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Performance of recycled waste concrete and its applicability in construction industry

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Abstract: Urbanization demands the renovation of the old structures commonly in the developing countries, resulting in a huge amount of construction debris annually. The construction debris due to failure of aged or faulty structures is considered as waste concrete which are normally composed of concrete rubble, bricks and tiles, sand and dust, timber, plastics, cardboard and paper, and metals. Recycled waste concrete is manufactured from waste concrete by recycling the aggregates of waste concrete. As well as the demand for natural coarse aggregate is also increasing, the scarcity of it may happen. So, proper recycling of waste concrete is important to have an alternative material for utilization in concrete and to reduce the high consumption of natural aggregate. To achieve the suitability of recycled waste concrete the strength and durability of it are confirmed first. In this work, five type of sample are made by varying the percentage of recycled and fresh coarse aggregates(brick aggregates and stone chips) in which workability is constant. Compressive and tensile strength decreases in accordance with increasing amount of recycled coarse aggregate at 7, 28 and 90 days. (Rapid Chloride Permeability Test) is performed on hardened concrete.

Keywords: *Waste Concrete, Recycling, Mechanical Properties, Permeability, Usability*

1. Introduction:

Concrete is a mixture of cementious material, aggregate, and water. The cementious material known as binding material, binds the individual units of aggregates unto a solid mass with the help of water. Aggregate is commonly considered as inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Although aggregate is considered inert filler, it is a necessary component that defines the thermal and elastic properties and dimensional stability of concrete. Aggregate is classified as two different types, coarse and fine. Concrete is a widely used construction material, so its mechanical and other properties are very important factor. Concrete has relatively high compressive strength, but lower tensile strength, which ranges from about 7 to 10% of the compressive strength. Though strength gives the overall view of quality of concrete but in practical case, durability, impermeability, workability may take into account.

Concrete is the premier construction material across the world and the most widely used in all types of civil engineering works. As urbanization and modernization accelerate the prosperity of a country so, during the past years, in most developing countries, a large number of old constructions have been demolished and millions of tons of construction debris have been produced. For example, two billion tons of aggregate are produced each year in the United States. Production is expected to increase to more than 2.5 billion tons per year by the year 2020 (M. Malesev et al. 2010). This situation leads to a question about the preservation of natural aggregates sources. Through proper recycling process the waste concrete can be used in new concrete production. The possibility of recycling waste concrete from the construction industry is thus of increasing importance (Robinson et al.2004). So, it helps to meet the demand for natural coarse aggregate. Toward this goal, diverse policies and exploitation programs have been proposed by the academia and industry (Padmini et al.2002; Limbachiya et al.2000). Building rubble could be transformed into useful recycled aggregates through proper processing (Chen et al. 2002). The recycled aggregates chosen by the writer contained bricks and tiles. The test results showed that the compressive strength of concrete made with recycled coarse aggregate containing brick and tile particles is about 75–80% that of normal concrete. Using unwashed recycled aggregate in concrete will affect its strength. Poon et al. (2002) in their study used recycled aggregates from C and D (construction and demolition) wastes sourced from two public filling areas. The mixes were varied by replacement of natural coarse and fine aggregate with recycled aggregates up to 100% by weight, with or without the incorporation of fly ash. The test results conducted by the writer showed that the replacement of coarse and fine natural aggregates with recycled aggregates at the levels of 25% and 50% had little effect on the compressive strength of the bricks and blocks, but higher levels of replacement reduced the compressive strength.

2. Objective:

The aim of the study is to determine the performance of recycled waste concrete and its applicability in durable concrete production. In pursuit of this aim, the following objectives have been set:

- To measure the strength property of concrete manufactured with recycled concrete aggregate.
- To observe the permeability of waste concrete.
- To investigate the applicability of recycled waste concrete.

3. Methodology:

To fulfill the objectives of this work, the following steps should be performed:

- Collection of material.
- Crushing and recycling the material.
- Material properties.
- Preparation of specimen according to ASTM C 39-93a.
- Curing of specimen.
- Compressive strength test and splitting tensile strength test according to ASTM C 39 and ASTM C 496 respectively.
- Rapid Chloride Permeability Test according to ASTM C 1202
- Ascertaining the charge passed through the samples.
- Analyzing test results and plotting relevant graph.
- Conclusion.

Table 1: Mixing percentages of fresh and recycled brick aggregates and stone chips

<table>
<tr><td colspan="2">Sample</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td colspan="2">Cement: FA: CA</td><td>1:1.8:3</td><td>1:1.8:3</td><td>1:1.8:3</td><td>1:1.8:3</td><td>1:1.8:3</td></tr>
<tr><td colspan="2">Percentages of Fresh aggregate</td><td>100</td><td>67</td><td>33</td><td>0</td><td>100</td></tr>
<tr><td colspan="2">Percentages of Recycled aggregate</td><td>0</td><td>33</td><td>67</td><td>100</td><td>0</td></tr>
<tr><td colspan="2">Admixture/Cement ratio (gm/gm)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>400/1000</td></tr>
<tr><td rowspan="2">Slump value (inch)</td><td>Brick aggregates</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td>Stone chips</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td></tr>
</table>

N.B.[FA= Fine Aggregates, CA= Coarse Aggregates]

4. Illustrations:

4.1 Compressive strength Test

According to the ASTM C 39, compressive strength test was performed in the laboratory by compressive strength testing machine.The specimens size were Φ4 inch x L8 inch .

Sample A is considered as controlled sample. Change of strength from the controlled samples is given in following bar diagram. Sample E has higher compressive strength at any days.

4.1.1 Using Brick Aggregates

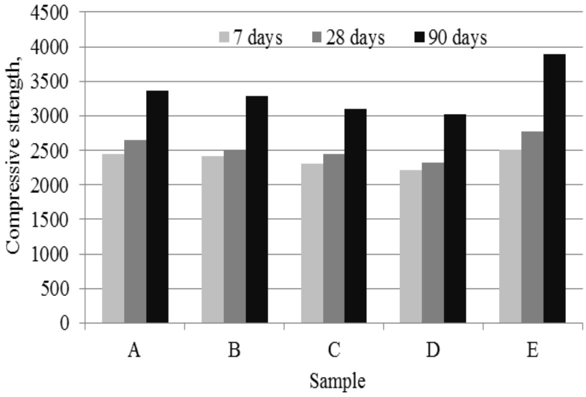

Figure 4.1.1: Bar diagram of compressive strength for five samples (brick aggregates)

The 90 days compressive strengths of sample B, C and D were respectively 2.38%, 7.74% and 10.12% less than that of controlled sample A (Figure 4.1.1). So it can be said that 33% replacement of fresh aggregate by recycled aggregate causes no remarkable deviation in compressive strength. It is also shown that up to 100% replacement of fresh aggregate by recycled aggregate, the obtained strength value is higher than the required minimum value for ordinary construction works. The compressive strength of sample E was15.8% higher than that of controlled sample A.

4.1.2 Using Stone Chips

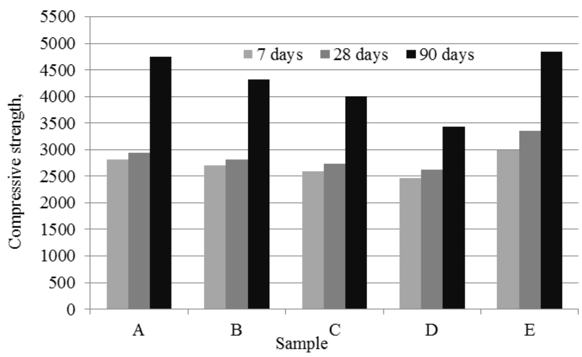

Figure 5.1.2: Bar diagram of compressive strength for five samples (stone chips)

The 90 days compressive strengths of sample B, C and D were respectively 8.86%, 15.61% and 27.64% less than that of controlled sample A (Figure 4.1.2). So it can be said that 33% replacement of fresh aggregate by recycled aggregate causes no remarkable deviation in compressive strength. It is also shown that up to 100% replacement of fresh aggregate by recycled aggregate, the obtained strength value is higher than the required minimum

value for ordinary construction works. The compressive strength of sample E was 2.3% higher than that of controlled sample A.
Stone chips has shown the better performance than brick aggregates in compressive strength test.

4.2 Splitting Tensile strength:
According to the ASTM C 496, splitting tensile strength test was performed in the laboratory by compressive strength testing machine.The specimens size were Φ4 inch x L8 inch.

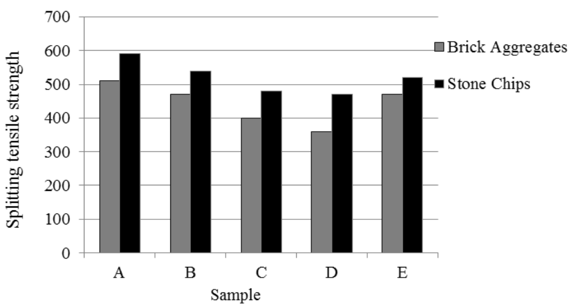

Figure 4.2.1: Variation of splitting tensile strength of five samples (brick aggregates and stone chips)

From Figure 4.2.1, it is shown that , in case of using brick aggregates the tensile strengths of sample B, C and D were respectively 7.84%, 21.57% and 29.41%,less than that of controlled sample A. Percentage replacement of fresh aggregate by recycled aggregate shows a uniform decreasing trend in tensile strength. Tensile strengths of sample E were 7.84% higher than that of controlled sample A.
In case of using stone chips, the tensile strengths of sample B, C and D were respectively 8.47%, 20.4% and 29.41%, less than that of controlled sample A. Percentage replacement of fresh aggregate by recycled aggregate shows a uniform decreasing trend in tensile strength. Tensile strengths of sample E were 11.86% higher than that of controlled sample A.

4.3 Permeability Result
According to ASTM C 1202, permeability test is performed. RCPT is done on hardened concrete specimen. In this test,charge is measured at 30 minutes interval for 6 hours.

4.3.1 Using Brick Aggregates

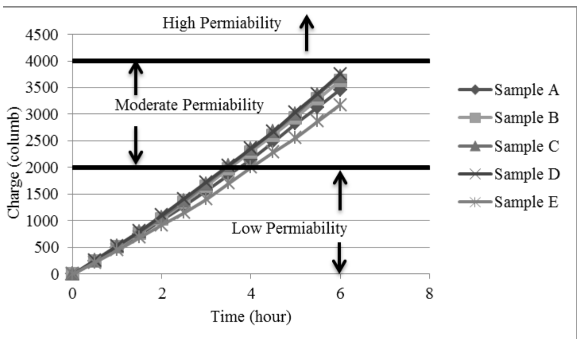

Figure 4.3.1: Comparison of charge passes through five samples (Brick Aggregates)

Figure 4.3.1 shows that, the concrete is moderate type for chloride ion permeability, which ranges between 2000-4000 coulombs and controlled sample shows less permeability than other samples having recycled aggregate. Moderate permeability allows the applicability in structural use, so 100% recycled waste concrete shows no remarkable effect on structure.

4.3.2 Using Stone Chips

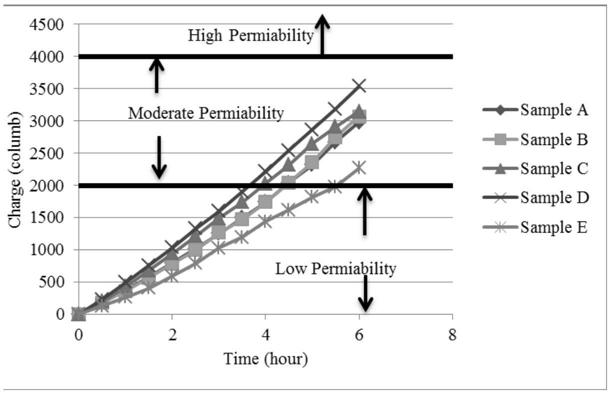

Figure 5.3.2: Comparison of charge passes through five samples (stone chips)

Figure 4.3.2, it is shown that the charge passing due to chloride ion ranges between 2000-4000 coulombs for all samples. Therefore, the concretes were moderate type for chloride ion permeability.

5. Conclusions:

- In case of using brick aggregates, 100%, 67% and 33% replacement shows respectively 10.12%, 7.74% and 2.38% decreasing in compressive strength and 29.41%, 21.57% and 7.84% decreasing in tensile strength.
- In case of using stone chips, 100%, 67% and 33% replacement shows respectively 27.64%, 15.61% and 8.86% decreasing in compressive strength; 20.34%, 18.64% and 8.47% decreases in tensile strength.
- Chloride Ion Permeability ranges between 2000-4000 Coulombs for both cases (brick aggregates and stone chips).It indicates, all samples are categorized as moderate for chloride ion permeability. So, using 100% of recycled waste concrete has no remarkable effect on structure in case of permeability .
- Using admixture with recycled aggregate, shows better strength and permeability.
- In all tests stone chips shows the better performance with respect to brick aggregates.

From this test results, it may concluded that the applicability of recycled waste concrete is possible in concrete production.

6. Recommendations:

Following recommendations may be considered for more betterment of the study:

- Effect of the mixing proportions of aggregates and binding materials should be studied.
- Alternative power supply system should be provided.
- The effect of admixture should be investigated broadly later.
- Financial analysis of recycled waste concrete should be done.

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