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Review Paper on Investigation of Self-Consolidating Concrete with Micro Steel Fibres

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ABTRACT :

One of the most commonly utilised building materials in the world is concrete. Nonetheless, concrete's weakness in tension has been known since the early 1800s. Tensile failure can occur suddenly and without warning when brittle behaviour is paired with weak tensile strength. It goes without saying that this is undesirable for any building material. Concrete requires some form of tensile reinforcement before it can be used in structural applications in order to increase its tensile strength and strain capacity and counteract its brittle tendency. Steel has always been the recommended material for tensile reinforcing in concrete. In contrast to standard reinforcing bars, which are positioned and constructed correctly in the tensile zone of the concrete member, fibres are thin, short, and randomly distributed throughout the concrete member. Fibres that are sold commercially are derived from natural resources including glass, steel, and plastic. Steel fibres are short, distinct pieces of steel that can be readily and randomly mixed into a fresh batch of concrete using a traditional mixing technique. With any combination of cross-sections, they have an aspect ratio, or length to diameter, between 20 and 100. The randomly distributed rebar is less effective than typical rebar, but the closely spaced fibres provide the concrete more tensile strength and hardness as well as help prevent cracks.

Keyword -Fiber Reinforced Concrete (FRC), Steel Fiber Reinfoced Concrete (SFRC), Mechanical properties.

1. 1 Introduction :

The second most often used material is general concrete (Colin, 2014). This demonstrates concrete's paramount importance in the modern era. Normal concrete is primarily composed of cement, water, admixtures, fine and coarse aggregate, and cement, which are mixed in various ratios using a vibrator. Researchers are under pressure to create unique concretes that are less harmful to the environment and have optimised status due to the construction industry's rapid development. Numerous studies are being conducted to increase concrete's effectiveness and make it stronger, more resilient, environmentally friendly,

Fibre in concrete

The notion of using fibres for reinforcement is not brand-new. Ancient people used straw in their mud bricks and horse hair in their mortar.The usage of asbestos fibres in concrete dates back to the early 1900s. When the health concerns of asbestos were discovered, a replacement for asbestos in concrete had to be found in the 1950s. Since ancient times, fragile materials like concrete have been reinforced with fibres composed of various materials.

However, it wasn't until 1963 that the first scientific explanation of the fracture mechanics concept was published (Romoualdi and Batson, 1963). It came to the conclusion that the fibres effectively function as crack arrestors by creating pinching forces that tend to close a crack. They also demonstrated that the square root of the fibre spacing has an inverse relationship with the increase in strength. The use of discontinuous fibres was proposed by Romualdi and Mandel in 1964 as a way to get around some of the practical casting and positioning challenges. Numerous studies on fiber-reinforced concrete have been conducted using chopped steel wires and other fibres, including nylon, polypropylene, fibreglass, asbestos, and fibres. Because of these discontinuous steel wires' appropriateness, accessibility, and simplicity of usage, researchers have only used them for structural applications.

1. 2 Literature survey & background

The effect of fly ash as a partial or complete replacement, micro silica as a minimum replacement for binder content and the effect of incorporating steel fibres in conventional concrete using vibrators as well as self-compacting done by various researchers in various parts of the world are summarized in this chapter.
Romualdi and Batson (1963a). reasoned that the use of linear elastic fracture mechanics to reinforced concrete demonstrates that the generally low elasticity of concrete is not inherent to the material and can be kept away from with appropriate reinforcement arrangement At proper 23 spacing, incipient

flaws kept from growing and proliferating all through the elastic zone. The outcome is a true phase material that displays quality properties not limited by the attributes of each different phase

Bicer (2018) This study examines an experimental method for analysing the different mechanical characteristics of concrete by mixing fly ash into the mixture. The study found that, up to a 50% rise in fly ash percentage, the density of the concrete composites increases linearly. The fly ash's density increased by 16.12% as its diameter shrank. The fly ash particles filled in the spaces in the concrete material because of their fineness and spherical form. The fly ash met the requirements of ASTM C-350.

Organic polymers are the source of synthetic polymer fibres, which include nylon, polyester, acrylic, and polypropylene. The most popular fibres for concrete composites among them are polyester and polypropylene. According to Beaudoin (1990), the most prevalent forms of these fibres are tri-dimensional mat, twisted, fibrillated, and smooth monofilament. Compared to other fibre kinds, they have a lower elastic modulus, are more chemically inert, and corrode less frequently in the alkaline cementitious matrix. The surfaces of polyester and polypropylene are hydrophobic. Low modulus of elasticity, poor bonding with cement matrix, combustibility, and low melting point are the main drawbacks of polymeric fibres. Their long-term characteristics are likewise dubious.

Bagha Ghanooni (2016) The purpose of the study was to determine how mineral admixture affected the mechanical behaviour of SCC. Metakaolin (MK), fly ash (FA), silica fume (SF), lime stone powder (LS), and ground granulated blast furnace slag (GGBS) were the mineral admixtures employed in the study in place of cement. The study's mix proportions were as follows: 400 kg/m3 of cement (C), 660 kg/m3 of total binder content, 12% of FA, 27% of LS, 12% of SF, and 24% of FA+SF. Of which, the mixture with 12% fly ash showed the best rheological characteristics. The mixture that had 12% silica fume in it had a higher compressive strength. Fly ash and silica fume used together produced the best outcome in terms of all mechanical and physical attributes.

The Hai-Thong group (2016) The optimisation of water demand, which affects the rheological characteristics of self-compacting concrete, was the subject of the study. It has been determined that mixing time affects SCC, including water, performance. In this case, 420 kg/m3 of binder was employed, along with a water/binder ratio of 0.6, 6 to 7 kg/m3 of superplasticizer, and 1 kg/m3 of viscosity-modifying agent. It was discovered that the viscosity-modifying ingredient in SCC uses more energy and prolongs mixing times.

Leung and associates (2016) According to the study, there are several uses for binary mineral admixtures, like fly ash and silica fume, in self-compacting concrete's mechanical qualities. It was found that the sorptivity and water absorption of concrete were decreased by the efficient use of fly ash and silica fume. Class-F fly ash was utilised, in accordance with ASTMC 618-99. The overall binder content in this study was 620 kg/m3, fine aggregate content was 780 kg/m3, and coarse aggregate content was 720 kg/m3. Fly ash and silica fume were substituted up to 40% with regular Portland cement, a water-to-binder ratio of 0.38, superplasticizers ranging from 3 to 5 l/m3, and viscosity-modifying agents from 3 to 14 l/m3.

Mohamed (2011) The study was conducted to investigate the effects of different percentages of fly ash and silica fume, both independently and combined, with varied curing conditions in self-compacting concrete. The binder content range examined in the study was 450 kg/m3 to 550 kg/m3. The overall binder content in this sample was between 450 and 550 kg/m3, with fine aggregate weighing 1109 kg/m3 and coarse aggregate 612 kg/m3. Fly ash and silica fume were substituted with regular Portland cement up to 50% of the total, with a water-to-binder ratio of 0.42. According to the study, a mix proportion with a binder content of 550 kg/m3 demonstrated superior filling and flowability compared to a mix with a binder content of 450 kg/m3. The mix with fly ash up to 30% showed a linear rise in compressive strength with respect to curing durations, while the mix with 15% silica fume had the highest compressive strength of all.

et al. Mertol (2015) The study on the flexural performance of Steel Reinforced Fibre Concrete (SFRC) prisms is the subject of this work. Twenty 180 x 250 x 3500 mm reinforced concrete beams make up the study. Ten beams covering under-reinforced to over-reinforced beams were built with longitudinal reinforcement ratios ranging from a lower value of 0.2% to a higher value of 2.5 percent. For every longitudinal reinforcement ratio, two beams were prepared: one using standard control concrete (CC) and the other using steel-reinforced fibre concrete (SFRC). The specimen's ultimate stress and strain, service stiffness, post-peak stiffness, and flexural toughness were evaluated based on the load per deflection values that were obtained.

The Aleksandra group (2016) In order to create a high-performing self-compacting concrete, Aleksandra created the Design of Experiments (DOE) method, taking into account the variables that affect the composition on rheological properties as represented by a statistical model. The relative roles of the suggested mix design elements are highlighted by the statistical model that was constructed. Based on the findings, it was determined that the two most important rheological property factors were the w/b ratio and the cement paste content.

et al. Sonebi (2015) A statistical model was created and used to conduct experiments to examine medium strength self-compacting concrete (MS-SCC). Cement, packing factor, pulverised fuel ash (PFA), water-to-powder (cement + PFA) ratio (W/P), and dosage of SP were the main variables that were used. PFA served as a filler substance. The study examined five crucial criteria that impact the mechanical characteristics, filling ability, segregation, passage, and flowing abilities of concrete. Orimet duration, J-Ring coupled to cone, fluidity loss, slump flow, V-funnel time, segregation, J-Ring combined to the Orimet, rheological parameters, L-box, and compressive strength at 7, 28, and 90 days were the ten parameters for which responses were generated.

Mandel and Romualdi (1964).Tensile strength for mortar reinforced with a random distribution of short steel wires is related to the inverse square root of the fibre spacing for spacing smaller than 10.2 mm, according to the same findings as for continuous wires. This is because cracks that start out as little imperfections are stopped from growing and spreading throughout the tension zone when they are spaced appropriately apart. In addition to suggesting that the presence of a "crack arrest mechanism" in steel fibre reinforced concrete may lead to high fatigue and impact resistance, the expressions for determining the average spacing and the percentage of reinforcement effective in crack control were provided.

It has been demonstrated by Shah and Rangan (1970) that a short steel fibre put randomly throughout the concrete increases its ductility by strengthening its resistance to the formation of internal cracks. It has been noted that the fibres' strong reinforcing action occurs when the matrix begins to fracture. The connection between stress and strain as well as the fibres' length and orientation all have a significant impact on their post-cracking resistance. Below a certain length, the spacing between reinforcements doesn't seem to have much of an impact on the propagation of cracks.

According to Chen and Carson (1971), mortar with 0.75 percent of 12.7 mm diameter fibre wire demonstrated the best tensile and compressive strength when tested using standard cylinders and indirect stress. At 2.0 percent of 25.4 mm and 12.7 mm fibre wire, the concrete demonstrated its maximum tensile strength (a 6% increase) and compressive strength, along with an improvement in ductility. They said that stronger

The mechanical characteristics of concrete and mortar reinforced with evenly spaced smooth steel fibres were investigated by Shah and Vijay Rangan in 1971. Various fibre kinds, quantities, lengths, and orientations were employed. In flexure, tension, and compression, fibres and traditional reinforcement were contrasted. It was observed that the significant reinforcing effects of the fibres were deduced subsequent to the initiation of matrix cracks. The stress-strain relationship and length orientation of the fibres had a significant impact on their post-cracking resistance. Below a certain length, the spacing between reinforcements appears to have no bearing on the propagation of cracks. Based on the characteristics of the constituent components, the composite materials technique was used to carry out an analytical prediction for the reinforcing action of fibres.

Fanella and Naaman (1985) investigated the stress-strain behaviour of fiber-reinforced concrete under compression using both analytical and experimental methods. Three distinct mortar matrices and three different types of fibers—made of steel, glass, and polypropylene—were employed in the study. Analysis was done on how each substance affected the concrete's toughness, peak stress strain behaviour, and stress strain curve form. It was determined that the characteristics of fiber-reinforced concrete composites were influenced by the configuration of the materials.

Tests were conducted by Nagaraja and Swami (1987) on specimens reinforced with non-metallic fibres to ascertain the modulus of elasticity, energy absorption, flexural strength, split tensile strength, and compressive strength. The results showed that, as compared to ordinary concrete, the addition of nonmetallic fibres has no effect on improving compressive strength. When compared to ordinary concrete, the malleable load carrying limit of fiber-reinforced concrete with non-metallic fibres rose somewhat.

In 1987, Nagarkar et al. tested concrete reinforced with steel and nylon fibres. They came to the conclusion that adding fibres enhances the compressive strength by 5 to 57%. But in the case of steel fibres as opposed to nylon fibres, this rise was more noticeable. Additionally, there was a 15–45% and 20–60% increase in the split tensile and flexure strengths, respectively.

The findings of a trial investigation on the flexural behaviour of steel fibre reinforced concrete were reported by Ezeldin and Balaguru (1992). Three distinct fibre geometries—hooked ends, corrugated ends, and end deformed ends—were employed. When fibre content was added to the concrete up to 120 kg/m3, a consistent blending was seen. The ASTM C 1018 method was used to calculate toughness, and accurate estimation of hooked end fibres for increasing toughness was finished. The toughness of hooked end fibres was not affected by their length.

According to Nguyen Van Chanh (1995), one of the fundamental and important characteristics of steel fibre reinforced concrete (SFRC) is its increased ability to withstand the creation and spread of cracks. When the specimens were subjected to flexural loading, the fiber-reinforced concrete exhibited relatively good ductility and stiffness because the fibres successfully controlled cracks and the matrix remained connected together even at the ultimate stress. It was determined that the fibres might change the behaviour of the concrete from brittle to ductile, allowing for improved energy absorption and resistance to cyclic impact loads.

A thorough examination into the characteristics of concrete containing steel fibres and rice husk ash was conducted by Sandesh D. Deshmukh et al. in 2005. A thorough investigation was conducted using rice husk ash content ranging from 0% to 20% by weight to test a variety of criteria, including workability of fresh concrete, compressive strength, flexural tensile strength, splitting tensile strength, and modulus of elasticity for hardened concrete. According to the experiment's findings, the ideal strength was obtained with 12.5% rice husk ash. Steel fibres were added to the concrete at a volume fraction of 0% to 1% in order to further improve it. The tensile strength qualities of rice husk ash mixed concrete are enhanced by the addition of steel fibres, according to experimental data.

According to Patodi & Kulkarni (2012), the matrix containing 0.3% of recron and 0.7% of steel fibre volume fraction performed best in terms of tensile stress, flexural stress, and shear stress. On the other hand, fibre reinforced concrete with 1% volume fraction of steel fibres showed the maximum increase in compressive strength. They came to the conclusion that steel fibres exhibit increased toughness and superior resistance against impact.

According to Alani & Aboutalebi (2013), concrete with comparable amounts of steel and synthetic reinforcing fibre exhibits nearly identical ultimate strengths under compression and tension as measured in split and flexural tests; however, concrete with synthetic fibre has a higher ductility.

Kene and associates (2012).It has been demonstrated through experimentation that adding steel fibres to concrete at a volume of 0.5% lowers cracking under various stress scenarios. Adding steel fibres instead of glass fibres can also make concrete less fragile. Steel fibres are helpful in axial tension to boost tensile strength because concrete has very little tension.

In 2010, Vengatachalapathy and Ilangovan conducted research on the impact of steel fibres on the behaviour and ultimate strength of deep beams that had holes or not. Nine beams in all were subjected to two point loading with a weight applied gradually. All deep beams were maintained in a simply supported configuration, with varying percentages of 0 to 1.0 for the steel fibre volume within the composite's overall volume. Experimental research was done on the load versus deflection behaviour of concrete beams, and crack patterns were noted. The investigation's findings demonstrated the impact of fibres on the durability and strength of reinforced concrete deep beams.

1.3 Conclusion :

In conclusion, the integration of micro steel fibers into SCC offers a promising approach to improving the performance of concrete, making it a suitable material for various structural applications that require high strength, durability, and reduced maintenance. Further studies could explore the long-term behavior of SCC with micro steel fibers in different environmental conditions to fully understand its potential benefits.
This conclusion summarizes the key findings and practical implications of using micro steel fibers in SCC based on the results of the experimental study.

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