RESEARCH ARTICLE OPEN ACCESS

An Investigative Study on the Use of Sintered Fly Ash Light Weight Aggregate and Robo Sand replacing the Conventional Aggregates in Making of Light Weight Concrete

Mr. Y. Krishna Prasad[1], Mr. V. Raghavachar[2], Prof. V. Bhaskar Desai[3]
[1] M. Tech (Structural engineering), Dept of civil engineering, JNTUA College of Engineering, Anantapur, A.P. India.
[2]Lecturer in Civil Engineering, Govt. Polytechnic, Satyavadu, A.P, India
[3]Professor of Civil engineering, JNTUA College of Engineering, Anantapur, A.P, India

ABSTRACT
This research study investigates how the conventional aggregates is to be replaced with fabricated aggregates such as sintered fly ash light weight aggregates and robo sand with various proportions to form light weight concrete. In the experimental work, initially the coarse aggregate is replaced with sintered fly ash light weight aggregates by 0%, 25%, 50%, 75% and 100% and for each percentage of coarse aggregate replacement, fine aggregate is substituted with robo sand by 0%, 25%, 50%, 75% and 100% for M 25 grade of concrete and totally for 25 mix proportions, 600 specimen are made to test for compression, split tensile, flexure, in plane shear strength through mode-II fracture studies and impact for 28 days. The main intension of the present study is to correlate the strength of modified concrete with conventional concrete of M25 Grade. The experimental values of this study noted here, have revealed that the mix of sintered fly ash light weight aggregate with robo sand has upgraded the strength at the period of 28 days.

Keywords: Sintered Fly ash aggregates, Robo sand, Compression, Split tensile, Flexural, In-plane shear, Impact strength.

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I. INTRODUCTION

The need to sustain the basic assets that are confronting the reduction has compelled engineers to investigate for alternative materials. Further dumping of solid waste developed by industrial and farming productivity is a severe concern in the fast developing countries like India as it pollutes the environment. Hence development of modern technologies to modify waste materials is very essential for the conservation and sustainable development of the society. Fly ash is a disposable item from thermal power stations, so that making the use of fly ash to produce sintered fly ash light weight aggregate, which can be used instead of natural coarse aggregate in concrete. In order to lower down the dependence on the natural sand in construction, artificially manufactured fine aggregate is used as a substitute material. Using the robo sand as a substitute material for sand in concrete will reduce the usage of natural river sand.

II. LITERATURE REVIEW

Arvind Kumar, Dilip Kumar [1] researched on substitution of natural coarse aggregates with sintered fly ash aggregate by 0%, 10%, 20%, 30%, 40%, and 50% in M25 grade of concrete and concluded that maximum strength attained at 30% replacement.

Arokiaprakash, Thenarsan [2] stated the optimum compressive strength values attained when the sintered fly ash aggregate is substituted 40% to natural coarse aggregate in M25 grade for 7, 14 and 28 days.

Tarachandhini [3] stated that the sintered fly ash aggregates can be effectively utilized as a substitution material in place of normal aggregates to generate light weight concrete and for 100% replacement, slight decrease in compressive strength values as compare to normal concrete of M25 grade.

Shaik Yajdani [4] studied on the substitution of natural sand with robo sand in 20% 40%, 60%, 80%, 100% for M20 and M 30 grade of concrete and optimum strength values are gained at 60% replacement and stated that robo sand can be utilized as a best substitute material for fine aggregate replacement.

Ramesh babu [5] studied on replacement of river sand with robo sand by 0%, 25%, 50%, 75%

and 100% for M30 and M40 and stated at 50% substitution of robo sand the strength results are maximum.

Rukmangadhara Rao, Vidya Sagar lal [6] studied the strength of concrete by the substitution of natural fine aggregate with robo sand in percentage of 0%, 50%, 75% and 100% and maximum results attained at 50% replacement.

From the above brief literature review, it has been recognized that little work is done by the earlier investigators in the usage of sintered fly ash aggregates and robo sand in concrete. Insufficient data is accessible for the correlation of strength properties. Hence an experimental investigation is essentially needed to recognize the strength parameters of concrete with substitution of sintered fly ash aggregate and robo sand in place of conventional aggregates.

III. OBJECTIVE

❖ To discover the strength parameters of concrete made by substitution of normal coarse aggregate with sintered fly ash aggregates by 0%-100% with steps in 25% and for each percentage substitution of coarse aggregate, normal fine aggregate is replaced with robo sand by 0%, 25%, 50%, 75% and 100%.

❖ To explore the comparison of modified concrete made with sintered fly ash aggregates and robo sand as substitute materials of coarse and fine aggregates with normal concrete and to obtain the optimal percentage replacement of sintered fly ash light weight aggregate and robo sand with coarse and fine aggregate.

IV. MATERIALS USED

a) **Cement:** OPC-53 Grade is used.
b) **Normal Fine aggregate (sand):** The locally accessible River sand from adjacent chitravathi stream is procured and which is passing through IS Sieve of 4.75mm size and which confirms to zone-II of IS: 383-1970[7] is utilized for this entire investigation.
c) **Robo sand:** Robo sand is obtained from the stone quarries near Chikballapur, Karnataka state which passes through 4.75mm IS Sieve.
d) **Normal Coarse aggregate:** Locally attainable crushed coarse aggregate of largest size of 20mm and that confirms to IS: 383-1970[7] is used.
e) **Sintered fly ash aggregates:** These are procured from the LITAGG industries Pvt Ltd, Ahmedabad, Gujarat.
f) **Water:** Locally obtainable potable water has been used for mixing and curing purpose.

Table 1: Characteristics of Elementary Materials

<table>
<tr><th colspan="2">Characteristics of Cement</th><th>Specific gravity</th><th colspan="2">Normal consistency</th><th colspan="2">Initial setting time</th><th colspan="2">Final setting time</th><th>Fineness</th></tr>
<tr><td colspan="2">Test values</td><td>3.14</td><td colspan="2">29%</td><td colspan="2">50 minutes</td><td colspan="2">575 minutes</td><td>5.4%</td></tr>
<tr><td colspan="2">Characteristics of Fine aggregate</td><td colspan="2">Specific gravity</td><td colspan="4">Fineness modulus</td><td colspan="2">Water absorption</td></tr>
<tr><td rowspan="2">Test values</td><td>Natural Fine aggregate</td><td colspan="2">2.64</td><td colspan="4">2.46</td><td colspan="2">0.5%</td></tr>
<tr><td>Robo sand</td><td colspan="2">2.55</td><td colspan="4">2.54</td><td colspan="2">2%</td></tr>
<tr><td colspan="2">Characteristics of Coarse aggregate</td><td colspan="2">Specific gravity</td><td colspan="2">Bulk density compacted</td><td colspan="2">Fineness modulus</td><td colspan="2">Water absorption</td></tr>
<tr><td rowspan="2">Test values</td><td>Natural Coarse aggregate</td><td colspan="2">2.66</td><td colspan="2">1620 kg/m^3</td><td colspan="2">6.98</td><td colspan="2">0.25%</td></tr>
<tr><td>Sintered fly ash aggregates</td><td colspan="2">1.8</td><td colspan="2">740 kg/m^3</td><td colspan="2">6.3</td><td colspan="2">21%</td></tr>
</table>

V. EXPERIMENTAL PROCEDURE

An Experimental study has been conducted on concrete with various replacements i.e. normal coarse aggregate replaced with sintered fly ash light weight aggregates in proportions of 0%, 25%, 50%, 75% and 100%, and normal fine aggregate replaced with robo sand in percentages of 0%, 25%, 50%, 75% & 100% with each percentage replacement of coarse aggregates. Thus totally 25 mixes are attained. An investigative study has been performed by casting, curing and testing of the specimens of all 25 proportions.

For one proportion numbers of specimens required are as follows.

(a) Three cubes for compression test having measurements 150mm *150mm*150mm
(b) Three cylinders for split tensile test having measurements 150mm (dia)*300mm (height)
(c) Three beams for flexural test having measurements 100mm*100mm*500mm
(d) Four categories of in plane shear cubes having size 150mm*150mm*150mm are given below
   i. Three specimens for 0.3 a/w ratio
   ii. Three specimens for 0.4 a/w ratio
   iii. Three specimens for 0.5 a/w ratio
   iv. Three specimens for 0.6 a/w ratio

These are utilized to obtain In-plane shear stress using mode-II fracture studies.

(e) Three circular discs for impact test having measurements of 150mm (dia)*75mm (height)

Thus totally 600 specimens are cast and tested.

5.1 Mix Design

The M25 concrete mix design is performed in ISI method adopting **IS 10262-2009[8]** and **IS 456-2000[9]** and it gives the mix proportion of **1:1.52:2.62** and w/c ratio 0.45 is constant. By using above mentioned mix ratio, 25 mixes are cast with various percentage replacements of conventional aggregates as representated in Table 2.

Table 2: Detailed Mix Proportion

Set NO.	1					2				
Designation of the Mix	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
CA %	100	100	100	100	100	75	75	75	75	75
SFA%	0	0	0	0	0	25	25	25	25	25
FA%	100	75	50	25	0	100	75	50	25	0
RS%	0	25	50	75	100	0	25	50	75	100
Set NO.	3					4				
Designation of the Mix	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20
CA%	50	50	50	50	50	25	25	25	25	25
SFA%	50	50	50	50	50	75	75	75	75	75
FA%	100	75	50	25	0	100	75	50	25	0
RS%	0	25	50	75	100	0	25	50	75	100
Set NO.	5									
Designation of the Mix	K21	K22	K23	K24	K25					
CA%	0	0	0	0	0					
SFA%	100	100	100	100	100					
FA%	100	75	50	25	0					
RS%	0	25	50	75	100					

Where
CA=Coarse Aggregate, SFA=Sintered Fly ash Aggregate
FA=Fine Aggregate, RS=Robo Sand
Here K1 mix designation represents conventional concrete mix of M25.

5.2 Mixing, Casting and curing of specimens

In experimental work to begin with steel moulds are neatly cleaned and all the internal surfaces are brushed by machine waste oil to promote easy removal of specimens from steel moulds. In the case in-plane shear moulds, iron plates are fixed to the firm with the binding wire to hold immovably after placing the concrete. All weights of materials are taken for required mix proportion and poured into the concrete mixer and blended together for obtaining uniform mix. All required steel moulds are kept on level surfaces and concrete is placed in three numbers into the moulds, and using tamping rod each layer is tamped thoroughly and moulds with concrete are kept on a vibration table for 8-10 sec for the removal of air pockets in concrete. For In-plane shear cubes, the notch plates are taken away after suitable time after casting. After completion of 24 hours, concrete samples are detached from moulds and immersed in a water tank for curing. Later 28 days the specimens are removed from the water tank and are allowed to dry for certain time and for clear recognition of cracks during testing all sides of specimens are washed by lime.

VI. TESTING

6.1 Compression test

Compressive strength of cubes is obtained by dividing maximum load with the cross sectional area. In compression testing machine the load is applied uniformly at the rate 14.00 N/mm^2/sec and cube is placed in such a way that the load is concentrically taken by the cube. The test results of 25 mixes are shown as 5 sets in Table 3 and values are represented in graphical form in Fig 1(a) & Fig 1(b).

Compressive strength =Ultimate load (N)/cross sectional area (mm^2)

Table 3: Compressive strength results for 28 days

Set No.1			**Set No.2**		
Mix Designation	**Compressive strength (N/mm^2)**	**Percentage variation**	**Mix Designation**	**Compressive strength (N/mm^2)**	**Percentage variation**
K1	34.44	0	K6	36.79	6.82
K2	36.32	5.45	K7	40.35	17.16
K3	38.83	12.74	K8	42.34	22.94
K4	36.75	6.71	K9	40.82	18.52
K5	34.89	1.3	K10	37.63	9.26

Set No.3			**Set No.4**		
Mix Designation	**Compressive strength (N/mm^2)**	**Percentage variation**	**Mix Designation**	**Compressive strength (N/mm^2)**	**Percentage variation**
K11	35.30	2.49	K16	32.16	-6.62
K12	36.23	5.19	K17	34.86	1.22
K13	38.38	11.44	K18	36.8	6.85
K14	36.84	6.97	K19	35.01	1.65
K15	34.78	0.98	K20	33.26	-3.42

Set No.5		
Mix Designation	**Compressive strength (N/mm^2)**	**Percentage variation**
K21	30.64	-11.03
K22	31.38	-8.88
K23	32.70	-5.05
K24	31.95	-7.23
K25	30.83	-10.48

6.2 Split tensile test

In split tensile test, the axis of cylindrical specimen is kept in the direction of the compressive plates of the machine which has a ultimate load of 2000 KN. The load is operated consistently until the specimen fails. Test results of 25 mixes are shown as 5 sets in Table 4. These values are represented in graphical format in Fig 2(a) & Fig 2(b).

Split tensile strength =2P/πdl (N/mm^2)

Table 4: Split tensile strength results for 28 days

Set No.1			Set No.2		
Mix Designation	**Split tensile strength (N/mm^2)**	**Percentage variation**	**Mix Designation**	**Split tensile strength (N/mm^2)**	**Percentage variation**
K1	3.73	0	K6	3.94	5.63
K2	3.88	4.02	K7	4.28	14.74
K3	4.08	9.38	K8	4.48	20.10
K4	3.91	4.82	K9	4.36	16.89
K5	3.78	1.34	K10	4.02	7.77

Set No.3			Set No.4		
Mix Designation	**Split tensile strength (N/mm^2)**	**Percentage variation**	**Mix Designation**	**Split tensile strength (N/mm^2)**	**Percentage variation**
K11	3.77	1.07	K16	3.55	-4.82
K12	3.82	2.41	K17	3.66	-1.87
K13	3.97	6.43	K18	3.83	2.68
K14	3.85	3.21	K19	3.69	-1.07
K15	3.68	-1.34	K20	3.48	-6.7

Set No.5		
Mix Designation	**Split tensile strength (N/mm^2)**	**Percentage variation**
K21	3.26	-12.6
K22	3.41	-8.58
K23	3.61	-3.22
K24	3.52	-5.63
K25	3.33	-10.72

6.3 Flexural test

Flexural strength is performed to find out the strength of concrete in resisting the bending failure. In this test the flexural strength is achieved through the standard test approach of two-point loading. Test results of 25 mixes are shown as 5 sets in table 5 and test values are represented in graphical form as in Fig 3(a) & Fig 3(b).

$$\text{Flexural strength} = PL/bd^2\ (N/mm^2)$$

Here P=maximum load
And L=beam length between supports
b & d are section dimensions

Table 5: Flexural strength results for 28 days

Set No.1			Set No.2		
Mix Designation	**Flexural strength (N/mm^2)**	**Percentage variation**	**Mix Designation**	**Flexural strength (N/mm^2)**	**Percentage variation**
K1	3.75	0	K6	3.83	2.13
K2	3.88	3.46	K7	4.10	9.33
K3	4.25	13.33	K8	4.38	16.8
K4	4.125	10	K9	4.19	11.73
K5	3.88	3.46	K10	4.06	8.26

Set No.3			Set No.4		
Mix Designation	**Flexural strength**	**Percentage variation**	**Mix Designation**	**Flexural strength**	**Percentage variation**

	(N/mm^2)			**(N/mm^2)**	
K11	3.66	-2.4	K16	3.55	-5.33
K12	3.82	1.86	K17	3.63	-3.2
K13	4.15	10.66	K18	3.88	3.46
K14	3.95	5.33	K19	3.78	0.8
K15	3.68	-1.86	K20	3.38	-9.86

Set No.5		
Mix Designation	**Flexural strength (N/mm^2)**	**Percentage variation**
K21	3.52	-6.13
K22	3.38	-9.86
K23	3.63	-3.2
K24	3.47	-7.46
K25	3.25	-13.33

6.4 Mode II fracture test

To obtain the in-plane shear stress, double central notched specimens having dimensions of 150mm*150mm*150mm are cast. Two notches are introduced at 1/3rd&2/3rd portion of the specimen during the time of casting. The Mode-II fracture test is performed on digital compression testing machine having the highest capacity 3000KN. The middle one-third portion between the two notches is loaded with a rate of 0.5KN/sec. Specimen is placed over the two square c/s steel supports, so that the middle portion could get punched along the notches at the time of ultimate load. The test set up and loading arrangement is depicted in plate 1.

In-plane shear strength (N/mm^2) =shear force/shear area
Where
Shear force=P/2; P=ultimate load (N)
Shear area (mm^2) =b*(w-a)
b & w are measurements of specimen in mm
a is the notch depth & various sizes a is 45mm,60mm,75mm and 90mm.

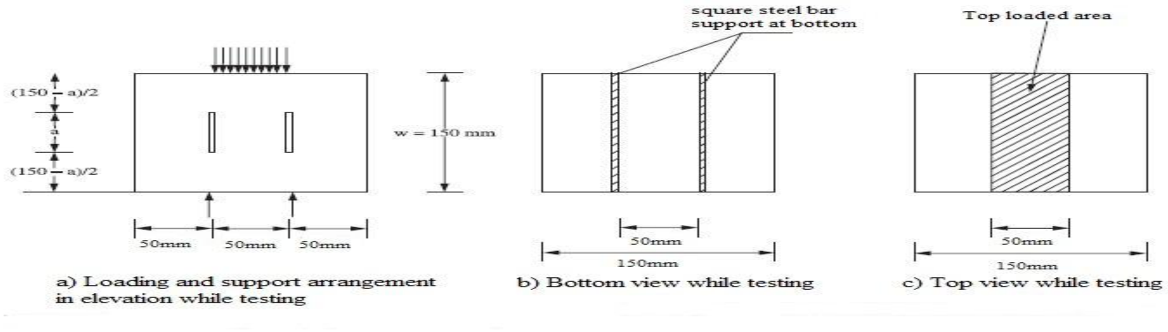

Plate 1: loading pattern of DCN specimens

The test results of in-plane shear stress of concrete of 25 mixes for various a/w ratios in mode-II shear are shown as 5 sets in table 6 and test values are shown in graphical format as in Fig 4(a) to 4(e).

Table 6: Maximum load and In-plane shear stress in mode-II fracture test results for 28 days

Set No.1								
Designation of the mix	**Ultimate load (KN)**				**In-plane shear stress (N/mm^2)**			
	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6
K1	144	126	108	98	4.57	4.66	4.8	5.44
K2	151	138	109	107	4.79	5.11	4.84	5.94
K3	167	154	124	115	5.30	5.7	5.51	6.38
K4	157	139	117	108	4.98	5.15	5.2	6.00
K5	147	134	111	102	4.67	4.96	4.93	5.66

Set No. 2								
Designation of the mix	**Ultimate load (KN)**				**In-plane shear stress (N/mm^2)**			
	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6
K6	159	136	121	102	5.04	5.03	5.37	5.66
K7	165	144	132	120	5.24	5.33	5.86	6.67
K8	176	158	144	128	5.58	5.85	6.4	7.11
K9	168	156	136	117	5.33	5.77	6.04	6.5
K10	162	143	128	109	5.14	5.29	5.68	6.05

Set No. 3								
Designation of the mix	**Ultimate load (KN)**				**In-plane shear stress (N/mm^2)**			
	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6
K11	154	146	132	118	4.88	5.40	5.86	6.55
K12	158	142	128	116	5.02	5.26	5.68	6.44
K13	166	151	132	123	5.27	5.59	5.86	6.83
K14	153	134	121	112	4.85	4.96	5.37	6.22
K15	140	127	108	101	4.44	4.70	4.8	5.61

Set No. 4								
Designation of the mix	**Ultimate load (KN)**				**In-plane shear stress (N/mm^2)**			
	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6
K16	133	121	107	95	4.22	4.48	4.75	5.27
K17	142	134	114	102	4.51	4.96	5.06	5.66
K18	155	144	129	115	4.92	5.33	5.73	6.38
K19	147	132	117	105	4.66	4.88	5.2	5.83
K20	141	126	107	98	4.47	4.70	4.8	5.44

Set No. 5								
Designation of the mix	**Ultimate load (KN)**				**In-plane shear stress (N/mm^2)**			
	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6	a/w=0.3	a/w=0.4	a/w=0.5	a/w=0.6
K21	130	124	108	98	4.12	4.59	4.8	5.44
K22	138	125	110	102	4.38	4.63	4.88	5.66
K23	151	133	123	108	4.79	4.92	5.46	6
K24	143	128	114	105	4.54	4.74	5.06	5.83
K25	133	121	108	95	4.22	4.48	4.8	5.27

6.5 Impact test

To know the impact strength of concrete, circular shape disc moulds having measurements of 150mm (dia) &75mmheight are used. The samples are positioned in impact testing equipment that consists of steel casting, steel ball and hammer weight of 2.3 kgs. Blows are given to disc samples using hammer and number of blows are noted until the sample fails. Test results of 25 mixes are shown as 5 sets in Table 7 and test values are represented in graphical form as in Fig 5(a) & Fig 5(b).

Table 7: Impact strength results for 28 days

Set No.1			Set No.2		
Mix Designation	**Number of Impact blows**	**Percentage variation**	**Mix Designation**	**Number of Impact blows**	**Percentage variation**
K1	655	0	K6	673	2.74
K2	677	3.36	K7	704	7.48
K3	713	8.85	K8	738	12.67
K4	689	5.19	K9	712	8.7
K5	667	1.83	K10	686	4.73

Set No.3			Set No.4		
Mix	**Number of**	**Percentage**	**Mix**	**Number of**	**Percentage**

Designation	Impact blows	variation	Designation	Impact blows	variation
K11	622	-5.03	K16	607	-7.32
K12	642	-1.98	K17	621	-5.19
K13	672	2.59	K18	641	-2.14
K14	660	0.76	K19	632	-3.51
K15	636	-2.90	K20	614	-6.26

Set No.5		
Mix Designation	Number of Impact blows	Percentage variation
K21	552	-15.72
K22	566	-13.58
K23	583	-11.0
K24	572	-12.67
K25	558	-14.80

VII. GRAPHICAL VARIATION

7.1 Compressive strength variation

7.1.1 Compressive strength variation with % SFA

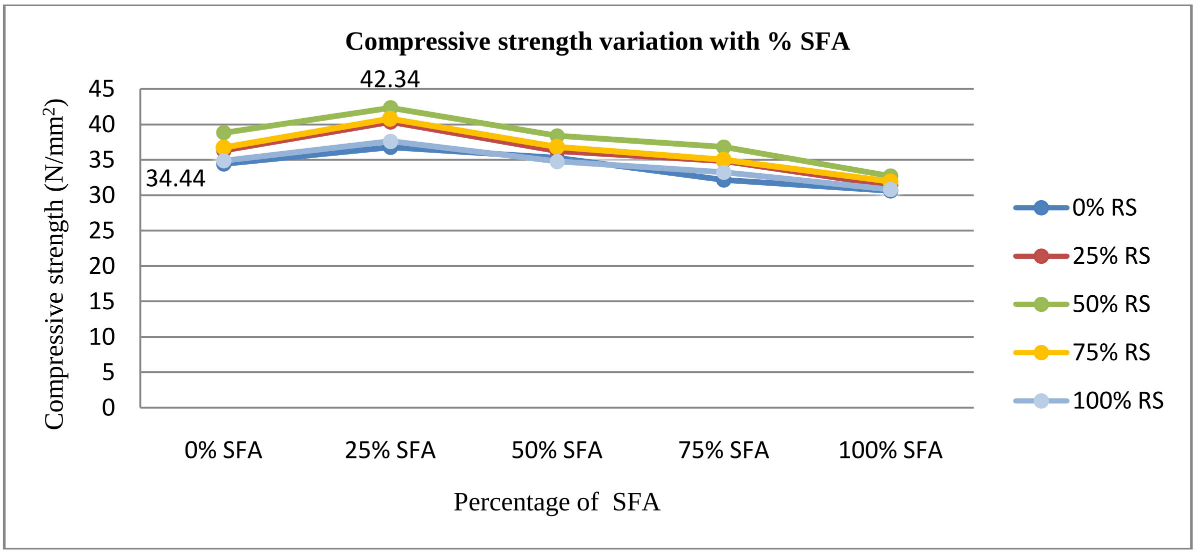

Fig 1(a): Compressive strength variation with percentages of sintered fly ash aggregate

Where SFA = sintered fly ash aggregate, RS= robo sand

7.1.2 Compressive strength variation with % RS

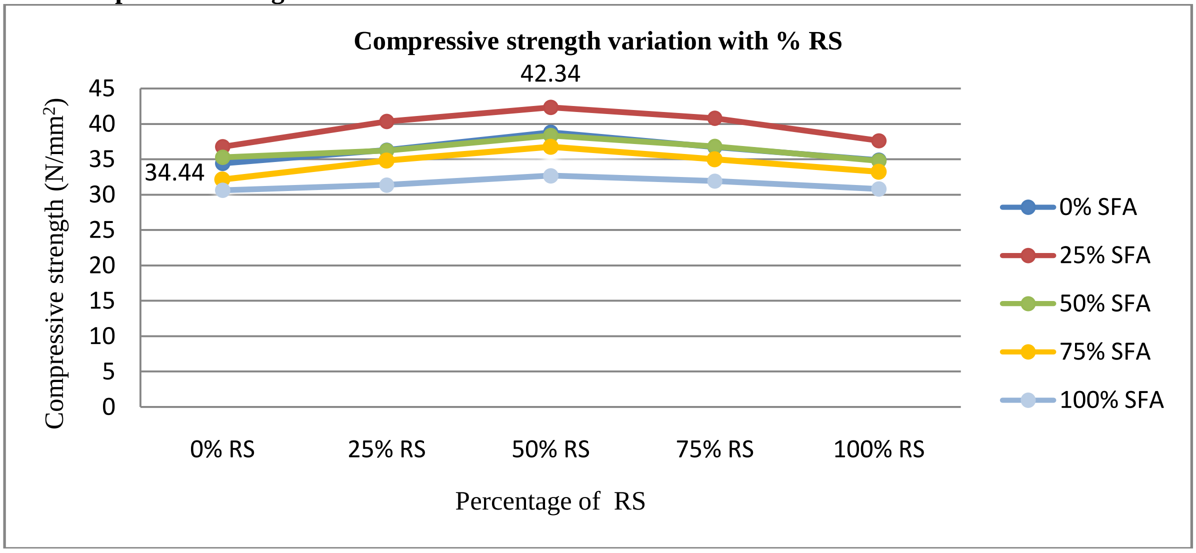

Fig 1(b): Compressive strength variation with percentages of robo sand

Where SFA = sintered fly ash aggregate, RS= robo sand

7.2 Split tensile strength variation
7.2.1 Split tensile strength variation with % SFA

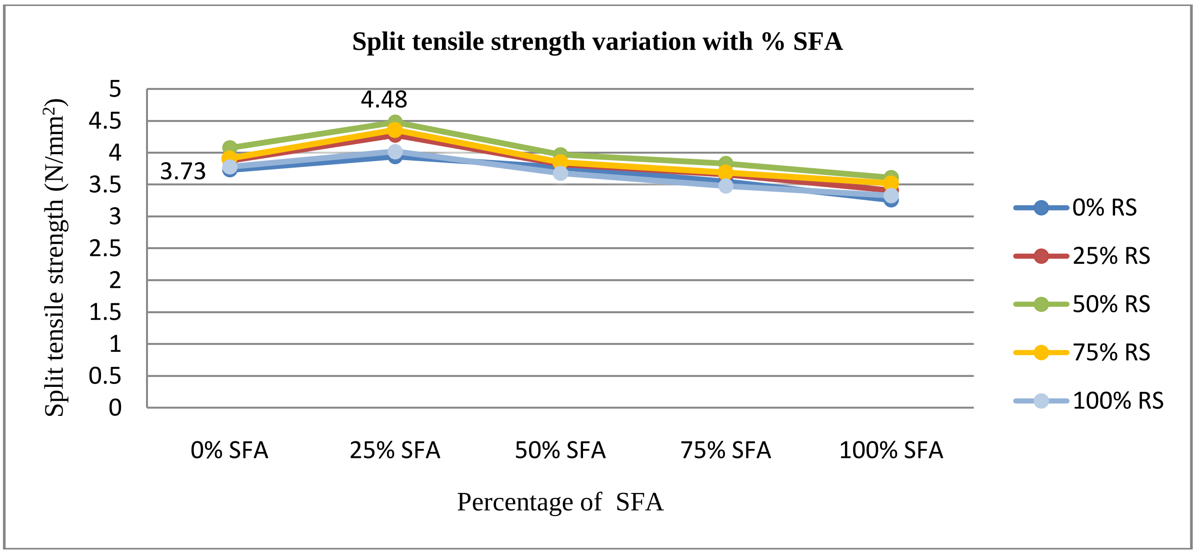

Fig 2(a): Split tensile strength variation with percentages of sintered fly ash aggregate

Where SFA = sintered fly ash aggregate, RS= robo sand

7.2.2 Split tensile strength variation with % RS

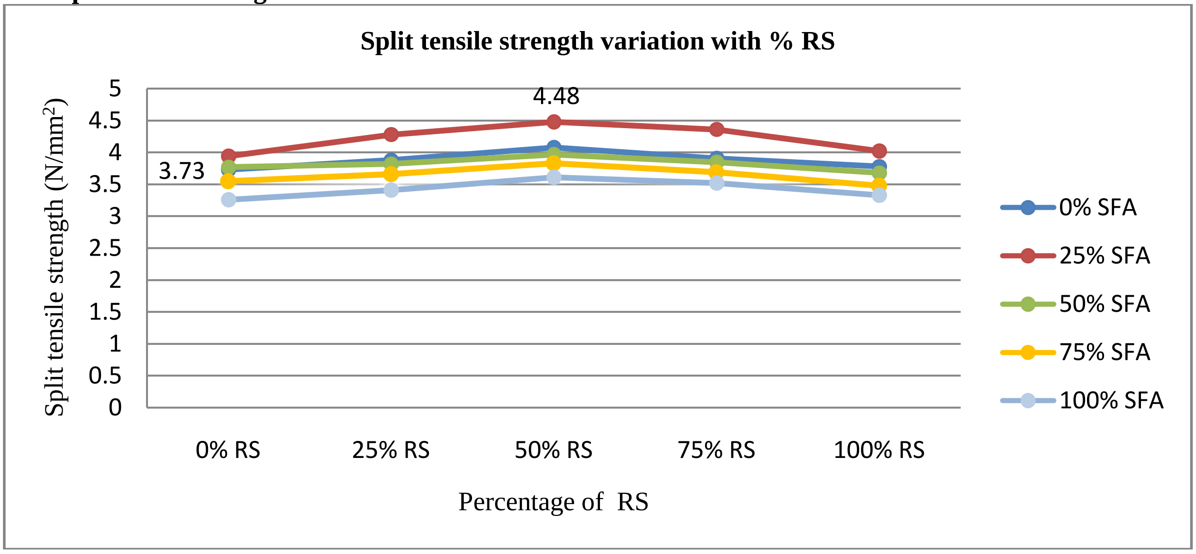

Fig 2(b): Split tensile strength variation with percentages of robo sand

Where SFA = sintered fly ash aggregate, RS= robo sand

7.3 Flexural strength variation
7.3.1 Flexural strength variation with % SFA

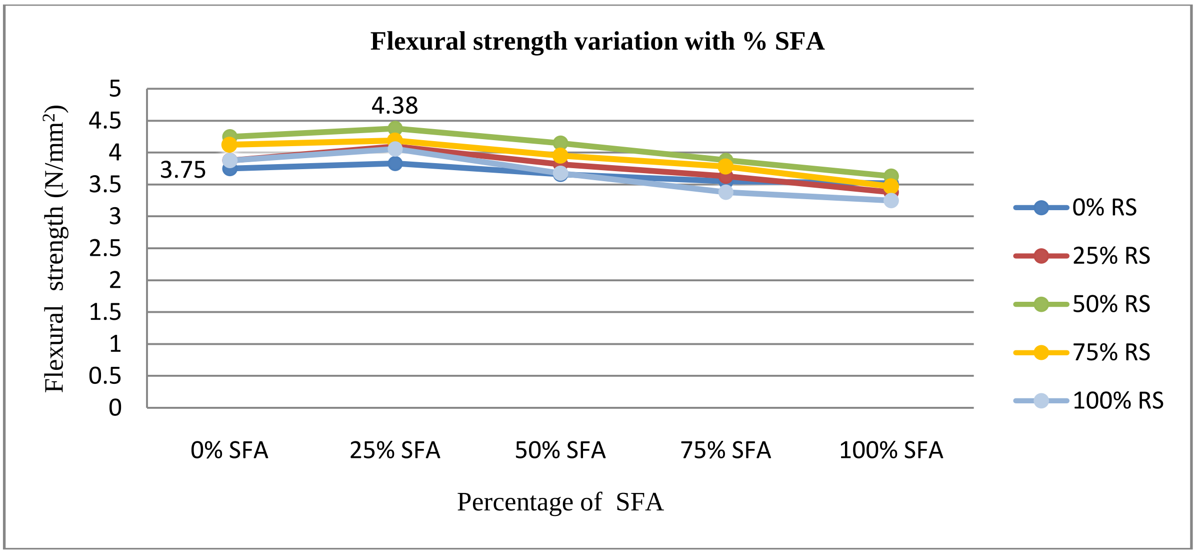

Fig 3(a): Flexural strength variation with percentages of sintered fly ash aggregate

Where SFA = sintered fly ash aggregate, RS= robo sand

7.3.2 Flexural strength variation with % RS

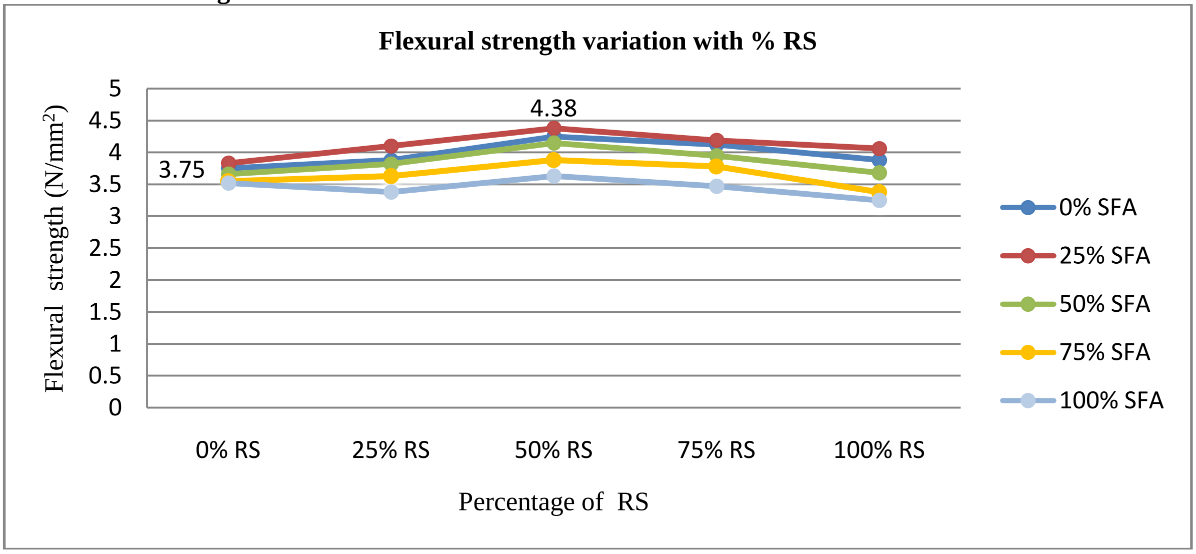

Fig 3(b): Flexural strength variation with percentages of robo sand
Where SFA = sintered fly ash aggregate, RS= robo sand

7.4 In-plane shear strength variation
7.4.1 In-plane shear strength for Set No.1 with different a/w ratios

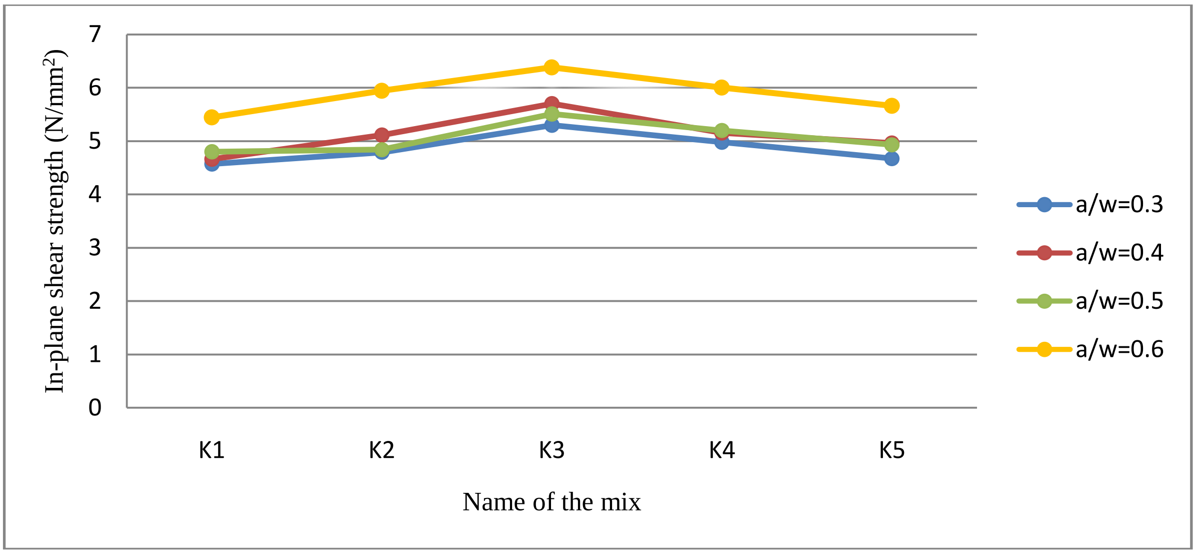

Fig 4(a): In-plane shear strength results of SET No.1 for various a/w ratios

7.4.2 In-plane shear strength for Set No.2 with different a/w ratios

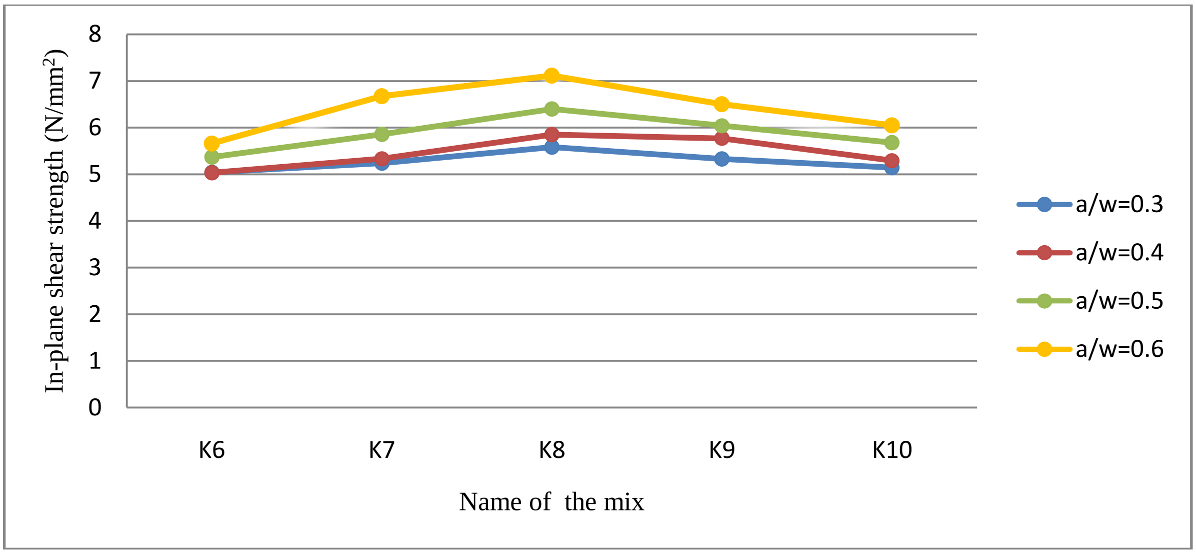

Fig 4(b): In-plane shear stress values of SET No.2 for various a/w ratios

7.4.3 In-plane shear strength for Set No.3 with different a/w ratios

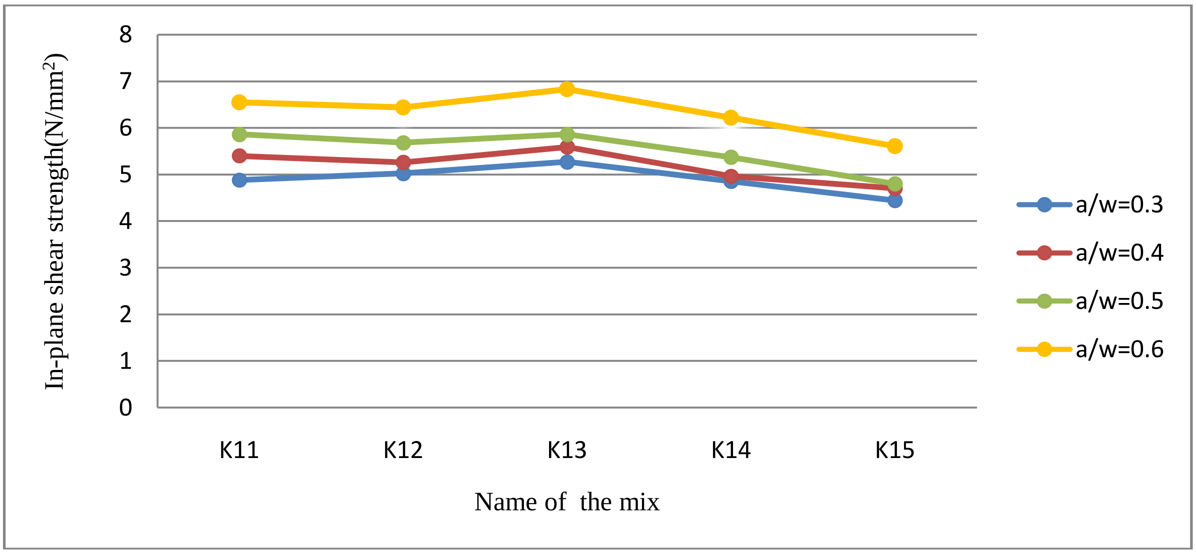

Fig 4(c): In-plane shear strength values of SET 3 for various a/w ratios

7.4.4 In-plane shear strength for Set No.4 with different a/w ratios

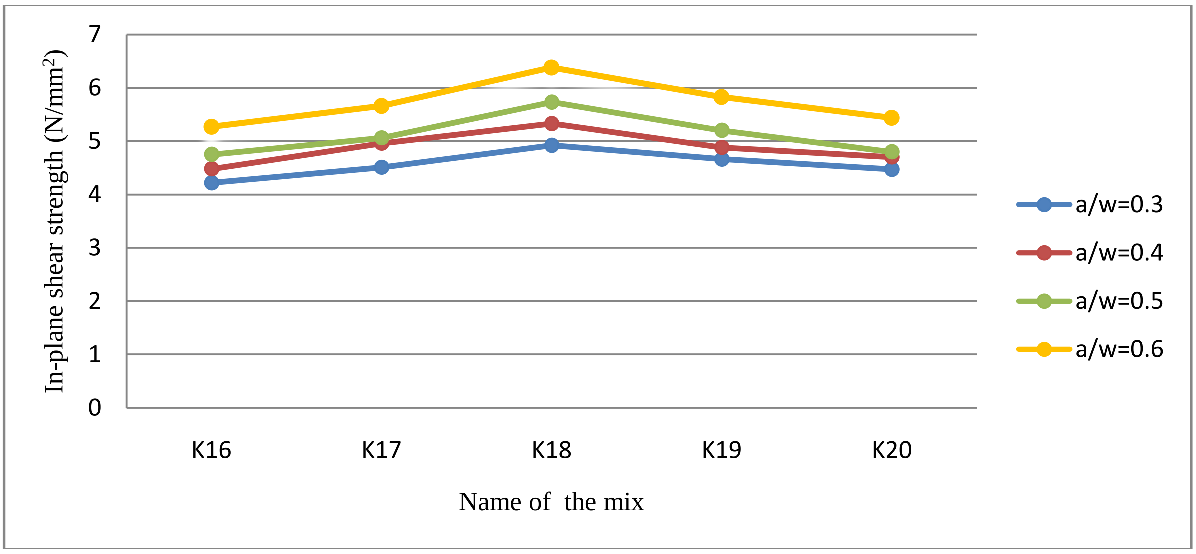

Fig 4(d): In-plane shear strength values of SET No.4 for various a/w ratios

7.4.5 In-plane shear strength for Set No.5 with different a/w ratios

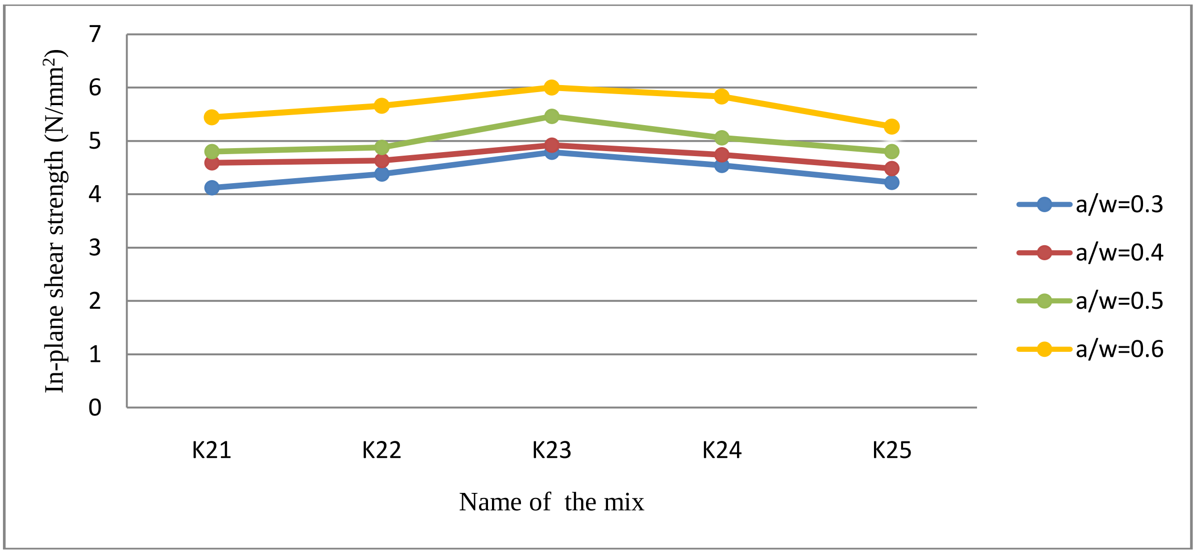

Fig 4(e): In-plane shear strength values of SET No.5 for various a/w ratios

7.5 Impact strength variation

7.5.1 Impact strength variation with %SFA

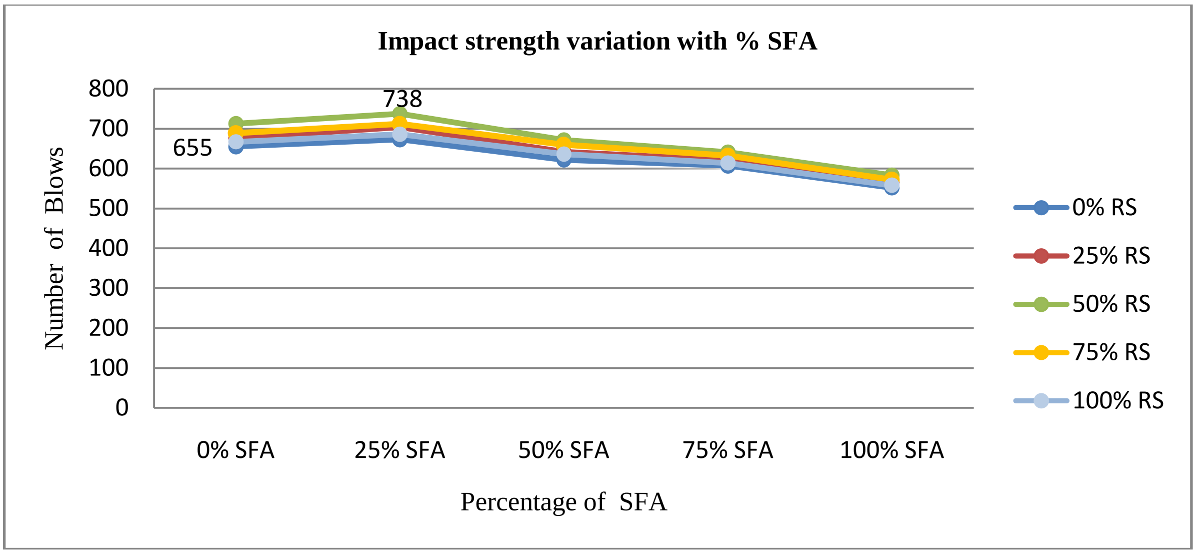

Fig 5(a): Impact test results variation with percentages of sintered fly ash aggregate

Where SFA = sintered fly ash aggregate, RS= robo sand

7.5.2 Impact strength variation with %RS

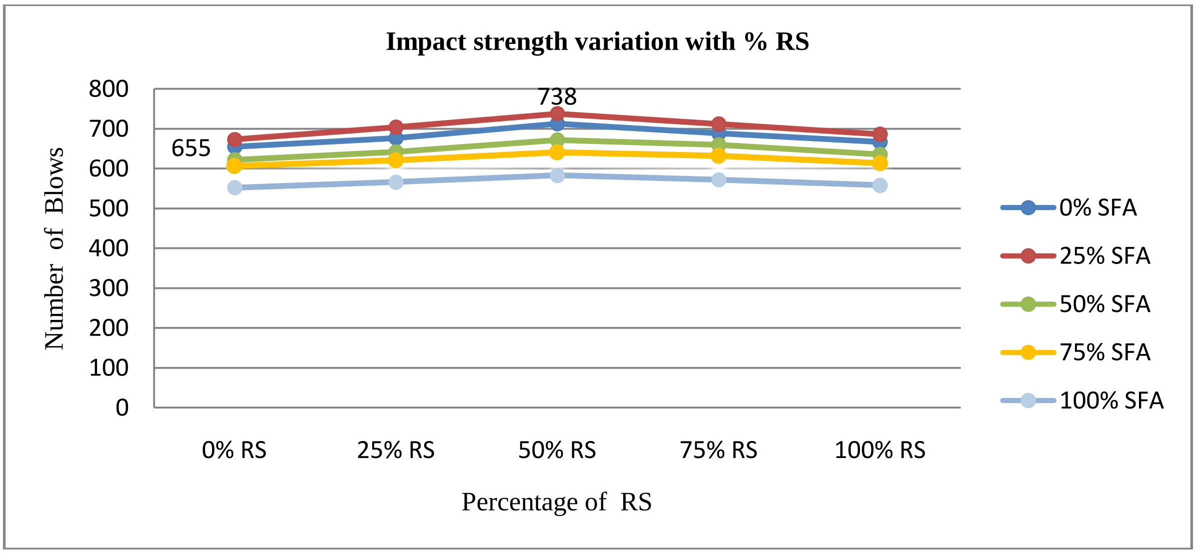

Fig 5(b): Impact test results variation with percentages of robo sand

Where SFA = sintered fly ash aggregate, RS= robo sand

VIII. DISCUSSION ON TEST RESULTS

8.1 Influence of sintered fly ash light weight aggregate and robo sand on compressive strength

The alteration of compressive strength of cube with percentage of sintered fly ash aggregate and percentage of robo sand are presented in Fig 1(a) & (b). By observing the test results it is perceived that the compressive strength has increased up to 25% substitution of coarse aggregate with sintered fly ash aggregate and 50% substitution of fine aggregate with robo sand after that compressive strength has reduced. Hence the optimal strength is obtained at sintered fly ash aggregate of 25% and robo sand of 50%.

Subsequently K8 mix gives the greatest compressive strength.

The maximum compressive strength 42.34 N/mm^2 is attained when normal coarse and fine aggregates are substituted by sintered fly ash aggregate with 25% & robo sand with 50% i.e. K8 mix for 28 days. 34.44 N/mm^2 is the compressive strength of nominal mix K1 for 28 days. K8 mix gives 22.94% more compressive strength in comparison with conventional mix K1. Also it can be observed that all mixes have good compressive strength values other than K16, K20, K21, K22, K23, K24 and K25 which have the lower results in comparison with conventional mix K1.

8.2 Influence of sintered fly ash light weight aggregate and robo sand on split tensile strength

The alteration of split tensile strength of cylinder with percentage of sintered fly ash aggregate and percentage robo sand are presented in Fig 2(a)&2(b). By analysing the test values it is observed that split tensile strength has increased up to 25% substitution of coarse aggregate with sintered fly ash aggregate and 50% substitution fine aggregate with robo sand and afterwards split tensile strength has reduced. Hence the optimal strength is obtained at sintered fly ash aggregate 25% and robo sand 50%. Subsequently K8 mix gives the greatest split tensile strength

The maximum split tensile strength 4.48 N/mm^2 is attained when normal coarse and fine aggregates are substituted by sintered fly ash aggregate with 25% & robo sand with 50% i.e. K8 mix for 28 days. 3.73 N/mm^2 is the split tensile strength of the conventional mix K1 for 28 days. K8 mix achieves 20.10% more split tensile strength values in comparison with conventional mix K1. Also it has been observed that all mixes have good split tensile strength values other than K15, K16, K17, K19, K20, K21, K22, K23, K24, and K25 which have lower results in comparison with conventional mix K1.

8.3 Influence of sintered fly ash light weight aggregate and robo sand on flexural strength

The alteration of flexural strength of beams with percentage of sintered fly ash aggregate and percentage of robo sand are shown in Fig 3(a)&3(b). By observing the values it is noted that flexural tensile strength has increased up to 25% substitution of coarse aggregate with sintered fly ash aggregate and 50% substitution fine aggregate with robo sand after that split tensile strength has reduced. Hence the optimum strength is acquired at sintered fly ash aggregate is 25% and robo sand is 50%. Subsequently K8 mix gives the greatest flexural strength values.

The maximum flexural strength 4.38 N/mm^2 is attained when normal coarse and fine aggregates are substituted by sintered fly ash aggregate with 25% & robo sand with 50% i.e. K8mix for 28 days. 3.75 N/mm^2 is the flexural strength of the normal mix K1 for 28 days. K8 mix achieves 16.8% more flexural strength in comparison with conventional mix K1. Also it is found that all mixes have good flexural strength values other thanK11, K15, K16, K17, K20, K21, K22, K23, K24, and K25 which have the lower results in comparison with conventional mix K1.

8.4 Influence of sintered fly ash light weight aggregate and robo sand on In-plane shear stress

All the double central notched specimens with various percentage replacements of sintered fly ash aggregates and robo sand in place of natural aggregates having different a/w proportions of 0.3, 0.4, 0.5 and 0.6 are tested for In-plane shear stress through mode-II fracture studies. The alteration of In-plane shear stress of the DCN specimens with percentage of sintered fly ash aggregate and percentage robo sand for different a/w ratios for 28 days are shown in Fig 4(a), 4(b), 4(c), 4(d) and 4(e). By analysing the test results it is noted that the in-plane shear stress has increased up to 25% substitution of coarse aggregate with sintered fly ash aggregate and 50% substitution fine aggregate with robo sand after that in-plane shear strength has reduced.

8.5 Influence of sintered fly ash light weight aggregate and robo sand on Impact strength

The alteration of number of impact blows with percentage of sintered fly ash aggregate and percentage of robo sand are shown in Fig 5(a)&5(b). By verifying the test results it is noted that the specimens of K8 took more impact blows compared with other mixes and percentage increase of impact blows for K8 is 12.67% in comparison with conventional mix.

IX. CONCLUSIONS

- From the current study, it tends to know that the altered concrete can be developed by adopting sintered fly ash light weight aggregate and robo sand in place of traditional aggregates to an ideal extent depending upon the different strength criteria.
- As sintered fly ash aggregates are little in size and spherical in shape compared to traditional coarse aggregate, it can efficiently be compacted and has an adequate binding with cement. It is also observed that, 25% substitution of sintered fly ash aggregate presents maximum strength.
- The Robo sand is the best alternative to replace fine aggregate and particles are angular in

shape with sharp edges and it has a good interlocking property and these particles occupy the voids easily and it gives more strength in comparison with normal river sand. In this study by analysing the results, 50% substitution of robo sand with natural river sand presents the maximum strength.

- From the present study , it is observed that the concrete has attained the maximum strength in compression, split tensile, flexural, in-plane shear and impact tests when 25% substitution of sintered fly ash aggregate as coarse aggregate and 50% substitution of robo sand in place of normal fine aggregate.
- From examining all the test results, it is observed that K2, K3, K4, K5, K6, K7, K8, K9, K10, K13&K14 mixes satisfy all strength parameters when compared to the conventional mix K1 and K8 mix gives the maximum values.
- This light weight concrete can be utilized for all tall structures to reduce the self weight and also useful for long span decks, wall panels, partition walls in framed structures and production of precast building blocks.

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