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An Experimental Study on Concrete Improved with Partial Replacement of Cement with Sugarcane Bagasse Ash along with Combined Replacement of Natural Aggregates with Light Expandable Clay Aggregates and Copper Slag

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ABSTRACT
The main focus of this experimental study is to explore the best combination of materials that give more or equal strength as compared to the strength of normal or traditional concrete.
This research work includes combined replacement of natural coarse aggregates and natural fine aggregates with Light Expandable Clay Aggregates (LECA) and Copper Slag (CS) respectively by 0%, 50%, and 100%. In each mix cement content is replaced with Sugarcane Bagasse Ash(SCBA) by 0%, 5%, 10%, 15%, 20%, and 25% with the above combination of mixing, 18 mixes resulting 432 specimens of M25 grade of concrete are cast and tested . The various strength parameters like compressive strength, split tensile strength, flexural strength, In-plane shear strength i.e., mode-11 fracture, resistance to failure by impact are tested at the age of 28days of curing and the results are found to be intrusting.

Keywords: Light expandable clay aggregates, Copper slag, Sugarcane bagasse ash, compression, tension, flexure, in- plane shear, impact.

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I. INTRODUCTION

In developing countries like India, Infrastructure and Industrial development consumes a lot of natural resources so that they are rapidly reduced and becomes costlier. It also shows adverse effect on environment. Disposal of an untreated solid waste generated from various factories and industries into the environment puts the human existence in danger.

The main objective of this project is to limit the natural resources by replacing them with some of the by products or industrial wastes generated from factories. The aim of this investigation is to give alternative materials that give comparable strength and performance as conventional concrete.

II. LITERATURE REVIEW

Deepika K P & Dr.Asha.K [1] in their study it was concluded that strength of concrete increases with the increase in copper slag replacement up to 80% with sand and 50%of replacement of fly with cement.

R.N. Raj Prakash &A. Krishnamoorthi [2] in their experimental Study on Light Weight Concrete observed that there is decrease in strength of concrete with the increase in percentage replacement of coarse aggregate with LECA.

G Nithin Kumar Reddy et.al., [3] from their investigation reported that SCBA concrete performed better when compared to conventional concrete up to 10% replacement of SCBA due to presence of high amount of silica in SCBA.

Fayaz Ahmad.S et.al., [4] in their studies reviewed the variation of compression and tension parameters of modified concrete which is replaced with 35% to 50% of copper slag as fine aggregate and 5% to 15% of SCBA as cement. It was concluded that the optimum value of copper slag is 40% and bagasse ash is 5%

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R.Priyanga et.al., [5] it Indicates *50*% replacement of LECA with coarse aggregate found to have high compressive strength (28.6 N/mm^2) than the normal weight concrete at age of 28 days.

Pamisetti Srikanth et.al., [6] in their experimental study it was observed that sugarcane bagasse ash can be used as binding material by replacing the cement up to 10%.

After careful observation of the above literature, it is felt that there is a scope to find the more or equally strong cement concrete by using copper slag and LECA with little amount of bagasse ash.

III. OBJECTIVE

a. To examine the various strength parameters of the different combinations of chosen materials and compare and conclude the results obtained with conventional concrete.
b. It reduces the scarcity of the natural resources and also economical in some areas.
c. To avoid wastage disposal problems in major industries.

IV. MATERIALS USED

The materials taken in the making of special concrete are mentioned below. The specifications of each material are given below.

Cement:-
The cement used is ordinary Portland cement of 53 Grade conforming to IS 12269-1987.

Natural Coarse Aggregate:-
Regionally accessible crushed coarse aggregate of maximum size 20mm is taken for the mixing. Some of the preliminary tests are conducted on it like specific gravity, sieve analysis according to table 2 of IS: 383-1970.

Natural fine aggregate:-
Locally available river sand which is free from organic impurities is passing through 4.75mm IS sieve and retained on 600μ sieve and conforming to zone II according to table 4 of IS 383-1970 is taken for this work. Several tests like specific gravity and fineness modulus are conducted according to IS: 2386-1963.

Sugarcane Bagasse Ash (SCBA):-
The bagasse ash used in this work is obtained from the M/s Mayura sugars Pvt. Ltd located in Sreekalahasthi in Andhra Pradesh state. Before using it as cement it is finely ground and sieved through 90μ IS sieve. The material passing through 90μ sieve is used in this investigation.

Copper Slag (CS):-
Copper slag is the industrial byproduct which is obtained from M/s Srinivasa Metallizers, Hyderabad, Telangana.

Light Expandable Clay Aggregates (LECA):-
LECA is procured from the LITAGG Industries Pvt. Ltd located in Ahmadabad city in the state of Gujarat.

Water:-
Portable water according to Indian standards is used for mixing and curing in this work.
The physical properties of some of the above mentioned materials are as follows.

Table 1: Some properties of constituent materials.

S .no	Name of the material	Property of the material	Test values
1	53 Grade OPC cement	Specific gravity	3.15
		Normal consistency	30%
		Initial setting time	40 minutes
		Final setting time	595 minutes
		Fineness	5.4%
2	Natural Fine Aggregate (Sand)	Specific gravity	2.60
		Fineness modulus	2.46
		Water absorption	0.50%
3	Natural Coarse Aggregate	Specific gravity	2.66
		Bulk density	1620kg/m^3
		Water absorption	0.25%
4	LECA	Specific gravity	1.20
		Bulk density	265kg/m^3
		shape	rounded
		Water absorption	18%
5	Copper Slag	Specific gravity	3.53

		Fineness modulus	2.53
		Water absorption	0.45%
6	Sugarcane Bagasse Ash (SCBA)	specific gravity	2.70

V. EXPERIMENTAL WORK

An experimental study is conducted on concrete with different replacements i.e., natural coarse aggregates and natural fine aggregates are replaced with LECA and CS in the amounts of (0%,0%), (50%,50%) & (100%,100%). And also in above 3sets, in each and every set the cement is replaced with SCBA in the amounts of (0%, 5%, 10%, 15%, 20%& 25%). Thus totally 18 different mix proportions are involved. Accordingly the experimental study is carried out by casting the specimens in required shape and size and specimens are tested after 28 days curing in water.

For each mix proportion the following number of each type of different specimens are cast and tested for the testing of specific strength parameter.

- 3 number of cubes having size 150mm*150mm*150mm for testing the compressive strength of concrete.
- 3 number of cylinders having 150mm diameter and 300mm height for the testing of split tensile strength of concrete.
- 3 number of beams having size 100mm*100mm*500mm for the testing of flexural strength of the concrete.
- Four types of 3 number of notched cubes having size 150mm*150mm*150mm with different size of notch for the testing of in-plane shear strength of the concrete through mode-II fracture.

3 cubes with a/w ratio of 0.3
3 cubes with a/w ratio of 0.4
3 cubes with a/w ratio of 0.5
3 cubes with a/w ratio of 0.6

- 3 number of circular discs having 150mm diameter and 75mm height for the testing of impact strength of concrete.

5.1. Mix design

Mix design of M25 grade concrete is done according to Indian Standard code of 10262:2009. The mix ratio obtained is 1:1.52:2.62(C: FA: CA) with constant water content ratio of 0.45. Thus the total 18 mixes are prepared. All these 18 mixes are divided into 3 sets and each set consists of 6 different mix proportions which are shown in table 2.

Table 2: Design details of specimens.

SET 1													
S.No	Name of the mix	Coarse Aggregate		Fine Aggregate		Cementitious material		Number of specimens cast and Tested.				
		NCA %	LECA %	NFA %	CS %	Cement %	SCBA %	Cubes	Cylinders	Beams	DCN Cubes	Disks
1	C0	100	0	100	0	100	0	3	3	3	12	3
2	C5	100	0	100	0	95	5	3	3	3	12	3
3	C10	100	0	100	0	90	10	3	3	3	12	3
4	C15	100	0	100	0	85	15	3	3	3	12	3
5	C20	100	0	100	0	80	20	3	3	3	12	3
6	C25	100	0	100	0	75	25	3	3	3	12	3

SET 2												
S.No	Name of the mix	Coarse Aggregate		Fine Aggregate		Cementitious material		Number of specimens cast and Tested.				
		NCA %	LECA %	NFA %	CS %	Cement %	SCBA %	Cubes	Cylinders	Beams	DCN Cubes	Disks
1	P0	50	50	50	50	100	0	3	3	3	12	3
2	P5	50	50	50	50	95	5	3	3	3	12	3
3	P10	50	50	50	50	90	10	3	3	3	12	3
4	P15	50	50	50	50	85	15	3	3	3	12	3
5	P20	50	50	50	50	80	20	3	3	3	12	3
6	P25	50	50	50	50	75	25	3	3	3	12	3

SET 3												
S.No	Name of the mix	Coarse Aggregate		Fine Aggregate		Cementitious material		Number of specimens cast and Tested.				
		NCA %	LECA %	NFA %	CS %	Cement %	SCBA %	Cubes	Cylinders	Beams	DCN Cubes	Disks
1	F0	0	100	0	100	100	0	3	3	3	12	3
2	F5	0	100	0	100	95	5	3	3	3	12	3
3	F10	0	100	0	100	90	10	3	3	3	12	3
4	F15	0	100	0	100	85	15	3	3	3	12	3
5	F20	0	100	0	100	80	20	3	3	3	12	3
6	F25	0	100	0	100	75	25	3	3	3	12	3

NCA= Natural Coarse Aggregate, LECA=Light Expandable Clay Aggregate.
NFA= Natural Fine Aggregate, .CS=Copper Slag, SCBA=Sugarcane Bagasse Ash.
Thus total concrete specimens cast and tested are 432.

5.2. Mixing, casting, and curing of specimens

Initially the required quantities of materials are measured on weighting machine with the accuracy up to 10 grams and then making sure that the different required moulds are in perfect size and shape. All the inner surfaces of moulds are neatly coated with mechanical waste oil with the help of painting brush. Additional care is taken in fixing the iron plates of different widths for in-plane shear cubes. Afterwards correctly weighted material is transferred into the concrete mixer and thoroughly mixed until uniform mix is acquired. Then all the specimen moulds are held on level surface and concrete is poured into the each mould in three layers, each layer of concrete is evenly compacted with tamping rod and excess amount of concrete on the mould is strike off with the striked off bar and top surface of the mould is smoothly finished with the help of trowel. And the moulds are vibrated on table vibrator for 10-12 sec to remove the air voids and honeycombs if any that exist in the concrete. After 2 hours of casting, the notch plates in shear cube moulds are carefully removed from concrete. Finally concrete specimens are removed from mould without any change in the size and shape after 24 hours of casting and all the specimens are completely immersed in water for curing. After 28 days of curing, samples are removed from water and permitted to dry and they are lime painted on all faces for clear visibility of cracks during testing.

VI. TESTING

6.1 Compressive Strength of cubical specimens

Compressive strength of the cube is found out by following the testing procedure according to the IS: 516-1959. Cubical concrete specimens are placed in automatic compression testing machine with 2000KN capacity such that the load is applied concentrically on the cube. The load is applied gradually on the cube with 0.50 KN/sec rate of loading until the cube fails to bear load. The ultimate load that takes the cube is recoded. The compressive strength of the cube is determined by ultimate load divided with cross sectional area of cube specimen which is perpendicular to direction of load acting.

$$\text{Compressive strength of the cube} = \frac{ultimate\ load P\ (in\ N)}{cross\ secctional\ area\ A\ (in\ \text{mm2})}$$

The results obtained are tabulated in table 3.

Table3: Compressive Strength test results of cube specimens.

Set 1			Set 2			Set 3		
Mix	Compressive strength (N/mm²)	% Variation of compressive strength w.r.t C0 mix	Mix	Compressive strength (N/mm²)	% Variation of compressive strength w.r.t C0 mix	Mix	Compressive strength (N/mm²)	% Variation of compressive strength w.r.t C0 mix
C0	34.44	0	P0	34.12	-0.93	F0	13.55	-60.65
C5	36.12	4.87	P5	34.5	0.17	F5	14.7	-57.31
C10	39.88	15.79	P10	35.6	3.36	F10	14.9	-56.73
C15	32.33	-6.12	P15	31.2	-12.48	F15	15.8	-54.12
C20	29.8	-13.47	P20	28.55	-17.1	F20	11.5	-66.6
C25	30.1	-12.6	P25	23	-33.21	F25	6.8	-80.25

6.2 Split Tensile Strength of a cylindrical specimens

Split Tensile strength of a cylinder (150mmdia & 300mm height) is tested according to BIS 5816-199. In this test the cylindrical specimens are placed horizontally in automatic compression testing machine of capacity 2000KN .such that the axis of the cylinder is parallel to the loading plates so that tensile force is acting on specimen perpendicular to the applied load. The ultimate load is recorded until the cylindrical specimen fails to take further load. It is ensured that the cylinder is not rotated along the axis during testing.

Split tensile strength $F = \frac{2P}{\pi dl}$

Where P= Ultimate load in N
d= Diameter of the cylinder 150 mm
l = Length of the cylinder 300 mm

The results obtained are tabulated in table 4.

Table 4: Split tensile strength test results of cylinder specimens.

Set 1			Set 2			Set 3		
Mix	Split Tensile strength (N/mm²)	% Variation of tensile strength w.r.t C0 mix	Mix	Split Tensile strength (N/mm²)	% Variation of tensile strength w.r.t C0 mix	Mix	Split Tensile strength (N/mm²)	% Variation of tensile strength w.r.t C0 mix
C0	3.73	0	P0	3.12	-16.35	F0	1.5	-59.78
C5	3.75	0.53	P5	3.35	-10.18	F5	1.54	-58.71
C10	3.85	3.21	P10	3.56	-4.55	F10	1.89	-49.33
C15	3.61	-3.21	P15	2.5	-32.97	F15	1.4	-62.46
C20	2.87	-23.05	P20	2.46	-34.04	F20	1.2	-67.82
C25	3	-19.6	P25	2.2	-41.01	F25	1.1	-70.5

6.3 Flexural Strength of Beams

Flexural strength of a beam specimen (100*100*500 mm) represents resistance to bending failure. This test is performed by standard approach of two-point loading method. Load applied on the beam specimen is indicated in dial gauge connected under the loading frame and for testing the flexural strength of the beam specimens, hydraulic jack and pump is used for the application of load. The deflection at specified points is measured by strain gauges. These strain gauges are placed at one-third distance from each end of the beam and another strain gauge is placed at the centre of the beam. Load is applied until the specimen gets failed. The results obtained are tabulated in table 5.

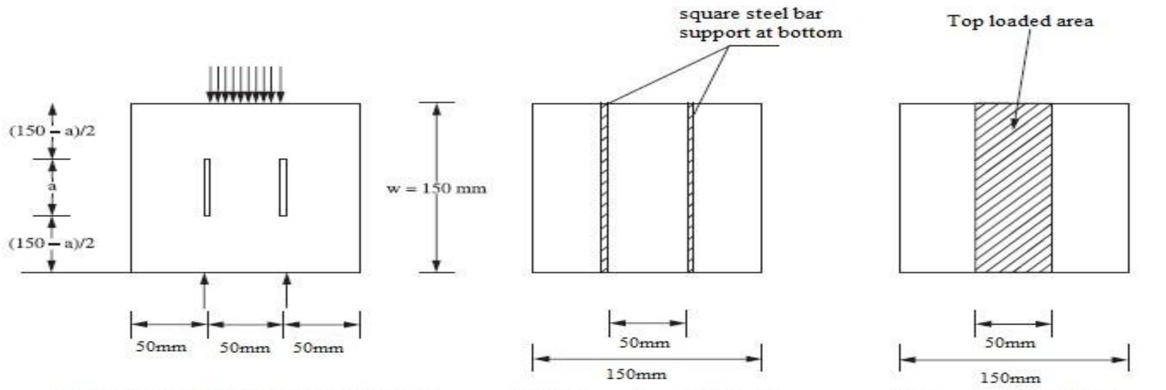
Flexural Strength= $\frac{PL}{BD^2}$

Table 5: Flexural Strength test results of a beam specimen.

Set 1			Set 2			Set 3		
Mix	Flexural strength (N/mm²)	% Variation of flexural strength w.r.t C0 mix	Mix	Flexural strength (N/mm²)	% Variation of flexural strength w.r.t C0 mix	Mix	Flexural strength (N/mm²)	% Variation of flexural strength w.r.t C0 mix
C0	3.75	0	P0	3.46	-7.73	F0	2.25	-40
C5	3.94	5.06	P5	3.5	-6.66	F5	2.43	-35.2
C10	4.32	15.2	P10	3.56	-5.06	F10	2.06	-45.06
C15	3.65	-2.66	P15	2.81	-25.06	F15	1.87	-50.13
C20	3.5	-6.66	P20	2.4	-36	F20	1.68	-55.46
C25	3	-20	P25	2.25	-40	F25	1.5	-60

6.4 Shear Strength or Mode-II Fracture test

Double Central Notched (DCN) cube specimens (150*150*150 mm) are used to find the in-plane shear strength. DCN cube specimens are casted with notches of different depths at exactly central portion of the cube. Then the load is exactly applied at central portion of the cube using digital compressive testing machine having 3000KN capacity. The test setup and loading position is presented diagrammatically below. The test results are tabulated in table 6.



a) Loading and support arrangement in elevation while testing
b) Bottom view while testing
c) Top view while testing

Shear cubes with different $\frac{a}{w}$ sizes of 0.3, 0.4, 0.5, and 0.6 are tested.
In plane shear strength is calculated by using a formula given below
In plane shear strength= $\frac{P}{2*d(d-a)}$ N/mm^2.

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

Table 6: Shear stress in Mode-II fracture test results.

Table 6(a):

Set 1								
Mix	**a/w =0.3**		**a/w =0.4**		**a/w =0.5**		**a/w =0.6**	
	Extreme load (KN)	**In plane shear stress (N/mm^2)**	**Extreme load (KN)**	**In plane shear stress (N/mm^2)**	**Extreme load (KN)**	**In plane shear stress (N/mm^2)**	**Extreme load (KN)**	**In plane shear stress (N/mm^2)**
C0	151.5	4.8	133.5	4.94	116.5	5.17	102	5.66
C5	134	4.23	113	4.18	109	4.84	98	5.44
C10	126	4	105	3.88	96.4	4.28	81.5	4.52
C15	110	3.49	98	3.62	90	4	81	4.5
C20	99	3.14	90	3.33	75	3.33	72.6	4.03
C25	90.5	2.87	86	3.18	72	3.2	60	3.33

Table 6(b):

Set 2								
Mix	**a/w =0.3**		**a/w =0.4**		**a/w =0.5**		**a/w =0.6**	
	Extreme load (KN)	**In plane shear stress (N/mm^2)**	**Extreme load (KN)**	**In plane shear stress (N/mm^2)**	**Extreme load (KN)**	**In plane shear stress (N/mm^2)**	**Extreme load (KN)**	**In plane shear stress (N/mm^2)**
P0	148	4.7	133	4.92	121	5.37	102	5.66
P5	118	3.74	109	4.03	90	4	76	4.22
P10	93	2.95	95	3.51	86	3.82	68	3.77
P15	85	2.7	89	3.29	79	3.55	65	3.61
P20	72	2.3	76	2.84	65	2.88	51	2.83
P25	69	2.2	72	2.66	62	2.75	48	2.66

Table 6(c):

Set 3								
Mix	**a/w =0.3**		**a/w =0.4**		**a/w =0.5**		**a/w =0.6**	
	Extreme load (KN)	**In plane shear stress (N/mm^2)**	**Extreme load (KN)**	**In plane shear stress (N/mm^2)**	**Extreme load (KN)**	**In plane shear stress (N/mm^2)**	**Extreme load (KN)**	**In plane shear stress (N/mm^2)**
F0	82	2.6	76	2.81	63	2.8	55	3.05

F5	78	2.47	75	2.77	62	2.75	53	2.94
F10	75	2.38	71	2.62	58	2.57	48.5	2.69
F15	68	2.15	64	2.37	55.4	2.46	46	2.55
F20	62	1.96	60	2.22	52	2.31	40	2.22
F25	50	1.58	46	1.7	40	1.77	36	2

6.5 Impact Strength of the Disk

To determine the impact strength of concrete, the circular discs are cast with diameter 150 mm and height 75 mm. Indigenously made testing equipment is used and which consists of steel casing, steel round ball and hammer weighing 2.3 kgs and having a free fall of 450 mm as per IS 2720-8(1983) is used for test the disks. Specimens are placed on the concrete sample and sufficient numbers of blows are given until the specimen fails. Number of blows are noted and tabulated in table 7.

Table 7: Impact test results.

Set 1			Set 2			Set 3		
Mix	**Number of Blows**	**% variation of number of blows w.r.t C0 mix**	**Mix**	**Number of Blows**	**% variation of number if blows w.r.t C0 mix**	**Mix**	**Number of Blows**	**% variation of number of blows w.r.t C0 mix**
C0	663	0	P0	630	-4.9	F0	542	-18.25
~~C5~~	~~684~~	~~3.16~~	~~P5~~	~~642~~	~~3.16~~	~~F5~~	~~486~~	~~-26.7~~
C10	727	9.65	P10	665	0.3	F10	452	-31.82
C15	683	3.01	P15	615	-7.23	F15	421	-36.5
C20	656	-1.05	P20	563	-15.08	F20	380	-42.68
C25	540	-0.17	P25	523	-21.11	F25	350	-47.2

VII. GRAPHICAL REPRESENTATION

7.1 Compressive Test Results

Fig7.1(a) Variation of compressive strength with respect to various percentages of SCBA.

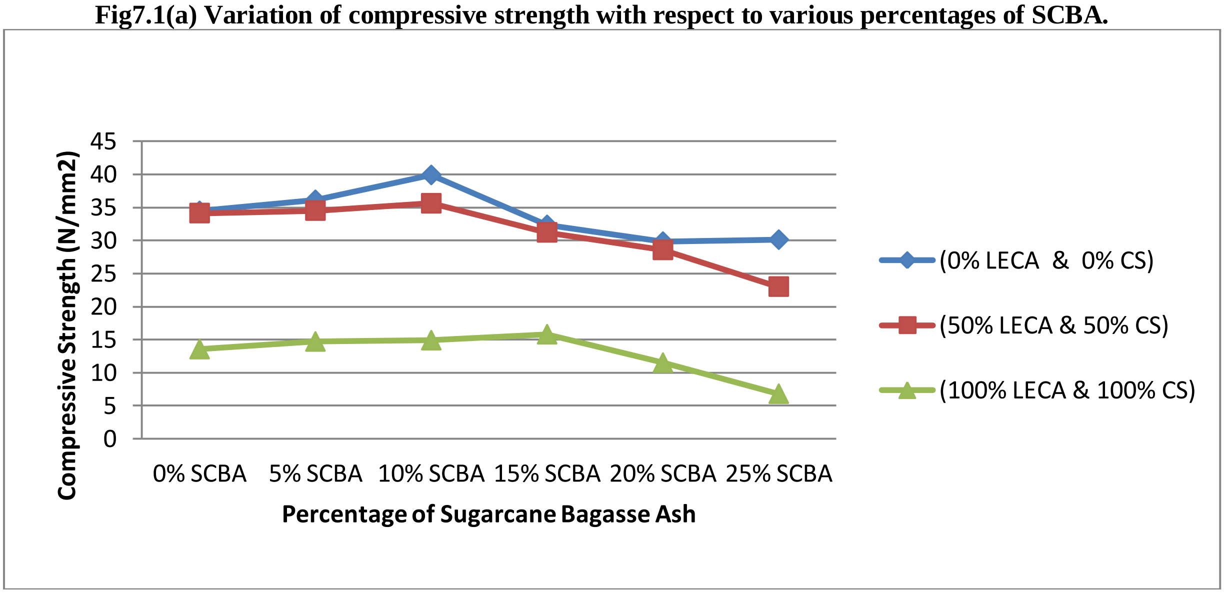
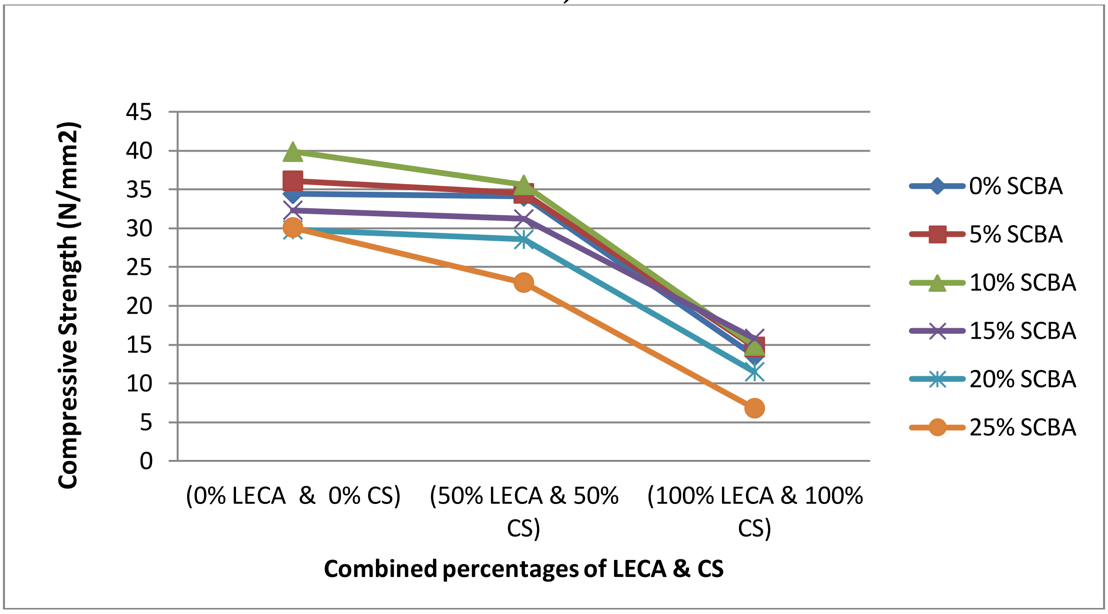


Fig7.1(b) Variation of compressive strength with respect to various percentages of aggregates (LECA & CS).



7.2 Graphical Variation of Tensile Test Results

Fig7.2(a) Variation of tensile strength with respect to different percentages of SCBA.

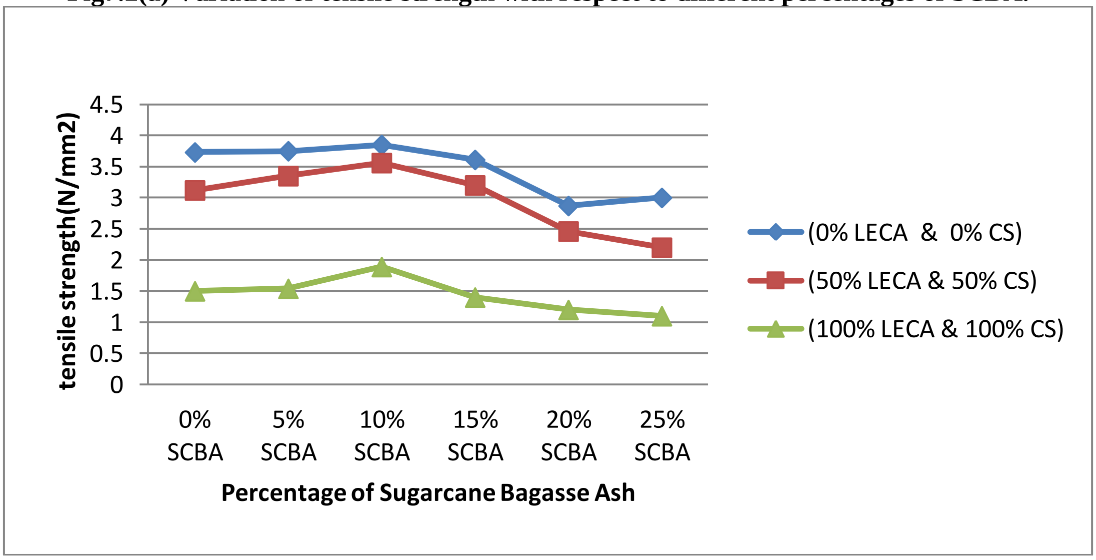
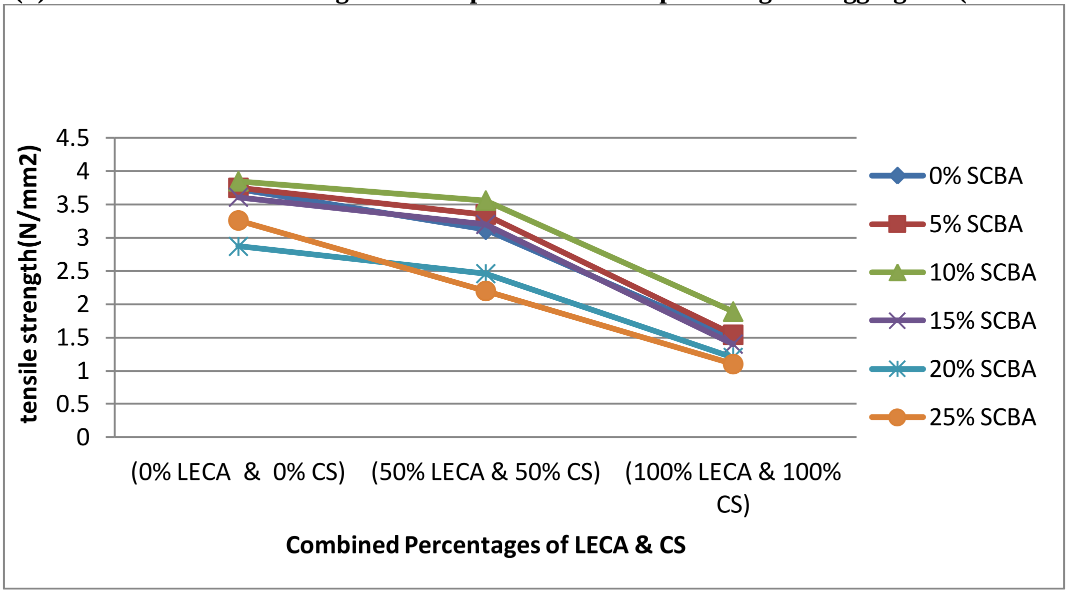


Fig7.2(b) Variation of tensile strength with respect to different percentages of aggregates (LECA & CS).



7.3 Graphical Variation of Flexural Test Results

Fig7.3(a) Variation of flexural strength with respect to different percentages of bagasse ash.

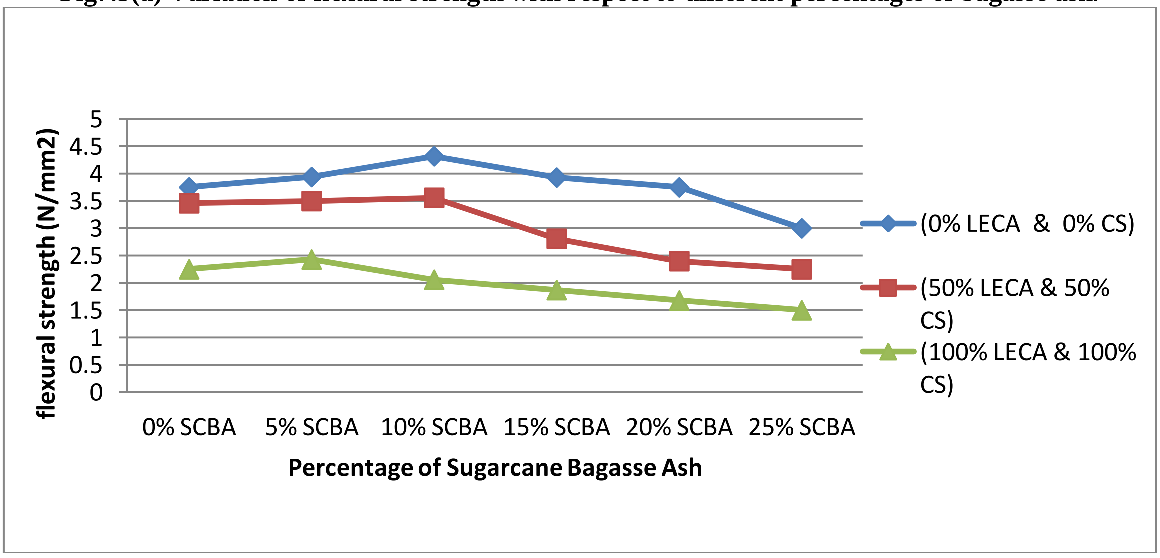
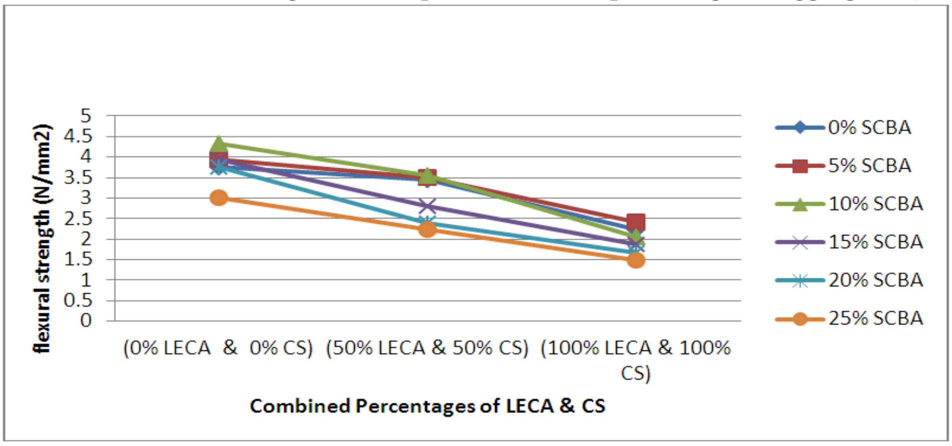


Fig7.3(b) Variation of flexural strength with respect of different percentages of aggregates (LECA & CS)



7.4 Graphical variation of Shear Test Results

Fig7.4(a) In-plane Shear Stress variation of SET-1 mixes for different notch sizes.

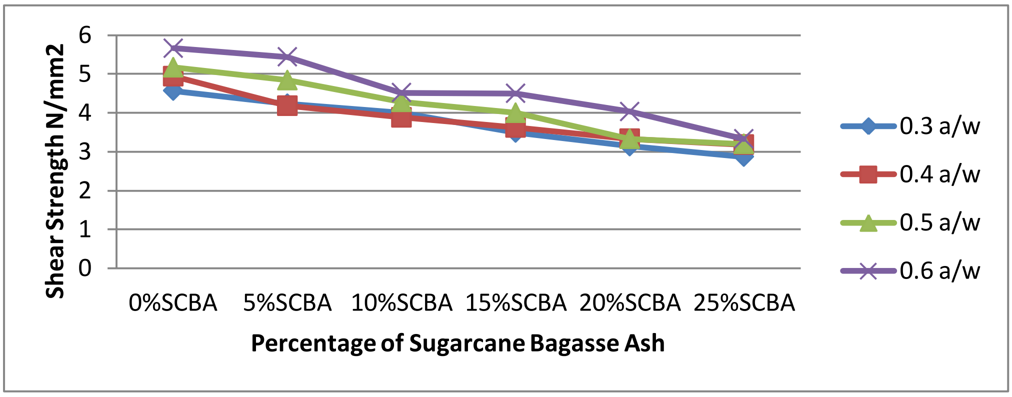


Fig7.4(b) In-plane Shear Stress variation of SET-2 mixes for different notch sizes.

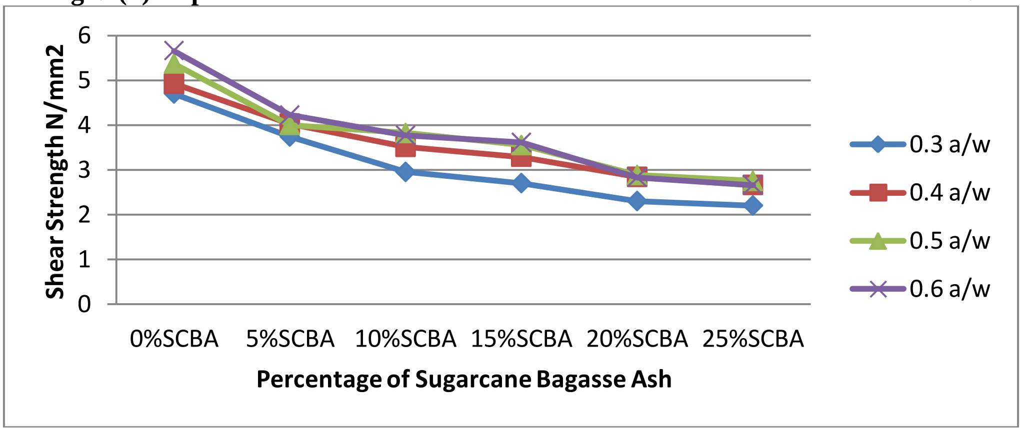
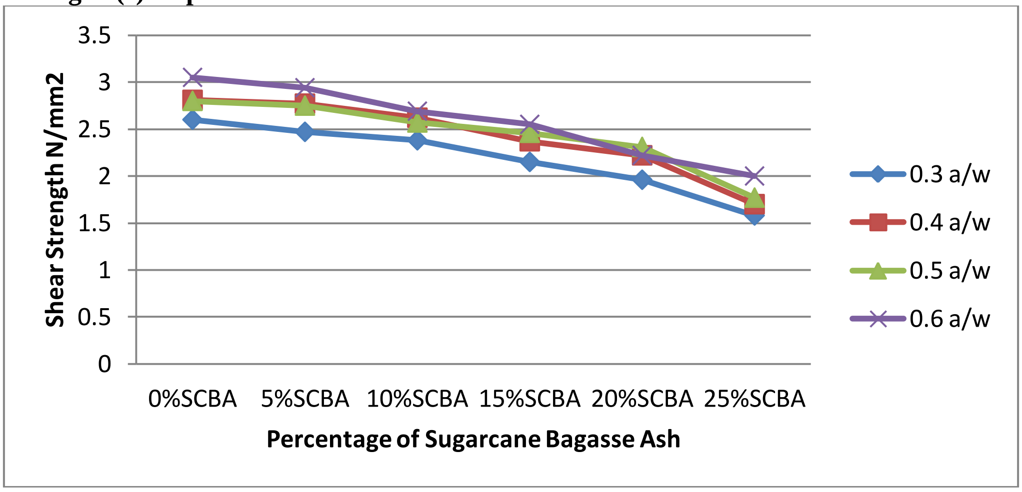
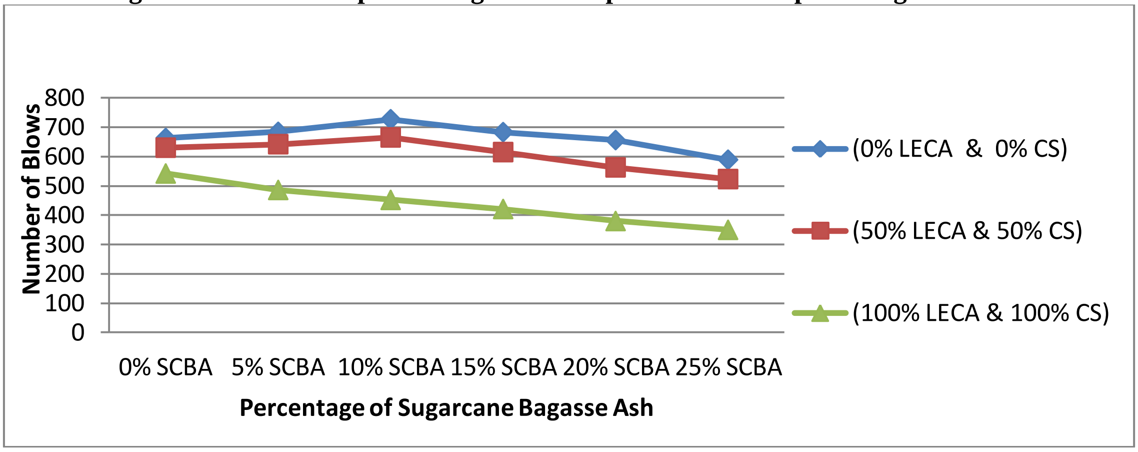


Fig7.4(c) In-plane Shear Stress variation of SET-3 mixes for different notch sizes.



7.5 Graphical Representation of Impact Test Results

Fig7.5 Variation of impact strength with respect to different percentage of SCBA.



VIII. DISCUSSION ON TEST RESULTS

8.1 Discussion on Compressive Strength.

From fig7.1 (a) and table (3) it may be construed that for the concrete with 50% natural coarse aggregates and 50% LECA along with 50% natural fine aggregates and 50% copper slag and along with sugarcane bagasse ash, the compressive strength is increased by 3.36% w.r.t C0 mix for 10% cement replacement. Further replacement of cement decreases the compressive strength.

For 5% replacement of cement, the compressive strength is increased by 4.87% w.r.t C0 mix and further 10% replacement of cement, the compressive strength is increased by 15.79% w.r.t C0 mix. Further replacement of cement gives decrease in compressive strength.

8.2 Discussion on Tensile Strength.

From fig7.2 (a) and table (4) concrete can be made of natural aggregates and the cement replaced with sugarcane bagasse ash. The tensile strength increases up to 10% replacement of cement with SCBA addition and after that tensile strength decreases. For 5% replacement of cement, the tensile strength is increased by 0.53% w.r.t C0 mix and further 10% replacement of cement, the tensile strength is increased by 3.21%w.r.t C0 mix. Further replacement of cement gives decrease in tensile strength.

concrete with 50% natural coarse aggregates and 50% Light Expandable Clay Aggregates along with 50% natural fine aggregates and 50% Copper Slag and along with sugarcane bagasse ash, the tensile strength is decreased only by 4.55% w.r.t C0 mix for 10% cement replacement. Further replacement of cement decreases the tensile strength.

8.3 Discussion on Flexural Strength

From fig 7.3 (a) and table (5) flexural strength of the concrete is increased by 15% w.r.t C0 mix when cement is replaced with SCBA by 10% with further increase in SCBA content it decreases the flexural strength. Concrete with 50% natural coarse aggregates and 50% Light Expandable Clay Aggregates along with 50% natural fine aggregates and 50% Copper Slag and along with sugarcane bagasse ash and its flexural strength is decreased only by 5.06% w.r.t C0 mix for 10% cement replacement. Further replacement of cement decreases the flexural strength.

8.4 Discussion on Shear strength

All the double central notched samples having different a/w ratios 0.3, 0.4, 0.5 and 0.6 and with various percentages of LECA as coarse aggregate and various percentages of copper slag as fine aggregate and various percentages of SCBA as cement are tested in Mode-II fracture(In-plane shear) test. The shear stress results of various mixes are shown in Fig 7.4(a), 7.4(b) and 7.4(c) and table 6(a), 6(b), and 6(c). It is observed that in-plane shear stress decreases with the increase in bagasse ash content. Difference between in-plane shear stress values of SET-1 and SET-2 is nominal. In-plane shear strength increases with increase in a/w ratio from 0.3 to 0.6.

8.5 Discussion on Impact Strength

From Fig7.2.(a) and table (7) shows that concrete made with 50% natural coarse aggregates and 50% LECA along with 50% natural fine aggregates and 50% copper slag and along with sugarcane bagasse ash. Impact strength is increased nominally by 0.3% w.r.t C0 mix for 10% cement replacement. Further replacement of cement decreases the impact strength.

Concrete made of natural aggregates and the cement replaced with sugarcane bagasse ash, the impact strength is increased up to 10% SCBA addition and after that impact strength decreases. For 5% replacement of cement, the impact strength is increased by 3.16% w.r.t C0 mix and further 10% replacement of cement, the impact strength is increased by 9.65% w.r.t C0 mix. Further replacement of cement gives decrease in impact strength.

IX. CONCLUSIONS

- From this experimental study, it is found that sugarcane bagasse ash can be used as binding material by replacing the cement up to 10% due to the presence of considerable amount of silica in SCBA giving better strength without replacement of natural aggregates(i.e., Mix C10%) . .
- Where LECA and CS are abundantly available cheaply, use of 50% replacement of both materials in place of coarse and fine aggregates (i.e., Mix P10%) respectively would yield good results from economy point.
- Adoption of LECA and CS in concrete reduces the self weight of the structure and waste disposal of waste from industries is also reduced.
- In- plane shear stress decreases with increase in percentage of SCBA and increases with increase in a/w ratio.

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