EXPERIMENTAL STUDY ON BAGASSE ASH AND ITS STRENGTH ON M25 & M30 GRADE CONCRETE

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Abstract - *The utilization of industrial and agricultural waste produced by industrial processes has been the focus of waste reduction research for economical, environmental, and technical reasons. Sugar-cane bagasse is a fibrous waste-product of the sugar refining industry, along with ethanol vapor. This waste product (Sugar-cane Bagasse ash) is already causing serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminum ion and silica. In this paper, Bagasse ash has been chemically and physically characterized, and partially replaced by weight of cement in concrete. Fresh concrete tests like compaction factor test and slump cone test were undertaken was well as hardened concrete tests like compressive strength, Tensile strength & NDT was obtained. A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement. Therefore, it is possible to use sugarcane bagasse ash as cement replacement material to improve quality and reduce the cost of construction materials.*

Key Words: **Bagasse Ash (BA), Quarry Dust (QD)**

1. INTRODUCTION

Concrete is the most popular building material in the world. However, the production of cement has diminished the limestone reserves in the world and requires a great consumption of energy. River sand has been the most popular choice for the fine aggregate component of concrete in the past, but overuse of the material has led to environmental concerns, the depleting of securable river sand deposits and a concomitant price increase in the material. Therefore, it is desirable to obtain cheap, environmentally friendly substitutes for cement and river sand that are preferably by products.

This paper is generated from a research project designed to determine whether benefits could be obtained by the use of Bagasse ash and Quarry dust materials together and to quantify benefits of concrete. Positive results will lead to the possibility of using the two by products in large quantities, while reducing the dependency on chemical admixtures.

2. BAGASSE ASH

Researchers all over the world today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for industry. This waste, utilization would not only be economical, but may also result in foreign exchange earnings and environmental pollution control. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties.

A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement.

2.1 Composition of Bagasse ash

The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO_2). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests and bagasse ash was collected during the cleaning operation of a boiler operating system.

2.2 Quarry Dust in Concrete

Quarry sand when mixed with concrete results in increasing the compressive strength and flexural strength. Durability of the structure is increased to about 10% of that of the conventional concrete and decreases the cost.

Table -1: Chemical Composition Ashes

Property	Quarry rock dust
Specific gravity	2.54-2.60
Bulk relative density (kg/m3)	1720-1810
Absorption (%)	1.20-1.50
Moisture content (%)	Nil
Sieve analysis	Zone II
Fine particles less than 0.075mm	12-15

Table -2: Chemical Composition Ashes

Component	Bagasse Ash (%)	Quarry rock dust (%)
SiO_2	78.34	62.48
Al_2O_3	-	18.72
Al_2	8.55	-
Fe_2O_3	-	06.54
FeO_2	3.61	-
CaO	2.15	04.83
Na_2O	0.12	-
K_2O	3.46	03.18
MgO	-	02.56
MnO	0.13	-
TiO_2	0.50	-
BaO	<0.16	-
TiO_2	-	01.21
P_2O_5	1.07	-
Loss of ignition	0.42	00.48

3. EXPERIMENTAL STUDY ON CONCRETE

A mix must be workable enough to fill the form spaces completely, with the assistance of a reasonable amount of shoveling, spading, and vibrating. Since a fluid or runny mix does this more readily than a dry or stiff mix, one can see that workability varies directly with fluidity. The weigh batched materials are hand mixed in pans separately for preparing the conventional concrete and bagasse ash concrete. The workability characteristics of mix were determined by the slump test, flow table test and compaction factor test. These tests are in accordance with relevant Indian standards.

3.1 Workability Test

The internal surface of the mould was thoroughly cleaned and free from superfluous moisture and any set concrete before commencing the test. The mould was placed on a metal pan which was smooth, horizontal, rigid and non-absorbent. The mould was carefully filled in four layers, each approximately one quarter of the height of the mould. Each layer was stamped with the tamping rod. The strokes were distributed in a uniform manner over the cross section of the mould and for the second and subsequent layers penetrated into the under lying layer. The bottom layer was tamped throughout the depth. After the top layer was rotted, the concrete was struck off level with a trowel such that the mould was exactly filled. The mortar which has leaked out between the mould and base plate was cleaned away. The mould was removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allowed the slump to subside and the slump was measured immediately by determining the difference between the height of the mould and that of the highest point of the specimen being tested. The slump measured was recorded in terms of mm of subsidence of the specimen during the test.

Slump = (30-25.4) = 4.6 cm = 46 mm

3.2 Compaction Factor Test

The apparatus consist of 2 hopper vessels A and B provided with hinged doors at their bottom. A cylindrical vessel B is opened so that the concrete falls into the vessel B. after this; hinged door of the vessel B is opened so that the concrete will fall into the cylinder C. The surplus concrete from this cylinder is struck off with steel floats. The contents of the cylinder are again filled with the sample in 5 cm layers. The concrete is being compacted by ramming and vibrating and then weighed to find compaction factor.

The compaction factor = 0.96

3.3 COMPRESSIVE AND TENSILE STRENGTH TEST FOR CUBE WITHOUT QD

As per IS 516:1959 Compression test was carried out on the three samples in each proportion were tested and the strength was obtained as an average. The individual variation of specimens was not more than ± 15 percent of the average. The specimens stored in water were tested immediately on the removal from grid were wiped off the specimens and any projecting pins removed. The dimensions of the specimens were recorded before testing.

$$f_c = P/A \quad N/mm^2$$

Where, P = Load at which the specimen fails in N.
A = Area over which the load is applied in mm^2.
f = compressive stress in N/mm^2.
Compressive Strength of Cube:
Replacement: Bagasse ash 0%, 10%, 20%, 25% and 30% of cement weight
Size of cube: 150x150x150mm

Table -3: Compressive Strength of M25 Concrete without QD

Trial	Days	0% BA	10% BA	20% BA	25% BA	30% BA
Average	7	16.33	17.83	12.61	10.94	9.53
Average	14	20.68	21.95	18.03	15.92	14.15
Average	28	27.60	28.62	26.78	23.70	21.13

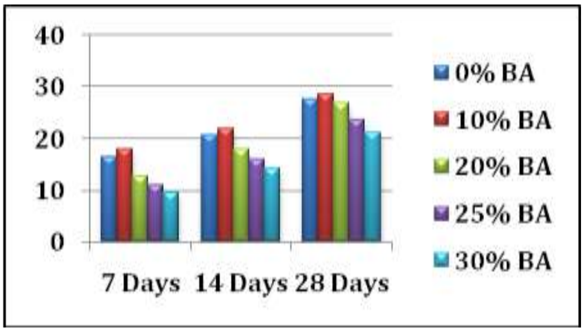

Chart -1: Compressive Strength of M25 Concrete without QD

Table -4: Compressive Strength of M30 Concrete without QD

Trial	Days	0% BA	10% BA	20% BA	25% BA	30% BA
Average	7	19.60	21.40	15.13	13.13	11.45
Average	14	24.81	26.34	21.63	19.11	16.98
Average	28	33.11	34.34	32.13	28.43	25.35

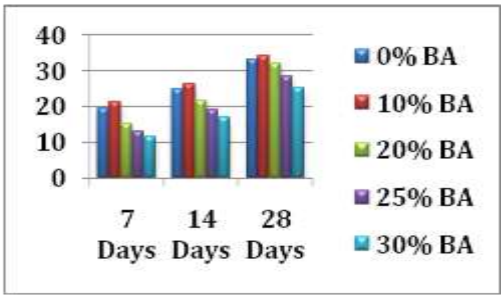

Chart -2: Compressive Strength of M30 Concrete without QD

Table -5: Tensile Strength of M25 Concrete without QD

Trial	Days	0% BA	10% BA	20% BA	25% BA	30% BA
Average	7	0.82	0.92	0.80	0.62	0.52
Average	14	1.22	1.44	1.06	0.93	0.83
Average	28	2.31	2.43	2.29	2.10	1.96

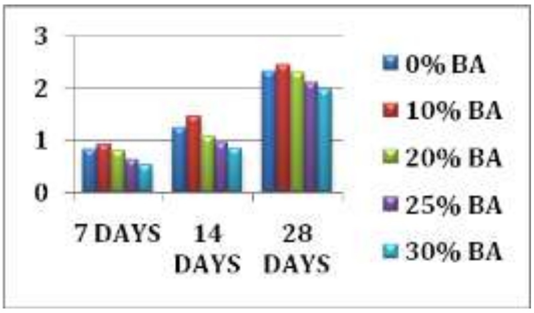

Chart -3: Tensile Strength of M25 Concrete without QD

Table -6: Tensile Strength of M30 Concrete without QD

Trial	Days	0% BA	10% BA	20% BA	25% BA	30% BA
Average	7	0.82	0.92	0.80	0.62	0.52
Average	14	1.22	1.44	1.06	0.93	0.83
Average	28	2.31	2.43	2.29	2.10	1.96

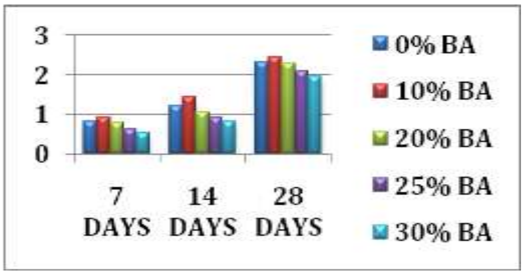

Chart -4: Tensile Strength of M30 Concrete without QD

3.3 SPLIT TENSILE STRENGTH TEST FOR CYLINDER WITHOUT QD

The cylindrical specimens were tested for split tensile strength at an age of 7 and 14 days. The specimen were submerged in clean fresh water in a curing tank and kept there until taken out just prior to test. The specimens are not to be allowed to become dry at any time until they have been tested. The specimens are tested immediately on removal from the water whilst they are still in a wet condition. The dimensions of the specimens and their weight were recorded before testing. Three specimens were tested for each percentage at 7 and 14days and average of three was taken. The size of the specimen is 10cm diameter and 20cm height.

$$f_t = 2P/\pi LD$$

Where,
P = Load on the cylinder in N.
L = Length of the cylinder in mm.
D = Diameter of the cylinder in mm.

Table -7: Split Tensile Strength of M25 Concrete without QD

Trial	Days	0% BA	10% BA	20% BA	25% BA	30% BA
Average	7	0.75	0.89	0.77	0.52	0.39
Average	14	0.82	0.92	0.80	0.62	0.52
Average	28	1.56	1.86	1.59	1.29	1.09

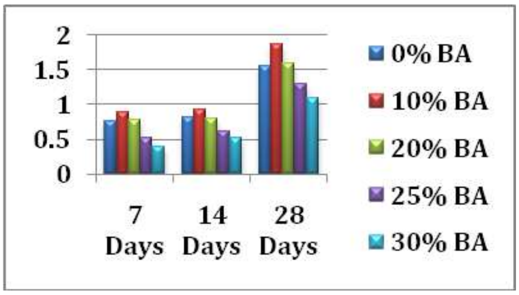

Chart -5: Split Tensile Strength of M25 Concrete without QD

Table -8: Spilt Tensile Strength of M30 Concrete without QD

Trial	Days	0% BA	10% BA	20% BA	25% BA	30% BA
Average	7	0.90	1.06	0.94	0.64	0.49
Average	14	0.98	1.05	0.95	0.71	0.62
Average	28	1.87	2.33	1.91	1.54	1.30

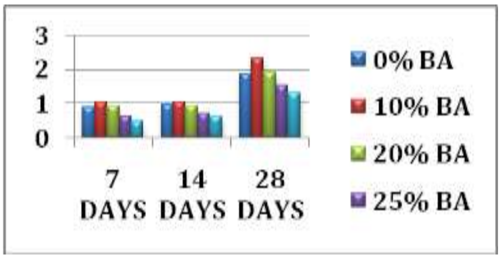

Chart -6: Split Tensile Strength of M30 Concrete without QD

3.4 E FOR CONCRETE ON CYLINDER WITHOUT QD

Concrete cylinder to be tested is measured for the diameter of 200mm and height of 100mm for specimen calculation using measuring scale.

The dial gauge is fixed to concrete cylinder which is used to measure the deflection. For every increment of loading by uniaxial compression, the deformation is measured by means of dial gauge fixed between certain gauge lengths. The process of loading is repeated for three different specimens till is fails.

The load at which the concrete cylinder fails and the change in length of the specimen is measured. Then the Young's Modulus of each specimen is calculated.

Table -9: E FOR CONCRETE ON M25 GRADE WITHOUT QD

Sample	Days	Concrete with 0% BA	Concrete with 10% BA	Concrete with 20% BA
		Value of E (N/mm^2)	Value of E (N/mm^2)	Value of E (N/mm^2)
Avg	7	32.80	32.83	26.83
Avg	14	32.33	33.02	27.35
Avg	28	32.11	33.78	26.84

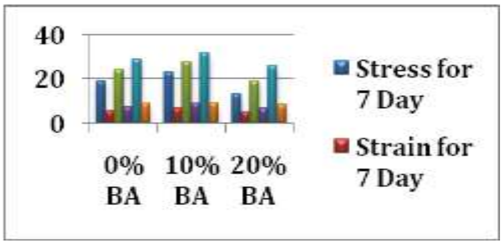

Chart -7: E FOR CONCRETE ON M25 GRADE WITHOUT QD

Table -10: E FOR CONCRETE ON M30 GRADE WITHOUT QD

Sample	Days	Concrete with 0% BA	Concrete with 10% BA	Concrete with 20% BA
		Value of E (N/mm^2)	Value of E (N/mm^2)	Value of E (N/mm^2)
Average	7	33.66	34.29	26.43
Average	14	33.20	33.81	26.54
Average	28	32.50	34.18	27.29

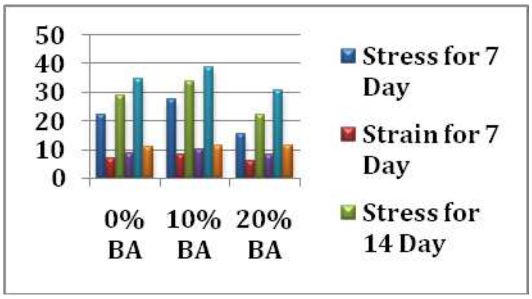

Chart -8: E FOR CONCRETE ON M30 GRADE WITHOUT QD

4. ANALYSIS

It is found that replacement of cement with 10% Bagasse ash gives more strength than the conventional concrete. So maintaining 10% Bagasse ash with cement and replacing the fine aggregate of sand with Quarry dust, the strength of the concrete is found out.

5. EXPERIMENTAL STUDY ON CONCRETE WITH QD

5.1 COMPRESSIVE AND TENSILE STRENGTH TEST FOR CUBE WITH QD

Table-11: Compressive Strength of M25 Concrete with QD

Trial	Days	0% BA & QD	10% BA without QD	10% BA with QD
Average	7	16.33	17.83	17.08
Average	14	20.68	21.95	21.54
Average	28	27.60	28.62	27.94

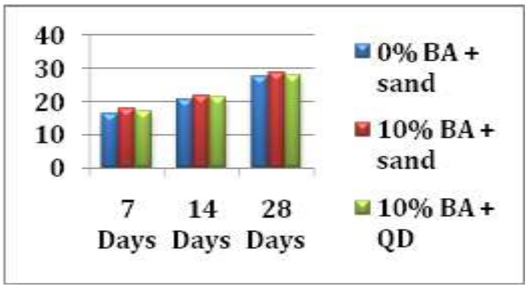

Chart -9: Compressive Strength of M25 Concrete with QD

Table-12: Compressive Strength of M30 Concrete with QD

Trial	Days	0% BA & QD	10% BA without QD	10% BA with QD
Average	7	19.60	21.40	20.69
Average	14	24.81	26.34	25.63
Average	28	33.11	34.34	32.44

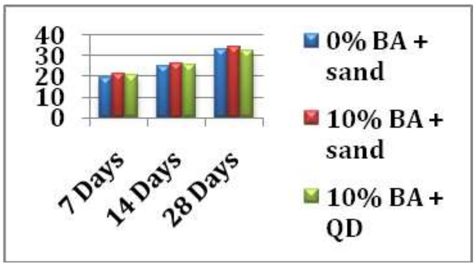

Chart-10: Compressive Strength of M30 Concrete with QD

Table-13: Tensile Strength of M25 Concrete with QD

Trial	Days	0% BA & QD	10% BA without QD	10% BA with QD
Average	7	0.82	0.92	0.87
Average	14	1.22	1.44	1.38
Average	28	2.31	2.43	2.36

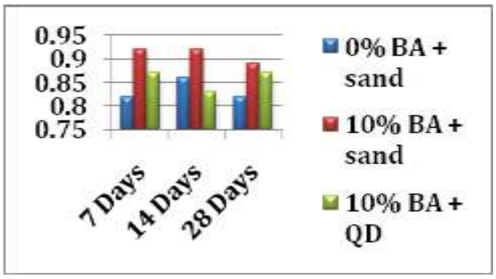

Chart-11: Tensile Strength of M25 Concrete with QD

Table -14: Tensile Strength of M30 Concrete with QD

Trial	Days	0% BA & QD	10% BA without QD	10% BA with QD
Average	7	0.98	1.11	0.95
Average	14	1.47	1.73	1.58
Average	28	2.77	2.91	2.65

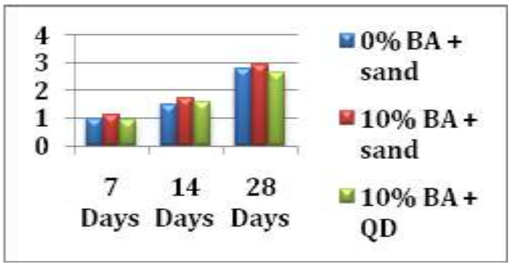

Chart-12: Tensile Strength of M30 Concrete with QD

5.2 SPLIT TENSILE STRENGTH TEST FOR CYLINDER WITH QD

Table -15: Split Tensile Strength of M25 Concrete with QD

Trial	Days	0% BA & QD	10% BA without QD	10% BA with QD
Average	7	0.75	0.89	0.82
Average	14	0.82	0.92	0.88
Average	28	1.56	1.86	1.80

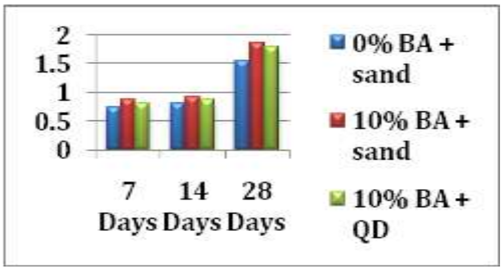

Chart-13: Split Tensile Strength of M25 Concrete with QD

Table -16: Spilt Tensile Strength of M30 Concrete with QD

Trial	Days	0% BA & QD	10% BA without QD	10% BA with QD
Average	7	0.90	1.06	0.91
Average	14	0.98	1.05	0.88
Average	28	1.87	2.23	1.99

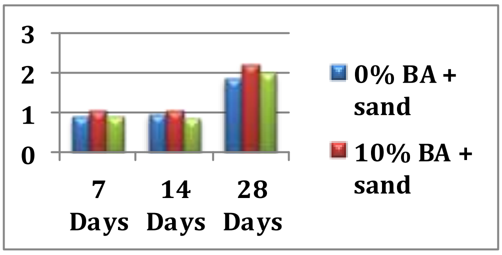

Chart-14: Split Tensile Strength of M30 Concrete with QD

5.3 E FOR CONCRETE ON CYLINDER WITH QD

Table -17: E FOR CONCRETE ON M25 GRADE WITH QD

Sample	Days	Concrete with 0% BA + Sand	Concrete with 10% BA + Sand	Concrete with 10% BA + QD
		Value of E (N/mm^2)	Value of E (N/mm^2)	Value of E (N/mm^2)
Average	7	32.80	32.83	36.85
Average	14	32.33	33.02	32.00
Average	28	32.11	33.78	26.84

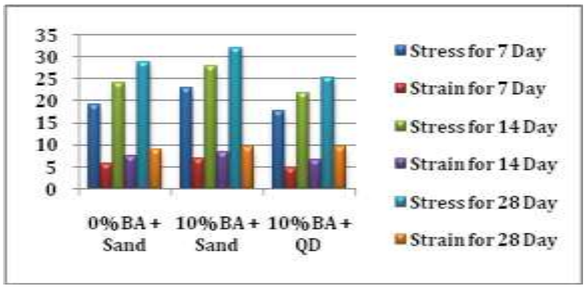

Chart-15: E FOR CONCRETE ON M25 GRADE WITH QD

Table -18: E FOR CONCRETE ON M30 GRADE WITH QD

Sample	Days	Concrete with 0% BA + Sand	Concrete with 10% BA + Sand	Concrete with 10% BA + QD
		Value of E (N/mm^2)	Value of E (N/mm^2)	Value of E (N/mm^2)
Average	7	33.66	34.29	32.39
Average	14	33.20	33.81	30.65
Average	28	32.50	34.18	28.79

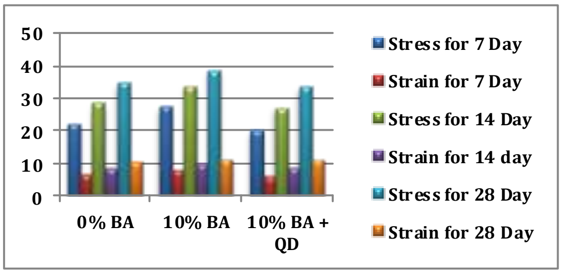

Chart-16: E FOR CONCRETE ON M30 GRADE WITH QD

6. CONCLUSIONS

The results show that the Sugar Cane Bagasse Ash (SCBA) in blended concrete had significantly higher compressive strength and tensile strength compare to that of the concrete without SCBA. It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 20%. Although, the optimal level of SCBA content was achieved with 10% replacement.

The compressive strength and tensile strength of normal concrete and 20% replacement of SCBA with cement are almost equal. The replacement of cement with SCBA 25% & 30% result is comparatively lower than normal concrete.

The full replacement of fine aggregate with optimal level of SCBA content 10% concrete has also achieved significant level on both compressive and tensile strength.

Since it is a byproduct, the initial cost of bagasse ash is minimal compared to that of Portland cement and that reduces the cost of concrete. Using larger amount of bagasse ash in concrete reduces bagasse ash disposal cost. By reducing the volume of bagasse ash landfills the air pollution can be decreased.

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