EXPERIMENTAL INVESTIGATION OF HSC WITH PARTIAL REPLACEMENT OF CEMENT WITH BAGASSE ASH

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ABSTRACT

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).

It in an urgent need to utilize agricultural and industrial waste to protect environment, health of people and to achieve economy to some extent. Sugarcane Bagasse ash is a fibrous waste product of sugarcane industry. Bagasse ash is mainly contains aluminium ion and silica. In this project work, raw bagasse ash is utilized as a replacement to cement by 5% and 10% with admixture to study some mechanical properties of HSC.

1.INTRODUCTION

Bagasse ash

Population scenario comes towards India by means of increasing industries. The fruitful efforts of industries lead to develop India. As the industries increases also the waste coming from them at the end of product increases. At the end of survey result coming that the amount of the approximately 250 to 300 million tons of industrial wastes are being produced every year by chemical and agricultural process in India. It is very essential to dispose these wastes safely without affecting health of human being, environment, fertile land, sources of water bodies; etc. Sugar cane bagasse, thefibrous residue after crushing and juice extraction of sugarcane, is a major industrial waste product from the sugar industry.

Nowadays, it is commonplace to reutilize sugar cane bagasse as a biomass fuel in boilers for vapor and power generation in sugar factories. Depending on the incinerating conditions, the resulting sugarcane bagasse ash (SCBA) may contain high levels of SiO_2 and Al_2O_3, enabling its use as a supplementary cementious material (SCM) in blended cement systems. Uses of Sugarcane bagasse ash waste in brick can save the sugarcane industry disposal costs and produce a ‘greener ‘bricks for construction.

Fig. 1: Raw Bagasse Ash

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Silica Fume

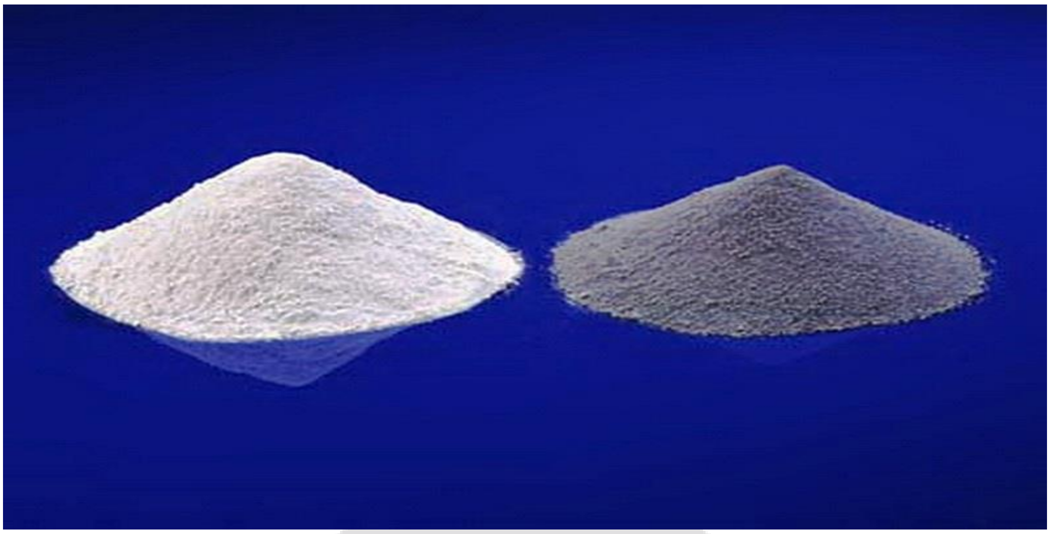

Fig. 2: Silica Fume

Silicon, ferrosilicon and other silicon alloys are produced by reducing quarts, with coal and iron or other ores, at very high temperatures (2000^0C) in electric arc furnaces. Some silicon gas or fume is produced in the process, which reaches the top of the furnaces with other combustion gases, where it becomes oxidized to silica in contact with air condenses as < 0.1µm to 1µm spherical particles of amorphous silica. This material is known as Silica Fume. It is also referred as micro silica or more properly, condensed silica fume. Silica fume is an ultra fine powder, with individual particle sizes 50 to 100 times finer than cement, comprising solid spherical glassy particles of amorphous silica. Condensed silica fume has a surface area of about 20000m^2/kg and a relative density generally in the range of 2.2 to 2.5.

2. MATERIALS AND ITS PROPERTIES

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.

2.1 Binding Material

2.1.1 Cement

Cement is a key ingredient of concrete manufactured by grinding the raw materials, mixing them intimately in certain proportions depending upon their purity and composition and burning at about 1300^0C to 1500^0C .At this temperature, the material sinters, and partially fuses to form nodular shaped clinker. The clinker is cooled and ground to fine powder with addition of about 3 to 5% of gypsum. The product formed by this procedure is cement, rather Portland cement. The cement primarily consists of silicates and aluminates of lime obtained from limestone and clay. There are various types of cement available, depending on its chemical composition, fineness and purpose. But in the present work it is decided to use Portland pozzolana cement (fly ash based) conforming to IS 1489 (Part 1).

Portland Pozzolana Cement (PPC)

PPC is manufactured by the intergrading of OPC clinker with 15 to 35% of pozzolanic material. Pozzolana is essentially a siliceous or aluminous material which while in itself possessing no cementitious properties, which will, in finely divided form and in presence of water react with calcium hydroxide, liberated in hydration process, at ordinary temperature, to form compound possessing cementitious properties. The pozzolanic materials generally used for manufacture of PPC are calcined clay or fly ash. Fly ash is a waste material generated in thermal power station when powdered coal is used as a fuel. The properties of this cement are same as those of Ordinary Portland Cement, except that it provides to the concrete higher resistance to chemical agencies and attack by sea water. Moreover, it has a low heat of hydration and low shrinkage on drying. It reduces the leaching of calcium hydroxide when used in hydraulic structures.

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

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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).

2.1.2 Bagasse Ash

For each 10 tonnes of sugarcane crushed, a sugar factory produces nearly 3 tonnes of wet bagasse. Since bagasse is a by-product of the cane sugar industry, the quantity of production in each country is in line with the quantity of sugarcane produced.

Table 1 :Basic composition of bagasse fibers (% by mass)

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

Bagasse is an extremely inhomogeneous material comprising around 30-40% of "pith" fibre, which is derived from the core of the plant and is mainly parenchyma material, and "bast", "rind", or "stem" fibre, which comprises the balance and is largely derived from sclerenchyma material. These properties make bagasse particularly problematic for paper manufacture and have been the subject of a large body of literature.

Fig. 3: Raw Bagasse ash

Table 2: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**	**%**

3.2.1. Sand

Sand is natural fine aggregate originating from bed rocks. There are three kinds or rocks, namely, igneous, sedimentary and metamorphic. Sand, due to river flow (weathering and alteration) possesses rounded shape and smooth texture. This helps in good workability of concrete.

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Fig.4: Sand **Fig. 5: Coarse Aggregate**

3.2.2 Coarse aggregate

The aggregate size bigger than 4.75mm, is considered as coarse aggregate. Coarse aggregate forms the main matrix of the concrete. Also in case of coarse aggregate maximum 20 mm aggregate size is suitable for concrete work. But where there is no restriction for 40 mm or large size may be permitted. In case of close reinforcement 10mm size also used. As per IS 456-2000, aggregates shall comply with the requirements of IS: 383.

Material	Cement	Bagasse Ash
Specific Gravity	3.15	1.97

4. EXPERIMENTAL PROGRAM

4.1 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 0.31water cement ratio worked out from mix design.

4.2 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 local quarry.

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 at 20kms.
- **Super plasticizer**

  Glenium 149 by Fosroc chemicals (India) Pvt. Ltd is used

  - **Water**

    Water used is potable water available at the college.

4.3 Test Methods

4.3.1 Compressive Strength Test

a) Preparation of specimen

The specimen consists of a cube of size 150 mm. The fresh concrete is poured into the moulds, which are greased or oiled. Concrete is placed into the mould, the concrete is compacted on vibrator. Care should be taken that the concrete should not segregate while placing and compacting.

b) Test Procedure

The testing is carried out on a compression testing machine as per IS:516-1959 code. The cubes should not be loaded on the face other than the face from where it is casted. The load is applied and the load at which the specimen fails is noted down.

c) Calculation of Strength

$$\text{Compressive strength} = \frac{\text{Load}}{\text{Cross}-\text{sectional area}}$$

$$\frac{P}{150 \times 150}\ \text{N/mm}^2$$

Where,

P = load at failure

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Fig. 6: Compression test on concrete

a) Preparation of specimen

The specimen consists of a cylindrical of dimension 150 mm&300 mm length. The fresh concrete is poured into the mould, which are greased or oiled before concrete is compacted with the help of vibrator. Care should be taken that the concrete should not segregate while placing and compacting.

b) Test procedure

The testing carried out on a compression-testing machine. Placing the cylindrical specimen horizontally between the loading plates of the comp testing machine and the load is applied in that position i.e. along the specimen fails. The load at failure is noted down.

In order to reduce the magnitude of the high compression stress near the points of application of the load, packing strips/ plates of suitable material are placed between the specimen and loading plates of the testing machine.

c) Calculation of split tensile strength

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

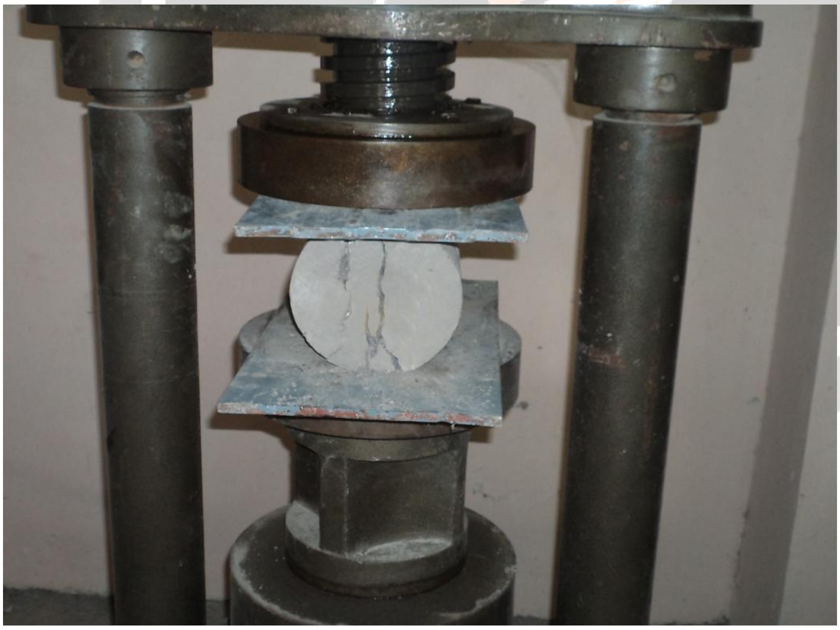

Fig. 7: Split tensile test on concrete

4.3.3 Flexural test

a) Preparation of specimen

The specimen consists of a prism of dimension 100 mm x 100 mm x 500mm. The fresh concrete is poured into the mould, which are greased or oiled before concrete is compacted with the help of vibrator. Care should be taken that the concrete should not segregate while placing and compacting.

b) Test procedure

Flexural test is to be carried out conforming IS: 516-1956. The dimension of each specimen has been noted before testing.

The bearing surfaces of supporting and loading rollers are wiped clean and any loose sand or other material was removed from the surface of specimen where there are to make contact with the roller. Specimen was placed on roller and two point loads

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were applied gradually without shock. The load was increased until the specimen failed and maximum load applied at failure was noted down.

c) Calculation of flexural strength

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

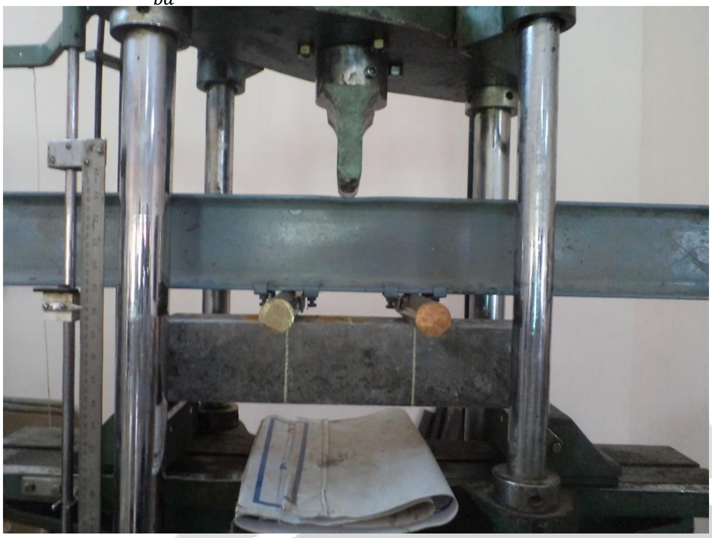

Fig. 8: Flexural test on concrete

5. STAGES OF EXPERIMENTAL PROGRAM

The Experimental Program was carried out in three stages:

Stage 1

Determination of physical properties of ingredients.

Stage 2

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

Stage 3

Experimental work conducted on concrete by replacing cement with bagasse ash with 0.3% super plasticizer.

5.1 Stage 1

Determination of physical properties of ingredients

Fine Aggregate

Table3: 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

Coarse Aggregate

Table4: 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

5.2 Stage 2

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 M60 grade of high strength concrete with 100%

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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 arrived at the final mixes.

Mix proportion then becomes

Cement	Fine Aggregate	Coarse aggregate
1	1.66	2.5

Mix proportion for M60 grade of concrete is 1:1.66:2.5

5.3 Stage 3

Experimental work conducted on concrete by replacing cement with bagasse ash with 0.5% super plasticizer.

Preparation of Specimens

Constant parameters

- Mix proportion of concrete selected - 1:1.66:2.5
- Type of cement: PPC
- Type of aggregate

i) Sand < 4.75mm

ii) Coarse Aggregates for flexural test < 20mm and for compressive test and split tensile test <25mm.

- Period of curing : 3, 7 , 15, 28,56 ,90 days
- Super plasticizer : 0.3 %
- Additive : 10%
- Water cement ratio : 0.31

Variable Parameters

- Cement replaced by bagasse ash from 0% to 10% at the increment of 5%.

Test

- For each test of concrete, three cubes of 150mm x 150mm x150mm size were cast and tested to determine compressive strength of concrete.
- For each test three cylinders of 150 mm dia. x 300 mm height size were cast and tested to determine split tensile strength.
- For each test three prism of dimension 500 mm x 100 mm x 100 mm size were cast and tested to determine flexural strength.

Table5 : Details of mix designations

Sr. No.	Mix Designation	Binding Materials		Fine Aggregate	Coarse Aggregate	Additive (Silica Fume)	Admixture (Super Plasticizer)
		Cement	BagasseAsh	Sand			
1.	BA05	95%	5%	100%	100%	10%	0.3%
2.	BA10	90%	10%	100%	100%	10%	0.3%

No. of cubes cast for each mix are 3 for 3 days , 3 for 7 days , 3 for 15 days ,3 for 28 days , 3 for 56 days , 3 for 90 days. Total cubes cast were 36.

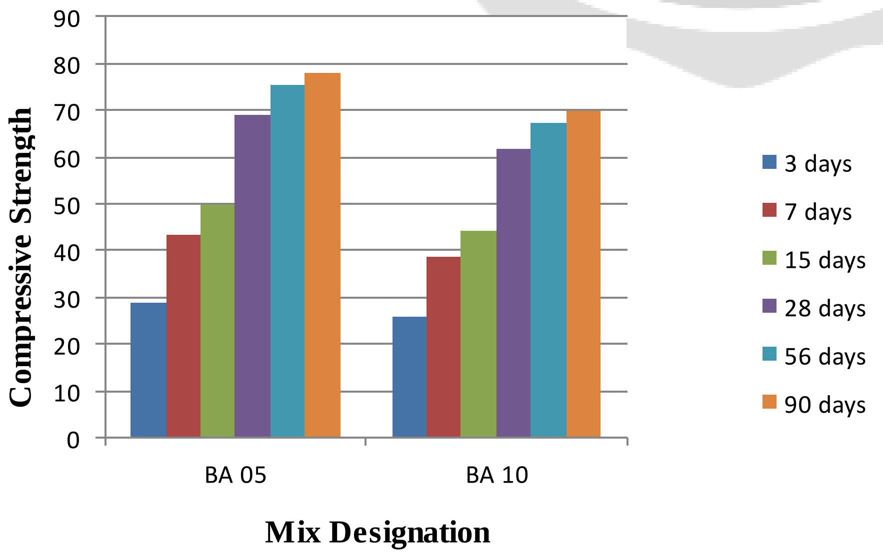

Fig.9: Variation in Compressive Strength of concrete

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Table 6 : Split tensile Strength of concrete (N/mm^2)

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.

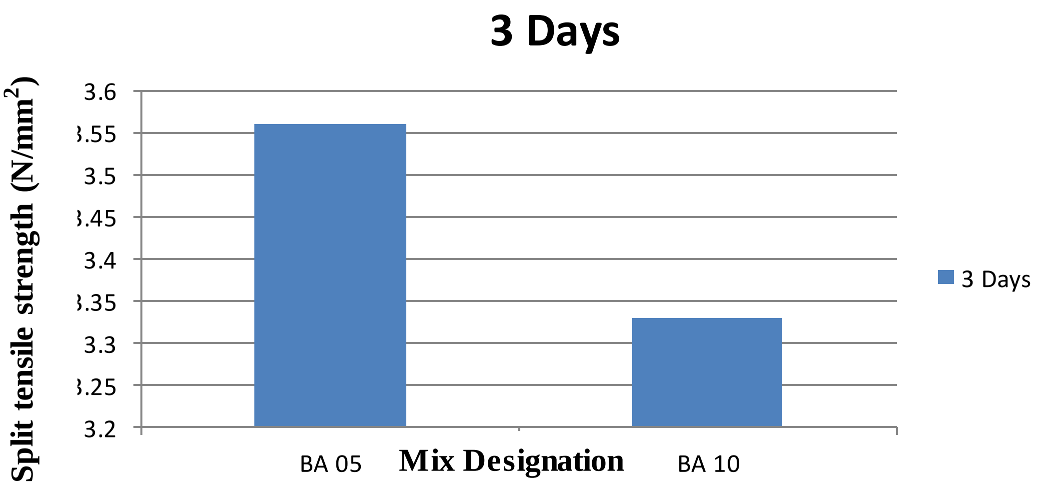

Fig.10: Variation in Split tensile Strength of concrete

Table7: Flexural strength of concrete (N/mm^2)

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.

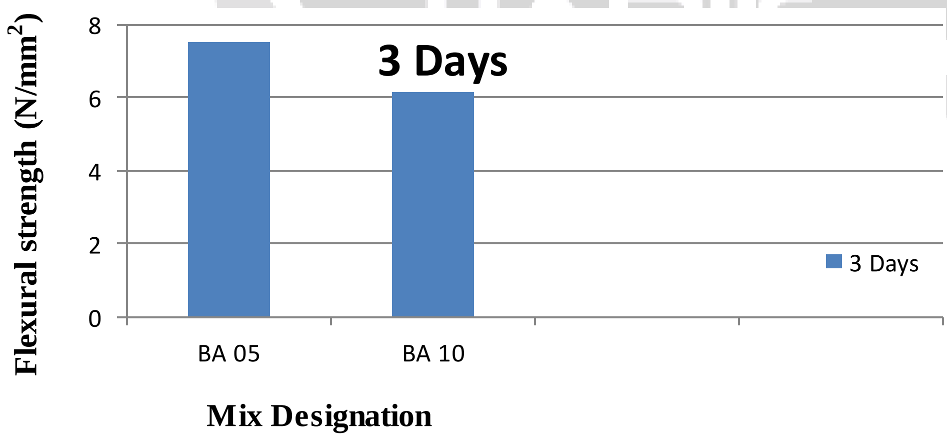

Fig.11: Variation in Flexural Strength of concrete

7. CONCLUSION

It is noted that mixes have given desired strength after 28days in both the mixes BA05 and BA10. After 90 days curing BA05 have given more than 70N/mm^2.So it can be concluded from the results that PPC cement may be replaced to the extent of percentage selected in this work.

8. FUTURE SCOPE

Following parameters may be studied in future:

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- 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 FINE bagasse ash.

REFERENCES

A Text Book Concrete Technology by M.S.Shetty