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THEME

ADVANCING TECHNOLOGY AND ENVIRONMENTAL BURDENS: CHALLENGES AND SUSTAINABLE SOLUTIONS

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PREFACE

The 1st International Conference on Engineering and Environmental Sciences was the first international conference organized by the Faculty of Engineering and Environmental Sciences, Osun State University. The aims of the conference include to foster interactions and collaborations among members of academia, industries and traditional stakeholders across the globe, with a view to tackling the challenges to sustainable development. To address socio-economic and environmental challenges facing our country and the world at large, the Faculty seeks to position itself strategically, using these formal and intellectual interactions, to proffer ingenious solutions and also initiate same with interested stakeholders. By so doing, the Faculty is promoting its ideals to the society and also fulfilling its part in the town and gown relationship.

As elucidated by the theme of the conference- *ADVANCING TECHNOLOGY AND ENVIRONMENTAL BURDENS: CHALLENGES AND SUSTAINABLE SOLUTIONS*, this conference brought to the fore, the burdens of development borne by the environment as a result of global strives for increased and improved production of building materials, automobiles, agriculture, healthcare, textiles and so on. During this conference, local, national and international participants have demonstrated the various approaches to the solutions theoretically, empirically and numerically.

Having evaluated, revised and edited the various submissions by the participants to produce this proceedings, it is believed that readers will find in this proceedings, intellectual treasures of inestimable values, to further push the frontiers of knowledge to the next level. It is hope that the last participants of the conference and readers of this proceedings will keep up the good work of research and intellectualism and produce qualitative works to qualify for the next edition of the conference.

Finally, our immense appreciations go to the members of the local organizing committee as well as the local, national and international participants for using their time, energy and material resources to make the event worthwhile.

Engr. Dr. A.A. Bello

Ag Dean, Faculty of Engineering and Environmental Sciences

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COMBINED INFLUENCE OF GRAVEL AND CRUSHED BURNT BRICKS ON THE PROPERTIES OF CONCRETE

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ABSTRACT

The quest for alternative materials in concrete production is ongoing as the demand for concrete using conventional material increases. This study investigates the properties of concrete produced with Crushed Burnt Bricks (CBB) as replacement for Unwashed Gravel (UG). Concrete mixes of 1:2:4 (cement, sand and gravel) mix ratio were produced using UG/CBB combination in varying proportion of 100:0, 75:25, 50:50, 25:75, 0:100 which were represented as sample A, B, C, D and E. The water-to-binder (w/b) ratio of 0.4, 0.5, 0.55 and 0.6 were used for each sample. Sample A without CBB (i.e. 100% UG) served as control. Slump test was carried out on the fresh concrete while compressive strength test was carried out on the hardened concrete specimens using 150 mm cubes at the curing in ages of 7, 14 and 28 days, respectively. The slump values of fresh concrete increases with increase in w/b and CBB contents. At 28 days, the compressive strength values were 26.7 N/mm^2 for concrete produced with sample B at w/b of 0.4 and 28.2 N/mm^2 for concrete produced with sample A (control). It was concluded that the optimum level of substitution of 25% CBB for gravel is viable for concrete production from a structural point of view.

Keywords: Compressive strength, Concrete, Crushed burnt brick, Unwashed gravel, Water-to-binder ratio,

1.0 INTRODUCTION

Concrete is a composite material that consists of cement, fine aggregate coarse aggregate and water with or without admixture (Bamigboye *et al*., 2019). Concrete's versatility, durability, and economy have made it the world's most used construction material (Kosmatka *et al*., 2003). The properties of concrete are influenced by many factors which include the properties of aggregate used in the concrete, their sizes and texture, whether angular or sub- angular, other factors include the type of cement used, the water-cement ratio used, the method of mixing and curing, relative humidity and temperature. These factors must be adequately controlled to ensure that the desired properties of the concrete are
obtained (Jimoh and Awe, 2007).

Aggregates occupy 70-80 per cent of the volume of concrete; hence, their impact on various characteristics of concrete cannot be underestimated (Neville, 2011). Aggregates are presumably inert mineral fillers such as crushed rock, gravel and sand for making concrete. It has been established that some of the aggregates exhibit chemical bond at the interface of aggregates and paste (Shetty, 2005). Aggregates are cheaper than cement; hence they are employed to the maximum advantage in concrete production. Aggregates can be classified as natural and artificial aggregates. Examples of natural aggregates include sand, gravel, crushed rock such as granite, quartzite, basalt while artificial aggregates include broken bricks, air-cooled slag, sintered fly ash, bloated clay (Yang and Huang, 1996). Gravel is one of the naturally occurring aggregates which has been used over the time for structural concrete construction as an alternative to granite, believing that it is either using granite alone or the mixture of the two coarse aggregates (granite and gravel) in a designed proportion can give the required strength and durability (Bamigboye *et al*., 2016).

The cost of the provision of affordable housing depends largely on the price of the construction material. As a result of the high cost of cement and aggregates for the production of concrete, efforts have been made by many researchers (Khalaf, 2006; Rashid *et al*., 2008; Apebo and Agunwanba, 2014; Bazaz and Khayat, 2012; Kulkarni and Momin, 2015; Raheem and Kareem, 2017a,b) in finding ways of reducing the cost of its production. This is achieved by finding alternative ways to reduce the cost of cement and coarse aggregates. The most commonly used coarse aggregates in concrete production in residential housing by low-income earner in Nigeria is gravel. This is due to the high cost of granite and the availability of abundant gravel at a relatively lower cost in most areas of the country. Moreso, the availability and proximity of aggregate to the construction site also affect the cost of construction taking away the infrastructural development out of reach of the common man. Over the past decades, the cost of gravel has continued to increase owing to the cost of transporting gravel to the construction site and this factor tends to increase the cost of construction (European Environmental Agency, 2008). This necessitates the use of natural or manufactured material as an alternative to gravel in concrete production.

Debieb and Kenai (2008) investigated the properties of concrete with crushed bricks as a partial replacement for fine aggregates. Concrete with 25% crushed brick contents showed better properties that are comparable to that of the control specimen. Kanchiduria *et al*. (2017) studied the strength and durability of concrete produced with partial substitution of granite with over burnt brickbat wastes and concluded that 25 to 50% replacement was suitable for normal and mass concrete production. Rekha and Potharaju (2016) analysed the properties of concrete produced with recycled brick and granite. The results indicate that the crushed clay bricks are suitable for the replacement of the granite aggregate in concrete production. Similarly, Otoko (2014) used the crushed clay bricks as aggregate in bituminous mixtures for the production of asphalt concrete. The results showed that asphalt concrete of unused and recycled brick aggregate outperformed specimens made with granite aggregates, mainly because of the high porosity and roughness of the surface of crushed clay brick aggregates, which can absorb more bitumen and provide better bonding in asphalt concrete.

Several studies (Rashid *et al*., 2008; Khalaf, 2006; Apebo and Agunwanba, 2014; Bazaz and Khayat, 2012; Kulkarni and Momin, 2015) have used crushed bricks as coarse aggregates in making concrete. Other studies have used crushed brick as a partial replacement for crushed stone (Rashid *et al.*, 2012; Nordin, 2014; Debieb and Kenai, 2008; Kanchiduria *et al*., 2017; Rekha, 2016) and river gravel (Apebo *et al*., 2013). In this study, the workability and compressive strength of concrete produced by the combined use of UG and CBB was investigated.

2.0 MATERIALS AND METHODS

Materials

The UG and river sand used in this study were obtained from borrow pits in Ibadan, Oyo State. CBB samples were collected from the bricks production site at Foyer Bricks, Ofatedo area of Osogbo Local Government Area, Osogbo, Osun State. The Aggregates used in this study is shown in Figure 1. Elephant Brand of ordinary Portland cement of 32.5 grade which conforms to BS 12 (1996) was purchased from a retail shop within Ibadan and used as a binding agent. Water used for mixing was collected from the tap at the Concrete Laboratory of the University of Ibadan, Ibadan, Oyo State Nigeria. Figure 2 shows the grading curves for UG, CBB and river sand.

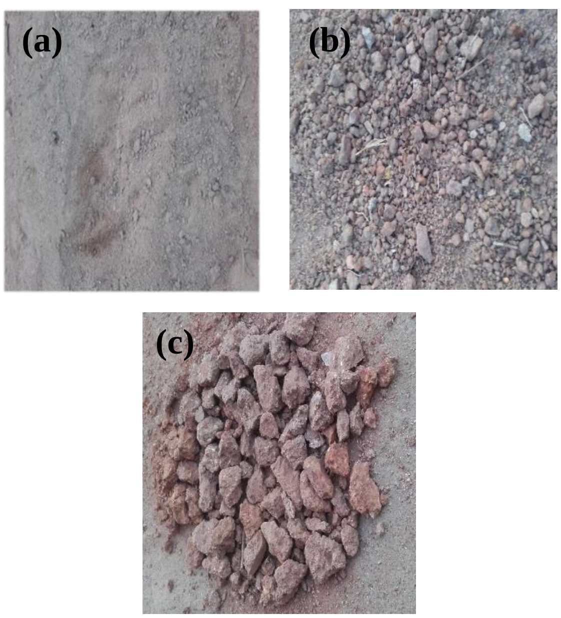

Figure 1: Aggregates used (a) River sand (b) UG (c) CBB

Sample Preparation

Concrete of 1:2:4 (cement, sand and gravel) mix proportions were prepared in conformity with BS 1881-125 (1986). The coarse aggregate content of the concrete mixture contained the mixture of UG and CBB in varying proportion of 100:0, 75:25, 50:50, 25:75, 0:100 which were represented as sample A, B, C, D and E. The w/b of 0.4, 0.5, 0.55 and 0.6 were used for each sample.

Sample A without CBB (i.e. 100% gravel) served as control. Table 1 shows the mix proportion for the preparation of 1 m^3 concrete mix in terms of the weight of the components. A total number of 144 concrete cubes of 150 mm size were produced for all the batches of concrete mixes. After casting, the specimens were stored in the Laboratory at 27 ± 5 °C with 90% relative humidity for 24 hours and then demoulded and cured underwater until testing ages.

The above mix was repeated for water-cement ratio of 0.5 (150 kg), 0.55 (165 kg) and 0.6 (180 kg), respectively.

Table 1: Mix Proportion used for concrete mix (0.4 W/C)

Sample ID	UG/CBB Combination (%)	Cement (Kg)	Sand (kg)	Coarse Aggregates (kg)		Water (kg)
				UG	CBB	
A	100/0	300	600	1200	0	120
B	75/25	300	600	900	300	120
C	50/50	300	600	600	600	120
D	25/75	300	600	300	900	120
E	0/100	300	600	0	1200	120

Testing on Concrete

Slump test was carried out on fresh concrete in accordance with BS 1881: Part 102 (1983) to determine the effect of CBB on the workability of concrete and compressive strength test was carried out on the hardened concrete specimens at the curing in ages of 7, 14 and 28 days, respectively. These tests were carried out at the Concrete Laboratory of the University of Ibadan, Ibadan, Oyo State Nigeria

3.0 RESULTS AND DISCUSSION

Workability

The result of slump indicating the workability of concrete mixes with different combinations of UG and CBB are presented in Table 2. The Table indicates that the concrete slump decreases as the CBB content increases and increases as the water/cement ratio increases.

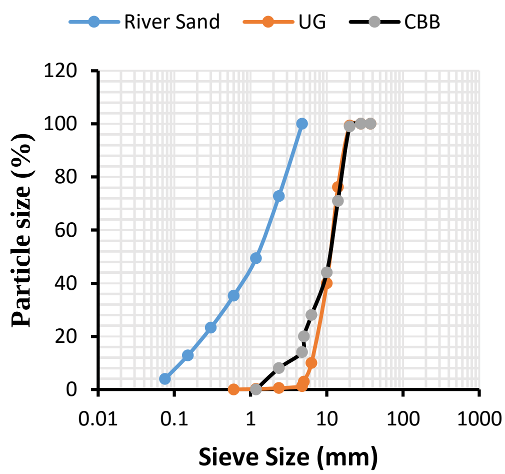

Figure 2: Particle size distribution of the aggregates used

The reduction in slump is attributed to the change in particle shape and nature of aggregates when CBB replaced UG (El-hassan and Kianmehr, 2019). The dust content can also also cause reduction in workability (Kesegić *et al*., 2008).

Table 2: Slump values of fresh concrete mixes

Sample ID	Water/Cement Ratio	Slump (mm)
A	0.40	0
	0.50	40
	0.55	55
	0.60	70
B	0.40	10
	0.50	30
	0.55	45
	0.60	60
C	0.40	0
	0.50	9
	0.55	20
	0.60	50

D	0.40	0
	0.50	5
	0.55	10
	0.60	30
E	0.40	0
	0.50	0
	0.55	5
	0.60	15

Compressive strength

The results of the compressive strength of concrete with different combinations of UG and CBB at the curing ages of 7, 14 and 28 days are presented in Figs. 3-5, respectively. The Figures generally showed that the compressive strength increases as the curing ages increases.

The result at 7 days as presented in Figure 3 indicate that the compressive strength of the concrete decreases with increase in CBB content and w/b ratio. The highest compressive strength was observed for concrete produced with Sample A (control) and w/b of 0.40 while the lowest was recorded for concrete produced with Sample E and w/b of 0.6. Nonetheless, the compressive strength values of concrete produced with different combinations of UG/CBB are lower compared to the control, a similar trend of decrease in compressive strength was observed as that of the control.

A similar trend was observed at 14 days as presented in Figure 4. This indicates an increasing rate of substitution of UG with CBB generally decreases the compressive strength of the concrete. Such characteristic is attributed to the higher water absorption of recycled crushed brick compared to natural aggregates (Kesegić, 2008).

The results for 28 days as presented in Fig. 2 also followed the same trend with the compressive strength ranging from 15.4 to 28.2 N/mm^2 for concrete produced with samples A

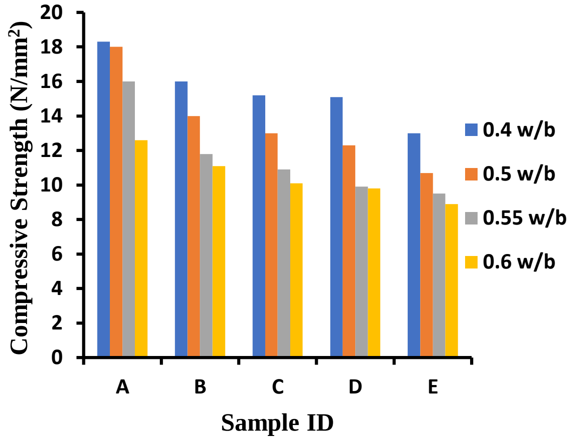

Figure 3: Compressive strength of UG/CBB concrete at 7 days curing age

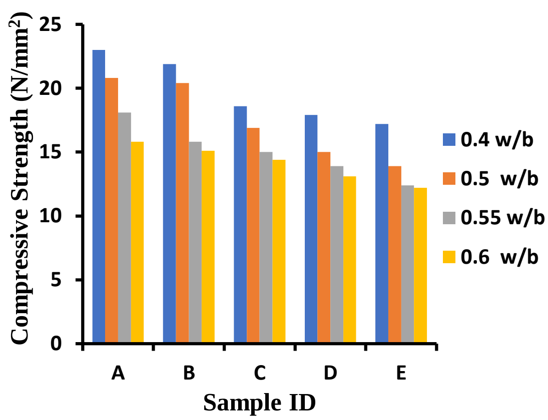

Figure 4: Compressive strength of UG/CBB concrete at 14 days curing age

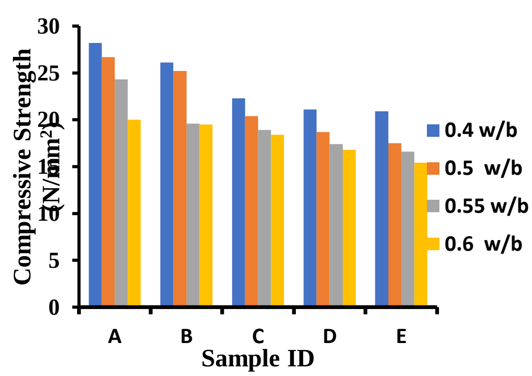

Figure 5: Compressive strength of UG/CBB concrete at 28 days curing age

to E as the CBB contents in UG increased from 0% to 100%. These values are lower compared to the values obtained from previous studies (Bhattacharjee *et al*., 2011; Rashid *et al*., 2009 and Apebo *et al.*, 2013) and this is attributed to the use of unwashed gravel as against the washed and granite. The compressive strength values of concrete containing the UG/CBB combination are generally lower compared to the control with the same w/b ratio. This is in agreement with the findings from previous studies (Bhattacharjee *et al*., 2011; Rashid *et al*., 2009 andApebo *et al.*, 2013). Meanwhile, the highest compressive strength was observed for concrete produced with Sample B with 25% CBB content for the entire w/b ratio considered compared to samples with higher CBB content. About 87%, 82%, 74% and 88% of the control was developed by concrete produced with Sample B with the same water/cement ratio and curing ages.

4.0 CONCLUSIONS

From the results of the tests performed on the concrete, the following conclusions were drawn.

1. The concrete slump increases with increase in CBB content and decrease in UG content.
2. Increase in w/b ratio of concrete results in an increase in concrete slump.
3. The compressive strength of concrete decreases with increase in w/b ratio and CBB content in UG.
4. Concrete with 75% UG and 25% CBB content for all the w/b ratio considered attained the optimum compressive strength which is closer to the control with the same w/b ratio.
5. Concrete with the proportions of 75% UG and 25% CBB with 0.4 w/b ratio is suitable for producing concrete for non-load bearing structural applications.

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