Green Concrete using Agro Industrial Waste (Sugarcane Bagasse ASH)

M. S. Chennakesava Rao, N. V. N. Prabath

Abstract*— Today researches 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. These wastes utilization would not only be economical, but may also help to create a sustainable and pollution free environment. The utilization of industrial and agricultural waste produced by industrial processes has been the focus of waste reduction research for economic, 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 has mainly contained silica and aluminum ion. In this project, the Bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 10%, 15% and 25% by the weight of cement in concrete. The bagasse ash was then ground until the particles passing the 90 µm sieve size reach about 85% and the specific surface area about 4716 cm^2/gm.Ordinary Portland cement was replaced by ground bagasse ash at different percentage ratios. The compressive strengths of different mortars with bagasse ash addition were also investigated. M25 concrete mixes with bagasse ash replacements of 0%, 5%, 10%, 15%, 20% and 25% of the Ordinary Portland cement were prepared with water-cement ratio of 0.42 and cement content of 378 kg/m^3 for the control mix. I will test fresh concrete tests like slump cone test where under taken as well as hardened concrete test like compressive strength, split tensile strength, flexural strength at the age of 7days, 28 days and 90 days was obtained. The test results indicated that up to 10% replacement of cement by bagasse ash results in better or similar concrete properties and further environmental and economic advantages can also be exploited by using bagasse ash as a partial cement replacement material ..

***Index Terms*— Baggase ash, Fibrous waste product.**

I. INTRODUCTION

The industrial and economic growth witnessed in recent decades has brought with it an increase in the generation of different types of waste (urban, industrial, construction etc.) despite the waste management policies which have been adopted nationally and internationally the practice of dumping and/or the inadequate management of waste from the various manufacturing sectors have had a notable impact on the receiving environment.

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Bagasse is a byproduct of the sugarcane industry. The burning of bagasse leaves bagasse ash as a waste, which has a pozzolanic property that would potentially be used as a cement replacement material. It has been known that the worldwide total production of sugarcane is over 1500 million tons. Despite variety use of bagasse, for production of wood, papers, animal food, compost and thermal insulation, statistics show that about one million tone extra of bagasse ash remains in the country.Sugarcane consists about 30% bagasse whereas the sugar recovered is about 10%, and the bagasse leaves about 8% bagasse ash (this figure depend on the quality and type of the boiler, modern boiler release lower amount of bagasse ash) as a waste. As the sugar production is increased, the quantity of bagasse ash produced will also be large and the disposal will be a problem.Sugarcane bagasse ash has recently been tested in some parts of the world for its use as a cement replacement material. The bagasse ash was found to improve some properties of the paste, mortar and concrete including compressive strength and water tightness in certain replacement percentages and fineness. The higher silica content in the bagasse ash was suggested to be the main cause for these improvements. Concrete is used in such large amounts because it is, simply, a remarkably good building material not just for basic road construction but also for rather more glamorous projects.Concrete production is responsible for so much CO_2 because making Portland cement not only require significant amounts of energy to reach reaction temperatures of up to 1500°C, but also because the key reaction itself is the breakdown of calcium carbonate into calcium oxide and CO_2. Of those 800kg of CO_2 around 530kg is released by the limestone decomposition reaction itself.Concrete is the world's most utilized construction material.

II. SCOPE OF WORK

A. Laboratory tests on cement, fine aggregate, coarse aggregate, bagasse ash, water.Whatever may be the type of concrete being used, it is important to mix design of the concrete. The same is the case with the industrial waste based concrete or bagasse ash replacement. The major work involved is getting the appropriate mix proportions.In the present work, the concrete mixes with partial replacement of cement with bagasse ash were developed using OPC 53 grade cement. A simple mix design procedure is adopted to arrive at the mix proportions. After getting some trail mix, cubes of dimensions 150 mm *150 mm *150 mm, cylinder of dimensions 150mm*300 mm and beams of dimensions 100mm*100mm*150mm was casted and cured in the curing tank. Compressive strength, Split tensile strength and Flexural strength of concrete were conducted to know the strength properties of the mixes. Initially, a sample mix design was followed and modifications were made accordingly while arriving at the trail mixes to get optimized mix which satisfies both fresh, hardened properties and the economy. Finally, a simple mix design is proposed.

III. SUGARCANE BAGASSE ASH

The sugarcane bagasse ash 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 sugarcane harvests. In this sugarcane bagasse ash was collected during the operation of boiler operating in the Nava Bharat Ventures Sugar Factory, located in the Samalkot, East Godavari District, Andhra Pradesh

Physical Properties of Bagasse Ash

Properties	Values
Specific Gravity	2.20
Colour	Black
Density (gm/cm^3)	1.20
Moisture content	6.28%

Chemical properties of bagasse ash

Components	Mass %
Silica as SiO_2	70.5
Calcium as CaO	4.7
Potassium as k_2O	12.16
Iron as Fe_2O_3	1.89
Sodium as Na_2O	3.82
Aluminum as Al_2O_3	1.36
Magnesium as MgO	4.68
Titanium as TiO_2	< 0.06

Physical properties of fine aggregate

S. No	Property	Value
1	Specific gravity	3.08
2	Fineness modulus	3.48
3	Bulk density: Loose Compacted	 14kN/m^3 15kN/m^3
4	Grading	Zone-II

Physical properties of cement

S. No	Property	Test results
1	Normal consistency	29%
2	Specific gravity	3.10
3	Initial setting time	92 minutes
4	Final setting time	195 minutes

Sieve analysis of fine aggregate

Sieve size	Retained	% retained	Cumulative % retained	%passed
4.75	-----	----	-----	100
2.36	6.5	0.65	6.5	99.3
1.18	80.5	8.7	87	91.3
600	149	23.6	236	76.4
300	733	96.9	969	3.1
150	15	98.4	98.4	1.6
Pan	16	100	1000	0

Physical properties of coarse aggregate

S. No	Property	Value
1	Specific gravity	2.69
2	Fineness modulus	3.02
3	Bulk density Loose Compacted	 14 kN/m^3 16 kN/m^3
4	Nominal maximum size	20 mm

IV. MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredients of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depending upon many factors, e.g. w/c ratio quality and quantity of cement, water, aggregate, batching, placing, compaction and curing. The cost of concrete is made up of the cost of material, plant and labour.

The variation in the cost of material arise from the fact that the cement is several times costly than the aggregates, thus the aim is to produce as lean a mix as possible.The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quality control adds to the cost of concrete. The cost of labour depends on the workability of mix.

Design of M25 grade concrete:

Stipulations for proportioning:

a) Grade designation : M25

b) Type of cement : OPC 53grade confirming

c) Minimum Cement content : 300 kg/m³

d) Maximum nominal size of aggregate : 20 mm

e) Maximum water – cement ratio : 0.5

f) Workability

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: 100 mm (slump)

g) Exposure condition : Moderate

h) Method of concrete placing : Non Pumpable

i) Degree of supervision : Good

j) Type of aggregate : Crushed angular aggregate

Test data for materials:

a) Cement used : OPC 53 grade confirming IS: 12269

b) Specific gravity of cement : 3.10

c) Mineral admixture : -----------

d) Specific gravity of

1) Coarse aggregate : 2.69

2) Fine aggregate : 3.08

3) Bagasse Ash : 2.3

e) Water absorption

1) Coarse aggregate : 0.5%s

2) Fine aggregate : 1.0%

f) Free (Surface) moisture

1) Coarse aggregate : NIL

2) Fine aggregate : NIL

g) Sieve analysis

Fine aggregate : Confirming to grading Zone II of Table 4 of IS: 383

Target strength for mix proportioning:

$f'_{ck} = f_{ck} + 1.65S$

= 25+1.65 × 4

= 31.60 N/mm²

Where

f'_{ck} =target average compressive strength at 28 days

f'_{ck} = characteristic compressive strength at 28 days

S = standard deviation

From Table 1of IS 10269:2009, standard deviation(s) = 4 N/mm²

Target strength = 31.60 N/mm²

Selection of water-cement ratio:

From Table 5 of IS 456, maximum water cement ratio = 0.45

Based on experience, adopt w/c=0.42

0.42< 0.45 hence O.K

Selection of water content:

From Table 2 of IS 10262:2009 maximum water = 186 litres (for 25 to 50 mm

Slump range) for 20mm aggregate

Estimated water content for 100mm slump = 150 + $\frac{6}{100} \times 150$ =159litres

Calculation of cement content:

Water-cement ratio = 0.42

Cement content = $\frac{159}{0.42}$

=378.57kg/m³

From Table 5 of IS 456 minimum cement content

For 'Moderate' exposure condition = 300kg/m³

378.57kg/m³> 300 kg/m³, hence, O.K

Proportion of volume of coarse aggregate and fine aggregate content:

B. Figures and Tables

From Table 3 of IS: 10262-2009

Volume of coarse aggregate corresponding to 20mm size aggregate &fine aggregate (Zone 2)

For water-cement ratio of 0.50= 0.62

But our water content is 0.42. Therefore water cement ratio lovers by 0.08, the proportion of

Volume of coarse aggregate is increased by 0.02 (@ of -/+ 0.01 for every 0.05 change in w/c ratio)

Volume of Coarse aggregate for the water - cement ratio 0.42 = 0.64

Volume of fine aggregate = 1-0.64

= 0.36

Mix calculations:

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m³

b) Volume of cement = $\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

$= \frac{378}{3.10} \times \frac{1}{1000}$

= 0.122 m³

c) Volume of water = $\frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000}$

$= \frac{159}{1} \times \frac{1}{1000}$

= 0.159 m³

d) Volume of admixture = Nil

e) Volume of all in aggregate = [a – (b + c + d)]

= 1-(0.122+0.159)

= 0.719m³

f) Mass of coarse aggregate = e × Volume of CA × Specific gravity of CA x 1000

= 0.719 × 0.64 × 2.69 × 1000

= 1238 kg

g)Mass of fine aggregate = e × Volume of FA× Specific gravity of FA × 1000

= 0.719 × 0.36 × 3.08 × 1000

= 797 kg

Mix proportions for trail:

Cement = 378 kg/ m³

Water = 159litre

Fine aggregate: = 797kg

Coarse aggregate = 1238kg

Water Cement ratio = 0.42

V. TEST RESULTS

A. The experimental observations discussed are presented. Observations of slump and compaction factor in respect of fresh concrete are noted. The test results such as compressive strength, split tensile strength and flexural strength of hardened concrete of M25 grade replacement of cement with bagasse ash in the ratio of 0%, 5%, 10%, 15%, 20% and 25% proportions mixes at the ages of 7 days , 28 days and 90 days are detailed**.**Compressive strength of concrete tested on cubes at different partial replacement of bagasse ash was tested in water curing tank and the test results were shown in below.

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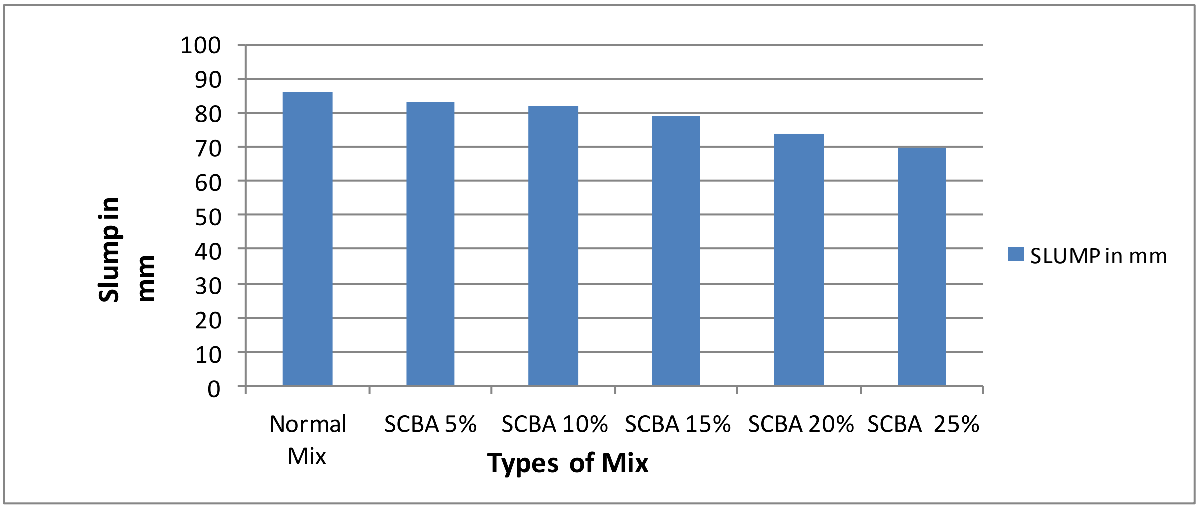
Slump cone test results

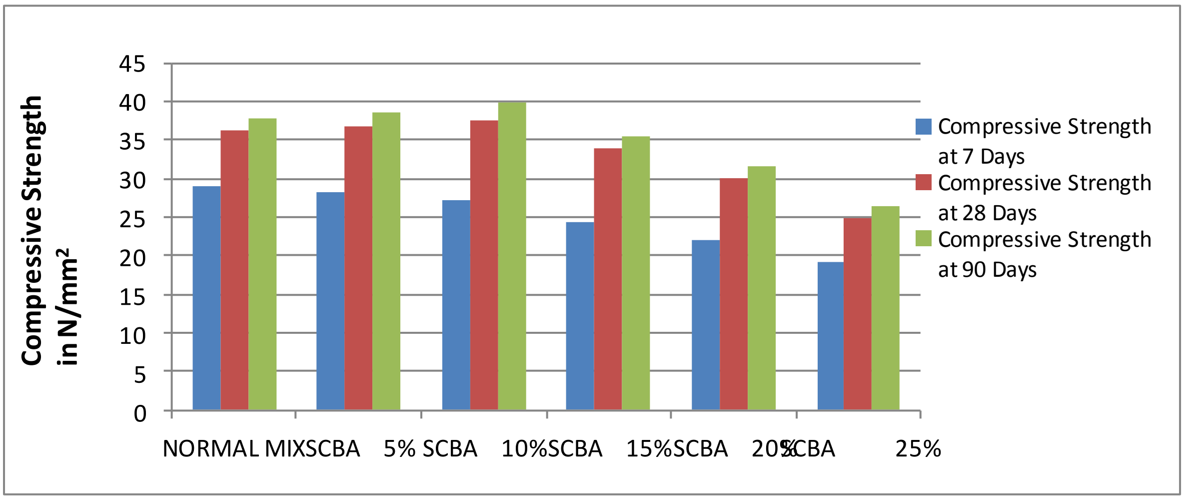
S.No	Mix Id	Slump (mm)
1	NORMAL MIX	86
2	SCBA 5%	83
3	SCBA 10%	82
4	SCBA 15%	79
5	SCBA 20%	74
6	SCBA 25%	70



Slump test vs Mix

S.No	Mix id	Compressive Strength (N/mm^2)		
		7 Days	28 Days	90 Days
1	NORMAL MIX	29.13	36.18	37.93
2	SCBA 5%	28.15	36.89	38.67
3	SCBA 10%	27.26	37.52	39.85
4	SCBA 15%	24.44	33.93	35.41
5	SCBA 20%	21.93	30.07	31.56
6	SCBA 25%	19.26	24.85	26.52

Compressive strength test results

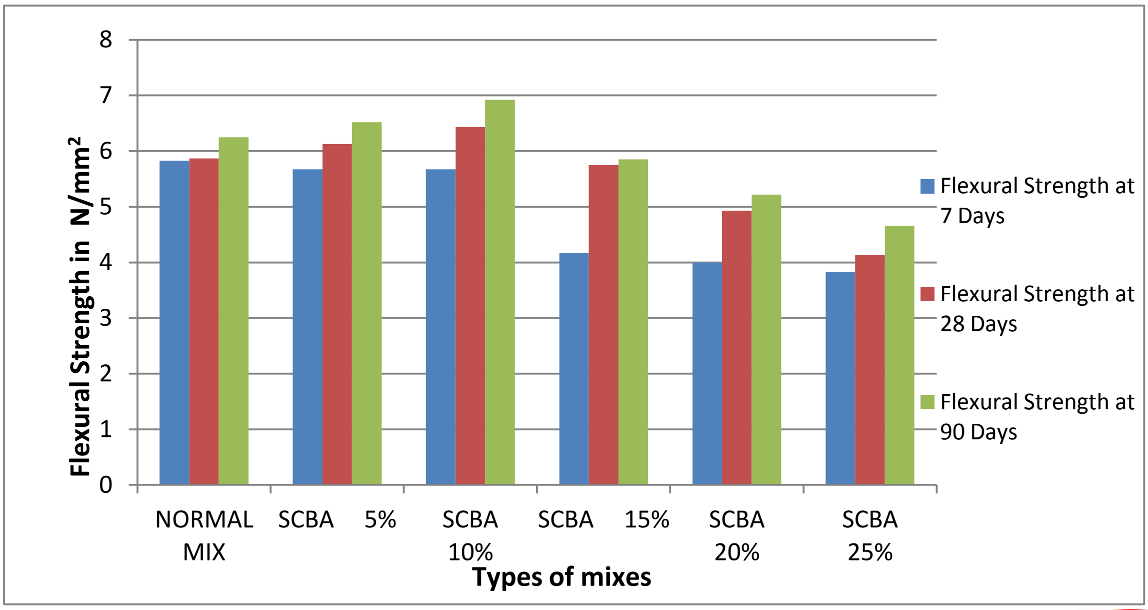


Split tensile strength:

The indirect tensile strength was measured on 150 x 300 mm cylinders and the results were shown below.A total of 54 cylinders were cast for the five mixes. Three specimens were tested each time and the average value at the particular age was reported as the tensile strength of the concrete.

Split tensile strength test results

S.No	Mix id	Split Tensile Strength (N/mm²)		
		7 Days	28 Days	90 Days
1	NORMAL MIX	1.89	2.55	2.64
2	SCBA 5%	1.63	2.59	2.72
3	SCBA 10%	1.60	2.75	2.83
4	SCBA 15%	1.42	2.25	2.31
5	SCBA 20%	1.17	1.92	2.03
6	SCBA 25%	1.06	1.76	1.83



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Flexural Strength graph vs Age

The flexural strength values obtained by testing standard cubes made with different SCBA mixes of 0-25%. The normal mix has strength above 30Mpa in compression as well as in flexure which is required strength.It was observed that the Flexural strength of SCBA 5% at the age of 7 days has decreased by 3% when compared with normal mix. It was observed that the Flexural strength of SCBA 5% at the age of 28 days has increased by a 4.42% when compared with normal mix. It was observed that the Flexural strength of SCBA5% at the age of 90 days has increased by 4.32% when compared with normal mix.It was observed that the Flexural strength of SCBA 10% at the age of 7 days has decreased by 3% when compared with normal mix. It was observed that the Flexural strength of SCBA 10% at the age of 28 days has increased by 9.5% when compared with normal mix, It was observed that the Flexural strength of SCBA 10% at the age of 90 days has increased by 10.72% when compared with normal mix.It was observed that the Flexural strength of SCBA 15% at the age of 7 days has decreased by 28.7% when compared with normal mix. It was observed that the Flexural strength of SCBA 15% at the age of 28 days has decreased by 2.4% when compared with normal mix. It was observed that the Flexural strength of SCBA 15% at the age of 90 days has decreased by 6.4% when compared with normal mix.It was observed that the Flexural strength of SCBA 20% at the age of 7 days has decreased by 31.5% when compared with normal mix. It was observed that the Flexural strength of SCBA 20% at the age of 28 days has decreased by 16.1% when compared with normal mix. It was observed that the Flexural strength of SCBA 20% at the age of 90 days has decreased by 14.88 % when compared with normal mix.It was observed that the Flexural strength of SCBA 25% at the age of 7 days has decreased by 34.32% when compared with normal mix. It was observed that the Flexural strength of SCBA 25% at the age of 28 days has decreased by 29.35% when compared with normal mix. It was observed that the Flexural strength of SCBA 25% at the age of 90 days has decreased by 26% when compared with normal mix.

VI. CONCLUSIONS

Based on the study, following conclusions can draw. The compressive strengths of SCBA mixes at the age of 7 days was gradually decreases its strength when compared with normal mix. It was observed that the compressive strength of SCBA 5% and SCBA 10% at the age of 28 days has reached its target mean strength; however the compressive strength was increased by 2.04% and 6.55% when compared with normal mix. It was observed that the compressive strength of SCBA 15%, SCBA 20% and SCBA 25% at the age of 28 days has decreases its compressive strength by 6.15%, 16.92% and34.13% respectively when compared with the normal mix.The split tensile strength of mixes SCBA 5% and SCBA 10% at the age of 28 days has increases its strengths by 4.42% and 9.5% respectively when compared with the normal mix.The split tensile strength of mix SCBA 15%, SCBA 20%, SCBA 25% at the age of 28 days has decreases it strengths by 11.8%, 24.8% and 32.7% when compared with the normal mix.The flexural strength of SCBA 5%, SCBA 10% at the age of 28 days has increases its strength by 4.42%, 9.5% when compared with the normal mix.Cement can be replaced with bagasse ash up to 10% without much loss in compressive strength.Considerable decrease in compressive strength was observed from 15% cement replacement. It has been shown in this study that 10% sugarcane bagasse ash can be used as a partial cement replacement material with technical and environmental benefits. Concerned stakeholder, such as sugar industries, cement industries and relevant government institutions, should be made aware about this potential cement replacement material and promote its standardized production and usage. Conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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