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Experimental Investigation of Sugarcane Bagasse Ash As Value Added Material on Strength of Masonry Prism

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***Abstract:*-- Sugarcane Bagasse Ash is generated as a combustion byproduct from the boilers of the sugar factories. The resulting Bagasse Ash contains higher amounts of Silicon dioxide and Aluminium Trioxide enabling its use as a supplementary cementitious material (SCM) in blended cement systems.The present work is an attempt to understand the behavior of compacted stabilized Lime Bagasse Ash mixtures for the manufacture of Bagasse ash bricks and also to determine the various strength of Masonry Prism. Masonry can be considered as a composite made of two materials. In order to understand the nature of stresses developed in the masonry a masonry prism of three brick height was built according to the codal provisions. Another relevant property of masonry is the bond strength (i.e. flexural and shear bond strengths) between brick and mortar which plays an important role in the masonry structures. Preliminary tests were performed on Cement, Sugarcane Bagasse Ash and M-Sand. In order to arrive at the optimum lime bagasse ash ratio cylindrical specimens of dimension 38mmx76mm were casted by adopting cement to sand ratio of 0.35:0.65. Masonry Prism was built by saturating the Bagasse ash bricks to 75% prior to casting of prisms with 0% and 20% replacement of cement by bagasse ash for 1:6 grade mortar. After 28 days of curing the prisms they were tested in UTM and the compressive strength, flexural strength and shear strength of prism was computed.**

Index Terms:- Bagasse Ash Bricks, Lime, Masonry Prism Compressive Strength, Flexural Stregth, Shear Strength

1. INTRODUCTION

Sugarcane is one of the major crops grown worldwide. The economical sugar from the sugarcane is extracted. About 40-45% fibrous residue is obtained after the extraction of the sugar. This fibrous residue known as sugarcane bagasse is re used in the same industry as fuel in the boilers for heat generation leaving behind 8 -10 % ash as waste, known as sugarcane bagasse ash(SCBA)[1].

Due to its high levels of $SiO_2$and Al_2O_3 it can be used as a supplementary cementitious material (SCM).. The present work deals with understanding the behavior of compacted stabilized lime bagasse ash mixtures for the manufacturing of Bagasse Ash Bricks.

Masonry Prisms

Masonry can be regarded as an assemblage of structural units which are bonded together in a particular pattern by mortar or grout.. Parameters which are most significantwhen considering structural masonry design relate to strength and elastic properties; e.g. compressive strength, flexuralstrength, shear strength, modulus elasticity etc.
The two material phases in masonry are joined by a weak interface and hence masonry is generally weak in tension. Masonry structures are therefore expected to resist only compressive forces. The conventional design practice emphasizes that masonry structures are subjected to compressive stresses alone and hence an accurate determination of compressive strength is extremely important**.**
Another relevant property of masonry is the bond strength (i.e. flexural and shear bond strengths) between brick and mortar which plays an important role in the masonry structures to resist lateral or eccentric load. In the masonry structure, in-plane forces which act parallel to the plane of the wall, are resisted by bond between brick and Mortar.

2. MATERIALS AND METHODS

2.1 Materials used

2.1.1 Cement: In the present work, Deccan Grade 53 Ordinary Portland Cement is used and the its physical properties are listed in TABLE 1
2.1.2 Fine Aggregates: Locally available M Sand is used as fine aggregate. In the present study the sand confirms to Zone II as per Indian standards. The specific gravity of sand is2.67 and the bulk density of the sand used is 1630 kg/m^3.TABLE 2 shows the test results of M-Sand.
2.1.3 Water: Water available in the college campus conforming to the requirements of water for casting and curing as per IS: 456-2009.

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2.1.4 Sugar cane bagasse ash: Sugarcane Bagasse as collected from the factory is dried for2-3 days so that there is no moisture content in it and sieving is done in order to reduce the particle size for using it as a cement replacement material. The sample passing through 150µm sieve is used throughout the work. TABLE 3 shows the physical properties of the sugarcane bagasse ash.

The entire work is divided into 4 phases

Phase 1: In the first phase All the Preliminary tests were carried out for Cement, M-sand, and Bagasse Ash.

Phase 2:.During the second phase Compacted stabilized cylindrical specimens of dimension 38mmx76mm are cast with lime and cement as stabilizers to arrive at the optimum lime bagasse ash or cement bagasse ash ratio which yields the maximum compressive strength by adopting the cement to sand ratio of 0.35:0.65.. Wet burlap and Steam curing techniques are adopted for Lime Bagasse Ash and Cement Bagasse Ash cylindrical specimens respectively.

Phase 3: In the third phase Lime-Bagasse Ash and Cement Bagasse Ash bricks were cast using lime bagasse ash and Cement Bagasse Ash ratio of 0.50 and Cement to sand ratio of 0.35:0.65 for both cases. Then the bricks were air dried for 4 days and then cured by Wet Burlap Curing for 28 days.

Phase 4: Masonry Prisms are built with MM3 and MM5 grade mortars with 0 % and 20% replacement of cement by bagasse ash. Prior to casting of Masonry Prisms the bricks were saturated to 75% and they were cast and cured for 28 days and then tested in UTM to determine Compressive , Flexural and Shear strength.

Table 1: Physical Properties of Cement

Sl.No	Particulars	Result	Allowable Values as per IS:4031-1988
1.	Specific Gravity	3.05	3.1-3.16
2.	Fineness	8%	<10%
3.	Standard Consistency	32%	32%-35%
4.	Initial Setting Time	55 minutes	30-60 Minutes
5.	Final Setting Time	4hour 10 minutes	600 minutes
6.	Soundness	8 mm	<10 mm

Table 2: Physical Properties of M-Sand.

Sl.No	Particulars	Result	Allowable values as per IS:383-1970
1.	Specific Gravity	2.67	2.65-2.80
2.	Fineness Modulus	2.24	2.0-4.0

Table 3: Physical Properties of Sugarcane Bagasse Ash

Sl.No	Particulars	Result
1.	Specific Gravity	1.97
2.	Fineness	5%
3.	Conductivity Value	0.79 mS/cm
4.	Loss on Ignition	10.84 %

3. TEST RESULTS OF BLENDED CEMENT

Table 4: Consistency Test results

Sl.No	% of Cement Replaced	Result	Allowable Values as per IS:4031-1988
1	5	35%	32% - 35%
2	10	41%	
3	15	44%	
4	20	45%	

Table 5: Test Results of IST

Sl.No	% of Cement Replaced	Result	Allowable Values as per IS:4031-1988
1	5	50min	30 min-60 min
2	10	1hr15min	
3	15	2hr10min	
4	20	3hr15min	

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Table 6: Test results of FST

Sl.No	% of Cement Replaced	Result	Allowable Values as per IS:4031-1988
1	5	6hr40min	600 minutes
2	10	7hr 20 min	
3	15	8 hr 35 min	
4	20	9hr 40 min	

4. COMPACTED STABILIZED LIME BAGASSE ASH SPECIMENS.

Bagasse ash is being utilized for the manufacture of lime stabilized bricks. The literature review indicates need for comprehensive studies on lime–bagasse ash compacts for exploiting such mixtures for the manufacture of bagasse ash bricks/blocks.

Lime–Bagasse ash mixtures are employed for the manufacture of bagasse ash bricks finding applications in load bearing masonry. Lime–pozzolana reactions take place at a slow pace under ambient temperature conditions and hence very long curing durations are required to achieve meaningful strength values.

4.1 Casting procedure

Bagasse ash was dried in the oven at 50ºC to constant weight. Bagasse ash, lime and requisite quantity of lime were mixed for 10 min. Ball milling was used mainly to ensure uniform mixing of the materials. Requisite quantity of water was added to the lime–Bagasse ash–sand mixture using a sprayer and thoroughly mixed manually. Known quantity (by weight) of the wetted mixture was fed into a metal mould and then compacted using UTM. The cylindrical specimen is then extruded by demoulding the split mould and kept in the open air for a day. After 24 h of casting the cylindrical specimens were cured either under wet burlap or steam cured in water-bath at 80º C under atmospheric pressure. After curing the cylindrical specimens were tested in Unconfined Compression Testing machine to determine the Compressive Strength.

Fig 4.1.1: Split mould 38mm dia x 76mm long

Fig 4.12: Casted Cylindrical Specimens

4.2 UCS TEST RESULTS

Table7: Strength of Lime Bagasse Ash Specimens With Steam Curing at 80ºC

Sl. No	Lime-Bagasse Ash Ratio	% of Lime	Average Compressive Strength	Average Water Absorption
1.	0.05	5%	0.49	27.51
2.	0.25	25%	2.31	25.94
3.	0.50	50%	2.49	20.96
4.	0.75	75%	1.45	22.20
5.	1.0	100%	0.56	20.67

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Table 8: Strength of Cement Bagasse Ash Specimens With Steam Curing at 80ºC

Sl. No	Cement -Bagasse Ash Ratio	% of Cement	Average Compressive Strength	Average Water Absorption
1.	0.05	5%	0.55	24.82
2.	0.25	25%	1.42	24.31
3.	0.50	50%	2.07	25.71
4.	0.75	75%	1.14	24.06
5.	1.0	100%	1.43	21.21

Table 9: Strength of Lime Bagasse Ash Specimens With Burlap Curing

Sl. No	Lime-Bagasse Ash Ratio	% of Lime	Average Compressive Strength	Average Water Absorption
1.	0.05	5%	0.52	24.82
2.	0.25	25%	2.20	24.31
3.	0.50	50%	2.57	16.48
4.	0.75	75%	1.42	24.06
5.	1.0	100%	0.53	21.21

Table 10: Strength of Cement Bagasse Ash Specimens with Burlap Curing

Sl. No	Cement Bagasse Ash Ratio	% of Cement	Average Compressive Strength (MPa)	Average Water Absorption (%)
1.	0.05	5%	0.58	23.4
2.	0.25	25%	1.56	22.5
3.	0.50	50%	2.20	18.62
4.	0.75	75%	1.24	22.68
5.	1.0	100%	1.52	21.24

4.3 BAGASSE ASH BRICK

Procedure for casting of bricks:

1. The required quantities of materials were weighed accurately using a weighing balance. Then the materials weighed were mixed in dry condition.
2. Then the measured quantity of water was added to dry mix stage by stage until required consistency is achieved.
3. Then the wet mix was prepared to fill it into the mould
4. Before filling it to the mould the wet mix was weighed and then filled in layers.
5. The wet mix was filled up to the complete height of the mould and then pressed manually to the full compaction.
6. Then the middle portion of the surface was broken using tamping rod and the remaining entire quantity was filled in the second time and compacted.
7. Then using the lever arm the brick is ejected out of the mould.
8. Then the brick is taken out of mould and kept for air curing for duration of 96 hours after the casting of bricks.

Fig 4.31 Bagasse Ash bricks

4.4 Compressive strength of Masonry Perpendicular to bed Joint

The numbers of specimens to be tested and average dimensions of the specimen are fixed as per the requirement. The figure below shows the set up of the masonry prism test loaded Perpendicular-to-bed joints and the prisms were tested in digital UTM and the results are noted.

4.5 Flexural strength of masonry prisms

Minimum of four brick prism of size (228.6*114.3*442.4mm) were built with bagasse ash bricks with mortar joint 12mm thickness with 1:6 grade mortar, 75% saturated SCBA bricks are used in the prism. The 1:6 grade mortar joint is replaced by bagasse ash at 0% and 20%. The span length of the prism should be greater than 2.5 * d. Once the prism is build it is cured for 28 days by burlap curing. After 28 days burlap curing the flexural strength of the prism is conducted using UTM machine.

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4.6 Shear Bond strength on masonry prism.

Shear bond strength plays very dominant role in masonry. Bond strength is a very important in mortar joints. During earthquake lateral load plays a very dominant role. As we know that bond between mortar and the bricks plays a very important role in resisting loads.

4.7 Masonry Prism Test Results

Table 11: Masonry Compressive Strength Perpendicular to bed joint

Mix ratio	% of BA Replaced	Average Compressive Strength (MPa) @ 28 days
1:4	0%	2.165
	20%	2.691
1:6	0%	1.882
	20%	1.06

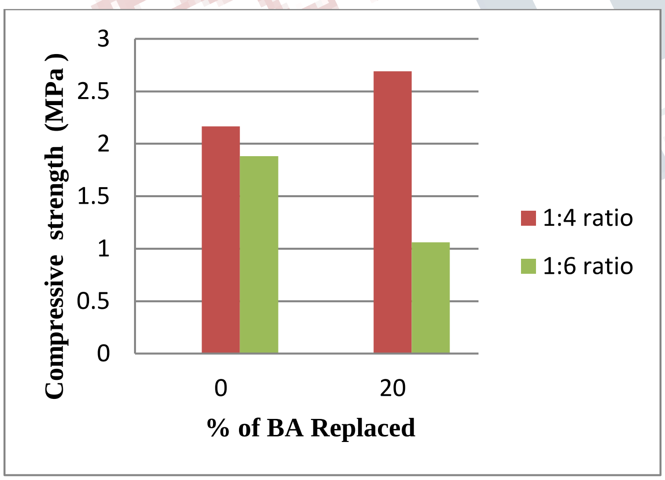
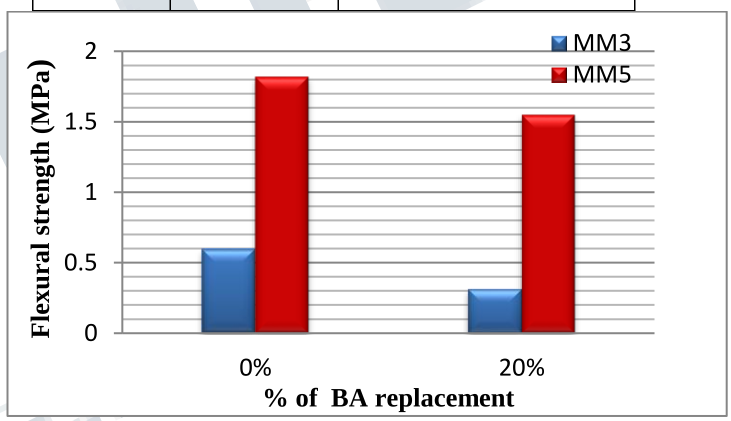


Fig 4.71: Compressive strength v/s % of BA Replaced

Table 12: Shear Strength results

Mix ratio	% of BA Replaced	Average Shear Strength (MPa)@ 28 days
1:4	0%	0.15
	20%	0.11
1:6	0%	0.19
	20%	0.3



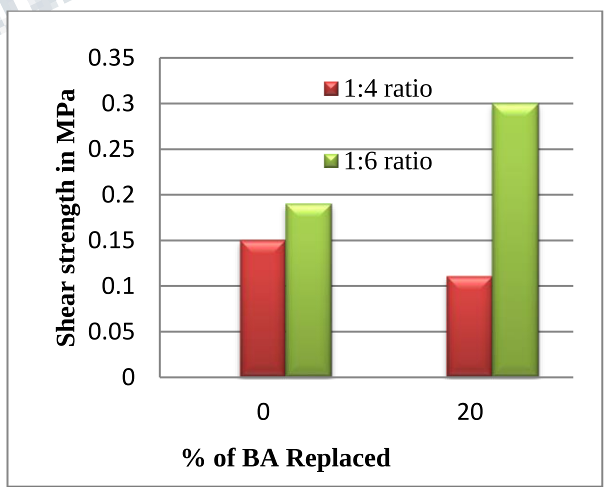


Fig 4.72: Shear strength v/s % of BA Replaced

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Table 13: Masonry Flexural Strength

Sl. No	Load applied	Mix ratio	% of BA Replaced	Average flexural strength (MPa) @ 28 days
1	Perpendicular to bed joint	1:4	0%	0.597
			20%	0.314
		1:6	0%	1.82
			20%	1.55
2	Parallel to bed joint	1:4	0%	0.725
			20%	0.532
		1:6	0%	1.01
			20%	0.922

Fig 4.73: Parallel to bed joint result (MM3 &MM5)

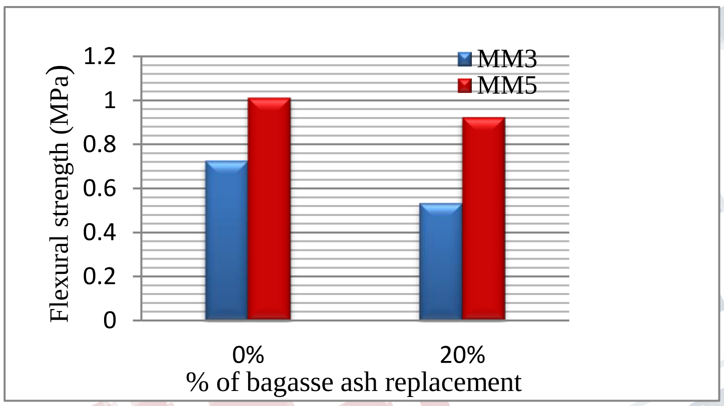

Fig 4.74: Perpendicular to bed joint result (MM3 &MM5)

5.0 CONCLUSIONS

1. All the values of the preliminary test results obtained are well within permissible limits prescribed by the codes.
2. It is observed that as the percentage of SCBA increases, workability of mortar also increases.
3. The Compressive strength values of cement replacement made at 0%, 5%, 10%, 15% and 20% by Bagasse Ash shows that the minimum compressive strength required for both MM3 grade mortar mix is achieved according to IS:2250-1981.
4. The compressive strength value of 50mm cube is greater than that of 70.6mm and150 mm cube. Hence it can be concluded that as the specimen size increases the compressive strength decreases.
5. Compressive Strength of Masonry Prism built with bagasse Ash Bricks with 1:6 grade mortar at 0% replacement of cement by Bagasse Ash is h igher than 20% replacement.
6. The flexural strength of masonry prism when load applied parallel and perpendicular to the bed joint in both cases prism build with 1:6 grade mortar with 0% bagasse ash has higher strength compared to 20% replacement .
7. Shear bond strength of masonry prism built with lime bagasse ash bricks with 1:6 grade mortar at 20% replacement of cement by bagasse ash is higher than 0%.
8. Compressive Strength of Masonry Prism built with bagasse Ash Bricks with 1:4 grade mortar The compressive strength at 20% BA replacement is higher than 0% replacement.
9. The prism built with 1:4 ratio mortar with 0% bagasse ash has higher strength compared to 20% replacement.
10. Shear bond strength of masonry prism built with lime bagasse ash bricks with 1:4 grade mortar at 0% replacement of cement by bagasse ash is higher than 20%.

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