The Mechanical Properties of Brick Containing Recycled Concrete Aggregate and Crumb Rubber as Sand Replacement

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Abstract: Recycled Concrete Aggregate (RCA) and crumb rubber are one of the recyclable building wastes. This would be the good candidate to replace the natural aggregate in concrete, since we know these material’s physical properties are strong and ductile. In concrete production, demand for sand has increased which has led to problems in the industry. As a result, the sand price rose, which in effect influenced the cement and sand brick prices. This research focuses on sand cement brick performance, containing recycled concrete aggregate and crumb rubber. This study aims to determine the mechanical properties of sand cement brick containing recycled concrete aggregate (RCA) and crumb rubber (CR) wastes, such as compressive strength and water absorption. The brick specimens were prepared using 100 % natural sand, they were then replaced by RCA at 15%, 30%, 45% and 60% with proportions of CR consisting of 1.5%, 3.0%, 4.5% and 6.0% by weight of natural sand. Just RCA 60 percent with 6.0 percent CR achieves lower strength than normal bricks based on the compressive strength tests whereas others display a high strength. Nevertheless, as predicted, all design mix reaches strength greater than 7N/mm². Besides that, 30 per cent of RCA with 3.0 per cent CR is the most desirable mix design that achieves high compressive power.

Keywords: partial sand replacement, brick, sand materials

1. Introduction

Brick is a common building material commonly composed of sand as an aggregate, cement as a binder, and water which, when it hardens, forms a sturdy stone-like mass material. The two important materials used for building are the sand and cement. (1). Although the building industry has become more advanced with technologies such as the Industrialized Building System (IBS), brick use is still on demand with building. Construction demand is growing as the population grows to meet people’s living needs. The population for the year 2010 is 28.6 million, according to the Department of Statistics, Malaysia, which is projected to grow by 10 million to 38.6 million in 2040. (2) As waste tire disposal often is a worldwide issue and has generated concern for authorities, academics and environmentalists. Malaysia production of scrap tires is about 10 million parts per annum, according to Ibrahim et al. (3), and they are actually being disposed of in an environmentally unfriendly manner. It is considered one of the big environmental problems faced by communities around the world as waste rubber is not readily biodegradable even after a long landfill treatment time.
Prior research has indicated the capability of utilizing Recycle Concrete Aggregate (RCA) in building applications. As indicated by Kumar et al. [4], so as to expand the capability of compressive quality of RFA, these can be improved by providing additional fibre. As 70-80% of the concrete strength which is from aggregates, preserving recycled demolished concrete as natural aggregate would be beneficial and also solving part of environmental problem [5-6]. RCA is pulverized by utilizing crusher, to produce a difference sizing which later is classified according to its size as coarse or fine aggregates. Abid et al. [7] and Shaban [8] enthusiasm for utilizing RCA as fine aggregates in construction material. It been cited by both of them that fine aggregate has no affect in alleviation in compressive strength and elastic modulus. Hence, as example, a brick, RCA as replacement for fine aggregates hold an enormous potential. Prior research expressed estimation of concrete aggregates water absorption imbue with RCA is higher than concrete with normal aggregate [9]. In terms of durability, RCA appears to be feeble than NA. Owing to the ratio of replacement of the coarse aggregate to the maturity of the concrete itself, RA become insubstantial contrast to NA since it has high porosity esteem. Substitution of 5 to 100% of natural aggregates with the recycled aggregate lowering their compressive strength by 5 to 25%. The water absorption potential of RCA is higher than the NAC, up to 24%. According to Bisht & Ramana (10) the replacement of CR at 5.5% in concrete show that the compressive strength and density was decreased while in water abrasion was increase. It can be concluded that the increasing the replacement of CR in concrete was affect the value of compressive strength, density and water absorption. Hence, the volume for substitution is exceptionally critical to study to decide the ideal volume of substitution for natural sand.

Utilizing the RCA and CR as fine aggregate substitution is fine of the conceivable outcomes. Hence, exploring the ability of RCA and fine CR as fractional fine material replacement compared to traditional sand cement bricks. Compressive strength and water absorption tests are important and have been conducted to achieve the study's target.

2. Methodology
The plan blend for cement sand brick utilized understanding with BS EN 998-2, where the endorsed mortar for stone work cement sand is 1:3 and it categorized in lesson M6. The ideal design mix of cement sand brick for partial sand replacement was 1.5%, 3.0%, 4.5% and 6.0% of CR and 15%, 30%, 45% and 60% of RCA. The brick moulded at a length of 215 mm, a width of 105 mm and a depth of 65 mm. Curing is a process that involves maintaining the appropriate moisture content and temperature of the samples for a suitable period of time immediately after placing it in place and finishing in such a manner that the desired properties of the sample can be collected. The bricks were stacked on the pallets of wood after pressing, and their amount of aggregate composition was marked.

3. Results and Discussion
3.1 Density Test
The results for density against ages in sand cement brick for each percentage of RCA and CR depicted in Figure 1. Gradually declining of density as the amount of RCA and CR in the mixtures increased. RCA and CR became regarded as low-density material, which showed that replacing sand with such materials helped to reduce the brick sample mass. Furthermore, the lower specific gravity value of recycled aggregates and CR indicates that these fine aggregates are lighter than natural fine aggregates.
The results show the density of sand cement brick is affected by the ratio of sand to RCA and CR aggregate. The presence of RCA and CR results in void between the aggregates, thereby decreasing the density of bricks. The overall result indicates that the average density of bricks containing RCA and CR is lower compared to the control bricks. The lowest density was obtained by R60C6 whereas Figure 1 shows a decrease of 5.15% at 7 days and decrease of 14.1% at 28 days compared to all replacement percentages.

3.2 Compressive strength

In terms of strength on 7 and 28 days for composite cement, compressive strength continues to rise as the replacement of waste decreases as seen in Figure 2.
As BS 6073-1:1981 specified that the compressive strength of bricks would not be less than 7 N/mm² for both 7 and 28 days, all the samples attain strength greater than the minimum strength. Obviously, it indicates that certain samples from the usual brick were receiving high intensity for the curing period. RCA 30% with C1.5% sample displays the most noteworthy strength while RCA 60% with CR 6% samples achieve as it were 14.9 MPa which is lower strength instead of typical brick. All things considered, the example with RCA of 30%, the increase in strength appears to be in line with the increase in CR volume by 1.5% and 3.0%.

The rising compressive strength trend is seen in samples containing RCA 15% for both 7 and 28 days of curing age. 3% CR with 30% of additional RCA gives the most noteworthy quality among the other samples. The declination of strength is appeared when the volume of CR increment from 4.5% to 6% for RCA 15%, 30% and 60%. The most elevated rate of increase strength between 7 and 28 days among other samples is 28.97% and 31.90% separately for 30% of RCA with a volume of CR 1.5% and 3.0%. Result uncover that certain sum of CR increase the strength with an addition RCA of 15%, 30%, 45% and 60%. The finding of this research has the same pattern as those conducted by Irwan et al. [11] and Noorwirdawati et al. [12] documented heavy bonding between the aggregate and the binder as an improvement in the quality of synthetic plastic resulting in a decrease in material strength.

Replacing recycled fine aggregates at a point of 50% and 75% shows a decrease in compressive strength in natural sand replacement [13]. Consequently, the outcome of a 50% substitute recycled aggregate in the flexural strength test indicated a marginal decrease due to porous recycled aggregate in concrete. The findings showed that specific gravity of brick aggregates was lower as compared to natural aggregates. Nevertheless, water absorption showed a 40% higher value than natural aggregates due to clay brick porosity [14].

### 3.3 Water absorption

Water absorption was performed to assess the amount of the brick's water absorption. The points of interest from the result of water absorption against age for each percentage of RCA and CR were shown in Figure 3 by showing the advancement of water absorption from 7 days to 28 days. The outcomes outlined the increasing of water absorption with RCA and CR on difference percentage of replacement for all mixture. In any case, up to RCA15% and R60% with CR6.0% replacement, a slight diminished of water absorption of sand cement brick for both 7 days. Results demonstrate that the sample with RCA15%C6.0% was less permeable when compared to another sample. Moreover, the most elevated water absorption coefficients were in sand cement brick with RCA60%C4.5%. Sample with 60% of RCA ingested additional water contrast to sample containing 15%, 30% and 45% of RCA.
Figure 3: Sand cement bricks average water absorption with RCA and CR over ages.

From the results in Figure 3 the water absorption percentage was found to be relatively higher when the percentages of RCA and CR increased. The sand cement brick containing R60 absorbed more water compared to the sand cement brick containing R15, R30 and R45. The sand cement brick with a higher content of RCA tends to possess a higher water absorption percentage compared to control brick and sand cement brick with lower RCA content. Meanwhile, the behaviour of CR also influences porosity since it has an elongated shape. However, higher water absorption was obtained by samples with a high volume of CR due to high porosity. The mixture does not combine and mix properly and this make it easier for water to penetrate into the brick samples.

4. Conclusions
Lower unit weight of RCA and CR was credited from the result of reduction in bricks density. RCA and CR at levels 30% and 3.0% as sand replacement ratio has great impacts on the compressive strength of the bricks. Growing characteristic of brick water absorption ability clearly affected by sand cement bricks with recycled fine aggregate, and CR. In any case, bricks with 15% RCA and 6.0% CR appear less permeable than brick controls.

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