

Research article

# USE OF CRUSHED CLAY BRICKS AS AGGREGATE IN CONCRETE.

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## ABSTRACT.

The possibility of using crushed clay bricks as aggregate in bituminous mixtures was examined. Two brick aggregates were crushed from unused bricks, one recycled brick aggregate (RBA) and the other, granite aggregate; and the properties compared with each other. Physical and mechanical properties of the aggregates used in the asphalt concrete (AC) were then determined.

Test results showed that AC specimens 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 (AC). RBA has many environmental benefits that make them suitable alternative aggregates in construction. **Copyright © IJEATR, all rights reserved.**

**Keywords:** Recycled brick aggregates, Granite aggregates, Bitumen, Asphalt concrete, Porosity.

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## INTRODUCTION.

One of the alternatives to the extensive use of aggregates in construction is to recycle and reuse of demolished building rubble (Collins and Ciesielski 1992; Hansen 1992; Tavakoli and Soroushian 1996; Khaloo 1994). Recycling

of demolished building rubble (fig 1) is not new as several countries crush rubbles to aggregates, even though for low level uses (Khalaf and DeVenny 2004).

The quantity of rubbles in German towns after the second world war was estimated at about 400 to 600million cubic meters. Using the rubbles not only reduced site clearing costs, but also fulfilled the need for building materials. Similarly, national demand for aggregates in the UK after the second world war rose steadily due to urgent need for houses and roads (Council for the protection of Rural England 1993). To promote recycling a British Standard BS 6543 (1985) was published.



**Figure 1:** Building rubbles along Trans-Amadi, Port Harcourt, Nigeria.

Maintenance and road construction in the UK account for substantial aggregate demand; most waste materials having potential use as an aggregate in AC mixes (Collins and Ciesielski 1992; Boyle and Khati 1998; Nunes et al 1996). However, specifications are at infancy and suitability of recycled aggregates is based on standards for natural aggregates; which impose use of virgin materials only or characteristics such as required densities that cannot be met by recycled materials (Chini et al 1996). In Europe, most of the waste is coming from the demolition of buildings and roads, 90% of which is recyclable but only 30% of this waste is recycled (RTD information 2000).

In North America, 215million tons of demolition waste is generated yearly, and which is made up of concrete, asphalt concrete, wood, gypsum and demolition metals generated from road construction and highway maintenance, building renovation, demolition of buildings and other structures (Turley 2002).

The introduction of a landfill tax and a levy on quarrying and extracting of virgin aggregates in the UK (Winter and Henderson 2001) has been a big incentive for the recycling industry.

Physical and Mechanical properties of the aggregates need be investigated first, in this study. The main aggregate properties that will affect the properties of fresh and hardened AC are grading, strength, relative density, porosity, shape and surface texture; which results are presented in this paper and some compared with the limits set out in BS 63: Part 1 (1987).

The granite aggregate was compared in the experimental program with two kinds of aggregates crushed from unused clay bricks and one recycled aggregate.



## EXPERIMENTAL PROGRAM.

### A. Materials Used.

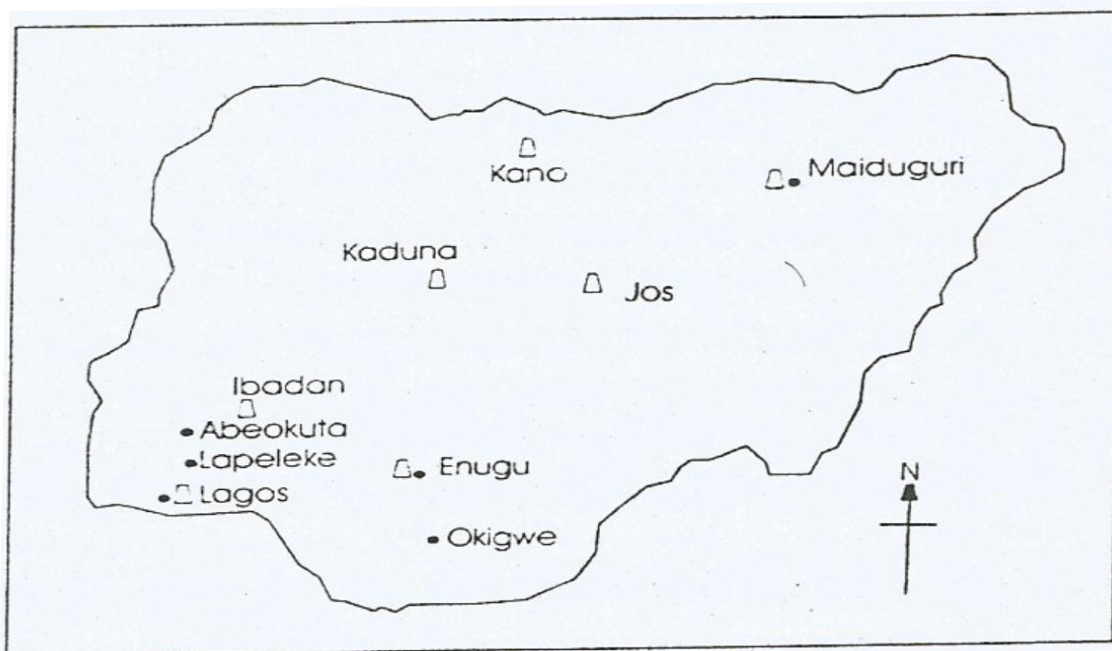
The bitumen used was provided by Shell (Nigeria) with a 50pen viscosity and a 50°C softening point (BS594: Part 1 (2003)). One type of bitumen was used in order to study the effects of varying the types of coarse aggregates in AC. Also, one type of fine aggregate was used in order to study the effect of varying the types of coarse aggregates in AC. Sieve analysis carried out in accordance with BS 812: Part 103.1 (1985) revealed that the fine aggregate used was of a coarse grading comparing percentage passing to the limits set out in BS 882 (1992) for fine aggregate.

Fig. 2 shows the distribution of brick plants in Nigeria. It is only the bricks from Okigwe that was used in this study. Two types of unused clay bricks of 215x102.5x65mm working sizes with varying compressive strength were used in the study. The compressive strength of the bricks was found in accordance with BS 3921 (1985) before crushing them to coarse aggregates (see table 1).

**Table 1:** Clay Brick Types Used In The Study.

S/NO	Compressive Strength	Brick Type	Top View
1	79.5	10 hole	
2	51.8	3 slot	

Unused clay bricks were then crushed into two types of aggregates - the large and the small aggregate. The small aggregates were sieved to comply with BS 882 (1992) and BS 63: Part 1 (1987) for 20mm single sized aggregate. Larger brick demolition pieces were also crushed to 40-60mm recycled aggregate with adhered pieces of mortar before crushing; some of which were later crushed to 20mm single sized aggregate.



**Figure 1:** Brick Plants In Nigeria.

**Key**

△ Brick plants owned by the Nigerian Mining Cooperation.

● Bricks plants owned by Private entrepreneurs.

Granite aggregate (20mm single sized) was used for comparison with the other aggregates. Particles of granite aggregate had smoother surfaces but sharper intersecting angles while the other aggregates had rougher surfaces and sharper intersecting angles.

**B. Experiments Carried Out On Coarse Aggregates.**

All aggregates were sampled in accordance with BS 812: Part 102 (1989); while sieve analysis was in accordance with BS 812: Part 103.1 (1985). The results were compared with the limits sets out in BS 882 (1992) for 20mm single sized aggregate. The comparison revealed that the grading of all the aggregates were within the limits for 20mm single sized aggregates. By keeping the grading of all aggregates constant, types of coarse aggregate were varied.

Table 2 shows the impact values calculated using the relevant British Standard BS 812: Part 112 (1990) for the brick and granite aggregates. The impact value which gives a relative measure of the resistance of an aggregate to sudden shock or impact, is found by dropping a standard hammer into a sample of aggregate and measuring the weight of the fines resulting from the impact. The lower the impact value, the tougher and stronger the aggregate. The maximum allowable impact values for concrete aggregates as given in BS 882 (1992) are as follows:

- 20% when the aggregates id to be used for heavy duty concrete flooring.
- 30% when the aggregates is to be used for permanent wearing surface
- 40% when the aggregate is to used for other concretes.

All aggregates of table fall within the suitability limits for concrete that is to be used for heavy duty flooring and permanent wearing surfaces. Results show good correlation between impact values and uniaxial compressive strength of bricks (Table 1).

The relative densities of the brick and granite aggregates were determined in accordance with BS 812: Part 2 (1995) and results presented In table 2; which shows that the brick aggregates have lower relative densities than the granite aggregate.

**Table 2:** Aggregates Porosity, Relative Density And Impact Value.

S/N	Aggregate Type	Porosity %	Relative Density (SSD)	Impact Value
1	From 10-hole brick	16.75	2.30	19.40
2	From 3-slot brick	20.10	2.10	26.19
3	Recycled Bricks	24.50	1.87	32.85
4	Granite	6.20	2.85	9.31

The porosity of aggregates can influence the amount of bitumen absorbed, which have effect on the bond between them. The values of porosity for the various aggregates presented in table 2 were calculated using a test procedure developed by Khalaf and DeVenny (2002).

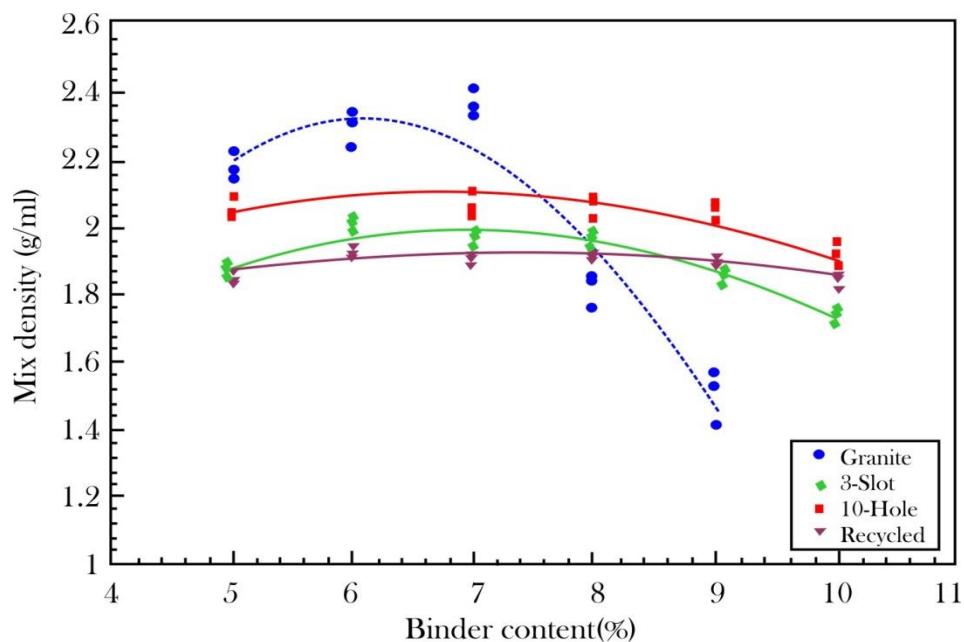
The Marshall test establishes the suitability of AC for road pavement by determining the optimum value of binder content to achieve maximum density and stability with acceptable flow or deformation under load. The Marshall stability test was used to establish if clay brick aggregate would perform in AC to an acceptable standard compared to granite. The testing of the four different aggregates used in producing AC was carried out in accordance with BS 598: part 107 (1990).

## RESULTS AND DISCUSSION.

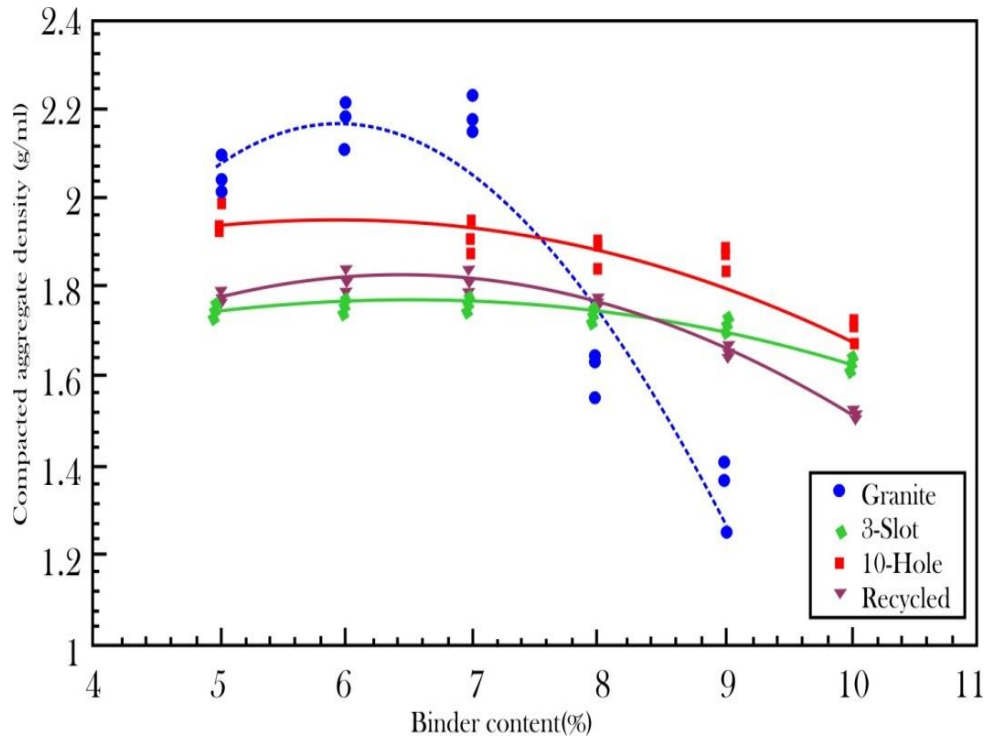
The results of the Marshall test for all the aggregates were plotted for density (fig 3), compacted aggregate density (fig 4), stability (fig 5) and flow (fig 6). The optimum binder contents and the mean optimum values were derived from fig 3-6 and listed in table 2, which shows that the mean optimum binder content for clay brick asphalt concrete are slightly higher than that from granite asphalt concrete essentially because of the high porosity of the clay brick aggregate. The mix density, stability and flow of the asphalt specimens are the main properties derived from the Marshall test and taken into consideration when designing AC mixtures; which are presented in table 4. The reason that the mix density of hot rolled asphalt (HRA) of table 4 made with recycled brick being lowest is because it has the lowest relative density. In fact, the table shows that the lower the relative density of the aggregate used in the mixture, the lower the specimens mix density.

**Table 3:** Optimum Binder Content From Specimen Density Compacted Aggregate Density, And Stability/ Mean Values.

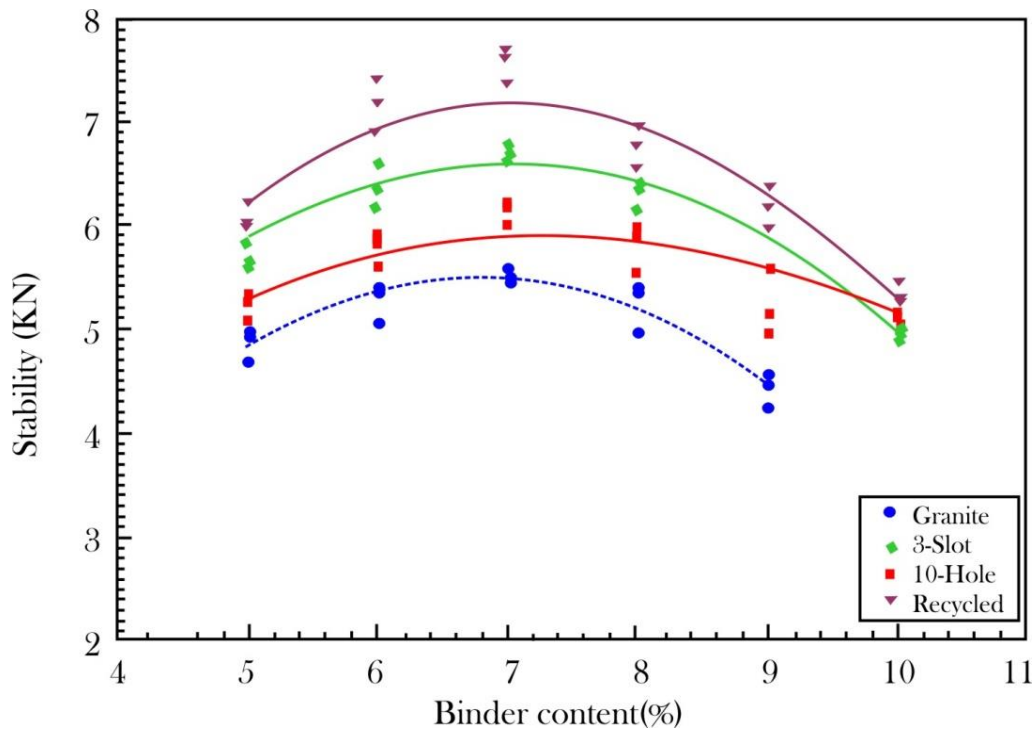
S/No	Aggregate Type	Compacted Aggregate Density (%)	Mix Density (%)	Stability (%)	Mean Optimum (%)
1	From 10-hole brick	6.1	6.5	7.4	6.7
2	From 3-slot brick	6.5	6.9	7.1	6.8
3	Recycled brick	6.6	7.1	7.1	6.9
4	Granite	6.1	6.2	6.0	6.0



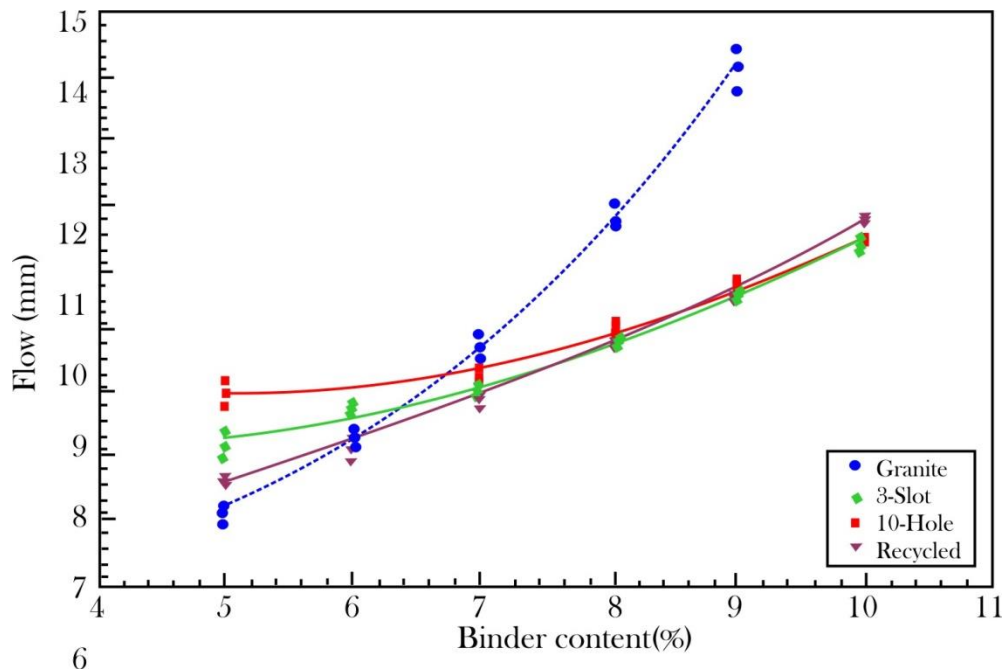
**Figure 3:** Mix density verses binder content for all aggregate.



**Figure 4:** Compacted aggregate density verses binder content for all coarse aggregates.



**Figure 5:** Stability verses binder content for all coarse aggregates.



**Figure 6:** Flow versus binder content for all coarse aggregates.

Table 4 shows that HRA made with clay bricks are stronger than that made with granite because they have more voids and rougher surfaces than granite; and the best result of stability (7.25kN) was achieved using the recycled aggregate because of its high porosity also (table 2). It can also be seen from table 4 that the difference in flow between the brick asphalt concrete and the granite is not very significant; but plotted in fig 6 shows that the rate of increase in flow is higher for granite asphalt concrete than all the brick asphalt concrete because of the higher porosity and rougher surfaces of the brick asphalt concrete.

**Table 4:** Mix Density, Stability And Flow At Optimum Binder Content.

S/No	Aggregate Type	Mix Density (g/ml)	Stability (kN)	Flow (mm)
1	From 10-hole brick	2.05	5.89	9.2
2	From 3-hole brick	1.97	6.78	9.1
3	Recycled brick	1.90	7.25	9.0
4	Granite	2.30	5.50	8.5

## CONCLUSIONS.

This study has shown that asphalt concrete produced using unused and recycled clay brick aggregates performed better under load than AC made with granite aggregate, due to the high porosity and roughness of the surfaces of the recycled brick aggregate. This also makes the AC produced from brick aggregates to require slightly higher amount of bitumen than that from granite, as it absorbs more bitumen due to the high porosity.

Brick AC is lighter in weight than that of granite because of its lower relative density. Thus, having the advantage of reduced energy required for mixing, transporting and laying. Impact value has little effect on the properties of

HRA. Instead, porosity, surface roughness and sharp intersecting angles produces better HRA. Also, rate of flow or deformation under load of HRA made with granite aggregate is faster than that made with other aggregates due to its lower porosity and surface smoothness.

It is therefore concluded that use of unused or recycled crushed clay brick as aggregate in bituminous mixtures is a feasible option.

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