ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

# *Experimental Studies on Concrete with Sugarcane Bagasse Ash as Partial replacement of River Sand*

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***Abstract*—River sand, one of the essential materials used in the production of concrete has become costly nowadays and its usage is limited in construction industry for sustainable construction. Nowadays many agricultural and industrial wastes are used as replacement of fine aggregate in concrete to meet out the demand of natural river sand and also helps to create a sustainable and pollution free environment. Sugar-cane bagasse is one such fibrous waste-product of the sugar cultivating industry.Sugar cane bagasse ash is the waste product of the combustion of bagasse. In this research work, Bagasse ash has been partially replaced from 0 to 50% by volume (in increments of 10%) of river sand in concrete. Fresh and hardened properties of concrete like workability, compressive strength, water absorption, modulus of elasticity and flexural strength was studied at different ages. Workability of concrete mixtures was reduced with increase in bagasse ash level. From the test results, it was concluded that the concrete containing 30% of Bagasse ash was achieved about 1.26 times higher compressive strength than the reference concrete and at 40% of Bagasse level, comparable compressive strength with that of reference concrete was attained. Modulus of elasticity of concrete was found to be decreased with increase in bagasse ash content. From this experimental study, it can be inferred that it is possible to manufacture concrete containing sugarcane bagasse ash with features similar to those of natural river sand aggregate concrete up to 40% partial replacement level.**

***Keywords*— Sugarcane Bagasse ash, Concrete, compressive strength, Modulus of elasticity.**

## *1. INTRODUCTION*

River sand is used in the construction industry mainly for concrete production. River sand is obtained by dredging from river beds. So it reduces the water level in river and led to environmental concerns. The demand of river sand also increases due to high requirement in construction industry. To meet out the demand of river sand many researchers are focusing onreplacement of either industrial or agricultural wastes such as rice husk ash, sugarcane bagasse ash, groundnut shell etc., in construction industry. These are used as partial replacement of fine aggregate which provide additional pozzolanic property in concrete. Using these wastes in concrete will develop the pollution free environment and also be economical in construction industry.

Sugarcane is one of the major crops grown in over 110 countries and its total production is over 1500 million tons.In India, sugarcane production is over 350 million tons/year that cause about 10 million tons of sugarcane bagasse as waste material.Sugarcane bagasse is fibrous waste product obtained after extracting sugar from sugarcane. The product of the combustion of bagasse is known as bagasse ash and it is used for energy in sugar factories.Sugarcane bagasse ash is disposed of in landfills and is nowbecoming an environmental burden [1].There are many studies have been carried out in the earlier period on useof bagasse ash to learn the pozzolanic activity by partly replacing with cement [2 – 5].

The present study was carried out to study the properties of concreteproduced with sugarcane bagasse ash as partial replacement of river sandfrom 0 to 50% by volume. It examines the workability properties of fresh concrete such as slump test and hardened properties such as compressive strength, water absorption at 7, 14, and 28 days. Flexural strength and modulus of elasticity were tested at 28 days.

## *2. MATERIALS USED*

### *A. Cement*

Ordinary Portland cement of OPC - 43 grade confirming to IS 8112-1989, is used in this project work. The physical properties of cement used in this work were tested in accordance with IS 4031-1988 and the test values are given in Table 1.

TABLE 1. PROPERTIES OF CEMENT

| SL.NO | PROPERTIES | RESULTS |
|---|---|---|
| 1. | Specific gravity | 3.15 |
| 2. | Standard consistency | 28% |
| 3. | Initial setting time | 160mins |

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Vol. 5, Special Issue 12, April 2018


| SL.NO | PROPERTIES | RESULTS |
|---|---|---|
| 4. | Final setting time | 280mins |

### B. *Fine Aggregates*

Locally available river sand passing through 4.75mm sieve was used as fine aggregate in this research work. The properties of fine aggregate are determined as per IS 2386-1963 and IS 383-1970 and are given in Table 2.

### C. *Sugarcane Bagasse ash*

Bagasse ash was collected from Sugar Mill near Mundiyampakkam, Tamilnadu. The material passing through 4.75mm is used as fine aggregate in this work. The physical properties of Bagasse ash are determined as per IS: 2386-1963 and given in Table2.

TABLE 2. PROPERTIES OF FINE AGGREGATES

| SL.NO | PROPERTIES | RIVER SAND | BAGASSE ASH |
|---|---|---|---|
| 1. | Specific gravity | 2.63 | 2.03 |
| 2. | Water absorption | 0.80% | 1.5% |
| 3. | Bulk density | 1543 kg/m$^3$ | 1520 kg/m$^3$ |
| 4. | Fineness modulus | 2.4 | 1.89 |
| 5. | Grading Zone | II | III |

### D. *Coarse Aggregates*

Crushed granite stone passing through 20mm and retaining on 4.75mm has to be used for experimental work. The properties of coarse aggregate are determined as per IS 2386-1963 and are given in Table3.

TABLE 3. PROPERTIES OF COARSE AGGREGATES

| SL.NO | PROPERTIES | RESULTS |
|---|---|---|
| 1. | Specific gravity | 2.74 |
| 2. | Water absorption | 0.40% |
| 3. | Bulk density | 1424 kg/m$^3$ |
| 4. | Fineness modulus | 8.65 |

### E. *Super plasticizer*

In order to increase the workability of fresh concrete SP based on Naphthalene formaldehyde conforming to IS 9103 has been used for concrete mixture as water reducing agents.

## *3. MIX PROPORTION*

Mix proportioning of concrete mixtures were done using IS 10262-2009 for M20 grade of Concrete and mix proportions arrived were given in Table4.

## *4. EXPERIMENTAL WORK*

The experimental work were carried according to the relevant IS standards. The fresh concrete has been test for workability by performing slump test on it. Then the concrete was cast in moulds for further investigations like strength parameters and water absorption.For carrying out the strength investigations a total 108 number of concrete cubes (10cm x 10cm x 10cm), 12 no of cylindrical specimen (30cm x 15cm), 12 no of prisms (50cm x 10cm x 10cm) were cast.Based upon the quantities of ingredient of the mixes, quantities of sugarcane bagasse ash for 0, 10, 20, 30, 40 and 50 percent replacement by volume of sand were estimated. In order to maintain the workability, the super plasticizer has been added while increasing the percentage of Bagasse ash in concrete. The cast concrete specimens were cured under standard condition in the laboratory and compressive strength test, flexural strength test,water absorption test and modulus of elasticity were done in the hardened state of the concrete after 7 days, 14 days and 28 days.

## *5. RESULTS AND DISCUSSION*

### A. *Workability*

Workability was performed by doing slump test in fresh concrete.In this work, it has been targeted to maintain the workability in terms of slump in the range of 75 to 100mm. Slump value decreases from 100 to 60mm (Table 4) when amount of bagasse ash is increased from 0 to 50% by volume. To maintain the slump value, dose of SP has been increased from 0.5% to 1.15% by weight of cement. The increasing ofSP requirement may be due to the porous nature of the bagasse particles, which have a larger surface area and average size leading to enhanced absorption of water [6].

TABLE 4. WORKABILITY RESULTS FOR VARIOUS PROPORTIONS OF BAGASSE ASH

| Sl.No | % of Bagasse ash | Cement Kg/m$^3$ | Fine Aggregate kg/m$^3$ | | Coarse Aggregates kg/m$^3$ | S.P (% by Wt. of Cement) | Slump mm |
|---|---|---|---|---|---|---|---|
| | | | River sand | Bagasse ash | | | |
| 1. | 0 | 380 | 690 | 0 | 1200 | 0.5 | 100 |
| 2. | 10 | 380 | 621 | 66 | 1200 | 0.5 | 80 |
| 3. | 20 | 380 | 552 | 132 | 1200 | 0.75 | 70 |
| 4. | 30 | 380 | 483 | 199 | 1200 | 1.0 | 70 |
| 5. | 40 | 380 | 414 | 264 | 1200 | 1.15 | 60 |

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ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018


| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | 50 | 380 | 345 | 332 | 1200 | 1.25 | $D_{60}$ |

### B. *Compressive strength*

Compressive strength was tested at 7, 14 and 28days curing of specimen. In general, compressive strength of concrete was increased up to 30% of Bagasse ash level and decreased beyond that level.Maximum compressive strength was attained at 30% replacementof bagasse ashand wasabout 1.26 times higher than the control concreteat 28 days. Comparable compressive strength with that of reference concrete was achieved at 40 percent of Bagasse ash level.This may be due to the fact that the quantity of Bagasse ash present in the mix is higher than the amount required combining with the liberated lime during the process of hydration thus leading to excess silica leaching out and causing deficiency in strength [3]. The test values are shown in Fig 1.

### C. *Water absorption*

Water absorption test were carried out to determine the percentage of water absorbed by concrete. When bagasse ash is added to the concrete at various percentages water absorption was increasing as the percentage of bagasse ash is increased. At 50 percent of bagasse ash, water absorption was about 1.2 times higher than the normal concrete. Water absorption test results are shown in Table 5. While comparing Water absorption and Compressive strength, up to 30% of bagasse ash there is small increases in percentage of water absorption and after 30% of bagasse ash it becomes heavy increases but in compressive Strength up to 30% of Bagasse ash the strength is increased and after that the strength is decreased rapidly (Fig 2).

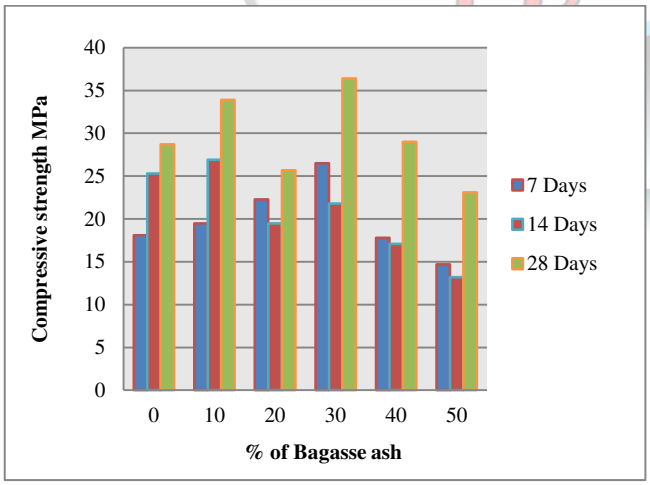


Figure 1. Comparison of compressive strength for different ages.

### D. *Flexural strength*

Flexural strength was determined as per IS: 516-1959. At 30 percent of bagasse ash flexural strength was about 2 times higher than the normal concrete and the strength has been reduced at 1.2 times than reference concrete at 50percent of bagasse ash.The test values are given in Table 6.

TABLE 5. WATER ABSORBTION TEST RESULTS FOR DIFFERENT AGES

| Sl.No | % of Bagasse ash | Water Absorption % | | |
|---|---|---|---|---|
| | | 7days | 14days | 28days |
| 1. | 0 | 2.9 | 3.1 | 3.7 |
| 2. | 10 | 2.8 | 2.9 | 3.8 |
| 3. | 20 | 2.6 | 2.8 | 3.0 |
| 4. | 30 | 3.2 | 3.6 | 3.8 |
| 5. | 40 | 2.7 | 3.1 | 3.9 |
| 6 | 50 | 3.0 | 3.5 | 4.2 |

### E. *Modulus of elasticity*

Modulus of elasticity has determined as per ASTM: C 469 – 02. The values are listed in Table 6. While increasing the percentage of bagasse ash the modulus of elasticity value decreases but at the optimum percentage the value is more comparing with the control specimen.

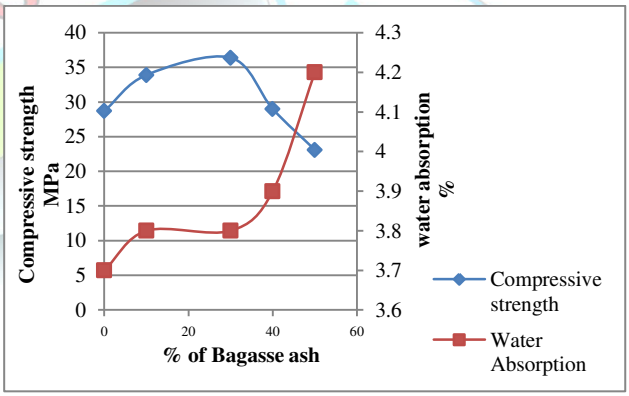


Figure 2. Comparison of water absorption and compressive strength for 28 days..

TABLE 6. MODULUS OF ELASTICITY AND FLEXURAL STRENGTH TEST FOR 28 DAYS

| Sl.No | % of Bagasse ash | Modulus of Elasticity GPa | Flexural Strength MPa |
|---|---|---|---|
| 1. | 0 | 27.61 | 2.16 |

| | | | |
|---|---|---|---|
| 2. | 10 | 24.37 | 4.19 |
| 3. | 20 | 22.14 | 3.96 |
| 4. | 30 | 38.70 | 4.36 |
| 5. | 40 | 24.27 | 3.57 |
| 6 | 50 | 23.17 | 3.51 |

### *6. CONCULSION*

From this experimental work, it made conclusion that,

- River sand can be replaced partially by the Bagasse ashup to 30% byvolume without considerable loss of strength properties.
- Percentage of water absorption increases with increase in percentage of bagasse ash whichindicate more permeable concrete that is due to porous nature of Bagasse ash and the impurities in it.
- Modulus of elasticity for control concrete is 27.61 GPa which is 1.40 times lesser than concrete containing 30 percentage of bagasse ash and it is reduced to 23.17 GPa at the 50 percentage of bagasse ash.
- From this experimental study, it can be inferred that it is possible to manufacture concrete containing sugarcane bagasse ash with features similar to those of natural river sand up to 40% partial replacement level.

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ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
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International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

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