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STRENGTH CHARACTERISTICS OF CONCRETE MODIFIED WITH PARTIAL REPLACEMENT OF CEMENT BY BAGASSE ASH

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ABSTRACT
Large amount of sugar is produced by the India after the Brazil. Extraction of fibrous residue of sugar cane after the crushing is known as bagasse. The residue remaining after the burning of the bagasse in sugarcane factories is known as bagasse ash. Earlier this bagasse ash is dumped in the dumping yards as this is not used anywhere. As a result of this it used to create a lot of ecological imbalance in the environment. A lot of research has been performed on the use of bagasse ash as an alternative material in the concrete.In this study bagasse ash is used as partial replacement of cement in percentages of 5%, 10%, 15%, 20%, 25%, 30% and various strength properties are determined. In this investigation cubes, cylinders, shears, impact disc, slabs, beams of M25 grade of concrete are cast .All this specimens are tested after the 28 days of curing. The results obtained from this investigation are analysed and observed to be interesting.

1. INTRODUCTION

The usage of the cement has been increasing for the past few years. During the manufacturing of the cement, large amount of heat is generated in the high temperature klins. As a result of this huge emission of the carbon-dioxide takes place which leads to the greenhouse effect. So to control the usage of cement, a partial substitute binding material is suggested which is known as bagasse ash. It contains high amount of silica. The percentage of silica content present in the bagasse ash depends on the burning condition. The main objective of this project is to use bagasse ash as partial replacement to cement, as it is pollution free and also economical.

2. LITERATURE REVIEW

Prashant O Modania et.al.,[1] investigated that replacement of fine aggregate with bagasse ash can be adopted in between percentages of 10% to 20%.

Anurag shrivas et.al., [2] examined the use of Rice husk Ash, Fly Ash, Wheat Straw Ash, Saw Dust Ash and Glass Powder in addition to the sugar cane bagasse ash with 10% replacement with the cement.

G. Dhanalakshmi et.al., [3] concluded that the 25% replacement of bagasse ash and coconut shell with the cement and aggregate will increase the strength of the nominal concrete by 80%

S. Naga bhargavi & Y. Anand babu et.al., [4] examined Various properties of the concrete with the sugar cane bagasse ash and cured in the HCL solution and the results indicates that compressive strength of the concrete decreased at 5% replacement and increased at 10%,15%, and decrease in the strength at 20% replacement

K Sampath Kumar et.al., [5] studied the partial replacement of the cement with the sugar cane bagasse ash(2%),rice husk(2%),stone dust(2%) will increase the strength by 8%.

A.D.V.S. Siva Kumar et.al., [6] investigated the properties of the sugar cane bagasse ash with the partial replacement of the cement at various room temperatures and finally concluded that compressive strength of the concrete increased upto 200 ^{o} c and slight decrease of the compressive strength at 600^{o} c and drastically decrease of the strength at 800^{o} c.

From the brief literature survey conducted here, it appears much less attention is paid to the use of bagasse ash in concrete and examining the strength parameters. Hence the present study is undertaken.

3. MATERIALS USED

Cement:-

Ordinary Portland cement of 53 grade conforming to IS 12269-1987 is used for the entire work.

Coarse Aggregate:-

Coarse aggregate of size 20 mm and 12mm are used in this study. A few tests are conducted on coarse aggregate such as fineness modulus, specific gravity according to IS: 2386-196 3 and IS:383-1970

Fine Aggregate:-

The river sand free from organic impurities like clay and silt and passing through 4.75 mm sieve and retained on 600 µ sieve is used in the present work. Several tests are performed on fine aggregate such as specific gravity, fineness modulus according to IS:2386-1963.

sugarcane bagasse ash:-

Each tonne of sugarcane generates nearly 26% of bagasse. The bagasse ash obtained after the burning of bagasse contains high amount of silicon dioxide (sio2). The present sugarcane bagasse ash is obtained from the Mayura sugars Pvt. Ltd (sreekalahasthi),A.P. To use bagasse ash as a partial replacement of cement it is sieved through 90microns IS sieve.

Some of the physical properties of materials used in this work are presented in Table 1.

Table 1: properties of constituent materials in M25 grade concrete

S.NO	Name of the material		Properties of the material	
1	OPC-53GRADE		Specific gravity	3.15
			Initial setting time	29 minutes
			Final setting time	590 minutes
			Fineness	5.5%
			Normal consistency	30%
2	Fine aggregate passing through 4.75 mm sieve		Specific gravity	2.64
			Fineness modulus	2.46
3	Coarse aggregate passing through 20mm sieve	Natural aggregate	Specific gravity	2.66
			Fineness modulus	6.99
			Bulk density compacted	1620Kg/m3
		Bagasse ash aggregate	Specific gravity	2.2
			Fineness modulus	6.89
			Bulk density loose	870kg/m3
			Water obsorption	23%
			Shape	Round

4. EXPERIMENTAL WORK

In this study M25 grade concrete is designed according to the Indian standards. The mix proportion obtained from the mix design is (1: 1.59 : 2.61) .Concrete is prepared and poured into these moulds in three layers each layer being compacted well and vibrated on the plan table vibrator in order to avoid the voids. These moulds are demoulded after commencement of the hardening, that is after the 24 hours of the casting. These specimens are placed in the curing tank and are tested after the 28 days as per BIS 9013-1978. Various strength properties such as compressive strength, split tensile strength, flexural strength, impact strength, shear strength are determined. In this study following different specimens are cast in the lab.

1. Cube moulds of size 150*150*150 mm ,
2. Beams moulds of size 0.10*0.10*0.5m,
3. Slab moulds of size 0.6*0.6*0.05m,
4. Impact moulds of size 150*50 mm,
5. Cylinder moulds 300*150mm.
6.shear moulds of 150*150*150 mm with notches of a /w = 0.3,0.4,0.5,0.6.

The total number of specimens cast and tested in this study are stated as follows:-

Table 2: Designation details of specimen

Mix	**Percentage replacement of bagasse ash with cement(%)**	**cubes**	**cylinders**	**Beams**	**In-plane shear cubes**	**Impact disc**	**slabs**
S0	0	3	3	3	12	3	3
S1	5	3	3	3	12	3	3
S2	10	3	3	3	12	3	3
S3	15	3	3	3	12	3	3
S4	20	3	3	3	12	3	3
S5	25	3	3	3	12	3	3
S6	30	3	3	3	12	3	3
TOTAL		**21**	**21**	**21**	**84**	**21**	**21**

Hence the total number of the specimens cast and tested in this study are **189**

4.1 Compressive strength

Cubes are placed in the universal testing machine which is having a capacity of 2000 KN. specimen is placed between the two plates and load is applied gradually until the specimen gets failed. The test results are tabulated in table 3 and graphed in Fig.1, The obtained results are as follows:-

Table 3 : cube compressive strength Results

S.No	Mix	Percentage replacement of bagasse ash with cement (%)	Ultimate Load (KN)	Cube compressive strength in N/mm^2	Percentage increase or decrease of compressive strength
1	S0	0	777.33	34.55	0
2	S1	5	785.33	34.90	1.0
3	S2	10	813	36.13	4.6
4	S3	15	708.66	31.49	-8.9
5	S4	20	679.66	30.20	-12.6
6	S5	25	575.66	25.5	-26.2
7	S6	30	512.66	22.78	-34.1

From the above observations it is clear that the compressive strength of the cube is increased by 1% at the 5% replacement of the cement with the bagasse ash where as at the 10% replacement of the cement with bagasse ash, it increases the compressive strength by 4.6%. Further increase in the replacement of the cement with bagasse ash there is a decrease in the compressive strength. Hence 10% addition of the baggasse ash is found to be optimum.

4.2 Split tensile strength

Concrete cylinders are placed in the UTM and tested as per BIS 5816-1999. Concrete cylinders are horizontally placed and load is applied until the specimen gets failure. Care is taken such that cylinder is not rotated along the axis of the cylinder. The obtained results are tabulated in the table 4 and graphed in the Fig .2

Table 4 : split tensile strength Results

S.No	Mix	Percentage replacement of bagasse ash with cement (%)	Ultimate Load (KN)	Cylinder split tensile strength in N/mm^2	Percentage increase or decrease of split tensile strength (%)
1	S0	0	289.66	4.10	0.00
2	S1	5	296	4.19	2.19
3	S2	10	306.6	4.34	5.87
4	S3	15	281	3.98	-2.99
5	S4	20	261	3.69	-9.90
6	S5	25	246.3	3.49	-14.96
7	S6	30	224	3.17	-22.67

From the above observations it is clear that the split tensile strength of the cube is increased by 2.19% with the 5% replacement of the cement with the bagasse ash where as at the 10% replacement of the cement with bagasse ash, the split tensile strength increases by 5.87%. With further increase in the percentage of bagasse ash there is a decrease in the split tensile strength by 22.67%.Hence 10% of bagasse ash addition is optimum.

4.3Flexural strength

For testing this beam specimens, a hydraulic jack and pump setup is used for loading and dial gauges are used in order to obtain the deflection .These dial gauges are placed at one-third distance from each end of the beam and also another dial gauge is placed at the centre of the beam. Load is applied until the specimen gets failure. Respective results are obtained and are tabulated in table no.5 and graphed in the Fig.3

Table 5: Beam Flexural Strength Results

S.No	Mix	Percentage replacement of bagasse ash with cement (%)	Ultimate Load (KN)	Flexural strength in N/mm^2	Percentage increase or decrease of flexural strength
1	S0	0	11.624	4.64	0.00
2	S1	5	12.36	4.94	6.35
3	S2	10	12.67	5.07	9.07
4	S3	15	11.30	4.52	-2.72
5	S4	20	9.832	3.38	-27.31
6	S5	25	8.77	2.83	-39.01
7	S6	30	6.66	2.66	-42.64

The percentage increase of flexural strength of the beam at the 5% replacement of the cement with the bagasse ash is 6.35% . Further increase in the replacement of the cement by the bagasse ash i.e. with 10%, it increases the flexural strength by 9.07%. This percentage is found to be optimum.

4.4 Impact disc

For testing the impact disc an In-house fabricated machine is used which is having a weight of 4.9kg and having a free fall of 450mm as per IS 2720-8 (1983). Specimens are placed in the arrangement and sufficient number of blows are given until the specimen gets failure. The number of the blows are noted and tabulated in table no.6 and graphed in the Fig.4

Table 6: Impact Discs test Results

S.No	Mix	Percentage replacement of bagasse ash with cement (%)	Number of impact blows	Percentage increase or decrease in number of blows
1	S0	0	663	0
2	S1	5	684	3.17
3	S2	10	727	9.65
4	S3	15	683	3.02
5	S4	20	656	-1.66
6	S5	25	589	-10.56
7	S6	30	540	-18.55

The impact strength of the impact discs depends on the no of impact blows given by in-house fabricated machine. Hence the total number of the impact blows given at 5% replacement of the cement with the bagasse ash is 684, which means 3.17% greater when compared to that of normal mix. Further increase in the percentage replacement of the cement with the bagasse ash by 10% , it has resulted in the increase of the impact strength by 9.65%. But further increase of the percentage replacement of the cement with the bagasse ash beyond 5% there is a gradual decrease of the impact strength by 18.5% at 30% replacement of the cement with the bagasse ash. Hence even here also optimum percentage of the bagasse ash addition is 10%.

4.5 Shear strength

Shear strength of the notched cube specimens can be tested by using different notch depths. During the casting of the cubes, blades are placed and these are removed after the initial setting time of concrete so that notches are created exactly at one third portion of the cube, where in load is to be applied using a digital compressive testing machine having a capacity of 3000 KN. The test setup and loading pattern is presented in the following figure.

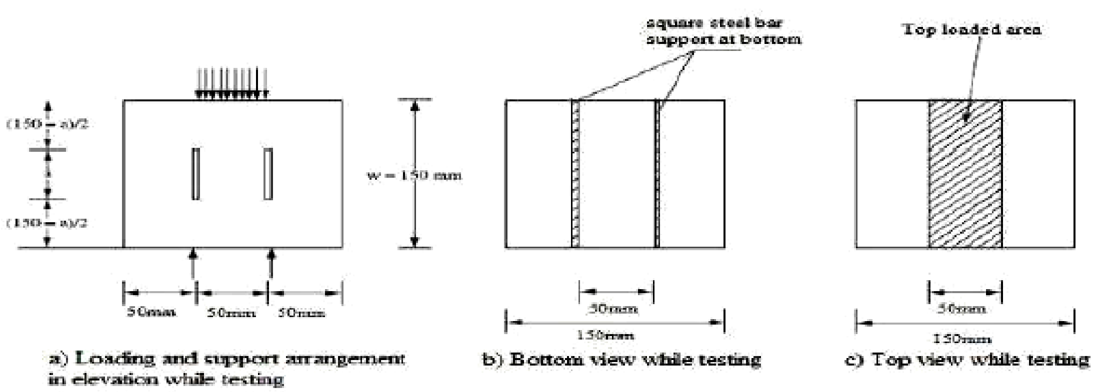


Plate1. Loading Diagram of DCN specimens

Shear cubes with different a /w sizes of 0.3, 0.4, 0.5, 0.6 are tested
In plane shear strength calculated by using a formula

In plane shear strength $= \frac{P}{2*d(d-a)} N/mm2$

Where P = Ultimate load in the mode-II shear
d = size of the cube = 150mm
a = depth of the notch in mm

The end results are tabuled in the table 7 and graphed in the Fig.5 and Fig.6 as follows

Table 7: Ultimate loads and shear stresses in Mode -II fracture test Results

Table 7(a):-

Mix	Percentage replacement of bagasse ash with cement (%)	a/w=0.3			a/w=0.4		
		Ultimate Load (KN)	In plane shear stress in N/mm^2	% Inc or dec Of Shear Stress	Ultimate Load (KN)	In plane shear stress in N/mm^2	% Inc or dec Of Shear Stress
S0	0	140	4.44	0	127	4.70	0
S1	5	137.66	4.37	-1.57	117.6	4.35	-7.44
S2	10	121.66	3.86	-13.06	97.3	3.6	-23.4
S3	15	97.33	3.09	-30.4	77.6	2.87	-38.93
S4	20	90	2.85	-35.8	77.3	2.86	-39.1
S5	25	76.6	2.43	-45.2	68.6	2.54	-45.9
S6	30	70	2.22	-50	63	2.33	-50.4

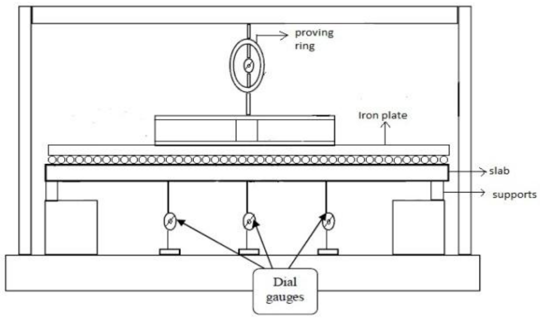
Table 7(b):-

Mix	Percentage replacement of bagasse ash with cement(%)	a/w=0.5			a/w=0.6		
		Ultimate Load (KN)	In plane shear stress in N/mm^2	% Inc or dec Of Stress	Ultimate Load (KN)	In plane shear stress in N/mm^2	% Inc or dec Of Stress
S0	0	115.66	5.14	0	102	5.66	0
S1	5	95.33	4.237	-17.70	85.33	4.74	-16.25
S2	10	86.66	3.85	-25.0	82.33	4.57	-19.25
S3	15	77.33	3.43	-33.26	75.6	4.2	-25.79
S4	20	71	3.15	-38.71	69.33	3.852	-31.97
S5	25	63.33	2.8	-45.52	57.33	3.18	-43.81
S6	30	56.66	2.51	-51.1	54.33	3.01	-46.82

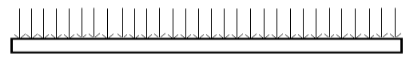
From the above table it may be observed that in-plane shear stress decreases with the increase in bagasse ash content. Also it is found that in-plane shear stress decreases with the increase in a /w ratio.

4.6 Moment carrying capacity of slab

All the Slabs are tested under simply supported condition and under udl. Dial gauges are placed at the centre and also at the corner of the slab to note down the deflection readings. The Test setup and loading pattern is presented in the following figure.



Schematic view of experimental setup



Loading of slab under UDL

Plate 2

The slabs are tested under the UDL condition. Slabs are tested and readings are tabulated as follows:-

Table 8.Moment carrying capacity of the slabs

Mix	Average Dial gauge reading	Load (KN)	Total Load per unit width	Moment carrying capacity KNM	Percentage increase or decrease of moment carrying capacity
S0	9.0	18.9	85.3554	1.543157	0.00
S1	9.7	20.1	91.0140	1.645461	6.63
S2	10.3	21.4	96.6727	1.747765	13.26
S3	9.3	19.5	88.1847	1.594309	3.31
S4	7.3	15.7	71.2087	1.287396	-16.57
S5	7	15.1	68.3794	1.236244	-19.89
S6	6	13.2	59.8914	1.082788	-29.83

Table 9.Strain energies of the slabs

`Mix	At First crack			At Ultimate Failure				
	Load (KN)	Moments (K N-m)		Load (KN)	Moments (K N-m)			
		by IS method	by Yield line theory		by IS method	by Yield line theory	% increase moments w.r.t. yield line theory	Strain energy (KN-M)
S0	18.85	1.54	1.28	386.98	31.67	26.27	0	355.56
S1	20.10	1.64	1.36	403.855	33.05	27.42	4.36	394.16
S2	21.35	1.74	1.45	420.73	34.43	28.56	8.72	508.72
S3	19.48	1.59	1.32	397.605	32.54	26.99	2.74	467.73
S4	15.73	1.28	1.06	388.23	31.77	26.36	0.32	300.4
S5	15.1	1.23	1.02	345.105	28.24	23.43	-10.82	271.35
S6	13.2	1.08	0.89	333.23	27.27	22.62	`-13.88	205.96

From the above results it is clear that the moment carrying capacity of the slab is increases up to 10% replacement of the cement with bagasse ash and after wards with a further increase, the moment carrying capacity gradually decreases. Hence even in this case the optimum content of bagasse ash addition is 10%.

Strain energy:-Strain energy is obtained from the graph drawn between the load on y-axis and deflection on x- axis. The area under this curve gives the strain energy stored in the specimen. Even here also 10% is optimum.

5. GRAPHS

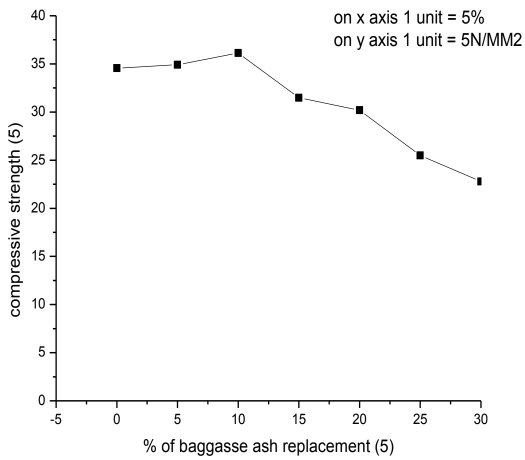


Fig .1 compressive strength of cube

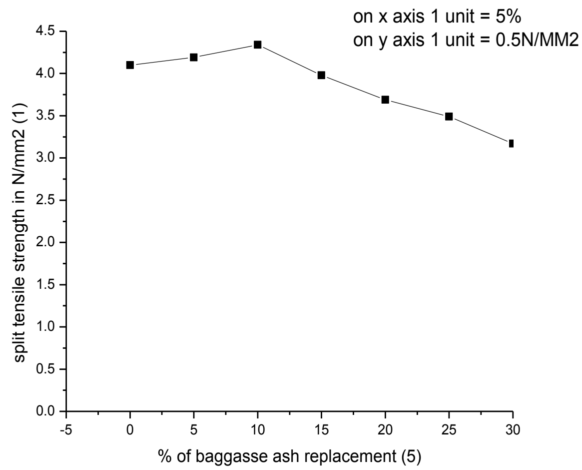


Fig.2 split tensile strength of the cylinder

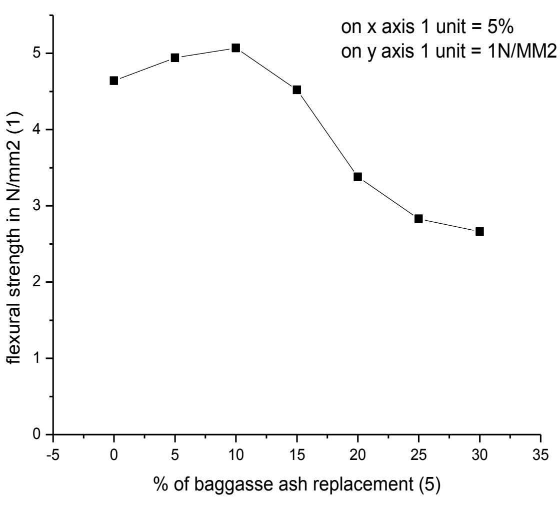


Fig 3. Flexural strength of beams

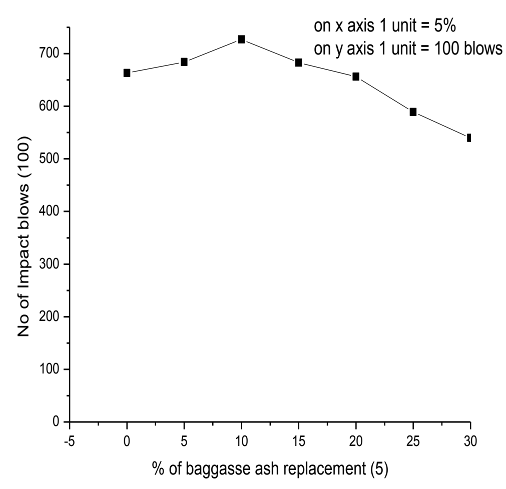


Fig 4. No of impact Blows for impact disc

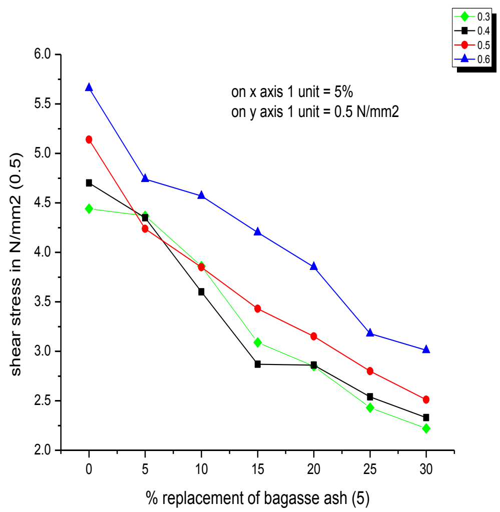


Fig 5.Shear stress as per a/w ratio

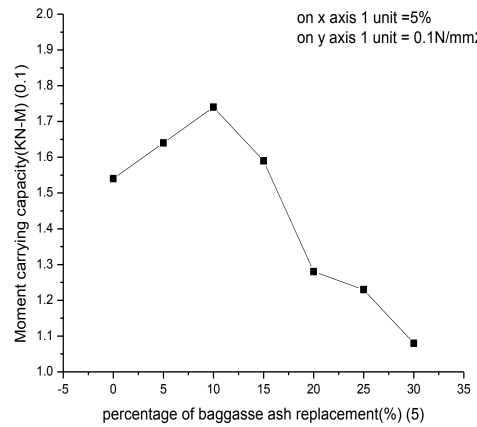


Fig 6.Moment carrying capacity of the slab

6. CONCLUSIONS

1. From the experimental study, it is observed that sugarcane baggasse ash can be used as binding material by replacing the cement.
2. From this study it is concluded that compressive strength, split tensile strength, flexural strength, impact strength etc., increase up to 10% replacement of cement by sugarcane bagasse ash.
3. In plane shear strength decreases with increase in a /w ratio.
4. It is also concluded that with 20% replacement of cement by sugarcane bagasse ash, the compressive strength obtained is comparable with the design strength of the M25 mix. Hence interms of economy point of view 20% replacement may be considered.
5. Most of the strength parameter studies show that up to 20% replacement of cement by sugarcane bagasse ash would give minimum decrease. Hence cement can be replaced by sugarcane bagasse ash up to 20%.
6. By the use of sugarcane bagasse ash as a mineral admixture in concrete, an eco friendly concrete can be produced and make environment as less polluted, and problem of disposing the sugarcane bagasse ash is limited to some extent.

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