Investigation of the Suitability of Waste Glass and Recycled Concrete Aggregate for Structural Concrete

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ABSTRACT
Environmental pollution and increase in manufacturing and storage costs in our era, has driven humans to recycle wastes. This study examines the possibility of using waste glass as glass powder and glass aggregates and recycled aggregates. Recycled aggregate was made by crushing the waste concrete of laboratory test cubes and pre-cast concrete columns. The result showed a better compressive strength of the concrete containing waste glass and recycled aggregates.

Three types of concrete mixtures were tested. Concrete made with natural aggregate as a control concrete and two types of concrete made with natural fine and recycled coarse aggregate. In this it is necessary to use quality recycled coarse aggregate and to follow the specific rules for design and production. The specimen containing both waste glass and recycled concrete gave better result than the one containing only waste glass. The results indicate that recycled brick aggregates can be used for new construction works instead of normal brick aggregates.

Key words: Recycling, Waste Glass Powder, Waste Glass, Coarse Aggregate, Recycled Aggregates.

I. INTRODUCTION
The use of partial cement replacement materials obtained from waste or by-product streams of other industries is favoured in concrete production due to their advantages in improving some or all of the properties of concrete, the economic incentives in using a waste or by-product material, and the environmental implications. High contents of silica in glass make it a potentially pozzolanic material. Glass constitutes about 5% of the municipal solid waste stream and only 20% of this is recycled.

Utilization of waste glass and recycled aggregates is very important for human development because huge amount of glass waste produce by human increases the need of land to get rid of use up previous landfill space, decreasing possible area that can be used for landfills of other waste increasing the need to establish new expansive landfills.

Demolition of old and deteriorated buildings and traffic infrastructure, and their substitution with new ones. The main reasons for replacements are changes of purpose, rearrangement of a city, expansion of traffic directions and increasing traffic load, natural disasters etc.. Now a day’s production and utilization of concrete is rapidly increasing consumption of aggregates, therefore these are to be recycled. Recycled concrete aggregate(RCA) is generally produced by two-stage, crushing of demolished concrete and screening and removal of...
contaminates such as reinforcement, paper, wood plastics and gypsum.

II. LITERATURE REVIEW.

Glass is a readily recyclable material,(1,2,3,4) in that it can be returned to the glass making furnace with minimal reprocessing. In many cases quantities of recovered glass can arise which are not recyclable.

The most important properties of recycled concrete aggregate (RCA) are briefly presented when demolished concrete is crushed, a certain amount of mortar and cement paste from the original concrete remains attached to stone particles in recycled aggregates. This attached mortar is main reason for lower quality of RCA compared to natural aggregate (6).

RCA compared to NA has following properties
i. Increased water absorption
ii. Decreased bulk density
iii. Decreased specific gravity
iv. Increased abrasion 12ss
v. Increased crushability
vi. Increased quality of dust particles

To obtain the desired workability of RCA it is necessary to add a certain amount of water to saturate recycled aggregate before or during mixing. The additional water quantity is calculated on the basis of recycled aggregates.

Recycled aggregates (5, 6) are broken down into two main categories, which are coarse and fine aggregates, coarse aggregates in general are larger than 2mm in diameter and fine aggregates are defined to be smaller than 2mm. When concrete is formed, the coarse aggregates with its large portion of the coarse aggregate and reduce the amount of cement required. When fresh aggregates are used to mix concrete, the aggregates themselves also contain some moisture either from water condensing on the particles or the aggregates was washed in some way with water.

NATIONAL STATUS:

Research on the use of RCA for structural concrete dates back to 10- years. The research scholars at IIT Kharagpur and IIT Delhi have worked on RCA which was mainly manually broken coarse aggregates, not machine crushed (2008).

However, the construction industry in India is yet to take note of the potential of RCA. More research is needed to popularize RCA in India. The fact that it can be used as an efficient replacement up to 100% of natural coarse aggregate is not appreciated in India yet. The concrete mix design needs to be modified to use RCA. The technical and economic benefits of manually recycled RCA over machine recycled RCA needs to be established through experimental research as it has good potential for structural application.

III. Research significance

Recycling, disposal and decomposing of water glass possess major problems for municipalities. This problem can be greatly eliminated by re-using waste glass as cement replacement in concrete. There is a limit on the availability of natural aggregate and minerals used for making cement and it is necessary to reduce energy consumption and emission of CO2 resulting from construction processes. The solution of this problem is sought through usages of glass as partial replacement of sand and aggregates. The concrete containing waste glass powder needs to be investigated by replacing glass with sand and coarse aggregates. Also the use of recycled aggregates is made.

IV. Methodology

We have identified a single source of a old demolished concrete within Jain Global campus and the waste coarse aggregate and broken glass (mainly clear glass) are collected for the experiments.
In this experimentation, an attempt has been made to find out the strength behaviour of concrete produced by replacing the cement with waste glass, glass aggregate and recycled concrete aggregate. Ordinary Portland Cement (OPC) 43 grade, locally available sand and coarse aggregates were used in this experiments. The sand used was a Zone-III had the specific gravity of 2.62. The specific gravity of the coarse aggregate was 2.93. The coarse aggregate used were 20mm and down size. The glass powder was obtained by crushing waste glass pieces. The 475-micron passing fraction and glass aggregates of 20mm in size were used for the experimentation. Old concrete waste was crushed in the Jaw crusher and sieved to prepare recycled coarse aggregate.

Various compositions used for the experiments are as follows:

A1- Cement + Sand + Recycled Coarse aggregate + Glass powder (15% replacement of sand by weight)

A2- Cement + Sand + Coarse aggregate + Glass (15% replacement of coarse aggregate by weight)

A3- Cement + Sand + Coarse aggregate + Glass aggregate (15% replacement of sand by weight) + Glass powder (15% replacement of sand by weight)

B1- Cement + Sand + Coarse aggregate + Recycled concrete aggregate (15% replacement of cement by weight) + Glass powder (15% replacement of sand by weight)

B2- Cement + Sand + Coarse aggregate + Recycled concrete aggregate + Glass aggregate (15% replacement of coarse aggregate by weight)

<table>
<thead>
<tr>
<th>Mix</th>
<th>Description</th>
<th>Cement (Kg)</th>
<th>Sand (Kg)</th>
<th>Coarse Aggregates (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>With 15% glass powder</td>
<td>2.60</td>
<td>4.05</td>
<td>8.50</td>
</tr>
<tr>
<td>A2</td>
<td>With 15% glass aggregate</td>
<td>2.60</td>
<td>4.76</td>
<td>7.2303</td>
</tr>
<tr>
<td>A3</td>
<td>With 15% glass powder+ 15% glass aggregate</td>
<td>2.60</td>
<td>4.05</td>
<td>7.2303</td>
</tr>
<tr>
<td>B1</td>
<td>RCA 15% + 15% glass aggregates</td>
<td>2.213</td>
<td>4.76</td>
<td>7.2303</td>
</tr>
<tr>
<td>B2</td>
<td>With 15% RCA + 15% Glass powder + 15% glass aggregate</td>
<td>2.213</td>
<td>4.05</td>
<td>7.2303</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mix</th>
<th>Description</th>
<th>Glass Powder (Kg)</th>
<th>Coarse glass Aggregates (Kg)</th>
<th>RCA (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>With 15% glass powder</td>
<td>0.714</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A2</td>
<td>With 15% glass aggregate</td>
<td>-</td>
<td>1.274</td>
<td>-</td>
</tr>
<tr>
<td>A3</td>
<td>With 15% glass powder+ 15% glass aggregate</td>
<td>0.714</td>
<td>1.274</td>
<td>-</td>
</tr>
<tr>
<td>B1</td>
<td>RCA 15% + 15% glass aggregates</td>
<td>-</td>
<td>1.274</td>
<td>0.390</td>
</tr>
<tr>
<td>B2</td>
<td>With 15% RCA + 15% Glass powder + 15% glass aggregate</td>
<td>0.714</td>
<td>1.274</td>
<td>0.390</td>
</tr>
</tbody>
</table>

Fig1: Glass aggregate being prepared
V. RESULT

Table-2 Observed compressive strength of the specimens

<table>
<thead>
<tr>
<th>Mix design (M20)</th>
<th>Compressive strength at 14-day (MPa)</th>
<th>Compressive strength at 28-day (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional concrete</td>
<td>16.8</td>
<td>24.15</td>
</tr>
<tr>
<td>A1</td>
<td>21</td>
<td>23.1</td>
</tr>
<tr>
<td>A2</td>
<td>18.58</td>
<td>20.37</td>
</tr>
<tr>
<td>A3</td>
<td>16.27</td>
<td>16.8</td>
</tr>
<tr>
<td>Conventional concrete</td>
<td>16.8</td>
<td>24.15</td>
</tr>
<tr>
<td>B1</td>
<td>20.26</td>
<td>25.20</td>
</tr>
<tr>
<td>B2</td>
<td>21</td>
<td>27.93</td>
</tr>
</tbody>
</table>

VI. CONCLUSION

The following conclusions can be highlighted from the output of this research and can be summarized as follows:
1. The data obtained in this project show that there is great potential for the utilisation of waste glass in concrete in the form of coarse aggregate and glass powder and also recycled concrete aggregate along with it. It is considered that the latter form would provide much greater opportunities for value adding and cost recovery, as it could be used as a replacement for expensive materials. The use of glass powder in concrete would prevent expansive Alkali Silica...
Reaction (ASR) in the presence of recycled concrete aggregate.

2. This study is an initial effort to propose the concept of concrete of concrete with waste glass together with recycled concrete aggregate.

3. Concrete specimens containing waste glass showed lesser strength in comparison to the specimens containing both waste glass and recycled concrete aggregate.

4. Concrete containing glass as coarse aggregate and glass powder can achieve comparable strengths (even better for Compositions A1 & B2) to that of natural sand and coarse aggregates (Table-2).

5. Increase in strength of the concrete was found when recycled concrete aggregate was added to the specimen containing waste glass.

VII. REFERENCES


