Identifying The Strength Characteristics Of Blended Concrete Manufactured Using Natural, Artificial & Waste Foundry Sand

Abstract

The hypothesis behind this project work is, Waste foundry sand can be effectively used to replace more than 50% by weight of natural sand in concrete by adding some amount of artificial sand to the mixture, without sacrificing characteristic compressive strength of concrete. Concrete manufactured using natural sand blended only with waste foundry sand, showed a decreasing trend in compressive strength, at a rapid rate with steady increase in blending percentage of waste foundry sand. The reuse of waste foundry sand in concrete manufacturing could prove to be a solution to the problem of its handling and disposal. Thus reuse of waste foundry sand will lead to cutting off expenses and serve as source of income for foundry industry.
1. Introduction
Concrete is the largest utilized man-made material in the world. For concrete manufacturing a large amount of natural sand is being extracted in India. To identify the amount of Total cement consumption in India for the year 2012 was estimated at about 442MT and it is expected to go up to 312MT by the year 2015. For each tons of cement, the building industry needs about six to seven times more tons of sand and gravel. (Pascal Peduzzi, 2014). This means sand requirement becomes nearly 1900MT for 2015 and the trends suggest that the requirement goes up by at least 8% each year. To cater this steep demand for fine aggregates in concrete, it is now imperative for civil engineers and builders to search for alternatives to natural sand. The paper endeavours finding solution to the problem, by means of blending the natural sand with 60% of artificial & waste foundry sand.

The artificial sand has its own drawbacks regarding its grading and making the concrete harsher, thereby adversely affecting the compressive strength and concrete durability. (Jadhav and Kulkarni, 2012)

In this paper initial testing was done for the index properties of waste foundry sand, artificial sand, natural sand and coarse aggregates and cement. These tests were conducted according to the respective codes of standard in India. To follow the initial testing, pilot compressive strength tests were conducted in two phases wherein only waste foundry sand was used to replace natural sand in various percentages in pilot testing phase-I. In the pilot testing phase-II waste foundry sand along with artificial sand was used in various percentages. From the results obtained an optimum blending percentage was selected for final testing. Following the pilot testing phase-II optimum blending percentage was used for the final testing. In the final testing the concrete was tested for compressive, split tensile and flexural strength tests. The strength results were compared for standard and blended concrete mixes.

2. Material Used
- **Cement:** A 43 grade ordinary Portland cement (Brand- Chettinad) confirming to IS: 8112-1989 was used for concrete manufacturing. Cement was not older than 40 days at the time of testing as well as concrete casting.
- **Fine Aggregates:** Locally available natural river sand passing through 4.75 mm IS sieve was used as fine aggregate along with artificial sand and waste foundry sand which were used as partial blending materials.
- **Coarse Aggregates:** Crushed stone from Jaysingpur was used as coarse aggregates having 20 mm MSA. The CA was having maximum fraction of angular shaped stone fragments for concrete manufacturing.
- **Water:** Potable water available at concrete technology lab at JJMCOE, Jaysingpur was used for concrete manufacturing as well as for testing purpose.

3. Test and Results
To find the optimum blending percentage of WFS and AS with natural sand pilot testing was carried out in two phases. In phase- I testing natural sand was replaced with waste foundry sand by varying percentages like 0, 30, 40, 50, 60 and 70 %. A M20 grade concrete was prepared with all these different replacement percentages. From this concrete cubes were cast for compressive strength
testing. For each batch 12 cubes were cast. These cubes were tested on 3rd, 7th, 14th and 28th days for compressive strength and following results were obtained.

![Figure 1: Comparison of compressive strengths of concrete cubes at 3rd, 7th, 14th and 28th days for pilot testing phase I](image)

From the above plot we can see that with increase in blending percentage of WFS with natural sand there is a marked decrease in strength, moreover even with the blending limited to as low as 30% the concrete cubes fail to attain the minimum required strength at the particular age. Due to this we went forward for the phase II of pilot testing, where in addition to the natural and waste foundry sand, the artificial sand was also used. As sand blending purely with WFS only has not produced satisfactory results phase II testing was initiated. Here natural sand was replaced with varying percentages of waste foundry sand in addition to artificial sand as well.

![Figure 2: Comparison of compressive strengths of concrete cubes at 3rd, 7th, 14th and 28th days for pilot testing phase II](image)
After pilot testing of concrete an optimum blended mix i.e. PT42 was chosen for further testing. Following are the results of the final testing of concrete.

1. Compressive Strength Test:

![Graph showing variations in compressive strengths of concrete cubes with age & comparison with standard values.](image)

<table>
<thead>
<tr>
<th></th>
<th>Day 3</th>
<th>Day 7</th>
<th>Day 14</th>
<th>Day 28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Mix</td>
<td>12.64</td>
<td>20.52</td>
<td>30.34</td>
<td>33.87</td>
</tr>
<tr>
<td>PT41</td>
<td>12.00</td>
<td>19.84</td>
<td>28.04</td>
<td>31.21</td>
</tr>
<tr>
<td>Standard values</td>
<td>12.40</td>
<td>20.15</td>
<td>27.50</td>
<td>30.00</td>
</tr>
</tbody>
</table>

Figure 3: Variations in compressive strengths of concrete cubes with age & comparison with standard values.

2. Split Tensile Strength Test:

![Graph showing split tensile strength of concrete cylinders for standard & blended concrete mixes on 28th day in MPa.](image)

<table>
<thead>
<tr>
<th></th>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Mix on 28th Day</td>
<td>2.25</td>
<td>2.34</td>
<td>2.14</td>
</tr>
<tr>
<td>PT41 Mix on 28th Day</td>
<td>1.92</td>
<td>1.87</td>
<td>1.99</td>
</tr>
</tbody>
</table>

Figure 4: Split tensile strength of concrete cylinders for standard & blended concrete mixes on 28th day in MPa.
3. Flexural Strength Test

![Figure 5: Flexural strength of concrete beams for standard & blended concrete mixes on 28th day in MPa](image)

From fig. 5, it can be seen that there is a 7% difference amongst the flexural strengths of the standard and mix PT42 concrete beams.

4. Conclusion

Following are the conclusions drawn from the research:

i. Compressive strength of concrete went on increasing with the age of concrete for both standard and blended concrete mixes. The rate of strength gain was high in case of standard mix as compared to blended concrete mixes.

ii. Concrete manufactured using natural sand blended only with waste foundry sand, showed a decreasing trend in compressive strength, at a rapid rate with steady increase in blending percentage of waste foundry sand. This might have happened owing to finer nature of waste foundry sand and decrease in fineness modulus of fine aggregates. Also as the fine aggregate gradation showed a poorly graded curve, may have caused the trend.

iii. Whilst concrete was manufactured using natural sand blended with waste foundry sand together with artificial sand, its compressive strength went on decreasing at a slow rate along with increase in percentage of blending. The rate of decrease of compressive strength became almost negligible between blending percentages 40% to 60%. The reason behind it may have been the fineness modulus of blended mixes approaching to value close to 3 and gradation curve of fine aggregates resembling to a well graded curve.

iv. Even though there was a decrease in compressive strength with increase in sand blending, the blended mix PT42 showed acceptable values of compressive strengths at the time of pilot
testing. The average compressive strength of concrete cubes for PT42 mix was 20.33MPa i.e. 1.63% more than 20MPa which minimum requirement for a compressive strength of concrete cube on the 28th day after casting.

v. Even with slow rate of strength gain on 3rd and 7th days, the blended concrete mix PT42 exhibits sufficient values of compressive strength on 14th and 28th days.

vi. A 12.77% decrease in the slump value of PT42 blended concrete mix as compared to standard concrete mix was observed. The slump value decline is may have occurred due to fine nature of waste foundry and artificial sand blended fine aggregate mix.

vii. There is 14.03% and 6.73% reduction in split tensile strength and flexural strength respectively for PT42 blended concrete mix as compared to standard concrete mix.

viii. 55.21% of cost savings can achieved by replacing the natural sand in concrete with a blend of 40% waste foundry sand, 40% natural sand and 20% artificial sand. As this mix gives sufficient compressive strength.

5. References


