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Experimental Investigation on Properties of Binary and Ternary Blended High Strength Concrete using Silica Fume and Bagasse Ash

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***Abstract*— Bagasse ash is the ash obtained from fibrous matter that remains after sugarcane are crushed to extract their juice. In this thesis work Portland cement is partially replaced with silica fume and sugar cane bagasse ash in M_{40} grade cement concrete.. Initially, 5%, 10%, 15%, 20%, 25% of silica fume is blended with Portland cement and optimum % of silica fume is determined by conducting several fresh and hardened concrete tests. A 10 % of silica fume blended with cement gives optimum results at 28 days curing for binary blended concrete. The compressive strength obtained for optimum binary mix is 50.86 N/mm^2 while that of the control mix is 50.22 N/mm^2. Next ternary blended concrete mixes is prepared using OPC, 10% silica fume and 5%, 10%, 15%, 20%, 25% percentages of bagasse ash. Optimum percentage of bagasse ash is obtained as 10% and the compressive strength obtained is 52.23 N/mm^2.**

Keywords—Bagasse Ash, Silica Fume, Ternary blended concrete

1. INTRODUCTION

Portland cement is the conventional binding material in concrete that is responsible for about 5% – 8% of global CO2 emissions. Several researchers and even the Portland cement industry are investigating alternatives to produce green building materials since manufacturing of cement consumes a large amount of lime stone from nature. Now days, with increasing demand and consumption of cement, researchers and scientist are in search of sustainable alternative to ordinary Portland cement. Among the waste materials generated bagasse ash, which is a byproduct of sugarcane industries is abundant and possess a very good pozzolanic property pozzolanic property.

These materials can be more effectively used and reduce the cost in construction industry. A binary blended concrete is a concrete in which ordinary Portland cement is partially replaced by another supplementary cementitious material. A ternary blended concrete is obtained when ordinary Portland cement is partially replaced by two supplementary cementitious materials.

Bagasse is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice. Sugarcane Bagasse Ash (SCBA) was obtained by burning of sugarcane and the bagasse ash were then ground until the particles passing the 90 micron. When this bagasse is burned it gives ash having amorphous silica. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO2) Therefore it is possible to use SCBA as a mineral admixture with cement as replacement material to improve quality and reduce the cost of construction materials in concrete. Bagasse has to be burnt and grounded to required fineness to be used as a supplementary cementitious material.

Fig.1Bagasse

Fig.2 Bagasse Ash

Silica fume is produced in electric arc furnace as a by product of the production of elemental silicons or alloys containing silicon. It consists primarily of very fine smooth spherical silicon oxide particles with an extremely high surface area. Micro-silica particles are 100 times smaller than the average cement particle. Silica fume is usually categorized as a supplementary cementitious material. These materials exhibit pozzolanic properties, cementitious properties and a combination of both properties.

Fig.3 Silica Fume

This thesis investigates the effects of partial replacement of cement by silica fume in binary blended concrete and partial replacement of cement by bagasse ash and silica fume in ternary blended concrete are experimentally studied. Fresh and hardened properties of fresh and hardened concrete are studied and compared.

II. METHODOLOGY

A. Literature Review

B. Procurement Of Materials

Ordinary Portland Cement, Coarse Aggregate, Poabs M sand, Bagasse Ash(from Agricultural Research Station, Thiruvalla), Silica Fume(from Bison India Pvt. Ltd, Edappaly, Kochi.), Super Plasticizer(Master Glenium Sky 8233)

C. Determination of Material Properties

D. Mix Proportioning

- M40 grade of concrete was selected and the mix was designed as per IS10262:2009

E. Specimen Preparation

- Specimens were prepared for control mix of M40 grade concrete. Cubes of size 150mm × 150mm × 150mm , Cylinders of size 150mm × 300mm, beams of size 100mm × 100mm × 500mm were casted
- Specimens were prepared for binary blended concrete in which OPC is replaced with varying percentage of silica fume.
- Specimens were prepared for ternary blended concrete in which OPC is replaced with 10% of silica fume and varying percentages of bagasse ash

F. Testing

- On fresh concrete slump test and compaction factor test were done on both binary and ternary blended concrete
- Compressive strength test were done on binary blended concrete
- Compressive strength test, Flexure strength test and Split tensile strength test were done on ternary blended concrete.

III. MATERIAL INVESTIGATION

A. Cement

Ordinary Portland cement confirming to IS 12269 (53 Grade, Dalmia) was used for the experimental work. Laboratory tests were conducted on cement to determine specific gravity fineness, standard consistency, initial setting time, final setting time. The various properties of cement determined from the laboratory tests are shown in the table below

TABLE.1 PROPERTIES OF CEMENT

SL NO:	Property	Value Obtained
1	Standard Consistency	35%
2	Fineness	5%
3	Specific Gravity	3.125
4	Initial Setting Time	240 min

B. Fine Aggregate

Locally available good quality Poabs M sand was used as fine aggregate. The various properties of fine aggregate determined from the laboratory tests are shown in the table below

TABLE.2 PROPERTIES OF FINE AGGREGATE

SL NO:	Property	Value Obtained
1	Specific Gravity	2.688
2	Fineness Modulus	2.586
3	Water Absorption	1.5
4	Bulk Density	1.226
5	Grade	Zone II
6	Sand Type	Fine

C. Corse Aggregate

TABLE.3 PROPERTIES OF COARSE AGGREGATE

SL NO:	Property	Value Obtained
1	Specific Gravity	2.67
2	Fineness Modulus	7.314
3	Water Absorption	0.8
4	Bulk Density	1.324

D. Silica Fume

Silica Fume used has a specific gravity of 2.73.

E. Bagasse Ash

Bagasse Ash used has a specific gravity of 2.59.

F. Water

Clean drinking water was used for casting as well as curing of the test specimens

G. Super Plasticizer

The super plasticizer used was Master glenium sky 8233 of specific gravity 1.08.

IV. MIX DESIGN

A. Mix Proportion

Mix proportion was arrived through various trial mixes. The grade of concrete used for the experimental study was M40. The proportion used in the experimental investigation, obtained by conducting various trials is shown below:

TABLE.4 PROPORTION OF MATERIALS FOR 1 m^3 OF M40 GRADE CONCRETE

Sl No	Material	Quantity
1	Cement	415
2	Fine Aggregate	801
3	Coarse Aggregate	1096
4	Super Plasticizer	1.244
5	Water	178
6	Water Cement ratio	0.38

TABLE.5 MIX DESIGNATION FOR BINARY BLENDED CONCRETE

Mix Designation	% of Cement	% of SF
1	95	5
2	90	10
3	85	15
4	80	20
5	75	25

TABLE.6 MIX DESIGNATION FOR TERNARY BLENDED CONCRETE

Mix Designation	% of Cement	% of SF	% of BA
1	90	10	0
2	85	10	5
3	80	10	10
4	75	10	15
5	70	10	20
6	65	10	25

V. RESULTS AND DISCUSSIONS OF BINARY BLENDED CONCRETE

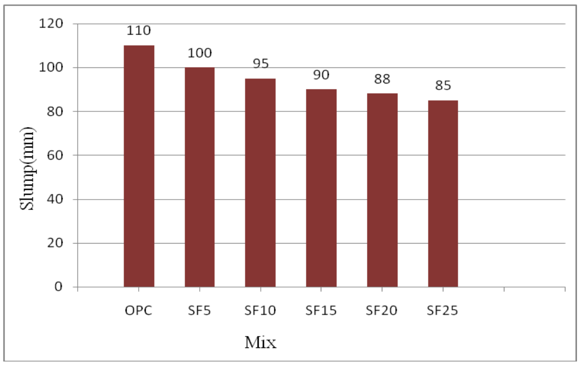

Fig.4 Slump in mm for Binary Blended Concrete Mixes

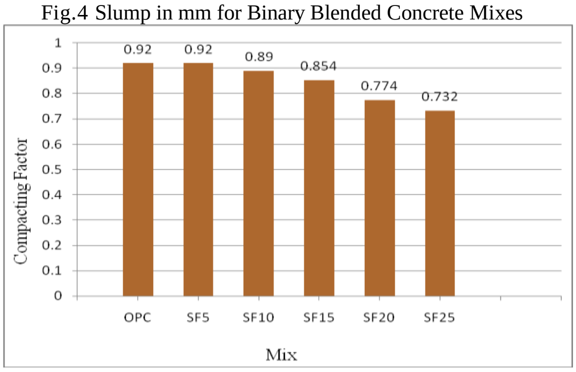

Fig.5 Compacting Factor for Binary Blended Concrete Mixes

The values of compacting factor vary from 0.92 to 0.732. Both compacting factor and slump showed same pattern of variation with SF25 mix having minimum workability and OPC mix having maximum workability. The water demand of concrete containing silica fume increases with increasing amounts of silica fume. This increase is caused primarily by the high surface area of the silica fume.

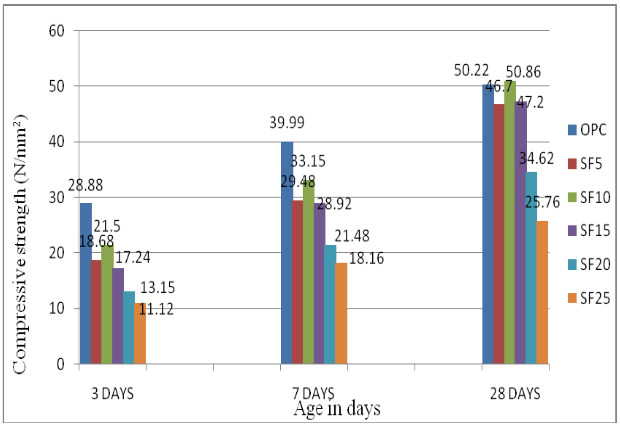

Fig. 6 Compressive Strength for Various Binary Blended Concrete at Different Ages

VI. RESULTS AND DISCUSSIONS OF TERNARY BLENDED CONCRETE

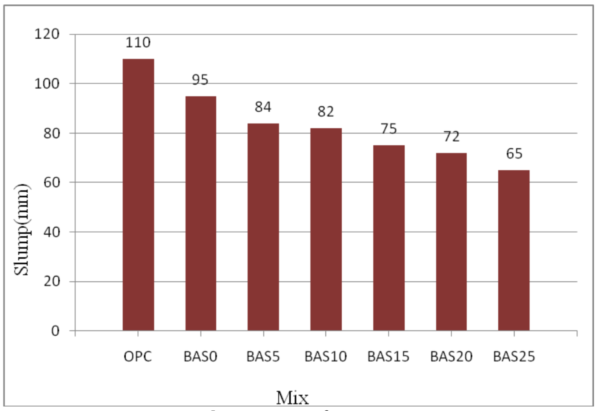

Fig.7 Slump in mm for TBC Mixes

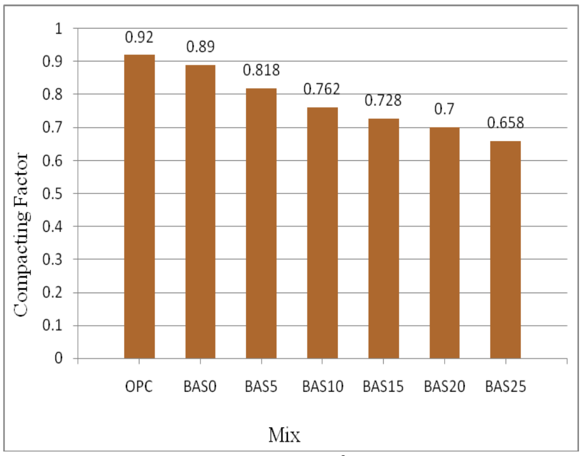

Fig.8 Compacting Factor for TBC Mixes

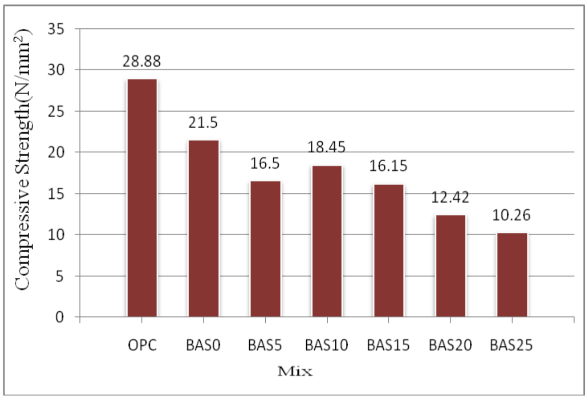

Fig. 9 Compressive Strength for TBC Mixes At 3 Days

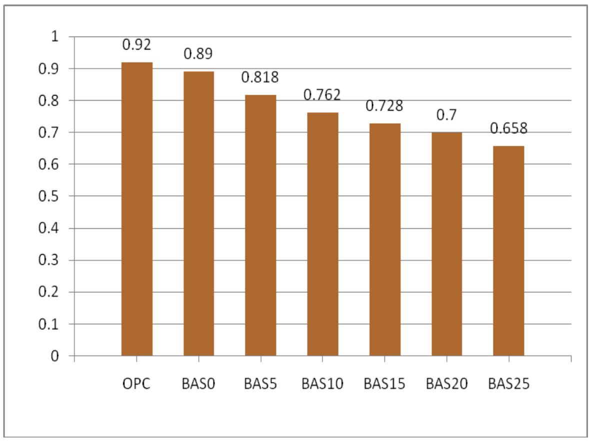

Fig. 10 Compressive Strength for TBC Mixes at 7 Days

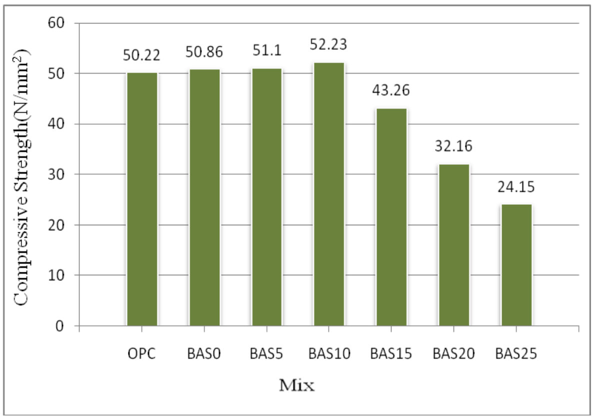

Fig. 11 Compressive Strength for TBC Mixes at 28 Days

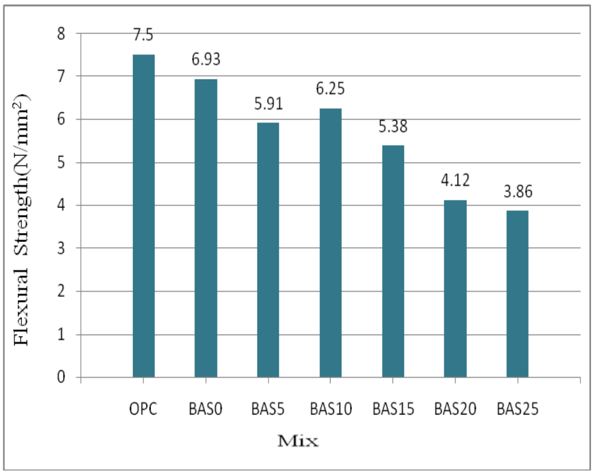

Fig. 12 Flexural Strength for TBC Mixes at 7 Days

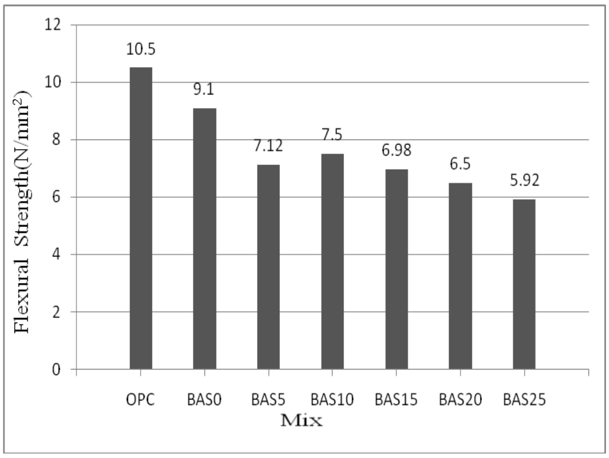

Fig.13 Flexural Strength for TBC Mixes at 28 Days

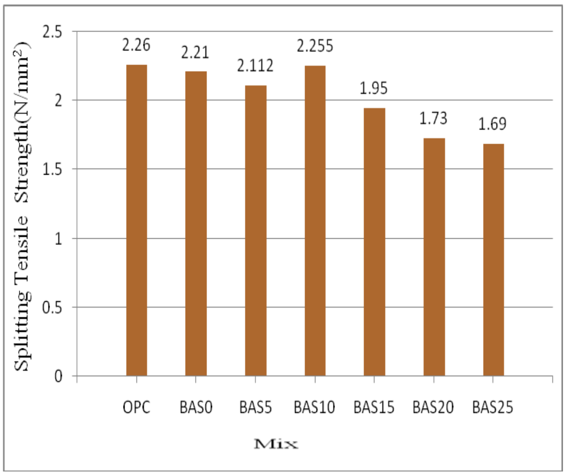

Fig. 14 Split Tensile Strength for TBC Mixes at 7 Days

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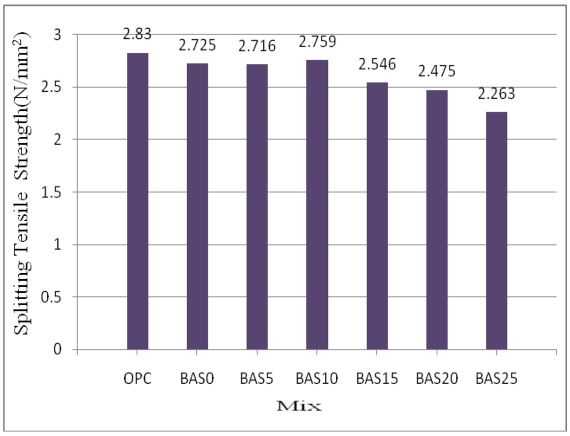

Fig. 15 Split Tensile Strength for TBC Mixes at 28 Days

VII. CONCLUSIONS

- The water demand of both binary and ternary blended concrete increases with increasing amounts SCM. This increase is caused primarily by the high surface area of the SCM.
- The addition of bagasse ash has decreased the workability of concrete. Workability of concrete is reducing at high replacement levels of bagasse ash.
- The compressive strength of binary blended concrete has reached the maximum at 10 % replacement of OPC with silica fume.
- The compressive strength of ternary blended concrete has reached greater values when cement is replaced with 10% SF and 10% bagasse ash. So the optimum value of bagasse ash replacement can be taken as 10%.
- The compressive strength increased by 7.29 % from control mix at 28 days.
- The flexure strength at 28 days is more than the target flexural strength.
- Splitting tensile strength at 28 days is similar to that of control mix. But more flexural strength can be expected at later ages as it is a pozzolanic material
- Bagasse ash is a by-product material, when used as a cement replacing material to an optimum dosage of 10% improves the properties of concrete, saves a great deal of waste disposal problems and also reduces the cement price hike and levels of CO_2 emission by the cement industry.

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