Development of High Volume Fly Ash Concrete Incorporating Steel Fibre

Esakkiraj. P, Sreesha. S, Sreevidya. V, Antony jeyendran. S

Abstract—Concrete is most frequently used composite material. Concrete is homogeneous mix of fine aggregate, Coarse aggregate and binding medium of concrete paste .Due to `high demand of cement Co_2 emission is very high, It leads to global warming. So in this project high volume fly ash concrete was incorporated. Fly ash is the waste material obtained from thermal power plant. In this paper we investigated about high volume fly ash in different percentage of replacement 55, 60, 75 percentage. Layered pavement is incorporated with Steel fiber in a different aspect ratio (15, 30, 40).layered pavement will give good thermal expansive properties. By varying fly ash content and Steel fibers Aspect ratio of different mixes were arrived hardened properties of these nine mixes were arrived such as Compression test, Split tensile test and Flexural test.

Keywords—HVFAC, Fly Ash, M Sand, Compression, Split, Flexural Test.

I. INTRODUCTION

Concrete is a composite material made of rough aggregates which, after some time, is connected to a liquid concrete. Whatever the case, cement generation produces enormous carbon dioxide measurement. If concrete formation can be diminished, carbon dioxide may be reduced. Beton is the most adaptable and widely used material for development. Normally, the standard cement is made of concrete from Portland, which goes like a sheet. The production of concrete dumps approximately an equal amount of CO2 into the atmosphere and expends enormous amount of usual properties. In order to reduce this effect, manageable alternatives have to be generated as opposed to Portland concrete by means of modern results such as fly debris, ground granular effect heating slag, etc.

In this document, we tried to use high volume fly ash and M-sand in concrete. Specific hardened properties for various aspect ratios of steel fibers and fly ash percentages in cement are studied. Project goals are the efficient use of fly ash to meet the needs.

- To study the various properties of high-volume fly ash concrete.
- To find out the response of steel fibre in high volume fly ash with various aspect ratio.
- To characterize the hardened concrete.

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II. LITERATURE REVIEW

Cengiz Duran Atis et al.,(2003) Right now, research facility examination was done to assess the quality and especially the shrinkage properties of cement containing high volumes of fly debris. The solid blends made with 50 and 70% substitution by mass of common Portland concrete OPC with fly debris were readied. Water - Cementitious material proportions ran from 0.28 to 0.34. Some solid blends were likewise made with Super plasticizer. The quality and shrinkage properties of the solid blends restored at 20°C temperature with 65% relative stickiness are accounted for. The research facility test results show that high-volume fly debris HVFA concrete achieved agreeable compressive and elasticity at 1 day old enough. It likewise indicated that half substitution HVFA concrete created higher quality than OPC concrete at 28 days and past. The incorporation of high volumes of fly debris in concrete with a low water- cementitious material proportion brought about a decrease in the shrinkage estimations of up to 30% when contrasted with OPC concrete. The solid blends made with super plasticizer showed higher shrinkage estimations of up to half when contrasted with the solid made with no super plasticizer[1].

Rooban Chakravarthy et al.,(2016) This exploration portrays the properties of acrylic fiber-fortified Cementitious composite containing high-volume fly debris. Right now, fly debris content (30% and 60%) and the acrylic fiber measurement (0%,1% and 2%) were shifted. Expanded substance of fly debris in the composite was seen as ready to incompletely remunerate the decrease in usefulness brought about by the incorporation of filaments. Then again, in spite of the fact that the utilization of filaments had insignificant effect on the compressive quality, the strands could altogether upgrade the flexural quality of the composite, especially in the composite containing higher fly debris content. At raised temperatures, it was discovered that the consideration of acrylic filaments was advantageous in the composite with higher fly debris content, as showed by the expanded quality maintenance and decreased Spalling harm at raised temperature[2].

Shailendra Gilhare et al.,(2017) Concrete is one of the most well-known materials utilized in the development business. In the previous scarcely any years, many research and alteration has been done to create solid which has the ideal qualities. Cementitious materials referred to as Pozzolans are utilized as solid constituents, notwithstanding Portland concrete. There is constantly a quest for concrete with higher quality and strength.

Right now, concrete cement with the joining of filaments has been acquainted with suit the present prerequisites. Plain concrete has great compressive quality yet has low elasticity, low malleability and low imperviousness to fire. To evade these inadequacies, broad research by solid technologist has driven them to locate an extremely encouraging solid material called as fiber fortified cement. A great deal of research work has been done and is going on the utilization of steel filaments and furthermore fly debris as concrete substitution in upgrading various properties of cement. Research work done by various scientists is talked about here to sum things up[3].

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Samarul Huda et al.,(2017) This paper examined an exploratory investigation of M30 Grade of solid utilizing fly debris, steel fiber, concrete, coarse total and fine total. Point of the exploratory work was to accomplish an extent of fixings and acquire quality of M30Grade. To accomplish this point tests were intended to differ the substance of fly debris and steel fiber in concrete and different fixings (fine total and coarse total). The molds were readied utilizing coarse total, fine total and the amount of concrete was slowly diminished by including fly debris and measure of steel fiber was likewise changed. Two arrangements of fly debris were changed from 10% to 30% in venture to 10% keeping the steel fiber content fixed. In the other set the measure of steel fiber was differed from 0.5% to 2% in venture of 0.5% keeping the other parameter fixed. Various blends were attempted, formed, restored according to recommended standards and tried according to endorsed standards ((IS Code 456-2000). It was seen that 6.3 kg of concrete, 15 kg of fine total, 24.6 kg of coarse total, 0.486 kg of steel fiber, 2.7 kg of fly debris delivers the ideal quality of M30 Grade of cement. It is normal that rehearsing architect will see this blend as appropriate and use it to develop working with a minimal effort[4].

Gunaseelan et al.,(2016) In excess of 88 million tons of fly debris is created in India every year. The majority of the fly debris is of Class F type. The rate usage is around 10 to 15%. To expand its rate use, a broad examination was completed to utilize it in concrete. This article shows the consequences of an exploratory examination managing concrete consolidating high volumes of Class F fly ash. Portland concrete was supplanted with three rates (40%, 45%, and half) of Class F fly debris. Tests were performed for crisp solid properties: droop, air content, unit weight, and temperature. Compressive, parting malleable and flexural qualities were resolved as long as 28 days of testing. Test outcomes showed that the utilization of high volumes of Class F fly debris as an incomplete substitution of concrete in concrete diminished its 28-day compressive, parting elasticity and flexural qualities of the solid. In light of the test outcomes, it was presumed that Class F fly debris can be appropriately utilized something like half degree of concrete swap in concrete for use in precast components and strengthened concrete solid development[5].

Shivakumara et al.,(2017) The dumping issue of fly debris has brought the disturbing circumstance up on the planet which started towards utilization of fly debris in industry. The development business is one which devours the concrete for its asphalt and different structures. The asphalt will bomb for the most part because of exorbitant elastic pressure. The utilization of plain high volume fly debris concrete (HVFAC) experiences low elasticity and restricted flexibility. These issues can be dispensed with by presenting the fortification. At the point when the strands are blended in with concrete the tractable property of cement is expanded. The point of this work is to examine the impact of variety of fiber content from 0% to 1.8% in high volume fly debris concrete. It is additionally planned to examine the impact of filaments on HVFAC with restoring period. The investigations referred to right now, fiber strengthened high volume fly debris concrete is causing an endeavor to examine the quality attributes to as long as 90 days restoring. Locally accessible materials are utilized. Fly debris utilized is from Raichur warm force plant and creased steel filaments are utilized. The examination uncovers the way that the quality attributes of fiber fortified high volume fly debris concrete (FRHVFAC)[6].

Cengiz Duran Atise et al.,(2003) Right now, research facility examination was completed to assess the quality and especially the shrinkage properties of concrete containing high volumes of fly debris. The solid blends made with 50 and 70% substitution by mass of customary Portland concrete OPC with fly debris were readied. The quality and shrinkage properties of the solid blends restored at 20°C temperature with 65% relative mugginess are accounted for. The research center test outcomes show that high-volume fly debris HVFA concrete achieved palatable compressive and rigidity at 1 day old enough. It additionally demonstrated that half substitution HVFA concrete created higher quality than OPC concrete at 28 days and past. The incorporation of high volumes of fly debris in concrete with a low water-cementitious material proportion brought about a decrease in the shrinkage estimations of up to 30% when contrasted with OPC concrete[7].

Tarun R.Naik et al.,(2002) This examination was performed to set up the impacts of the source and measure of fly debris on scraped area obstruction of concrete. The water to cementitious materials proportion was saved steady at 0.30 for all blends.

Solid scraped area obstruction was not significantly by incorporation of Class C fly debris up to 40% of all out cementitious materials. Notwithstanding, a slight lessening in scraped spot opposition of high-volume fly debris HVFA concrete particularly at fly debris content above 50%was noted when contrasted with the reference blend without fly debris[8].

Cengiz Duran Atiseon et al.,(2002) Right now, scraped spot obstruction of high volume fly debris concrete was researched. Correlations were likewise made between fly debris cements with 50 and 70% substitution. Examination results have demonstrated that the scraped area obstruction expanded as compressive quality expanded. Examination of the outcomes demonstrated that, for high quality evaluations 40 MPa, the scraped area obstruction of high volume fly debris concrete with 70% supplanting with concrete was seen as higher than that of partner control NPC concrete and cement made with half fly debris. Super plasticizer and relieving conditions have no huge impact on the general pattern of the scraped area of cement contemplated[9].

III. MATERIAL USED

A. Cement

Cement is classified as the durable & adhesive material which enables the bonding material to unite and compact the different construction materials. Ordinary / Normal Portland cement is one of the most widely used Portland cement types. Cement is white, fine powder. Cement. It is combined with sand , gravel and stone to create concrete. It also includes water and cement. Cement and water constitute a paste which connects all other materials when the concrete is harded under IS8112 1982.

Table 1.Properties of Cement

SNO	PROPERTIES	VALUES
1.	Specific gravity	3.12
2.	Initial setting time	30 min
3.	Final setting time	600 min

B. Fly Ash

It is referred to as ASTM Class C fly debris, or high-calcium fly debris, since usually the outcome of consuming sub-bituminous coals is over 20% CaO. Again, fly debris is referred to as ASTM class F fly debris, or low calcium fly debris from the bituminous and anthracite charges. It consists mainly of aluminosilicate glass and is less than 10% CaO. Fly debris shade can be dimmed, depending on the compounds and minerals.

Table 2.Properties of Fly ash

SNO	PROPERTIES	VALUES
1.	Specific gravity	2.16
2.	Consistency	29%

C. Fine aggregate

The sand created is a replacement for concrete building of the river sand. It is made of hard granite stone crushing. The sand is crushed and is cubic with ground edges, washed and graded as a building material. M-Sand is under 4.75 mm in thickness. The development of sand from hard granite rocks that be crushed, which means transport from far away sand beds can easily be obtained at the nearby spot. Natural sand is becoming increasingly depleted and expensive, and M-Sand needs to be used. Manufactured sand has a potential to provide alternative to natural sand and helps in maintaining the environment as well as economical balance. Non-availability of natural sand at reasonable cost, forces to search for alternative material Generated sand is regarded as a suitable substitute for river sand. The sand produced has a good quality and good finish that lacks natural sand and this has led to good coherent cement mortaring.

Table 3.Properties of Fine Aggregate

SNO	PROPERTIES	VALUES
1.	Specific gravity	2.37
2.	Fineness modulus	2.9

D. Coarse Aggregate

Coarse aggregates can have round, angular, or irregular shape. The coarse aggregate grading limits are given in IS 383 – 1970 – table 2, Clause 4.1 and 4.2 for single size aggregate as well as graded aggregate.

Table 4.Properties of Fine Aggregate

SNO	PROPERTIES	VALUES
1.	Specific gravity	2.71
2.	Sieve analysis	5.29
3.	Bulk density	1568 kg\m^3 (compacted)
		1312 kg\m^3 (loose)
4.	Impact factor	22.08 %
5.	Crushing value	34.67%
6.	Water absorption	4.47%

E. Water

Water suitable for drinking is acceptable. Standard drinking water is used for construction. The concrete specimen is mixed and cured.

F. Steel fiber

Steel fibers are used to increase the strength of the concrete pavement.

Table 5.Aspect ratio of Steel Fiber

DIAMETER (D) mm	LENGTH (L) mm	L / D RATIO mm
1.5	30	20
1.5	45	30
1.5	60	40

IV. MIX DESIGN

In both the fresh and the hardened states, the mixing composition is chosen to meet all concrete output requirements. Concrete blending can be regarded as a proportional procedure for specified durability and quality of the most economical concrete blend for the necessary site conditions. The main principle of the concrete blend design is to select the proportion of the ingredients for 1m3 of concrete with the substitution of fly ash to cement and steel fiber as the basis for the irresolute volume blend design.

Table 6.Normal Mix

Cement (kg\m^3)	350.0
Fly ash (kg\m^3)	0.0
Fine aggregate (kg\m^3)	732.97
Coarse aggregate (kg\m^3)	1303.05
Water (kg\m^3)	140
Fibers (kg\m^3)	0.0
Super plasticizer (ml)	10000

Table 7.Proportion for 55% replacement of fly ash with various proportions of steel fibers

CONSTITUENTS	55% FA 0.25% SF	55%FA 0.5% SF	55%FA 1%SF
Cement (kg\m^3)	213	213	213
Fly ash (kg\m^3)	261	261	261
Fine aggregate(kg\m^3)	528	528	528
Coarse agg(kg\m^3)	1223	1223	1223
Water (kg\m^3)	155	155	155
Fibers (kg\m^3)	0.138	0.275	0.55
Super plasticizers(kg\m^3)	7500	7500	7500

Table 8.Proportion for 65% replacement of fly ash with various proportions of steel fibers

CONSTITUENTS	65% FA 0.25% SF	65%FA 0.5% SF	65%FA 1%SF
Cement (kg\m^3)	166	166	166
Fly ash (kg\m^3)	308	308	308
Fine aggregate(kg\m^3)	529	529	529
Coarse agg(kg\m^3)	1225	1225	1225
Water (kg\m^3)	155	155	155
Fibers (kg\m^3)	0.138	0.275	0.55
Super plasticizers(kg\m^3)	7500	7500	7500

Table 9.Proportion for 75% replacement of fly ash with various proportions of steel fibers

CONSTITUENTS	55% FA 0.25% SF	75%FA 0.5% SF	5%FA 1%SF
Cement (kg\m^3)	188	188	188
Fly ash (kg\m^3)	356	356	356
Fine aggregate(kg\m^3)	530	530	530
Coarse aggregate(kg\m^3)	1227	1227	1227
Water (kg\m^3)	155	155	155
Fibers (kg\m^3)	0.138	0.275	0.55
Super plasticizers(kg\m^3)	7500	7500	7500

V. RESULTS AND DISCUSSION

A. Compression test results

The compressive strength of concrete is defined as a load that causes a standard specimen to fail at a given load rate divided by the cross-sectional area under uniaxial compression. The pressure check should be conducted on a scale of 150 mm x 150 mm x 150 mm.

Table 10.Test results for compression strength

FLY ASH %	ASPECT RATIO	STEEL FIBER %	CUBES(N/ mm^2)	
			7 days	*28 days*
0% (conventional)	-	-	1.92	45.4
55 %	30	0.25	4.54	9.51
		0.5	4.21	9.02
		1	3.29	47.7
	45	0.25	3.88	48.4
		0.5	3.72	48.1
		1	3.39	8.02
	60	0.25	3.81	48.3
		0.5	3.72	48.4
		1	32.6	7.67
65%	30	0.25	3.88	48.4
		0.5	3.78	48.3
		1	3.60	8.01
	45	0.25	3.79	8.32
		0.5	3.53	47.9
		1	47.5	3.23
	60	0.25	3.33	7.62

		0.5	3.18	7.40
		1	3.12	7.32

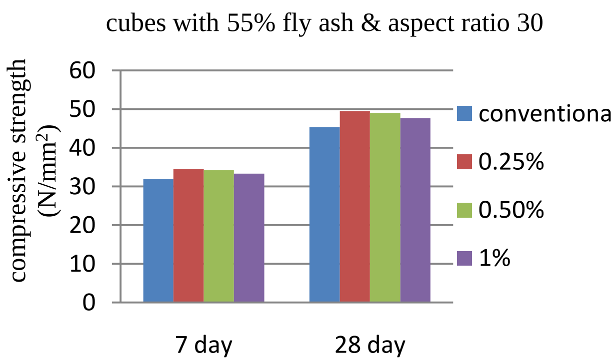

Fig1. Bar chart showing Compression test results of 55% Fly ash with aspect ratio 30

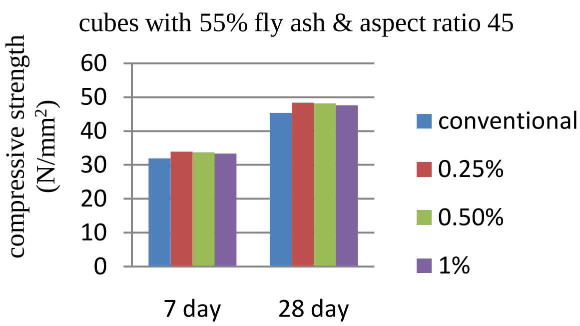

Fig 2. Bar chart showing Compression test results of 55% Fly ash with aspect ratio 45

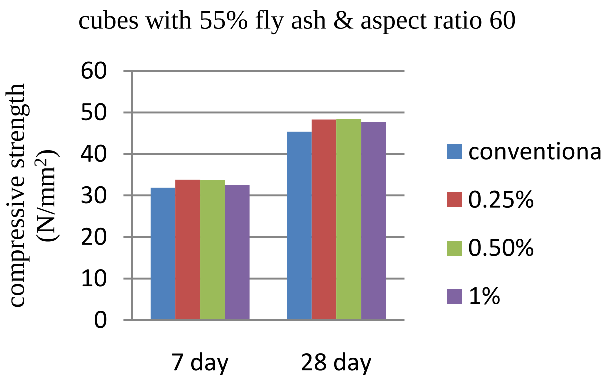

Fig.3. Bar chart showing Compression test results of 55% Fly ash with aspect ratio 60

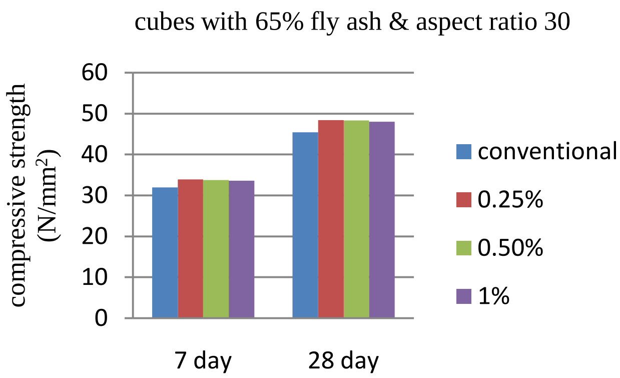

Fig 4 Bar chart showing Compression test results of 65% Fly ash with aspect ratio 30

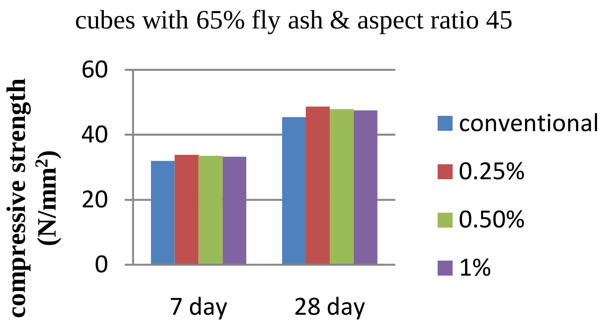

Fig 5. Bar chart showing Compression test results of 65% Fly ash with aspect ratio 45

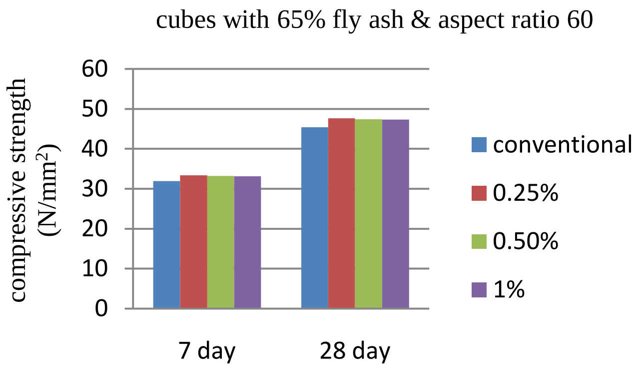

Fig 6. Bar chart showing Compression test results of 65% Fly ash with aspect ratio 60

B. Split tensile test

By applying the force this way, a concrete 150 mm dia per 200 mm height cylinder is subject to pressure action on two opposite ends by applying the forceThe cylinder is compressed near the loaded region and is subject to the same tensile stress in terms of the cylinder 's length.

Table 11. Test results for Split tensile

FLY ASH %	ASPECT RATIO	STEEL FIBER %	CYLINDERS (N/mm²) 7 days	CYLINDERS (N/mm²) 28 days
0% (conventional)	-	-	3.1	4.76
55 %	30	0.25	3.48	4.98
		0.5	3.45	4.93
		1	3.40	4.91
	45	0.25	3.38	4.83
		0.5	3.37	4.82
		1	3.36	4.80
	60	0.25	3.38	4.84
		0.5	3.37	4.82
		1	3.36	4.80
65%	30	0.25	3.37	4.82
		0.5	3.36	4.80
		1	3.34	4.81
	45	0.25	3.37	4.82
		0.5	3.36	4.81
		1	3.40	4.79
	60	0.25	.33	4.62
		0.5	3.18	4.40
		1	3.12	4.32

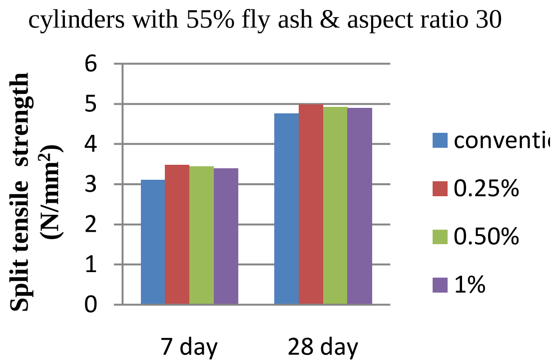

Fig.7 Bar chart showing Split tensile test results of 55% Fly ash with aspect ratio 30

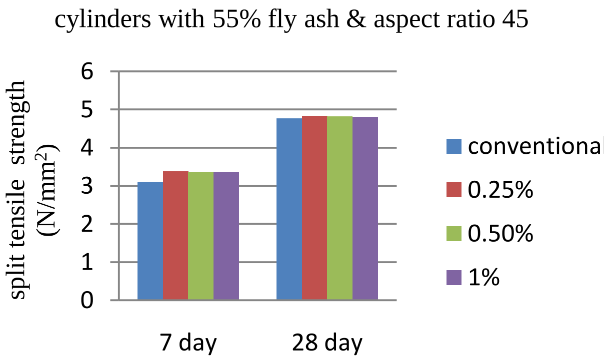

Fig 8 Bar chart showing split tensile test results of 55% Fly ash with aspect ratio 45

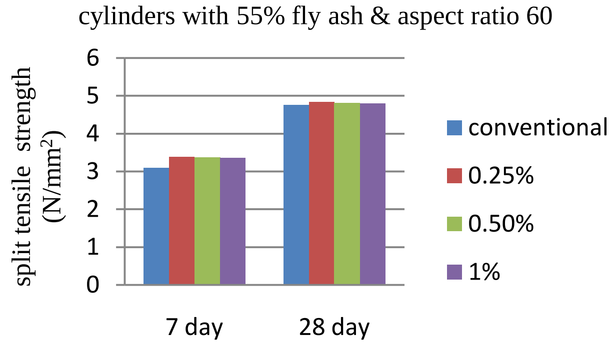

Fig 9.Bar chart showing split tensile test results of 55% Fly ash with aspect ratio 60

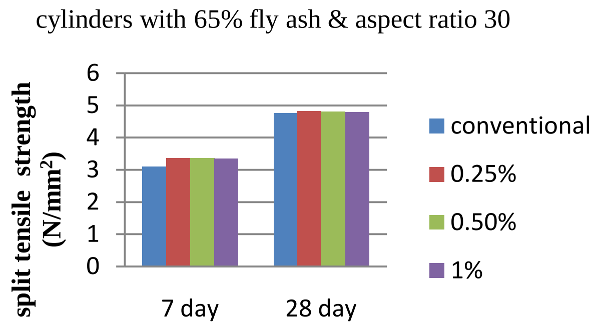

Fig10. Bar chart showing split tensile test results of 65% Fly ash with aspect ratio 30

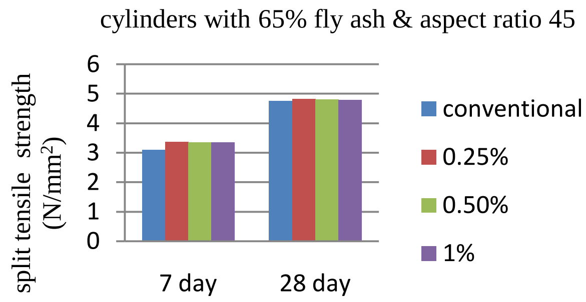

Fig 11. Bar chart showing Split tensile test results of 65% Fly ash with aspect ratio 45

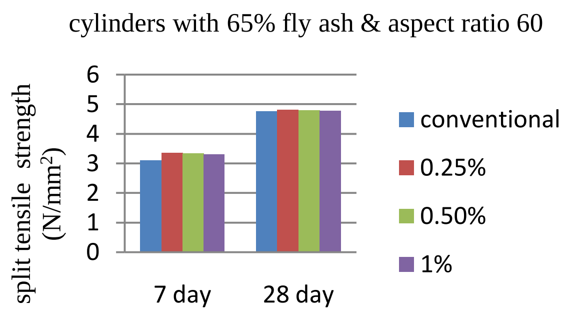

Fig 12. Bar chart showing Split tensile test results of 65% Fly ash with aspect ratio 60

C. Flexural test

Initially, the beam is cast according to its measurements and after 1 week of treatment, the test is conducted for better performance. The beam is measured on its side relative to its cast position. At the third point (152.4 mm from each support) the load should be added to the specimen. The specimen should be withdrawn from the cure tank only just before the testing. The results can even be adverse for small quantities of drying. On each beam there will be two tests.

Table 12.Test results for flexural strength

FLY ASH %	ASPECT RATIO	STEEL FIBER %	PRISM (N/mm^2)	
			7 days	*28 days*
0% (conventional)	-	-	7.14	10.2
	30	0.25	0.08	14.4
		0.5	8.86	2.66
		1	8.45	2.08
	45	0.25	9.83	4.05
		0.5	8.66	2.4
		1	7.63	0.9
	60	0.25	8.68	2.4
		0.5	8.44	2.06
		1	7.28	0.4
65%	30	0.25	8.68	2.4
		0.5	8.43	2.05
		1	7.28	0.4
	45	0.25	8.58	2.26
		0.5	8.41	2.02
		1	8.30	0.98
	60	0.25	8.20	1.26
		0.5	8.13	0.98
		1	8.02	0.24

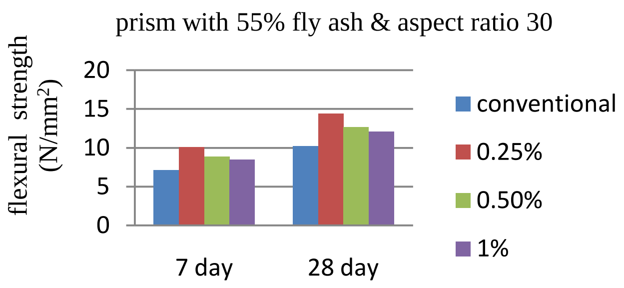

Fig 13. Bar chart showing flexural test results of 55% Fly ash with aspect ratio 30

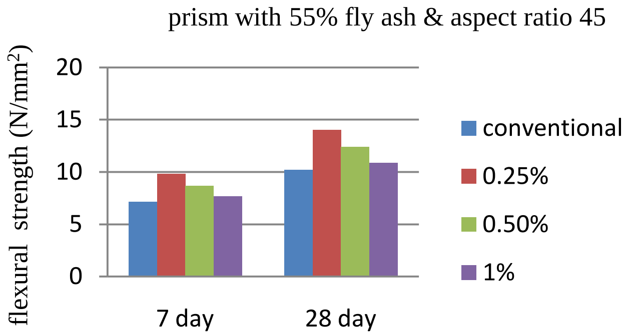

Fig 14. Bar chart showing flexural test results of 55% Fly ash with aspect ratio 45

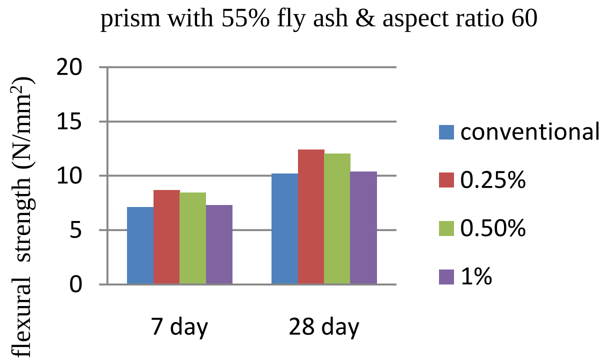

Fig 15. Bar chart showing flexural test results of 55% Fly ash with aspect ratio 60

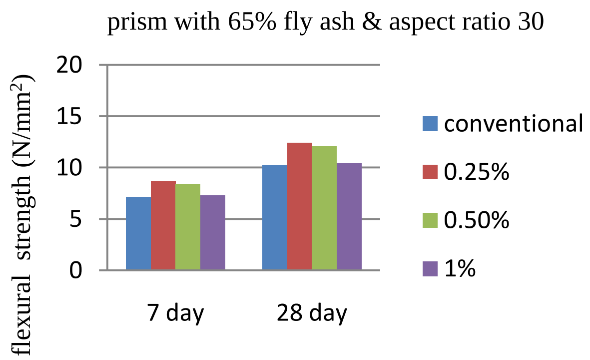

Fig 16. Bar chart showingflexural test results of 65% Fly ash with aspect ratio 30

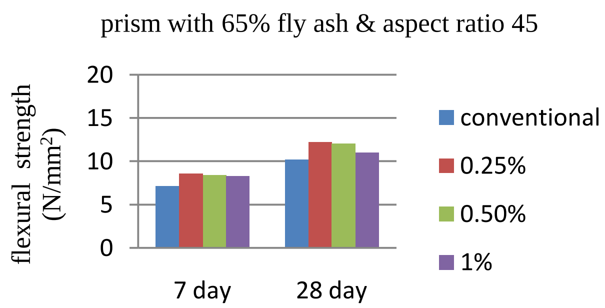

Fig 17. Bar chart showing flexural test results of 65% Fly ash with aspect ratio 45

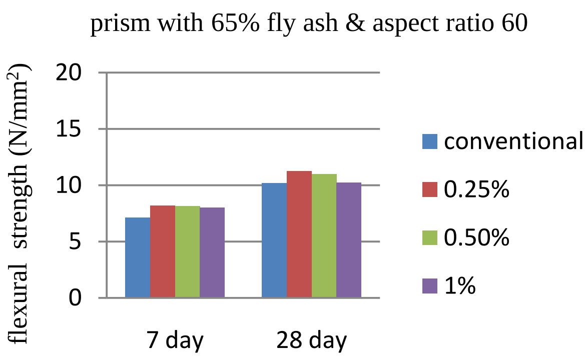

Fig 18. Bar chart showing flexueal test results of 65% Fly ash with aspect ratio 60

VI. CONCLUSION

In this study, the HVFAC with the use of steel fiber at different aspect ratio is found to be economical and eco friendly. From the study usage of fly ash as a replacement of cement up to 65% and the hardened concrete the results obtained were satisfactory. Since the fly ash is used which greatly reduces the CO_2 emission. The hardened properties of concrete were increasing up to fly ash 65% beyond this there is an decrease in strength parameters. Increase in steel fiber percentage beyond 1% the changes may occurs in hardened properties. The steel fiber increase the tensile strength of concrete. The maximum Hardened properties are obtained for 55% Fly ash with an increase of 29.4% strength value at 28 days when compared to Normal mix.

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