International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 11, November-2018

AN EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF CEMENT MORTAR WITH STEEL FIBRES

[1]Mrs. A.LEKHYA, [2]Mr. B.VISHNUVARDHAN REDDY (Ph.D pursuing)

[1]*(Asst. Professor, Department of Civil engineering)*, *St.Marrys Group of Institutions, Deshmuki village, pochampally mandal, yadadri bhuvanagiri dt-508284, Telangana, India*

[2]*(Asst. Professor, Department of Civil engineering)*, *St.Marrys Group of Institutions, Deshmuki village, pochampally mandal, yadadri bhuvanagiri dt-508284, Telangana, India*

ABSTRACT

Cement mortar posses' very low tensile strength, partial ductility and little resistance to crack. Addition of minor closely set apart, homogenously distributed fibre's act as blow arrester, substantially increase static & dynamic stuffs through growing water content flow, plastic shrinkage and drop in strength will arise. With reducing water contented hydration process is imperfect, rise in gel space proportion will happen. By adding plasticizers and extra chemicals for workability and to achieve strength will act for the time period. To come through these two problems by the addition of small quantity of fibre's efficiently control early age plastic shrinkage & cracking.

It is generally acknowledged that steel fibres are added to advance the toughness, abrasion resistance and impact strength. In this work, the mechanical and durability properties of cement mortar by adding 1%, 2% steel fibres by weight of cement and sand are deliberate and compared with the control mix.

INTRODUCTION

GENERAL

Plain solid forces a low rigidity, restricted malleability, and little imperviousness to breaking. By the expansion of little, firmly separated and consistently scattered strands to cement would go about as break arrester and significantly build static and element properties. Every kind of fiber has its own particular trademark properties and constraints.

In this way, an extremely constrained amount of examination work has been done on the use of filaments in basic cement. Thus, the present examination would prompt a more grounded and solid Fiber Reinforced mortar, which can be prescribed for applications like development of extraordinary building and safe houses, section boards, divider planes and so on.

Ordinary cement blends are normally inclined to plastic shrinkage amid the curing stage and frequently prompt crazing and splitting. The expansion of moderately little measures of strands can viably dispose of this issue by controlling this early – age plastic shrinkage splitting. Not just the fiber cement is simple and savvy to utilize, additionally empowers to create a solidified cement, which has enhanced surface quality and more prominent effect resistance.

In the present trial examination, endeavors are made to mull over on the different quality properties like compressive quality, split elasticity, flexural quality furthermore strength properties like water retention, Acid assault on both normal concrete mortar and by including steel filaments, at stipulated ages with distinctive rates of strands independently. Studies were made on leftover compressive quality, weight reduction and Acid assault at indicated age

OBJECTIVE OF PRESENT WORK

The principle objective of this work is to study the properties which influence the strength and durability of cement mortar prisms.

1. Adopting different percentage of steel fibers as 1%, 2% by weight of cement and sand.
2. Establishing the following mechanical properties of mortars through testing of the mortar specimens in the laboratory from the day of casting.
   - ➢ Flexural strength is tested after 7, 14, 28 days curing.
   - ➢ Compressive strength is tested after 7, 14, 28 days curing.
   - ➢ Split tensile strength is tested after 7, 14, 28 days curing.
3. Assessment of following durability related properties.
   - ➢ Rate of water absorption is conducted after 28 days curing.
   - ➢ Acid Attack test is conducted after 28 days curing in water then in acids for 28days.
4. Comparison of properties of the control mix with and without fibres.

LITERATURE SURVEY

HISTORY OF SYNTHETIC FIBRE REINFORCEDCONCRETE

- 1965: First Usage: Use of Monofilament Short Fibres U.S. Army Corps of Engineers for Blast Resistance Structures.
- 1970s-1980s: Usage of Low Volume Fractions Monofilaments & Fibrillated Fibres.
- 1990s: Development of High Volume Fibre Application with improvement in dispersion characteristics.

- 2000 – Onwards: Development of Structural Synthetic Fibres.
- Development of HPFRCC High Performance FRC.
- Development of Engineered Cement Composites ECC.

➢ Roman Coliseum was built in 80 AD, used horse-hair as secondary reinforcement.
➢ Tipu Sultan's palace at Srirangpattnam has been built with Sheep's wool.
➢ A Pueblo house built in 1540 with straw reinforcement adobe brick is believed to be the oldest house in USA.
➢ Use of horsehair in plaster has many historical references.

PROPERTIES OF MATERIALS USED IN THIS WORK

STEEL FIBRES

Figure : Hooked Steel Fibres

Steel Fiber General Description

Filaments in solid are for the most part Metallic strands. Metallic strands incorporate low carbon chilly drawing steel filaments, stainless steel fiber, and sheet steel strands and so on. We have sorts of Hooked Ends, Corrugation, Flat Ends and Micro steel fiber and so on.

Steel strands are fibers of wire, distorted and slice to lengths, for support of solid, mortar and other composite materials. It is a chilly drawn wire fiber with folded and flatted shape. It is frequently used to rather than Xorex steel fiber.

Steel fiber with snared finishes is made utilizing top notch low-carbon steel wire. This is a sort of elite steel fiber, with the attributes of the high rigidity, great sturdiness, and so on. The item is broadly utilized as a part of solid reinforcing. Snared finishes steel fiber is made in agreement to the nation standard.

MIX PROPORTIONS, PREPARATION OF TEST SPECIMENS
ORDINARY PORTLAND CEMENT

In this work ordinary Portland cement was used. The following tests were carried out to check the quality of cement.

- Fineness
- Initial & Final setting times
- Normal consistency
- Specific Gravity
- Compressive strength test on 7, 28 days for 1: 3 cement mortars.

Table Initial & final setting times are tested on Vicat apparatus

Specific Gravity	Setting Time Minutes		Compressive Strength N/ mm^2	
	Initial setting time	Final setting time	7 Days	28 Days
3.12	62 mins	180 mins	30.00	50.8

Properties of the sand

Type of aggregate	Maximum size in mm	Fineness Modulus	Bulk density kg/mt^3	Specific gravity	Water absorption	Organic impurities
River sand	1.2	3.48	1600	2.65	1%	nil

Properties of steel fibres

Fibre Properties	**Quantity**
Average fibre length, mm	30
Average fibre diameter, mm	0.56
Aspect ratio	54
Tensile strength (MPa)	> 1100
Ultimate elongation (%)	< 2
Specific gravity	7.85

No of prisms required for Flexural strength was shown in the table:

Mix	7 days	14 days	28 days
0 % control mix	3	3	3
1% steel fibres	3	3	3
2% steel fibres	3	3	3

- To do test for Compressive strength 40x40x160 mm prisms were casted and total no of prisms required to test for different time periods was tabulated.

No. of prisms required for compressive strength was shown in the table

Mix	7 days	14 days	28 days
0 % control mix	3	3	3
1% steel fibres	3	3	3
2% steel fibres	3	3	3

- To do tests for split tensile strength 40x40x160 mm prisms were casted and total no of prisms required to test for different time periods was tabulated.

No. of prisms required for split tensile strength was shown in the table

Mix	7 days	14 days	28 days
0 % control mix	3	3	3
1% steel fibres	3	3	3
2% steel fibres	3	3	3

- To conduct water absorption test similar 40x40x160 mm prisms were casted and tested on 28 days time period.

No. of prisms required for water absorption test was shown in the table

% by weight of cement	0 %	1 %	2%
No. of prisms	3	3	3

- To conduct Acid resistance test 40x40x160 mm beams are casted. These are tested after 28 days of immersing in 5% H_2SO_4 solution.

No. of prisms required for Acid resistance was shown in the table

% by weight of cement	0 %	1 %	2%
No. of prisms	3	3	3

TEST METHODS

Figure -Test set-up for compressive strength test

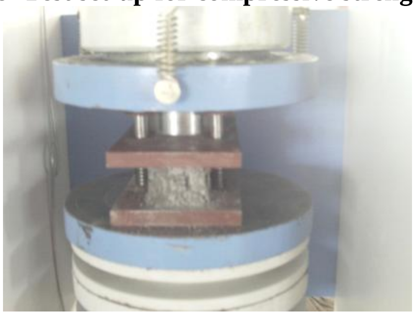


Figure - Compressive strength test prism after failure

SPLITTING TENSILE STRENGTH TEST

Split tensile strength test was also carried out using the broken specimens got from the flexural strength test. Fig (5.7) shows the line diagram of split tensile strength test setup and Fig. (5.8, 5.9) shows the test set up before and after testing the specimens.

Tests were carried out at the age of 7, 14 and 28 days on three identical wet specimens. Split tensile strength was calculated using the formula.

Split tensile strength (σ_T)= $2 P / \pi b d$ (N/mm^2)

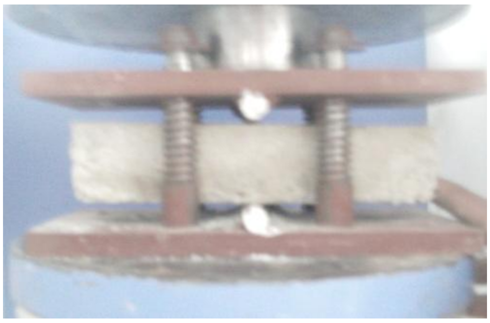


Figure - Test setup for split tensile strength

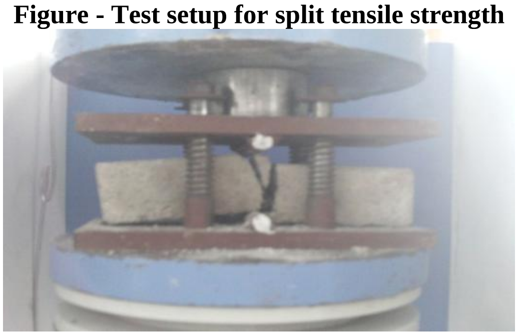


Figure - Split tensile test prism after failure

WATER ABSORPTION TEST

The water absorption characteristic of control mortar specimens with different fibres was determined on 40 x 40 x 160 mm prism specimens by following the procedure similar to that of BS: 1881 – part 5-1970 (35). After 28 days moist curing, the specimens were dried in an oven at a temperature of 110 ^{0}c for 24 hours as shown in Fig (5.10).

The specimens were then removed from the oven and were cooled to room temperature. The dry mass of the specimens was taken and then they were immersed in water as shown in Fig (5.11). The specimens were taken out at regular intervals of time to measure the change in mass. The process was continued till the end of the saturated period. The water absorption at the end of the period was obtained by expressing the change in the mass as a fraction of the initial mass of the specimens. Using this data, the following parameters were calculated.

Porosity (n) = $(W_{sat} - W_d) / (W_{sat} - W_{Sub})$

Coefficient of absorption (K_a) = $(q/A)^2/t$

Where,

W_{sat} = Saturated weight of specimen in water

W_{sub} = Submerged weight of specimen in water

W_d = Oven dried weight

q = Quantity of water (ml) with time't' (minutes) by specimen

A = Surface area (cm^2) of specimen through which water penetration takes place.

Figure - Heating of prisms in oven

ACID ATTACK TEST

Concrete is not fully resistance to acids. Most acid solutions will slowly or rapidly disintegrate Portland cement concrete depending upon the type and concentration of acid, and acids like oxalic acid, phosphoric acids are not harmless.

The most susceptible is $Ca(OH)_2$ in the cement hydrate. However, C-S-H gel can also be attacked. Comparatively siliceous aggregates are more resistant to calcareous aggregates. Concrete can be attacked by liquids with $_{P}H$ value below 6.5, but the attacks are severe only at a $_{P}H$ below 5.5, below 4.5 the attack is very severe. As the attack proceeds, all the cement compounds are evenly broken down and leached away, to either with any carbonate aggregate material. With the sulphuric acid attack, calcium sulphate formed can proceed to react with calcium aluminate phase in cement to form calcium sulphoaluminate, which on crystallization can cause expansion and disruption of concrete. If acids or salt solutions are able to reach the reinforcing steel through cracks or porosity of concrete, corrosion can occur which will cause cracking.

Acid attack on concrete specimens of size 40 X 40 X 160 mm is usually determined by immersing test specimens in 5% H_2SO_4 solution shown in fig. (5.12). The deterioration of concrete specimens is presented in the form of percentage reduction in weight and percentage increase in the resistance of fibre concrete against the weight losses in comparison with Ordinary concrete mixes at 28 days. Fig.(5.13) shows the specimens taken from acid after 28 days.

Durability factor = $(w_1 - w_2 / w_2)*(t/n)$

Where,

W_2 = Final weight of sample after taken out from (H_2SO_4) solution.

W_1 = Initial weight of sample

t = No of days of testing

n = Total no of days of testing (28 days)

Figure - Specimens in H_2SO_4 solution

Figure - Specimens after taken out from H_2SO_4 solution

PROPERTIES OF MORTAR MIX WITH & WITHOUT STEEL FIBRES

FLEXURAL STRENGTH

Flexural strength (σ_t) = p L / b d^2 (N/mm^2)

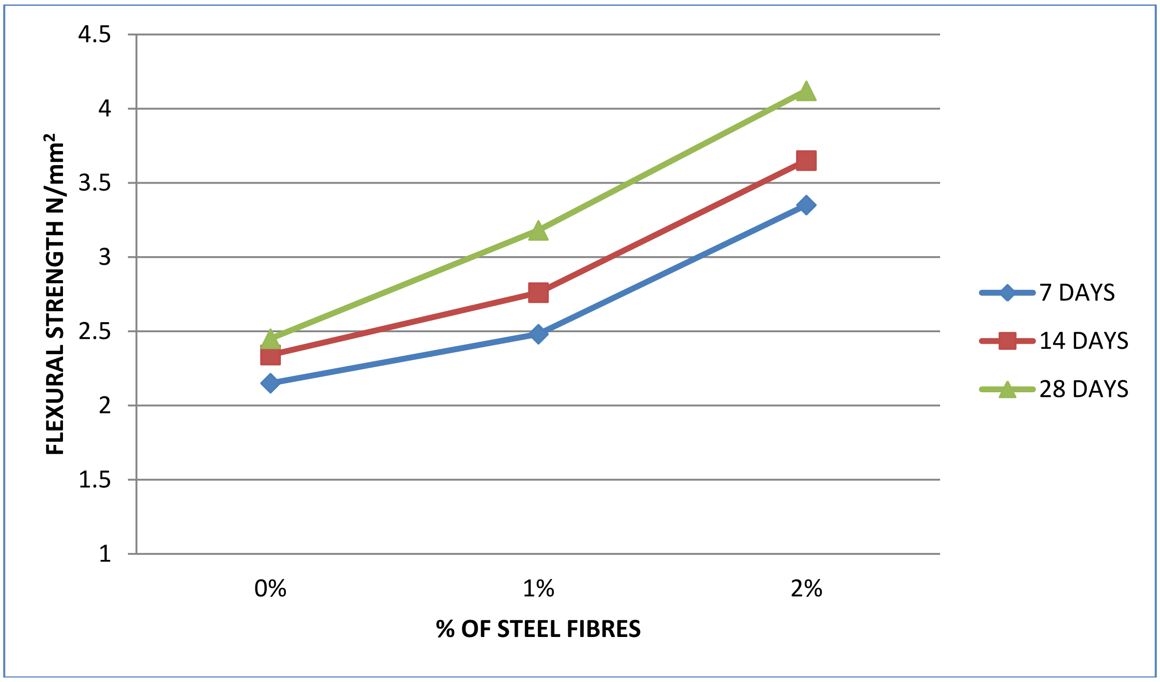
Where P = Applied load in (Newton)

d = Depth of the beam in (mm) = 40mm

b = Breadth of the beam in (mm) = 40 mm

L = Span of the beam in (mm) = 160 mm

Graph - Flexural strength of control mix and mortar mixtures with 1%, 2% steel Fibre



COMPRESSIVE STRENGTH

Graph shows development of compressive strength of control mix and mortar mixtures with 1%, 2% steel Fibre by weight of cement and sand. At all ages of testing, mortar mixtures with Steel Fibre shows increase in compressive strength when compared to control mixture

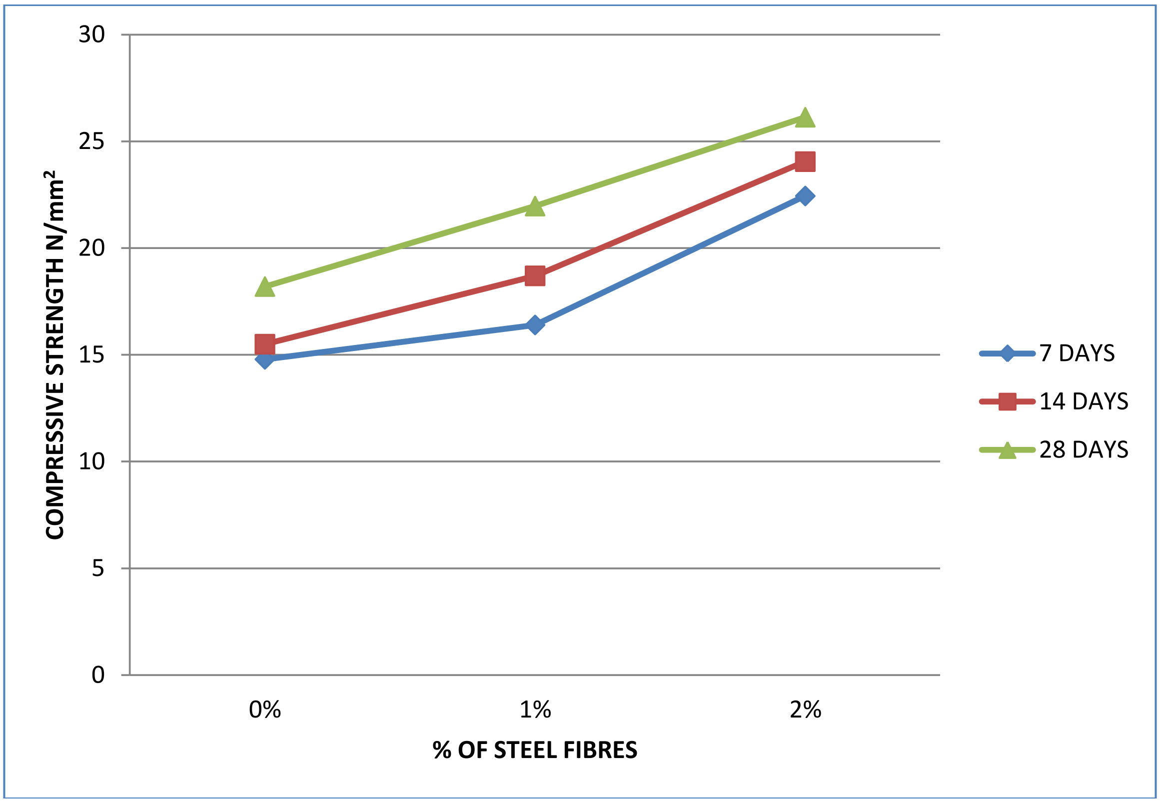
Compressive strength = P/A (N/mm^2)

P = Applied load in Newton (N)

A = Surface area in (mm^2) = (b x L) = 40 X 160 mm^2

L = Span of the beam in (mm) = 160 mm

b = Breadth of the beam in (mm) = 40 mm



SPLITTING TENSILE STRENGTH

Graphshows development of split tensile strength of control mix and mortar mixtures with 1%, 2% steel Fibre by weight of cement. At all ages of testing, mortar mixtures with steel Fibre shows increase in split tensile strength when compared to control mixture.

Split tensile strength (σ_T)= 2 P / π b d (N/mm^2)

Where P = Applied load in (Newton)

L = Span of the beam in (mm) = 160 mm

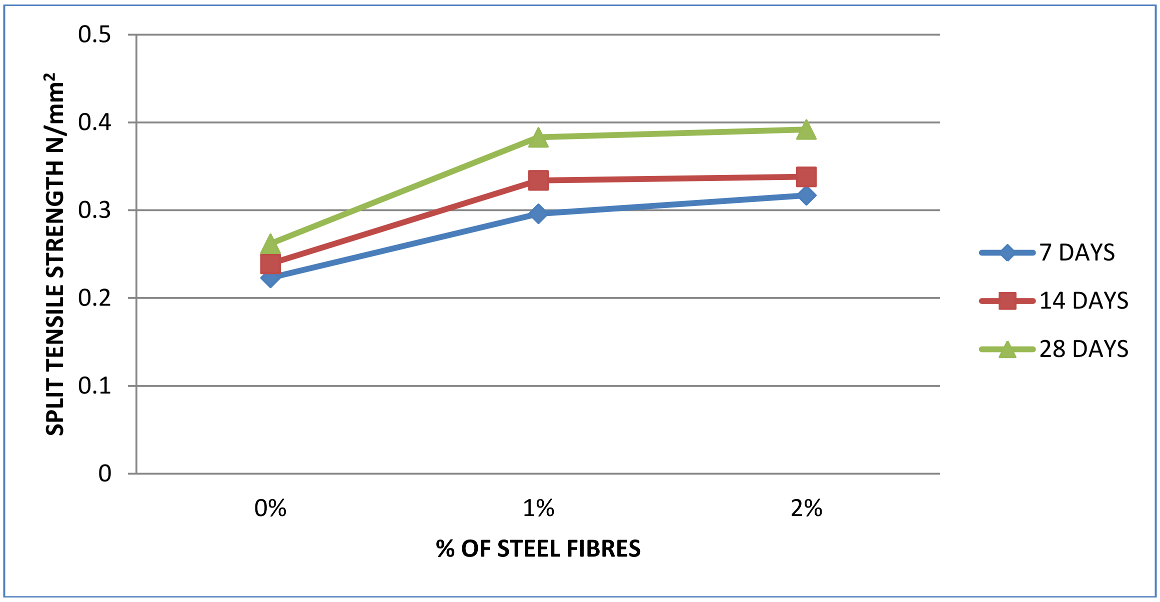
b = Breadth of the beam in (mm) = 40 mm

d = Depth of the beam in (mm) = 40mm

Table - Splitting tensile strength of cement mortar with steel fibre, in MPa

Mix	**At 7 Days**	**At 14 Days**	**At 28 Days**
0 %	0.225	0.235	0.265
1%	0.289	0.340	0.375
2%	0.320	0.330	0.398

Splitting tensile strength of control mix and mortar mixtures with 1%, 2% steel Fibre



DURABILITY PROPERTIES OF STEEL FIBRE

WATER ABSORPTION TEST

Water absorption test of control mix and mortar mixtures with 1%, 2% steel Fibre by weight of cements and sand. Test results show cumulative water absorption decreased by increasing the percentage of steel Fibre. But rate of absorption gets slows down time increases from 15 – 240 minutes and reaches to saturation point with very slight change afterwards.

Porosity (n) = $(W_{sat} - W_d) / (Wsat - W_{Sub})$

Coefficient of absorption (K_a) = $(q/A)^2$

Where,

W_{sat} = Saturated weight of specimen in water

W_{sub} = Submerged weight of specimen in water

W_d = Oven dried weight

q = Quantity of water (ml) with time't' (minutes) by specimen= $W_{Sub} - W_d$

A = Surface area (cm^2) of specimen through which water penetration takes place

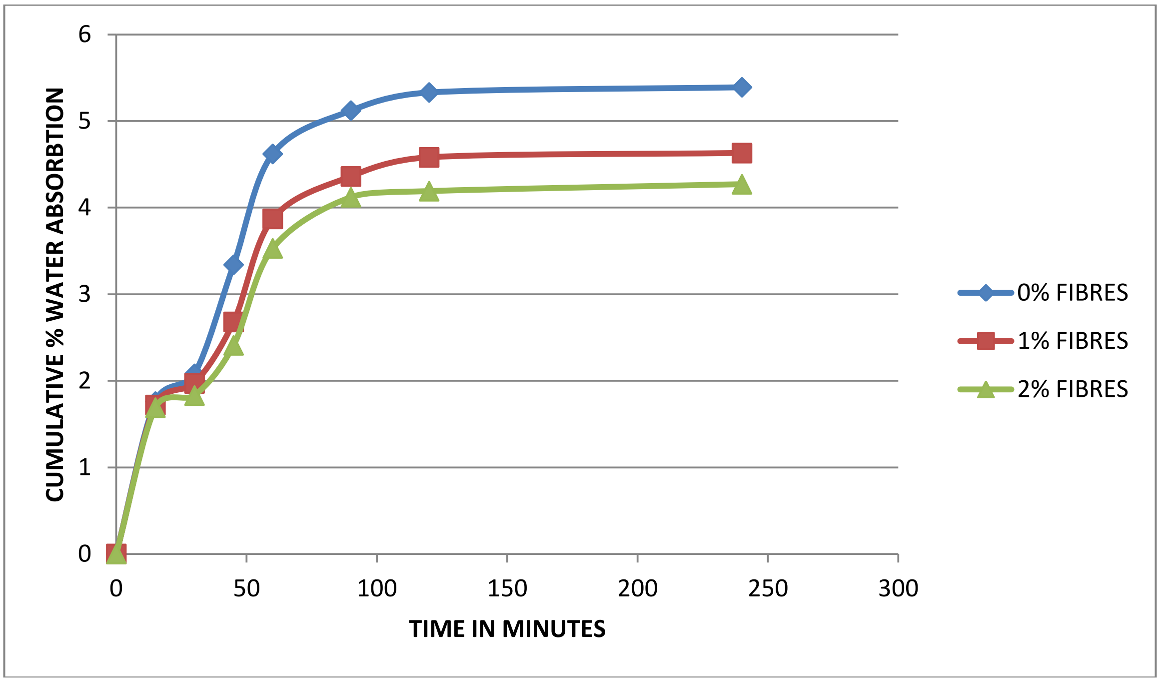
Table - Cumulative percentage of water Absorption in % wt.

Time in minutes	**0%**	**1%**	**2%**
15	1.75	1.71	1.69
30	2.07	1.95	1.85
45	3.35	2.65	2.45
60	4.66	3.89	3.55
90	5.10	4.45	4.15
120	5.45	4.52	4.21
240	5.35	4.75	4.07

Table - Properties of mortars obtained from water absorption test results

Mix	Dry density Kg/m^3	Wet density Kg/m^3	Porosity
0% Control mix	2031	2199	20.00
1% Steel fibre	2075	2242	10.5
2% Steel fibre	2199	2265	7.32

Graph - Cumulative % of water absorption



ACID ATTACK TEST

Below shows results obtained from Acid Attack test of 5% H_2SO_4 solution control mix and mortar mixtures with 1%, 2% steel fibre by weight of cement and sand. Test results shows weight loss decreases by increasing the percentage of steel Fibre. Loss of compressive strength deceases by adding Fibres when compared to control mix.

Durability factor = $(w_1 - w_2/ w_2)*(t/n)$

Where,

W_1 = Initial weight of sample

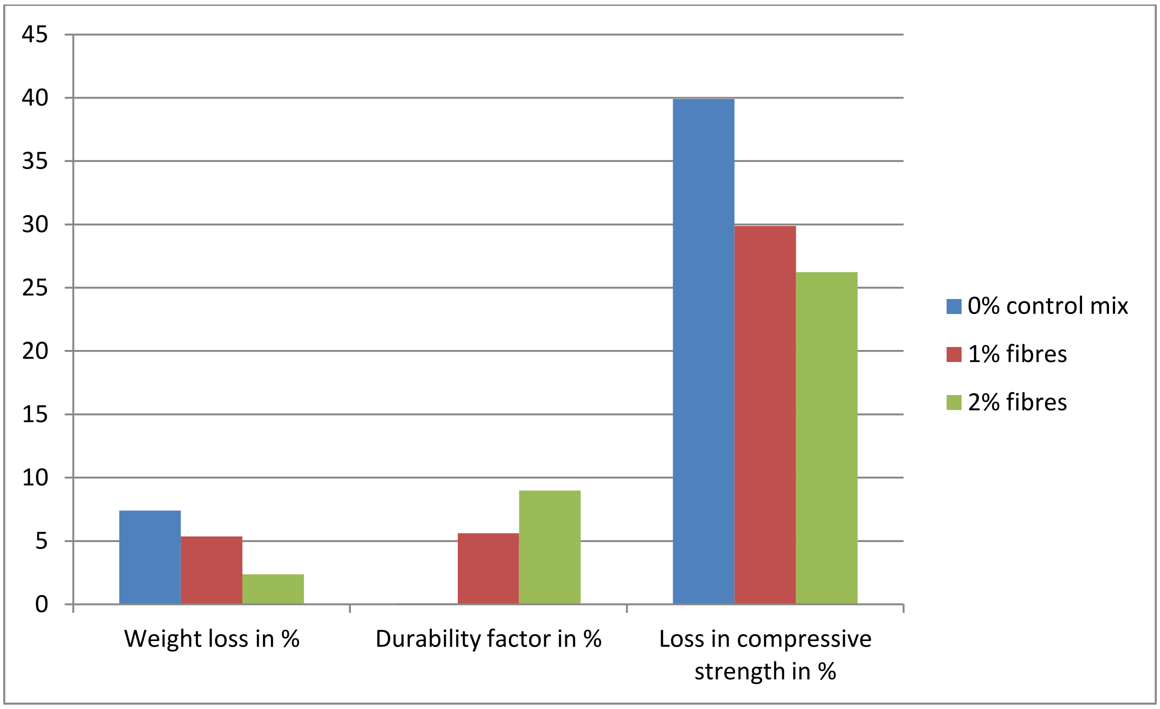
W_2 = Final weight of sample after taken out from (H_2SO_4) solution.

t = No of days of testing

n = Total no of days of testing (28 days)

Properties of mortars obtained from acid attack test for 5% H_2SO_4 solution after 28 days

Graph - Properties of mortars obtained from acid attack for 5% H_2SO_4 solution after 28 days



CONCLUSIONS

- Use of steel fibres exhibit great improvement in mechanical properties.
- The addition of steel fibres in the mortar, gave higher strength, both flexural and compressive, at all ages.
- The percentage difference in flexural strength by the addition of Steel fibres increases by 22.95 % for 1% mixing, 40.5 % for 2 % mixing.
- The percentage difference in compressive strength by the addition of Steel fibres increases by 17.15 % for 1% mixing, 38.67 % for 2 % mixing.
- The percentage difference in split tensile strength by the addition of Steel fibres increases by 31.59 % for 1% mixing, 33.16 % for 2 % mixing.
- Steel fibres reduce the permeability and water migration in cement mortar, which ensures protection of concrete due to the ill effects of moisture.
- Porosity of the mix decreases by 47.5% when 1% fibres are used and 62.5% when 2% fibres are used.
- The percentage difference in weight loss for Acid attack by immersing in 5 % H_2SO_4 solution by the addition steel fibres decreases by 27.7% for 1 % mixing , 64.45 % for 2 % mixing.
- The percentage difference in loss of compressive strength for Acid attack by immersing in 5 % H_2SO_4 solution by the addition steel fibres decreases by 27.62% for 1 % mixing , 34.26 % for 2 % mixing.

REFERENCES

- M. Ramli, E. Shannon Dawood, High-strength flowable mortar reinforced by steel fibre, Slovak Journal of Civil Engineering,Vol. XIX, 2011, no. 3, 10 – 16.
- DragicaJevtić, DimitrijeZakić, AleksandarSavić, Modeling of Properties of Fibre Reinforced Cement Composites , Architecture and Civil Engineering Vol. 6, No 2, 2008, pp. 165 – 172.
- AmitRana, Some Studies on Steel Fibre Reinforced Concrete, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 1, January 2013
- Nguyen Van CHANH, Steel Fibre Reinforced Concrete
- TugceSevil, Mehmet Baran, TurhanBilir, ErdemCanbay, Use of steel fibre reinforced mortar for seismic strengthening.
- AL-RABIAH.A.R., et.al studies on Durability Requirements for Reinforced concrete construction in aggressive marine environments.
- CHIH-TA TSAI, LUNG-SHENG LI, CHIEN-CHIH CHANG and CHAO-LUNG HWANG, Durability design and application of steel fibre reinforced concrete in Taiwan.
- IS 4031- 1968 Methods of physical tests for hydraulic cement.
- M.S.Shetty, Concrete Technology, Theory and Practice
- Neville A.M., "Properties of concrete", Final Edition
- ASTM C128-15, Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate, ASTM International, West Conshohocken, PA, 2015, www.astm.org
- ASTM C136 / C136M-14, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates, ASTM International, West Conshohocken, PA, 2014, www.astm.org
- IS 2386 Part-I 1963 Indian standard methods of test for aggregates for concrete: Part-III specific gravity, density, voids, absorption and bulking, Bureau of Indian Standards, New Delhi.
- IS 383 (1970). Specification for coarse and fine aggregates from natural sources for concrete. Bureau of Indian Standards, New Delhi.
- IS 456 (2000). Plain and reinforced concrete code for practice. Bureau of Indian Standards, New Delhi.
- IS 516 (1991). Methods of tests for strength of concrete [CED 2: Cement and Concrete]. Bureau of Indian Standards, New Delhi.
- ASTM C 365 & C39 / C39M-15a, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, ASTM International, West Conshohocken, PA, 2015, www.astm.org
- BS EN 13892-2:2002 Methods of test for screed materials. Determination of flexural and compressive strength
- IS 5816 (1999). Method of Test Splitting Tensile Strength of Concrete [CED 2: Cement and Concrete]. Bureau of Indian Standards, New Delhi.
- ASTM C496 / C496M-11, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens, ASTM International, West Conshohocken, PA, 2004, www.astm.org
- ASTM C78 / C78M-15, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading), ASTM International, West Conshohocken, PA, 2015, www.astm.org
- ASTM C469 / C469M-14, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression, ASTM International, West Conshohocken, PA, 2014, www.astm.org