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EXPERIMENTAL BEHAVIOR OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT AND SAND USING SUGARCANE BAGASSE ASH AND CRUSHER SAND

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Abstract: In the present study, cement was replaced with sugarcane bagasse ash using fine aggregate as crusher sand. The experimental studies on sugarcane ash concrete with crusher sand mixes with 10%, 20% and 30 % were studied to find the optimum mix composition in M25 grade concrete.The researchers have done considerable work on replacing the cement with sugarcane bagasse ash (SCBA) without affecting the strength.Compressive strength, split tensile strength and flexural strength of concrete mixtures with 10%, 20% and 30 % of sugarcane bagasse ash as cement replacement and 30% of crusher sand

Keywords: Aggregates, sugarcane bagasse ash, Compressive strength, Split Tensile Strength, Flexural Strength and workability characteristics.

1. Introduction: Concrete is basically a mixture of cement, fine aggregate and course aggregates. Utilization of industrial and agricultural waste products as cement replacement materials in concrete technology has been an interesting subject of research for economical, environmental, and technical reasons. The cement industry is the second largest CO_2 emitting industry behind the power generation. It is found that each tone of cement production produces cement by agricultural waste or agro-waste is an alternative solution for the decreasing of CO_2 emission due to less cement consumption for construction industry. Agricultural products are mostly processed annually in the industrial plants such as sugar cane, rice, palm, and etc., therefore, the agricultural wastes has turned up enormously. Fortunately, agricultural wastes are exploited as energy sources in industrial processes to become sugar cane bagasse ash (SCBA), rice husk ash, and oil palm ash. Though, SCBA is a valueless agricultural wastes of sugar industry, it is a pozzolan or pozzolanic material used to replace part of cement because its chemical composition consisted of high SiO2 is the main phase of pozzolanic reaction in cement.The researchers have done considerable work on replacing the cement with sugarcane bagasse ash (SCBA) without affecting the strength.

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River sand (fine aggregate), which is one of the constituents used in the production of concrete , has become expensive and scarce. So there is large demand for alternative materials. The crusher dust produced from granite crushers is one of the alternative materials for river sand.

The utilization of crusher dust which can be called as ROBO sand has been accepted as a building material in the western countries.

The aim of the experiment is to investigate study of compressive strength, flexural strength and split tensile strength of M25 conventional concrete by replacing the 30% of sand with ROBO sand and 10%, 20% and 30% of cement with SCBA. Tests were conducted on concrete cubes, beams and cylinders to study of compressive strength, flexural strength and split tensile strengths. The results are compared with the normal conventional concrete. .[10] discussed about Microwave Semiconductor Devices such as Tunnel diode, Gunn diode and valanche transit time devices and analyzes Monolithic Microwave Integrated Circuits (MMIC)

2. Experimental Investigation:

2.1. Material Used

The following materials are used for producing the high strength concrete.

2.1.1 Water

Water is needed for the purpose of hydration of cement and to provide workability during mixing and placing of concrete. For this study portable water pH value 7 and conforming to the specifications of IS 456-2000 is used for concreting as well as curing of the specimen

2.1.2. Cement

53 Grade OPC is high quality cement prepared from the finest raw material Owing to optimum water demand, it contributes to a very low co-efficient of permeability of the concrete prepared. This improves the density of the concrete matrix and increases the durability of the concrete. OPC is high performance cement far exceeding the codal requirement of IS 122269-1987.

2.1.3. Fine aggregate

The fine aggregates serve the purpose of filling all the open spaces in between the coarse particles. Thus it reduces the porosity of the final mass and considerably increases its strength. Usually Natural river sand is used as a fine aggregate. The sand confirmed to grading zone II of IS 383-1970.

2.1.4. Coarse Aggregate

Optimum size of the coarse aggregate in most situations was about 20mm size was adopted. They generally possess all the essential qualities of a good building stone showing very high crushing strength, low absorption value and least porosity.

2.1.5. Crusher sand

In the present work locally available artificial sand was collected. The properties of the artificial sand were studied in accordance with BIS 2386-1963 and theSand passing through4.75 mm sieve as per IS:383 provisions were used as fine aggregates

2.1.6. Sugarcane bagasse ash

SCBA used in this study was obtained by burning SCB at 600^{o}C for 5 hours under controlled conditions and its physical, chemical, and mineralogical characterization was done to evaluate the

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possibility of its use as binder partially replacing cement in the mortar applications. In this sugarcane bagasse ash was collected in the Government Sugar Factory, located in the city of palacode, dharmapuri distic,Tamilnadu.

Table 2.1: Properties of cement

S.No	Description	Values
1	Specific gravity	3.25
2	Fineness (by sieve analysis)	8%
3	Consistency	30%
4	Initial setting time	30 minutes

Table 2.2: Properties of coarse aggregate

S.No	Description	Values
1	Specific gravity	2.75
2	Bulk Density	1754.7 kg/m³
3	Water absorption	0.5%
4	Fineness modulus	6.78
5	Impact Value	13.33%
6	Cushing Value	17.3%
7	Abrasion Value	26.5

Table 2.3: Properties of Fine Aggregate

S.No	Description	Values
1	Specific gravity	2.64
2	Fineness modulus	2.76
3	Water absorption	1%
4	Bulk Density	1668.0 kg/m³

Table 2.4: Physical Properties of SCBA

S.No	Description	Values
1	Density g/cm^3	2.52
2	Surface area cm^2/g	5140
3	Particle size µm	28.9
4	Color	Redish grey

Table2.5: Chemical Properties of SCBA

S.No	Description	Values
1	Silica (SiO_2)	73.63%
2	Calcium oxide (CaO)	1.89%
3	Magnesium oxide (MgO)	1.68%
4	Iron oxide (Fe_2O_3)	2.63%
5	Aluminium oxide (Al_2O_3)	4.69%
6	Sodium oxide (SO_3)	1.00%
7	Potassium oxide (K_2O)	2.96%
8	Loss of ignition (L.O.I)	6.18%

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Table2.6: Properties of Crusher sand

S.No	Description	Values
1	Specific gravity	2.4
2	Fineness modulus	2.6
3	Water absorption	1%
4	Bulk Density	1813.23 kg/m^3

Table 2.1 shows the properties of cement are within the allowable limits. From Table 2.2 it was observed that the properties of coarse aggregate values satisfy the standards. Table 2.3 gives the properties of natural river sand. Table 2.4 is the physical properties of sugarcane bagasse ash . Table 2.5 is the chemical properties of sugarcane bagasse ash used as partially replacement of cement on concrete. Table 2.6 gives the properties of crusher sand.

3. Concrete Mix Details

Two sets of mixes are prepared for M_{25} grade concrete. First Mix is ordinary conventional concrete. Second mix replacing the 30% of sand with crusher sand and 10%, 20% and 30% of cement with SCBA. For each trial 3 cubes were cast, in which 12 cubes for testing the compressive strength at 7,14 and 28 days.

Table 3.1: Mix Ratio

Cement	Fine aggregate	Coarse aggregate	Water
1	1.164	2.87	0.44

4. Testing details:

4.1 Workability test

4.1.1 Slump cone test

The concrete slump test is an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete. It refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It is also used to determine consistency between individual batches.

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Figure 4.1.1 Slump height measurement

4.1.2. Compaction factorTest

. Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test. The sample of concrete is placed in the upper hopper up to the brim and trap-door is opened so that the concrete falls into the lower hopper. The trap-door of the lower hopper is opened and the concrete is allowed to fall into the cylinder. The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades. The concrete in the cylinder is weighed. This is known as weight of partially compacted concrete. The cylinder is filled with a fresh sample of concrete and vibrated to obtain full compaction. The concrete in the cylinder is weighed again. This weight is known as the weight of fully compacted concrete. As per IS 1199 – 1959 code,

$$compaction\ factor\ test = \frac{\text{partially compacted concrete}}{\text{fully compacted concrete}}$$

Figure 4.1.2 Compaction factor Apparatus

The workability of various percentage of SCBA is evaluated are shown in the table 4.1 below

% of SCBA	**Workability**	
	Slump(mm)	Compaction factor
0	60	0.95
10	200	0.96
20	225	0.97
30	270	0.97

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Table 4.1-Fresh Concrete Workability

4.2. Compressive Strength Test:

The strength results obtained from the experimental investigations are showed in tables. All the values are the average of the three trails in each case in the testing program of this study. The results are discussed as compressive strength at the age of 7th, 14th and 28th day of various percentages. It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 10%. Although, the optimal level of SCBA content was achieved with 1.0% replacement. Partial replacement of cement by SCBA increases workability of fresh concrete; therefore use of super plasticizer is not substantial. The density of concrete decreases with increase in SCBA content, low weight concrete produced in the society with waste materials (SCBA).

Figure 4.2: Compressive Strength Test

S. No	% SCBA	%CRUSHER SAND	7 days Mpa	14 days Mpa	28 days Mpa
1	0	0	19.0	23.8	26.3
2	10	30	23.3	28.4	32.0
3	20	30	25.5	27.7	29.2
4	30	30	21.2	22.7	25.7

Table 4.2. Compressive Strength test result

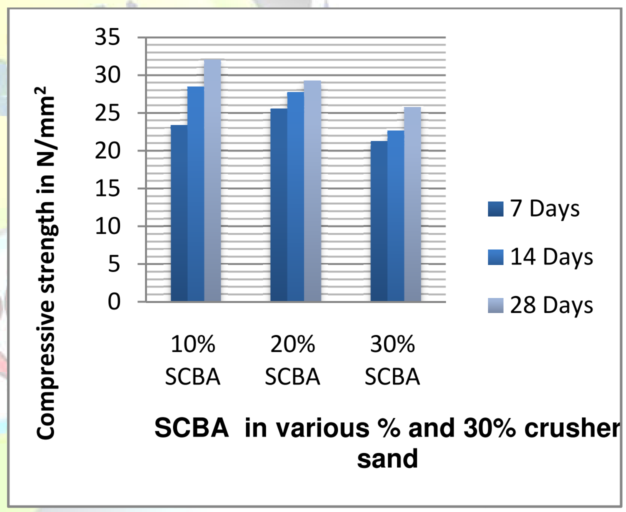

Figure 4.2.1 Compressive strength of cubes

4.3. Split Tensile Strength Test

To determine the tensile of concrete. The test is carried out by taking the wet specimen from water after 7 days and 28 days of curing. Wipe out water from the surface of specimen and draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place. Note the weight and dimension of the specimen. Set the compression testing

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machine for the required range. Keep a plywood strip on the lower plate and place the specimen. Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate. Place the other plywood strip above the specimen. Bring down the upper plate to touch the plywood strip.
Apply the load continuously without shock at a rate of approximately 14-21kg/cm2/minute (Which corresponds to a total load of 9900kg/minute to 14850kg/minute). Note down the breaking load.

The tensile test was conducted in Concrete and Engineering Laboratory for different samples and readings for all the samples are noted . These specimens are tested by testing machine after 14 days curing or 28 days curing for their respective strengths under different combinations

Figure 4.3: Split tensile Test

Split tensile strength was calculated as follows:

Spilt Tensile strength (MPa) = 2P / π DL
Where,

P = Failure Load (kN)
D = Diameter of Specimen (100 mm)
L = Length of Specimen (300 mm)

Test Results of splitting tensile strength for conventional and optimum percentage of SCBA of M_{25} grade concrete as shown in table 4.3, below.

S. No	% SCBA	% CRUSHER SAND	7 days Mpa	14 days Mpa	28 days Mpa
1	0	0	1.82	2.06	2.29
2	10	30	1.90	2.09	2.50
3	20	30	1.96	2.43	2.56
4	30	30	2.09	2.30	2.31

Table 4.3: Test Results of Split Tensile Strength

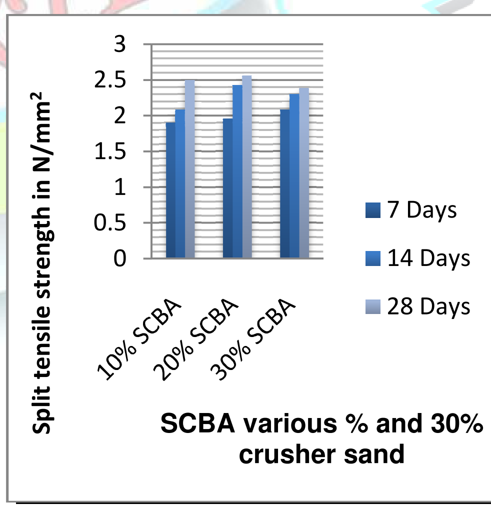

Figure 4.3.1 Split tensile strength of concrete

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4.4. Flexural strength test

Based on the various tests conducted, it can be succinctly concluded that SCBA is a good pozzolana for concrete cementation and partial blends of it with OPC could give good strength development and other engineering properties in concrete. An optimum of 10% SCBA blend with OPC could be used for reinforced concrete with dense aggregate. The value fell short of meeting requirements for reinforced concrete with dense aggregate because of excessive fines from increasing SCBA and increased the strength of bonding. The flexural strength at the age of 7th, 14th and 28th day of various percentages.

Figure 4.4. Flexural Strength test

A beam specimen is placed in the ultimate testing machine of 2000kN capacity for testing. The Flexural strength is calculated by using the formula,

$$\sigma = P\, l / bh^2$$

Where,

P = load in Newton shown in dial gauge
l = length of prism in mm i.e. 500 mm
b = breadth of prism i.e. 100 mm
h = height of prism i.e. 100 mm

S. No	% SCBA	% CRUSHER SAND	7 days Mpa	14 days Mpa	28 days Mpa
1	0	0	2.96	3.30	3.78
2	10	30	4.5	5.5	6.63
3	20	30	2.93	5.0	5.07
4	30	30	2.26	3.34	5.5

Table 4.4 Test result of flexural strength

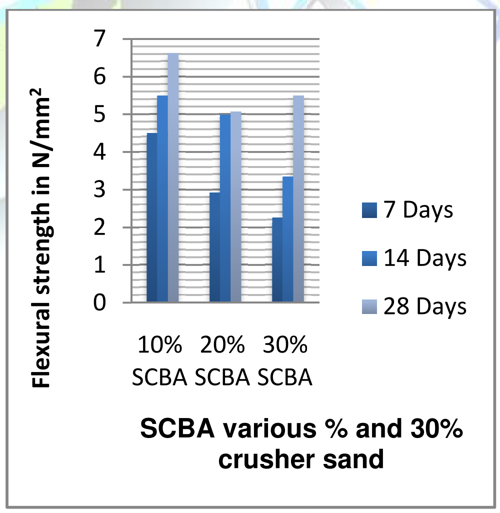

Figure 4.4.1 Flexural Strength test of concrete

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5. Results & Discussion:

From graph 4.2, it was noticed that the compressive strength gradually increases as the percentage of steel slag is increased up to 40% replacement. After replacement of 40% compressive strength is gradually decreased. Hence we can conclude that complete replacement of coarse aggregate with blast furnace steel slag has reduced the compressive strength in concrete.

From the UPV results, shows that the quality of concrete is come under excellent while increasing the steel slag up to 60%. While increasing the replacement of blast furnace steel slag above 60% quality of concrete is comes under good.

The compressive strength for M60 grade of concrete is shown in Graph 4.2, as above. As the curing days increases the strength also increases.This compressive strength test result also similar to the rebound hammer test.

From split tensile strength test, flexure strength test and also durability test results shows, the blast furnace steel slag aggregate concrete is better than the conventional concrete.

6. Conclusion:

1. Bagasse ash can increase the overall strength of the concrete when used up to a 20% cement replacement level .

2. Bagasse ash is a valuable pozzolanic material and it can potentially be sold at a price similar to that of slag and fly ash .

3. Partial replacement of cement by SCBA increases workability of fresh concrete; therefore use of super plasticizer is not essential.

4. The density of concrete decreases with increase in SCBA content low weight concrete produced in the society with waste materials (SCBA).

5. The cementious material is responsible for early hydration. However later pozzolanic activity of bagasse ash produces more amount of CSH in the bio-cement consequently accelerates and enhances the hydration with strength of the sample. Hence bagasse ash is a potential replacement material for cement production.
6. Economic point of view the percentage of cement replaced saves money.
7. sugarcane bagasse ash (SCBA) as a replacement for cement may provide additional enhancements in resistance to chloride ion penetration and waterproofing properties.

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