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A Review Study: Utilization Of Steel Fibres In Concrete Reinforcement

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Abstract: Concrete is extensively used material in construction industry because of good workability and ability to be moulded into any shape and size. Steel fibres are generally used as resistance of cracking and strengthening of concrete. This paper deals with comprehensive and detailed study on the behavior of the concrete mixed with steel fiber in place of the traditional reinforcements. In the recent times steel and poly fiber has emerged as the member playing key role in the modern-day concrete in place of the conventional concrete. Steel/ polyfiber is playing a vital role in tunnels (shotcretes, lining), Structure (concrete girder, crash barrier, beams, columns and slab as a replacement to the of concrete to the traditionally used reinforcement

Index Terms - Steel fibre reinforced concrete, Compressive Strength, Crack resisting, flexural strength.

I. INTRODUCTION

Concrete is one of the most consumed man-made construction material. It is a mixture of cement, sand, aggregates, water and also different types of admixtures in a particular ratio. The fresh concrete has a property of plasticity before casting but it transforms first from liquid state to plastic state and later into solid state like a rock, due to chemical reactions between cement and water with the advancement of time.

The durability of the concrete structures is used to be based on ordinary Portland cement, round steel bars of mild steel. With time these materials are replaced by Pozzolana cement and TMT bars respectively Moreover, concrete is no more considered as a simple compound of materials consisting of cement, aggregate, water rather assumed to be an engineered material which can exhibit properties such as high fluidity, self-compactable, high strength, high durability, better serviceability and long service life. However, the two properties still have limited its use are; its brittleness and weak tension.

The principle motive behind incorporating fibres into a cement matrix is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite. FRC composite properties, such as crack resistance, reinforcement and increase in toughness are dependent on the mechanical properties of the fibre, bonding properties of the fibre and matrix, as well as the quantity and distribution within the matrix of the fibres.

Fibre reinforced concrete is a relatively new construction material developed through extensive research and development work during the last two decades. The last two decades have witnessed an extensive utilization of fibrous substances: steel fibre, polypropylene fibre, plastic fibre, glass fibre, agricultural waste fibre, waste tyre rubber fibre in preparing different types of concrete such as lightweight concrete, foam concrete, high-performance concrete, temperature resistant concrete, corrosion-resistant concrete. Due to the property that fibre enhances toughness of concrete, FRC is used on large scale for structural purposes.

The fibre is described by a convenient parameter called aspect ratio. The aspect ratio of the fibre is the ratio of its length to its diameter. For FRC to be a valuable construction material, it must be able to compete economically with existing reinforcing system. It has been proved as a reliable construction material having superior performance characteristics compared to the conventional concrete. Incorporation of fibres in concrete has been found to improve several of its properties cracking resistance, ductility and fatigue resistance, impact and wear resistance.

TYPES OF FIBRE REINFORCED CONCRETE (FRC)

They are classified as;

a) Steel fibre reinforced concrete
b) Glass fibre reinforced concrete
c) Polymer fibre reinforced concrete
d) Natural fibre reinforced concrete
e) Synthetic fibre reinforced concrete

This study aims to envisage the use of Steel fibre reinforcement in cement concrete, which consists of various percentages of Steel fibre. Control mix, used as a reference while other samples contain different ratios of Steel fibre in cement concrete. Decision analysis reveals that the characteristics of Steel fibre used are improve the Compressive strength as well as the flexural strength of the concert. Steel fibres are those consisting of cement concrete mix and steel as fibres. This mix, have large number of volume fractions, geometries, orientations and material properties. Steel fibre increases properties like ductility, energy absorption, shear resistance and stiffness. The steel fibres can be straight, crimped, twisted, hooked, ringed and paddled end. Diameter vary from 0.5 to 1 mm as an substitution to TMT bars.

II. LITERATURE REVIEW

To purpose and defend the research work, a number of research papers are analyzed. Following are the excerpts from the different research work performed by number of academicians and researchers.

MILIND V MOHOD (2012) ET AL in this experimental investigation for M30 grade of concrete to study the compressive strength and tensile strength of steel fibres reinforced concrete containing fibres varied by 0.25%, 0.50%, 0.75%, 1%, 1.5% and 2% by volume of cement cubes of size 150mmX150mmX150mm to check the compressive strength and beams of size 500mmX100mmX100mm for checking flexural strength were casted. All the specimens were cured for the period oF 3, 7 and 28 days before crushing the result of fibres reinforced concrete 3 days, 7 days, and 28 days curing with varied percentage of fibre were studied and it has been found that there is significant strength improvement in Steel fibre reinforced concrete. The optimum fibre content while studying the compressive strength of cube is found to be 10% and 0.75% for flexural strength of the beam. Also, it has been observed that with the increase in fibre content up to the optimum value increase the strength of concrete.

VIKRANT VAIRAGADE ET AL (2012) presented the applicability of previously published relation among compressive strength tensile strength flexural strength of normal concrete to steel fibres reinforced concrete was evaluated and mechanical properties of steel reinforced concrete were analyzed in this experimental study cement sand coarse aggregate water and steel fibres were used for compressive strength test both cube specimens of dimensions 150mm × 150mm × 150mm and cylindrical specimen of length 200mm and diameter 100mm were cast for M20 grade filled with 0% and 0.5% fibres after 24 hours the specimens were to curing tank wherein they were allowed cure for 7 days and 28 days. Finally result of compressive strength for M20 grade of concrete on cube and cylinder specimens with 0% and 0.5% steel fibres for aspect ratio 50 and 53.85 is it observed that for addition of 0.5% fibres shows slightly more compressive strength than normal concert.

AISWARYA SUKUMAR, ELSON JOHN ET AL (2014) in this study it was observed that the physical properties of the concrete after adding the different volume fractions of fibres are used in the concrete. In the mix design is carried out as per 10262:2009 the proportioning is carried out to achieve strength at specified age, workability of fresh and durability requirements. The materials selected for this experimental study includes normal natural coarse aggregate, manufactured sand as fine aggregate, cement, Superplasticizer both end hooked steel fibres and portable drinking water. The physical and chemical properties of each ingredient has considerable role in the desirable properties of concrete like strength and workability finally the test result of compressive strength split tensile strength and flexural strength it can be seen that in the presence of Steel fibre there is an increase in compressive strength split tensile strength and flexural strength the small in fibre specimen compared to the non- fibres specimens.

ER. GULZAR AHMAD, ER KSHIPRA KAPOOR (2016) ET AL this research carried out test on Steel fibre reinforced concrete to check the influence of fibres on strength of concrete. According to various research papers, it has been found that steel fibres give the maximum strength in comparison to glass and polypropylene fibres. Now a days there exists many reinforcement techniques for improving the strength of those materials which lacks load carrying and less durable capacity. Use of Steel fibre to enhance the strength and reduce maintenance is an effective technology established in recent times. fibre reinforced concrete has been successfully used in slabs on grade, shotcrete, architectural panels, precast products, offshore structures, structures in seismic regions, thin and thick repairs, crash barriers, footings, hydraulic structures and many other applications. The usefulness of fibre reinforced concrete in various Civil Engineering applications is thus indisputable. This review study is a trial of giving some highlights for inclusion of steel fibres especially in terms of using them with new types of concrete.

ABDUL GHAFFAR (2014) ET AL this research is based on the investigation of the use of steel fibres in structural concrete to enhance the mechanical properties of concrete. The objective of the study was to determine and compare the differences in properties of concrete containing without fibres and concrete with fibres. This investigation was carried out using several tests, compressive test and flexural test. A total of eleven mix batches of concrete containing 0% to 5% with an interval of 0.5% by wt. of cement. „Hooked" steel fibres were tested to determine the enhancement of mechanical properties of concrete. The workability of concrete significantly reduced as the fibre dosage rate increases.

AWADHESH CHANDRAMAULI, AMIT BAHUGUNA (2018) ET AL In this study different type of fibres are used for different purpose. One type of fibre is stronger and stiffer while the second type of fibre is flexible and leads to increase toughness and energy absorption capacity of the concrete matrix. One type of fibre is smaller, and it improvies the bridges of micro-cracks, and this leads to a higher the tensile strength of the concrete. The second fibre is larger and it decreases the propagation of macro-cracks in concrete and therefore improves the toughness of concrete member. The result shows that FRC has maximum strength at 1.5% as compare to 2.25%with little effect on compressive strength but increase tensile strength of concrete matrix (Hamrawy 2007).

MAJID JARAL, ER. SUHAIB (2018) ET AL Compressive strength and split tensile strength were slightly increased due to the increased percentage of fibre content. The Experimental work also showed that the workability of SFRC gets reduced as we increased the fibre amount. Flexural strength was also increased by the addition of steel fibres. As percentage of fibre increases flexural strength also increases in both the position that is at randomly reinforced fibre concrete and fibres reinforced at 1/3rd depth from top of the surface. SFRC is a sustainable improvement inside the present technology. The studies additionally establish that the residences of hardened SFRC, consisting of flexural electricity, are remarkably higher than those of conventional RCC. Thus, the use of metal fibre for powerful pavement construction can be cautioned undoubtedly. Addition of metallic fibres reduces the workability of concrete; hence it becomes important to utilize top notch plasticizers. And those SFRC is used for foremost, high budget tasks only because Steel fibres are value effective.

VASUDEV R, DR. B G VISHNURAM (2013) ET AL this paper aims to have a comparative study between ordinary reinforced concrete and Steel fibre reinforced concrete. The fibres which were used in the study were the turn fibres. They were the scraps from the lathe shops. Experimental investigations and analysis of results were conducted to study the compressive & tensile behavior of composite concrete with varying percentage of such fibres added to it. The concrete mix adopted were M20 and M30with varying percentage officers ranging from 0, 0.25, 0.5, 0.75 & 1%. On the analysis of test results the concrete with turn steel fibres had improved performances compared to the concrete with conventional steel fibres which were readily available in market. These sustainable improvements or modifications could be easily adopted by the common man in their regular construction.

A.M. SHENDE (2012) ET AL Critical investigation for M-40 grade of concrete having mix proportion 1:1.43:3.04 with water cement ratio 0.35 to study the compressive strength, flexural strength, split tensile strength of Steel fibre reinforced concrete (SFRC) containing fibres of 0%, 1%, 2% and 3% volume fraction of hook taint. Steel fibres of 50, 60 and 67 aspect ratios were used. A result data obtained has been analyzed and compared with a control specimen (0% fibre). A relationship between aspect ratio vs. Compressive strength, aspect ratio vs. flexural strength, aspect ratio vs. Split tensile strength represented graphically. Result data clearly shows percentage increase in 28 days Compressive strength, Flexural strength and Split Tensile strength for M-40 Grade of Concrete.

GHUGAL Y.M. (2003) 'Studied Effects of Steel fibres on Various Strengths of Concrete'. They have presented the results of the experimental investigation of various strengths of Steel fibre reinforced concrete (SFRC). Variables considered in the research work are various strengths and fibre volume fractions. Various strengths considered for investigation are compressive strength, flexural strength, split tensile strength, bond strength and shear strength. Concrete mix of M25 grade and crimped steel fibres with aspect ratio 50 are used. The fibre volume fraction is varied from 0.5% to 4.5 % at an interval of 0.5% by weight of cement. Standard test specimens for compressive strengths, split tensile strength, flexural strength and push-off

specimens for shear strength were cast and water cured for 7 and 28 days. All the test specimens were tested according to relevant Indian Standards and standard test procedures available in the literature wherever applicable. All the strengths are found to be increasing continuously with increase in fibre volume fraction. The experimental results obtained for various strengths are modeled in terms of the material properties of matrix, fibre and compressive strength. The mathematical expressions developed for various strengths are presented. The inclusion of Steel fibre in to the normal concrete showed the excellent strength performance in this investigation compared to the normal concrete. The results predicted by mathematically modeled expressions are in excellent agreement with experimental results.

GANESHAN N ET AL (2007) in their entitled 'Steel fibre reinforced high performance concrete for seismic resistant structure' have attempted to carry out large scale investigations on SERHPC structural elements like columns, beams and beam column joints. In this paper they have presented consolidated details of the investigations. They have used crimped steel fibres in FRC. Also they have considered 10% replacement of cement by silica fume and 20% by fly ash. Regarding compressive behavior the authors have given following findings. SFRHPC can be obtained using conventional constituents of concrete and fibres, with due care in the selection of ingredients and proportioning of the mix. An increase in the volumetric ratio of transverse reinforcement increases the ultimate strength of HPC and SFRHPC. However, the percentage of increase is higher for SFRHPC specimens than for HPC. As the confinement increases strain at peak load increases. Addition of steel fibres improved this peak strain further. The addition of short discrete randomly oriented steel fibres improves the dimensional stability of the structure to a great extent. This investigation indicates that the combined effect of confinement in the form of square/rectangular/circular hoops and randomly oriented steel fibres enhances the strength and ductility of compression members such as columns to a great extent and this is the major requirement for a seismic resistant structure.

ELAVARASI.D ET AL studied the Structural behavior of High Strength Steel fibre Reinforced Concrete (HS-SFRC) block pavement. In this study an experimental program was carried out to investigate the structural behavior of High strength Steel fibre reinforced (HS-SFRC) block pavements. High strength plain cement concrete blocks (HSC) were also casted for comparison purpose. Three different fibre contents (0.5%, 0.75% & 1.0% by volume fraction) were considered. The results obtained have shown that the addition of the steel fibres has increased the compressive strength, flexural strength, tensile strength and abrasion resistance and the deflection of beam and pavement block was decreased at the age of 28 days. It is observed that strength properties of HS-SFRC 1.0% are high compared to 0.5% & 0.75% of fibre content. It is clearly shown that the increase in strength is due to the increase in fibre content. The test results were compared with High strength concrete (HSC – control mix).

S.S. KADAM ET AL studied the Effect of different aspect ratio of Steel fibre on mechanical properties of high strength concrete. In this study, the effects of different aspect ratio (65 and 80) of Steel fibre on mechanical properties of high strength concrete are addressed. Mechanical properties of high strength

concrete investigated by varying positions of Steel fibre in concrete cubes and beams. Percentage of Steel fibre by volume was 0.5%, 1.0% and 1.5%. A series of 78 specimens (39 cubes and 39 beams) of different aspect ratio and varying positions of steel fibres were cast. And it was observed that as percentage of fibre increases workability reduces. The reduction in workability is due to more water required to lubricate more amount of fibre. As amount of fibre increases less space is available for movement of fibre. Experimental findings addressed that as volume of fibre increases; there will be increase in flexural strength. More flexural strength was observed at aspect ratio 80. In flexural strength test more displacement was observed at one third depth than randomly reinforced fibres. Steel fibre reinforced concrete can be used for construction of pavement, industrial floors, bridge deck slabs satisfactorily. For aspect ratio 80 it was found that compressive strength increases in both positions of steel fibre. Empirical equations for predicting basic strength properties of concrete were presented based on regression analysis.

III. RESEARCH METHODOLOGY

The plan and procedure used to perform the study are described in the methodology section.

MATERIAL USED.

i. **CEMENT:** This study used Ordinary Portland cement (OPC) of 43 grades (Ultratech brand).

TEST OF ORDINARY PORTLAND CEMENT: -

a) Fineness –

b) Specific gravity –

c) Consistency –

d) Initial and Final setting time –

ii. **WATER:** The correct amount of water in concrete mix cause proper cement hydration and maximize the strength. In present research, the water used in all mixes was local tap water.

iii. **AGGREGATE:** The aggregate is classified as fine aggregate and coarse aggregate. Fine aggregate is material passing through an IS sieve that is less than 4.75mm gauge beyond which they are known as coarse aggregate. According to IS 383:2016, the fine aggregates classification, the study used the natural sand of Zone-II. The coarse aggregate of a maximum of 20 mm is suitable for concrete work. Besides their size, shape and surface have significant impact on fresh and hardened properties of concrete.

   a. Sieve Analysis-

   b. Specific gravity –

   c. Elongation & Flakiness

   d. Aggregate Impact Value –

   e. Water Absorption

   f. Fineness Modulus –

iv. **STEEL FIBRE:** The characteristics and performance of Steel fibre Reinforced Concrete, (SFRC) changes with varying concrete binder formulation as well as the fibre material type, fibre geometry, fibre distribution, fibre orientation and fibre concentration.

   a. Length-

b. Diameter

c. Aspect Ratio (L/d)

d. Specific gravity

v. CONCRETE MIX AND MATERIAL TESTING

The various tests were conducted on material used to prepare the concrete mix and on the concrete mixes containing various proportion of Steel fibre in accordance with the American Standard for Testing of Materials (ASTM) and Indian standards (IS). The following tests were performed:

a. Sieve Analysis: Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963

b. Water Absorption: This test helps to determine the water absorption of coarse aggregates as per IS: 2386 (Part III) – 1963. For this test a sample not less than 2000g was used.

c. Initial and final setting time: The initial and final setting time as per IS: 4031 (Part 5)-1988. Vicat's apparatus conforming to IS: 5513 – 1996 is used to determine the initial and final setting times of the concrete

d. Workability of Concrete: Slump cone test was performed to determine the workability of the fresh concrete properties following the IS: 1199 – 2018 code. The test utilized a shape called droop cone whose top distance across is 10 cm, base breadth is 20 cm and height are 30 cm

e. Compressive Strength: Aimil make compression testing machine of capacity 2000KN was employed to investigate the compressive strength of concrete samples using procedure outlined in IS code 516:2021

f. Flexural Strength Test: It is also known as modulus of rupture, or bend strength, transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three-point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress. To investigate the Flexural Strength of concrete samples using procedure outlined in IS code 516:2021.

vi. OBJECTIVES

a. Review previous research on FRC material and structural behaviour of structural members.

b. Review previous experimental research on the impact behaviour of slabs and use of fibres.

c. The strength of both fresh and harden state concrete should be desirable and according to requirement.

d. Behaviour of fibrous concrete should be more than conventional concrete and hence fibrous concrete can be used in certain structural members.

e. Review effect of fibres on compressive strength of concrete

f. From present investigation we find the behaviour of structural member cast with fibre-based concrete

g. The effect of fibre concrete is to determine the increase in tensile strength of concrete.

h. By adding the fibre reinforcement in concrete resulting the improvement of mechanical properties viz flexural strength and compressive strength.

i. To examine the effect of fibre volume fraction on SFRC material performance.

j. To make a comparison for the performance of concrete with and without Steel fibre reinforcement on the material levels both graphically and qualitatively.

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