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Utilization of Sugarcane Bagasse Ash as Partial Replacement of Cement and Quarry Sand as Partial Replacement of Sand in Concrete

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ABSTRACT:Concrete is one of the most important materials in construction and In the future, the demand for concrete is going to increase more due to the growing construction industry. The basic materials are cement, fine aggregate, coarse aggregate, and water required in the production of concrete. Most of the materials like fine aggregate and coarse aggregate which are used in concrete come from natural sources. While production of some materials like cement causes environmental pollution. It is necessary to secure natural resources and the environment so there should be some alternative to the traditional materials. Sugarcane bagasse ash is a waste product from sugar industries and Quarry dust is a by-product from the crushing and quarrying process of stones which is considered as a waste. The use of such products as a replacement material makes concrete environmentally sustainable and economical. This research discusses and studies experimentally the idea of utilization of sugarcane bagasse ash as a partial replacement for cement and quarry dust as a partial replacement for fine aggregate in concrete. Two concrete mixes were prepared of M25 grade (M25, M25+20% quarry sand). Three concrete mixes were prepared of M25 grade with partially replacing cement with Sugarcane bagasse ash and fine aggregate with Quarry sand (10%, 20%, 30%). The effect of the replacements on the workability and compressive strength were checked. From the test results, it was observed that when a certain % of SCBA is introduced as a replacement of cement in the concrete which have the same % of quarry sand as a replacement of sand it improves the workability of the concrete and the strength of the concrete. It is also observed that 10% to 20% replacement of cement and sand by SCBA and quarry sand is possible without a big change in compressive strength when compared to the ordinary concrete mix of M25 grade.

KEYWORDS: Cement, Concrete, Fine Aggregate, Quarry sand, Sugarcane bagasse ash

I. INTRODUCTION

The world is evolving and it requires infrastructure. due to growth in infrastructure, the construction industry needs to evolve. The faster, quicker, sustainable, and economical ways of construction should be introduced. In the construction industry concrete plays an important role as a material. For the production of concrete required ingredients are cement, fine aggregate, coarse aggregate, and water. But the materials used in the production of concrete-like fine aggregate and coarse aggregate come from natural sources and during the production of material like cement it cause environmental pollution. It is the responsibility of the civil engineer to maintain a balance between construction and a sustainable environment. To save the environment and natural resources for future generations to use there should be an alternative. Which can be used as a replacement for the traditional materials used in concrete.

Sugarcane is one of the major crops grown in many countries all over the world. In India only over 300 million tons/ year of sugarcane is produced [1]. After extraction of all sugar from sugarcane, large fibrous excess is obtained known as bagasse [2]. Bagasse is a by-product from sugar industries that is burnt to generate the power required for different activities like it is used as fuel to heat the boilers in the factory. The burning of bagasse leaves bagasse ash as a waste [3]. Sugarcane bagasse ash contains silica and aluminum ion, which is pozzolanic in nature. The minimum silica, and iron oxide content is 70%, and SiO3 should be less than 4% For natural pozzolans. Bagasse ash fulfills these requirements so the ash behaves as pozzolanic material [4]. To study

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pozzolanic activity and their suitability as binders few studies have been carried out on the ashes obtained directly from the industries. It is used in concrete without adverse effects on concrete durability [5]. Thus it is possible to use sugarcane bagasse ash as a replacement material for the cement to reduce the cost and improve the quality of concrete [6]. So the SCBA is an effective alternative for partial replacement of cement.

The aggregates are extracted from quarries by using various methods and there are remains of the rocks in the form of fine dust after the extraction of aggregates. This fine dust is generally known as quarry dust or quarry sand [7]. Quarry sand, is a by-product release from the cutting and crushing process of stone it becomes useless material and considered as a waste [8]. Quarry sand has a particle size distribution close to that of sand [7]. Also, the specific gravity of sand and quarry dust almost the same[9]. Quarry sand does not contain organic impurities or silt and can be produced as per required fineness and to meet the desired gradation [10]. It is also found that utilization of quarry sand as fine aggregates in concrete provides sufficient workability and also the required strength. The utilization of quarry sand as a replacement not only relieves the pressure on sand but also reduces the need for the dumping of quarry sand which was considered a waste product in the quarries [7]. So the quarry sand is an effective alternative for the partial replacement of sand.

II. MATERIALS USED

A. **Cement:** Ordinary Portland cement (OPC) of grade 53 is adopted for making concrete. The cement according to the Indian specification must satisfy the IS 12269- 1987 (reaffirmed 1999).

B. **Fine Aggregate:**The natural fine aggregates are the river sand which is the most commonly used natural material for the fine aggregates are used for the study.

C. **Coarse Aggregate:**The crushed aggregates are of 20mm nominal size used for the study.

D. **Water:** For the study, water not containing undesirable organic substances or inorganic constituents in excessive proportions is used.

E. **Sugarcane Bagasse Ash:**For the study, the sugarcane bagasse ash is obtained from the nearest sugar industry.

F. **Quarry Sand:**For the study, the dust is selected from the nearest source as raw materials without any processing of the dust from the quarry.

III. EXPERIMENTAL INVESTIGATION

A. Physical Properties of Materials:

Table 1 – Physical properties of materials

Materials	Properties	Values	Reference
Cement	Fineness	7% (<15)	[1], [11]
	Specific gravity	3.1 – 3.15	[1], [3], [11]
	Density (kg/m3)	3100 - 3150	[1], [3], [12], [13]
Fine aggregate	Fineness modulus	2.4 – 3.5	[1], [10], [11], [13], [14], [15]
	Specific gravity	2.46 – 2.7	[1], [7], [9], [10], [11], [12], [13], [14]
	Density (kg/m3)	2460 - 2700	[1], [7], [9], [10], [11], [12], [13], [14]
Coarse aggregate	Fineness modulus	6.86 – 7.17	[1], [11]
	Specific gravity	2.64 – 2.83	[1], [11], [12], [13]
	Density (kg/m3)	2640 - 2830	[1], [11], [12], [13]
Sugarcane bagasse ash	Fineness modulus	2.12	[1]
	Specific gravity	1.25 – 2.65	[1], [3], [11], [12]
	Density (kg/m3)	1250 - 2650	[1], [3], [11], [12]
Quarry sand	Fineness modulus	2 - 3	[14], [15]

	Specific gravity	2.5 – 2.8	[7], [14], [15]
	Density (kg/m3)	2500 - 2800	[7], [9], [14]

The above table represents the value ranges of the physical properties of material obtained after studying the research paper related to the topic. The value ranges help to determine the value that will be obtained after performing the tests to determine the physical properties of the material.

Table 2 – Physical properties of materials obtained after conducting tests

Materials	Properties	Values
Cement	Fineness	9.2%
Fine Aggregate	Fineness modulus	2.75
	Specific gravity	2.65
	Density (kg/m3)	2650
Sugarcane bagasse ash	Fineness	14%
Quarry sand	Fineness modulus	3.74
	Specific gravity	2.32
	Density (kg/m3)	2320

The above table represents the values obtained after the performance of the test to know the physical properties of the materials to be replaced and the materials which are to be used as a replacement. As Sugarcane bagasse ash is going to partially replace the cement the test for the fineness of the material is conducted on both. As Quarry sand is going to partially replace fine aggregate (sand) the test conducted on both are sieve analysis to know the fineness modulus and pycnometer test to know the specific gravity and density of the material.

B. Chemical Properties of Materials:

Table 3 – Chemical composition of SCBA

Chemical Composition of Sugarcane Bagasse Ash		
Component	Mass %	Reference
Silicon dioxide (SiO2)	62% - 71%	[1], [2], [3], [6], [13], [16]
Aluminum oxide (Al2O3)	1.9% - 8.55%	[1], [2], [3], [6]
Ferric oxide (Fe2O3)	1.22% - 6.98%	[1], [2], [3], [6]
Calcium oxide (CaO)	1.28% - 11.8%	[1], [2], [3], [6], [13], [16]
Potassium oxide (K2O)	1.77% - 3.53%	[1], [3], [6]
Magnesium oxide (MgO)	0.3% - 2.83%	[1], [2], [3], [13], [16]
Sulphur trioxide (SO3)	0.56% - 1.48%	[1], [3], [13], [16]
Loss of Ignition	0.42% - 4.73%	[1], [3], [6], [13], [16]

The above table represents the chemical composition of Sugarcane bagasse ash (SCBA). It also represents the different chemical components present in the composition with their mass % range. This data is obtained after studying the research paper related to the topic.

Table 4 – Chemical composition of Quarry Sand

Chemical Composition of Quarry Sand		
Component	Mass %	Reference
Silicon dioxide (SiO2)	62.48%	[9], [17]
Aluminum oxide (Al2O3)	18.72%	[9], [17]
Ferric oxide (Fe2O3)	6.54%	[9], [17]
Calcium oxide (CaO)	4.83%	[9], [17]
Magnesium oxide (MgO)	2.56%	[9], [17]
Sodium oxide (Na2O)	Nil	[9], [17]

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Potassium oxide (K2O)	3.18%	[9], [17]
Titanium dioxide (TiO2)	1.21%	[9], [17]
Loss of Ignition	0.48%	[9], [17]

The above table represents the chemical composition of Quarry Sand. It also represents the different chemical components present in the composition with their mass % values. This data is obtained after studying the research paper related to the topic.

C. Mix Proportioning:

The M25 grade of concrete is selected having a nominal mix proportion of 1:1:2 as the base. The W/C ratio selected for the mix proportions is 0.45.

Five batches of concrete mixes were prepared.Batch no. 1 - M25 grade concrete ordinary mix, Batch no. 2 - M25 grade + 20% replacement of Sand by QS,Batch no. 3 - M25 grade +10% replacement of Cement by SCBA +10% replacement of Sand by QS, Batch no. 4 - M25 grade +20% replacement of Cement by SCBA +20% replacement of Sand by QS, andBatch no. 5 - M25 grade +30% replacement of Cement by SCBA +30% replacement of Sand by QS.

D. Casting of Specimen:

Fig . Casting of the specimens

Mould size of 150x150x150mm was selected and used to cast the specimens for the compression test. The aggregate size of 20mm was selected to use in the casting. The specimens were cast and tested at the age of 7days, 14days, and 28days after curing.

IV. TEST PERFORMED

Fig . Slump cone test and Compression test

A. **Slump cone test:** The slump cone test is conducted to check the workability of freshly made concrete. It measures the consistency of freshly made concrete before it sets. The slump cone test is performed on all 5 batches of concrete mix and the result is given further in tabular form.

B. **Compression test:**The slump cone test is conducted to check the workability of freshly made concrete. It measures the consistency of freshly made concrete before it sets. The slump cone test is performed on all 5 batches of concrete mix and the result is given further in tabular form.

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V. RESULTS

A. Slump cone test results:

Table 5 – Slump cone test results

Batch No.	Slump value	Slump type	Images
Batch no. 1 - M25 grade concrete ordinary mix	96mm	Shear slump	
Batch no. 2 - M25 grade + 20% replacement of Sand by QS	30mm	True slump	
Batch no. 3 - M25 grade +10% replacement of Cement by SCBA +10% replacement of Sand by QS	65mm	Shear slump	
Batch no. 4 - M25 grade +20% replacement of Cement by SCBA +20% replacement of Sand by QS	69mm	Shear slump	
Batch no. 5 -M25 grade +30% replacement of Cement by SCBA +30% replacement of Sand by QS	75mm	Shear slump	

B. Compression test results:

Table 6 - Compressive strength after 7 days of curing

Batch no.	Compressive strength after 7 days of curing (N/mm2)			Average value (N/mm2)
	Specimen - 1	Specimen - 2	Specimen - 3	
Batch no – 1	20	20.19	21.7	20.63
Batch no – 2	23.1	24.6	22.3	23.33
Batch no – 3	22.4	21.6	18.5	20.83
Batch no – 4	16.7	19.8	20.3	18.93
Batch no – 5	15.1	16.4	20.5	17.33

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Table 7 - Compressive strength after 14 days of curing

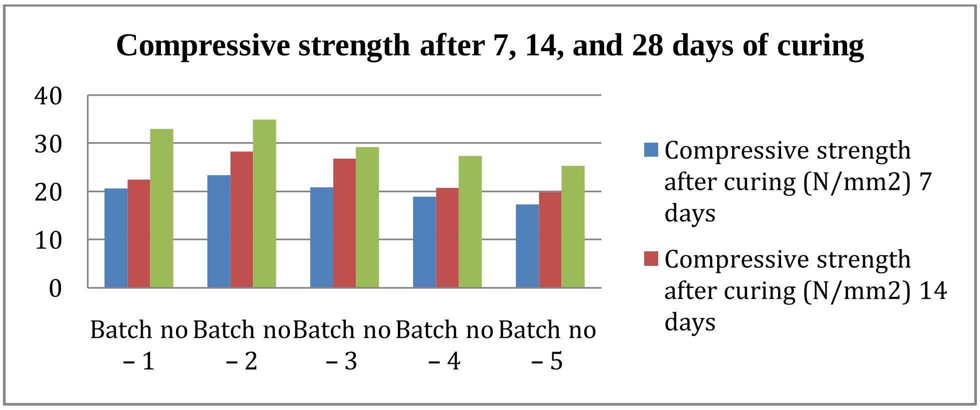
Batch no.	Compressive strength after 14 days of curing (N/mm2)			Average value (N/mm2)
	Specimen - 1	Specimen - 2	Specimen - 3	
Batch no – 1	21.9	22.1	23.3	22.43
Batch no – 2	26.8	28.5	29.6	28.3
Batch no – 3	30.1	24.1	26.2	26.8
Batch no – 4	21.1	20.7	19.9	20.77
Batch no – 5	18.7	19.2	21.7	19.87

Table 8 - Compressive strength after 28 days of curing

Batch no.	Compressive strength after 28 days of curing (N/mm2)			Average value (N/mm2)
	Specimen - 1	Specimen - 2	Specimen - 3	
Batch no – 1	30.8	33.6	34.6	33
Batch no – 2	30.5	35.9	38.3	34.9
Batch no – 3	31.9	27	28.6	29.17
Batch no – 4	28.4	27.6	26.1	27.37
Batch no – 5	26.4	25.3	24.2	25.3

Table 9 - Compressive strength after 7, 14, and 28 days of curing

Batch no.	Compressive strength after curing (N/mm2)		
	7 days	14 days	28 days
Batch no – 1	20.63	22.43	33
Batch no – 2	23.33	28.3	34.9
Batch no – 3	20.83	26.8	29.17
Batch no – 4	18.93	20.77	27.37
Batch no – 5	17.33	19.87	25.3



The above tables represent the results obtained after the test performed on the concrete and concrete specimens. Table no. 5 represents the slump obtain for all 5 batches of concrete mix. Table no.6 represents the compressive strength value after curing of 7 days. Table no.7 represents the compressive strength value after curing of 14 days. Table no.8 represents the compressive strength value after curing of 28 days. Table no.9 represents the average compressive strength value after curing of 7, 14, and 28 days. The graph represents the graphical comparison of values in table no.9.

VI. CONCLUSION

Based on the above discussions, the following conclusions are drawn,

1. The presence of quarry sand as a replacement for sand in concrete reduces the workability of the concrete.
2. The concrete mix in which only sand is partially replaced by quarry sand gives higher compressive strength than ordinary and other

concrete mixes. It represents that the use of quarry sand in concrete improves strength.

3. The concrete mixes in which cement is partially replaced by SCBA and sand is partially replaced by quarry sand show a medium level (Slump value: 50 – 100mm) of workability.
4. When a certain % of SCBA is introduced as a replacement of cement in the concrete which has the same % of quarry sand as a replacement of sand it improves the workability of the concrete and the strength of the concrete.
5. From the results, it is observed that when 10% of cement and sand are replaced by SCBA and quarry sand respectively it gives good compressive strength than 20% and 30%replacement of cement and sand by SCBA and quarry sand respectively. But it is slightly lower than the ordinary mix of M25 grade.
6. From the results, it is observed that when 20% of cement and sand are replaced by SCBA and quarry sand respectively it gives good compressive strength than 30% replacement of cement and sand by SCBA and quarry sand respectively. But it is slightly lower than the ordinary mix of M25 grade and 10% replacement of cement and sand by SCBA and quarry sand respectively.
7. From the results, it is observed that with the increasing replacement percentage the compressive strength of the concrete reduces.
8. From the results, it can be concluded that 10% to 20% replacement of cement and sand by SCBA and quarry sand is possible without a big change in compressive strength.

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