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Enhancement of Mechanical Properties of Bagasse Ash Based Hollow Concrete Blocks using Silica Fumes as Admixtures

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Abstract
Concrete is the world's most consumed construction material because it combines good mechanical and durability properties. Place ability, work ability and it is relatively inexpensive. However cement production in values significant CO_2 emission which is known as the green house gas mostly important for the global warming. Cement which is one of the components of concrete plays a great role but is the most expensive and environmentally unfriendly material.

Each ton of the cement produce approximately one ton of CO_2 and the cement industry is responsible for about 5% of global anthropogenic CO_2 emission. As we know that the cement rise to CO_2 emissions generated by the calcinations of $CaCO_3$ and by the combustion of fossil fuels, being responsible for about 5% of the global CO_2 emissions. These emissions can be substantially reduced if 20% to 30% of bagasse ash is replaced in concrete industry. Thus that helps to maintain green effect in environmental conditions.

Considering these environmental effects, the utilization of Bagasse ash in hollow blocks is needed so as to minimize these complications.

Laboratory tests will be conducted for the samples at each percentage of cement replacement with an mineral admixture of silica fumes in the production of hollow concrete blocks for two different mixes such as 1:13 and 1:1:2.

The results indicate that up to 10% replacement of BASF in hollow concretes blocks can be considered as the optimum replacement level for load bearing structures for shorter length while 20% - 30% replacement level is useful for long term strength. The results holds good even for lean mix. Therefore it can be adopted for any mix proportion.

BA based hollow concrete blocks with 10% replacement of cement can be used for non-load bearing structures as per IS 2185.

Need for present study

ENVIRONMENTAL PROBLEMS IN DISPOSAL OF BAGGASE ASH :

The environmental problems in open dump or land filling of bagasse ash are:

- Soil and water contamination.
- Health problems to human beings and animals which survive near the open dump and creates infectious diseases.
- Affects the growth of vegetation.
- Uncontrolled burning and burning at very high temperature of 1500°C requires grinding for reuse in concrete which increases the energy cost

ENVIRONMENTAL PROBLEMS WITH CEMENT

The main problem with cement is its production in terms of the high amount of energy and carbon fuel that are used and the gases like carbon dioxide and nitrogen oxide that are released into the atmosphere and affect our air quality.

The cement industry accounts for 1.5% of nitrogen oxide emissions and create 71.6 million metric tons of carbon dioxide emissions. These issues could significantly influence the effects of global warming and people's health.

Carbon dioxide emissions :

With every ton of cement produced, almost a ton of CO2 is emitted. About 0.5 tons comes from the decomposition of the limestone and the balance is generated by the power plant supplying the electricity to turn the kiln and ball mills to grind the cement plus the fuel burned to fire the kiln.

Nitrous oxide emissions :

Ozone is formed when nitrogen oxides and volatile organic compounds mix in sunlight. Ozone near the ground can cause a number of health problems.

SOLUTION FOR THE ENVIRONMENTAL PROBLEM :

- The recycling of bagasse ash (waste product of sugar industries) as a cement replacement in hollow block with silica fume as admixture could provide a satisfactory solution to environmental concerns associated with waste management.

- The impact of bagasse ash content as a partial replacement of cement has been investigated on mechanical properties of hardened concrete, including compressive strength, water absorption and density for two different mix ratio 1:13 and 1:1:2

Table 1.8 - Compressive strength test results 1:13 Mix proportion with silica fumes

Sample No	% Replacemet of bagasse ash	Compressive strength at various curing ages (Mpa)			
		7 days	14 days	21 days	28 days
BASF0	0	5.28	6.36	7.38	8.02
BASF10	10	4.92	5.82	6.48	7.48
BASF20	20	4.36	5.16	5.67	6.75
BASF30	30	4.21	4.86	5.20	5.35

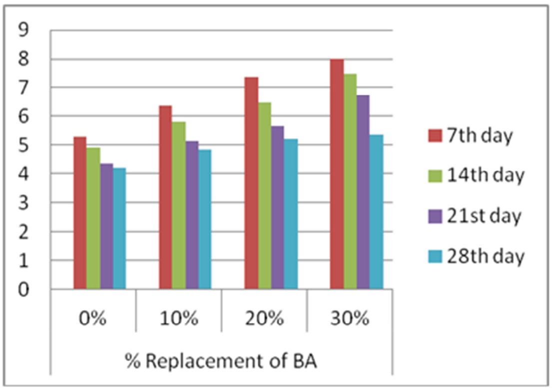

Table 1.9 - Compressive strength test results 1:13 mix proportion without silica fumes

Sample No	% Replacement of bagasse ash	Compressive strength days at various curing ages (Mpa)			
		7 days	14 days	21 days	28 days
BA0	0	2.3	2.9	3.06	3.2
BA10	10	1.5	2.1	2.4	2.8
BA20	20	0.7	1.8	2.1	2.5
BA30	30	0.6	1.6	1.73	1.8

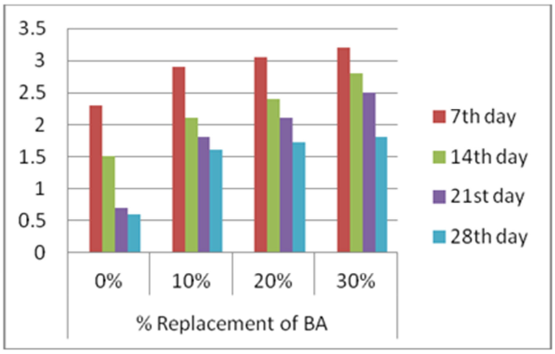

Table 1.10 - Compressive strength test results 1:1:2 mix proportion with silica fumes

Sample No	% Replacement of bagasse ash	Compressive strength days at various curing ages (Mpa)			
		7 days	14 days	21 days	28 days
BASF0	0	6.51	7.32	7.74	9.98
BASF10	10	6.18	6.91	7.30	9.40
BASF20	20	4.26	5.76	6.53	7.10
BASF30	30	4.17	5.63	6.01	6.80

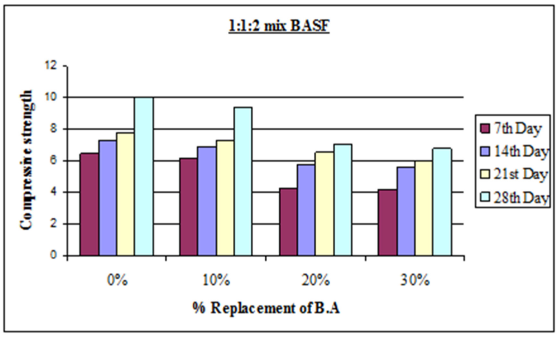

Table 1.11 -Result of the water absorption test at 28 days with silica fumes

Specimen	Water absorption (%)
1) 1:13	
0% B.A	2.03
10% B.A	1.74
20% B.A	2.30
30% B.A	2.39
2) 1:1:2	
0% B.A	2.44
10% B.A	2.16
20% B.A	2.72
30% B.A	2.24

Table 1.12 -Result of the water absorption test at 28 days without silica fumes

Specimen	Water absorption (%)
1) 1:13	
0% B.A	2.39
10% B.A	2.53
20% B.A	3.35
30% B.A	2.84

Table 1.13 - Result of the density test with silica fumes at 28 days

Specimen	Density in Kg/m^3
1) 1:13	
0% B.A	1706.32
10% B.A	1584.12
20% B.A	1519.05
30% B.A	1524.94
2) 1:1:2	
0% B.A	1683.70
10% B.A	1626.41
20% B.A	1586.27
30% B.A	1598.19

Table 1.14 - Result of the density test without silica fumes at 28 days

Specimen	Density in Kg/m^3
1) 1:13	
0% B.A	1674.76
10% B.A	1575.04
20% B.A	1498.56
30% B.A	1512.35

- The above test results it is seen that the compressive strength for 7, 14, 21 and 28th day for lean mix 1:13 BASF based hollow concrete blocks at all replacement level are higher than BA based hollow concrete blocks.
- From the above test results, it is observed that the strength of the BASF hollow concrete blocks for 1:13 mix with 10% replacement attains a maximum compressive strength of 7.48Mpa & for 1:1:2 mix BASF blocks attains maximum of 9.40 Mpa at 28th day compressive test compared to BA based hollow concrete blocks
- Thus the BASF based hollow concrete blocks falls under grade A as per IS 2185 for load bearing structures and BA hollow blocks comes under grade C for non-load bearing structures
- Water absorption percentage for BASF hollow blocks at 10% replacement attains 1.74% and BA hollow blocks attains 2.53%. Thus the BASF based hollow concrete blocks absorb less water than the BA based hollow concrete blocks. This indicates by addition of silica fume the strength increases substantially and a good reduction in water absorption is observed at all replacement level in the production of hollow concrete block.
- Thus in lean mix 1:13 for BASF blocks, 10% replacement is considered as the optimum replacement level for short term where as the 20%-30% replacement can be used for long term strength.

Estimation

Average quantity of sugarcane received in sugar industry per day	= 650tons
Bagasse ash generated for 650 tons of sugarcane	= 650 x 0.26 = 16.9tons
Quantity of hollow blocks produced in per ton of bagasse ash (10% of bagasse ash is used in single hollow block)	= 10,000 blocks

MACHINERY & EQUIPMENT

Sl No.	Description	Qty	Units	Rate per unit (Rs)	Amount (Rs)
1	Hydraulically operated concrete block making machine with quadruple (4) vibrators: hydraulic system – 5 HP Mould vibrators – 5 HP Ram vibrators – 3 HP (1.5 HP – 2 Nos.) Travel motor – 1 HP	1	No.	275000	275000
2	Concrete mixer: 10/7 cft with 5 HP motor, hydraulic hopper and road wheels	1	No.	100000	100000
3	Platform electronic weighing scale 500 kgs capacity	1	No.	75000	75000
4	Water dosing pump	1	No.	30000	30000
5	Electrical and EB charges for 25 HP power connection				70000
Total				550000	
6	Erection and commissioning charges @ 10%			55000	
7	Ram and mould for hollow blocks	4	Sets	15000	60000
8	Wheel borrows with pneumatic wheels	2	Nos.	10000	20000

TOTAL **6,85,000**

(3) PREOPERATIVE EXPENSES Rs 75000

(4) TOTAL FIXED CAPITAL Rs 10,00,000

WORKING CAPITAL (PER MONTH)

(1) SALARY & WAGES (PER MONTH)

Sl	Description	No.	Salary (Rs)	Amount (Rs)
1	Skilled or semi-skilled workers	2	5000	10000
2	Manager/Supervisor	1	10000	10000
Total			20000	
Perquisites @ 15%			3000	

TOTAL **23000**

(2) RAW MATERIALS (PER MONTH)

Sl	Description	Quantity	Units	Rate per unit (Rs)	Amount (Rs)
1	Cement	90	Bag	300	27000
2	Quarry dust	900	Cft	19	17100
3	Crushed stone chips	840	Cft	18	15120

TOTAL **59220**

(3) UTILITIES (PER MONTH)

Sl	Description	Quantity	Units	Rate per unit (Rs)	Amount (Rs)
1	Power	1500	kWh	5	7500
2	Water	250	KL	20	5000

TOTAL **12500**

(4) MISCELLANEOUS EXPENSES (PER MONTH)

Sl	Description	Amount (Rs)
1	Consumables	5000
2	Repairs and maintenance	5000
3	Sales expenses	6000

TOTAL **16000**

FINANCIAL ANALYSIS

(1) COST OF PRODUCTION (PER ANNUM)

Sl	Description	Amount (Rs)
1	Total recurring cost	94,720
2	Depreciation on machinery and equipment @ 10%	60,500
3	Depreciation on moulds, wheel borrows, etc. @20%	16,000
4	Amortisation of pre operative expenses @ 10%	7,500
5	Interest on capital investment @ 15%	82,500
	TOTAL	**2,61,220**

(3) NET PROFIT (PER YEAR) =Rs 4,58,780

Therefore by selling bagasse ash blended hollow concrete blocks, the net profit per year is Rs.4,58,780 .

(4) PROFIT RATIO ON SALES $= \frac{\text{Net profit per year}}{\text{Sales turnover per year}} \times 100$

$= \frac{4,58,780}{7,20,000} \times 100$

$= 63.7\%$

CONCLUSION

Based on the test results of the experimental investigation using SCBA with silica fume as admixture in hollow concrete blocks the following observation can be drawn:

- Burning the bagasse at high temperatures will produce ash with crystalline silica. This ash can be successfully replaced in the production of hollow concrete blocks with silica fume as admixture.
- The reuse of bagasse ash as a cement replacement in the production of hollow concrete blocks using silica fume as admixture could provide a satisfactory solution to environmental concerns associated with waste management.
- The compressive strength of BASF blended hollow concrete block increases substantially due to silica fume addition at all proportions.
- The water absorption of BASF blended hollow concrete blocks is reduced compared to BA blended hollow concrete blocks.
- The density holds good for BASF blended hollow concrete block.
  The results indicate that up to 10% replacement of BASF in hollow concretes blocks can be considered as the optimum replacement level for load bearing structures for shorter length while 20% - 30% replacement level is useful for long term strength. The results holds good even for lean mix. Therefore it can be adopted for any mix proportion.
- BA based hollow concrete blocks with 10% replacement of cement can be used for non-load bearing structures as per IS 2185.
- Further the utilization of waste ash in making cementitious binder will not only help in alleviating the disposal and health hazard problems it also reduces usage of cement that could reduce green house emissions. Thus it avoids air pollution in the environmental point of view
- It can be made economical for building construction.

Hence it can also be used in the building construction to acquire the green building certificate from government organization and thereby provide a real time solution for safe disposal of bagasse ash from sugar industries. The structural and non structural hollow concrete block masonry has innumerable applications and its scope is huge. Hence BASF finds potential utility in hollow blocks production. However it is further needed to develop such materials to balance economy, reduce pollution problems and achieve energy conservation.

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IS Codes

- IS 2185(Part- I, 1979-Reaffirmed 2003)- Specification for concrete masonry units.
- IS 383-1970-Specification for coarse and fine aggregate from natural sources for concrete.
- IS 269(1989)-Ordinary Portland Cement 33 grade Specification.