# ENGINEERING PROPERTIES OF CONCRETE MADE WITH BRICK DUST WASTE

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# ENGINEERING PROPERTIES OF CONCRETE MADE WITH BRICK DUST WASTE

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**ABSTRACT.** This research work reports the potential of using Brick Dust Waste (BDW) as a partial substitute for Portland Cement (PC) in the development of concrete. BDW is a recycled waste materials that is sourced from the demolishing of fired clay brick buildings or the discarded by-product materials from the cutting of fired clay bricks into shape and sizes for the construction of chimneys, and other uses needing the use of fired bricks. This results in the disposal of BDW as an environmental problem of concern. BDW has pozzolanic properties that enables it play an important role in the strength and durability of concrete, its use in concrete will alleviate the increasing challenges of scarcity and high cost of cement and will help to strike a balance between the sustainability of the environment and the demand on construction due to the increase in population growth worldwide. In order to investigate the Cement replacement potential of BDW, four types of mixes were designed at varying BDW replacement levels—10%, 20%, 30% and 40% with a water binding ratio of 0.6 and tested at 7, 14, and 28 days. The testing programme included material characterisation, the determination of slump value and compressive strength.

**Keywords:** Brick dust waste, Concrete; Sustainability, Cement; strength.

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### Limestone Aggregates

The limestone aggregate used throughout this investigation was size 10/4. The aggregate was supplied by a local quarry and complied with the requirements of PD 6682-1 [12] and BS EN 12620 [13]. Some geometrical, mechanical and physical properties of the limestone aggregate in compliance with BS EN 1097-6 [14], BS EN 933-4 [15] and BS 812-112 [16] are shown in Table 3. The results of sieve analysis of the limestone aggregate performed in accordance with BS EN 933-1: [17] are also given in Table 4.

### Sand

The sand used throughout this study was natural sea-dredged sand from the Bristol Channel. Some geometrical, mechanical and physical properties of the sand in compliance with BS EN 1097-6 [14], BS EN 933-4 [15] and BS 812-112 [16] are also are given in Table 3.The results of sieve analysis of the sand performed in accordance with BS EN 933-1: [17] are given in Table 4.

Table 1 Some engineering properties and oxide/mineralogical compositions of BDW

| | |
|---|---|
| **Properties** | |
| Specific gravity | 2.5 |
| Bulk density (kg/m$^3$) | 1837 |
| Maximum Dry Density (MDD)(Mg/m$^3$) | 1.5 |
| Optimum moisture content (OMC) (%) | 17 |
| Colour | Brick red |
| **Oxide** | % |
| $SiO_2$ | 52 |
| $Al_2O_3$ | 41 |
| $Fe_2O_3$ | 0.7 |
| CaO | 4.32 |
| MgO | 0.12 |
| $K_2O$ | 0.53 |
| $SO_3$ | 0.33 |
| $TiO_2$ | 0.65 |
| $Na_2O$ | 0.05 |
| L.O.I | 2.01 |
| **Compound** | |
| Kaolinite | 54% |
| Aunite | 5% |
| Quartz | 41% |

current investigation developed four mixes, by using BDW to replace the Portland Cement PC in the control mix, the various combinations as shown in Table 5. The first mix was referred as MC1 which is the mix produced by replacing 10% of the PC in the control mix with BDW. For the second mix (MC2), 20% of the PC in the control concrete mix was replaced with BDW. The third mix was designated MC3 and the mix was produced by replacing 30% of the PC in the control concrete mix with BDW. The final mix was designated MC4 and the mix was produced by replacing 40% of the PC in the control concrete mix with BDW.

**Sample preparation and testing**

Cube (100 mm × 100 mm × 100 mm) test specimens were used in the production of all the concrete. For all mix compositions, the test specimens, were prepared in accordance with BS EN 206 [18], BS EN 12350-1[19] and BS EN 12390-1 [20]. The consistency of the fresh concrete was measured using slump test in accordance with BS EN 12350-2 [21]. De-moulding of the test specimens was done after 24 hours. The curing of the test specimens were carried out in accordance with BS EN 12390-2 [22]. All the cube specimens were tested for 7, 14 and 28 -day compressive strength in accordance with BS EN 12390-3 [23] and BS EN 12390-4 [24]. For all mix compositions, the results reported are the average obtained from five individual specimens for compressive strength

Table 4 Sieve analysis of the limestone aggregate and sand

| SIEVE SIZES (mm) | SAND | LIMESTONE 10/4. |
|---|---|---|
| 31.5 | 100 | 100 |
| 16 | 100 | 100 |
| 8 | 100 | 77 |
| 4 | 100 | 2 |
| 2 | 83 | 0.3 |
| 1 | 54 | 0.28 |
| 0.5 | 21.8 | 0.19 |
| 0.25 | 6 | 0.14 |
| 0.125 | 1.2 | 0.1 |

Table 5 The various combinations

| MIX CODE | % REPLACEMENT | WEIGHT OF VARIOUS MIX MATERIALS (KG) | | | | |
|---|---|---|---|---|---|---|
| | | PC | BDW | Sand | Limestone | Water |
| MC (Control) | 0 | 6.0 | 0.0 | 12 | 12 | 3.6 |
| MC 1 | 10 | 5.4 | 0.6 | 12 | 12 | 3.6 |
| MC 2 | 20 | 4.8 | 1.2 | 12 | 12 | 3.6 |
| MC 3 | 30 | 4.2 | 1.8 | 12 | 12 | 3.6 |
| MC 4 | 40 | 3.6 | 2.4 | 12 | 12 | 3.6 |

**Note** PC = Portland Cement; BDW = Brick Dust Waste and concrete also confirms that the slump values of concrete made by replacing PC with BDW varies with the addition of BDW. This is believed to be due to the complex mechanisms associated with the degree at which ground bricks absorbs more water in the mix, which varies in a non-systematic manner from one mix composition to another. The use of ground clay bricks as partial PC replacement increases the water demand due to the increase in fineness of BDW compared to PC.

The variations observed with regards to the compressive strength was a progressive increase in strength values for each mix composition as the curing age increases. Mix MC1 which has a 10% replacement of ordinary PC with BDW attained a higher strength at 28 days. This higher strength gain might be due to the gradual formation of the calcium silicate hydrate gel (C-S-H gel) in the hydration process due to a 62% increase in silicon dioxide ($SiO_2$), which BDW has over ordinary PC, making it possess more dicalcium silicate ($C_2S$), which is responsible for the strength gain at the later days age. This also explains the continuous increase in strength over a prolonged curing age [9].

According to Bektas et al (2007), this behaviour of a higher gain in strength as experienced in this current research is well expected, since BDW is known to be a pozzolanic material that produces more secondary C-S-H gels. There was an early strength gain for the control mix, at 7 and 14 days curing age. This might be due to a high amount of tricalcium silicate ($C_3S$) present within the PC, which is responsible for early strength gained and forms the bulk of the C-S-H gel and calcium hydroxide ($Ca(OH)_2$) produced during hydration. The 20% replacement of BDW is considered as the optimum replacement level in the research, previous work by Toledo et al [10], reported no detrimental effect in terms of strength up to 20% replacement of ground clay bricks in concrete

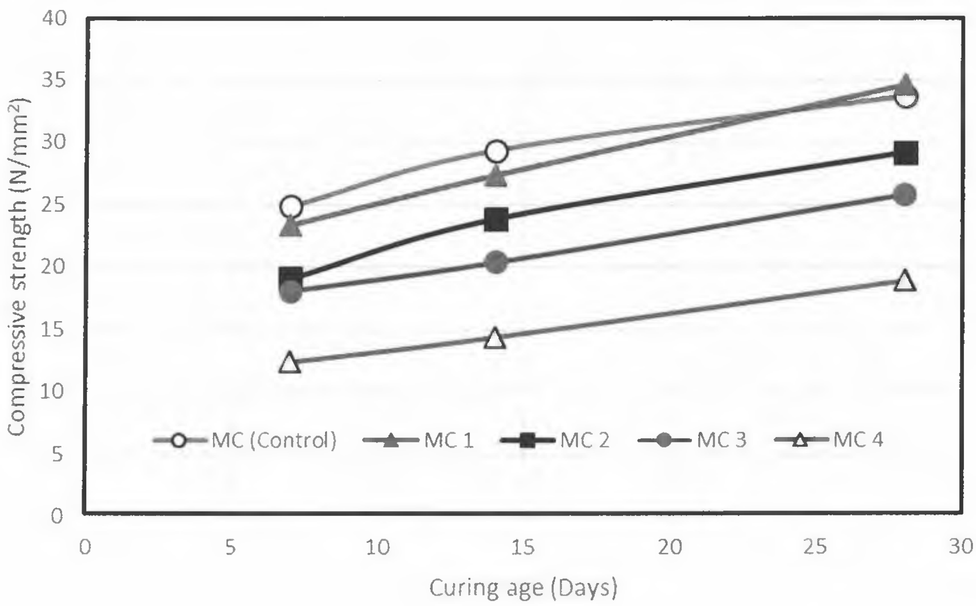


Figure 2 Compressive strength for all mixes

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