Effect of High Performance Concrete in PCC Structure by Partial Replacement of Agricultural Waste

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Abstract

Background/Objectives: The experimental investigations are carried out to study the effect of agricultural waste in PCC structure by partial replacement of cement and aggregate with wastes. The agricultural and industrial wastes used are Bagasse Ash, Fly ash and Coconut shell. Here the Bagasse ash and coconut shell has been physically characterized, and partially replaced by weight of cement and aggregate in concrete. Methods/Statistical Analysis: This study has been aimed to evaluate the strength of the concrete by performing standard tests like compressive strength, split tensile strength and flexural strength at the age of 3, 7 and 28 days and physical properties test were also conducted and compared. The bagasse ash and coconut shell have been replaced partially with the concrete of about optimum of 25% respectively. Instead of cement, bagasse ash is utilized with varying proportions and the strength values are evaluated and tabulated. Similarly coconut has been utilized with the conventional concrete for the replacement of coarse aggregate. Findings: The strength parameters are evaluated with the specimen of bagasse ash and coconut shell. In this study, bagasse ash has been partially replaced with the cement to determine the physical and chemical properties of the concrete and then it is compared with the conventional concrete. Similarly coconut shell has been replaced partially with the coarse aggregate for evaluating the strength parameters. In past research, the bagasse ash replacement was given the results of about 90% with 15% of replacement of cement with bagasse ash. In this present study, obtained the optimum strength of about 80% with the replacement of bagasse ash as of about 25%. The utilization of more than 25% of bagasse ash in concrete, strength is gradually reduced with the target strength of conventional concrete. Applications/Improvements: Further research in this study is to use the chemical admixture to improve the bonding strength, then the strength might have been increased with that of conventional concrete. The major application of this concrete is to use as a constructional material for the non structural elements like kitchen slab, man hole cover and compound walls.

Keywords: Bagasse Ash, Coconut Shell, High Performance Concrete, PCC

1. Introduction

To reduce the environmental impact, pozzolanic materials will be used as a replacement material. The use of waste not only be economical, but it may also increase the income of our country and environmental pollution control. Recycling in concrete has advantages since it is widely used and has a long service life, which means that the waste is being removed from the waste stream for a long period. The study of coconut shell as a substitute for aggregates is another way of using the gifts a coconut tree provides. The main objective of this research is to test the coconut shell and bagasse ash whether it can be used as a substitute for the aggregates and cement in proper...
proportioning of the concretes. The moisture absorption of the shell is also noted, because it well stands absorption of water in the concrete. Therefore, the absorption of water in the concrete will not affect its strength since lesser voids can be formed\(^2\). A controlled volume of coconut shell and ash is tested with replacement in specimen by 100% of total aggregate mixed with coarse aggregate and cement and testing the specimen.

### 2. Materials used

#### 2.1 Cement

Ordinary Portland cement is used for this study. In general, the overall production of cement, the ordinary Portland cement accounts about 80-90 percentage. Several tests were conducted for the cement viz., consistency test, setting test, soundness test, Autoclave and Lechatlier, Fineness test. The properties of cement are presented in Table 1.

#### Table 1. Properties of cement

| Tests                  | Values          |
|------------------------|-----------------|
| Consistency Test       | 115             |
| Setting Time           | 10 Hours 30 Minutes |
| Specific Gravity       | 3.14            |
| Autoclave and Lechatlier | -0.01 and 1    |
| Fineness Test          | 2.44gms         |

#### 2.2 Fine Aggregate

Locally available materials are used as fine aggregate. In the present study the sand conforms to zone II as per the Indian standards. The specific gravity of sand is 2.68. Those fractions from 4.75 mm to 150 microns are termed as fine aggregate.

#### 2.3 Coarse Aggregates

The coarse aggregates used were 20 mm and 12.5 mm of nominal sizes and is tested as per Indian standards and results are within the permissible limit. The specific gravity of coarse aggregate is 2.66. The properties of the material test are conducted for coarse aggregate and fine aggregate test results are evaluated and reported in Table 2.

#### Table 2. Properties of material

| Materials          | Fine Aggregate | Coarse Aggregate | Coconut Shell |
|--------------------|----------------|------------------|---------------|
| Bulk Density       | 1.09           | 3.495            | 0.15          |
| Specific Gravity   | 2.61           | 2.66             | 2.33          |
| Water Absorption   | 0.603          | 0.184            | 0.804         |

#### 2.4 Coconut Shell

The coconut shells shown in Figure 1 were obtained from a local field near Pollachi were sun dried for some time before being crushed manually. The crushed shells were later transported to the laboratory where they were washed and allowed to dry under ambient temperature. The particle sizes of the coconut shell ranges from 5 to 20 mm and then the shells are tested as per Indian standards to check their physical properties. Sieve analysis have been carried out and the results are tabulated in Table 3.

#### Table 3. Sieve analysis and grading

| Sieve Size | Quantity Retained | Quantity percentage | Cumulative percentage | Passing percentage |
|------------|-------------------|---------------------|-----------------------|--------------------|
| 40mm       | 0                 | 0                   | 100                   |                    |
| 20mm       | 1.045             | 13.48               | 13.48                 | 86.52              |
| 12.5mm     | 6.14              | 79.23               | 92.71                 | 7.29               |
| 10mm       | 0.500             | 6.45                | 99.16                 | 0.84               |
| 4.75mm     | 0.058             | 0.75                | 99.91                 |                    |

Figure 1. Coconut shells.
2.5 Bagasse Ash
In spite of being a material of hard degradation and that presents few nutrients, the bagasse ash is used on the farms as a fertilizer in the sugarcane harvests. Bagasse ash shown in Figure 2 is collected from Sakthi sugar factory, sathyamangalam, Erode, Tamilnadu.

3. Results and Discussion
3.1 Mix Proportion of Replacement Material in Concrete
Materials used in the mix proportions are bagasse ash and coconut shell for the replacement of cement and coarse aggregate separately. From the past study we have found that the optimum replacement is 25%. The bagasse ash have been replaced with the cement in the mix proportions of target grade is M40. Similarly, coconut also replaces with the coarse aggregate for about 25% in the proportions. The mix proportion of replacement material in concrete in presented in Table 4.

3.2 Compressive Strength
Compressive strength of concrete mixes made with and without bagasse ash and coconut shell was determined at 3, 7 and 28 days with the concrete cube of size 150 x 150 x 150 mm. The test results are reported in Table 5. The gain of compressive strength by adding a different percentage of bagasse ash and coconut shell in concrete with respect to their compressive strength at the age of 3 and 7 days are determined and shown in Figure 3. The compressive strength of the concrete is gradually reduced with the varying percentage of replacement materials as bagasse ash and coconut shell. For the control specimen the strength is reached about 43.6% that is without the presence of any agricultural waste. Then, 25% of bagasse ash is added to the concrete, the compressive strength is attained upto 41.16% and it is reached the target strength of M40 grade of concrete.

Table 5. Compressive strength result

| Specimen         | 3 Days (Mpa) | 7 Days (Mpa) | 28 Days (Mpa) |
|------------------|--------------|--------------|---------------|
| Control Specimen | 12.36        | 20.27        | 43.6          |
| Bagasse Ash      | 11.022       | 18.31        | 41.16         |
| Coconut Shell    | 10.08        | 16.71        | 39.77         |

Figure 3. Compressive strength results.

3.3 Split Tensile Strength for Concrete
In this method the concrete is moulded into cylinder shape and are tested with a testing machine shown in Figure 4 for 3 days, 7 days and 28 days. Split tensile strength of concrete mixes made with and without bagasse ash and
coconut shell was determined at 3, 7 and 28 days with the concrete size of 600 x 300 mm. The test results are tabulated in Table 6. The gain of split tensile strength by adding a different percentage of bagasse ash and coconut shell in concrete with respect to their compressive strength at the age of 3, 7 and 28 days are determined. The split tensile strength of the concrete for the control specimen reaches the strength of about 49.46 Mpa then the cement alone is replaced with the bagasse ash about 25% it attains the split tensile strength of about 48.06 Mpa it almost crosses the target mean strength of the conventional concrete.

![Tested specimen.](image1)

| Specimen | 3rd Day | 7th Day | 28th Day |
|----------|---------|---------|----------|
| Blank    | 26.34   | 33.73   | 49.46    |
| SCBA     | 25.71   | 32.06   | 48.06    |
| Shell    | 23.78   | 30.62   | 47.24    |

3.4 Flexural Strength of Beams
In this method the concrete is moulded with the use of beam mould shown in Figure 5 and are tested with a testing machine for 3 days, 7 days and 28 days. Flexural strength of concrete mixes made with and without bagasse ash and coconut shell was determined at 3, 7 and 28 days with the concrete size of 750 x 150 mm. The flexural strength have been conducted and the strength for the varying proportions of concrete are evaluated and tabulated in Table 7. The gain of flexural strength by adding a different percentage of bagasse ash and coconut shell in concrete with respect to their conventional at the age of 3, 7 and 28 days are determined. Flexural strength of the concrete for the control specimen attains the strength of about 45.02 Mpa. The replacement coarse aggregate with coconut shell, the flexural strength of the concrete is gradually reducing and it reaches the 50% of the target mean strength.

![Tested specimen.](image2)

| Specimen | 3rd Day | 7th Day | 28th Day |
|----------|---------|---------|----------|
| Blank    | 29.09   | 35.57   | 45.02    |
| Ash      | 18      | 20.91   | 40.63    |
| Shell    | 14.12   | 20.18   | 31.24    |

3.5 Ultimate Breaking Time in Secs
The ultimate breaking time for bagasse ash and coconut shell added concrete are tested under continous intervals of time and the values are tabulated in Table 8 and Table 9. At the 28th day, the breaking time for the concrete with the replacement of 25% about 70 secs. The breaking time will be gradually increase for the bagasse ash replaced concrete. Similarly for the coconut shell the breaking time is increased due to the presence of agricultural waste. The ultimate breakig time is varying from 160-180 secs.

![Tested specimen.](image3)

| Ash added concrete | Ultimate breaking time in Secs |
|--------------------|--------------------------------|
| Cube               | 3rd day | 7th day | 28th day |
|                    | 50      | 60      | 70       |
| Cylinder           | 40      | 60      | 70       |
| Beam               | 125     | 195     | 175      |

In past research study, the bagasse ash replacement was given the results of about 90% with 15% of replacement of cement with bagasse ash. In this present study, obtained
the optimum strength of about 80% with the replacement of bagasse ash as of about 25%. The utilization of more than 25% of bagasse ash in concrete\textsuperscript{34}, strength is gradually reduced with the target strength of conventional concrete.

| 25% shell added concrete | Ultimate breaking time in Secs |
|--------------------------|-------------------------------|
|                          | 3\textsuperscript{rd} day | 7\textsuperscript{th} day | 28\textsuperscript{th} day |
| Cube                     | 50                        | 80                      | 70                        |
| Cylinder                 | 50                        | 70                      | 65                        |
| Beam                     | 112                       | 175                     | 165                       |

Further research in this study is to use the chemical admixture to improve the bonding strength, then the strength might have been increased with that of conventional concrete. The major application of this concrete is to use as a constructional material for the non-structural elements like kitchen slab, man hole cover and compound walls.

4. Conclusion

From the study it was found that the utilization of agricultural waste in the production of concrete is widely used. Based on the experimental investigation concerning strength tests like compressive strength test, flexural strength test and split tensile strength test and also the ultimate break-in time for the varying proportions of concrete with bagasse ash\textsuperscript{3} and coconut shell, the following observations are listed below:

- The workability of concrete decreased with the increase in bagasse ash content due to the increase in water demand.
- On replacing of bagasse ash in cement, the compressive strength of 3\textsuperscript{rd} and 7\textsuperscript{th} day strength falls up to 80% of the blank and 35% falls down to 47% of the original strength.
- Hence it is decided to study the replacement with respect to 25%, the pilot test is performed to avoid time delay and wastage of materials.
- As per the IS Code specification the compressive strength of 25% ash added cubes reaches 80% of the strength while comparing with original control cube.
- The 25% replacement of bagasse ash and coconut shell in concrete instead of cement and aggregate, will give the maximum gain in compressive strength and split tensile strength.
- The replacement of bagasse ash and coconut shell in concrete will give strength up to 80% of the original strength, if we add any admixtures in the concrete, the strength will reach up to the maximum level of the original strength.

5. References

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