AN EXPERIMENTAL INVESTIGATION ON UTILIZATION OF VARIOUS WASTES IN THE LEAN CONCRETE BLOCKS

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ABSTRACT

The masonry unit used for the construction of masonry works in the western Gujarat region of India, Kutch is a lean concrete blocks of size varying as per the purpose of masonry work i.e. for load bearing or partition work. These blocks are manufactured by blending the cement, fine aggregate and coarse aggregate at proportion of 1:6:4 with w/c of about 0.5, the resulting mix is than utilized to produce the blocks with help of vibro-pressure machineries. These consume the natural resources such as natural fine aggregate and natural coarse aggregate and hence diminishes the environment gradually. Generation of wastes from various industries also results in pollution of environment because of improper disposal of these wastes and lack of exploration for utilization of such wastes. This paper identifies a potential use of wastes from foundry industry and construction industry for utilization in construction industry and represents the experimental investigation on utilization of foundry waste as a partial replacement of natural sand by 10%, 20%, 30%, 40% and recycled aggregate as a partial replacement of natural coarse aggregate by 25%, 50%, 75% and 100%. This various trial mixes are compared in the terms of compression strength and water absorption with respect to the standard mix proportion. The result shows the increase in compressive strength and reduction in water absorption with increase in content of foundry sand whereas reduction in compressive strength and increase in water absorption with increase in content of recycled aggregate.

KEYWORDS: Western Gujarat, Kutch, Lean concrete blocks, Foundry waste, Recycled Aggregates (RCA), Compressive Strength, Water Absorption

INTRODUCTION

The recycling of Construction and Demolition Wastes has long been accepted to have the possible to conserve natural resources and to decrease energy used in its production. RCAs fit into present day motto of ‘Reducing, Reusing, Recycling and Regenerating’. The use of recycled aggregate weakens the quality of recycled aggregate concrete which limits its application. Foundries for the metal-casting industry generate by products such as used foundry sand. Metal foundries use large amount of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. Use of foundry sand in various engineering applications can solve the problem of disposal of foundry sand and other purposes. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual and dust. Foundry Sand can be used as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete. Energy plays an important role in era of developing countries like India. By earning carbon credit by using industrial waste foundry sand for Building Materials like fine aggregate, the energy & environment can be saved. The masonry unit used for the construction of masonry works in the western Gujarat region of India (Kutch) is a lean concrete blocks of size varying as per the purpose of masonry work i.e. for load bearing or partition work. As the raw material required for the manufacturing of clay bricks is not available within the Kutch region, therefore the production of such bricks is not done in this region and hence the clay bricks are imported from the vicinity of Kutch regions for construction of masonry works which incurs the cost of bricks in addition of transportation and handling charges and as result of which such a masonry units proves to be the costlier and uneconomical for the lower and middle class locality. And hence the local engineers and contractors have developed an alternative masonry unit called lean concrete blocks which are commonly known as ‘blocks’ in that locality.

MATERIALS USED

A. Cement

In the most general sense of the word, cement is a binder, a substance that sets and hardens independent, and can bind other materials together. The cement used in this research is TATA OPC 53 grade cement. The Ordinary Portland Cement of 53 grades conforming to IS: 8112-1989 is being used. Tests were conducted on the cement like Specific gravity, consistency tests, setting tests, soundness, Compressive strength N/mm² at 28 days.

Table – 1 Properties of Cement

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Physical properties</th>
<th>TATA OPC 53</th>
<th>Result</th>
<th>Requirements as per IS:8112-1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific gravity</td>
<td>3.14</td>
<td>3.10-3.15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Standard Consistency (%)</td>
<td>31.7 %</td>
<td>30-35</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Initial setting time (hours, min)</td>
<td>81 min</td>
<td>30 minimum</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Final setting time (hours, min)</td>
<td>231 min</td>
<td>600 maximum</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Compressive strength N/mm² at 28 days</td>
<td>58 N/mm²</td>
<td>55 N/mm² minimum</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Western Gujarat region of India (Kutch)
Source: http://en.wikipedia.org/wiki/Little_Rann_of_Kutch

Figure 2: TATA cement (OPC)
B. Coarse Aggregate
The fractions from 10 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is being use. The Flakiness and Elongation Index were maintained well below 15%.

![Figure 3: 10mm Coarse aggregate](image)

C. Fine aggregate
Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used as fine aggregate conforming to the requirements of IS: 383. The river sand is washed and screened, to eliminate deleterious materials and oversize particles.

![Figure 4: Fine aggregate (River sand)](image)

D. FOUNDRY WASTE SAND
Metal foundries use large amounts of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. This study presents the information about the civil engineering applications of foundry sand, which is technically sound and is environmentally safe. Use of foundry sand in various engineering applications can solve the problem of disposal of foundry sand and other purposes. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of cement or as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete.

![Figure 5: Used foundry sand](image)

E. RECYCLED AGGREGATE
Recycled coarse aggregate obtained by crushing the locally available construction waste, debris and tested concrete cubes with sizes of 10 mm were used.

<table>
<thead>
<tr>
<th>Table-4: Properties of NA &amp; RCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROPERTY OF AGGREGATE</td>
</tr>
<tr>
<td>Sp. Gravity</td>
</tr>
<tr>
<td>Impact Value</td>
</tr>
<tr>
<td>Crushing Value</td>
</tr>
<tr>
<td>Los Angeles Abrasion Loss</td>
</tr>
</tbody>
</table>

F. Water
Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

DESIGN MIX
The size of block which are used widely for load bearing masonry construction are of dimension: (150mm×200mm×400mm) and hence the same dimension will be used for experimentation and study work. The mix proportion for manufacturing of such blocks is as shown in table-5. The blocks casted are sun dried and they are cured by spraying method of curing.

| Table-5 design mix proportions for lean concrete blocks |

G. TESTING
A. Compression Test
The compression test will be carried out on the specimens at the end of 7 days, 14 days and 28 days of curing. The procedure to be followed is as given below:

1. After cleaning the bearing surface of the compression testing machine, the concrete block will be placed on its face side having dimension 200 mm × 400 mm. The axis of the specimen is to be carefully aligned with the center of the lower pressure plate of compression testing machine. Then an upper pressure plate is to be lowered till the distance between pressure plate and the top surface of the specimen achieved. No packing used between face of the pressure plates and block.

2. The load will be applied without shock and increased gradually until the specimen gets crushed.
3. The compressive strength calculated in N/mm$^2$ from the maximum load sustained by the block before failure.

Compressive strength = $P/A$

Where, $P$ = failure load (N)

$A =$ cross sectional area (mm$^2$)

4. Average of three values was taken for determining compressive strength of lean concrete block.

![Figure 8: Compression Testing Machine with arrangement of laying block](image)

B. Water Absorption Test

The 150mm×200mm×400mm block after casting will be cured for 28 days curing. These specimens will then oven dried for 24 hours at the temperature 110°C until the mass became constant and again weighed. This weight was noted as the dry weight (W1) of the block. After that the specimen will be water at normal temperature for 24 hours. Then this weight will noted as the wet weight (W2) of the block.

\[
\% \text{ water absorption} = \left(\frac{W2 - W1}{W1}\right) \times 100
\]

Where, $W1 =$ Oven dry weight of block in grams

$W2 =$ After 24 hours wet weight of block in grams.

RESULTS

Table-7 Compression strength at 7 days, 14 days and 28 days between block of type A, B1, B2, B3 and B4

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>7 DAYS</th>
<th>14 DAYS</th>
<th>28 DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.84</td>
<td>7.56</td>
<td>10.17</td>
</tr>
<tr>
<td>B1</td>
<td>5.96</td>
<td>7.67</td>
<td>11.10</td>
</tr>
<tr>
<td>B2</td>
<td>3.01</td>
<td>11.55</td>
<td>14.59</td>
</tr>
<tr>
<td>B3</td>
<td>9.55</td>
<td>12.48</td>
<td>17.68</td>
</tr>
<tr>
<td>B4</td>
<td>12.10</td>
<td>15.00</td>
<td>21.58</td>
</tr>
</tbody>
</table>

Table-8 Compression strength at 7 days, 14 days and 28 days between block of type A, C1, C2, C3 and C4

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>5.84</td>
<td>7.56</td>
<td>10.17</td>
</tr>
<tr>
<td>C1</td>
<td>5.63</td>
<td>7.36</td>
<td>9.95</td>
</tr>
<tr>
<td>C2</td>
<td>5.28</td>
<td>6.94</td>
<td>9.4</td>
</tr>
<tr>
<td>C3</td>
<td>5.01</td>
<td>6.51</td>
<td>8.67</td>
</tr>
<tr>
<td>C4</td>
<td>4.19</td>
<td>6.08</td>
<td>7.55</td>
</tr>
</tbody>
</table>

CONCLUSION

Based on above limited study the following conclusion can be drawn:

- There is increase in compressive strength with increase in content of foundry sand and maximum strength comes at 40% replacement of natural sand with used foundry sand.
- Reduction in water absorption with increase in content of foundry sand and it is minimum for maximum replacement value.
- There is reduction in compressive strength with increase in content of recycled aggregate and it can be replaced upto 75%.
- Increase in water absorption with increase in content of recycled aggregate.
- Utilization of this wastes independently or combination of both results in greener masonry component which saves the natural resources and results in sustainable development.
- As the wastes are being utilized whose cost is much lesser than that of natural resources the ultimate economy can be achieved in the masonry construction.

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