Concrete Made by Two-Stage Mixing Approach(TSMA) using Fly Ash and Nominal Concrete Made by Normal Mixing Approach(NMA) Strength Characteristics: Compressive and Flexural

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Abstract

Sustainability in broad sense is the ability to preserve a certain process or state over a long period of time in the future. In the ecological terms, the process is sustainable when it is able to maintain ecological processes, productivity and biodiversity in the future. To preserve the environment, create no ecological imbalances and have no impact on human health and the process can continue in this manner for a long-time into the future without compromising with the productivity can be achieved by the process of production and use of sustainable materials up to disposal or reuse/recycling. In the current paper we will discuss two parameters on which the concrete made by the two-stage mixing approach(TSMA) has been tested for strength characteristics viz. compressive strength and flexural strength. These parametric properties are compared with the conventional concrete with the variation of percentage of recycled coarse aggregates(RCA) and fly ash.

Keywords: concrete, recycled aggregates, cement, compressive strength, flexural strength, RCA, fly ash, Two-stage mixing approach(TSMA), Normal mixing approach(NMA).

I. INTRODUCTION

It is acknowledged that wastage in India in the construction industry is as high as 30%. This is a large, yet relatively simple and straightforward challenge to tackle. These wastages are activities that absorb man hours, resources and materials but create no value. Most developed countries have different forums, institutes, researchers or academic institutions for seeking solutions to evaluate these wastages and lean construction practices that emerged are encouraging. Lean construction is a "way to design production systems to minimize waste of time, materials and efforts in order to generate the maximum possible value". India does not have a fully focused lean construction forum while some novel initiatives are being taken in some parts of India to adopt leaner construction practices. The paper presents a comparison of the compressive as well as flexural strength characteristics of the concrete made through NMA and TSMA. Concept of use of recycled material in concrete is in great demand to create concrete saving both resources and time. Researches have been carried out on recycled materials that can be used in concrete all over the world. One of the recycled material that can be used in concrete is recycled aggregates.

II. LITERATURE REVIEW

Tam V.W.Y et al(2005)[8], proposed the technique of modified mixing of concrete. They concluded that the poor quality of RAC was due to higher water absorption and higher porosity. The weaker interfacial transition zone (ITZ) between Recycled Aggregates(RA) and cement mortar restricts the application of RAC for higher grade applications. In this study, the weakness of RAC is strengthen by the two-stage mixing approach(TSMA), weak link is located at the ITZ of the RA. TSMA provides a way for the cement slurry to gel up with the RA, which in turn provides a stronger ITZ by filling up the pores and cracks within RA. Laboratory tests shows that the compressive strength has been improved. This TSMA can provide an effective method for enhancing the compressive strength and other properties of RAC, and thus, the approach opens up a wider scope of RAC applications.

According to Yong P.C and Teo D.C.L(2009)[10], the RAC can achieve high compressive strength, split tensile strength as well as flexural strength. RAC has higher 28-day compressive strength and higher 28-day split tensile strength compared to natural concrete whereas the 28-day flexural strength of RAC is lower than that of natural concrete. Recycled Coarse Aggregate(RCA) shows good potential as coarse aggregate for the production of new concrete.
Patil S.P et al(2013)[6], have concluded in their research on RCA that the compressive strength of concrete containing 50% RCA has strength similar to that of normal concrete. Splitting tensile test shows that concrete has good tensile strength when replace upto 25-50%. The strength of concrete is high during initial stages but gradually reduces during later stages.

According to Bendapudi S.C.K and Saha P(2011)[1], primary goal is reduction in the use of portland cement, which is easily achieved by partially replacing it with various cementitious materials. The best known of such materials is fly ash- a residue of coal combustion, which is an excellent cementitious material. In India alone, we produce about 75 million tons of fly ash per year, the disposal of which has become a serious environmental problem. The effective utilization of fly ash in concrete making is, therefore, attracting a lot of concrete technologists and government departments. The new Indian Standard on concrete mix proportions(IS 10262-2009)[14] are already incorporated fly ash as a supplementary material to cement. Fly ash replacement of cement is effective for improving the resistance of concrete to sulfate attack expansion. The higher is the compressive strength of concrete, the lower is the ratio of splitting tensile strength to compressive strength.

Vyas C.M and Pitroda J.K(2013)[9], have worked on the combination of RCA and Fly Ash and have concluded that the applications of RCA in the construction area are very wide. The main aim of using RCA is to reduce the use of natural aggregates. Another improving method is using Fly ash along with RCA. Application of fly ash in the recycled coarse aggregate concrete can improve the durability as well as strength characteristics of the RAC.

According to Kamala R. and Rao B. K(2012)[4], the results obtained shows that there is decrement in the Flexural strength of beams for 56 days. The maximum 28 days tensile strength was obtained with 40% replacement of crushed tile aggregates and the strength is more at 28 days of curing compared to the Normal cement concrete(NCC) mix.

Katz A.(2003)[5], by experimental analysis on the properties of concrete made with recycled aggregate from partially hydrated old concrete and two different types of cements showed that the difference in the quality of the two types of cement was clearly seen and the ratios of the flexural and the splitting strengths to the compressive strength values were within a reasonable range. The higher values of the flexural and splitting strengths relative to the predicted ones were clearly seen especially for the OPC recycled concrete. Smaller values than the predicted ones are expected for lightweight aggregate concrete.

The analysis done by Puri N., Kumar B. and Tyagi H.(2013)[7], shows that a significant increase in flexural strength was observed when natural aggregates were replaced with RCA. However a decrease in flexural strength was observed when natural aggregates were replaced with PVC aggregates. Very low flexural strength has been shown by concrete in which fine aggregates were replaced by pulverized leather waste.

As per the experimental work done by Deshpande N.K, Kulkarni S.S and Pachpande H.(2012)[2], For M25 grade concrete the flexural strength of nominal M25 grade concrete is 3.5N/mm²[3]. Conventional materials satisfies the requirement with 3.76N/mm². Split tensile test and Flexural strength both are tests for tensile strength of concrete. Concrete made by using recycled aggregates showed slightly lower values of tensile strength as well as flexural strength, hence the loss in tensile strength should be considered while designing members using recycled aggregate concrete.

III. MATERIALS USED

A. Cement
Ordinary Portland cement of 43 grade satisfying the requirements of IS: 8112-1989[12]. The specific gravity of cement was found to be 3.005.

B. Fine aggregates
The sand generally collected from haryana. Sand is the main component grading zone-I of IS: 383-1978[11] was used with specific gravity of 2.62 and water absorption of 1% at 24 hours.

C. Coarse aggregates
Mechanically crushed stone from a quarry situated in haryana with 20 mm maximum size, satisfying to IS: 383-1978[11] was used. The specific gravity was found to be 2.63 and water absorption is 0.5% at 24 hours.

D. Recycled coarse aggregates
Aggregates obtained by the processing of construction and demolition waste are known as recycled aggregates. RCA for the experimental analysis was procured from the C & D waste plant in Delhi which is in collaboration with Municipal Corporation Of Delhi.

E. Fly Ash
Fly ash is used as partial replacement of cement which replaces 10% of total cementitious material in all the cases of the experiments. Class F fly ash is used from haryana having specific gravity as 2.4 and satisfying IS 3812-1999[13].

1) Methodology
NMA follows the following steps...
First, coarse and fine aggregate are mixed.
Second, water and cementitious materials are added and mixed.
However, TSMA follows different steps:
- First, coarse and fine aggregates are mixed for 60 seconds and then half of water for the specimen is added and mixed for another 60 seconds.
- Second, cementitious material is added and mixed for 30 seconds.
- Thirdly, the rest of water is added and mixed for 120 seconds.
The specific procedure of TSMA creates a thin layer of cement slurry on the surface of RA which is expected to get into the porous old mortar and fill the old cracks and voids.
Using recycled concrete as the base material for roadways reduces the pollution involved in trucking material.

IV. EXPERIMENTAL OBSERVATIONS

Following table shows the experimental observations of the test samples made from TSMA and nominal mix by NMA.

1. M-25(10-25) signifies the specimen mix having 10% fly ash and 25% RCA content.
2. M-25(10-50) signifies the specimen mix having 10% fly ash and 50% RCA content.
3. M-25(10-75) signifies the specimen mix having 10% fly ash and 75% RCA content.
4. M-25(10-25) signifies the specimen mix having 10% fly ash and 100% RCA content.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Specimen</th>
<th>7th day (MPa)</th>
<th>28th day (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nominal M-25</td>
<td>17.84</td>
<td>31.7</td>
</tr>
<tr>
<td>2</td>
<td>M-25(10-25)</td>
<td>18.81</td>
<td>33.77</td>
</tr>
<tr>
<td>3</td>
<td>M-25(10-50)</td>
<td>20.21</td>
<td>32.88</td>
</tr>
<tr>
<td>4</td>
<td>M-25(10-75)</td>
<td>22.51</td>
<td>32.88</td>
</tr>
<tr>
<td>5</td>
<td>M-25(10-100)</td>
<td>15.10</td>
<td>27.99</td>
</tr>
</tbody>
</table>

These observations can be depicted in graphical form as follows:

Chart 1: 7th day Compressive strength

Chart 2: 28th day Compressive strength
Concrete Made by Two-Stage Mixing Approach (TSMA) using Fly Ash and Nominal Concrete Made by Normal Mixing Approach (NMA) Strength Characteristics: Compressive and Flexural

Graph 1: Compressive strength (both 7 and 28 day)

Table 2: Flexural strength

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Specimen</th>
<th>7th day strength</th>
<th>28th day strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nominal M-25</td>
<td>2.63</td>
<td>3.68</td>
</tr>
<tr>
<td>2</td>
<td>M-25 (10-25)</td>
<td>2.84</td>
<td>3.96</td>
</tr>
<tr>
<td>3</td>
<td>M-25 (10-50)</td>
<td>2.71</td>
<td>3.67</td>
</tr>
<tr>
<td>4</td>
<td>M-25 (10-75)</td>
<td>2.54</td>
<td>3.53</td>
</tr>
<tr>
<td>5</td>
<td>M-25 (10-100)</td>
<td>2.26</td>
<td>2.98</td>
</tr>
</tbody>
</table>

These observations can be depicted in graphical form as follows:

Chart 3: 7th day Flexural strength

Chart 4: 28th day Flexural strength
V. RESULTS AND DISCUSSIONS

A. Results

The above experimental analysis provides us with the following results:

1. The compressive strength of M-25 grade nominal concrete made by NMA gives 7 day and 28 day strengths as 17.84 MPa and 31.7 MPa respectively. The same mix shows flexural strength at 7 day and 28 day as 2.63 MPa and 3.68 MPa respectively.

2. Using TSMA, addition of 10% fly ash, the specimen made by 25% RCA gives compressive strength at 7 day and 28 day as 18.81 MPa and 33.77 MPa respectively. The same mix shows flexural strength at 7 day and 28 day as 2.84 MPa and 3.96 MPa respectively.

3. Using TSMA, addition of 10% fly ash, the specimen made by 50% RCA gives 7 day and 28 day strengths as 20.21 MPa and 32.88 MPa respectively. The same mix shows flexural strength at 7 day and 28 day as 2.71 MPa and 3.67 MPa respectively.

4. Using TSMA, addition of 10% fly ash, the specimen made by 75% RCA gives 7 day and 28 day strengths as 22.51 MPa and 32.88 MPa respectively. The same mix shows flexural strength at 7 day and 28 day as 2.54 MPa and 3.53 MPa respectively.

5. Using TSMA, addition of 10% fly ash, the specimen made by 100% RCA gives 7 day and 28 day strengths as 17.10 MPa and 27.99 MPa respectively. The same mix shows flexural strength at 7 day and 28 day as 2.26 MPa and 2.98 MPa respectively.

B. Discussion

The specimen mix M-25(10-25) shows an increase of 5.46% in 7 day and 6.52% in 28 day compressive strength and shows an increase of 7.98% in 7 day and 7.60% in 28 day flexural strength, however, specimen mix M-25(10-50) shows an increase of 13.32% in 7 day compressive strength and 3.72% in 28 day strength and shows an increase of 3.04% in 7 day and decrease of 0.27% in 28 day flexural strength with respect to nominal mix specimen.

The specimen mix M-25(10-75) shows an increase of 26.17% in 7 day and 3.72% in 28 day compressive strength and shows a decrease of 3.42% in 7 day and 4.07% in 28 day flexural strength, whereas, specimen mix M-25(10-100) shows decrease of 15.10% in 7 day and 11.70% in 28 day compressive strength and shows a decrease of 14.06% in 7 day and 19.02% in 28 day flexural strength with respect to nominal mix specimen.

From 28 day strength point of view, specimen M-25(10-25) shows optimum increase in compressive strength i.e. 6.52% and flexural strength i.e. 7.60% with respect to nominal mix specimen.

VI. CONCLUSIONS

Samples after casting were tested and gave the above results depicted by chart 1.2.3 and 4. The outcome of this work reveals that concrete made by replacement of 25% and 50% RCA and addition of 10% fly ash using TSMA gives more compressive as well as flexural strength for both 7 day and 28 day strength than the referred nominal concrete specimen made by NMA however on using 75% RCA the concrete shows increase in compressive strength but a decrease in flexural strength. On using 100% RCA, the concrete shows decrease in compressive as well as flexural strength than the nominal concrete.

Maximum 28 day compressive and flexural strength is obtained by concrete made by using TSMA involving replacement of 25% RCA and addition of 10% fly ash. This concrete so made will be strong as well as cost effective and can be used in any constructional works in place of normal concrete.
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