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Experimental Study On Partial Replacement Of Fine Aggregate With Sugarcane Bagasse Ash In Concrete

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ABSTRACT :

The purpose of this experimental investigation is to determine whether sugarcane bagasse ash (SCBA) can replace part of the fine aggregate in concrete manufacturing. The effects of different mix proportions of SCBA on concrete qualities such compressive strength, workability, and durability are investigated through methodical experimentation. With an eye on providing insights into the mechanical and structural performance of SCBA, the study attempts to evaluate the material's potential as a sustainable substitute for conventional fine aggregate. The findings advance knowledge of SCBA's applicability as an additive in concrete building, providing eco-friendly remedies and resolving waste management issues in the sugar sector.

Keywords: Experimental study, Partial replacement, Fine aggregate, Sugarcane bagasse ash, Concrete

INTRODUCTION

The introduction lays the groundwork for an experimental study on the partial substitution of sugarcane bagasse ash (SCBA) for fine aggregate in concrete. It briefly describes the study's rationale, highlighting the potential of SCBA as an environmentally friendly substitute and the rising need for sustainable building materials. This project seeks to advance sustainable construction practices and increase knowledge of the applicability of SCBA as a supplemental material in concrete production by addressing waste management challenges in the sugar industry and providing insights into concrete performance.

METHODOLOGY

- Selection of materials: Procurement of fine aggregate, sugarcane bagasse ash, cement, water, and additives.
- Mix design: Determination of various mix proportions incorporating different percentages of SCBA.
- Sample preparation: Mixing of materials according to specified proportions to produce concrete specimens.
- Testing procedures: Conducting laboratory tests including compressive strength, workability, and durability evaluations.
- Data collection: Systematic recording of test results for analysis and comparison.
- Statistical analysis: Utilization of statistical tools to interpret experimental findings and draw conclusions.
- Quality control measures: Implementation of procedures to ensure consistency and reliability of test results.
- Environmental considerations: Assessment of the environmental impact of SCBA utilization in concrete production.

MATERIALS

3.1 CEMENT

Portland Pozzolana Cement (PPC) is utilized as the primary binder in the experimental study on partial replacement of fine aggregate with sugarcane bagasse ash (SCBA) in concrete. PPC, a blend of Portland cement and pozzolanic materials like fly ash or SCBA, enhances concrete's durability and strength. Its slower hydration rate allows for prolonged workability, aiding in the incorporation of SCBA into the mix. The study evaluates PPC's compatibility with SCBA and its influence on concrete properties.

Sl.No	Observations	Trail I	Trail II	Trail III
1.	Weight of the specific gravity bottle (W_1), kg	42.8	42.9	42.9
2.	Weight of the bottle + 1/3rd filled cement (W_2), kg	71.9	90.2	82.5
3.	Weight of the bottle + 1/3rd filled cement + kerosene (W_3), kg	139.8	153.4	145.9
4.	Weight of the bottle + Kerosene (W_4), kg	118.3	118.4	118.5
5.	Specific gravity	3.1014	3.1148	3.0965

Table 1: specific gravity of cement

Average specific gravity of cement= **3.104**

Sample No	I	II	III
Weight of Cement (W_1), kg	100	100	100
Weight of cement retained on sieve after sieving (W_2), kg	4.5	6.5	6.09
% of Residue by Weight (W_2/W_1)*100	4.5	6.5	6.0
Average Fineness	**5.67%**		

Table 2: Fineness test on cement

The Average Fineness of the given cement sample is = **5.67%**

Sl. No	Weight of cement taken for test (gm)	Quantity of water added in		Penetration index reading (mm)
		%	ML	
1	300	31	93	42
2	300	33	99	40
3	300	35	105	25
4	300	37	111	18
5	300	39	117	6

Table 3: Normal Consistency test

The Average Normal Consistency Test of the given cement sample is = **5.67%**

Trail	Setting Time (min.)	Penetration Index (mm)
1	0	0
2	5	0
3	10	0
4	15	2
5	20	4
6	25	5
7	30	7

Table 4: Initial and Final setting time

3.2 Fine aggregate

The workability and finish ability of concrete are impacted by the fine aggregate gradation. The current investigation made use of bagasse ash. There was a sieve analysis, and the findings are shown in the table. The table provides the specific gravity of sand, or fine aggregate.

Sieve Size (mm)	Weight Retained (g)	% of Weight Retained	Cumulative Weight of Retained (g)	Cumulative% Retained	% Passing
4.75	0	0	0		100
2.36	42.5	2.13	42.5	0	97.87
1.18	153	7.65	195.5	2.13	90.22
0.60	585	29.25	780	9.78	60.97
0.425	663.5	33.18	1444.0	39.03	27.80

0.30	0	0	1444.0	72.20	27.80
0.15	350.5	17.53	1794.5	89.73	10.27
0.090	164.5	8.23	1959	97.95	2.05
0.075	10	0.5	1969	98.45	1.55
Pan	8	040	1977	98.85	1.15

Table 5: sieve analysis of fine aggregate

Fineness modulus of fine aggregate = sum of cumulative retained/100

Fineness modulus of fine aggregate = 5.80

Sl.No	Weight of pycnometer	Weight of aggregate	Weight of pycnometer +water	Weight of pycnometer+aggregate	Weight ofpycnometer+aggregate +Water	Specific gravity
1	0.650	0.640	1.500	1.290	1.960	2.66
2	0.650	0.625	1.500	1.275	1.950	2.77
3	0.650	0.634	1.500	1.284	2.022	2.53
Average Specific Gravity						2.65

Table 6: Specific Gravity Test

Water absorption test

Weight of sand taken = 2kg

Weight of sand soaked in water = 2.035kg

Weight of oven dried sand = 2kg

Calculation

Weight of water absorption = A-B/B*100

= 2.035-2/2*100

= 1.7 kg

The physical properties results

Size = 4.75mm

Texture = Rough

Specific gravity = 2.65

Fines = 2.89

Water absorption = 1.7%

3.3 COARSE AGGREGATE

Locally accessible coarse aggregate was employed in this investigation. The table displays the specific gravity of the coarse aggregate as well as the results of the sieve examination.

Sieve Size (mm)	Weight Retained (g)	Cumulative Weight of Retained (g)	Cumulative % Retained	% Passing
80	0	0	0	100
40	0.950	0.95	19	81
25	0.210	1.16	23.2	77.8
20	0.625	1.78	35.7	64.3
16	0.865	2.65	53	47
12.5	0.960	3.64	72.6	27.4
10	0.420	4.05	81	19
6.3	0.820	4.87	97.4	2.6
4.74	0.070	4.94	98.8	1.2

2.65	0.600	5	100	0
Total	5.520	29.04	580.76	-

Table 7: Sieve analysis test on coarse aggregate

Fineness modules = cumulative % of retained/100

= 580.7/100

= 5.8076

Water absorption test

Weight of aggregate = 5kg

Weight of aggregate Soaked in water = 5.05kg

Weight of aggregate oven dried as = 5kg

Calculation

% of water absorption = A-B/B*100

= 5.05-5/5*100

= 1%

The physical properties results

Size = 20mm

Shape = Irrigator

Texture = Rough

Specific gravity = 2.79

Fines = 5.80

Water absorption = 1%

3.4 BAGASSE ASH

Following the sugarcane plant's juice extraction, bagasse was produced. This garbage is burned at a temperature of around 600^0C to heat water in a boiler and create steam, which powers power plants. Bagasse ash is produced during combustion and has a gray-black hue. The source of sugarcane bagasse ash (SCBA) was the MRK Sugar Mill located in Sethiyathope, Tamil Nadu, India. To find the particle size, 90 µm and 45 µm sieves were used for the dry sieving process.

Sl. No	**BS sieve Size**	**Percentage retained (%)**	**Cumulative percentage retained (%)**	**Cumulative percentage passing (%)**
1	>2mm	0	0	100
2	2mm	13.78	13.78	86.22
3	1mm	16.57	30.15	69.65
4	710 µm	5.79	36.14	63.82
5	600 µm	4.87	41.01	58.99
6	500µm	3.64	44.65	55.35
7	425µm	4.17	48.82	51.18
8	300µm	12.29	61.11	38.89
9	150µm	28.36	89.42	10.53
10	36µm	9.62	99.09	0.92
11	<36µm	0.92	100	0
Total	-	100	365.33	-

Table 8:sieve analysis test

Calculation

Fineness modules = cumulative % of retained/100

= 365.33/100
= 3.65

3.5.4.3 Water Absorption Test

Bagasse ash

Weight of bagasse ash = 5kg
Weight of bagasse ash soaked in water = 5.55kg
Weight of bagasse ash oven dried = 5kg

Calculation

% of water absorption = A-B/B(100)
= 5.55-5/5(100)
= 0.11(100)
= 11%

4. MIX DESIGN :

The Design of M20 concrete mix, The various data required for concrete mix design were summarized below,

- Grade of designation = M20
- Type of cement = PPC 43 grade
- Maximum nominal size of aggregate = 20mm
- Minimum cement content = 320 kg/m^3
- Maximum water cement ratio = 0.55
- Workability = 75mm (slump)
- Exposure condition = Mild
- Degree of supervision = Good
- Maximum cement content = 450 kg/m^3
- Chemical admixture = Not recommended

Mix Design Procedure – M20

Step-1: Determination of Target Mean Strength

fck = fck+1.65×4
= 20+1.65×4
= 26.60 N/mm^2

Step-2: Selection of Water – Cement Ratio

Water Cement ratio corresponding to M20 grade for mild exposure condition was selected. The maximum value of water cement ration for M20 grade concrete subjected to mild exposure condition is 0.50. Water cement ration 0.50 was selected for the mix design.

Step-3: Selection of Water Content

Maximum water content for 20mm aggregate = 186 liter

Change in volume of water cement ratio,

Water = 186+(186*3/100)

= 191.58 lit/m^3

Step-4: Calculation of Cement Content

Water cement ratio = 0.50
191.58/0.50 = Cement

Cement = 383 kg/m^3

Step-5: Mix Calculation

- Volume of concrete = 1m^3
- Volume of cement = (mass of cement / sp.gravity of cement) x (1/1000)
  - = (383.16/ 3.15) x (1/1000)
  - = 0.122m^3
- Volume of water = (mass of water / sp.gravity of water) x (1/1000)
  - = (192/2) x (1/1000)
  - = 0.192 m^3
- Volume of all in aggregate (Z) = a – (b + c)
  - = 1-(0.122 + 0.192) = 0.686 m^3
- Mass of coarse aggregate = Z x volume of CA x specific gravity of CA x 1000
  - = 0.686 x 2.68 x 1000
  - = 1103 kg
- Mass of fine aggregate = Z x volume of FA x specific gravity of FA x 1000

  = 0.686 x 0.4 x 2.65 x 1000

  = 727 kg.

Step-6: Mix Proportion

Water	=	191.6 lit/m^3
Cement	=	383 kg/m^3
Fine Aggregate	=	727 kg/m^3
Coarse Aggregate	=	1103 kg/m^3
Water cement ratio	=	0.50

THE MIX PROPORTION IS 1:1.5:3

1. EXPERIMENTAL PROGRAMME

4.1 SPECIMEN DETAILS

Cubes = 150*150*150

4.2 MIXING OF CONCRETE

Using a trowel, mix the concrete carefully to prevent losing any water or other materials. Every batch of concrete is large enough to leave roughly 10% extra after the required number of test specimens have been molded.

Fig 1: Mixing of Concrete

4.3 MOULDS

The metal used to make the mold is sturdy enough to avoid distortion. Its design makes it easier to remove the molded specimens without causing any damage. A base plate with a 150*150*150 mm flat surface is included with the cube mold.

To ensure that no water escapes during the filling process, a small layer of mold oil is applied to the joints connecting the mold's pieces before it is assembled for use. A similar layer of oil is put between the bottom's contact surfaces. To keep the concrete from sticking to the internal surface of the assembled mold, a small layer of mold oil is applied.

Fig 2: Casting of concrete

4.4 COMPACTING

The test specimens are constructed with full compaction of the concrete—that is, without segregation or excessive latinate—as soon as is practically possible after mixing. Layers of concrete, about five centimeters deep, are poured into the mold. To guarantee a symmetrical distribution of the concrete within the mold, each scoop full of concrete is placed by moving the scoop around the upper edge of the mold as the concrete sides from it. Manual compacting is used to compact each layer.

4.5 CURING

After adding water to the dry ingredients, the test specimen is kept in situ, vibration-free, in moist air with a minimum relative humidity of 90%, and at a temperature of roughly 270 °C for a whole day. Following this time frame, the specimen needs to be labeled, taken out of the molds, and, unless testing is needed within the next 24 hours, immediately immersed in new, clean water. It should be kept there until right before the test. The specimens must remain wet during the whole testing process.

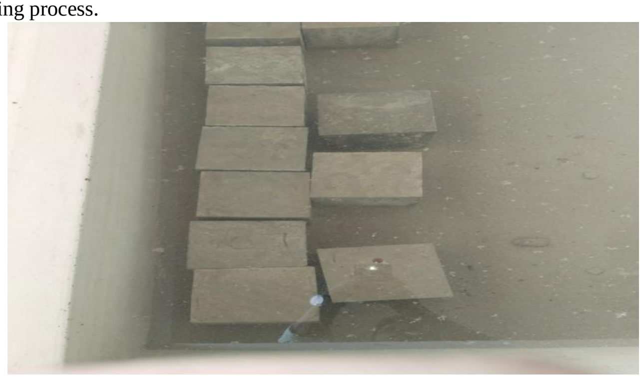

Fig 3: curing of concrete

4.6 TEST ON FRESH CONCRETE

4.6.1 SLUMP CONE TEST

The slump test is a standard procedure used to measure the workability of fresh concrete. In this test, a cone-shaped mold is filled with freshly mixed concrete in layers, which is then compacted and levelled. The mold is removed, and the amount of vertical settlement, or slump, of the concrete is measured. This measurement indicates the consistency and flow ability of the concrete mix, providing valuable insights into its quality and suitability for construction applications.

Mix	%of Bagasse Ash	% of SF	Slump Value (mm)
CO	0	0	90
S1	5	2	187
S2	10	2	200
S3	15	2	220

Table 9: slump test

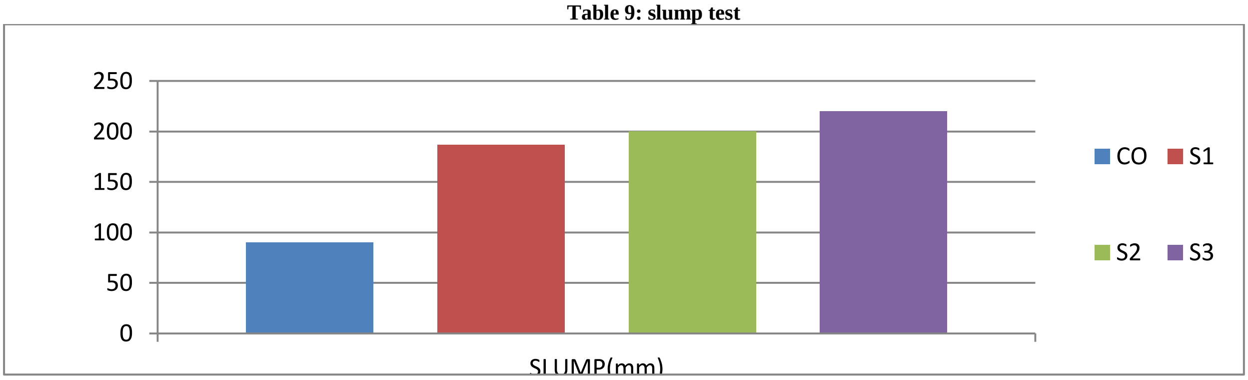

Fig 4: bar comparison for slump cone test

4.6.2 COMPACTION FACTOR TEST

The compaction factor test is a method used to assess the workability of fresh concrete. It involves filling a standardized container with freshly mixed concrete, compacting it using standardized equipment, and then measuring the reduction in volume after compaction. This reduction in volume, expressed as a ratio, is termed the compaction factor. The test helps to evaluate the ease of placing and compacting concrete, providing crucial information about its consistency and ability to achieve desired density levels in construction projects.

Mix	%of Baggase Ash	% of SF	Compaction Factor (mm)
CO	0	0	90
S1	5	2	187
S2	10	2	200
S3	15	2	220

Table 10: compaction factor test

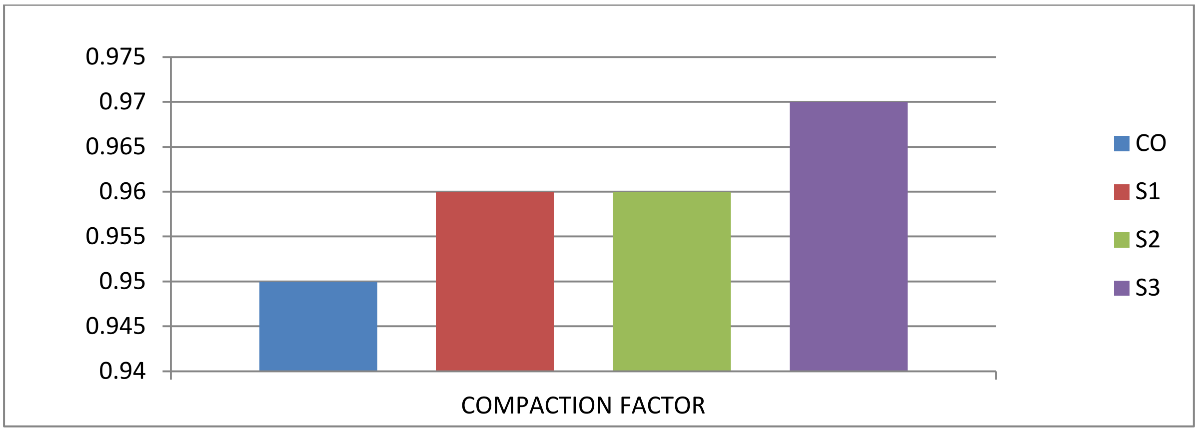

Fig 5:compaction factor test

4.7 TEST ON HARDENED CONCRETE

4.7.1 COMPRESSIVE STRENGHT

Compressive strength testing is a fundamental evaluation conducted on hardened concrete to assess its ability to withstand axial loads. It involves subjecting cylindrical or cube-shaped specimens to increasing compressive forces until failure occurs. The maximum load sustained by the specimen divided by its cross-sectional area yields the compressive strength. This parameter serves as a critical indicator of concrete's durability and load-bearing capacity in structural applications, guiding design and construction practices to ensure safety and longevity of concrete structures.

Mix	Percentage replacement of baggase ash (%)	Compressive strength(MPA)	Compressive strength(MPA)	Compressive strength (MPA)
		7days	14days	28days
CO	0	13.25	18.38	22.36
S1	5	13.95	19.49	22.95
S2	10	14.14	20.52	23.83
S3	15	10.05	16.89	19.16

Table 11: comparison of compressive strength at various ages

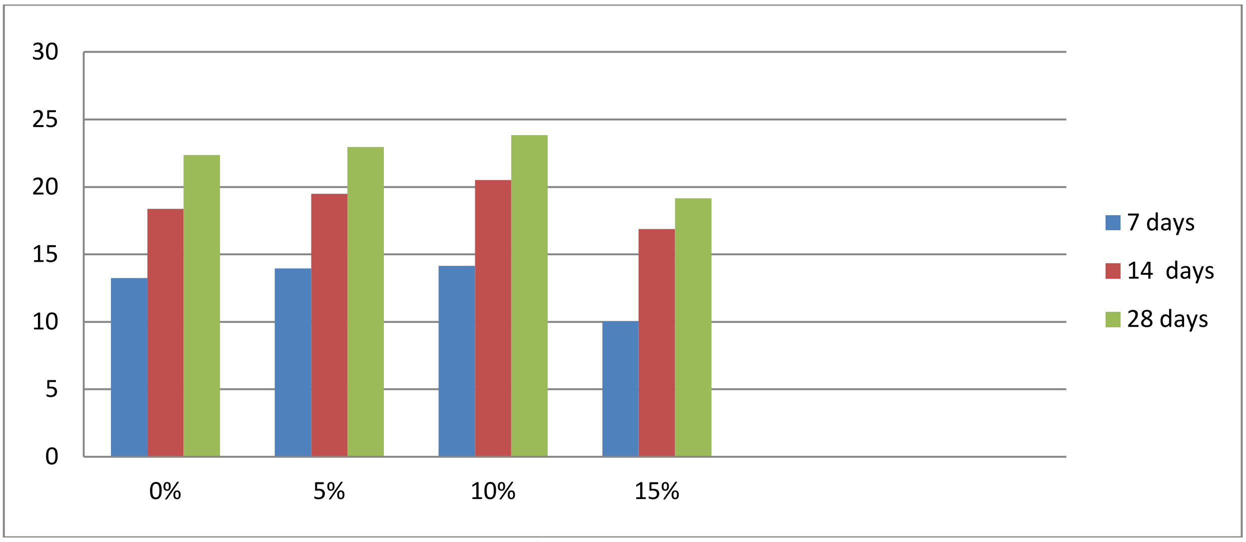

Fig 6: Comparison of Compressive Strength at Various Ages

CONCLUSION

- From the experiments and analysis of results of findings in this research work, we established the following facts. Due to scarcity of natural sand and of high cost. As finer aggregate in cement concrete for various reasons, search for alternative material like SCBA qualifies itself as a suitable substitute for sand at low cost.
- The possibility exists for the partial replacement of fine aggregate with bagasse ash which is produced boiler plant in sugar mill . Bagasse ash is compatible with the cement.
- Use of bagasse ash as fine aggregate can reduce the cost of construction materials and it is useful in environmental protection also.
- With the utilization of boiler bagasse ash in concrete, water misfortune from draining diminished at all the substitution levels.
- Compressive Strength of concrete is maximum at 10% replacement with a value of 14.15 N/mm2, 23.83N/mm2 at 7days and 28 days respectively and with further increase in the percentage of replacement there is decrease in the strength of concrete.
- At last, the utilization of bagasse ash in concrete is prescribed as a different option for fine aggregates in concrete but limited to 10% by weight of fine aggregate.

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