EXPERIMENTAL STUDY ON M20, M25 & M30 GRADE CONCRETE WITH VARIABLE PERCENTAGES OF STEEL FIBERS & SILICA FUME

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Abstract- ***Concrete is relatively brittle, and its tensile strength is typically only about one tenths of its compressive strength. Regular concrete is normally reinforced with steel reinforcing bars. For many applications, it is becoming increasingly popular to reinforce the concrete with small, randomly distributed fibers. Their main purpose is to increase the energy absorption capacity and toughness of the material, but also increase tensile and flexural strength of concrete. This study presents experimentally the combined effect of using Silica Fume and steel fibers (SF) on mechanical properties of hardened concrete. Silica Fume is used as addition by 1% to 10%, and Steel Fibers is used as volume substitution by 1%, 2%, 3%, 4% & 5%. Compressive strength, flexural strength and Workability tests are evaluated using different combinations between Silica Fume and Steel Fibers. This project involves various tests with different proportions of Silica Fume and Steel Fibers compared with three grades of concrete M20, M25 and M30. Significant improvement in the mechanical properties of concrete is observed on using Silica Fume due to its high pozzolanic activity confirming the formation of higher amount of C–S–H gel in the presence of Nano particles. Optimum content of Silica Fume is expected between 2% to 4 % which improves flexure for samples with 3% Steel Fibers, compared to samples without either Silica Fume or Steel Fibers.***

Keywords— Silica Fume; Steel Fibers; Compressive Strength; Flexural Strength; Workability Test.

INTRODUCTION

Fiber-reinforced concrete: (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. Within these different fibers that character of fiber-reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities.

Effect of fibers in concrete: Fibers are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Generally fibers do not increase the flexural strength of concrete, and so cannot replace moment resisting or structural reinforcement. Indeed, some fibers actually reduce the strength of concrete.

In FRC, thousands of small fibers are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. Fibers help to improve the post peak ductility performance, pre-crack tensile strength, fatigue strength, impact strength and eliminate temperature and shrinkage cracks. Several different types of fibers, both manmade and natural, have been incorporated into concrete. Use of natural fibers in concrete precedes the advent of conventional reinforced concrete in historical context. However, the technical aspects of FRC systems remained essentially undeveloped. Since the advent of fiber reinforcing of concrete in the 1940's, a great deal of testing has been conducted on the various fibrous materials to determine the actual characteristics and advantages for each product.

OBJECTIVES AND SCOPE OF THESTUDY

In the recent times, seismic effects have become a major governing factor in analysis, design and construction in India. This is mainly due to the occurrence of medium to severe earthquakes in regions which were not prone to earthquake earlier. Bhuj in the western India and many cities in South India had experienced earthquakes after 1990 and earlier these parts were considered as non-seismic zone.

Due to this unexpected attack, losses in lives, property and infrastructural resources are on the rise particularly in residential areas with majority of non-engineered systems. So, besides improving codal provisions and construction practices, it is necessary to adapt local materials in construction with down-to-earth technology. So far the work on composites is confined to application of aircraft & automobile industries with very little work being imparted in civil infra-structural activities. The application of composites in civil infrastructural activities mostly concentrated on the mechanical strength on composites and not on its usage in structural system.

On the other hand solid waste disposal has become one of the major problems in modern cities. At present there are two major methods in practice to dispose wastes. One is land filling and the other is burning. First one requires more valuable land and second one pollutes the environment. So, alternate methods to dispose solid waste should be found. By considering these requirements, here an attempt is made to study the possibilities of reusing the coir fiber materials as fiber composites in concrete which not only tries to solve the ductility problem but also the problem of waste disposal atleast to a small extent.

Hence the focus of the study is to characterize the mechanical, structural and micro structural properties of local and waste materials as composites in terms of flexibility, ductility & energy absorption to improve seismic resistance. Since the materials chosen in this research work are locally available materials, a detailed characterization through various testing and analytical methods are essential. Linear regression analyses have been carried out for mechanical strength properties and equations are proposed.

The current approach to the design of earthquake resistant structures is based on damage prevention during low magnitude earthquakes allowing some damage during moderate and intermediate tremors and on prevention of collapse during severe earthquakes numerical damage index has to be defined to facilitate the quantification of damage in analysis and design of engineering systems.

Damage indices are potentially valuable design tools, since they provide a means by which different design or retrofit options can be compared objectively. So here damage index based on ductility and energy absorption are also evaluated according to the previous proposed equations.

LITERATURE REVIEW

Balaguru and Ramakrishnan (1988) concluded that initial and final setting times of plain and fibre reinforced concretes were the same. Fibre concrete had lower slump & air- content and the rate of loss of these parameters with time was also higher. It was also observed that shrinkage of fibre concrete was slightly less but it underwent slightly more creep deformations. In the area of air void characteristics, the specific surface of air bubbles was lower for Fibre reinforced concrete.

Horiguchi, Saeki and Fujita (1988) concluded that the pullout strength increases with increase in the volume fraction of steel fibres. The maximum pull-out strength with 2.5 percent fibre reinforcement was found to be 1.6 times that of the unreinforced concrete. The magnitude of pullout 18 reductions. The silica fume does not appear to enhance corrosion.This finding is relevant in the manufacture of fibres for marine applications.

Bentur (1989) reported that the use of alkali resistant glass fibres with silica fume was effective in improving durability performance of alkali resistant glass fibre reinforced cement composites (GFRC). Findings regarding silica fume replacement in the matrix and durability performance were also discussed. It was suggested that fibre usage eliminates the aging induced by microstructural effects, while the matrix modification reduces the influence of chemical attack.

Darmawanludirdja et al (1989) developed a simple test to estimate the water permeability of concrete using gravity as the pressure head through a 12.5mm x 10mm disk at atmospheric pressure. It was suggested that the same apparatus could also be adapted for measuring ion diffusion

Ezeldin and Balaguru (1989) reported the experimental results on the bond behaviour of normal and high-strength concretes made with and without fibres. The bond tests were conducted using a modified pull out test in which the concrete surrounding the bar was in uniform tension. Addition of silica fume results in higher bond strength but causes brittle bond failure. The slip (relative movement between the bar and the concrete) at maximum bond load increases with increase in fibre content.

Nanni and Johari (1989) conducted an experiment for pavement construction using steel fibre reinforced concrete (SFRC). The concrete matrix contained fly ash, either Class F (used as a filler) or Class C (used as a binder). He had presented compression and split tension results of laboratory cylinders and field cores reinforced with different types of steel fibre in various percentages. It was found that post-cracking characteristics were greatly enhanced by fibres beyond ultimate strength and also concluded that 19 toughness indexes can be obtained from stress-strain curves in split tension test.

EXPERIMENTAL INVESTIGATIONS

Behavior of concrete, particularly this type of concrete depends on many parameters like materials used, sequence of mixing the materials, mixing procedure, dosage of steel fiber etc., Apart from the mix design modifications required for such concrete. It is essential to have a reliable data base, so that the field engineers or researchers can work towards the further developments. It has already been said that most of the steel fiber concrete have no information with regard to either the behavior of steel in concrete. The main objective of the present investigation is, thus to obtain specific experimental data, which helps to understand the concrete behavior in the presence of steel fiber.

The present investigations carried out are mainly directed towards obtaining specific information regarding the concrete durability, serviceability with natural fiber apart from their behavior in hardened states. The natural fibers considered are Steel fibers. Workability being the minimum requirement for any good concreting practice, this can be achive with the help of Aspect ratio and percentage of fiber content for this present investigation.

SILICA FUME: Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. Nano silica which is a type of silica fume is used. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolona. Concrete containing silica fume can have very high strength and can be very durable

Fig 1. Silica Fumes

STEEL FIBER: Steel fiber reinforced shotcrete (SFRS) is shotcrete (spray concrete) with steel fibers added. It has higher tensile strength than unreinforced shotcrete and is quicker to apply than weld mesh reinforcement. It has often been used for tunnels.

Fig 2. Steel Fibers

COMPRESSIVE STRENGTH TEST: The compressive strength is calculated by the value of compressive stress that is touched when the material fails completely. The compressive test is conducted for the knowing the compressive strength. The mould dimensions of150mmx100mmx100mmaretakenfor the calculation of compressive strength of the given mould.

Compressive strength = load/area

For each set 2 standard cubes were cast to determine 7-days, and 28 days compressive strength after curing. Also two cubes were casted to know the compressive strength of concrete.

FLEXURAL STRENGTH TEST: It is the ability of a beam or slab to bear the bending. Ordinarily the strength is 12 to 20% of compressive strength. It is valuable for field control and acknowledgment for pavement. However at this point multi day's it isn't utilized to decide field control, just compressive quality is anything but difficult to pass judgment on the nature of cement.. To determine the flexural strength of concrete four numbers of prisms were casting. Then it was cured properly.

CONCRETE MIX DESIGN

MIX DESIGN PROCEDURE:

1. The strength of the cement as available in the country today has greatly improved since 1982. The 28-day strength of A, B, C, D, E, F. Category of cement is to be reviewed.

2. The graph connecting, different strength of cements and W/C is to be re-established. The graph connecting 28-day compressive strength of concrete and W/C ratio is to be extended up to 80Mpa, if this graph is to be cater for high strength concrete.

3. As per the revision of 456-2000, the degree of workability is expressed in terms of slump instead of compacting factor. This results in change of values in estimating approximate sand and water contents for normal concrete up to 35Mpa and high strength concrete above 35Mpa. The table giving adjustment of values in water content and sand % for other than standard conditions, requires appropriate changes and modifications.

4.in the view of the above and other changes made in the revision of IS456-2000, the mix design procedure as recommended in IS 10262-82 is required to be modified to the extent considered necessary and examples of mix design is worked out.

MIX DESIGN FOR STEEL FIBER REINFORCED CONCRETE

Weight of Cement = 400 gm,

Vol of water added = $\frac{0.85 * 32}{400*100}$ = 108.8 ml

Final setting time obtained = 280 minutes

Specific gravity of fine aggregates = 2.70

Compressive strength required at 28 days = 20 Mpa

Degree of quality control = Good

Consistency of cement = 32%

Initial setting time obtained = 90 minutes

Specific gravity of cement = 2.80

Specific gravity of coarse aggregates = 2.70

Maximum size of aggregates = 10 mm

Water absorption of Coarse aggregates = 4%

Water absorption of Fine aggregates = 12% Target mean strength of concrete f_{ck} = 24.96 N/mm^2

For M20 Grade Concrete, Mix Proportion is 1: 1.67: 3.17

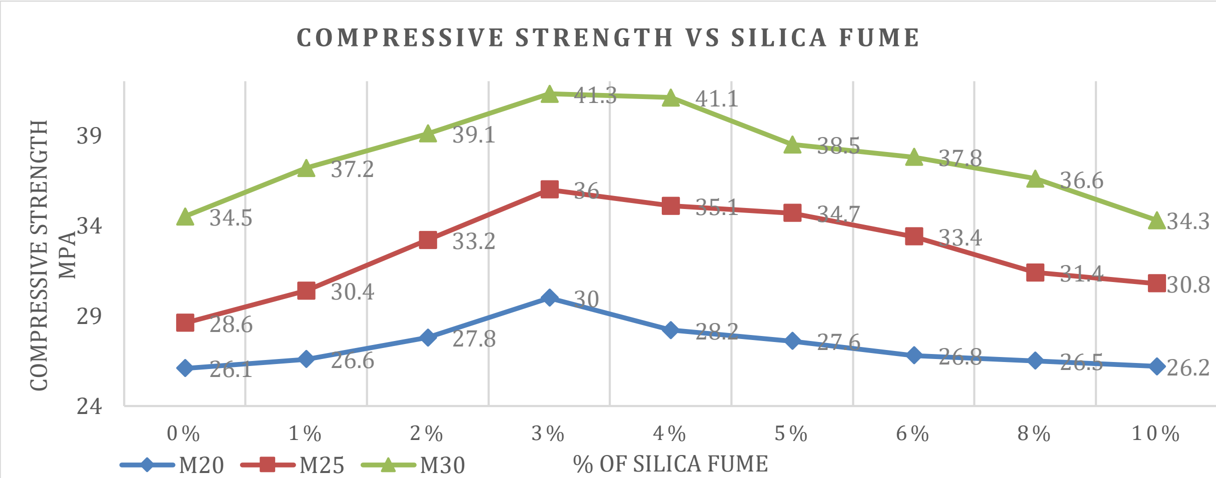
For M25 Grade Concrete, Mix Proportion is 1: 1.32: 2.24

For M30 Grade Concrete, Mix Proportion is 1: 0.83: 1.58

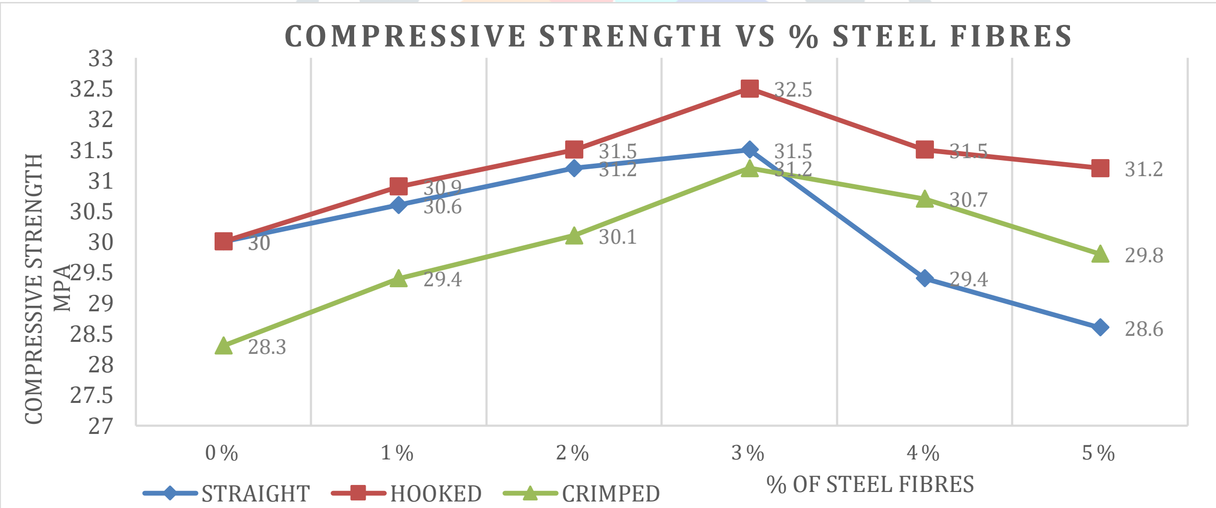
TEST RESULTS

COMPARISON OF COMPRESSIVE STRENGTH RESULTS

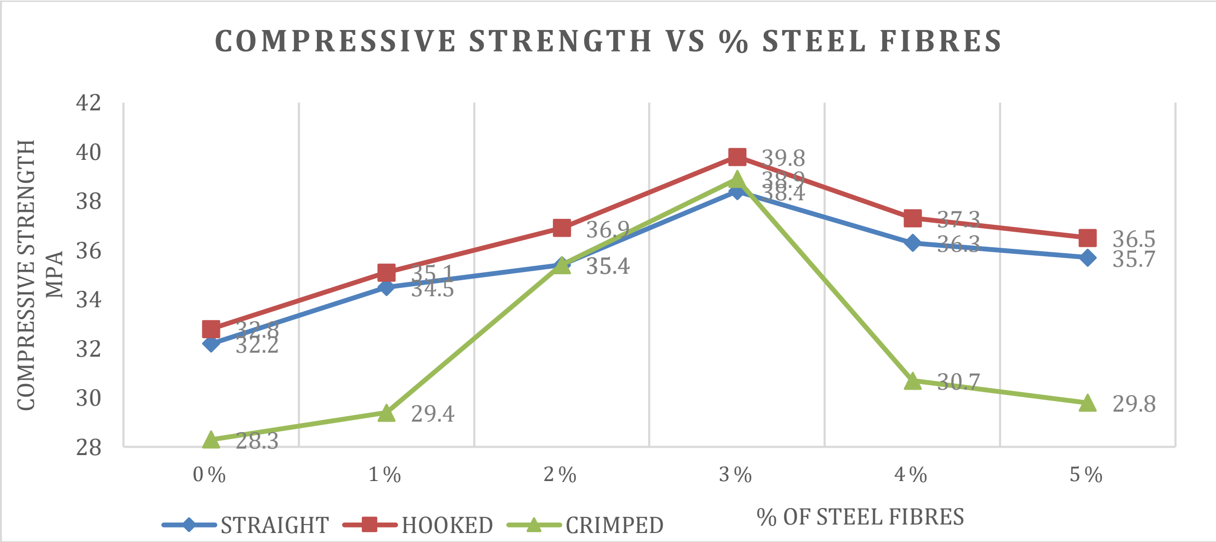
Graph 1: Showing Compressive Strength for different % of Silica Fume:



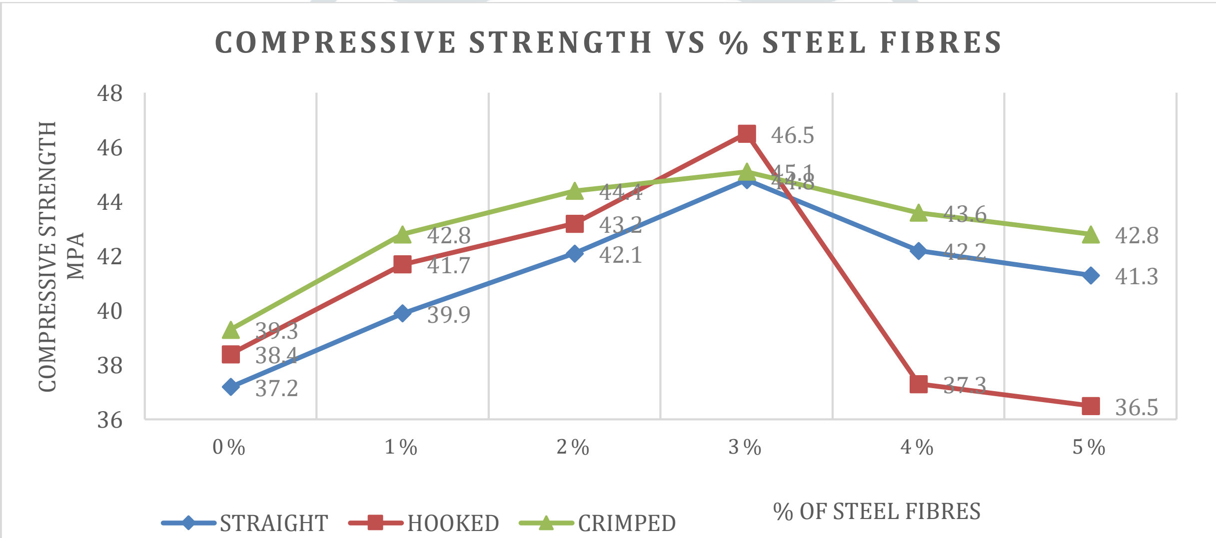
Graph 2: Showing compressive strength with different steel fibres for M 20 grade:



Graph 3: Showing compressive strength with different steel fibres for M 25 grade:

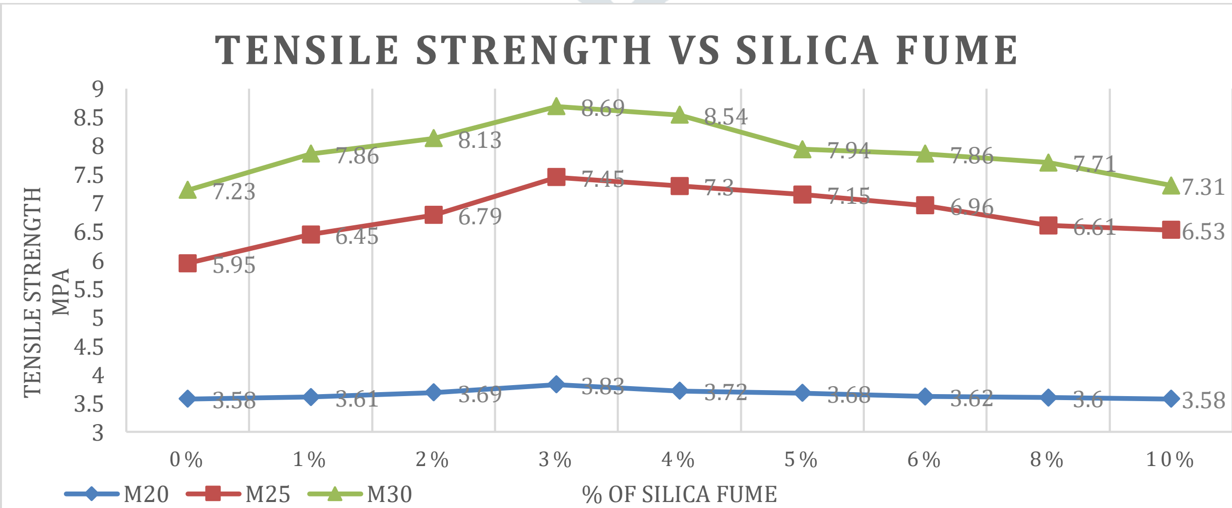


Graph 4: Showing compressive strength with different steel fibres for M 30 grade:

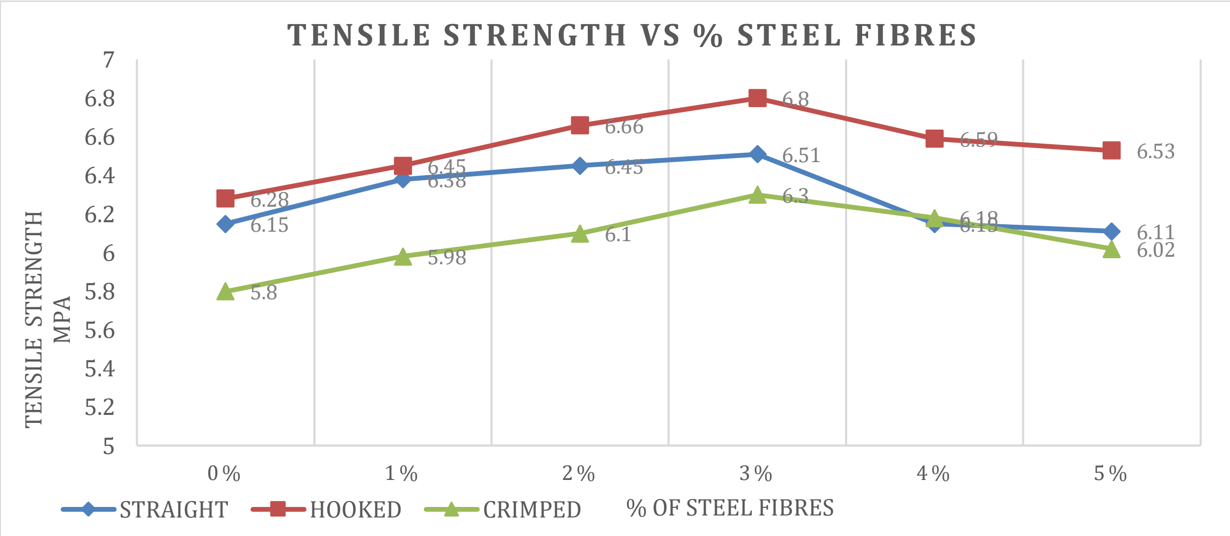


COMPARISON OF TENSILE STRENGTH RESULTS

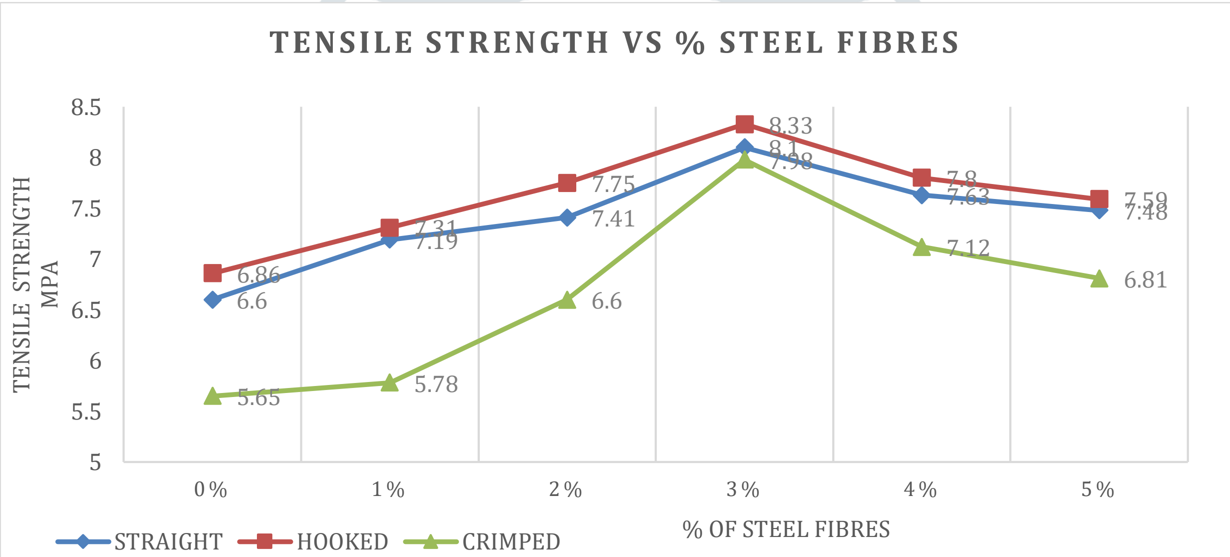
Graph 5: Showing Tensile Strength for different % of Silica Fume:



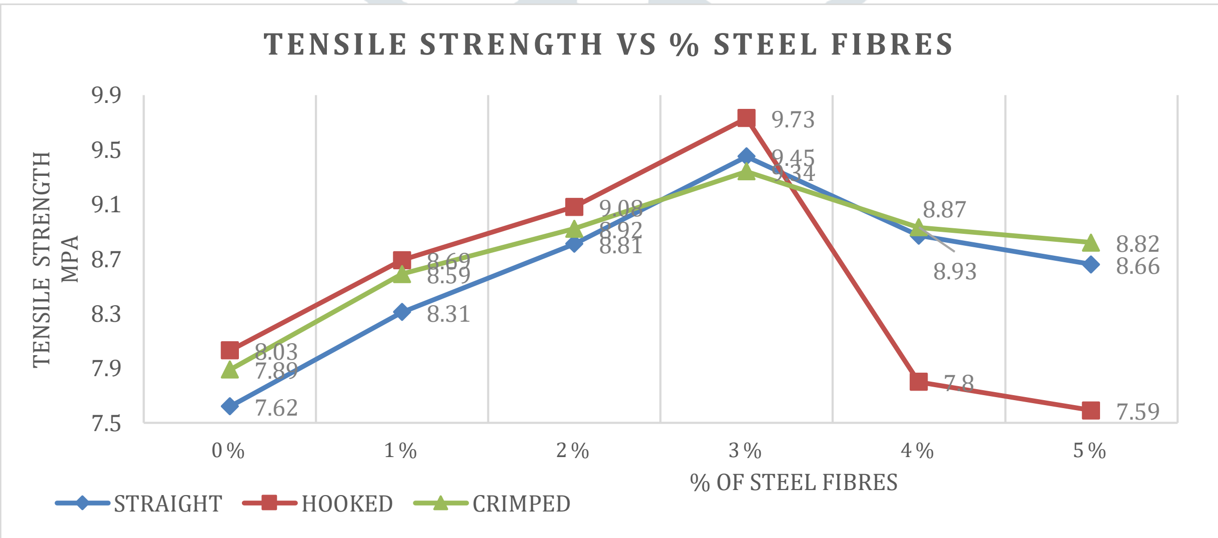
Graph 6: Showing Tensile Strength with different steel fibres for M 20 grade:



Graph 7: Showing Tensile Strength with different steel fibres for M 25 grade:

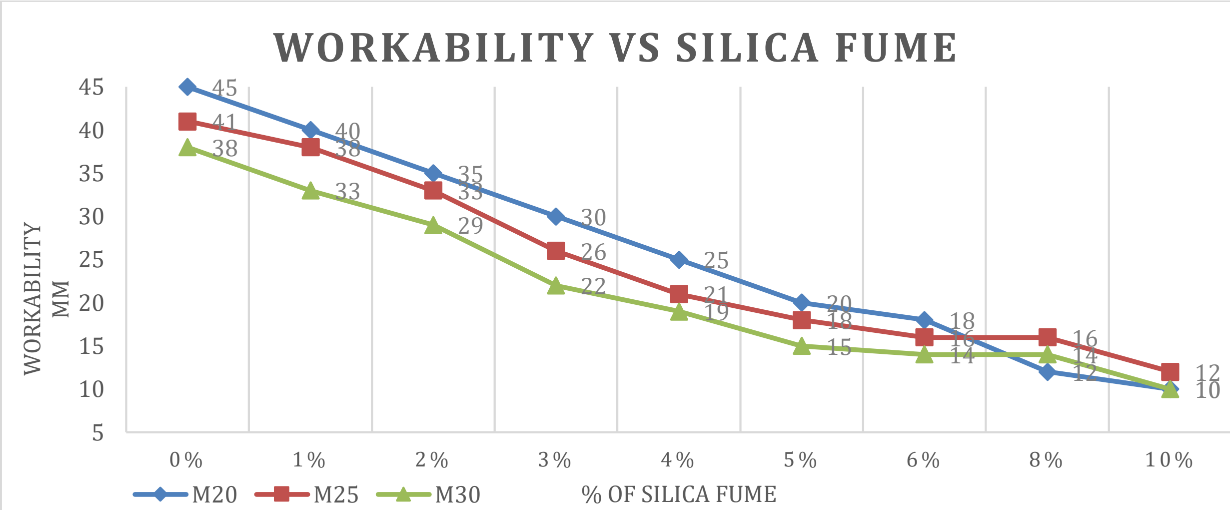


Graph 8: Showing Tensile Strength with different steel fibres for M 30 grade:

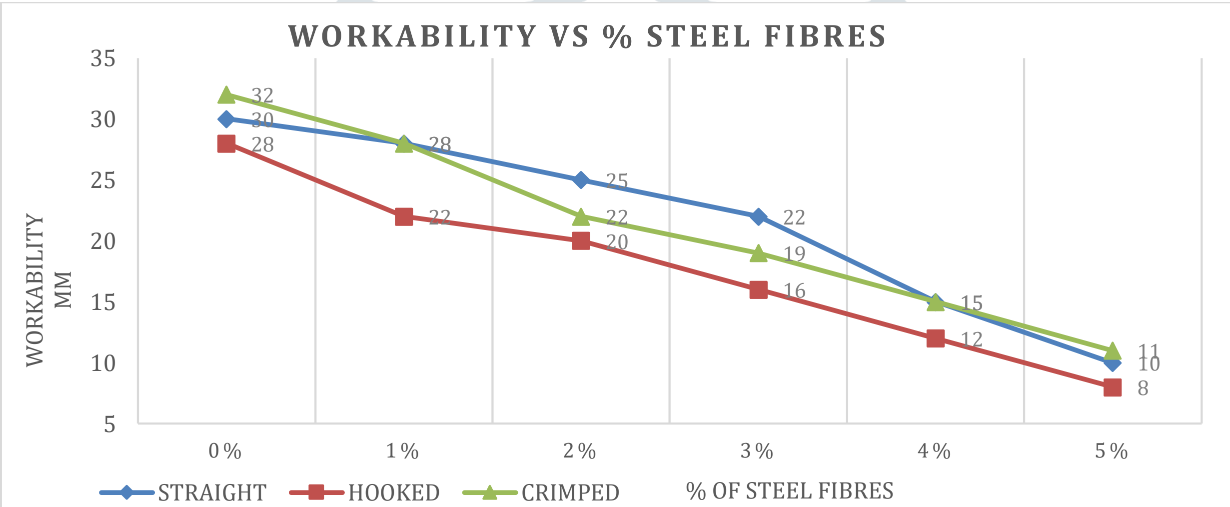


COMPARISON OF WORKABILITY TEST RESULTS

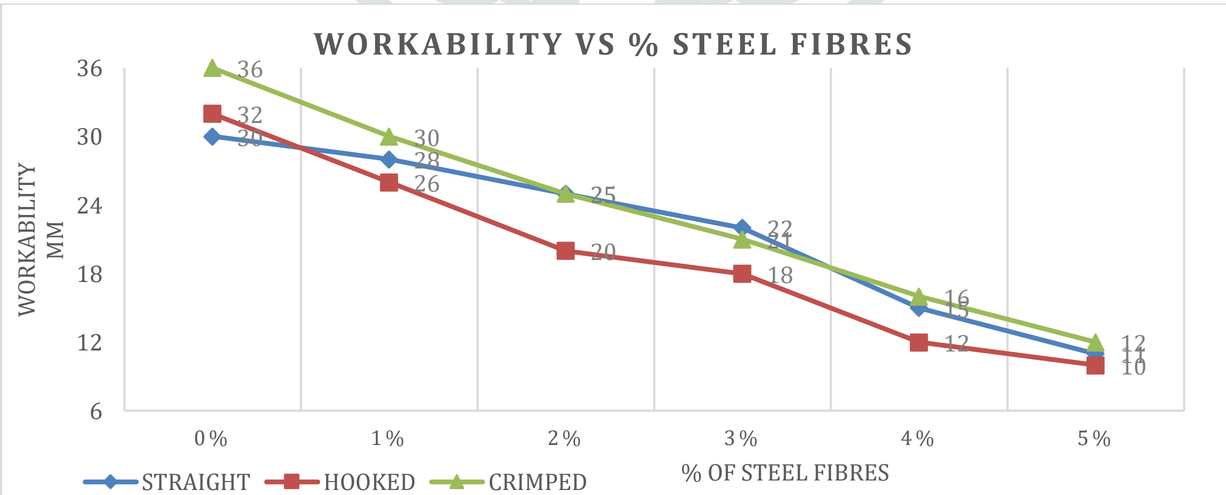
Graph 9: Showing Workability test with different % of Silica Fume:



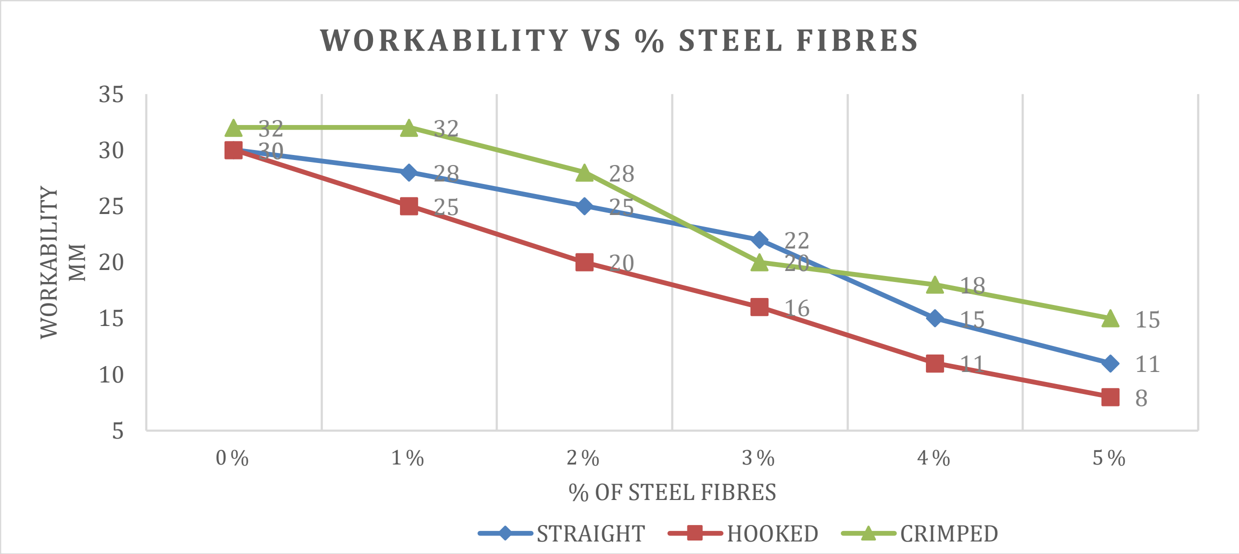
Graph 10: Showing Workability test with different steel fibres for M 20 grade:



Graph 11: Showing Workability test with different steel fibres for M 25 grade:



Graph 12: Showing Workability test with different steel fibres for M 30 grade:



ADVANTAGES AND DISADVANTAGES

1. Fiber reinforced concrete has started to find its place in many areas of civil infrastructure applications where the need for repairing, increased durability arises. Also FRCs are used in civil structures where corrosion can be avoided at the maximum.

2. Fiber reinforced concrete is better suited to minimize cavitation erosion damage in structures such as sluice-ways, navigational locks and bridge piers where high velocity flows are encountered.

3. A substantial weight saving can be realized using relatively thin FRC sections having the equivalent strength of thicker plain concrete sections. When used in bridges it helps to avoid catastrophic failures.

4. Also in the quake prone areas the use of fiber reinforced concrete would certainly minimize the human casualties. In addition, fibers reduce or relieve internal forces by blocking microscopic cracks from forming within the concrete (20).

5. The main disadvantage associated with the fiber reinforced concrete is fabrication. The process of incorporating fibers into the cement matrix is labor intensive and costlier than the production of the plain concrete. The real advantages gained by the use of FRC overrides this disadvantage.

CONCLUSIONS

1.The study on the introduction of effect of Steel fibers can be still promising as Steel fiber reinforced concrete is used for sustainable and long-lasting concrete structures. Lot of research work had been done on steel fiber reinforced concrete and lot of researchers work prominently over it. This review study tried to focus on the most significant effects of addition of steel fibers to the concrete mixes. The steel fibers are mostly used fiber for fiber reinforced concrete out of available Natural fibers in market. It is confirmed that the compressive and flexural strength of concrete can be significantly improved using external Steel fiber wraps. It is observed that bonding between concrete and Fiber is excellent and no sign of delaminating is noted.

2.Concrete is strong in compression but weak intension.

3.The tensile property of concrete can be improved by the addition of small volume of fibers.

4.Addition of fibers not only increases tensile strength but also increases bond strength, decreases permeability, also resists seismic loading as well through its ductility.

5.From the Workability test, it is observed that the optimum mix of Silica Fume is 3% in all the three Grades of concrete M20, M25 & M30.

Workability Test:

For M20 Concrete: - 30 mm
For M25 Concrete: - 26 mm
For M30 Concrete: - 22 mm

6.The test results for optimum mix Silica Fume after 28 Days are as follows:

Compressive Strength:

For M20 Concrete: - 32.5 Mpa
For M25 Concrete: - 39.8 Mpa

For M30 Concrete: - 46.5 Mpa

Tensile Strength:

For M20 Concrete: - 6.80 Mpa

For M25 Concrete: - 8.33 Mpa

For M30 Concrete: - 9.73 MPa

7. From the total project, it is examined that the Compressive Strength, Flexural Strength and Workability tests are obtaining the Maximum values for 3% Silica Fume with 3% Hooked Steel Fibers in comparison with Straight and Crimped Steel Fibers.

8. Toughness of concrete also increases.

9. Properties of fiber reinforced concrete are affected by type of fiber, fiber geometry, fiber volume, orientation and distribution of fibers.

10. Fiber reinforced concrete is widely used in air field, road pavements, industrial floorings, bridge decks, canal lining, explosive resistant structures, refractory linings, shotcrete etc.

11. According to many researchers, the addition of Steel fiber into concrete creates low workable or inadequate workability to the concrete, therefore to solve this problem of super plasticizer without affecting other properties of concrete may introduce. Steel fiber also had good mechanical properties and results as like artificial fibers.

REFERENCES

1. M.N Alias and R. Brown, FRC Composites 48 (1992)p373-378.

2. Daniel, J.I., Roller, J.J., and Anderson.E.D.,*Fiber reinforced Concrete*, Portland Cement Association, Chapter 5, pages22-26,1998.

3. Hannant, D.J., *Fiber cements and fiber concretes*, John Wiley and Sons, ltd., New York, 1978, 213pages.

4. Clive, M., Calafut, T., *hybiscus mortar-The definitive user's guide and data book*, Plastics design library, PDL Handbook Series,1998.

5. William, J.K.James, H.H.Jefferey, A.M."STEEL FIBER: Structure, Properties, Manufacturing Processes and Applications" pp 15-33 in *Handbook of steel fiber and steel fiber Composites*, Edited by Harshen G. Karian, Mercel Dekker Inc, New York,1999.

6. Frank, H.P., *Steel fiber*, Gordon and Breach Science Publishers, 1968.

7. Thoedore, O.J. K., *Steel fiber*, Reinhold Publishing Corporation, NewYork,1960.

8. Ahmed, M., *Steel fibers - Science and Technology*, Society of Plastics Engineers, Inc, New York,1982.

9. Balaguru P., Slattum K., "Test methods for Durability of Steelfiber in Concrete and UV Light Exposure", pp 115-136 in *Testing of Fiber Reinforced Concrete* Edited by Stevens D.J., ACI SP-155, American Concrete Institute,Detroit,1995.

10. Fiber reinforced concrete by Professor Kamran M. Nemati Spring Quarter2012

11.A.P.Singh, S.P.Singh, C.D.ModheraS.Bhalla, B.Bhattacharjee, D.Shah, S.Bhalla, "Enhancing structural performance utilizing fibers", *Proceedings of the international UKIERI concrete congress new delhiindia 8-10 march 2011 page no.153-176*

12.Dr.G.Mohankumar,L.BangaruChandran, "Structural behavior of hybrid fiber reinforced concrete beams", *The Indian concrete journal published bynACC Limited vol.83 october 2009 no.10.pageno.14-20*

13.Dr.J.Premalatha, Dr.R.Sundararajan, "Effect of steel fibers and longitudinal reinforcement in effective moment of inertia of reinforced high strength fibrous concrete beams", *The Indian concrete journal published bynACC Limited vol.83 october 2009 no.10.pageno.7-13*

14 .Dr.Lalumangal.Arun Edwin, Dr. S.Suresh, "Studies on fiber reinforced prepacked concrete"