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# Study on Potential of Clay Brick Industry Waste as Replacement of Aggregate in Concrete

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**Abstract**: Many ways that can be used to produce such a strong and long lasting use of concrete. This is because many country have been facing with the problem of tons of Construction and Demolition Waste (CDW) and Malaysia also is one of the listed country. From the previous study, it is proved that using brick aggregate as alternative aggregates can also reduce natural aggregate consumption, concrete density, and most important is being considered as the environmentally friendly approach. Therefore, for this study, clay brick waste will be used as the replacement of aggregate in concrete. The aim for this research is to discover the mechanical properties and the potential use of the clay brick industry waste as a replacement of aggregate in concrete. The mechanical properties that will be reviewed the most are the workability of the concrete, compressive strength and water permeability of the concrete. All the data and information are extracted from previous research papers. It is proven that different percentage replacement of aggregate into the concrete will give different mechanical performance of the concrete. Generally, up to 20.00 % of the aggregate percentage replacement is acceptable, but still, natural aggregate presented as the best mechanical performance in concrete.

**Keywords**: Clay Brick, Aggregate, CDW, Percentage Replacement, Concrete

## 1. Introduction

As stated by Bektas, in their research, 80.00 % of the concrete volume was made from aggregate, where it is typically extracted from natural sources, but with existing aggregate rapidly exhausted, concrete industry is searching for other alternatives [1]. So, in this study, we will be using clay brick industry waste to replace both types of aggregate in the concrete.

Brick is considered as the second highest commonly used building material after concrete, and it is regarded as Construction and Demolition Waste (CDW) if damage occurs during production, demolition and construction. The usage of this waste as concrete's aggregate has become familiar in construction industry for recent decades [2]. Around the world, many countries are facing with CDW

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problem. Based on the research, the annual CDW in the United States has reached 145 million tons of waste, which is one-third of it was being landfilled [3] [4]. Similarly, as Hong Kong, which these C&D waste accounts for about 28.00 % of landfill solid waste. In India, as it is appointed as the second largest brick producer in the world [5], about 14.5 million tons of C&D wastes are produced annually, including gravel, bitumen, bricks, sand, concrete, and masonry [4] [6]. Therefore, by using this waste as an aggregate in concrete, we can help reduce such pollution in our own world.

The result and data will be collected from the previous study. This study will be focused on the potential and mechanical properties of the main component in this study as aggregate replacement aggregate into the concrete. Therefore, to achieve the objective, the mechanical properties that will be reviewed are workability, water permeability test and compressive strength. In order to obtain these mechanical properties result, different type of percentage replacement will be reviewed to identify whether it would affect these mechanical properties.

## 2. Clay Brick as Aggregate Replacement

In this research, clay brick industry waste was recycled and used as an aggregate replacement into the concrete. The brick was crushed and sieved to specific grading for both fine and coarse aggregate and lastly being heated to obtain a great concrete. Clay brick is a sustainable material that is made from organic minerals found in shale and local, naturally abundant sources of clay; clay brick's long-lasting life cycle offers ongoing environmental and health benefits. Table 1 below summarizes the physical and mechanical properties of brick aggregate found by several researchers [7].

**Table 1: The physical and mechanical properties of brick aggregate found by several researchers** [7]

| Properties | NG | NS | RG | RS |
|---|---|---|---|---|
| Specific weight (kg/m³) | 2822 | 2987 | 2232 | 2496 |
| Bulk density (kg/m³) | 1695 | 1847 | 1924 | 1010 |
| Water absorption (%) | 1.5 | 1.0 | 11.5 | 14.0 |
| Sand equivalent | - | 69.29 | - | 84.02 |
| Porosity (%) | - | - | 38.82 | 59.54 |
| Fineness modulus | - | 2.71 | - | 3.91 |
| Impurities (%) | 3.31 | - | 0.79 | - |
| Los-Angeles (%) | 36.3 | - | 31.6 | - |
| Dry | 19.0 | - | 13.0 | - |
| Wet | 39.6 | - | 34.2 | - |

RG: Coarse crushed bricks aggregates, RS: Fine crushed bricks aggregates, NS: Natural Sand and NG: Natural Gravel

Even though clay brick concrete has been used broadly as aggregate, however the usage of low-element crushed brick is much finite. It must be notable that in small and non-automated factories, the usage of clay bricks in construction industry in developing countries are manufactured. Hence, most clay bricks did not meet general specifications [8]. When the mechanical performance of these brick aggregate are contrasted with normal aggregate, this matter can be understood well. There has been little research into the ability of crushed brick aggregate, but only a few instances of the usage of these aggregate into concrete have been recorded [8]. Table 2.5 below summarizes that many previous kinds of research prove that using recycled brick as aggregate replacement in concrete has many kinds of potential. Since clay brick is relatively more porous and weaker than regular aggregate, study on the mechanical performance were studied in most tests, as it was the most significant parameters used in construction.

**Table 2: Summary of the utilization of recycled brick aggregate**

| Reference | Aggregate Type | Finding |
|---|---|---|
| [9] | Coarse Aggregate | -Compressive strength improved to 8% with a higher size of aggregate of up to 37.5 mm; further increase in size, decreased strength.<br>-With the content of cement of 400 kg/m3, compressive strength is reduced and aggregate size is increased. |
| [10] | Coarse Aggregate | - Brick aggregate replacement of up to 20% had no effect on the concrete's compressive strength.<br>-The compressive strength was diminished by an increased ratio of replacement.<br>- At all replacement stages, there was marginal impact on split tensile power. |
| [7] | Fine and coarse aggregate | -Specimen concrete with brick aggregate had smaller strengths of compression and flexure.<br>-Compressive strength and elasticity modulus at maximum coarse and fine aggregate replacement levels were decreased by around 40 percent and 50 percent, respectively.<br>-Concrete containing brick aggregate had greater shrinkage beyond 28 days at all replacement stages |
| [11] | Coarse Aggregate | Manufactured concrete with greater strength brick aggregate give a higher compressive strength with respect to the control.<br>-Manufactured concrete with a smaller strength brick aggregate gives a devaluation of about 18% in compressive strength with respect to the control<br>-No major devaluation in strength after heating to 800C for both category of brick aggregate concrete |
| [12] | Fine Aggregate | -A decline in slump was determined at all stages of substitution of brick aggregates.<br>-With up to 100% brick aggregate substitution, the drop in compressive strength of 28-day was up to 27%. |
| [13] | Coarse Aggregate | -By rising recycled brick aggregate by up to 50%, the devaluation in 28-day compressive strength was up to 25%.<br>-Bad workability was seen in samples containing 50% of RA. |
| [14] | Coarse Aggregate | -At all replacement stages, the compressive and flexural strength of -28 days has been decreased.<br>-The highest water permeability was demonstrated by concrete mixtures of 50% RA and showed an improvement of approximately two times compared to the water permeability of NAC |
| [15] | Coarse Aggregate | - Compressive strength loss was found in concrete with recycled brick aggregate. |
| [7] | Fine and coarse Aggregate | -Overall concrete with brick fine or coarse aggregate of poor quality give smaller compressive strength than concrete of natural.<br>-The 90-day compressive strength of coarse and fine aggregate hard-burnt brick concrete was reduced to 35.5MPa, where is approximately 62% of the normal aggregate. |
| [16] | Coarse and Fine Aggregate | -Concrete compressive strength has been reduced by boost brick aggregate |
| [17] | Coarse Aggregate | - A little increased to 50% in compressive strength-The workability of concrete improved with a rise in the quantity of crushed brick as coarse aggregates |

| | | |
|---|---|---|
| [18] | Coarse Aggregate | Devaluation of up to 50% in 28-day compressive strength by up to 14% in brick aggregate substitution.<br>-The concrete permeability index for water that have 50% brick aggregate was nearly twice the control concrete. |
| [19] | Coarse and Fine Aggregate | -Increased by up to 100% of replacement, the compressive strength of concrete went up to 38%.<br>-Compressive strength of concrete nearly have no effect with 75% of brick fine aggregate replacement. But with continuous substitution (100%) decreased approximately 15% strength at a cement content of 350 kg/m3 and a w/c ratio of 0.50. |

## 3. Methodology

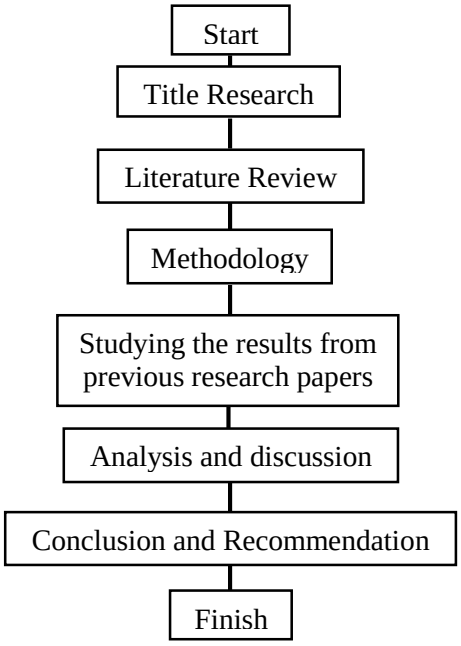


**Figure 1: Flow chart of the methodology**

Generally, this chapter describes the sequence of the methodology used in this study as shown in Figure 1. All the data and information are extracted from previous research papers. There were various online sources used to gain the data, such as Mendeley and google scholar.

## 4. Discussion

This chapter elaborate about relationship between percentage replacements of clay brick aggregate in concrete with the mechanical properties of the concrete.

### 4.1 Compressive Strength of Clay Brick as Aggregate Replacement

Generally, it was revealed that when the recycled brick was used as both fine and coarse aggregate, there is a reduction in compressive strength [7] [20] [21] [22] [19] [8]. [12] [7] stated its porous nature could be attributed to the devaluation in compressive strength because of the inclusion of brick aggregate. The consumption of water during mixing has promoted a bigger porosity of brick aggregate and thus increased the water ratio to bind in the design of the mix, resulting in a devaluation of compressive strength. Poon also stated similar things when use recycled brick aggregate used [21]. The strength is decreased due to the low basic strength of brick which may be one of main reason in the strength devaluation [14]. It could influence the mode of failure when subjected to compression load and as it had smaller compression resistance [23] [19].

Despite the substitution of recycled brick as a coarse aggregate had decreased compressive strength. Cachim showed that the substitution amount of brick aggregate with 20.00 % give no major impact on the concrete's splitting tensile and compressive strengths [1] [10]. This may due to potential pozzolanic action given by the brick aggregate's very fine section. However, the mechanical strength of concrete will also be decreased above the 20.00 % gross substitution of recycled brick. Yang also stated that compressive strength of concrete was not naturally affected by the coarse aggregate replacement level with the recycled brick of up to 50.00 % [18]. While for Adamson, it shows an increase in its compressive strength with 50.00 % of aggregate replacement. This is because of the comparatively lower strength of natural aggregates compare to brick aggregates [17]. The summary on these performances were shown on Figure 2 below.

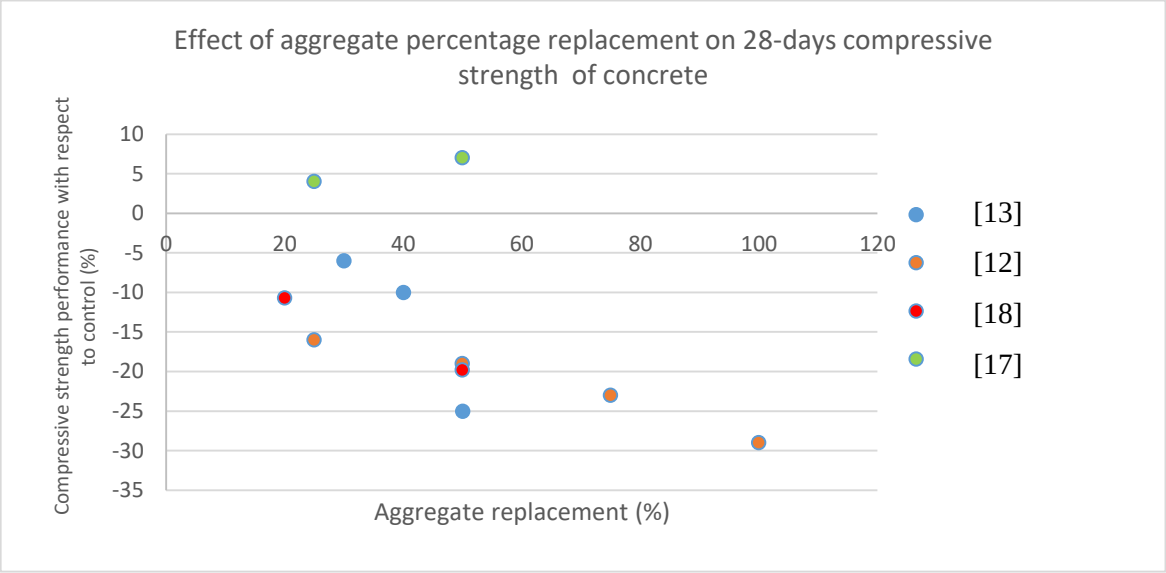


**Figure 2: Summary on the effect of aggregate percentage replacement on 28-days compressive strength of concrete**

4.2 Workability of Clay Brick as Aggregate Replacement.

The workability of all mixtures was calculated (ASTM C143/C143M, 2015). The mixtures with replacement of recycled crushed brick aggregate was found to be coarser and more rigid, conclude as a comparatively smaller slump compared to conventional natural aggregate concrete (with similar w/c). In contrast to conventional concrete, greater friction between particles of brick (compared to natural aggregate) was known to be the primary explanation for small slump compared to regular concrete (with natural aggregate). This fact was proven by Khatib which is it was observed that there is depletion is slump at all brick aggregate substitution levels [12]. As for Debieb [7], to reduce amount of compositions and to compare it a general basis, Kenai carries out a same workability research project of slump between 60 to 70 mm, adapting the content of water. Because of the mixed architecture, coarse aggregates have not absorbed any water. This system used is refer on coarse aggregates that have been drowned in water for 24 hours before being use in a saturated dry surface state (SSD). However, part of the mixing water could not be completely soaked and absorbed by fine brick aggregates thus higher water content was then needed as a natural sand substitute for mixes with these fine brick aggregates. Bektas also said that the workability of the concrete with 20.00 % replacement was reduced to 32.00 % [1]. Slump tests were also carried out by Yang on all batches of concrete [18]. The control mix slump displacement was reported as 33 mm, while a slump of 24 mm was shown as 100.00 % RCA replacement. For the RCB-80, 20 mm of slump was recorded, which was 40.00 % lesser than the control combination. Mixture of RCB-50 was resulted with 10 mm where it was the lowest slump. Hence, as the proportion of RCA increased, it can be indicated from the outcome that there was a propensity for the slump to decrease. When the CCB content was boosted, the pattern became even greater. This

outcome may be due to the high amount of crushed cement mortar contained by CCB and RCA, which was rather thin and had a brittle texture. Thus, during blending, some of them could split.

As for Adamson, it shows an increase in workability of the concrete. Even though with 50.00 % aggregate replacement, it still shows a good mechanical performance. This may be due to more brick aggregate porosity. Higher porous aggregates can retain higher water, therefore increases fresh concrete's workability in exchange [17]. The summary on these performances were shown on Figure 3 below.

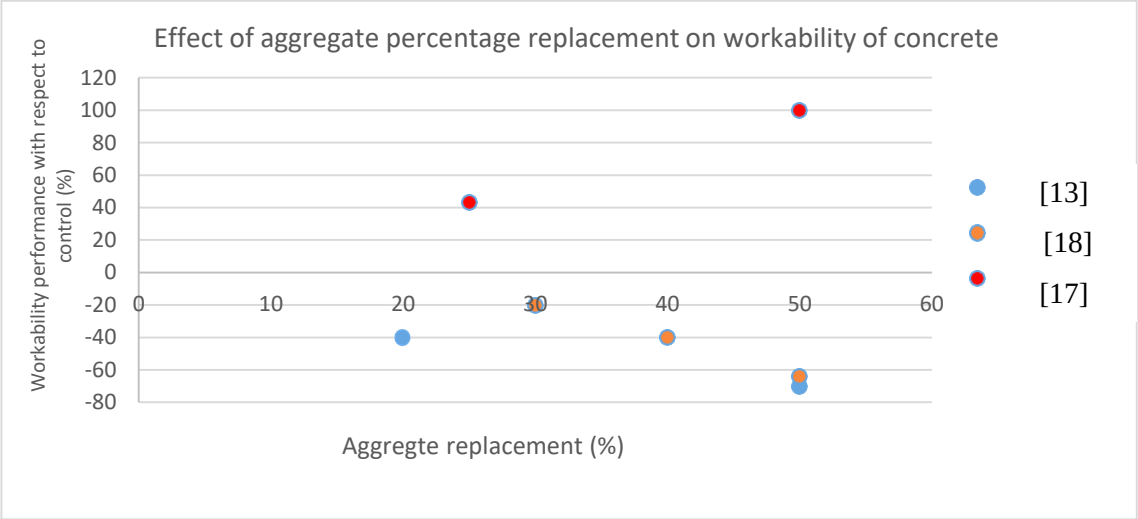


**Figure 3: Summary on the effect of aggregate percentage replacement on workability of concrete**

4.3 Water Permeability of Clay Brick as Aggregate Replacement

Yang proposed that the toughness of concrete containing recycled brick aggregate may be decreased due to the porous nature of the aggregate, as emulated by the increased water permeability index [18]. Literally, the water permeability could almost double when brick aggregates are integrated, according to [7]. As by Zong, the highest water permeability was demonstrated by concrete mixtures of 50.00 % recycled brick aggregate and showed an improvement of approximately two times compared to the water permeability of NAC [14]. The summary on these performance was shown on Figure 4 below.

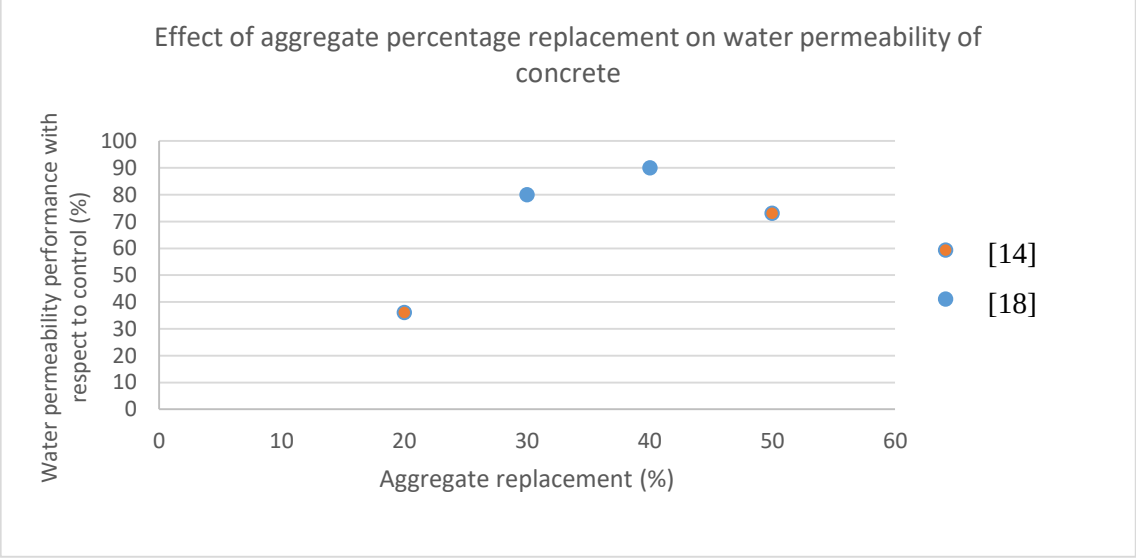


**Figure 4: Summary on the effect of aggregate percentage replacement on water permeability of concrete**

## 5. Conclusion

As I read along with all the past research, I can conclude that the mechanical properties of concrete containing clay brick waste as aggregate replacement are totally lower than using natural aggregate. Graph shown in result clearly prove that using clay brick waste as aggregate replacement will produce a lower mechanical performance on the concrete. However, there are certain cases stated that this concrete depends on the percentage of the aggregate replacement. Generally, up to 20.00 % of the aggregate percentage replacement is acceptable [17], but still, natural aggregate presented as the best mechanical performance in concrete. I myself did not recommend to use clay brick as both aggregate in concrete. There are also certain research prove that using these waste may give a slight effect on the concrete and in fact there were also shows a better mechanical performance on the concrete. All of this is due to the low strength of natural aggregate used in those study compared to the clay brick waste.

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