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Experimental Study on Performance of Concrete with Various Steel Fibers

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Abstract: Concrete is a delicate material which has a low strength and limited ductility. These weak points of concrete can be resolved by including fibers made up the various Materials with high technical specifications. This special type of concrete is known as special types of concrete which exhibits superior properties in terms of strength and durability method due to the addition of steel fibers when compared to conventional concrete. These inconsistent characteristics of steel fibers have highly influence on the performance of SFRC.M25 grade of concrete are 0.5%,1.0, 1.5%, 2.0%,was planned in which workability tests were conducted to investigate the properties of the fresh concrete mixes. The concrete were investigated using Compressive Strength tests, and Flexural Strength were casted. Mechanical properties of concrete like durability tests and examination of micro structure of the concrete have been planned to be carried out.

1. INTRODUCTION

Concrete is one of the most widely used construction materials in the world due to its high compressive strength, durability, and versatility. It plays a vital role in modern infrastructure development, including buildings, bridges, dams, and transportation systems. However, despite its advantages, conventional concrete exhibits certain limitations such as low tensile strength, brittle behavior, and limited ductility. These inherent weaknesses often lead to cracking under tensile stresses, which may reduce the durability and service life of structures. To overcome the low tensile strength of concrete, steel reinforcement is commonly used in reinforced concrete structures. Steel bars help to resist tensile stresses and control crack propagation, thereby improving the structural performance of concrete elements. Nevertheless, reinforced concrete structures also face several challenges. The self- weight of concrete structures is significantly higher compared to steel structures with the same load carrying capacity. This increased self-weight requires larger structural members and foundations, which in turn increases material consumption, transportation costs, and construction expenses. In addition, cracks formed in conventional concrete can allow the penetration of water and aggressive chemicals, which may lead to reinforcement corrosion and deterioration of the structure. In recent years, significant research efforts have been directed toward improving the mechanical performance and durability of concrete through the incorporation of fibers. Among the various types of fiber-reinforced concrete, Steel Fiber Reinforced Concrete (SFRC) has gained considerable attention in the field of civil engineering. Steel fibers are short, discrete fibers that are uniformly distributed and randomly oriented within the concrete matrix. The inclusion of steel fibers enhances the mechanical properties of concrete by improving its tensile strength, flexural strength, ductility, toughness, and crack resistance. Steel Fiber Reinforced Concrete is designed to satisfy the requirements of production, construction, and service life of structures. The presence of steel fibers in the concrete matrix helps to bridge micro cracks and prevent their propagation into larger cracks. This crack-bridging mechanism significantly improves the post-cracking behavior of concrete and enhances its energy absorption capacity. As a result, SFRC exhibits superior performance in terms of flexural-tensile strength, resistance to splitting, impact resistance, and fatigue resistance compared to conventional concrete. Furthermore, the addition of steel fibers improves the durability characteristics of concrete. It reduces permeability, enhances frost resistance, and increases resistance to abrasion and plastic shrinkage cracking. These improvements make SFRC particularly suitable for structures subjected to dynamic loads, impact loads, and harsh environmental conditions, such as industrial floors, pavements, tunnel linings, airport runways, and seismic- resistant structures. Due to its enhanced mechanical and durability properties, Steel Fiber Reinforced Concrete has become an effective solution for improving the overall performance and reliability of concrete structures.

The use of steel fibers not only increases the toughness and shock resistance of concrete but also contributes to better crack control and extended service life of structures. Therefore, the application of SFRC in modern construction has gained significant importance, and ongoing research continues to explore its potential benefits in various structural applications.

II. MATERIAL USED AND WORK METHODOLOGY

Cement

The properties of cement are related to the properties of concrete, including absorption Initial and final moment and compressive strength. Cement quality is another important factor OPC- 53 grade cement was used to perform test.

Fine Aggregate

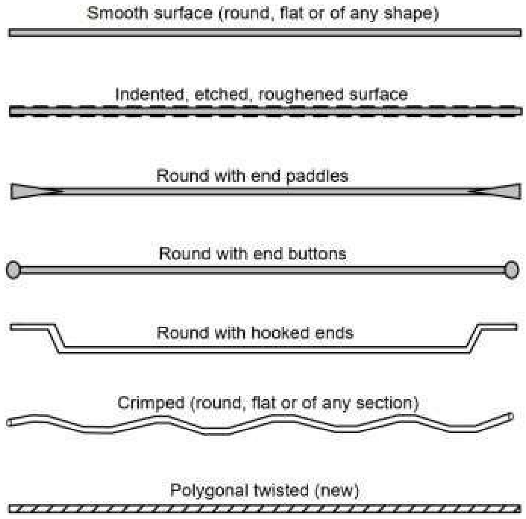
All ordinary sands are suitable for SSC In this test, sand with the largest dimension1:18 mm was used in the test they are taken

Coarse Aggregate

All aggregate type is suitable for SSC. The largest size is usually 16-20mm; but the size used in SSC is approximately 40mm or largest combination used in this experiment is 2037.5 mm

Steel Fibers

In this study, two forms of steel fibre were used, different in terms of diameter, shape, length and aspect ratio (1/d). the first image is a plain micro steel fibre with length (13) mm, diameter (0.2) mm and aspect ratio 65. The second image is a hook tipped steel fibre with length (30) (mm), diameter (0.5) mm and aspect ratio are 60. Figure 1 shows the micro steel fibres and hook tip steel fibres and others are used in this study (3).



III. EXPERIMENTAL INVESTIGATIONS

Mix Proportions

The mixing process is divided into three forms. In the first stage, all binders were weighed accordingly and mixed by hand until all materials are mixed homogeneously. This is to ensure that all the glue is mixed well to create a homogeneous mixture. The second step is to mix the glue with the aggregate for 5 minutes. At the last stage, a measure of water was added to the mixture. This step is important to ensure water distribution to ensure that the concrete of each sample has a water cement ration. After this, the stone is poured into the mould [7]

Volume of Concrete	Cement	Fine Aggregate	Coarse Aggregate	Water
Bykg/m^3	502	540	1094	242
Byratio	1	1.1	2.1	0.48

Sample Code	Crimped Steel fibers	Weight of Fiber (gm)
MIX 0	-	-
MIX 1	0.5	71
MIX 2	1	142

Grade of Concrete	Water cement Ratio	Mix proportion
MM-I2X03	10..555	2113:2.21:3.4
M-25	0.5	1:1.9:3.1

M-30	0.45	1:1.65:2.8
M-40	0.4	1:1.76:3.1

An experimental program was created to analyse the impact of the type of steel fibres used to reinforce the concrete. This separated the behavior of ordinary concrete from that of fibre- reinforced concrete. Different mixtures were created to have the same matrix but different amounts of fibre content (starting from one fibre-free mixture and three mixtures with 0.75, 1.5, and 2.0% by mass of concrete [2]

Preparing Specimens

Molds of different sizes and shapes (cube, cylinder and beam) were used to create the model. Concrete is poured into the mold in three layers and each layer is compacted using a tamping rod. The sample is removed from the mold after 24 hours and hardened by immersion in wet media.

Curing

In this study, the samples were cured by soaking in water 7,14 and 28 days. Samples are processed until they are ready for testing for certain days.

Fig: Casting Specimens

FRESH CONCRETE TEST

S.No	No.of Curing days	Compressive strength(N/mm2)
1	7	24
2	14	29.5
3	28	40.13

Slump Test

To test the work ability or consistency of new concrete slump Test is carried out as per IS: 119 9 1959. In this test, new concrete is poured into a 300mm high truncated cone in approximately 4 layers compacted 25 times per layer with specially sized rods Then hold the slump cone with both hands and record the drop height, which is the expected slump value

Compaction Factor Test

Used to measure the work ability concrete compaction Factor Test Complies with IS: 1199-1959.Inthistest,a preparation is made for the new concrete to fall freely and continuously from two places. Place the hoppers into the cylinder with the empty weight to perform the results

Compressive Strength Test

In this study, the gauges were cast and tested with steel fiber reinforcement. Dimensions of the cube are 150X150X150 mm as per IS 4562000. The containers were fixed and tested after 7 and 28 days, and the capacity of the concrete was recorded in KN the force side of the cube

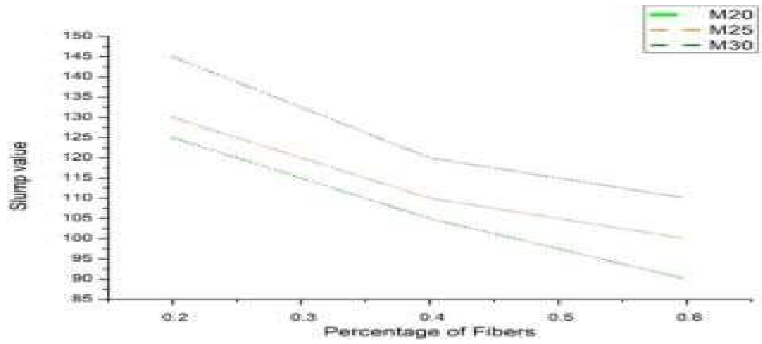
Fig: Compression Strength Test Flexural Strength Test

To test the Flexural strength, specimens with a length(100x100x500) mm were cast. After24 h ours of casting, the samples were removed from the mold and sent to the curing they were cured for28days. In the hydraulic universal testing machine, the specimens were test

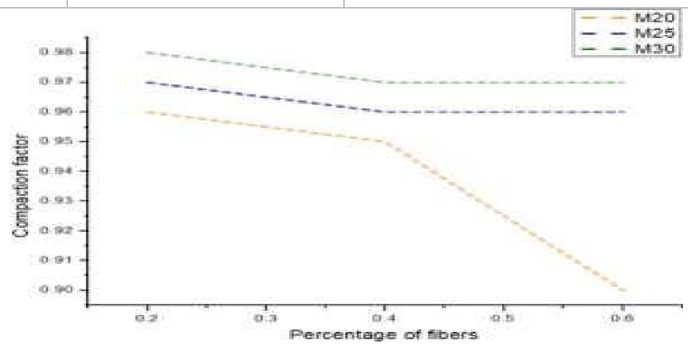
- Calculate the flexural strength of the concrete beam using the formula
- Flexural Strength = Maximum Load×Span LengthWidth×Depth2
- Flexural Strength=Width×Depth2 Maximum Load× Span Length
- Ensure that the dimensions are in consistent units (e.g., convert mm to meters for area calculation).
- “Alternately” (unless you really mean something that alternates).

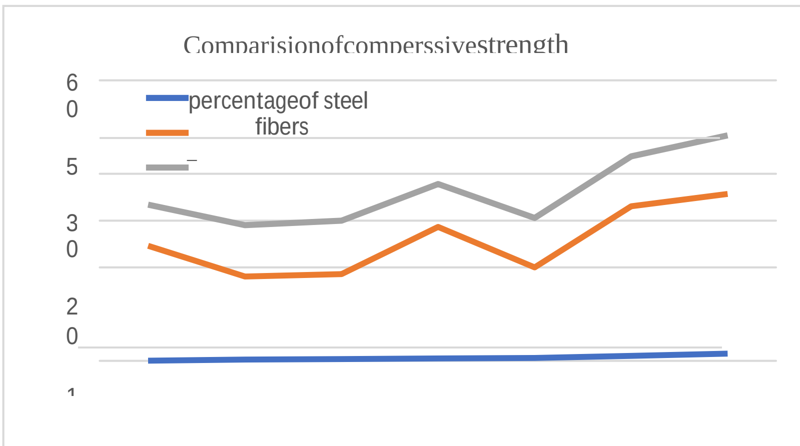
Fig: Flexural Strength Test

RESULTS AND DISCUSSION - Fresh Concrete Results



S.no	No.of Curing days	Flexural strength (N/mm2)
1	7	10
2	14	13
3	28	19





- Slump test and results obtained from visually observed Compression coefficient test It can be1said that the addition of fiber makes the matrix harder and the steel used has more fibers.
- The reason for the low density is that the addition of steel fibers creates a structure in the concrete that prevents the separation and flow of the mixture.
- Due to the high fiber content and large surface area, the fibers will definitely extract more cement slurry for coating.
- Slump decreases as steel fibre content increases.

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