



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 5, May 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

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Experimental Investigation for Mechanical Properties of High Strength Concrete with Raw Bagasse ash as Partial Replacement to Cement

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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. Sugar-cane bagasse is a fibrous waste-product of the sugar refining industry, along with ethanol vapor. 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 chemically and physically characterized, and partially replaced in the ratio of 5% and 10% by weight of cement in concrete. Hardened concrete tests like compressive strength at the age of 3, 7, 15 and 28 days, and split tensile strength and flexural strength at the age 3 days was obtained. The test result indicate that the strength of concrete increase up to 10 % SCBA replacement with cement.

KEYWORDS: bagasse ash, Flexural Strength ,compressive Strength, percentage.

I. INTRODUCTION

Cement- based materials are the most abundant of all man-made materials and are among the most important constructional materials and it is most likely that they will continue to have the same importance in the future; however these construction and engineering materials must meet new and higher demands. When facing issues of productivity, economy, quality and environment, they have to compete with other construction materials such as plastic, steel, wood. One direction in this evolution is towards high strength concretes (HSC). The use of HSC offers more industrialized production. This balance is made possible by the dispersing effect of high range water reducing admixture (super plasticizer) combined with cohesiveness. Usually high strength concretes have compressive strengths in the range of 60-100 N/mm². However, lower grades can also be obtained and used depending on the requirement. The main objectives of using Bagasse ash in high strength concrete are to reduce heat generation and to obtain better durability properties. It is known that Bagasse ashes generally have negative effects on the concrete strength, particularly at early ages. Using large quantities of this material in concrete seem to be in contradiction to the original aims of preparing high strength concrete. However, as observed by many researchers, Bagasse ash concrete may have better strength performance when they are prepared at lower w/b ratios. With the recent advancement in concrete technology and the availability of various types of mineral and chemical admixtures, and special super plasticizer, concrete with a compressive strength of up to 100 MPa can now be produced commercially with an acceptable level of variability using ordinary aggregates. These developments have led to increased applications of high-strength concrete (HSC) all around the globe. Concretes that were considered to be high strength 50 years ago are now regarded as low strength. For instance, concrete produced with compressive strength of 30 MPa was regarded as high strength in the 1950's. Gradually, concretes with compressive strength of 40-50 MPa in the 1960's, 60 MPa in the 1970's, and 100 MPa and beyond in the 1980's have evolved and used in practical structures. In spite of the rapid development in concrete technology in recent years, concrete with compressive strength higher than 40-60 MPa is still regarded as HSC. In the North American practice (ACI 318, 1999), high strength concretes are those that attain cylinder compressive strength of at least 41 MPa at 28 days. In the FIP/CEB (1990) state-of-the-art report on high strength concrete, it is defined as concrete having a 28-day cylinder compressive strength of 60 MPa.

. II. LITERATURE REVIEW

The use of bagasse ash in concrete enhances the performance of concrete to a greater extent. And the incorporation of more fly ash helps in conserving and economizing cement and in reduction of disposal problem with good compressive strength, flexure strength.

III. METHODOLOGY

3.1 Outline of Experimental Program

The aim of the study is to check the feasibility of concrete with alternate materials available locally for general purpose, so it was decided to go with 1:1.66:2.5 Mix Proportion with 0.31 water cement ratio worked out from mix design.

3.2 Sources of Raw Material

Fine aggregate :-Locally available river sand is used as fine aggregate.

Coarse Aggregate :-The coarse aggregate was available at college site from RMC.

Binding Materials

- **Cement:** Pozzolana Portland cement (PPC) of brand, Ambuja Cement is used.
- **Bagasse ash:**The BA used in this present study was taken from Sugar factory which is located in Sant Tukaram Sugar Factory, Pune
- **Super plasticizer:** Glenium 149 by Fosroc chemicals (India) Pvt. Ltd is used
 - **Water :** Water used is potable water.

1. COLLECTION OF MATERIALS, 2. TESTING OF MATERIALS, 3. MIX DESIGN, 4. MIX PROPORTION, 5. MIXING PROCEDURE, 6. MOULDING, 7. DEMOULDING AFTER 24 HOURS, 8. CURING FOR 3 DAYS & 7 DAYS, 9. TESTING OF SPECIMEN, 10. RESULT ANALYSIS & CONCLUSION

Figure 1. Schematic representation of methodology

IV. TESTING OF MATERIALS

Concrete is the most versatile construction material, which basically consists of Binding Material, Fine aggregate, Coarse aggregate and Water with the option of admixtures to improve its performance.

4.1 Binding Material

4.1.1 Cement

Portland Pozzolana Cement (PPC)

Advantages

- In PPC, costly clinker is replaced by cheaper pozzolanic material, hence economical.
- Soluble Calcium hydroxide is converted into insoluble cementitious products resulting in improvement of permeability, ultimately durability of concrete.
- It generates reduced heat of hydration and that at a low rate.
- It improves fire resistance qualities of the concrete.
- It helps to reduce alkali aggregate reaction, where it is encountered.

Various characteristics of PPC used for this work are as below.

Sr. No.	Characteristics	Requirement as per IS:1489(part 1): 1991	Test Results
Chemical Requirements			
1.	Total loss on Ignition (%)	5.0 (Max.)	1.10
2.	Magnesia (% by mass)	6.0 (Max.)	1.29
3.	Sulphuric Anhydride (% by mass)	3.0 (Max.)	1.88
4.	Insoluble Material (% by mass) (where X is the declared % age of fly ash in the given PPC)	$X + \{4.0(100-X)/100\}$ (max)	22.37
Physical Requirement			
1.	Fineness Specific surface (m^2/kg)	300(Min.)	376.6
2.	Setting Time (minutes)		
	(a)Initial setting time	30(Min.)	185
	(b)Final setting time	600(Max.)	265

3.	Soundness		
	(a)Le-Chatelier method (mm)	10(Max.)	0.5
	(b)Auto-clave (%)	0.8(Max.)	0.03
4.	Drying Shrinkage (%)	0.15(Max.)	0.050
5.	Compressive Strength (MPa)		
	(a)72+-1h(3 days)	16(Min.)	35.8
	(b)168+-2h(7 days)	22(Min.)	46.3
	(c)672+-4h(28 days)	33(Min.)	62.4
6.	Total chloride content (%)	0.10(Max.)	0.015

The declared percentage of fly ash in the given PPC is 26.0% (declared).

4.1.2 Bagasse Ash

Basic composition of bagasse fibers (% by mass)

Cellulose	Hemicelluloses	Lignin	Ash	Waxes
45–55%	20–25%	18–24%	1–4%	<1%



Fig. 4.1.2: Bagasse ash

Chemical Composition of Bagasse Ash

Sr. No.	Chemical Constituents	Values	Units
1	Silica	62.43	%
2	Calcium oxide	11.8	%
3	Potassium oxide	3.53	%
4	Magnesium oxide	2.51	%
5	Sodium oxide	1.48	%
6	Aluminum as AL	4.28	%
7	Manganese oxide	0.02	%
8	Loss on Ignition	4.73	%

4.2 Aggregate

4.2.1 Fine Aggregate

4.2.1.1 Sand



Fig. 4.2.1.1: Sand

Table: Physical Properties of Sand

Sr.No.	Property	Average
1.	Specific Gravity	2.66
2.	Fineness Modulus	3.23
3.	Water Absorption	0.5%
4.	Surface Texture	Smooth
5.	Particle Shape	Granular
6.	Density	1723.37kg/m ³

4.2.2 Coarse aggregate



Fig. 4.2.2: Coarse Aggregate

Table: Physical Properties of Coarse Aggregate

Sr.No.	Property	Average
1.	Specific Gravity	2.83
2.	Fineness Modulus	7.17
3.	Water Absorption	0.60%
4.	Particle Shape	Angular
5.	Crushing value	17.40
6.	Impact value	12.50
7.	Density	1663.01kg/m ³

4.3 Water

As per IS : 456 water used for mixing and curing shall be clean and free from injurious amount of oils, acids, alkalis, salts, sugar, organic material or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete.

4.4 Admixture

1. Mineral admixtures: Silica fume, Ground granulated blast furnace slag, Rice husk ash, Fly ash

2. Chemical admixture: Accelerating admixture, Retarding admixture, Water-reducing admixture, Air entering admixture, Super-plasticizing admixture

4.4.1 Chemical Admixture

Plasticizer

- Increase Strength by reducing the water/cement ratio, maintaining same workability.
- Reduce permeability and improve durability by reducing water/cement ratio.

- Reduce heat of hydration and drying shrinkage by reducing cement content.

Table

Material	Cement	Bagasse Ash
Fineness(m ² /kg)	300-325	500-514
Specific Gravity	3.15	1.97

V. MIX DESIGN

Mix Design for M60 Concrete as per ACI method of concrete mix design

To produce high Strength concrete, the major work involves designing an appropriate mix proportion and evaluating the properties of the concrete thus obtained. There are many standard methods for mix design and mix proportioning methods. For this investigation the preliminary mix design was carried out by ACI method for M70 grade of high strength concrete with 100% natural coarse aggregates.

After the initial mix design the trial mixes are prepared and tested for the fresh properties of concrete. If the design mix may not satisfy all requirements of fresh properties of concrete. Trial mixes are revised by fine tuning the mix proportions till all requirements are met. After doing the repeated trials we arrived at the final mixes.



Figure 5. Making of trial batch

VI. TESTING OF SPECIMEN

6.1 Compressive Strength Test

a) **Preparation of specimen:-** The specimen consists of a cube of size 150 mm.

b) **Test Procedure:-**It is carried out oncompression testing machine as per IS:516-1959 code.

c) **Calculation of Strength**

$$\text{Compressive strength} = \frac{\text{Load}}{\text{Cross-sectional area}} = \frac{P}{150 \times 150} \text{ N/mm}^2$$



Fig. 6.1: Compression test on concrete

6.2 Split test or split tensile strength test

- a) **Preparation of specimen :-**The specimen consists of a cylindrical of dimension 150 mm&300 mm length.
- b) **Test procedure:-** The testing carried out on a compression-testing machine. Placed horizontal
- c) **Calculation of tensile strength**

$$\text{Tensile strength} = \frac{2P}{\pi LD}$$

Where, P = load at failure , L = length of cylinder ,D = diameter of cylinder



Fig. 5.3.2: Split tensile test on concrete

6.3 Flexural test

- a) **Preparation of specimen:-**The specimen consists a prism of dimension 100x 100 x 500mm.
- b) **Test procedure :-** Flexural test is to be carried out conforming IS: 516-1956.
- c) **Calculation of flexural strength**

$$\text{Tensile strength} = \frac{PL}{bd^2}$$

Where,

P = load at failure

L = length of specimen

d = depth of specimen b = width of specimen



Fig. 6.3.2: Flexural test on concrete

Test Result

Table6.3.2: Effect of Bagasse ash on Compressive Strength of concrete (N/mm²)

Mix Designation	3 days	7 days	15 days	28 days
BA 05	28.84	43.30	49.72	69.20
BA 10	25.71	38.67	44.32	61.69

No. of cubes cast for each mix are 3 for 3 days , 3 for 7 days , 3 for 15 days ,3 for 28 days.Total cubes cast were 24.

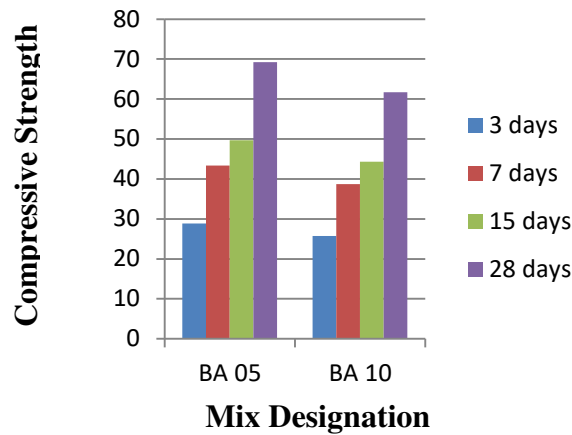


Table 6.3.3: Effect of bagasse ash on split tensile Strength of concrete (N/mm²)

Mix Designation	3 days
BA 05	3.56
BA 10	3.33

No. of cylinders cast for each mix are 3 for 3 days. Total cylinders cast were 6.

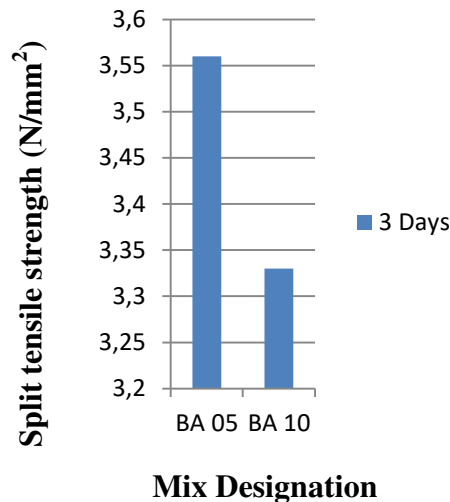


Table 6.3.4: Effect of bagasse ash on flexural strength of concrete (N/mm²)

Mix Designation	3 days
BA 05	7.53
BA 10	6.12

No. of beams cast for each mix are 3 for 3 days.

Total beams cast were 6.

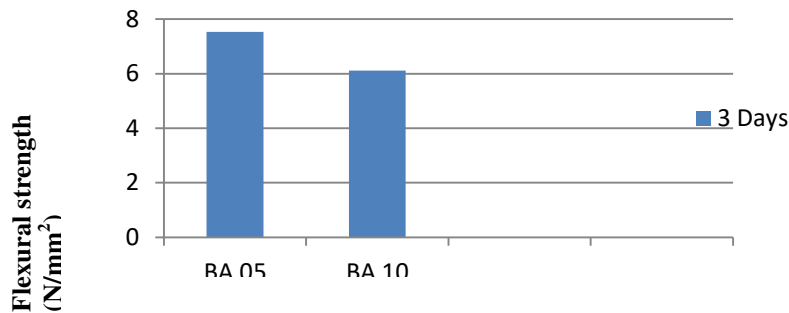


Fig.6.3.3: Variation in Flexural Strength of concrete

VII. CONCLUSION

From this experimental study it is clear indicated that using sugar cane bagasse ash in concrete increase strength.

Following parameters will be study in future work:

- To find out optimum amount of sugar cane bagasse ash that can be used in concrete for partially replacement of cement without significant loss of strength.
- To check the various properties of concrete with variation of content of sugar cane bagasse ash. By using plasticizers is helpful for obtaining higher workability without using excess of water. Test results indicate that the strength of concrete increase up to 10% Sugar Cane Bagasse Ash replacement with cement. Waste management and waste disposal reduces of sugar factory as ample amount of bagasse ash is generated after the use of bagasse as fuel at industry. It gives good compressive and flexural strength.

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