PERFORMANCE EVALUATION OF SELF COMPACTING CONCRETE CONTAINING MOUND ASH & STEEL FIBRE

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ABSTRACT

Now a day's high quality concrete is the goal for every producer to supply to every customer. With raising the cost of raw materials using the costs of raw materials using the cost effective concrete possible is essential in any project. One method for achieving this goal is by incorporating a pozzolanic replacement material, such as fly ash into concrete. Fly ash is a pozzolanic replacement material that is a finely divided residue that results from the combustion of coal. Self-compacting concrete is defined as remarkable deformability in the fresh condition and elevated segregation resistance. The employ of fine materials in SCC is needed sush as fly ash to make certain the obligatory concrete properties. Fly ash will improve the compressive strength but splitting tensile strength will not increase. Use of steel fibre can solve this problem. Hooked steel fibres were prepared from mild steel drawn wires. In this research, to carry out test on Steel Fibre Reinforced Concrete with Mound Ash at a fibre content 0%, 0.5%, 1%, & 1.5% and Mound Ash content 0, 10, 20, 30% and determine the compressive strength, tensile strength, flexural strength, permeability & durability.

Keyword: - *Self-compacting concrete, Mound ash, Acid resistance, Sulphate attack, Steel fibre*

1. INTRODUCTION

Concrete is one of the most important construction materials, the improvement of concrete is needed and essential in order to increase the performance and sustainability. Self-compacted Concrete is the concrete for next decade and it is popular now a day's because it is not require vibration. SCC flows underneath its own weight at the same time as left after uniform in composition without vibration. SCC should have best flow ability property. By adding the pozzolanic material we get the SCC as our requirement.

Fibre-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres – each of which lends varying properties to the concrete. In addition, the character of fibre-reinforced concrete changes with varying concretes, fibre materials, geometries, distribution, orientation, and densities.

Fly Ash is a by-product material generated by thermal power plants from combustion of pulverized coal. This is a fine residue produced from the burnt coal is carried in flue gas, separated by electrostatic precipitators, and collected in a field of hoppers. This residue which is collected is called as fly ash and is considered to be an industrial waste which can be used in the construction industry. Fly ash is one of the best major industrial wastes as a construction material.

Mound ash is mixture of fly ash, bottom ash and pond ash etc. mixed together, transported to ash deposition area in dry state or moisture condition through conveyer belt or other means and together in the mixed condition in the form of a mound is known as mound ash.

Steel fibre - reinforced concrete is basically a cheaper and easier to use form of rebar reinforced concrete. Rebar reinforced concrete uses steel bars that are laid within the liquid cement, which requires a great deal of preparation work but make for a much stronger concrete. Steel fibre-reinforced concrete uses thin steel wires mixed in with the cement. This imparts the concrete with greater structural strength, reduces cracking and helps protect against extreme cold. Steel fibre is often used in conjunction with rebar or one of the other fibre types.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials

(1) Cement: Ordinary Portland Cement 53 Grade conforming to IS 12269 – 2013 is be used.
(2) Coarse Aggregate: The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The coarse aggregates from crushed basalt rock, conforming to IS: 383 is being use. The Flakiness Index and Elongation Index were maintained well below 15 %.
(3) Fine Aggregate: Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is washed and screens to eliminate deleterious materials and oversize particles.
(4) Steel Fibre: Hooked Steel Fibre of 30mm length and 0.6mm diameter is to be used.
(5) Fly Ash: Class-F fly ash of STALLIN ENERGY PVT. LTD. is to be used.
(6) Mound Ash: Mound Ash from the sikka power plant is to be used.
(7) Super Plasticizer: Glenium Sky 8734 is to used.

Table 1 Properties of Mound Ash and Steel Fibre

MOUND ASH			HOOKED STEEL FIBRE		
Sr. No.	**Test Description**	**Result Fly Ash (%)**	**Sr. No.**	**Test Description**	**Result Steel Fibre (%)**
1	Sio2	57.5	1	C	0.05
2	Al2o3	-	2	Si	0.14
3	Fe2O3	7.61	3	Mn	0.44
4	Cao	3.78	4	P	0.026
5	Na2o	0.96	5	S	0.02
6	TiO2	1.28	6	Cr	0.12
7	MgO	-	7	Ni	0.17
8	Cl	0.02	8	Cu	0.28
9	P2O5	0.18	9	Mo	0.038
10	SO3	0.44	10	N	0.007
11	Moisture as MOI	0.05			
12	Loss on ignition	0.26			
13	Residue greater than 45	14.66			

(8) Water: Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. It helps to from the strength giving cement gel; the quantity and quality of water are required to be looked into very carefully.

2.2 Mix Proportions

One control and fifteen SCC mixes with different replacement of mound ash and adding steel fibre were prepared and examined to quantify the properties of SCC. Table-2 presents the composition of SCC mixture. The replacement was carried out at levels of 0%, 10%, 20% and 30% of cement content. After iterative trial mixes the

water/powder mass ratio (w/p) was selected as 0.41. The total powder content was fixed 500kg. Each mix design should be tested by more than one test method in order to obtain different workability parameters.

Table 2 Mix Proportion of SCC

Mound Ash %	Steel Fibre %	Cement (kg)	Steel Fibre (kg)	Mound Ash (kg)	Water (kg)	Fly Ash (kg)	Coarse Aggregate (kg)	Fine Aggregate (kg)	Super Plasticizer (kg)
0	0	54.45	0	0	24.9	6.05	71.39	111	0.73
	0.5	54.45	0.485	0	24.9	6.05	71.39	111	0.73
	1	54.45	0.974	0	24.9	6.05	71.39	111	0.73
	1.5	54.45	1.459	0	24.9	6.05	71.39	111	0.73
10	0	49.00	0	5.45	24.9	6.05	71.39	111	0.73
	0.5	49.00	0.485	5.45	24.9	6.05	71.39	111	0.73
	1	49.00	0.974	5.45	24.9	6.05	71.39	111	0.73
	1.5	49.00	1.459	5.45	24.9	6.05	71.39	111	0.73
20	0	43.55	0	10.9	24.9	6.05	71.39	111	0.73
	0.5	43.55	0.485	10.9	24.9	6.05	71.39	111	0.73
	1	43.55	0.974	10.9	24.9	6.05	71.39	111	0.73
	1.5	43.55	1.459	10.9	24.9	6.05	71.39	111	0.73
30	0	38.15	0	16.3	24.9	6.05	71.39	111	0.73
	0.5	38.15	0.485	16.3	24.9	6.05	71.39	111	0.73
	1	38.15	0.974	16.3	24.9	6.05	71.39	111	0.73
	1.5	38.15	1.459	16.3	24.9	6.05	71.39	111	0.73

2.3 Procedure of making concrete Specimen

Making concrete specimen such as cube for compressive strength, cylinder for splitting tensile strength and beam for flexural strength are simple and it's done in three simple steps.

(1) Cleaning & Fixing Mould*:* Clean the mould properly and apply oil on inner surface of mould. But no oil should be visible on surface. Fix the mould with base plate tightly. No gap should be left in joints so that cement slurry doesn't penetrate. Place the mould level surface.

(2) Placing & Finishing Concrete: Preparation of concrete analogous to the traditional concrete. Drum mixture have been accustomed prepare concrete. Mix of all the materials are exhausted the laboratory at temperature machine have been turned 3 to 5 min. Place the concrete into mould in layer. Make the top surface of concrete cube even and smooth. Leave the mould completely undisturbed for first two to four hour after casting. After ending undisturbed period, put down identification mark and casting date on the top of concrete specimen.

(3) Curing*:* Remove the cube specimens from mould after 24 hours of casting. For removing specimen from mould, first loosen all nut-bolts and carefully remove specimen because concrete is still weak and can be broken. Immediately after removing, put the specimen into a tank of clean water for curing. Make sure specimen is fully submerged in water. After 7 and 28 days of curing take out specimens from water tank and send to laboratory for testing.

3. RESULTS AND DISSCUSSIONS

3.1 Fresh Concrete Properties

Fresh concrete properties assessed by flow ability, passing capability, consistency and segregation conflict of SCC with mound ash and steel fibre. It is done by slump flow test, V-funnel Test, L-box test and U-box test. It was observed that inclusion of steel fibre in SCC decreased the workability. Workability also decreased by replacing cement with mound ash.

(1) Slump flow Test:

Slump flow performs to check the filing ability of concrete. By experiment, I observed that all the S.C.C. mixes shown the slump value in the range of 651mm to 720mm. Steel-fibre with hooked end caused jamming of concrete particles during flow. By increasing fibre content, slump flow value will decreased. It means workability will decreased.

In all mixes, there was no segregation of aggregate observed near the edge of concrete. Workability will decrease with increasing of mound ash with steel fibre content remain constant.

Maximum slump dia. 720mm was observed in normal mix design with 0% mound ash & 0% steel fibre. As well as minimum slump dia. 651mm was observed in mix design with 1.5% of steel fibre & 30% mound ash. Following table indicate the slump value.

Table 3 Slump flow value

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	720	712	705	696
0.5	698	690	681	674
1	679	667	662	655
1.5	664	658	654	651

Table 4 T-50 Slump Value

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	3.4	3.5	3.5	3.6
0.5	3.9	3.8	4	4.1
1	4.2	4.3	4.4	4.4
1.5	4.7	4.8	4.8	4.9

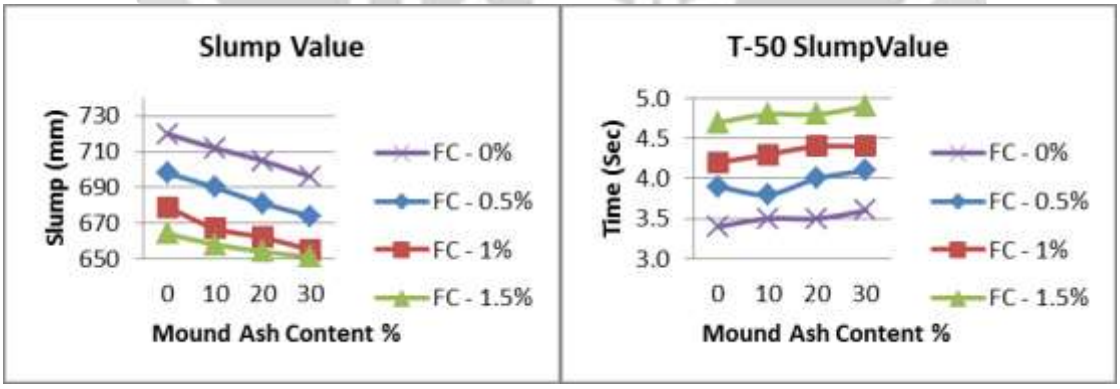

Chart 1 Slump Value & T-50 Slump value

(2) V-funnel Test:

To determine the flexibility or viscosity of the concrete, we should perform v-funnel test. By increasing the steel fibre content with constant mound ash content the flow time value will increase. Same way with constant steel fibre content, increase the mound ash, flow time value will also increase. During the experiment I observed that maximum flow time value is 11.2 second in mix design with 1.5% steel fibre & 30% mound ash and minimum flow time value is 8.7sec in normal mix design with 0% mound ash & 0% steel fibre.

Table 5 V-funnel Test results

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	8.7	8.8	9	9.4
0.5	9.1	9.2	9.4	9.7
1	9.5	9.7	10.4	10.5
1.5	10.2	10.2	10.6	11.2

Table 6 T-5 V-funnel Test Result

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	1.3	1.3	1.5	1.6
0.5	1.5	1.6	1.7	1.8
1	1.6	1.8	1.8	2
1.5	1.9	2.1	2.3	2.5

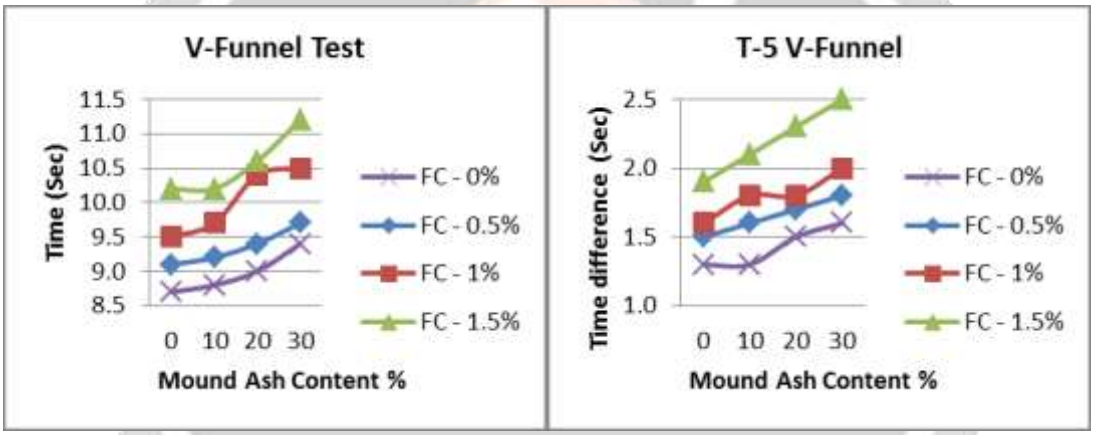

Chart 2 V-funnel And T-5 V-funnel Test Result

(3) L-box Test:

This test assessed the flow of the concrete and also the extent to which it is subject to blocking by reinforcement. The L-box ratio (H2/H1) for all S.C.C. mixes was between 0.8-0.9 and within the limits of EFNARC range (0.8-1.0). Result shows that blocking ration decreasing with increasing steel fibres & mound ash.

Table 7 L-box Test Result

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	0.90	0.88	0.87	0.86
0.5	0.88	0.85	0.84	0.83
1	0.86	0.83	0.83	0.82
1.5	0.84	0.82	0.81	0.81

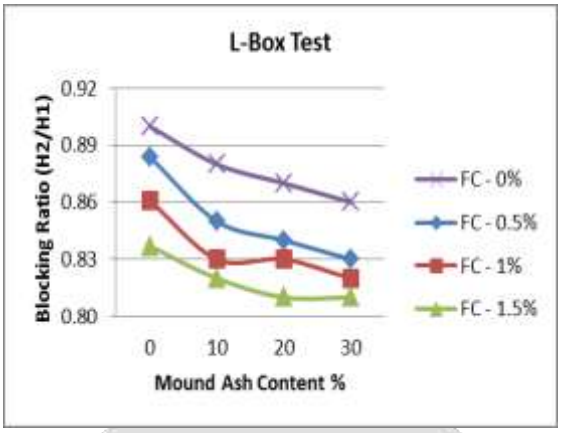

Chart 3 L-box Test

(4) U-box Test:

This test is used to measure the filling ability of self-compacting concrete. The height variation of concrete in two compartments of U-box was found in range of 18-29 mm. All values are within the range of EFNARC. U-box values increased with increase steel fibre content and mound ash content.

Table 8 U-box Test Result

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	18	20	21	23
0.5	20	22	24	24
1	21	23	25	27
1.5	23	25	27	29

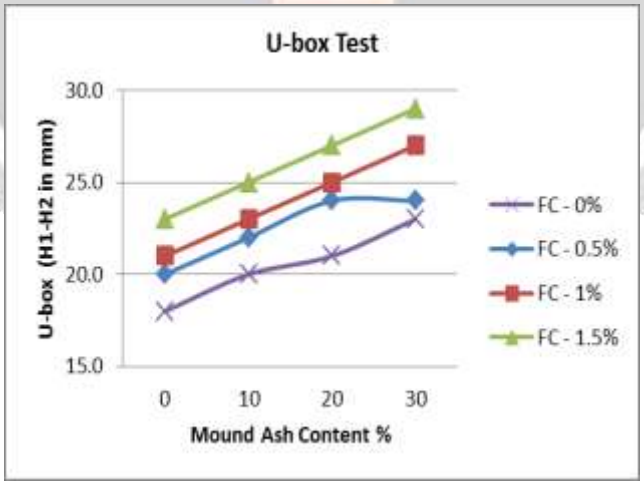

Chart 4 U-box Test Result

3.2 Hardened Concrete Properties.

(1) Compressive Strength:

Compressive strength of concrete made of cubes size 150 x 150 x 150 mm was determined at 7 and 28 days. Compressive strength was calculated by dividing the failure load by the cross-sectional area of the specimen. Experimental results of the various mix design given in the table below.

Table 9 Compression Test @ 7 days

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	28.47	30.01	31.24	30.24
0.5	29.01	30.74	31.90	30.77
1	29.87	31.11	32.37	31.54
1.5	30.44	32.31	32.55	32.12

Table 10 Compression Test @ 28 days

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	36.73	40.21	45.66	42.87
0.5	36.98	40.65	46.16	43.45
1	37.26	41.17	46.79	44.12
1.5	38.44	42.12	47.94	44.68

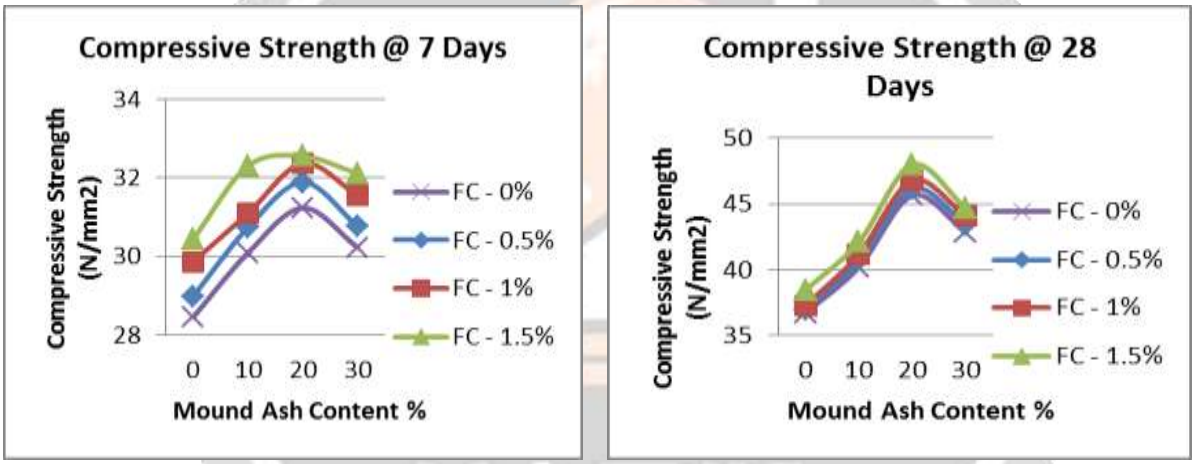

Chart 5 Compression Test Result

Above result shows that compressive strength was increased 5% with increased up to 31% with increase of mound ash content up to 20%. If mound ash content increased 20% to 30% than the strength was decreased to 22%. It shows that strength was increased 31 % with respect to normal S.C.C. in 20% mound ash & 1.5% steel fibre content.

(2) Split Tensile Strength:

Specimens used for the test was of size 150mm diameter and 300mm length. These specimens were tested under the digital CTM of capacity 2000 KN. The specimen was kept under CTM at the center load was applied with pace rate 1.2 KN/S and ultimate loading was noted. The results are shown in below table.

Table 10 Split Tensile Test Result

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	3.6	3.8	3.8	3.7
0.5	3.9	4.0	4.1	3.8
1	4.2	4.3	4.2	4.0
1.5	4.7	4.7	4.9	4.4

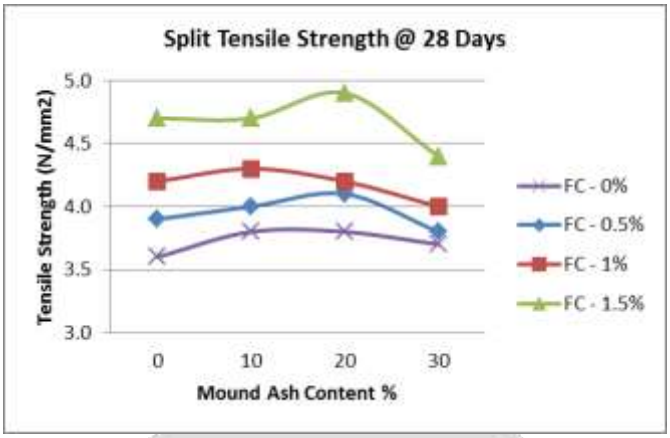

Chart 6 Split Tensile Test Result

By the experiment I observed that tensile strength was increased up to 36% with increased of steel fibre content. Tensile strength was increased at some extent with increased of mound ash content up to 20% but after than the strength was decreased. There was no major increase or decrease in strength by increasing mound ash content. Mound ash content of 20% & steel fibre content of 1.5% will give the maximum tensile strength.

(3)Flexural Strength:

By the experimental I observed that increased of mound ash content was minor affect the flexural strength. For improvement of flexural strength, the role of mound ash is not important. But the steel fibre content was affecting the strength.

Flexural strength was increased up to 24% with 1.5% of steel fibe content. Flexural strength was decreased to 17% with 30% of mound ash and 1.5% of steel fibre.

Table 11 Flexural Strength Result

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	7.1	7.2	7.2	7.2
0.5	7.3	7.5	7.4	7.2
1	8	8.1	8.2	7.8
1.5	8.5	8.7	8.8	8.3

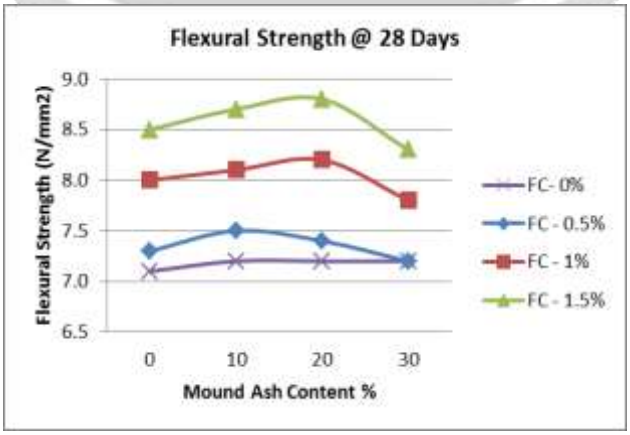

Chart 7 Flexural Strength Result

(4) Durability of Concrete:

- Acid Resistance Test

Acid attack is performed to check the acid resistance of concrete. With reference to the above table results, it was observed that capacity of concrete to acid resistance is increased with increase the mound ash content in concrete. It was shown that the compressive strength decreased up to 7.72% in the mix with 0% mound ash and 1.5% of steel fibre.

By the result if we increase the steel fibre content the acid resistance will decrease. With 0% steel fibre and 30% of mound ash concrete mix showed the best appropriate resistance to acid.

Table 12 Reduction in strength (%)

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	6.97	6.32	5.72	4.34
0.5	7.41	6.89	6.2	4.81
1	7.51	7.04	6.41	5.21
1.5	7.72	7.36	6.75	5.64

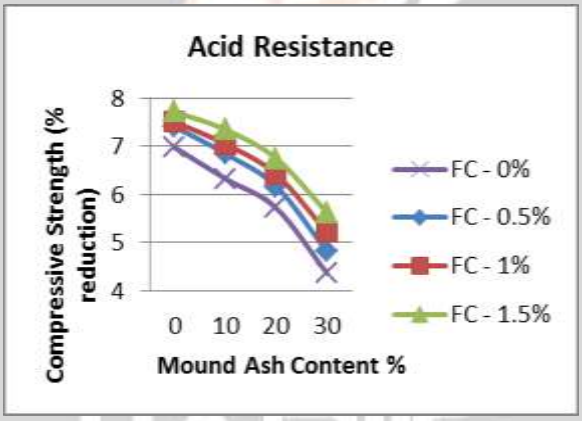

Chart 8 Reduction in strength (%)

- Sulphate Resistance Test

By the results it was observed that with the increase of mound ash, the capacity to resist the sulphate attack was increase. Minimum resistance was find out at 0% mound ash.

Vice-versa the capacity of sulphate resistance was decreased with increased of steel fibre content. It means the sulphate resistance capacity was higher at 0% steel fibre and will be lower at 1.5% steel fibre.

Table 13 Reduction in strength (%)

	Mound Ash (%)			
Steel Fibre (%)	**0**	**10**	**20**	**30**
0	3.76	3.13	3.00	2.99
0.5	3.92	3.64	3.16	3.04
1	3.97	3.81	3.40	3.40
1.5	3.98	3.99	3.73	3.54

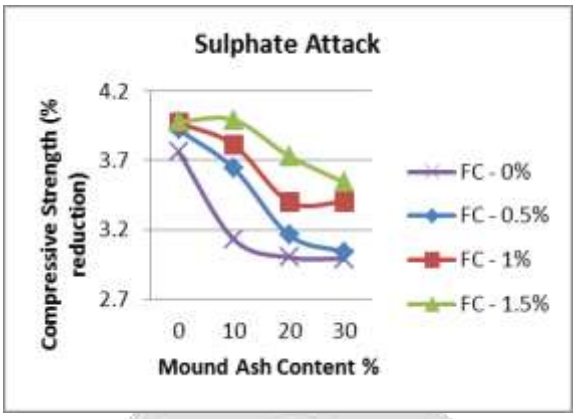

Chart 9 Reduction in strength (%)

4. CONCLUSION

- In this experiment work, two different parameters were considered, replacing cement and adding steel fibre. With different range of replacing or adding mound ash and steel fibre in normal S.C.C., following conclusions are drawn,
- Increase of steel fibre content in SCC reduced the workability but the fresh concrete properties such as slump flow (651-720 mm), V-funnel (8.7-11.2 S), L-box (0.81-0.9), U-box (18-29 mm) values were found in the range set by EFNARC
- Compressive strength increase up to 31% with inclusion of 20% mound ash, however mound ash content higher than this reduced in compressive strength.
- Compressive strength was increase 8% with inclusion of 1.5% of steel fibre.
- Split tensile strength was increase up to 36% with inclusion of 1.5% of steel fibre.
- There was increase of 24% in flexural strength with respect to normal mix when add 1.5% steel fibre.
- There were no significant changes in split tensile strength and flexural strength by replacing cement with mound ash.
- It was observed that the acid resistance was decreased by adding steel fibre. Vice-a-versa it was increase by replacing cement with mound ash.
- It was observed that sulphate resistance property was decreased to 3.99% by adding steel fibre. Vice-a-versa it was increased by replacing cement with mound ash to 2.99%.
- From this work it can be concluded that the mix containing 20% mound ash and 1.5% steel fibre gives better result in hardened concrete property.

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