

# An Experimental Study on Behaviour of Slurry Infiltrated Fibrous Concrete Produced By Partial Replacement of Cement with Fly Ash and Fineaggregate with Robo Sand

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**ABSTRACT:** SIFCON is a high-strength, high-performance material containing a relatively high volume percentage of steel fibres. it has high ductility, crack resistance and impact resistance SIFCON is produced by a process in which fibers are put into an empty mould, after which the fiber mass is infiltrated by a slurry. The mechanical tests like compressive strength, splitting tensile test were done and measured the strength of casted cubes and cylinders. For getting of our aim I have used 15\*15\*15 cm, D =15cm and L=30 cm moulds for cubes and cylinders respectively...

In this paper, cement and fine aggregates are partially replaced by Fly Ash and Robo sand in SIFCON. Fly Ash is a pozzolanic material, which blends with Portland cement to improve the durability and it, reduces the porosity of concrete as the particle size of Fly Ash is very less. Robo sand is one of the most used among such materials to replace river sand, which can be used as an alternative to fine aggregate in concrete.

In the present investigation workability and strength was evaluated in three stages. In first stage steel fiber content with various proportions of 2.5% and 5% from which optimum value is taken. In second stage cement is partially replaced by Fly Ash in proportions of 5% and 10% and fibers of first stage optimum value. In third stage natural sand is replaced by Robo sand in proportions of 0% and 50% to compare strength value with various fibers of (2.5% and 5%) is studied for cubes and cylinders. The strength characteristics like compressive strength and tensile strength are evaluated.

**KEYWORDS:** SIFCON, FLY ASH, ROBO SAND, STEEL FIBERS

## I. INTRODUCTION

Slurry-infiltrated fibres concrete (SIFCON) can be considered as a special type of fibre concrete with high fibres content. The matrix usually consists of cement slurry or flowing mortar. SIFCON has excellent potential for application in areas where high ductility and resistance to impact are needed. Only very limited information is available about its behaviour under different types of loading. SIFCON is a type of fibre reinforced concrete (FRC) but it is produced by using a method which is very different from ordinary fibre reinforced concrete. To achieve uniform fiber distribution small length of fibre is used.

These short discrete fibres are preplaced in the moulds to its full capacity or to the desired volume fraction thus forming a network. Then a fine liquid cement based slurry or mortar is allow to infiltrate over the fibre network. When compared to conventional concrete SIFCON contains relatively high cement and water content. SIFCON has no coarse aggregate but high cementous content. To improve the flow characteristics, controlled quantity of super plasticizer may be used. In SIFCON has no coarse aggregates however it may contain fine (or) coarse sand and additives such as fly ash, Fly Ash and latex emulsions.

All steel fiber types namely straight, hooked and crimped can be used. It possesses excellent mechanical properties coupled with greater energy absorption characteristics and casting process is also different for SIFCON. The fibers content is generally varies from 2% to 20%percent by volume. SIFCON is fabricated by infiltrating a bed of pre-placed fibers with cement slurry. There are four main design factors that should be considered in a SIFCON product these are slurry strength, fiber volume, fiber alignment and type of fiber. The fiber volume depends on the fiber type and the vibration effort needed for proper compaction. Smaller or shorter fibers may pack denser than longer fibers and higher fiber volumes can be achieved with careful and sufficient vibration.

## SIFCON

SIFCON is unique construction material possessing high strength as well as large ductility and far excellent potential for structural applications when accidental (or) abnormal loads are encountered during services SIFCON also exhibit new behavioral phenomenon, that of "Fiber lock" which believed to be responsible for its outstanding stress-strain properties. The matrix plays the role of transferring the forces between fibers by shear, but also acts as bearing to keep fibers interlock

## II. LITERATURE SURVEY

The starting place of SIFCON dates to 1979, whilst Prof. Lankard carried out vast experiments in his laboratory in Columbus, Ohio, USA and proved that, if the proportion of metal fibres in a cement matrix can be elevated notably, then a cloth of very high strength. Dr.P.Thamilselvi et al., investigated on "Behaviour of Exterior Beam Column Joints using SIFCON" they concluded with the sifcon specimens were found to possess 4times more stiffness than frc and 4.5times than conventional specimens. Kuldeep Dagar et al., researched on "SLURRY INFILTRATED FIBROUS CONCRETE (SIFCON) have taken steel fibers with different aspect ratios with different mix ratios he compared with plain concrete and sifcon specimen and concluded that sifcon specimen gives 4times than the plain concrete Niveditha.A<sup>1</sup> focused on " Effects of Partial Replacement of Cement by Metakaolin in Sifcon taken the mix ratio of 1:1 with different percentage of metakaolin with 5% fibers by its volume he concluded with using metakaolin reduces CO<sub>2</sub> emission and excellent improvement in combination with sifcon. M. Gopala Krishnan investigated on "Experimental Study on Slurry Infiltrated Fibrous Concrete With Sand Replaced By M sand" he had taken different steel fibers content (4%,6%,8%&10%) and replaced sand with m sand .he concluded that increases in steel fiber content increases strength but the strength is depended on the fiber alignment and mix ratio . rakesh kumar chaudary<sup>1</sup>) investigated on "Study of Behaviour of Sifcon Produced by Partial Replacement of Cement with Glass Powder and Low Tensile Strength Steel Fiber". He said that using some environmentally available with reduced the pollution by using high content of cement .he had taken various steel fibers percentage conducted mechanical test on sifcon specimens . he concluded there is increases in strength by increasing the fibers. Patil Deepesh<sup>1</sup> investigate on "Study of Mechanical and Durability Properties of SIFCON by Partial Replacement of Cement with Fly Ash as Defined By an Experimental Based Approach he concluded with the durability characteristics about sifcon specimen by using flyash 5 %,10%&15% with some steel fibers increases the strength and there is improve mechanical properties because of good bonding and less pores. P. Ashokkumar studied about "An Experimental Study on Behaviour of SIFCON Beam with fly ash and lathe waste" the structural behaviour of reinforced concrete beam using SIFCON section under cyclic loading. When optimum dosage of fly ash is 40% and optimum fibre content is 4%. The stiffness of flexural beam was found to be 105% more than conventional RC beam. The ductility factor was found to be 78% than conventional RC beam. The energy absorption capacity of flexural beam with SIFCON beam was found to be 175% more than conventional RC beam. p.dinesh kumar<sup>2</sup> studied on "study on strength properties of sifcon" He concluded with tension and flexural strength with an increase in the volume of steel fibers fraction 12% addition of steel fibers increases the strength about 36.2% when compared to conventional concrete as well as it also gives high strength, high ductility resistant and gives interlock between slurry. chiranth gowda .m<sup>1</sup> et.al., (studied on "an experimental study on sifcon using m – sand and partially replacing cement with silica fume" in this experiment they taken (4%6%8%&10% ) theyhad observed that upto 8% the strength got increased and at 10%fibres there is failure of strength because of bonding between the mixture they finally have concluded that addition of steel fibres increases the strength parameters of sifcon and contributes the reduction of cracks.

## III. PROPOSED METHODOLOGY AND DISCUSSION

### METHODOLOGY

Sifcon is best suited in few areas.

- Precast concrete members products, bridge decks, overlays and pavement rehabilitation.
- It can also used in long span structures
- it resist the sudden impact.
- It can also used at refractory application such as furnace lintel and saddle piers.
- In security application such as security vault and secret rooms.

**PROPOSED METHODOLOGY AND DISCUSSION: H.SUDHARSHAN RAO & N V RAMANA from JNTUA** investigated on "BEHAVIOUR OF SLURRY INFILITATRD FIBROUS CONCRETE (SIFCON)TWO WAY SLAB IN FLEXURE IPC CODE:C04B14/38 (vol2 oct 2005 pg 423-433) In this paper they have taken nine SIFCON slabs, three fiber reinforced slabs ,three plain concrete slab . they have conducted tests



on each specimen they have observed that SIFCON specimen is having 10 times more strength than the fiber reinforced slab. They said that SIFCON eliminates the shear stirrups in RCC beam. Their aim of the project is to describe the behavior of SIFCON slab in flexure under both monotonic and cycling loading. They concluded with the results obtained with SIFCON slab and FRC slab. The maximum first load is obtained 21.58 kN has been achieved for slab reinforcement with 12% volume fibers whereas for SIFCON SLAB achieved 58.93 kN. The increase of first crack to ultimate load is ranging of 65% to 200% SIFCON specimen which indicates excellent load carrying.

**MATERIALS USED**

Concrete is a equivalent mixture of cement, fine aggregate, coarse aggregate water and admixtures in a proportioned quantity. Whereas in SIFCON coarse aggregate is absent. In this present project work cement is partially replaced with Fly Ash, and fine aggregate is replaced with Robo sand.

**CEMENT**

OPC 53 grade cement conforming to IS:12269-1987 is used as a binding material.

Properties of cement	Results
Specific gravity	3.13
Fineness	5%
Initial setting time	29 min
Final setting time	580 min
Normal consistency	32%

**Table 1 PROPERTIES OF CEMENT**

**FLY ASH**

It is one of the recently developed supplementary cementitious materials that conforms ASTM C 680 CLASS –N pozzolone specification. Fly Ash differs from other supplementary cementitious material.

Physical properties	Results
Appearance	white
PH(10% SOLIDS)	4.5-5.5
BULK DENSITY	0.4-0.5
Specific gravity	2.6

**TABLE 2 PROPERTIES OF FLY ASH**

**FINE AGGREGATE**

In the present investigation locally available river sand, clean and dry Robo sand conforming to IS :383-1970 was used. The river sand is tested according to IS 2886(part-1V)-1963 properties given in below table

Properties of fine aggregate	Results
Specific gravity	2.66
Fineness modulus	3.3
Water absorption	1.8%
grading zone	Zone II

**TABLE 3 PROPERTIES OF FINEAGREGATE**



**WATER AND SUPERPLASTICIZER**

Ordinary water fit for human utilization are used for preparing sifcon specimen. The super plasticizer CONPLAST-430 is used to increase the workability

parameter	Results
Specific gravity	1.20to 1.21 at 30 <sup>0</sup>
Chloride content	NIL IS9103-1999 ans BS:5075
Air Entrainment	Additional1% air is entrained

**Table 4 specifications of CONPLAST SP-430**

**STEEL FIBERS**

For the present work I have used crimped steel fibers

diameter	0.5mm
length	30mm
Aspect ratio	50

**Table 5 properties of steel fiber**

**Mix proportion and specimen casting**

Generally sifcon the percentage of fibers can be from 2to 20 percent . Normally for making SIFCON mix ratio of cement and sand can be 1:1 ,1:1.5 or 1:2 and water cement ratio is varies from 0.3to 0.45.

Different specimens are taken with variation of steel fiber content .The strength characteristics like compressive strength and tensile strength are evaluated. Specimens are casted and tests are carried out after curing periods of 7 and 28days.

- Cement and fine aggregate = 1:1.5
- Fly Ash = 5 % & 10%
- Robo sand = 0% & 50%
- Water/cement = 0.45
- Steel fibers = 2.5% & 5%

**CASTIND AND CURING SPECIMEN**

In this present work different specimen such as cubes &cylinders were casted . Prepared slurry is poured after applying lubricant to the moulds without any compaction. Specimen with different variations in Fly Ash percentage ,robo sand percentage and steel fibers content . All the specimens were prepared with IS recommendation. Moulds are allowed to dried for 24hours and then hardened specimens are demoulded and kept in water for 7,28days

**TEST AND RESULTS**

Workability test results

**L BOX TEST**

Blocking ration  $H_2/H_1 = 0.85$

Where  $H_1$  = height of concrete at horizontal portion

$H_2$  = height of concrete in vertical portion

**V funnel test**

Time of flow  $T_f = 0.85$  SEC

**IV. RESULTS ON TEST CONDUCTED ON HAREDENED SIFCON SPECIMEN**

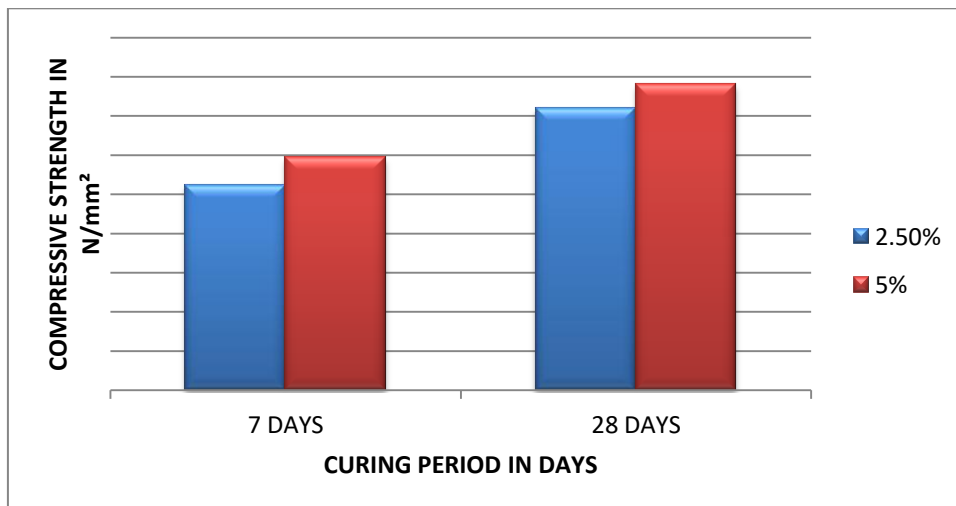
**SET -1**

**Cubes Compression test result**

In this SET -1 I have used cement sand as constant .There are three mixes in variation of steel fibers content for MIX-1 2.5%fibers, MIX-2 5% fibers with absence of admixture. The strength increased at 2.5% &5% fibers. Due to high amount of steel fibers .strength is highly influenced on alignment of steel fibers. As per results I got optimum value at steel fibers 5% and this optimum value is taken for partially replacement of cement in Fly Ash.

**TABLE NO: 6 (set-1)VARIOUS PERCENTAGE OF STEEL FIBERS %**

SPECIMEN DESIGNATION	STEEL FIBERS CONTENT	COMPRESSION STRENGTH (N/mm <sup>2</sup> )	
		7days	28days
MIX-1	2.5%	26.2	35.9
MIX-2	5%	29.7	39



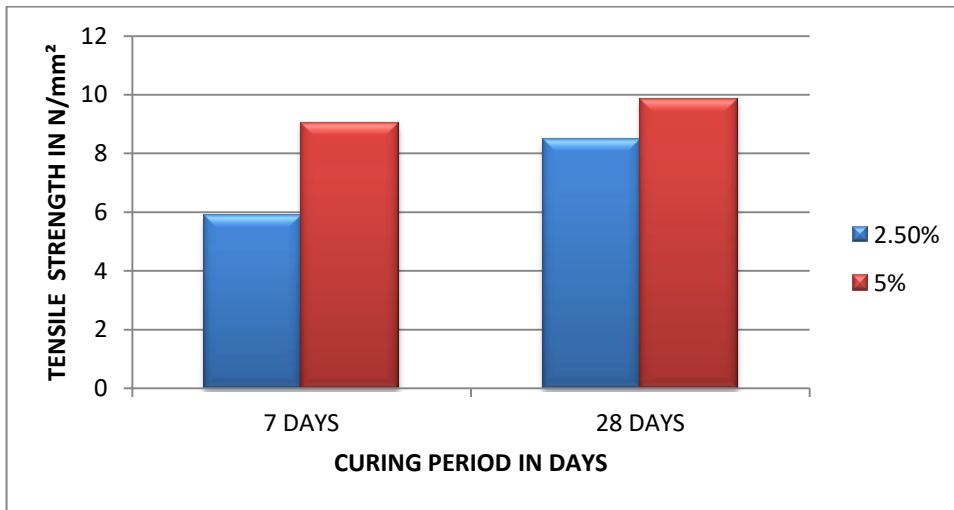
**Fig-1 (set:1) COMPRESSIVE STRENGTH VERSES CURING PERIOD VARIOUS FOR PERCENTAGE OF STEEL FIBERS**

**CYLINDER SPLIT TENSILE STRENGTH RESULTSET-1**

Set-1 (Tensile strength result):The optimum value is taken at steel fibers of 5% for next set

**TABLE NO: 7 (set-1)VARIOUS PERCENTAGE OF STEEL FIBERS %**

SPECIMEN DESIGNATION	STEEL FIBERS CONTENT	Tensile strength (N/mm <sup>2</sup> )	
		7days	28days
MIX-1	2.5%	5.09	8.5
MIX-2	5%	9.06	9.86



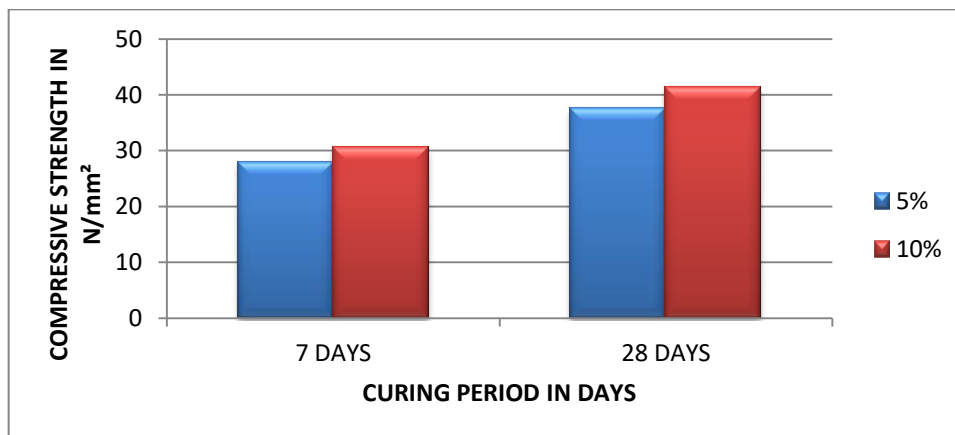
**Fig-2: (set-1) SPLIT TENSILE STRENGTH VERSES CURING PERIOD VARIOUS FOR PERCENTAGE OF STEEL FIBERS**

**CUBES COMPRESSION STRENGTH RESULTS FOR SET -2**

**SET -2 ( compressive strength ) : CEMENT IS REPLACED WITH METAKAOLIN ( 5%,10%) & SP 4%** In this set i have taken the partially replacement of cement with Fly ash, sand remains constant , steel fibers 5% from (TABLE NO: 6) and CONPLAST SP 430 super plasticizer (4%) is taken to avoid the voids. As per TABLE NO: 8 there are three mixes with the variation of Fly ash percentage. For MIX-3 (5%) & MIX-4 (10%) as shown in table no 6. As per results i got optimum at 10% Fly ash it is considered in further sets.

**TABLE NO:8 (set-2) PERCENTAGE OF FLY ASH IN CEMENT. PARTIALLY REPLACEMENT OF CEMENT WITH FLY ASH**

SPECIMEN DESIGNATION	FLY ASH%	COMPRESSION STRENGTH (N/mm <sup>2</sup> )	
		7days	28days
MIX-3	5%	27.96	37.65
MIX-4	10%	30.06	41.45



**Fig-3: (set-2) COMPRESSIVE STRENGTH VERSES CURING PERIOD FOR PARTIALLY REPLACEMENT OF CEMENT WITH FLY ASH**

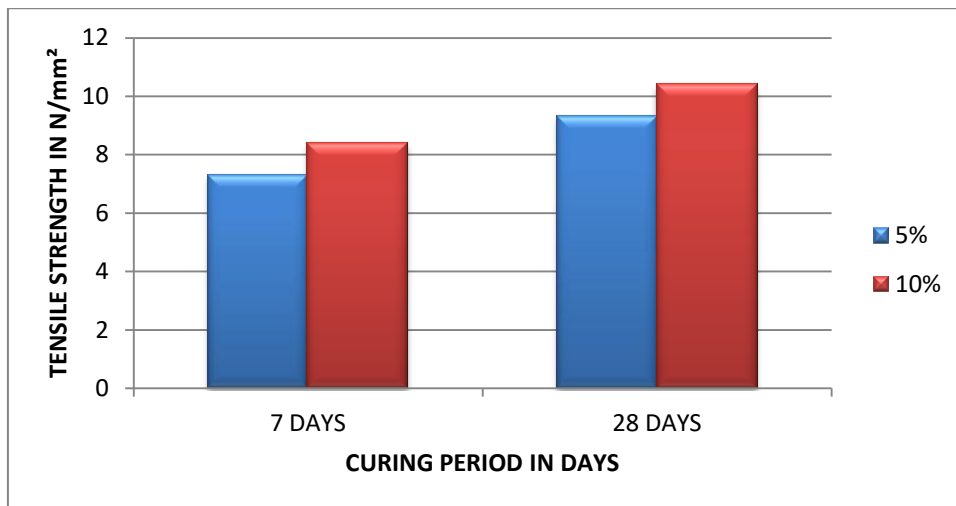


**SET -2**

**CYLINDER SPLIT TENSILE STRENGTH RESULTS:** in this tensile strength result v got optimum of 10% Fly ash is taken for further test

**TABLE NO:9(set-2) PERCENTAGE OF FLY ASH IN CEMENT. PARTIALLY REPLACEMENT OF CEMENT WITH FLY ASH**

SPECIMEN DESIGNINATION	FLY ASH%	Split tensile STRENGTH (N/mm <sup>2</sup> )	
		7days	28days
MIX-3	5%	7.31	9.31
MIX-4	10%	8.4	10.4



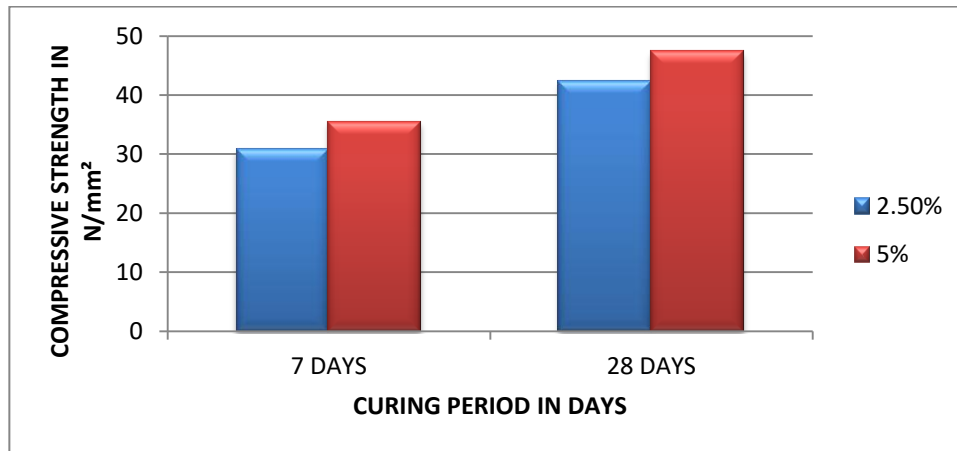
**Fig-4: (set-2) SPLIT TENSILE STRENGTH VERSES CURING PERIOD FOR PARTIALLY REPLACEMENT OF CEMENT WITH FLY ASH**

**CUBES COMPRESSION STRENGTH RESULTS FOR SET -3**

**SET -3 : VARIOUS PERCENTAGE OF STEEL FIBERS, REPLACEMENT OF CEMENT WITH FLY ASH(10%), FINE AGGREGATE WITH ROBO SAND (50%) & SP 4%** In this set consists of three mixes where three mixes are taken with cement is partially replaced with Fly ash (10%) and fine aggregate is replaced with replaced by Robo sand (50%) and CONPLAST SP -430 super plasticizer (4%) is used as per IS recommendation. As per the result in the below TABLE NO 9 I have observed that strength is increasing at fibers of ( 2.5% & 5%) with Robo sand 50%.

**TABLE NO: 9 (set-3) VARIOUS PERCENTAGES OF STEEL FIBERS ALONG WITH PARTIALLY REPLACEMENT OF CEMENT WITH FLY ASH (10%) REPLACEMENT FINE AGGREGATE WITH ROBO SAND (50%) & SP 4%**

SPECIMEN DESIGNINATION	STEEL FIBERS CONTENT	COMPRESSION STRENGTH (N/mm <sup>2</sup> )	
		7days	28days
MIX-5	2.5%	30.8	42.36
MIX-6	5%	35.5	47.1



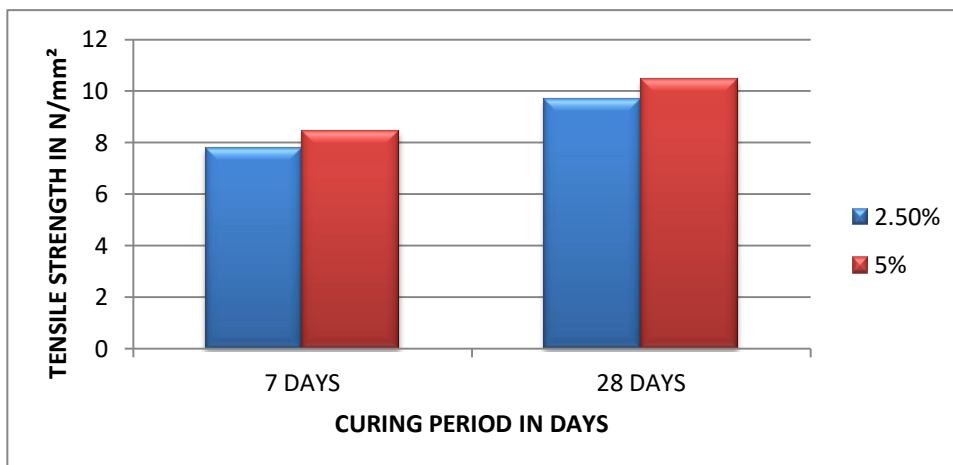
**FIG-5: (SET-3) COMPRESSION STRENGTH VERSES CURING PERIOD FOR VARIOUS PERCENTAGES OF STEEL FIBERS ALONG WITH REPLACEMENT OF CEMENT WITH FLY ASH (10%) AND FINE AGGREGATE WITH ROBO SAND (50%)**

**CYLINDER TENSILE STRENGTH RESULTS FOR SET -3**

**SET-3: VARIOUS PERCENTAGE OF STEEL FIBERS, REPLACEMENT OF CEMENT WITH FLY ASH (10%), FINE AGGREGATE WITH ROBO SAND.**

**TABLE NO: 10 (set-3) VARIOUS PERCENTAGES OF STEEL FIBERS ALONG WITH PARTIALLY REPLACEMENT OF CEMENT WITH FLY ASH (10%) REPLACEMENT FINE AGGREGATE WITH ROBO SAND (50%) & SP 4%**

SPECIMEN DESIGNATION	STEEL FIBERS CONTENT	SPLIT TENSILE STRENGTH (N/mm <sup>2</sup> )	
		7days	28days
MIX-5	2.5%	7.8	9.7
MIX-6	5%	8.47	10.47



**FIG-6: (SET-3) TENSILE STRENGTH VERSES CURING PERIOD FOR VARIOUS PERCENTAGES OF STEEL FIBERS ALONG WITH REPLACEMENT OF CEMENT WITH FLY ASH (10%) AND FINE AGGREGATE WITH ROBO SAND (50%)**



## V. RESULTS DISCUSSION

Based on the compressive and tensile strength tests the optimum values from set 1 & set 2 are taken to get the ultimate strength. Based on the steel fibers alignment and the fibers content the ultimate strength values are obtained. For my aim of this paper is to study the partial replacement of cement with Fly ash and fine aggregate with Robo sand. I got the target strength at set-3 i.e., partially replacement of cement with Fly ash at 10% and fine aggregate with Robo sand 50%. Steel fibers help to interlock the slurry and give high strength. It should be noted that 5% of steel fibers, 10% of Fly ash and Robo sand 50% got target strength. As the amount of increase of steel fibers there is occurrence of cracks will be more and bonding will not be proper.

## VI. CONCLUSION

- It is observed that strength is increasing based on the fiber alignment and fiber content.
- The inclusion of Fly ash as a partial replacement of cement provides an excellent improvement in developing the strength compared to conventional.
- As per the results the compressive and tensile strength of SIFCON for cubes and cylinder which contain a combination of 5% fibers, 10% Fly ash, 50% Robo sand is larger than cubes and cylinder specimen with only 5% fibers.
- The cost of construction is high with SIFCON but it can be used on security rooms and also used for blast resistance structures and severe failure.
- The optimum values are significantly improved results over controlled SIFCON specimen under 28 days curing.
- From the workability tests it was observed that SIFCON is self-compactable and has better workability.

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