AN EXPERIMENTAL ANALYSIS OF PARTIAL REPLACEMENT OF COARSE AGGREGATE BY WASTE CERAMIC TILE IN CONCRETE

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Abstract: In accordance with conservation efforts, this research focuses on ceramic tile waste as partial coarse aggregates replacement for concrete production, prevention of environmental pollution with considering the elements of sustainable and cost-saving construction projects, especially material usage. Moreover, many of the construction industry in India produce construction waste that contributes largely in solid waste. Utilizing ceramic tile waste, this research will focus on ceramic wastes obtain from the construction industry in India. Presently, much of ceramic industries production goes to waste, which is not undergoing the recycle process yet. A total forty cubes with the same dimensions (150 mm x 150 mm x 150 mm) were cast with five different proportion. Three cube as one type of control proportion that is 0% percentage of ceramic waste as partial replacement of coarse aggregates and the remaining 18 cubes and 3 beams are 10%, 20%, 30%, 40% and 50% of ceramic as partial replacement of coarse aggregates. Besides that, all other parameters are constant. The concrete cube were tested as destructive test at last which is compression test that to find out compressive strength of specimens of hardened concrete at 3 days, 7 days and 28 days. Before undergoing the destructive test, the performance of the concrete was determined by undergoing slump test, compressive strength test, flexural strength. From the results of the study, samples of concrete with 20% & 30% ceramic coarse aggregate replacement has reached optimum strength. Findings showed that concrete
containing Ceramic Tile 20% & 30% showed the highest amount of strength compared with other specimen. Addition of 20% & 30% ceramic material has led to compaction of concrete structures in ceramics and exhibit low water absorption rate.

**Keywords:** Conventional Concrete (CC), Ceramic Tile Waste Concrete (CTA), Ordinary Portland Cement (OPC), Light Weight Concrete (LWC).

### 1. INTRODUCTION

In accordance with conservation efforts, this research focuses on ceramic tile waste as partial aggregates replacement for concrete production prevention of environmental pollution and considers the elements of sustainable and cost-saving construction projects, especially material usage. As a developing country, construction sector is one sector that can build our economy and produce successful contractors. Despite this industry brings a lot of advantages to the country such as creating more job opportunity and brings a positive economic growth, but there are some issues that need attention from the public as well. Most of the construction and demolition waste in our country are not recycle but end up in landfills occupying valuable land not to mention the cost incurred in land filling (Wen, 2007)[8]. However, many of the construction industry in Malaysia produce construction waste that contributes largely of solid waste. In general, solid waste material is a result of the construction work waste material or residual results from renovation of the building such as stone, woods iron, cement and other waste materials. This research will focused on ceramic wastes obtained from the industry in Malaysia[9]. Presently in ceramic industry the production goes as waste, which is not undergoing the recycle process yet. Conventionally, the coarse aggregate used in concrete productions are gravel, crushed stone, granite, and limestone.
2. EXISTING WORK

Fresh ceramic waste coarse aggregate and quarry dust fine aggregates concrete more less cohesive and workable than conventional concrete because high water absorption of ceramic waste (Abdullah et al., 2006)[10]. Besides that, the compressive strength for ceramic coarse aggregate concrete varied from 15 - 30 N/mm²[11]. Research completed by (Torgal, 2010) found that large differences in early curing ages and smaller differences at long curing ages.
The result indicate that compressive strength of both concrete with replacement ceramic coarse aggregates (CTA) and Ceramic sand (CSA) are higher than conventional concrete (control). The results are very promising but underperformed in water absorption under vacuum test.

In the of cement partial replacement (Levat et al., 2009) found that substitution of ceramic waste percentages of below 30% had no negative effects on the mechanical behavior of Portland cement, thus demonstrating the viability of reusing ceramic roofing tile waste in the production of pozzolanic cements.[12]

The result below shows the mean value 36 test that have been done, Fresh ceramic waste coarse aggregate was more cohesive and workable than conventional concrete the fact that due to the lower water absorption and smooth surface texture (Bakri, 2008).

### 3. PROPOSED WORK

In proposed work, Mix Design, Material property testing and various Laboratory test on Cement, Coarse aggregate, fine aggregate and Ceramic Tile Waste Aggregate the trial mix proportions and water cement ratio used for both conventional and ceramic tile waste concrete for the targeted M20 grade of concrete.

#### Test data for materials

<table>
<thead>
<tr>
<th>Grade designation</th>
<th>: M20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>: OPC53 grade</td>
</tr>
<tr>
<td>Specific gravity of Cement</td>
<td>: 3.15</td>
</tr>
</tbody>
</table>
Specific gravity of Coarse Aggregate : 2.65
Specific gravity of Fine Aggregate : 2.629
Specific gravity of Ceramic tile Aggregate : 3.15
Fine aggregate : Zone II

**Target mean strength**

\[ f'_{ck} = f_{ck} + 1.65 \times S \]

where,

\[ f'_{ck} = \text{Target Compressive strength at 28 days} \]
\[ f_{ck} = \text{Characteristic compressive strength at 28 days} \]
\[ S = \text{Standard deviation} \]

After calculation and design mix proportion obtained as follows,

**Mix Proportion**

- Cement = 383.2 Kg
- Water = 220.79 Kg
- Fine Aggregate = 721.99 Kg
- Coarse Aggregate = 989.70 Kg
- Ceramic Tile Aggregate = 189.40 Kg

**Various Laboratory test**

Based on previous research done by (Pachero, 2009), reutilization of ceramic waste already been practiced but the amount of waste reused in that way is still negligible. Ceramic waste divided by two categories: First, all fired wasted generated by the structural ceramic factories that use only red pastes such as brick, block and roof tiles. Second, all fired wasted produced in stoneware ceramic white paste such as wall, floor tile and sanitary ware.

The chemical composition of fired ceramic is not different from the raw material to make this product. Only the mineralogical composition is modified when the materials are heated. Red paste shows high proportion of iron oxide that is responsible for the red color of bricks.

**Test on cement**

- Compressive Strength[^1]
- Water ratio[^2]
- Flexural strength test\(^3\)
- Initial and final setting time\(^4\)

**Test for aggregate\(^9\)**
- Sieve analysis\(^6\)
- Water absorption\(^7\)
- Aggregate impact value\(^8\)
- Aggregate crushing value
- Specific gravity\(^7\)

<table>
<thead>
<tr>
<th>SL.No.</th>
<th>Particulars</th>
<th>Obtained Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific Gravity</td>
<td>3.15</td>
</tr>
<tr>
<td>2</td>
<td>Impact Value</td>
<td>24%</td>
</tr>
<tr>
<td>3</td>
<td>Water Absorption</td>
<td>14.4%</td>
</tr>
</tbody>
</table>

Table 1: Properties of Ceramic Tile Waste aggregate

**Ceramic Tile Waste Aggregate (CTA):**

Coconut shell aggregate concrete M20 grade has better workability because of smooth measures. The various percentages of ceramic tile waste aggregate were added to improve the strength. Fresh concrete properties for conventional concrete and ceramic tile waste concrete added with various percentage of aggregate are shown in the Table 2. respectively.

<table>
<thead>
<tr>
<th>SL.No</th>
<th>Water Ratio</th>
<th>% Replacement</th>
<th>Slump (mm)</th>
<th>Density (kg/ m(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
<td>0%</td>
<td>40</td>
<td>2425</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>10%</td>
<td>45</td>
<td>2413</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>20%</td>
<td>42</td>
<td>2398</td>
</tr>
<tr>
<td>4</td>
<td>0.5</td>
<td>30%</td>
<td>37</td>
<td>2386</td>
</tr>
<tr>
<td>5</td>
<td>0.5</td>
<td>40%</td>
<td>33</td>
<td>2375</td>
</tr>
<tr>
<td>6</td>
<td>0.5</td>
<td>50%</td>
<td>30</td>
<td>2360</td>
</tr>
</tbody>
</table>
Table 2: Fresh concrete properties for CC and CTA

4. PERFORMANCE EVALUATION
The 3-day, 7-day and 28-day compressive strengths were measured. The mechanical properties like compressive strength, split tensile strength, flexural strength for various members. Conventional concrete and ceramic tile waste aggregate concrete replacement of coarse aggregate were studied.

Compressive Strength Test
Cube of size 150 mm × 150 mm × 150 mm is used for making of both conventional and ceramic tile waste concrete for compressive strength test. The results obtained for the compressive strength of Conventional concrete and ceramic tile waste aggregate concrete with coarse aggregate for 3 days, 7 days and 28 days are shown in Table 3.

<table>
<thead>
<tr>
<th>SL.No</th>
<th>% Replacement</th>
<th>Age in Days</th>
<th>3 days</th>
<th>7 days</th>
<th>28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0%</td>
<td></td>
<td>16.25</td>
<td>18.73</td>
<td>25.80</td>
</tr>
<tr>
<td>2</td>
<td>10%</td>
<td></td>
<td>17.32</td>
<td>18.99</td>
<td>26.24</td>
</tr>
<tr>
<td>3</td>
<td>20%</td>
<td></td>
<td>17.63</td>
<td>19.35</td>
<td>26.51</td>
</tr>
<tr>
<td>4</td>
<td>30%</td>
<td></td>
<td>17.93</td>
<td>19.86</td>
<td>27.43</td>
</tr>
<tr>
<td>5</td>
<td>40%</td>
<td></td>
<td>16.22</td>
<td>17.60</td>
<td>24.14</td>
</tr>
<tr>
<td>6</td>
<td>50%</td>
<td></td>
<td>16.88</td>
<td>17.36</td>
<td>23.95</td>
</tr>
</tbody>
</table>

Table 3: Compressive Strength Test on cubes

Flexural Strength Test on Beam
Two-point load method was adopted to measure the flexural strength of CC and CTA. As per ASTM C78-84 guidelines, beams of 150 mm × 150 mm × 1000 mm size were adopted.

The load was applied without shock and was increased until the specimen failed, and the maximum load applied to the specimen during the test was recorded. The test results of flexural strength beams for all the mixes are given in Table 4.

<table>
<thead>
<tr>
<th>SL.No</th>
<th>% Replacement</th>
<th>28 days Flexural Strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 %</td>
<td>2.067</td>
</tr>
</tbody>
</table>

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Table 4: Flexural Strength Test on Beam

<table>
<thead>
<tr>
<th>SL.No</th>
<th>%Replacement</th>
<th>Split tensile strength in MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>30%</td>
<td>2.733</td>
</tr>
<tr>
<td>3</td>
<td>50%</td>
<td>2.369</td>
</tr>
</tbody>
</table>

Table 5: Split Tensile Strength Test on Cylinder

<table>
<thead>
<tr>
<th>SL.No</th>
<th>%Replacement</th>
<th>Age in Days</th>
<th>3 days</th>
<th>7 days</th>
<th>28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0%</td>
<td></td>
<td>2.63</td>
<td>3.43</td>
<td>4.38</td>
</tr>
<tr>
<td>2</td>
<td>10%</td>
<td></td>
<td>2.46</td>
<td>3.98</td>
<td>4.40</td>
</tr>
<tr>
<td>3</td>
<td>20%</td>
<td></td>
<td>2.60</td>
<td>3.89</td>
<td>4.44</td>
</tr>
<tr>
<td>4</td>
<td>30%</td>
<td></td>
<td>2.57</td>
<td>3.81</td>
<td>4.61</td>
</tr>
<tr>
<td>5</td>
<td>40%</td>
<td></td>
<td>2.49</td>
<td>3.75</td>
<td>4.69</td>
</tr>
<tr>
<td>6</td>
<td>50%</td>
<td></td>
<td>2.41</td>
<td>3.69</td>
<td>4.72</td>
</tr>
</tbody>
</table>

5. CONCLUSION

Research on the usage of waste construction materials is very important since material waste is gradually increasing with the increase in population and increasing of urban development. The main aim of this investigation was the utilization of tiles collected from the demolished buildings and the wastes obtained from the tile industries. The use of these tile aggregates as partial replacement in coarse aggregate in concrete has positive effect on the environment and obtaining lower costs since the tile aggregates are easy to obtain. Their cost is cheaper than the natural aggregates. The ceramic tile aggregate are partial replaced with coarse aggregate because the tile aggregate are easy to obtain and their cost is cheaper than the natural aggregate. After completions of all experimental, programs are conducted that ceramic tile aggregate can be used in place of coarse aggregate with certain percentage of replacement, Based on the compression strength test, split tensile strength test. The following are the conclusions obtained after performing the above experiments,
The maximum compression strength is obtained when 30% of ceramic tile aggregate was replaced with coarse aggregate.

The maximum split tensile strength is obtained when 30% of Ceramic tile aggregate was replaced with coarse aggregate.

The compressive strength and split tensile strength for 10% and 20% replacement of CTA is not increased. There is little variation in the strength when compared with normal concrete. The optimum result is obtained for 30% replacement of CTA with coarse aggregate.

By addition of ceramic tile aggregates into coarse aggregate, proper utilization of ceramic tile waste can be achieved.

In case of combinations, the compressive strength is increasing for all the cases. From the above conclusion, it can be stated that the replacement of ceramic tile waste in place of partially in coarse aggregate the mechanical properties of both conventional and ceramic waste concrete.

REFERENCES


