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Experimental study on replacement of sugarcane bagasse ash as fine aggregate in foam concrete

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Abstract
Today researchers all over the world are focusing on ways of utilizing either industrial or agricultural wastes as a source of raw materials for the construction industry. The sugarcane bagasse is locally utilized in sugar industries for power production that yields a huge amount of dumped waste sugarcane bagasse ash. This waste utilization would not only be economical but may also help to create a sustainable and pollution-free environment. As river sand resources are depleting worldwide due to uncontrolled extraction of sand for concrete production. Sugarcane bagasse is one such fibrous waste- product of the sugar refining industry, along with ethanol vapor. Bagasse ash mainly contains aluminium ions and silica. This study presents the laboratory work on lightweight foamed concrete made by partial replacement of fine aggregate with sugarcane bagasse ash by using the synthetic foaming agent. The untreated bagasse ash has been partially replaced in the ratio of 5%, 10%, and 15% by volume of fine aggregate in concrete. The study intends to ascertain the compressive strength of foam concrete with sugarcane bagasse ash in different percentages as above mentioned. Mix design of M30 is performed for foam concrete and the compressive strength was tested for 7 days, 14 days and 28 days for cube specimens and split tensile strength for cylinders. And the same is compared with varying the percentages of SCBA. The result shows that bagasse ash can be a suitable replacement for fine aggregate.

Keywords: sugarcane bagasse ash, foam concrete, sodium lauryl ether sulfate

Introduction

Foam Concrete

It is a type of porous concrete. Foam concrete is a lightweight composition of cement, water, foam agent and fine aggregates or sand with no coarse aggregate. The synonyms are aerated concrete and lightweight concrete. This action incorporates small enclosed air bubbles within the mortar thereby making the concrete lighter. One of the methods of reducing the density of concrete relies on the introduction of stable voids the voids within the hardened cement paste or mortar, the voids can be produced by gas or by air. Because a foaming agent introduces the air, the concrete produced is called foam concrete.
The bubbles vary in size from around 0.1 to 1.5 mm. Foamed concrete requires no compaction, and will flow readily from a pump outlet to fill restricted and irregular cavities it can be pumped successfully over significant heights and distances. The foam concrete is created by the uniform distribution of air bubbles throughout the mass of concrete. The foam cells must have walls, which remain stable during mixing, transportation, pumping, and placing of fresh concrete. The density of foam concrete is determined by the ratio of foam to slurry and densities range typically between 300 and 1900 kg/m^3.

Sugarcane Bagasse Ash

Sugarcane is one of the major crops grown in over 110 countries and its total production is over 1500 million tons. In India only, sugarcane production is over 300 million tons/year which causes about
10 million tons of sugarcane bagasse ash as an un-utilized and waste material. After the extraction of all economical sugar from sugarcane, about 40-45% fibrous residue is obtained, which is reused in the same industry as fuel in boilers for heat generation leaving behind 8 -10 % ash as waste, known as Sugarcane Bagasse Ash (SCBA). The SCBA contains high amounts of unburnt matter, silicon, aluminum, and calcium oxides. But the ashes obtained directly from the mill are not reactive because they are burnt under uncontrolled conditions and at very high temperatures. The ash, therefore, becomes an industrial waste and poses.

Objective

The main objective of this Project:

- To determine the mix proportion of the concrete mix based on the particle size which satisfies the requirement of the concrete in fresh condition and produces greater strength.
- Characterization of industrial waste materials: Sugarcane Bagasse Ash as fine aggregate.
- Comparison of Compressive strength with replacement of sugarcane bagasse ash in fine aggregate and normal foam concrete.

Methodology

Flow chart of Foam Concrete adopted for the study, Different materials involved in foam concrete is shown in Fig. 1 & 2.

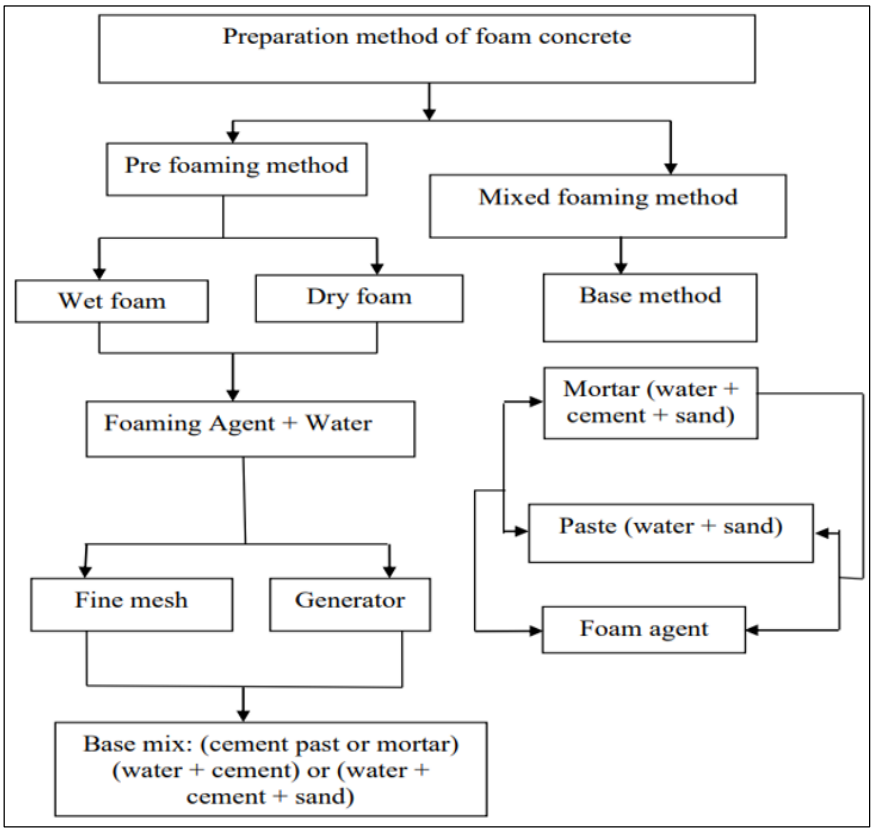

Fig 1: Flow chart of Foam Concrete preparation

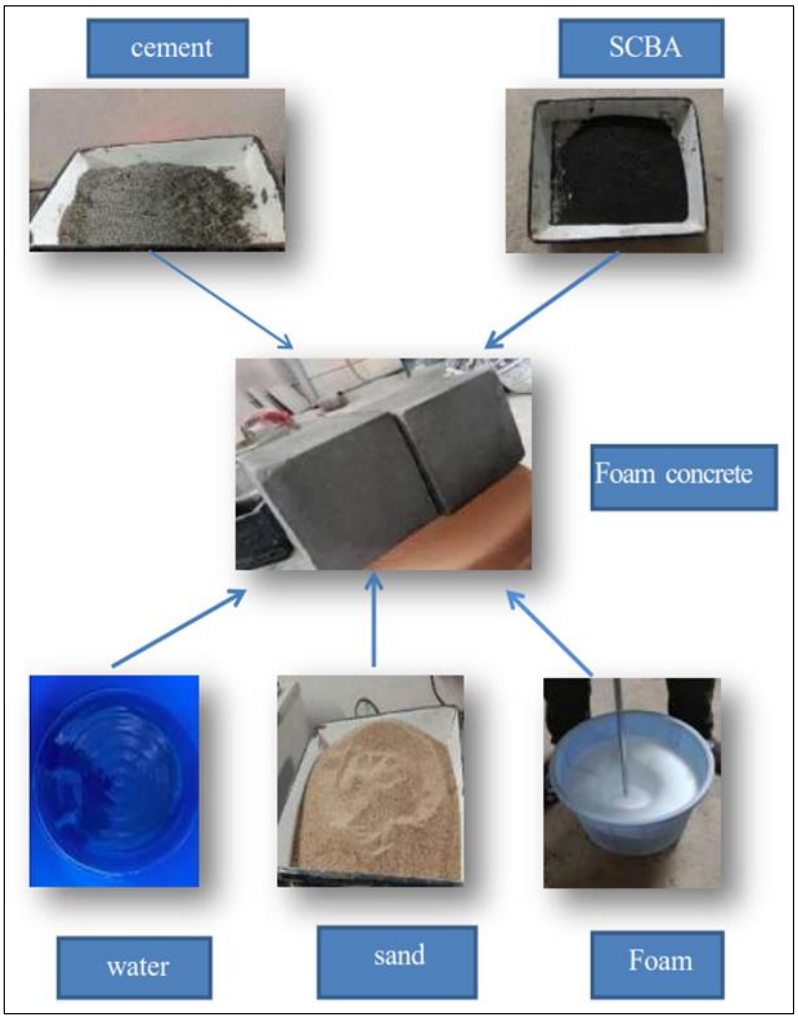

Fig 2: Different materials involved in foam concrete

Materials and methods

Cement

In this study Ordinary Portland cement, 53 grade of cement was used. Different tests were conducted on all materials cement, Fine aggregate, Sugarcane Bagasse Ash, Foaming agent, is given in table 1 to 4.

Table 1: Physical Properties of the OPC 53 grade cement

Sl. No	Physical Properties	OPC 53 grade cement	Fine aggregate	Bagasse ash
1	Fineness	97%	2.55	8%
2	Specific gravity	3.12	2.68	2.44
3	Standard consistency	32%	-	-
4	Initial setting time	38 minutes	-	-
5	Final setting time	480 minutes	-	-
6	Unit weight		-	0.89 gm/m^3

Sugarcane Bagasse Ash

In this project, we collected sugarcane bagasse and we burnt that, in order to obtain ash from that residue as shown in figure below and some tests are conducted on sugarcane bagasse ash and results are tabulated in table III.

Fig 3: Burning of sugarcane waste

Table 2: Physical Properties of Sugarcane Bagasse ash

Sl. No.	Properties	Values
1	Molecular formula	496.7g/mol
2	Chemical formula	**$CH_3(CH_2)_{11}(OCH_2CH_2)_nOSO_3Na$**.
3	Other names	lauryl ether sulfate sodium disodium 1-dodecoxydodecane sulfate
4	Chemical structure	

Foaming Agent

In this Particular study, we have taken sodium lauryl sulfate as foaming agent, Synthetic foaming agents are a substance that is strongly hydrophilic and easily dissolve in water give air bubbles. The following table shows the various properties of foaming agent.

Results and Discussions

In this study, cement content is calculated by assuming water/cement and sand/cement ratios. The main formula used to calculate amount of materials required is:

Target density = [cement content (C) + water content (W) + Fine aggregate (FA)]

To calculate volume of foam:

V (m^3 of concrete) = [V (Foam) + V (cement) + V (Sand) + V (water)]
$1m^3$ = V (Foam) + $W_c/(S_c \times D_w)$ + $W_w/(S_w \times D_w)$ + $W_s/(S_s \times D_w)$

Where,

W_c = weight of cement;
W_s = weight of sand;
W_w = weight of water
D_w = Density of water;
S_c = specific gravity of cement
S_s = specific gravity of sand
S_w = specific gravity of water.

Assuming a target plastic density of 1900 kg/m^3
Water – cement ratio w/c is 0.35 (assume)
Proportion = 1:2.5 (cement: fine aggregate) Foaming agent = 0.18% (cement weight)
Density = cement + water + fine aggregate = 500 + 170 + 1250 = 1920 kg/m^3

Table 3: Trial Mix Proportion

Water	Cement	Fine Aggregate	Foam
170	500kg	1250kg	0.9 liters
0.35	1	2.5	1.8

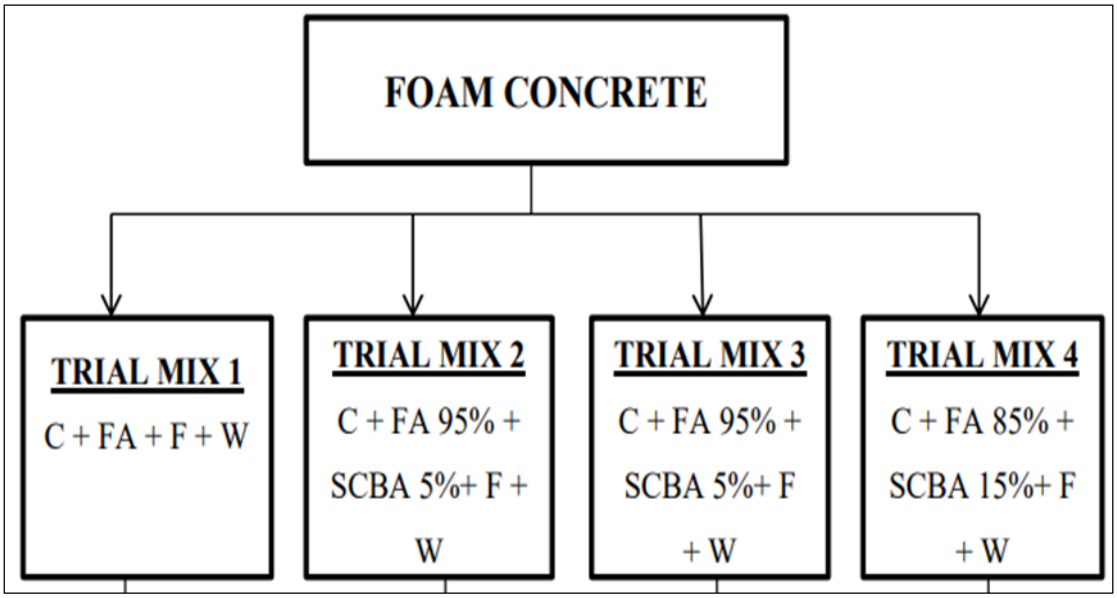

Fig 4: Flow chart of different trial mixes for Foam concrete

Results and Discussions
Compressive Strength Results
The compressive strength tests were conducted on 150x150x150mm specimens and results are tabulated below.

Table 4: Compressive Strength of Specimens 7, 14 days & 28 days

Sl No.	Type of Concrete	Age	Compressive Strength (N/mm^2)			Avg Comp St. (N/mm^2)
			I	II	III	
1	Normal Foam Concrete	7	22.5	14.26	21.2	19.32
		14	22.5	20.2	19.3	20.66
		28	23.98	24.73	24.50	24.40
2	SCBA 5% + FA 95%	7	20.5	16.26	19.46	18.74
		14	21.2	23.39	21.2	21.93
		28	22.5	16.16	21.2	19.62
3	SCBA 10% + FA 90%	7	22.5	14.26	22.5	19.75
		14	22.5	20.2	18.5	20.4
		28	25.47	26.10	25.6	25.75
	SCBA 15% + FA 85%	7	18.31	16.75	17.53	17.53

4		14	20.5	16.16	21.2	19.28
		28	20.5	16.75	18.90	18.71

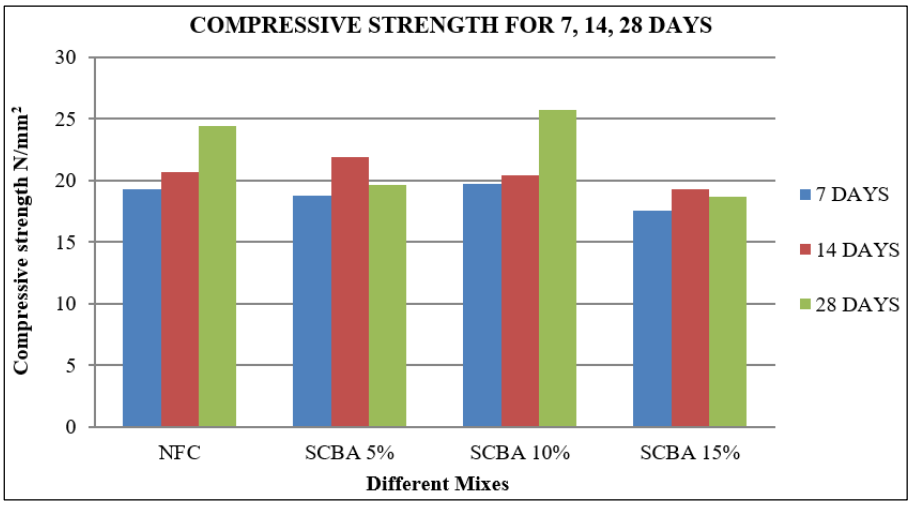

Fig 5: Comparison of compressive strength of foam concrete

Fig. 5. Represents the comparison between compressive strength at the age of 7, 14, 28 days respectively for all the four mixes. From comparison strength test graph, the maximum strength of 25.75 N/mm^2 is obtained for SCBA -10%. Mix-III with 10% replacement of fine sand with SCBA showed the highest strength among all the four mixes. We can see that after adding 10% sugarcane bagasse ash in foam concrete in place of the fine aggregate the compressive strength has been increased. If we are increasing beyond 10% SCBA, the compressive strength will decreases gradually.

Split Tensile Strength Results

The tensile strength tests were conducted on 150x300mm cylinder specimens and results are tabulated below.

Table 5: Split tensile Strength results of Specimens for 7, 14 days & 28 days

Sl No.	Type of Concrete	Age	Split tensile Strength (N/mm^2)		Avg. Strength (N/mm^2)
			I	II	
1	Normal Foam Concrete	7	2.6	2.7	2.65
		14	2.90	3.0	2.95
		28	3.29	3.69	3.49
2	SCBA 5% + FA 95%	7	0.82	0.80	0.81
		14	1.04	0.86	0.95
		28	1.16	1.25	1.20
3	SCBA 10% + FA 90%	7	0.6	0.68	0.64
		14	0.95	0.79	0.87
		28	1.04	1.26	1.15
4	SCBA 15% + FA 85%	7	0.82	0.74	0.78
		14	0.96	0.88	0.92
		28	1.02	1.06	1.04

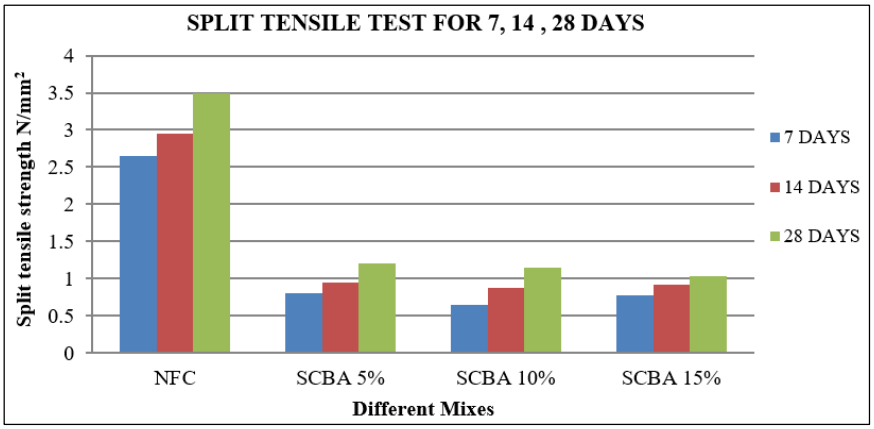

Fig 6: Comparison of split tensile strength of foam concrete

Fig. 6. represents the comparison between split tensile strength at the age of 7, 14, 28 days respectively for all the four mixes. In split tensile test graph, the maximum strength obtained for normal foam concrete is 3.49 N/mm^2. we can see that, there is no increase in split tensile test after adding sugarcane bagasse ash to the foam concrete for all the trial mixes.

Conclusion

In this study, the effect of sugarcane bagasse ash as replacement of fine aggregate in foam concrete has studied and results are compared. Some of the conclusions are discussed below.

- The compressive strength of mortar prepared with SCBA as partial replacement of sand decreases with an increase in the percentage of SCBA.
- The results of Foam concrete work revealed that the compressive strength of containing SCBA have high values than compared to normal foam concrete and split tensile strength containing SCBA have shown a reduction.
- Since bagasse ash is a by-product material, its use as sand replacing material reduces the dredging process near the river. In addition, its use resolves the disposal problems associated with it in the sugar industries.
- The compressive strength findings show that the strength of the mixes containing 10% bagasse ash rises over time (28 days vs 7 days), which might be attribute to bagasse ash's pozzolanic characteristics.
- Bagasse ash, in its purest form, has the potential to be used as a concrete element because it may be used as a fine aggregate substitute.

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