Study on Partial Replacement of Cement in Concrete with Bagasse Ash and Coir Fibre

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Abstract: The utilization of industrial and agricultural waste produced by industrial processes has been the focus of waste reduction research for economical, environmental, and technical reasons. Sugarcane bagasse is a fibrous waste-product of the sugar refining industry. This waste product (Sugar-cane Bagasse ash) is already causing serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminum ion and silica. In this paper, Bagasse ash has been partially replaced in the ratio of 0%, 5%, 10%, 15% and 20% by weight of cement in concrete and 2% of coir fibres of 20-25mm length is used by volume of cement in concrete to increase tensile strength. Fresh concrete tests like compaction factor test and slump cone test were undertaken as well as hardened concrete tests like compressive strength, split tensile strength at the age of 7, 14 and 28 days was obtained. The result shows that the strength of concrete increased as percentage of bagasse ash increased up to certain replacement.

1. Introduction

Ordinary Portland cement is recognized as a major construction material throughout the world. Researchers all over the world today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for industry. This waste utilization would not only be economical, but may also result in foreign exchange earning and environmental pollution control. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties. A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement. Therefore it is possible to use sugarcane bagasse ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials such as mortar, concrete pavers, concrete roof tiles and soil cement interlocking block. The present study was carried out on SCBA obtained by controlled combustion of sugarcane bagasse, which was procured from the Tamilnadu province in India. Sugarcane production in India is over 300 million tons/year leaving about 10 million tons of as unutilized and, hence, wastes material. Coir fibres are agricultural waste products obtained in the processing of coconut oil and are available in large quantities in the tropical regions of the world, most especially in Asia, Africa and America. Coir fibres are not commonly used in the construction industries but are often dumped as agricultural wastes. One of the suggestions in forefront has been sourcing development and use of alternative, non-conventional local construction materials including the possibility of using some agricultural waste and residual as a partial or full replacement of conventional construction materials. The main reasons for using natural fibres as reinforcement in concrete has been comprehensively investigated in many countries which can be used in production of building materials are mainly based on coconut, bamboo, cane, henequen and sisal fibres.

2. Objective of the Study

The aim of this study is not only to make the less cost of construction, but also to provide a good quality concrete by replacing cement with waste materials bagasse ash and coir fibre. The physical and mechanical properties of plain concrete are also compared with bagasse ash, coir fibre composed concrete. The main objective was to encourage the use of these waste products as construction materials.

3. Scope of Work

This paper analyzes the effect of SCBA in concrete by partial replacement of cement at the ratio of 0%, 5%, 10%, 15% and 20% by weight and 2% of coir
fibre was added additionally. The experimental study examines the compressive strength, split tensile strength of concrete. The main ingredients consist of Ordinary Portland cement, SCBA, Coir fibres, river sand, coarse aggregate and water. After mixing, concrete specimens were casted and subsequently all test specimens were cured in water at 7, 14 and 28 Days.

4. Materials and Methods

4.1. Cement

The most common cement is used is ordinary Portland cement. Out of the total production, ordinary Portland cement accounts for about 80-90 percent. Many tests were conducted to cement some of them are consistency tests, setting tests, etc.

4.2. Fine Aggregate

Locally available free of debris and nearly riverbed sand is used as fine aggregate. The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water. In the present study the sand conforms to zone II as per the Indian standards. The specific gravity of sand is 2.61. Those fractions from 4.75 mm to 150 micron are termed as fine aggregate, and the bulk density of fine aggregate (loose state) is 1552.91kg/m$^3$ and rodded state is 1642.85kg/m$^3$.

4.3. Coarse Aggregates

The crushed aggregates used were 20mm nominal maximum size and are tested as per Indian standards and results are within the permissible limit. The specific gravity of coarse aggregate is 2.69; the bulk density of coarse aggregate (loose state) is 1498.25kg/m$^3$ and rodded state is 1711.64kg / m$^3$.

4.4. Water

Water available in the college campus conforming to the requirements of water for concreting and curing as per IS: 456-2009.

4.5. Sugarcane Bagasse Ash (SCBA)

The sugarcane bagasse ash was tested for abrasion and value was obtained as 8.2% which should be lesser than 10% as per IS standards to utilize it as a replacement matter in cement. Sugarcane bagasse ash was collected during the cleaning operation of a boiler operating in the Ponni Sugar Factory, located in Perundurai, Erode, Tamilnadu.

4.6. Coir Fibres (CF)

Dry coir fibre is collected from a local farm house, Coimbatore. The coir fibre sample is soaked in a beaker with water for 24hours and then pH meter test is done. The result shows that the pH value is above 7. Hence it is not acidic and safe to utilize in concrete.

5. Experimental Procedure

In this experiment, total of 75 numbers of concrete specimens were casted. The specimens considered in this study consisted of 45 numbers of 150mm side cubes, 30 numbers of 150mm diameter and 300mm long cylinders. The mix design of concrete was done according to Indian Standard guidelines for M30 grade and the water cement ratio are 0.48. Based upon the quantities of ingredient of the mixes, the quantities of SCBA for 0, 5, 10, 15 and 20% replacement by weight and 2% of coir fibre was added additionally were estimated. The ingredients of concrete were thoroughly mixed manually till uniform consistency was achieved. Before casting, machine oil was smeared on the inner surfaces of the cast iron mould. Concrete was poured into the mould and compacted thoroughly using tamping rod. The top surface was finished by means of a trowel. The specimens were removed from the mould after 24hr and then cured under water for a period of 7, 14 and 28 days. The specimens were taken out from the curing tank just prior to the test. The tests for compressive, split tensile strength were conducted using a 2000KN compression testing machine. These tests were conducted as per the relevant Indian Standard specifications.

6. Experimental results

The strength results obtained from the experimental investigations are showed in tables. All the values are the average of the two trails in each case in the testing program of this study. The results are discussed as follows.

6.1 Workability

A high-quality concrete is one which has acceptable workability (around 6.5 cm slump height) in the fresh condition and develops sufficient strength. Basically, the bigger the measured height of slump, the better the workability will be, indicating that the concrete flows easily but at the same time is free from segregation. Maximum strength of concrete is related to the workability and can only be obtained if the concrete has adequate degree of workability because of self-compactability. The workability of CO and...
S series concrete are presented in Table 1. The table shows the influence of SCBA and CF content on the workability of mixtures at constant water to binder ratio of 0.48. The results show that unlike the CO series, all investigated SCBA and CF mixtures had high slump values and acceptable workability.

### Table 1. Fresh concrete test

<table>
<thead>
<tr>
<th>Mix</th>
<th>% of SCBA</th>
<th>% of CF</th>
<th>Workability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Slump (mm)</td>
</tr>
<tr>
<td>CO</td>
<td>0</td>
<td>0</td>
<td>90</td>
</tr>
<tr>
<td>S1</td>
<td>5</td>
<td>2</td>
<td>187</td>
</tr>
<tr>
<td>S2</td>
<td>10</td>
<td>2</td>
<td>200</td>
</tr>
<tr>
<td>S3</td>
<td>15</td>
<td>2</td>
<td>220</td>
</tr>
<tr>
<td>S4</td>
<td>20</td>
<td>2</td>
<td>225</td>
</tr>
</tbody>
</table>

### Table 2. Result comparison of compressive strength for M30

<table>
<thead>
<tr>
<th>Mix</th>
<th>% of SCBA</th>
<th>% of CF</th>
<th>7th day (N/mm²)</th>
<th>14th day (N/mm²)</th>
<th>28th day (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>0</td>
<td>0</td>
<td>25.61</td>
<td>33.75</td>
<td>37.69</td>
</tr>
<tr>
<td>S1</td>
<td>5</td>
<td>2</td>
<td>24.69</td>
<td>33.82</td>
<td>38.22</td>
</tr>
<tr>
<td>S2</td>
<td>10</td>
<td>2</td>
<td>23.22</td>
<td>34.22</td>
<td>38.58</td>
</tr>
<tr>
<td>S3</td>
<td>15</td>
<td>2</td>
<td>22.64</td>
<td>33.33</td>
<td>37.25</td>
</tr>
<tr>
<td>S4</td>
<td>20</td>
<td>2</td>
<td>20.64</td>
<td>24.9</td>
<td>27.78</td>
</tr>
</tbody>
</table>

### Chart 3. Compressive strength on 7,14 and 28th day

### Chart 4. Split tensile strength on 7,14 and 28th day

### 6.2 Result analysis

The strength test results obtained for concrete cube and cylinder specimens with partial replacement of SCBA and Coir fibres are shown in Table 2, 3 and 4. From tables, it is clear that the addition of SCBA in different percentage with a constant 2% of coir fibers with replacement of cement increases its strength under compression and tension at 5-15%, then the strength was decreased.

Comparison of the results from the 7, 14 and 28 days samples shows that the compressive strength increases with replacement of SCBA up to 10% and CF 2% (S2), then it decreases. Also the replacement of cement with 15% SCBA and 2% CF (S3) is still...
similar to conventional concrete (CO). It was shown that the replacement of cement with SCBA more than 15% decreases the compressive strength to a value which is lesser compared to conventional concrete. This may be due to the fact that the quantity of SCBA (pozzolan) present in the mix is higher than the amount required to combine with the liberated lime during the process of hydration thus leading to excess silica leaching out and causing a deficiency in strength as it replaces part of the cementitious material but does not contribute to strength. Also, it may be due to the defects generated in dispersion of SCBA that causes weak zones. Coir fibres act as a bonding material in concrete which improves the tensile strength comparatively. On the other hand split tensile test had not obtained the expected strength. At 10% of SCBA and 2% CF replacements the tensile strength got reduced up to 3/4th of that of the conventional concrete. With 15% of SCBA and 2% of CF replacement tensile strength got increased which is nearing to conventional concrete’s strength.

7. Conclusion

The results show that the SCBA and Coir fibres in blended concrete had significantly higher compressive strength and split tensile strength compared to conventional concrete. It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 15% keeping 2% CF as constant in M30 concrete. Although, the optimal level of SCBA content was achieved with 10% replacement. Partial replacement of cement by SCBA and CF increases the workability of fresh concrete; therefore use of super plasticizer is not substantial. The density of concrete decreases with increase in SCBA content, low weight concrete produced in the society with waste materials (SCBA). Addition of coir fibres in concrete has reduced the brittle property of concrete. Even at maximum loads, Coir fibres hold the concrete with a good bondage.

8. References

1. Utilization of sugarcane bagasse ash in concrete (by Snehith & Kaushik) vol. 4, April 2011.
10. Study on the mechanical properties of concrete using scba and coir fibres (Deepa K Venu, Prof. M. Rajalingam) issue 4, April 2016.