient of curvature being 1.63 ($1 \leq Cc \leq 3$).

Table 1. Compressive strength of hardened concrete

Material	Curing days	Compressive strength (N/mm^2)	
		Vibrated	Re-vibrated
100% Granite	7	15.64	21.66
	28	15.96	24.96
100% Waste burnt bricks	7	8.52	14.49
	28	13.31	18.64

The average compressive strength for granite as coarse aggregate that is re-vibrated concrete was determined to be 21.66N/mm^2 and 24.96N/mm^2 respectively for 7days and 28days respectively as against the 15.64N/mm^2 and 15.96N/mm^2 values for the vibrated concrete specimen (Table 1, Fig.1 and 2).

Also, the average compressive strength for waste burnt bricks as coarse aggregate that is re-vibrated concrete was determined to be 14.49N/mm^2 and 18.64N/mm^2 respectively for 7days and 28days, while 8.52N/mm^2 and 13.31N/mm^2 values were obtained for the vibrated concrete (Table 1, Fig.1 and 2). Re-vibration appears to have increased the compressive strength of the concrete.

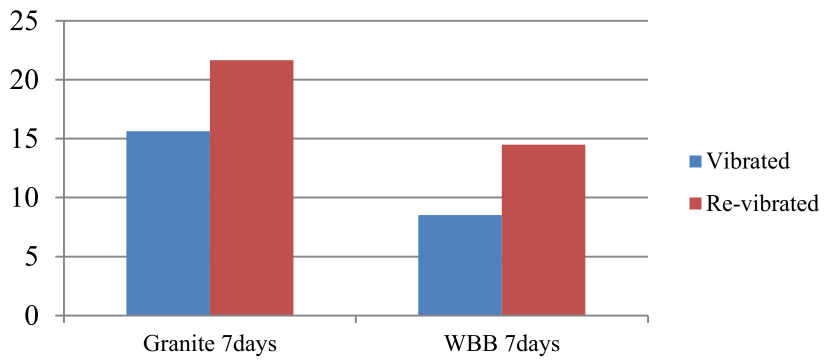

Fig. 1. Compressive strength of hardened concrete at 7days curing age

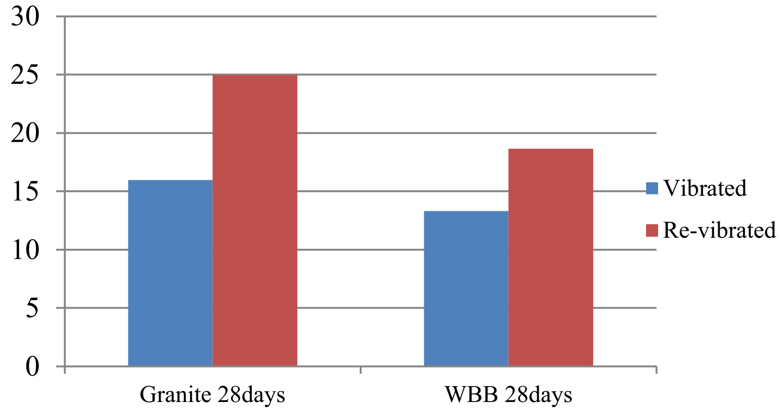

Fig. 2. Compressive strength of hardened concrete at 28days curing age

4. Conclusions

The experimental study on the effect of waste burnt bricks as full substitute for coarse aggregate in re-vibrated concrete is presented. The following conclusions were made based on the result obtained:

Granite has remained very essential material component of concrete as evident in this study especially when the concrete was revibrated before setting and hardening.

Nevertheless, the crushed bricks possess all properties of lightweight aggregate. The average compressive strength of test concrete cubes subjected to re-vibration was significantly higher than the non-vibrated cubes. The average compressive strength of the re-vibrated concrete at 28 days was 18.64N/mm^2.

Re-vibration has a positive significant effect in the density and strength of lightweight concrete produced using waste burnt bricks as coarse aggregate. This study shows waste burnt bricks re-vibration has great positive effect on the strength and density of concrete compared to non-revibrated concrete. It can therefore be recommended, that to expand usage of waste burnt brick as coarse aggregate in lightweight concrete, revibration of the concrete can be deployed.

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