Study On Strength Properties Of Concrete By The Partial Replacement Of Coarse Aggregate By Waste Ceramic Tiles

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Abstract:Background/Objective: The research was carried out to study the mechanical properties of concrete by partial replacement of coarse aggregate with waste ceramic tile. The M25 grade of concrete was used to examine compressive strength, splitting tensile strength and flexure strength after 7 days and 28 days of curing. The coarse aggregate is to be replaced (by weight) with waste ceramic tile by 10%, 20%, 30%, 40% and 50% to get optimized results. Methods/Statistical Analysis: In this research work, emphasis was made on examining the optimized quantity of waste ceramic tile used as replacement with coarse aggregate(by weight) by the medium of experimental investigation. Findings: It was found that concrete with 30% ceramic tile waste gives the best result when compared with the strength of 0% waste ceramic tile mix. As per results, Compressive strength increases upto 30% replacement, maximum strength is obtained for CW30 for which the strength increment is about 5.5% higher when compared with control mix. Similarly, the splitting tensile strength and flexural strength increases upto 30% replacement and further decreases, maximum strength is obtained for CW30 for which the splitting tensile strength increment is about 15.97% and flexural strength increment is about 12.34% when compared with control mix. Application/Improvement: A Sustainable Concrete mix can be made by using ceramic tile waste which could be used in beams, columns, slabs and other structural elements. As ceramic waste tile has significant role in the concrete. The reuse and recycling of these materials is still not a common practice especially in India, where most of the tile wastes produced is deposited in dumping ground. Use of recycled concrete aggregate and tile waste aggregate in lean concrete production helps in solving a vital environmental issue apart from being a solution to the problem of inadequate concrete aggregates in concrete.

Due to the increasing demand of construction material and degradation of environment, there is need to explore alternative construction material from industrial as well as household waste and recyclable materials. Ceramic tiles are often dumped as waste material after it becomes useless. But it can be recycled and can be used as a construction material in present world which is seeking for alternative construction materials which are economical, environment friendly as well as provides same quality as that of a normal aggregate made of stones. Ceramic tile aggregates are hard having considerable value of specific gravity, rough surface on one side and smooth on other side, having less thickness and are lighter in weight than normal stone aggregates. Using ceramic tile aggregate in concrete not only it will be cost effective, but also provide considerable strength to the concrete.

II. EXPERIMENTAL PROGRAM

2.1 Materials Used

2.1.1 Cement

Ordinary Portland cement of 53 grade confirming to IS 12269:1987 is chosen for the study. For the cement the standard consistency test, initial setting time test, final setting time test, specific gravity test and mortar cube compressive strength were conducted. The physical properties of cement are shown in Table 1.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Properties</th>
<th>Observed values</th>
<th>Requirements as per IS 12269:1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific Gravity</td>
<td>3.14</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Standard Consistency (%)</td>
<td>27.5%</td>
<td>26%-38%</td>
</tr>
<tr>
<td>3</td>
<td>Initial Setting Time(minutes)</td>
<td>85</td>
<td>&gt; 30 minutes</td>
</tr>
<tr>
<td>4</td>
<td>Final Setting Time(minutes)</td>
<td>320</td>
<td>&lt; 600 minutes</td>
</tr>
</tbody>
</table>

Table 1 Physical properties of cement (OPC 53 grade)

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2.1.2 Coarse Aggregate:
The coarse aggregate with a maximum size 20mm having a specific gravity 2.69 and fineness modulus of 6.55 is used. The bulk density value is obtained as 1.63 g/cc. Porosity and void ratio is obtained as 52.63% and 1.11% respectively.

2.1.3 Fine Aggregate
M sand is used as fine aggregate. As per IS 383:1970, sand is confirming to Zone II. Specific gravity and fineness modulus of the sand used is obtained as 2.616 and 2.601 respectively.

2.1.4 Crushed Ceramic Tiles
Waste broken ceramic tiles were collected from the solid waste of ceramic manufacturing unit and they are crushed into small pieces by manually. The crushed waste ceramic tile material with a maximum size 20mm is to be used as partial replacement to the natural coarse aggregate. Specific gravity of the crushed waste tiles is 2.45 and fineness modulus is 6.72. The physical properties of natural coarse aggregates and waste ceramic tile as coarse aggregate is shown in Table 2 and Waste ceramic tile as coarse aggregate is shown in Figure 1.

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Natural Coarse Aggregate</th>
<th>Ceramic Tile Coarse Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>2.69</td>
<td>2.45</td>
</tr>
<tr>
<td>Bulk density (g/cc)</td>
<td>1.63</td>
<td>1.812</td>
</tr>
<tr>
<td>Porosity (%)</td>
<td>44.14</td>
<td>52.63</td>
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<tr>
<td>Void Ratio</td>
<td>0.79</td>
<td>1.11</td>
</tr>
<tr>
<td>Fineness Modulus</td>
<td>6.55</td>
<td>6.72</td>
</tr>
</tbody>
</table>

2.2 Mix Design
The main objective of experimental work is to investigate compressive strength, split tensile strength and flexural strength of concrete. M25 grade of concrete is used to examine the mechanical properties of concrete with 0.40 water - cement ratio. The Constituents of control concrete and concrete partially replacing coarse aggregate with waste ceramic tile are as shown in Table 3.

The different mixes were labeled as CW0, CW10, CW20, CW30, CW40 and CW50. The control Mix (CW0) was proportioned in accordance to IS 10262: 2009. The performance of the experimental mixes was compared with that of the control mix. The mix design was prepared to examine the properties of concrete as per IS 10262-1982 and the mix proportion obtained for M25 mix is 1: 2.15: 3.86. The mix designation of various mixes with different percentage of waste ceramic tile (WCT) is given in Table 3.

### Table 3 Mix designation of various mixes with different percentage of WCT

<table>
<thead>
<tr>
<th>Mix Designation</th>
<th>Cement (%)</th>
<th>Fine Aggregate (%)</th>
<th>Natural Coarse Aggregate (%)</th>
<th>Waste Ceramic Tile as coarse aggregate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>CW10</td>
<td>100</td>
<td>100</td>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>CW20</td>
<td>100</td>
<td>100</td>
<td>80</td>
<td>20</td>
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<tr>
<td>CW30</td>
<td>100</td>
<td>100</td>
<td>70</td>
<td>30</td>
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<tr>
<td>CW40</td>
<td>100</td>
<td>100</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>CW50</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

III. TEST RESULTS AND DISCUSSION

3.1 Compressive Strength
The 150 mm cube mould are used for testing the compressive strength after 7 days and 28 days as per IS: 516 1959. Specimens has been made for control mix and compared with different percentages replacement of coarse aggregate with waste ceramic tile i.e. for 10%, 20%, 30%, 40% and 50% by weight. Specimens were tested after 7 days and 28 days age of curing and average results of are shown in Figure 1. The compressive strength is examined for different percentages of waste ceramic tile with replacement of coarse aggregate (by weight) i.e. for 10%, 20%, 30%, 40% and 50%. Compressive strength for 10% replacement i.e. CW10 increased by 1.6% and for 20% and 30% replacement...
i.e. CW20 and CW30 increased by 3.6 % and 5.5% respectively as compared with control mix after 28 days testing. Compressive strength for 40% and 50% replacement i.e. CW40 and CW50 decreased by 2.30% and 6.06% as compared with control mix after 28 days testing. Therefore 30% waste ceramic tile can be considered as optimum content for concrete mix for compressive strength of concrete because at 30% replacement there is maximum rise in compressive strength i.e about 5.5 % increment in strength after 28 day when compared with control mix after 28 days testing. The splitting tensile strength results of individual concrete mix are also shown graphically. Splitting tensile strength increases upto 10%, 20% and 30% replacement for CW10, CW20 and CW30 i.e. increased by 4.14%, 11.24% and 15.97 % respectively and after the strength decreases for 40% and 50 % replacement by 16.86% and 22.19 % respectively as compared with control mix i.e CW0. The maximum values of splitting tensile strength of concrete with addition of waste ceramic tile is obtained for30% replacement which is considered as the optimum percentage.
3.3 Flexural Strength
The beam specimens 100mm x 100mm x 500mm were used for testing the flexural strength after seven days and twenty-eight days. Specimens has been made for control mix and compared with different percentages replacement of coarse aggregate with waste ceramic tile i.e. for 10%, 20%, 30 %, 40% and 50 %. Figure 6 shows the test set up of flexural strength and Figure 7 shows the average flexural strength after 7 days and 28 days in N/mm².

As discussed in Figure 7, when ceramic waste tileconcrete beams are subjected to pure bending, the flexural strength of beam first increases then decreases. It is observed that the flexural strength increases upto10%, 20% and 30% replacement i.e for CW10,CW20 and CW30 the flexural strength increment is about 3.3%, 7.2% and 12.34% higher than the control specimen. Then the strength decreases for 40% and 50% replacement i.e for CW40 and CW50 the strength get decreased by about 4.73% and 12.14% respectively when compared with control specimen strength. Therefore CW30 is adopted as optimum content as there is higher increasein strength when compared with control mix.

IV. CONCLUSIONS
From these experiments work, the conclusion can be drawn
- The compression, split tensile and flexural strength of M25 grade concrete increases when the coarse aggregate is replaced with waste ceramic tile up to 30% and further replacement of coarse aggregate with waste ceramic tile the strength decreases gradually.
- The maximum compression strength is obtained when 30% of ceramic tile aggregate was replaced with coarse aggregate, here the strength increment is about 5.5% when compared with the strength of control mix.
- The maximum splitting tensile strength is obtained when 30% of Ceramic tile aggregate was replaced with coarse aggregate, here the strength increment is about 15.97% when compared with the strength of control mix.
- The maximum flexural strength is obtained when 30% of Ceramic tile aggregate was replaced with coarse aggregate, here the strength increment is about 12.34% when compared with the strength of control mix.
- The usage of waste tiles partially as a replacement for coarse aggregates will clear the wastes from construction and production site, also environmental pollution is reduced as impact of mining is reduced, natural resources are conserved and power consumption required for quarrying is minimised.

V. ACKNOWLEDGEMENT
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VI. REFERENCE
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