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Experimental Study on Concrete Using Sugarcane Bagasse Ash

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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 vapour. This waste product (Sugar-cane Bagasse Ash) is already causing serious environmental pollution, which calls for urgent ways of handling the waste.

The cement has been partially replaced by weight with Sugarcane bagasse ash of 0%,5%,10% 15%, 20% and 25%. The mix considered in the present studying was M30. For this mix to find out the fresh concrete test like slump cone test, hardened concrete test like Cubes of size 150mmx150mmx150mm and cylinder size 150 mm in diameter and 300mm long to check the compressive strength and beams of size 500mmx100mmx100mm for checking flexural strength were casted. All the specimens were cured for the period of 7,14 and 28 days before testing

Keywords SCBA, Concrete, ordinary Portland cement, compressive strength, pozzolanic.

1. 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. At the same time, these practices represent an economic cost. How-ever if waste is managed correctly it can be converted into a resource which contributes to savings in raw materials, conservation of natural resources and the climate, and promotes sustainable development.

Sugar cane is one of the most important agricultural plants that is grown in India. Bagasse is a by-product 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 where-as 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 been recently 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. Although the silicate content may vary from ash to ash depending on the burning conditions and other properties of the raw materials including the soil on which the sugarcane is grown, it has been reported that the silicate undergoes a pozzolanic reaction with the hydration products of the cement and results in a reduction of the free lime in the concrete.

2.LITERATURE REVIEW

1) **Ganesan, K.Rajagopal, K.Thangavel, k. (2007)**In this research, few studies have been reported on the use of bagasse ash (BA) as partial cement replacement material in respect of cement mortars. In this study, the effects of BA content as partial replacement of cement on physical and mechanical properties of hardened concrete are reported. The properties of concrete investigated include compressive strength, splitting tensile strength, water absorption, permeability characteristics, chloride diffusion and resistance to chloride ion penetration. The test results indicate that BA is an effective mineral admixture, with 20% as optimal replacement ratio of cement.

2) **Srinivasn, R.(2010)**Studied on Bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 15% and 25% 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, split tensile strength, flexural strength and modulus of elasticity at the age of seven and 28 days was obtained. The result shows that the strength of concrete increased as percentage of bagasse ash replacement increased. This paper reviews the use of bagasse ash as replacement of cement material in concrete.

3) **Hailu, B.Dinku, A.(2012)**In this research, Ordinary Portland cement and Portland Pozzolana cement were replaced by ground bagasse ash at different percentage ratios. The compressive strengths of different mortars with bagasse ash addition were also investigated. Four different M-35 concrete mixes with bagasse ash replacements of 0%, 5%, 15% and 25% of the Ordinary Portland cement were prepared with water to cement ratio of 0.55 and cement content of 350kg/m^3 for the control mix. 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 economical advantages can also be exploited by using bagasse ash as a partial cement replacement material.

4) Sumrerng Rukzon, Prinya Chindaprasirt **(2012)**presented the use of bagasse ash (BA) as a pozzolanic material for producing high-strength concrete. Portland

cement type I (PC) is partially replaced with finely ground bagasse ash. The concrete mixtures, in part, are replaced with 10%, 20% and 30% of BA respectively. In addition, the compressive strength, the porosity, the coefficient of water absorption, the rapid chloride penetration and the chloride diffusion of concretes are determined. The test results indicate that the incorporation of BA up to 30% replacement level increases the resistance to chloride penetration. Besides, the use of 10% of BA produced concretes with good strength and low porosity. Reasonably, the substitution of 30% BA is acceptable for producing high-strength concrete.

5)**Rathi, V.R. Vaishali, D.et.al., (2013)**Studied about SCBA has been chemically and physically characterized and partially replaced in the ratio of 0%, 10%, 15%, 20%, 25% and 30% by weight of cement in concrete. The properties for fresh concrete are tested like slump cone test and for hardened concrete compressive strength at the age of 7 and 28 days. The test result indicate that the strength of concrete increase up to 15% SCBA replacement with cement.

6)**Siva kumar, M .and Mahendran, N.(2013)**presented the Bagasse ash mixture provides strength equal to the nominal strength of the concrete and reduces the cost at a large scale replacement of the cement. The tests reveal the cost to be lesser than the initial cost. Use of Bagasse ash also contributes to the reduction of waste disposal by the industries which reveal that the environmental hazards from the waste materials.Various moulds were casted for the different properties of bagasse ash and Cement concrete i.e. replacement of cement with various percentage of Bagasse ash. The various specimens were tested for the compressive strength and the most optimum value was found out. Cost analysis was done on the account of optimum replacement of the account.

7)**Abdul kadir, T.S. Lawal, A.A. (2014)** In this research SCBA was passing the residual through 45µm sieve, standard size of ordinary Portland cement (OPC). It was then used to replace OPC by weight in ratio of 0%, 10%, 20% and 30%.The cubes were tested at 7, 14, 21 and 28days of curing ages for density and compressive strength. The results showed a decrease in concrete density with increase in % replacement of SCBA. Average compressive strength of 26.8N/mm2 was obtained for control specimens at 28days (i.e. 0% SCBA) while 22.3, 20.1 and 17.3N/mm2 compressive strength at 28days were obtained for 10%, 20% and 30% replacement respectively. This showed that only 10% and 20% replacement of cement by weight of SCBA satisfied ASTM-595(1985) specification. It was concluded that SCBA is a low weight material and 10% replacement of SCBA has the highest strength.

8)**Yashwanth, M.K. (2014)** The present study is to investigate experimentally the fresh and hardened properties of lightweight concrete using sugarcane bagasse ash(SCBA) as replacement for cement by weight at 0%, 5%, 10%, 15% and 20% and expanded polystyrene (EPS) beads as 100% replacement for coarse aggregate respectively. From the result it was found that there is marginal increase in workability with bagasse ash content up to 10% beyond that there is possibility of reduction in slump value. The compressive strength of lightweight concrete increases with bagasse content up to 15% and beyond this there is possibility of drastic reduction in strength and this 15% bagasse ash replacement strength is slightly less than

OPC based lightweight concrete at 28 days but this value is comparable.

9)**Ajay Goyal, Hattori Kunio, et.al.,** studied about obtaining amorphous sugarcane bagasse ash, several trails were conducted to define optimum burning time and temperatures. Sugar cane bagasse ash used in this study was obtained by burning SCB at 600^0C for 5 hours under controlled conditions.

10]. **Patel Ankit, N.(2014)**Studied on one of the agro waste sugarcane baggase ash which is fibrous waste product obtained from sugar mills as by product. Similarly fly ash resulting from the combustion of coal at electricity generating power station is highly processed and tested, through this a pozzolanic material is obtained known as Pozzocrete. In this experimental study SBA is used as partial replacement of fine aggregate in the ratio of 10% at which the optimum strength of concrete is obtained and then with such replacement, cement is replaced with Pozzocrete (P60) at ratio of 10%, 20% and 30%. The specimens of 150*150*150* mm were casted and tested at 7, 14 and 28 days and compare with traditional concrete in terms of strength and cost. Through experimental result we conclude that compressive strength of concrete increase with increase in partial replacement of pozzocrete.

[11]. **Neeraja, D. Jagan, S. et.al.,(2014)**Investigated on using the industrial and agricultural wastes. In this study, the feasibility of using Sugarcane Bagasse Ash (SBA), a finely ground waste product from the sugarcane industry, as partial replacement for cement in conventional concrete is examined. The percentages selected for this study are 0%, 5%, 10% and 15% by the weight of cement in concrete. Based on the experimental tests, it can be concluded that SBA, an agro waste product, can be utilized effectively in partial replacement of cement, thus reducing CO2 emissions and disposal problems to some extent.

3.MATERIALS AND THEIR PROPERTIES

Raw materials required for the concrete mix used in the present work are

- Cement OPC 53 Grade (Ultra tech super Shakti)
- Fine aggregate: Natural river sand
- Coarse Aggregates:20mm(Locally Quarried and Crushed)
- Water: Potable drinking water
- Admixtures-Nil
- sugarcane bagasse ash

3.1 CEMENT: Ordinary Portland cement is very common and easily available everywhere. Ordinary Portland cement of grade 53 was used in this project to prepare the control specimen

WATER: Available Water in lab was used for mixing and curing.

FINE AGGREGATE: Fine aggregate which is free from debris, obtained from nearby river having 2.46 of specific gravity and passing through 4.75 mm sieve were used and Water absorption as 1.62%.and grading have zone-IV.

COURSE AGGREGATE: Course aggregate is commonly known as crushed aggregates. The nominal maximum size of 20mm and 10mm aggregate were used in this study. Obtained from having of specific gravity came 2.67 and passing through max.25 mm sieve were used.Water Absorption as 0.21%.

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 (SiO2). 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 Madhucon Sugar and Power Industries Ltd, located at Rajeshwarapuram, Khammam District, Telangana.

Sugarcane Bagasse Raw Material
Physical properties of bagasse ash
Properties Values
Specific Gravity: 2.20
Colour:- Black
Density (gm/cm3):-1.20
Moisture content :6.28%

CHEMICAL PROPERTIES OF BAGASSE ASH

Table-3.8 Chemical composition of Bagasse Ash

Components	Mass %
Silica as SiO2	70.5
Calcium as CaO	4.7
Potassium as k2O	12.16
Iron as Fe2O3	1.89
Sodium as Na2O	3.82
Alluminium as Al2O3	1.36
Magnesium as MgO	4.68
Titanium as TiO2	< 0.06

These values are taken from the Madhucon sugar and power industries ltd. Located at Rajeshwarapuram, Khammam District.

Sugarcane Bagasse Ash

Sugarcane is one of the major crops grown in over 110 countries and its total production is over 1500 million tons. In India only, sugarcane production is over 400 million tons/year that cause about 10 million tons of sugarcane bagasse ash as an un-utilized and waste material. According to the world, Brazil leads the world in sugarcane production in 2011 with a 734 TMT tons harvest. India was the second largest producer with 342 TMT tons, and China the third largest producer with 115 125 TMT tons harvest. The average worldwide yield of sugarcane crops in 2011 was 70.54 tons per hectare. The most productive farms in the world were in Ethiopia with a nationwide average sugarcane crop yield of 126.93 tons per hectare.

WORKABILITY:
SLUMP TEST:

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor is it always representative of the pliability of the concrete.

The pattern of slump is shown in Fig. It indicates the characteristic of concrete in addition to the slump value. If the concrete slumps evenly it is called true slump. If one half of the cone slides down, it is called shear slump. In case of a shear slump, the slump value is measured as the difference in height between the height of the mold and the average value of the subsidence.
The vertical difference between top of the mold and the displaces original center of the top surface of the specimen 100 mm
The pattern of slump is shown True Slump/Shear Slump/ Collapse Slump.

MIX DESIGN

Estimated quantities in 1 m3 of concrete
:Cement = 492.5 Kg/M3
Fine Aggregates = 610.86 Kg/M3
Coarse Aggregates = 1045.78 Kg/M3
Water = 197 kg/m3

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Water-cement ratio = 0.40

The ratio comes to be 1: 1.24: 2.12 @ 0.40 for M30 grade concrete.

Sno	%of Replacement of sugarcane baggase ash add	Cemen9(in kgs)	Fine aggregate	Coarse Aggregate	Water	bagasse (gms)
1	0%	1.65	1.24	2.12	0.4	0
2	5%	1.56	1.24	2.12	0.4	0.083
3	10%	1.48	1.24	2.12	0.4	0.165
4	15%	1.40	1.24	2.12	0.4	0.248
5	20%	1.32	1.24	2.12	0.4	0.330
6	25%	1.24	1.24	2.12	0.4	0.413

4. RESULTS

Different tests were conducted on the specimens to determine and compare the strength properties of sugarcane baggase ash

1 Compressive Strength

2. Flexural Test

Tests were made at the ages of 7, 14 and 28 days. The ages were calculated from the time of the addition of water to the dry ingredients. For each trial mixes, three specimens were tested at each selected age. Specimens stored in water were tested immediately on removal from the water and while they were in the wet condition. Surface water and grit were wiped off the specimens and the projecting fins were removed if found.

1. Compressive Strength For cubes

Compressive Strength for cube

Compressive strength for cube = P/A×1000

Where,

P= Failure Load in KN

A=Area of cube surface=150×150mm^2

S.NO	MATERIAL (sugarcane	CUBES UNDER COMPRESSIVE STRENGTH N/mm2AGE

	baggase ash)	IN(DAYS)		
		7	14	28
1	0%	18	23	35
2	5%	20	29	32
3	10%	18	27	29
4	15%	20	20	25
5	20%	35	29	40
6	25%	18	23	30

Compressive Strength Test Results For cubes M30

Grade Plain Cement Concrete For7, 14 And 28 Days.

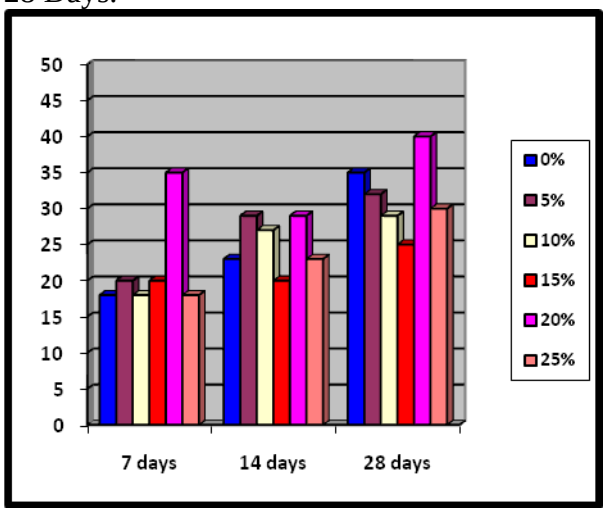

Fig-1: Compressive Strength test results for cubes M30 grade plain concrete for different levels of replacement

Discussions':

Compressive strength of cubes at the age of 7,14,28 days is increased in 20% of SBA .when compare to conventional concrete

Compressive strength of cubes at the age of 7,14,28 days is decreased in 25% of SBA. when compare to conventional concrete

Compressive strength of cubes at the age of 7 days are increased in 90%,100% of SBA % when compared to conventional concrete

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The results from above tests show that Sugarcane Bagasse Ash can be utilized for partial replacement
of cement up to 20% by weight of cement without any major loss of strength.

2.Compressive Strength For cylinders
Compressive strength for cylinders = P/A×1000
Where,
P=Failure Load in KN
A=Area of cube surface=150×300mm^2

S.NO	MATERIAL (Sugarcane baggase ash)	CYLINDERS UNDER COMPRESSIVE STRENGTH AGE IN(DAYS)		
		7	14	28
1	0%	9	10	12
2	5%	10	12	13
3	10%	10	13	14
4	15%	11	10	13
5	20%	11	13	15
6	25%	9	10	12

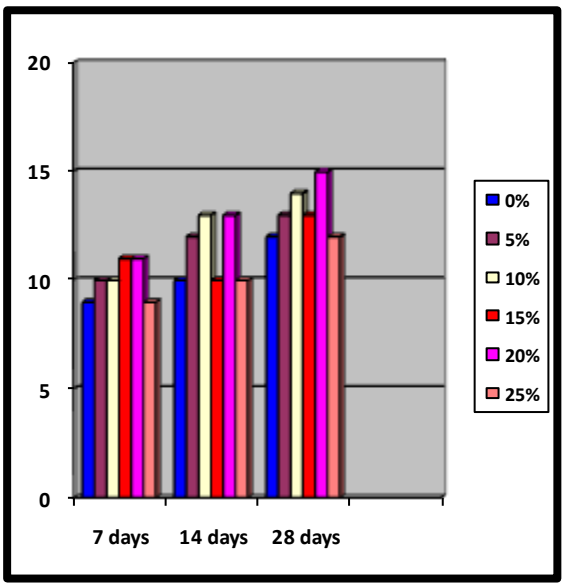

Fig-2: Compressive Strength test results for cylinders M30 grade plain concrete for different levels of replacement

Discussions:

Compressive strength of cylinders at the age of 7,14,28 days is increased in 20% of SBA .when compare to conventional concrete

Compressive strength of cylinders at the age of 7,14,28 days is decreased in 25% of SBA. when compare to conventional concrete

Compressive strength of cylinders at the age of 7 days are increased in 90%,100% of SBA % when compared to conventional concrete.

5.Conclusions:-

Based on the study, following conclusions can draw.

1. The compressive strengths of SCBA mixes at the age of 7 days was gradually increases its strength when compared with normal mix.
2. It was observed that the compressive strength of SCBA 20% at the age of 28 days has reached its target mean strength; however the compressive strength was increased by 51% and 70% when compared with normal mix.
3. It was observed that the compressive strength of SCBA 25% at the age of 28 days has decreases its compressive strength by 80% when compared with the normal mix.
4. Cement can be replaced with bagasse ash up to 20% without much loss in compressive strength.
5. Considerable decrease in compressive strength was observed from 25% cement replacement.
6. t has been shown in this study that 20% 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.

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