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EXPERIMENTAL INVESTIGATIONS ON FLY ASH BLENDED CONCRETE WITH STEEL FIBERS

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ABSTRACT

Fly ash is generated due to the combustion of pulverized coal which deliberately cause or initiates a major problem to the environment because of its dumping. It is a burnt and a powdery form of inorganic mineral. Utilization of Fly ash by replacing with the cement will definitely solve the problem of its dumping and on the other way it will decrease the costing of concrete. Probably, it the most commonly used SCM in the field of concrete industry. SCMs are the secondary cementitious material, which is used in the concrete by replacing cement. It imparts strength to the concrete as well as it makes the concrete more compact and durable. The use of Flyash has great beneficial effect on the concrete because it works as filler. Flyash, is the totally fundamental element of the blend like aggregate (CA+FA), cement(C), water and expansion of FA blend in this present reality of ebb and flow concrete like FRC. It is significant among the used reproduced pozzolans like Metakaoline, Rice Husk, Blast Furnace Slag and surkhi etc. It is the mostly used pozzolanic material all through the world and vigoursly added substance in the present use of cement in current world. The absolute necessary ingredient of the mixture are coarse aggregate (CA), fine aggregate (FA), cement(C), water and chemical mixture. It is utilized pozzolans such as Metakaoline, Rice Husk, Blast Furnace Slag and surkhi and so forth. It is the most generally utilized pozzolanic material all through the world. Addition of chemical is in practice in the real world of modern concrete.

SCOPE OF THE WORK

This study helps to design the concrete for structural purpose using FA. We have used 10%, 20%, 30% 40% and 50% replacement of cement in making of cubes to test the compressive strength of concrete. We have also used different percentages of Steel Fibers to observe the effect of it on the mechanical properties of steel fibers. For this research project, various proportions of Flyash and steel fibers has been used. The proportions of flyash used by replacing cement has been taken as 10%, 20%, 30%, 40% 50% and steel fibers as a Additive material as 0.5%, 1%, 1.5%, 2% and 2.5 % respectively.

- Steel fiber concrete can be used for lighter structures, large structures and for new design products.
- The concrete will contain less amount of Portland cement by using other cementations materials, fly ash.
- The study can help for a better economy and less consumption of traditional resources of concrete, steel and other building materials.

DESIGN OF EXPERIMENT

The Fly Ash is taken as partial replacement of cement (variable parameters w/w) respectively. The design of experiment shows the relation between variable parameters, values, levels and replica of test cubes in 3, 7 and 28 days as conducted for thesis work is presented below in Table 4.1.

Table of Design Experiment

Design of Experiment				
Sr. no	Variable Constituents	Level	Value	Replicate
1	Duration of curing Days	4	3,7,14,28	3
2	Fly Ash(%w_c/w)	5	10,20,30,40,50	3
3	Steel fibre (%%w_c/w)	5	0.5,1,1.5,22.5	3

The experimental programme consisted of casting and testing of 229 cubes specimens [150×150×150mm] with twenty one different type of concrete mixes by varying fly ash percentage and steel fiber concentration and 39 beam specimens [100×100×500mm] and 39 cylinder specimens [150×300mm] with thirteen different type of concrete mixes by varying fly ash percentage and steel fiber concentration. The specimens have been tested for compressive strength, flexural strength, tensile strength test and rebound hammer test respectively. Withal, the study presents the effect of sulphuric acid (H_2SO_4) and Hydrochloric Acid (HCl) solutions on the C/S of concrete with varying proportions of concrete mix determined by cube specimens testing.

The main objective of this study is to investigate the properties of FASFRC at the macrostructure as well the microstructural level. At the macro structural level, the compressive, flexural, tensile strength, rebound hammer test and also the effect of chemicals on hardened concrete were performed whereas, in micro-structural analysis SEM, XRD and porosity of concrete at different ages for different mixes has been studied. The details of experiment is shown below in Table 4.2

Table Details of Experiment

Name of test	Size of specimen (mm)	No. of mix	No of specimen for each proportion	Total no of speci mens
Compressive strength test	150X150X150	25	9	225
Rebound hammer test	150X150X150	25	3	75
Flexural strength test	100X100X100	13	3	39
Tensile strength test	150X300	13	3	39
Corrosion test	150X150X150	1	2	21

Materials Used

Cement, fine aggregates, coarse aggregates, fly ash, steel fibers and water used throughout the investigation, had some the following properties:

Cement Used
The bond utilized as a part of this test work is 43 grades Ordinary Portland Cement. All properties of bond are tried by utilizing IS 12269 – 1987 determined for 43 grades Ordinary Portland Cement. The consequences of the different tests on bond properties are given in Table 1.1.

Flyash used
The Fly cinder utilized here in this review, has been gathered from NPTC control plant, Delhi. Its organization is given in Table 1.4.

Fine aggregate used
The sand which was locally available has been used as Fine aggregate. The particle size distribution and properties are given in Table 1.2.

Coarse Aggregate used
MSA, crushed aggregate locally available is being used here. The properties are listed in Table 1.3. Coarse aggregates have been sieved to remove all the foreign materials.

Steel Fibers used

The steel fiber is procured from Nina Concrete System Pvt. Ltd., Delhi. The steel fiber used in the study is the Double Hooked ended type URW1050 having aspect ratio 50. The length of providing steel fiber is 50mm and the diameter of fiber is 1.0mm. The steel fiber reinforced concrete containing the constant dosages of 0.0%, 0.5% fiber up to 2.5 % is used by total volume of concrete. Properties of steel fiber used are tabulated in Table 1.4.

Water used
As per IS: 456-2000 water for concrete should be of potable quality. Ordinary tap water, which is fit for drinking, has been used in preparing all concrete mixes and curing in this investigation.

Concrete Mix
The process of selecting suitable ingredients of concrete and determine their proportion required in a concrete mix is known as Mix Design. In this experimental work the method used for mix design is British (DOE) Method. The Mix design involves the calculation of the amount of cement, coarse aggregate and fine aggregate in addition to other related parameters depend on the properties of constituent materials used to cast Fly Ash Fiber Reinforced Concrete. The proportions for designed mix of M25 Mix Design are as: Cement: Fine aggregate: coarse aggregate (1: 132: 2.40) and water 0.41. Mix design for M25 grade concrete has been shown in Table 3.6.

RESULT ANALYSIS

Workability

Generally, workability is carried out by Slump Test for the nominal concrete. In this study, the workability of FASFRC has been determined by Slump test, as per I.S. 1199-1959.The slump value for all the required mix proportions have been shown in the tabular form below in Table 5.1.

Table 5.1 Slump value of FASFRC (Flyash Blended Steel fiber reinforced Concrete)

Mix proportions	Slump value
S0 (0.0% & 0.0%)	**24**
S1(20% & 1.0%)	20
S2(20% & 1.5%)	18
S3(20% & 2.0%)	18
S4(30% & 1.0%)	16
S6(30% & 1.5%)	10
S7(30% & 2.0%)	9
S8(40% & 1.0%)	8
S9(40% & 1.5%)	8
S10(40% & 2.0%)	7

The graphs of slump value for all the required mix proportions have been shown below in Table 5.1

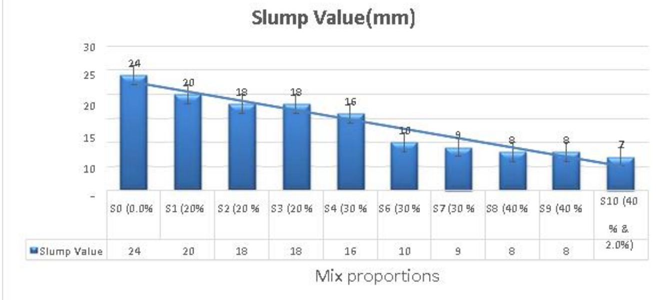

Figure: 5.1 Graphs of slump values of different mix proportions of FASFRC

Result analysis of Workability Test

In the slump test, it has been observed that, there is gradual decline in the slump value of the concrete with the percentage increase of flyash and steel fibers in the nominal concrete as compared to control. The slump value of cement is 24, whereas, for S10 (40 % & 2.0%) it is coming up to 7.

Compressive Strength Test

The compressive strength for control and fly ash steel fiber reinforced concrete have been summarized below in Tables 5.2. Graphs are plotted between the fly ash and steel fiber percentage vs. compressive strength as shown below in figs. (5.2) to (5.5)**.** From the test results, it is observed that the optimum compressive strength is obtained with the mix proportion S2 (1.0% & 20%) at the end of 28 days. The compressive strength of S2 is 36.97 N/mm^2 at the end of 28 days.

The graphs of FASFRC mix vs. compressive strength at 7, 14 & 28 days with 20 % replacement of cement with flyash is shown below in Figure 5.2.

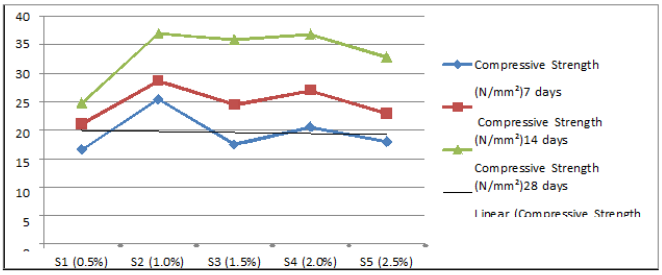

Fig.5.2 FASFRC mix vs. compressive strength at 7, 14 & 28 days of 20 % fly ash

The graphs of FASFRC mix vs. compressive strength at 7, 14 & 28 days with 30 % replacement of cement with flyash is shown below in Figure 5.3.

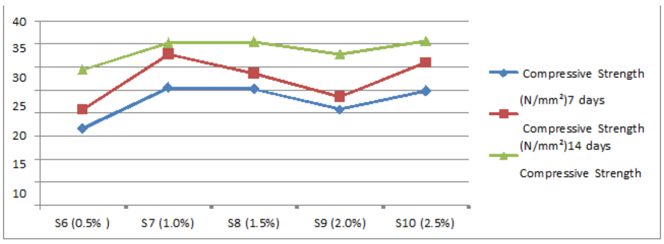

Fig.5.3 FASFRC mix vs. compressive strength at 7, 14 & 28 days of 30 % fly ash

The graphs of FASFRC mix vs. compressive strength at 7, 14 & 28 days with 40 % replacement of cement with flyash is shown below in Figure 5.4.

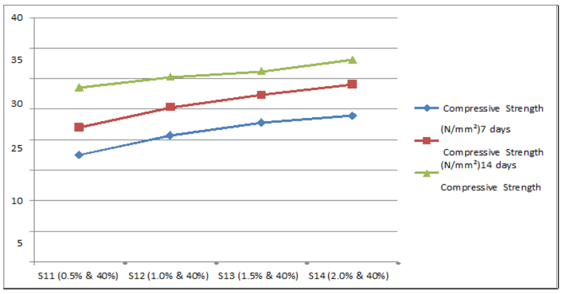

Fig.5.4 Type of SF mix vs. compressive strength at 7, 14 & 28 days of 40 % fly ash

The graphs of FASFRC mix vs. compressive strength at 7, 14 & 28 days with 50 % replacement of cement with flyash is shown below in Figure 5.5.

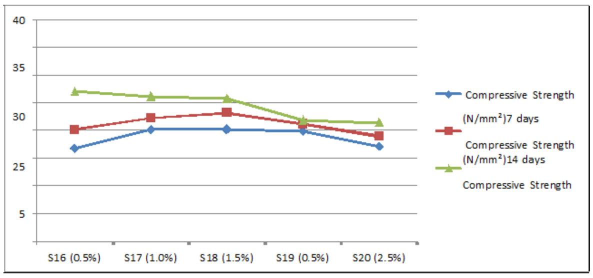

Fig.5.5 Type of SF mix vs. compressive strength at 7, 14 & 28 days of 50 % fly ash

Result Analysis of Compressive Strength Test

From the compressive strength test results and graphs, it is observed that optimum compressive strength is obtained is 36.97 N/mm^2 with S2 (1.0% & 20%).The compressive strength of control is 33.27 N/mm^2 at the end of 28 days. Thus, it can be anticipated that, there is an increase of 11.12 % in the compressive strength of with the 1.0 % addition of steel fiber and 20% replacement of flyash in the nominal concrete

Rebound Hammer Test

Rebound hammer test is performed to determine the compressive strength of concrete by using rebound hammer as per IS: 13311 (Part 2) – 1992. Rebound Hammer Test of each cube specimens for various type of fly ash steel fiber reinforced concrete (FASFRC) is determined. The results of rebound hammer are shown in Table (5.3) Graphs are plotted between the fly ash and steel fiber percentage vs. rebound hammer and is shown in figs. (5.9) to (5.12). The Compressive Strength (N/mm²) of flyash steel fibre reinforced concrete by rebound hammer at 7, 14 and 28 days (NDT)at all proportions is shown below in Table 5.3.

Table 5.3 Compressive Strength (N/mm²) of flyash steel fibre reinforced concrete by rebound hammer at 7, 14 and 28 days (NDT)

Mix Type (SF % &FA%)	Compressive Strength (N/mm²)		
	7 days	14 days	28 days
S0 (0.0% & 0.0%)	21.15	26.00	33.95
S1 (0.5% & 20%)	17.00	22.20	27.96
S2 (1.0% & 20%)	25.90	30.75	36.94
S3 (1.5% & 20%)	18.55	28.00	**37.20**
S4 (2.0% & 20%)	22.60	27.10	36.66
S5 (2.5% & 20%)	23.15	23.92	34.00
S6 (0.5% & 30%)	20.30	26.30	29.40
S7 (1.0% & 30%)	25.60	35.24	35.34
S8 (1.5% & 30%)	29.20	32.96	35.96
S9 (2.0% & 30%)	24.00	23.80	33.50
S10 (2.5% & 30%)	25.43	31.09	36.09
S11 (0.5% & 40%)	19.80	24.00	29.80
S12 (1.0% & 40%)	21.50	26.66	33.50
S13 (1.5% & 40%)	23.30	26.00	33.30
S14 (2.0% & 40%)	25.80	30.00	34.45
S15 (2.5% & 40%)	20.05	24.00	28.00
S16 (0.5% & 50%)	18.80	24.20	29.00
S17 (1.0% & 50%)	21.95	24.60	30.75
S18 (1.5% & 50%)	20.70	24.10	28.70
S19 (0.5% & 50%)	21.60	24.00	24.79
S20 (2.5% & 50%)	19.20	20.60	22.30

With the analysis of the Rebound hammer Test, it is found that results shows almost the same trend which was observed in the destructive compressive strength test. The optimum strength obtained is 37.20 N/mm^2 with S3 (1.5% & 20%)**.** The graph of FASFRC mix vs. compressive strength test (NDT) at 7, 14 & 28 days with 20 % replacement of cement with flyash is shown below in Figure 5.7.

Flexural Strength

As per the specifications of IS: 516-1959, the flexural strength of the flyash blended concrete has been determined. All the flexural strength test results has been summarized in tabular form, From, the flexural strength test, it is observed that the mix proportion S2 (1.0% & 20%) attained optimum flexural strength of 9.84 N/mm2, as followed by S8 (1.5% & 30%) the flexural strength obtained is 9.79 N/mm^2 at the end of 28 days the graphs are being plotted for flexural strength versus mix proportions of FASFRC as presented below in Figure (5.13 to 5.17) respectively. The graph of FASFRC mix vs. Flexural strength test at 28 days with 20 % replacement of cement with flyash and varying percentage addition of SF is shown below in Figure 5.11.

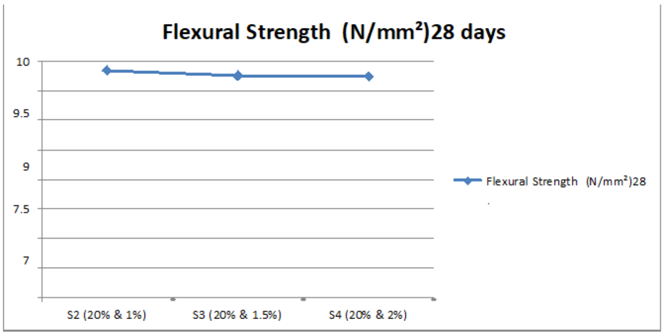

Fig.5.11 Type of mix vs. flexural strength at 28 days of 20 % fly ash

The graph of FASFRC mix vs. Flexural strength test at 28 days with 30 % replacement of cement with flyash and varying percentage addition of SF is shown below in Figure 5.12.

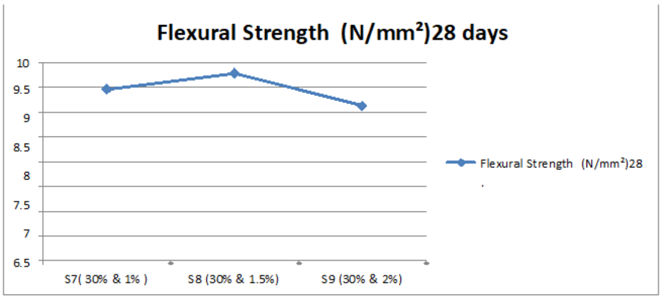

Fig.5.12 Type of mix vs. flexural strength at 28 days of 30 % fly ash

The graph of FASFRC mix vs. Flexural strength test at 28 days with 40% replacement of cement with flyash and varying percentage addition of SF is shown below in Figure 5.13.

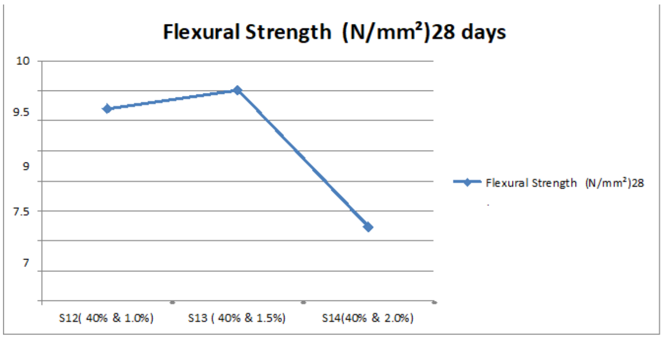

Fig.5.13Type of mix vs. flexural strength at 28 days of 40 % fly ash

The graph of FASFRC mix vs. Flexural strength test at 28 days with 50%replacement of cement with flyash and varying percentage addition of SF is shown below in Figure 5.14.

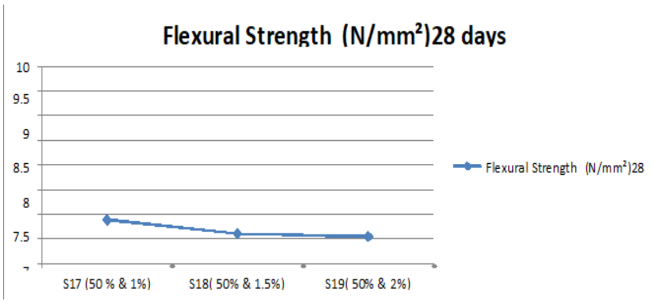

Fig.5.14Type of mix vs. flexural strength at 28 days of 50 % fly ash

The graph of FASFRC mix vs. Flexural strength test at 28 days with all percentage (10%, 20%, 30%, 40% & 50%) replacement of cement with flyash and percentage addition (1%, 1.5% & 2%) of SF is shown below in Figure 5.15. strength of the FASFRC was performed by the three point loading as the specification of IS: 516-1959, which is presented in the tabular form below in Table 5.5.

Table 5.5 Splitting tensile Strength (N/mm²) of fly ash steel fibre reinforced concrete after 28 days

Mix Type (S.F. % & F.A. %)	Splitting Tensile Strength (N/mm²)
S0 (0.0% & 0%)	3.96
S2 (1.0% & 20%)	**4.82**
S3 (1.5% & 20%)	4.66
S4 (2.0% & 20%)	4.52
S7 (1.0% & 30%)	4.61
S8 (1.5% & 30%)	4.55
S9 (2.0% & 30%)	4.52
S12 (1.0% & 40%)	4.54
S13 (1.5% & 40%)	4.35
S14 (2.0% & 40%)	4.34
S17 (1.0% & 50%)	4.36
S18 (1.5% & 50%)	4.33
S19 (2.0% & 50%)	4.26

From the test results, it is observed that the optimum tensile strength is obtained is 4.82 N/mm2 with S2 (1.0% & 20%) mix. It is compatible with the test result of compressive strength and Flexural strength test

The graph of FASFRC mix vs. tensile strength test at 28 days with all percentage (10%, 20%, 30%, 40% & 50%) replacement of cement with flyash and percentage addition (1%, 1.5% & 2%) of SF is shown below in Figure 5.16

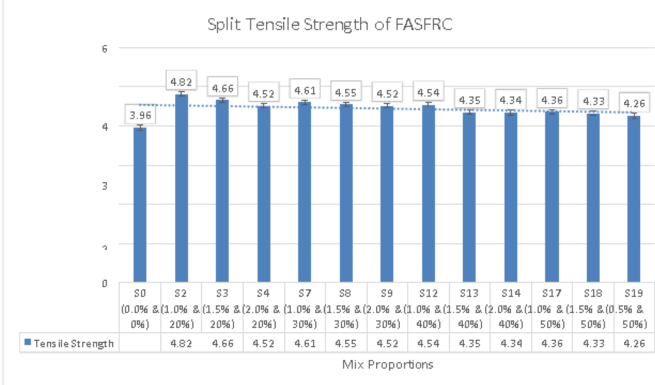

Fig. 5.16 Graphs of Type of mix vs. tensile strength at 28 days

Result Analysis of Split Tensile Strength Test

As per the tensile strength test results and graphs, it is observed that optimum tensile strength obtained is 4.82 N/mm2 with S2 (1.0% & 20%) mix. The tensile strength of control is 3.96 N/mm2 at the end of 28 days. Thus, it can be anticipated that, there is an increase of 21.71% in the tensile strength with the 1.0 % addition of steel fiber and 20% replacement of flyash in the nominal concrete

CONCLUSION AND RECOMMENDATIONS

Project Conclusions

On the basis of the present study following conclusions are drawn:-

1) Compressive strength of FASFRC found maximum when 20% cement is replaced by fly ash.
2) Compressive strength of concrete increases gradually by addition of Steel fiber from 8.1% to 11.12%. There is extensive increment in the compressive strength as compared with plain concrete (without fibers).
3) Flexural strength of FASFRC gradually increases by addition of Steel fiber from 7.08% to 13.56%. There is considerable increment in the flexural strength of FASFRC compared with nominal concrete.
4) Split Tensile strength of FASFRC gradually increases by addition of Steel fiber from 7.08% to 21.71%. There is significant increase in the tensile strength of FASFRC compared with nominal concrete

Microstructure analysis of Control with Steel Fiber fibre shows that the pore spaces are filled with flyash which reduces the porosity of concrete.

Recommendations

On the basis of the present study, it is recommended to use FASFRC as compared to nominal concrete which is presented as below:

- The compressive strength of Flyash blended concrete with steel fiber obtained at 20%

replacement of cement with Fly ash and with further addition of steel fiber at 1%,by weight of cement is optimum, among all the replacement made by flyash (i.e. 20%, 30%, 40% and 50%) & with steel fibers at these percentages (0.5%, 1%, 1.5%, 2% and 2.5%) . Thus, FASFRC is recommended to be used for lighter structures, large structures and for new design products. The concrete will contain less amount of Portland cement by using this cementations materials - fly ash

- The optimum compressive strength obtained is 36.97 N/mm² with replacement of cement by flyash (20%) with addition of steel fibers(1%) which is 11.12 % more than compressive strength obtained for control(33.27 N/mm²) at the end of 28 days. Therefore, this FASFRC can help for a better economy and less consumption of traditional resources of concrete, steel and other building materials.
- In the corrosion test, FASFRC gained considerable strength as compared to the compressive strength of control mix. Hence, again FASFRC is recommended on a large scale as compared to nominal concrete, because it shows better corrosion resistance against acid attack and consequently increasing its durability.
- There is a wide scope to use FASFRC as shotcrete in the tunnel linings.
- To improve its workability, it can be used with the plasticizers which can provide more compact and durable concrete.

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