EXPERIMENTAL STUDY ON THE BEHAVIOUR OF CONCRETE BY USING RECYCLED AGGREGATES AND BACTERIAL SOLUTION

Mrs.J.Thivya¹, Yokesh Ram.B²
¹Assistant Professor, Civil Engineering Department, University College of Engineering-Dindigul, Tamilnadu
²PG Student (Structural Engineering), Civil Engineering Department, Anna University Regional Campus-Madurai, Tamilnadu

Abstract
Concrete is a vital construction material. However, the continous extraction of coarse aggregate has led to decrease in quantity of primary and quality aggregatges. Recycling concrete wastes will lead to reduction in landfill spaces and preserves natural resources. Not only that, concrete which is a brittle material tends to crack which exposes the reinforcement to atmosphere which inturn induce problems and affect the structural integrity of the structure. Self-Healing concrete in general rectifies these flaws. The strength properties will be compared with the conventional concrete after the curing period of 7, 14 and 28 days by partially replacing coarse aggregate by recycled aggregates for a percentage of 0%, 10%, 20% and 30%. The grade of concrete used in this project is M20. The bacteria Bacillus Subtilis of concentration 10^5 cells/ml of mixing water is used.

Keywords: Bacteria, Concrete, Recycled Aggregates, SCM, Self-Healing.

1. INTRODUCTION
Concrete is a vital building material that is an essential component of public infrastructure and most buildings. It is a very brittle material, so it is commonly expected to crack with time. These cracks, do expose the steel reinforcement leading to corrosion which heightens maintenance costs and compromises structural integrity over long periods of time. Self-healing concrete in general seeks to rectify these flaws in order to extend the service life of any given concrete structure. Supplementary cementing materials (SCMs) are often used in concrete mixes to reduce cement contents, improve workability, increase strength and enhance durability. Crushing concrete to produce coarse aggregate for the production of new concrete is one common means for achieving a more environmentally friendly concrete. The aim of this project is to use recycled aggregates partially as a replacement for coarse aggregate in the range of 0%, 10%, 20%, 30% and also to add bacterial solution to all the concrete mix. The Bacteria Bacillus Subtilis is to be used in this project. The bacterial concrete makes use of calcite precipitation by bacterial in the presence of the suitable media results in microbially induced calcite precipitation. The strength properties will be compared with the conventional concrete after the curing period of 7, 14 and 28 days. The grade of concrete used in this project is M20. The usage of recycled aggregates in the field of construction preserves the natural resources and also the cost of them is comparatively low when compared with conventional aggregates.

1.1. Literature Review
Yong.P.C and Teo.D.C (2009), performed experiment in which the 28 day strength concrete cubes were crushed to suitable size and reused as recycled coarse aggregate. The w/c used in all mixes is 0.41. The proportion of cement: sand: gravel is 1:1.11: 2.07. And they concluded that RAC can achieve high compressive strength, split tensile strength as well as flexural strength.

Parekh.D.N.et al., (2009), reported the basic properties of recycled fine aggregate and recycled coarse aggregate. Basic concrete properties like compressive strength, flexural strength, workability etc were explained here for different combinations of recycled aggregate with natural aggregate. And concluded that RA can be used in concrete and that there are few (if any) applications issues related to its use.

Kim Van Tittelboom.et.al (2010), investigated the use of Bacillus Sphaericus which is a calcium precipitating bacteria to repair the crack. The concrete Cubes and Beams were made out for the study. Ultrasonic measurements were done before and after treatment of the cracks. Comparing the results, before and after treatment of the cracks, led to the conclusion that transmission time decreased for both measurements at crack level and measurements further away from the crack.

M.V.SeshagiriRao.et al.,(2013), Overviewed the development of bioengineered concrete using bacterial strain Bacillus subtilis JC3. The study showed that a 25% increase in 28 day compressive strength of cement mortar was achieved. It showed that a cell concentration of 10^5 cells/ml generates the greatest reduction in porosity. Studies showed that bacterial concrete has better acid resistance in aggressive environments.
Ashwija K.C., et al., (2013)[5], investigated the variation in compressive strength of concrete using two different bacteria, Bacillus Subtilis and Bacillus Sphaericus. Three different cell concentrations \(10^5\), \(10^6\) and \(10^7\) cells/ml of mixing water for each bacterium. It was shown that the addition of bacteria with cell concentration of \(10^5\) cells/ml of mixing water increases the compressive strength. The compressive strength results of concrete cube test specimens with Bacillus Subtilis gives a strength of about 19.11 Mpa for 7 day and for cube test specimen with Bacillus Sphaericus 20.6 Mpa for 7 days.

Sudhir P.Patil., et al., (2013)[6], In this research concrete waste is from demolished structure had been collected and coarse aggregate of different % was used for preparing fresh concrete. And concluded that the slump of recycled aggregate concrete is more than the normal concrete. At the end it can be said that the RCA upto 50 % can be used for obtaining good quality concrete. The compressive strength of concrete containing 50% RCA has strength in close proximity to that of normal concrete.

2. MATERIAL PROPERTIES AND DESCRIPTION

2.1. Recycled Aggregates

Reusing the aggregates from demolished buildings for the manufacture of new concrete is known as Recycled Aggregates. The main reasons for the increase of this volume of demolition concrete waste are:

- Many old buildings and other structures have overcome their limit of use and need to be demolished.
- Structures even adequate to use are under demolition because there are new requirements and necessities.
- Creation of building wastes which result from natural destructive phenomena (earthquakes, storms etc).

In spite of that concrete demolition waste has been proved to be an excellent source of aggregates for new concrete production. There are many studies that prove that concrete made with this type of coarse aggregates can have mechanical properties similar to those of conventional concretes and even high-strength concrete is nowadays a possible goal for this environmentally sound practice. However, the fine fraction of these recycled aggregates has not been the subject of thorough similar studies since it is believed that their greater water absorption can jeopardize the final results. The results of several studies presented in the past have caused the existing codes concerning recycled aggregates for concrete production to strongly limit the use of these products.

<table>
<thead>
<tr>
<th>Table 2.1 Properties of RA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tests</td>
</tr>
<tr>
<td>Specific gravity of RA</td>
</tr>
<tr>
<td>Water absorption of RA</td>
</tr>
<tr>
<td>Impact value of RA</td>
</tr>
</tbody>
</table>

2.2. Bacteria

In this study Bacteria Bacillus Subtilis is used. The micro-organism used for manufacturing of microbial concrete should be able to possess long term effective crack sealing mechanism during its lifetime serviceability. The principle behind bacterial crack healing mechanism is that the bacteria should be able to transform soluble organic nutrients into insoluble inorganic calcite crystals which seals the cracks. For effective crack healing, both bacteria and nutrients incorporated into concrete should not disturb the integrity of cement sand matrix and also should not negatively affect other important fresh and hardened properties of concrete. Only spore forming gram positive strain bacteria can survive in high pH environment of concrete sustaining various stresses. It was reported that when bacteria is added directly to the concrete mix in suspension, their lifetime is limited due to two reasons; one is continuing cement hydration resulting in reduction of cement and sand matrix pore diameter and other is due to insufficient nutrients to precipitate calcite crystals. However, a novel method of protecting the bacterial spores by immobilization before addition to the concrete mixture appeared to substantially prolong their life-time.

<table>
<thead>
<tr>
<th>Table 2.2 Properties of Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Shape</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>Temperature</td>
</tr>
</tbody>
</table>

3. RESULTS AND DISCUSSION

3.1. Compressive Strength

Compressive strength is most important property of the hardened concrete. The concrete cubes were casted, cured and tested accordance with the IS standard and 7, 14, & 28 days.
Compressive strength result of concrete are listed in table. The highest compressive strength value is 26.67Mpa which is obtained at 28 days by replacement of 10% of coarse aggregate by recycle aggregates by weight of concrete when compared to the conventional mix. Fig 3.1 shows that the compressive strength of concrete for various mixes. From the result, the optimum strength is obtained at replacement of 10% of coarse aggregate by recycle aggregates by weight of concrete. Further increase in percentages shows a gradual decrease than the 10% replacement but has high compressive strength than conventional till a replacement of 30%.

After curing of cylinders for respective days it was placed in testing machine having a maximum capacity of 1000 KN. The load is applied on the cylinder specimens. The cylinder specimen was failed at ultimate load which was noted from dial gauge reading. From the result, it was found that the split tensile strength was increased at replacement of 10% of coarse aggregate by recycled aggregates by weight of concrete when compared to the conventional mix.

Based on the result, the highest split tensile strength value is 2.595 Mpa which is obtained at 28 days.
3.3. Flexural Strength of concrete
After curing of prism specimens, which are placed in testing machine having a maximum capacity of 100 KN. The load is applied on the prism specimens. The specimen is failed at ultimate load which is noted from dial gauge aggregate by recycled aggregates by weight of concrete when compared to the conventional reading. From the result flexural strength is increased at replacement of 10% of coarse concrete. Flexural strength is the property of the hardened concrete. The concrete prisms were cast, cured and tested accordance with the IS standard for 28 days flexural strength result of concrete are listed in table 3.3. Based on the result, the highest flexural strength value is 7.05 Mpa which is obtained at 28 days. Fig 4.3 shows that the flexural strength of concrete for various mixes.

Table 3.3 Flexural Strength of concrete

<table>
<thead>
<tr>
<th>DAY</th>
<th>28TH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERCENTAGE</td>
<td>In N/mm²</td>
</tr>
<tr>
<td>0</td>
<td>5.2</td>
</tr>
<tr>
<td>10</td>
<td>7.05</td>
</tr>
<tr>
<td>20</td>
<td>6.24</td>
</tr>
<tr>
<td>30</td>
<td>4.78</td>
</tr>
</tbody>
</table>

4. CONCLUSION
Experimental investigations were conducted to determine the Characteristics and Strength of concrete by replacing of coarse aggregate with Recycled Aggregates. Concrete specimens were casted and tested to determine the Compressive strength, Split tensile strength and Flexural strength. Based on the test results it was inferred, which percentage gave better results than the conventional concrete with respect to 7,14 and 28 days Compressive strength, Split tensile strength and Flexural strength when replaced with Recycled Aggregates.

- According to the comparative studies undertaken it is clear that with 10% and 20% replacement of coarse aggregate by recycled aggregates a maximum compressive strength of 26.67 and 24.95 N/mm² which is more than the conventional concrete was obtained. The other results showed a progressive increase for 10% and 20% replacement beyond which the strength was about equal to conventional.
- Further increment of concentration of Bacillus Subtilis to the percentages of Recycle Aggregates could further increase the strength of concrete.
- Usage of Recycle aggregates is eco friendly and by using the recycle aggregates the usage of coarse aggregate is partially reduced in concrete, thereby the mining activities can be minimized and also minimizing the waste by reusing the materials.
- Microbial Concrete technology have proved to be better than conventional technologies because of its eco-friendly nature, self healing abilities and very convenient for usage.
- The optimum percentage obtained are 10%.

REFERENCES


