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COMPARATIVE STUDY ON STRNGTH PARAMETERS OF CRIMPED STEEL FIBERS

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ABSTRACT
This paper presents the flexural strength of crimped steel fiber reinforcement of lintel beams. Examining flexural strength, crack control, and durability, the research aims to provide insights into the efficacy of crimped steel Fibers in enhancing the performance and resilience of concrete structures. The study considers factors such as Fiber type, aspect ratio, and volume fraction, contributing to a comprehensive understanding of the influence of steel Fibers on concrete properties. Results obtained from this project can guide the optimization of concrete mix designs for improved structural performance and durability in diverse engineering applications.

Keywords: Crimped steel fiber reinforcement, M20 Grade Concrete, Lintel Beam, Flexural Strength.

1 INTRODUCTION

1.1 History and Purpose
After failure commences, cement concrete exhibits brittle failure, which is characterised by a nearly total loss of loading capability. In addition to treating other concrete weaknesses like low growth resistance, high shrinkage cracking, low durability, etc., this characteristic—which restricts the material's application—can be overcome by adding a small amount of short, randomly distributed Fibres (crimped steel).

1.2 Crimped Steel Fibres Are Important
Because of the microcracks that exist at the mortar-aggregate interface, plain concrete is inherently fragile. Fibres are added to the mixture to eliminate the weakness. Fibres of different types, such as those present in traditional composite materials, have been added to the concrete mixture to boost its toughness, or ability to resist the formation of cracks. Within the microcracks, the fibres facilitate load transfer. This kind of concrete is called Crimped Steel Fibre Reinforced Concrete (CSFRC)**.**

LITERATURE REVIEW

Previous Studies on Crimped Steel Fibers
In the previous researches of crimped steel fibers demonstrates an increase in flexural strength with the incorporation of crimped steel fibers. The fibers act as crack arrestors, improving the post-cracking behaviour and structural integrity. The literature reveals a consensus on the positive impact of crimped steel fibers in augmenting flexural strength. The literature review highlights the significant contributions of crimped steel fibers to the flexural strength and performance of concrete beams. By understanding the influence of fiber characteristics, mix proportions, and durability considerations, engineers can optimize the design and construction of fiber-reinforced concrete structures for diverse applications, ranging from residential buildings to infrastructure projects. Further research is warranted to explore advanced fiber types, optimized mix designs, and innovative construction techniques to maximize the benefits of steel fiber reinforcement in concrete beams.

Advantages and Limitations of Crimped steel fibers
Crimped steel fibers offer several advantages in reinforcing concrete structures. Firstly, they enhance the flexural strength of concrete, providing additional reinforcement and improving load-carrying capacity. Additionally, crimped steel fibers aid in crack control by minimizing crack width and propagation, thus enhancing the

durability of concrete elements. Their inclusion also increases ductility, allowing structures to withstand higher levels of deformation and energy absorption, particularly in dynamic loading scenarios. Furthermore, crimped steel fibers improve fatigue resistance, making them suitable for applications subjected to cyclic loading, such as bridge decks and pavements. They also contribute to impact resistance, reducing the susceptibility of concrete structures to damage from impacts or explosions. Importantly, crimped steel fibers offer corrosion resistance, unlike conventional steel reinforcement, thereby enhancing the long-term durability of reinforced concrete structures, especially in aggressive environments. However, crimped steel fibers come with limitations.

Relevant Research on the Crimped Steel Fiber Reinforcement

Research on crimped steel fiber reinforcement in concrete has yielded significant insights into its effectiveness in improving the mechanical properties and durability of concrete structures. Studies have focused on various aspects, including the influence of fiber characteristics such as aspect ratio, length, diameter, and crimping pattern on the flexural strength, crack control, and ductility of fiber-reinforced concrete. Additionally, research has explored the optimal fiber content and mix proportions to achieve desired mechanical properties while maintaining workability and constructability. Experimental investigations have demonstrated the superior performance of crimped steel fibers in enhancing the flexural strength, fatigue resistance, and impact resistance of concrete beams, slabs, and pavements. Furthermore, research has addressed durability considerations, evaluating the corrosion resistance, freeze-thaw resistance, and alkali-silica reaction of fiber-reinforced concrete in various environmental conditions. Overall, the body of research on crimped steel fiber reinforcement provides valuable guidance for optimizing concrete mix designs, construction practices, and structural performance in diverse engineering applications.

Factors Affecting Properties of Crimped Fiber Reinforced Concrete

A composite material that has fibres dispersed either randomly or in an ordered fashion inside the cement matrix is called fiber-reinforced concrete. The efficient passage of stress between the matrix and the fibres is obviously what determines its characteristics. A quick discussion of the factors is provided below:

The relative stiffness of the fibre matrix: For effective stress transfer, the matrix's modulus of elasticity needs to be significantly lower than that of the fibre. As a result, low modulus materials like nylon and polypropylene are unlikely to increase strength; yet, they can aid in the absorption of significant amounts of energy, which increases their degree of toughness and resistance. Strongness and rigidity are added to the composite by high modulus fibres like carbon, glass, and steel.

2. Volume of Fibres: The amount of Fibres utilised in the composite affects its strength significantly. Volume's impact on toughness and strength is depicted in Figs. 1 and 2. The composite's tensile strength and toughness improve roughly linearly with an increase in fibre volume, as seen in Fig. 1. Higher fibre content in concrete and mortar is probably going to separate the two materials.

3. Aspect Ratio of the Fibre: This is a crucial component that also affects the composite's behaviour and characteristics. A rise in aspect ratio is said to enhance the final concrete in a linear fashion up to a ratio of 75. Relative toughness and strength decrease beyond 75. Aspect ratio's impact on strength and toughness is displayed in Table 1.

Type of concrete	Aspect ratio	Relative strength
Plain Concrete with randomly disperse fibers	0	1
-----//-----	25	1.5
-----//-----	50	1.6
-----//-----	75	1.7
-----//-----	100	1.5

Table-1: Aspect ratio of the Fiber

4. Direction of Fibres: Conventional reinforcement uses bars aligned in a specified direction, whereas fibres are randomly oriented. This is one of the distinctions between conventional reinforcement and fibre reinforcement. A 0.5% volume of fiber-reinforced mortar specimen was examined to observe the impact of randomness. The fibres were randomly dispersed in the third group of specimens, in the direction perpendicular to the load, and aligned in the direction of the load in the first set. When compared to randomly distributed or perpendicular Fibres, it was found that Fibres oriented parallel to the applied load provided greater tensile strength and toughness. Incorporating steel fibre significantly reduces the workability and compaction of concrete. The conglomeration of fresh mix is negatively impacted by this condition. Concrete cannot be compacted, not even by extended external vibration. Based on the Fiber's diameter and length, the Fibre volume at which this condition occurs varies. Inequality in the distribution of the Fibres is another effect of low workability. Increased water to cement ratios typically result in better workability and compaction standards for the mix.

6. Coarse Aggregate Size: For the composite to remain substantially stronger, the maximum size of the coarse aggregate should be limited to 10 mm. As an aggregation, fibres also play this function. Their impact on the characteristics of newly mixed concrete is intricate, despite their straightforward geometry.

7. Mixing: Careful conditions are required to prevent fibre balling, segregation, and general difficulties in achieving a uniform mixing of the components in fiber-reinforced concrete. The challenges and tendency for balling are exacerbated by increases in the aspect ratio, volume percentage, size, and quantity of coarse aggregate. It is challenging to combine steel fibre when it contains more than 2% of the volume and an aspect ratio more than 100. On site, different concrete grades were utilised in different proportions.

Fig 1: Site Mix Design of Concrete Grades

Mechanical properties of crimped steel fibres

Diameter	0.75MM
Length	60MM
Tensile Strength	1023MPa
Tolerance for Diameter and Length	(+)10%

Table-2: Mechanical properties of Crimped steel fibers

Three Types of Crimped steel fibers:

1. 3D Hook

Fig 2: 3D Hook

2. 4D Hook

Fig 3: 4D Hook

3. 5D Hook

Fig 4: 5D Hook

Flexural Strength Test Results

Beam specimens of 100x100x500 mm are cast for the purpose of testing flexural strength. Within twenty-four hours of casting, the specimens are taken out of the moulds and let to cure for seven to eighteen days in a curing tank.According to I.S. 516-1959, the flexural strength specimens are tested on a flexural strength testing equipment with three points of loading applied over a 400 mm load effective span. Up until the specimen fails, the load and related deflections are recorded. Three beams are tested, and the average value for each % of fibre content is recorded.

Fig 5: Flexural strength testing

Specimen Details:

1. Sizes of Lintel Beam Specimen: 100x100x500 mm
2. Grade Of Concrete: M20
3. Mixtures: Crimped steel fibers having 3D, 4D, 5D Hooks
4. Samples: 6Nos

Hooks↓ \ Days→	7 Days (MPa)	28 Days (MPa)
3D Hook	2.5	6.4
4D Hook	2.8	7.2
5D Hook	3.1	8.3

Table-2: Flexural Test Result Table

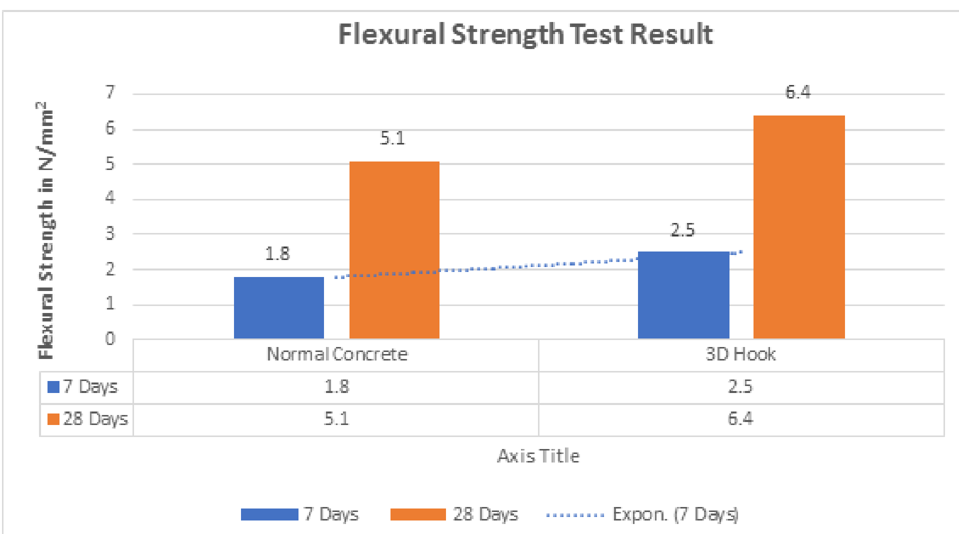

Fig 6: Data of readings of test for 3D Hooks

The above table shows the comparison between the readings of flexural strength of 3D hooked with normal concrete and it is clear that 3D hook of crimped steel fibers is good in flexural strength than normal concrete.

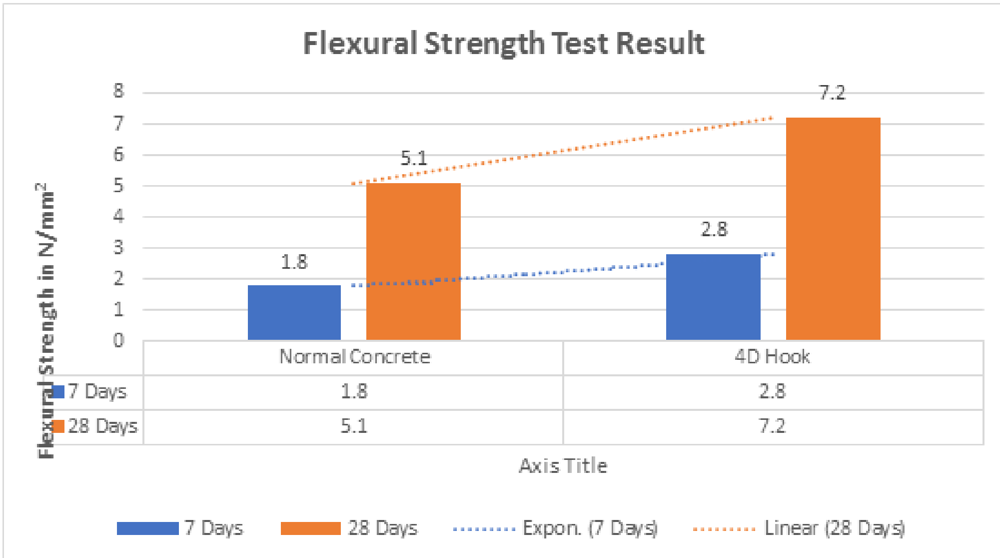

Fig 7: Result of 4D hook

The above table shows the comparison between the readings of flexural strength of 4D hooked with normal concrete and it is clear that 4D hook of crimped steel fibers is better in flexural strength than normal concrete.

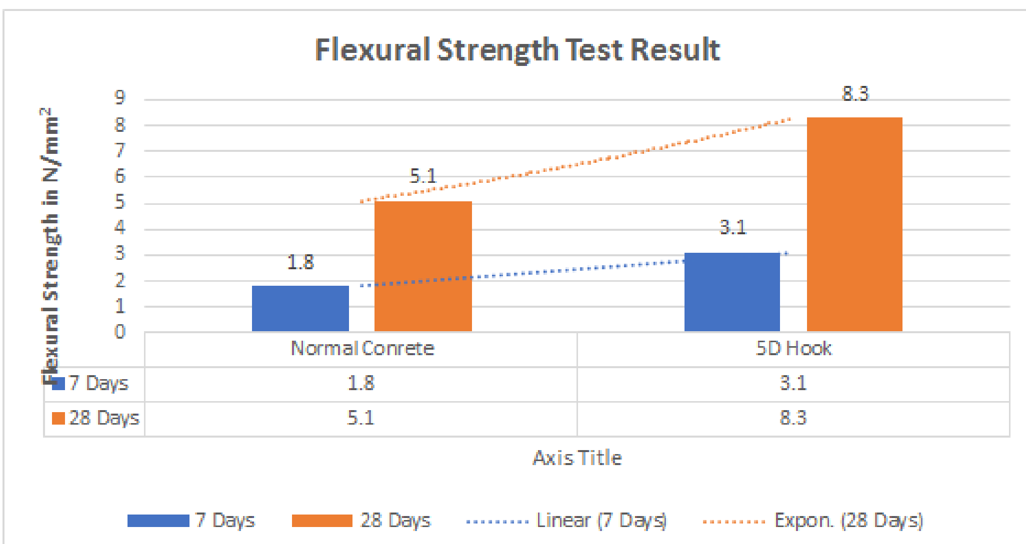

Fig 8: Result of 5D hook

The above table shows the comparison between the readings of flexural strength of 5D hooked with normal concrete and it is clear that 5D hook of crimped steel fibers is good in flexural strength than normal concrete.

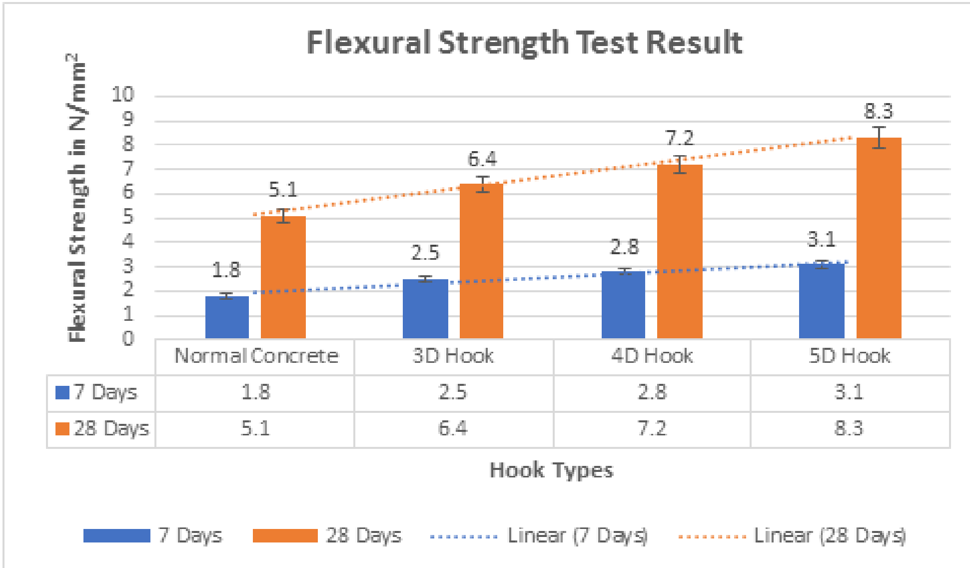

Fig 9: Data of readings of test for normal, 3D, 4D, 5D.

The above table shows the comparison between the readings of flexural strength of 5D hooked with normal concrete and it is clear that 5D hook of crimped steel fibers is best in flexural strength than normal concrete.

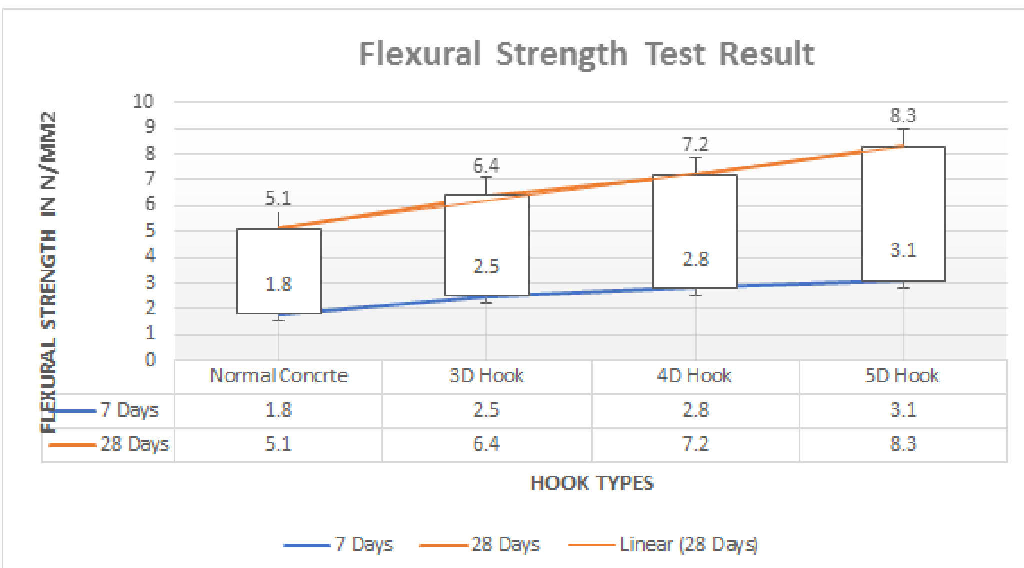

Fig 10: Comparative analysis of results for normal concrete, 3D, 4D, 5D.

The results of a flexural test on beams with lintels made of concrete of M20 grade, which has numerous fibres at varying volume fractions, are displayed. The maximum flexural strength when all other fibres are taken into account is obtained by adding a 5D hook, 50 mm in length, crimped steel fibre. Try it For the specified volume divisions, the parting elasticity results for M20 assessment of cement with crimped steel fibre reinforced strands are shown in figure. In comparison to the other hooks, it was observed that the 3D, 4D, and 5D hooks had the most strength.

CONCLUSIONS

Validation of Finite Element Analysis

To sum up, the experimental investigation into the performance and efficacy of crimped steel fibre reinforcement in flexural applications has yielded significant knowledge. Among the study's principal discoveries and conclusions are:

1. The flexural strength of concrete can be increased in comparison to normal/plane concrete by using 3D, 4D, and 5D Hooks of Crimped Steel Fibres.
2. Despite the fact that the Crimped Steel Fibres cannot totally stop cracks, it may be assumed that they can be somewhat reduced.
3. The concrete is capable of withstanding the flexural moment thanks to the use of Crimped Steel Fibres.

The results of this study, taken as a whole, provide credence to the employment of crimped steel fibre reinforcement as a viable means of improving the flexural performance and longevity of reinforced concrete buildings, hence providing chances for robust and sustainable building methods.

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