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Study on Retrofitting and Strengthening of Reinforced Concrete Beams Using Fibrous Concrete

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Abstract: Reinforced concrete structures are frequently in need of repair and strengthening as a result of numerous environmental causes, ageing, or material damage under intense stress conditions, as well as mistakes made during the construction process. RC structures are repaired using a variety of approaches nowadays. The usage of FRC is one of the retrofitting strategies. Steel fiber reinforced concrete (SFRC) was used in this investigation because it contains randomly dispersed short discrete steel fibers that operate as internal reinforcement to improve the cementitious composite's characteristics (concrete). The main rationale for integrating small discrete fibers into a cement matrix is to reduce the amount of cement used. The principal reason for incorporating short discrete fibers into a cement matrix is to reduce cracking in the elastic range, increase the tensile strength and deformation capacity and increase the toughness of the resultant composite. These properties of SFRC primarily depend upon length and volume of Steel fibers used in the concrete mixture. In India, the steel fiber reinforced concrete (SFRC) has seen limited applications in several structures due to the lack of awareness, design guidelines and construction specifications. Therefore, there is a need to develop information on the role of steel fibers in the concrete mixture. The experimental work reported in this study includes the mechanical properties of concrete at different volume fractions of steel fibers. These mechanical properties include compressive strength, split tensile strength and flexural strength and to study the effect of volume fraction and aspect ratio of steel fibers on these mechanical properties. However, main aim of the study was significance of reinforced concrete beams strengthened with fiber reinforced concrete layer and to investigate how these beams deflect under strain. The objective of the investigation was finding that applying FRC to strengthen beams enhanced structural performance in terms of ultimate load carrying capacity, fracture pattern deflection, and mode of failure or not.

I. INTRODUCTION

Reinforced concrete structures are frequently in need of repair and strengthening as a result of numerous environmental causes, ageing, or material damage under intense stress conditions, as well as mistakes made during the construction process. RC structures are repaired using a variety of approaches nowadays. The usage of FRC is one of the retrofitting strategies. Steel fiber reinforced concrete (SFRC) was used in this investigation because it contains randomly dispersed short discrete steel fibers that operate as internal reinforcement to improve the cementitious composite's characteristics (concrete). The main rationale for integrating short discrete fibers into a cement matrix is to prevent elastic cracking, increase tensile strength and deformation capacity, and improve the toughness of the composite. The length and volume of Steel fibers used in the concrete mixture determine the SFRC characteristics. Due to a lack of understanding, design requirements, and building specifications, steel fiber reinforced concrete (SFRC) has only been used in a few constructions in India. As a result, more knowledge on the role of steel fibers in concrete mixtures is required.

An experimental study will be undertaken in which crimped Steel fibers of two different aspect ratios 30 and 60 with volume fractions (V_f) of 0.5%, 1% and 1.5%. The experimental work reported in this study includes the mechanical properties of concrete at different volume fractions of steel fibers. Compressive strength, split tensile strength, and flexural strength are among the mechanical parameters studied, as well as the effect of volume fraction and aspect ratio of steel fibers on these mechanical properties. The study's major goal, however, is to determine the importance of reinforced concrete beams reinforced using fiber reinforced concrete layers, as well as to investigate the load deflection behavior of these beams. It should also be noted that the use of FRC slowed the emergence and propagation of cracks. The costs and challenges of rebuilding failing structures compelled government and commercial organizations to seek out innovative ways and materials to extend and improve the life of these structures.

The usage of fiber reinforced concrete is one of the most convincing ways to improve the structural performance of a construction (FRC). Fiber reinforced concrete (FRC) has a random distribution of small discrete fibers that work as internal reinforcement to improve the concrete's characteristics. The main objective for inserting short discrete fibers into a cement matrix is to improve the resultant composite's toughness and tensile strength, as well as its cracking deformation properties. The type of fibers used in the concrete has a big impact on the qualities of FRC. Concrete has been reinforced with several different types of short discrete fibers. Synthetic organic materials such as polypropylene or carbon, synthetic inorganic materials such as steel or glass, natural organic materials such as cellulose or sisal, and natural inorganic asbestos are all choices. The most common reinforcement fibers used in FRC are short discrete steel, glass, polyester, and polypropylene fibers. The diameter, specific gravity, young's modulus, tensile strength, and other properties of the fibers, as well as the amount to which these fibers alter the qualities of the cement matrix, are used to guide the type of fibers used.

A. Fiber-Reinforced Concrete

Fiber-reinforced concrete (FRC) is a type of concrete that contains short discontinuous fibers that are uniformly distributed and randomly oriented to add structural strength. Steel fibers, glass fibers, synthetic fibers, and natural fibers are all types of fibers that give concrete different qualities. In addition, different concretes, fiber types, geometries, distribution, orientation, and densities modify the nature of fiber-reinforced concrete. The use of fibers or reinforcement is not a new notion. Since ancient times, fibers have been employed as reinforcement. Horse hair was once used in mortar and straw was once utilized in mud bricks. Asbestos fibers were employed in concrete in the early 1900s. The concept of composite materials was born in the 1950s, and fiber-reinforced concrete was one of the hot issues. There was a need to find a replacement for asbestos Despite the fact that these tactics are sometimes practical and effective, they are often uneconomical or insufficient to achieve the desired goals. in concrete and other building materials after the health dangers linked with the substance were revealed. Steel, glass (GFRC), and synthetic fibers like polypropylene fibers were all employed in concrete by the 1960s. New fiber-reinforced concretes are still being researched. Fibers in concrete have an effect. Fibers are commonly used in concrete to prevent cracking caused by shrinkage of the plastic and drying shrinkage. They also reduce the permeability of concrete, resulting in less water bleeding. Concrete with certain sorts of fibers has higher impact, abrasion, and shatter resistance. The volume fraction refers to how much fiber is added to a concrete mix as a percentage of the overall volume of the composite (concrete and fibers) (V_f). V_f usually ranges between 0.1 and 3%. The aspect ratio (l/d) is obtained by dividing the length of the fiber (l) by the diameter of the fiber (d) (d). When calculating the aspect ratio of fibers having a non-circular cross section, an equivalent diameter is used. If the modulus of elasticity of the fibers is greater than that of the matrix (concrete or mortar binder), they aid to carry the load by enhancing the material's tensile strength. When the aspect ratio of the fiber is increased, the matrix's flexural strength and toughness are usually segmented. Overly long fibers, on the other hand, tend to "ball" in the mix and cause workability issues. According to current study, adding fibers to concrete has a minor impact on the material's impact resistance. This observation is significant since it contradicts popular belief that adding fibers to concrete promotes ductility. The findings also showed that micro fibers outperform longer fibers in terms of impact resistance.

In construction projects, blends of steel and polymeric fibers are frequently utilized to combine the benefits of both products: structural enhancements offered by steel fibers and resistance to explosive spalling and plastic shrinkage supplied by polymeric fibers. Steel fiber or macro synthetic fibers can completely replace traditional steel reinforcing bar ("rebar") in reinforced concrete in certain circumstances.

B. Properties Of Fiber Reinforced Concrete

The mechanical properties of concrete are influenced by the addition of fibers, which are highly dependent on the type and percentage of fiber. Fibers with a high aspect ratio were shown to be more effective. Crimped-end fibers can attain the same qualities as straight fibers while utilizing 40% less strands for the given length and diameter. Performance of any engineering materials depends upon its physical, mechanical properties, durability and cost. Studying properties of such material is, therefore, necessary.

1) *Compressive Strength:* Fibers have a negligible effect on the static compressive strength of concrete, with gains ranging from essentially none to perhaps 25%. Steel fibers have little effect on compressive strength in members with conventional reinforcement in addition to steel fibers. The fibers, on the other hand, significantly improve the material's post-cracking ductility or energy absorption.

2) *Tensile strength*: Fibers aligned in the tensile stress direction can result in significant gains in direct tensile strength, up to 133 % for 5% of smooth, straight steel fibers. The gain in strength for more or less randomly dispersed fibers, on the other hand, is significantly smaller, ranging from no increase in some cases to about 60% in others, with many studies finding intermediate values. The SFRC splitting-tension test yields comparable results. Adding fibers alone to boost direct tensile strength is therefore unlikely to be worthwhile. Steel fibers, like in compression, provide significant increases in the composites' post-cracking behavior or toughness.
3) *Flexural Strength:* Steel fibers are often found to have a far better influence on SFRC flexural strength than on either compressive or tensile strength, with increases of over 100 % observed. Increases in flexural strength are sensitive not only to fiber volume, but also to the aspect ratio of the fibers, with a higher aspect ratio resulting in a greater gain in strength.
4) *Modulus of Elasticity:* The modulus of elasticity of FRC increases slightly as the fiber content increases. It was discovered that each 1% increase in fiber content by volume results in a 3% increase in the modulus of elasticity.
5) *Other Properties:* Toughness, fatigue, strength, impact resistance, durability, torsion, shear, and other attributes of fiber reinforced concrete. When fibers are added to concrete, the toughness of the mixture is boosted by 10 to 40 times that of ordinary concrete. The addition of these fibers to concrete enhances the fatigue strength by around 90% and 70% of the static strength for non-reverse and complete reversal loading, respectively, at 2 x 10^6 cycles. The use of fibers also improves the impact resistance of concrete. Fibrous concrete has a 5 to 10 times higher impact resistance than normal concrete. The impact resistance, on the other hand, is mostly determined by the amount of fiber used. The inclusion of fibers eliminates the features of plain concrete beams that cause rapid failure. It improves stiffness, torsional strength, ductility, rotational capacity, and the number of cracks per unit area while reducing crack breadth. Concrete's shear characteristics are also affected by fibers. The addition of these fibers boosts the shear strength of reinforced beams by about 100%. Shear-friction strength, first fracture strength, and ultimate strength all improve with the addition of randomly distributed fibers.

A convenient parameter describing a fiber is its aspect ratio (L/D), defined as the fiber length divided by an equivalent fiber diameter. Typical aspect ratio ranges from about 30 to 150 for length of 6 to 75mm.

II. OBJECTIVES OF STUDY

The goal of this experiment is to see if fibrous concrete with variable aspect ratio steel fibers may be used to strengthen and retrofit reinforced concrete beams. As a result, any structure that needs to be repaired should take this strategy, which has the least amount of environmental impact, cost, and other construction-related constraints.

As a result, the goal of this research is to improve the ultimate performance of reinforced concrete beams while keeping both cost and operational constraints in mind. The following objectives have been identified for the study: **-**

1) To investigate the impact of adding steel fibers with varying aspect ratios to concrete strength qualities.
2) To investigate the impact of varied percentages of steel fibers on concrete strength parameters.
3) To look at the structural performance of steel fibrous beams and concrete beams in terms of first crack load, failure mode, and load deflection behaviour.
4) To compare the structural behaviour of steel fibrous reinforced concrete beams and the beams retrofitted with steel fibers, and to explore the structural performance of damaged concrete beams retrofitted with steel fibers.

III. TEST PROGRAM

The test program as follows was planned –

1) To determine the flexural strength of the beam and then to strengthen them with layer of steel fibrous concrete to evaluate its effects on the flexural strength of the beam.
2) To obtain the properties of constituent materials of concrete used in the investigation as per relevant Indian Standard codes. To design concrete mix for selecting reference mix.
3) To cast cubes, cylinders containing steel fibers of different aspect ratio with different percentages with above designed mix to determine the effect of steel fibers on the compressive and split tensile strength of concrete.
4) To cast plain concrete beams containing steel fibers of different aspect ratio with different percentages with above designed mix to determine the effect of steel fibers on the flexural strength of the beam and know the best aspect ratio and percentage of steel fiber to be used in retrofitting of reinforced concrete beams.

5) To load beam under monotonically increasing load till it fail in flexure.
6) To load beam which is retrofitted with layer of steel fibrous concrete till it fails.
7) To retrofit beam after first crack appears and then loading again.
8) To measure deflection of all beams.

These are the tests which will be performed in structural lab to measure the compressive strength of cubes, split tensile strength of cylinders and the flexural strength of beam and then, beam will be retrofitted and will measure its strength. Change in load carrying capacity, failure mode and deflections of all beams will be studied.

IV. METHODOLOGY

A. Design mix for M30 was Calculated

Materials	Water (liters)	Cement (kg)	Fine aggregates (kg)	Coarse aggregates (kg)
Quantity/m^3	174.87	361.873	693.741	1207.752
Ratio	0.450	1.00	1.92	3.3

Three trial mixes were prepared by making variation in w/c ratio and tested for compressive strength after 28 days of curing. Finally, the trial mix which gave the strength close to the characteristic strength was selected.

Trial mix	w/c ratio	Water(liters)	Cement(kg)	Fine aggregates(kg)	Coarse aggregates(kg)
Mix 1	0.450	174.87	361.873	693.741	1207.752
Mix 2	0.43	160	370	675	1200
Mix 3	0.42	160	380	711	1283

From the test results of trial mix 1, 2 and 3, suitable target mean strength which was closer to 38.25 MPa was arrived with trial mix 3 at w/c ratio of 0.42. So, trial mix 3 with cement content 380kg/m³ was adopted for study. Split tensile and flexural strength for this concrete mix was found to be 3.32MPa and 4.21Mpa, respectively.

S. No	Grade of concrete	Trial mix	Load at failure (kN)	Cube compressive strength(f_{ck}) N/mm²	Average Compressive strength N/mm²
1	M30	Mix 1	810	36	35.90
			813	36.13	
			807	35.86	
2	M30	Mix 2	833	37.02	36.76
			822	36.53	
			827	36.75	
3	M30	Mix 3	870	38.66	38.60
			862	38.31	
			873	38.80	

B. Tests for Compressive Strength of FRC

The above design combination was used to create all specimens. Cubes of 150mmx150mmx150mm were produced, cured for 28 days, and then tested for concrete compressive strength. The cubes were cast by altering the amounts of steel fibers with varied aspect ratios in the aforementioned mix design by volume. As previously stated, aspect ratios of 30 and 60 were used in this investigation. To investigate the effect of steel fibers on concrete compressive strength, three different volume fractions were chosen: 0.5%, 1% and 1.5%, respectively.

C. Tests for Split Tensile Strength of FRC

The Steel fibers' effect on the split tensile strength of concrete was also investigated. Cylinder specimens of 150mmX300mm were cast with steel fibers and cured for 28 days before the findings were determined. The specimens were also casted with two different aspect ratios, 30 and 60, in three different volume fractions for split tensile strength (0.5%, 1 % and 1.5%).

D. Tests for Flexural Strength of FRC

Since the influence of steel fibers on flexural strength was calculated experimentally for the use of steel fibers in retrofitting of reinforced concrete beams, Casting and curing of 100mmX100mmX500mm beams took 28 days. At varied volume fractions, the effects of steel fibers with different aspect ratios were found. When retrofitting reinforced concrete beams, the proportion of steel fibers employed when the flexural strength is at its highest should be used.

E. Strengthening of Beam

The use of layers of FRC to strengthen the beams (sets 2 and 3) was done. The concrete surface was roughened with rough sand paper and cleaned to eliminate any dirt and debris after 28 days of cure. After the surface was prepared, the epoxy resin was prepared according to the manufacturer's instructions. Fiber reinforced concrete was prepared according to the design mix with the maximum flexural strength predicted above, and 40mm layers of fiber reinforced concrete were bonded to the bottom of the beam with epoxy resin. 100 parts epoxy and 50 parts hardeners were mixed until a consistent colour mix was achieved. On the prepared concrete surface, epoxy glue was spread with a brush. Whole operation was carried out at room temperature. Concrete beams then cured for 28 days at room temperature before testing.

F. Loading Arrangement

Under two-point loading, the load was applied with the help of a hydraulic jack and a test cylinder plant. Because the jack only had a single point load, it was changed to a two-point load using a custom-built loading system consisting of a pair of sturdy mild steel channel sections welded face to face. A 25mm diameter roller was employed to apply load on the specimen. A roller was positioned under the channel portion to transmit the applied force to the beam specimen as a two-point load. Roller was constrained to the side of the room.

The weight was transferred using a 25mm thick plate on the roller. The specimen with the loading configuration is shown in Figure below. The applied load was measured with the help of a cylinder plant of 600kN capacity.

In set one beams ultimate load, deflection, slopes and crack pattern was studied. This set was reference set.

In second set of beams BW1 was wrapped with fiber reinforced concrete layer of 40mm bottom as discussed earlier. These were then cured for 28 days. After curing testing was done in the same manner as was done on reference beams. Ultimate loads, deflection, slope and crack pattern was noted at regular interval of loads.

In third set of beams BL1 beams were retrofitted. In this set beams were loaded prior to wrapping up to service load. Beam BL1 was first loaded till first crack appeared on it.

Processes of loading were same as that of earlier beams. After cracks appeared beam was retrofitted with fiber reinforced concrete layers on top and bottom. Epoxy resin was applied and then layers of FRC were applied on beam. These beams also cured for 28 days before testing. After curing beams were again given incremental load as given earlier. At equal interval of loads values of deflection, slopes and crack pattern was noted.

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V. RESULTS

To begin, a mix design was created by calculating the physical properties of materials, and then tests on three trial mixes were conducted to determine the compressive strength of cubes of size (150 mm * 150 mm * 150 mm), with trial mix number three proving to be the strongest and thus being used in all subsequent experiments.

Compressive strength, split tensile strength and flexural strength tests were carried out on concrete mixed with steel fibers of two different aspect ratios (i.e. 30 and 60) at different %ages of steel fibers (i.e. 0.5%, 1%, and 1.5%) by casting specimens of cubes, cylinders and beams respectively. It was observed that maximum strength is achieved when steel fibers of aspect ratio 60 were used at 1.5% by volume for compressive strength, split tensile strength and flexural strength respectively. Hence, this configuration was used to retrofit reinforced concrete beams in the further stages.

A. Effect of Steel Fibers on Compressive Strength of Concrete

After curing for 28 days, the specimens were allowed to dry and were tested for compressive strength. Table 4.1 shows the results obtained for the compressive strength of cubes with different %age of steel fibers at aspect ratio 30. It was observed that maximum increase in compressive strength was found to be 5.36% on the addition of 1% volume fraction of steel fibers in concrete.

Table 4.1- (Compressive Strength of FRC with Aspect ratio 30)

S. No	Grade of concrete	Volume fraction (V_f)	Ultimate load at failure	Cube compressive strength(f_{ck}) N/mm²	Average Compressive strength N/mm²
1	M30	0.5%	866.2	38.50	38.86
			882.0	39.20	
			875.2	38.90	
2	M30	1%	930.6	41.36	40.75
			918.0	40.80	
			902.2	40.10	
3	M30	1.5%	892.2	39.66	39.20
			871.8	38.75	
			882.1	39.20	

Table 4.2- (Compressive Strength of FRC with Aspect ratio 60)

S. No	Grade of concrete	Volume fraction (V_f)	Ultimate load(kN)	Compressive strength (MPa)	Average (MPa)
1	M30	0.5%	880.6	39.13	39.40
			875.2	38.89	
			904.6	40.20	
2	M30	1%	920.6	40.9	41.55
			934.4	41.5	
			950.2	42.2	
3	M30	1.5%	930.4	43.4	43.33
			983.2	43.7	
			965.2	42.9	

Table 4.2 shows the results obtained for the compressive strength of cubes with different %age of steel fibers at aspect ratio 60. It was observed that maximum increase in compressive strength was found to be 12.5 % on the addition of 1.5 % volume fraction of steel fibers in concrete. Variation in compressive strength of concrete at different %ages of steel fibers and different aspect ratio is shown and it was observed that the compressive strength achieved at every percentage variation of steel fiber is more for each specimen with aspect ratio 60 as compared to specimen with aspect ratio 30. Hence, it can be seen from above tables that the addition of steel fibers in concrete improved the compressive strength of concrete which may be due to the fact that addition of steel fibers improved the performance of concrete in terms of crack resistance and composite action between the concrete and steel fibers. Use of steel fiber in concrete increased the compressive strength by 4-19% by using the aspect ratios of 45, 60 and 80 respectively.

B. *Effect of Steel Fibers on Split Tensile Strength of Concrete*

The specimens were examined for split tensile strength after 28 days of curing. The split tensile strength of cylinders with varied %ages of steel fibers at aspect ratio 30 is shown in Table 4.3. When 1 % volume fraction of steel fibers was added to concrete, the maximum improvement in split tensile strength was found to be 18.07 %.

Table 4.3- (Split tensile strength of cylinders using Aspect ratio 30)

S. No	Grade of concrete	Volume Fraction (V_f)	Split Tensile Strength (N/mm^2)	Average split Tensile Strength (N/mm^2)
1.	M30	.5%	3.42	3.65
			3.65	
			3.88	
2.	M30	1%	3.70	3.92
			3.96	
			4.12	
3.	M30	1.5%	3.72	3.91
			3.86	
			4.16	

The split tensile strength of cylinders with varied percentages of steel fibers at aspect ratio 60 is shown in Table 4.4. The inclusion of 1.5 % volume fraction of steel fibers in concrete resulted in a maximum improvement in split tensile strength of 19.87 %. The addition of steel fibers to concrete boosted split tensile strength by 11-54 % when compared to the control mixture.

Table 4.4- (Split tensile strength of cylinders using Aspect ratio 60)

S. No	Grade of concrete	Volume Fraction (V_f)	Split Tensile Strength (N/mm^2)	Average split Tensile Strength (N/mm^2)
1.	M30	.5%	3.56	3.71
			3.82	
			3.76	
2.	M30	1%	3.74	3.96
			4.10	
			4.06	
3.	M30	1.5%	3.82	3.98
			3.94	
			4.22	

When compared to concrete without steel fibers, the split tensile strength of concrete with steel fibers increased dramatically, which could be attributable to the fact that tensile strength of concrete improves as the composite activity between steel fibers and concrete occurs.

1) Effect Of Steel Fibers On Flexural Strength Of Concrete

Table 4.5 shows the results for flexural strength of beams with various %ages of steel fibers at aspect ratio 30. It was discovered that the maximum improvement in flexural strength was

The inclusion of 1.5 % volume fraction of steel fibers in concrete increased the strength by 14.58 %.

Table 4.5- (Results of flexural strength of beams using fibers of Aspect ratio 30)

S. No	Grade of concrete	Volume Fraction (V_f)	Split Tensile Strength (N/mm^2)	Average split Tensile Strength (N/mm^2)
1.	M30	0.5%	4.37	4.38
			4.36	
			4.43	
2.	M30	1%	4.47	4.61
			4.82	
			4.54	
3.	M30	1.5%	4.80	4.95
			4.94	
			5.12	

Table 4.6 shows the results obtained for the flexural strength of beam with different %age of steel fibers at aspect ratio 60 and maximum increase in flexural strength was found to be 17.59 % on the addition of 1.5 % volume fraction of steel fibers in concrete.

Table 4.6- (Results of flexural strength of beam using fibers of Aspect ratio 60)

S. No	Grade of concrete	Volume Fraction (V_f)	Split Tensile Strength (N/mm^2)	Average split Tensile Strength (N/mm^2)
1.	M30	0.5%	4.32	4.41
			4.41	
			4.52	
2.	M30	1%	4.86	4.94
			4.92	
			5.04	
3.	M30	1.5%	5.12	5.08
			5.24	
			4.90	

C. Ultimate Load Carrying Capacity

The ultimate loads obtained from different sets of beams are shown in table 4.7. It was observed that the ultimate load increased when a layer of fibrous concrete is being applied at the bottom of the beams. An increase in 13.1 % in ultimate load value was observed with application of layer of fibers reinforced concrete at the bottom of strengthened beam. This increase in load carrying capacity of the beam may be attributed to the fact that layer of FRC has increased the flexural rigidity of beam and it can be concluded that use of fibers in concrete can be suggested for increasing the ultimate load carrying capacity of beam.

The ultimate load carrying capability of beams upgraded with FRC layer increased by 5.35 %. However, as compared to strengthened beams, the retrofitted beams show a smaller gain. Because of already established fractures, higher stresses were transferred to the fibrous concrete layer in reference beams, resulting in a reduction in load carrying capability.

Table 4.7- (Ultimate loads obtained from different sets of beams)

S. No	Beam	Pressure at failure (kg/cm^2)	Ultimate load (kN)	FRC layer	Load increased (%)
1.	Reference beam (BR2)	47.5	161	-	-
2.	Reference beam (BR1)	49.6	168	-	-
3.	beam with FRC layer (BW1)	53.8	190	At the bottom	13.1
4.	Beam retrofitted (BL1)	51.41	177	At the bottom	5.35

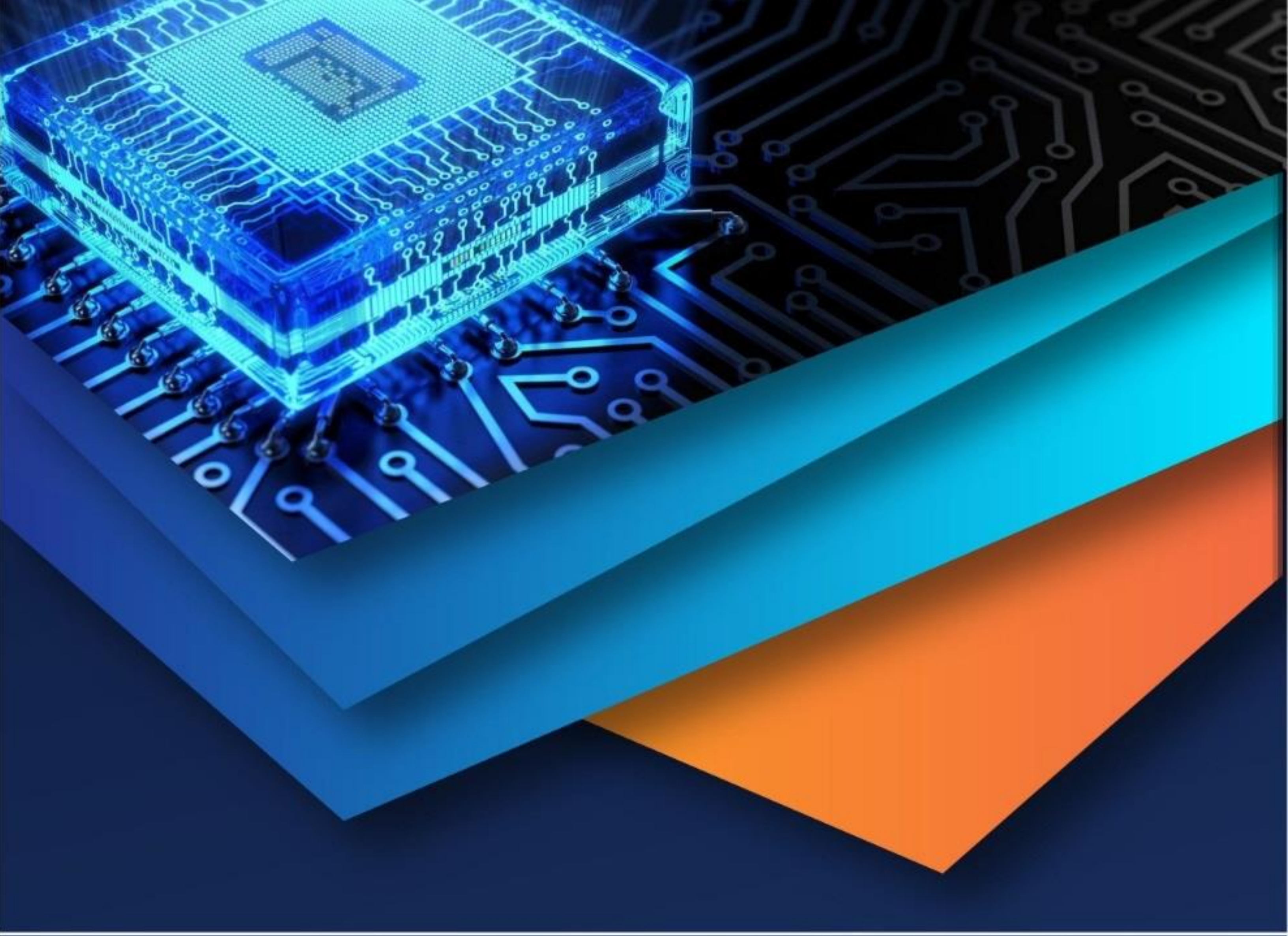
VI. CONCLUSIONS

The following are some of the findings of this research: -

A. The addition of steel fibers enhanced the compressive strength of standard concrete by as much as 12.25 %, and the greatest strength was found for aspect ratio 60 at a volume fraction of 1.5 %. As a result, steel fibers can readily be employed to boost concrete's compressive strength.
B. Experimental test findings also demonstrated a rise in split tensile strength. It was discovered to vary for different aspect ratios at different volume %ages of steel fibers, with the largest variance being 19.8% for aspect ratio 60 at 1.5 % volume fraction.
C. The addition of steel fibers to concrete improved the flexural rigidity of beams, resulting in greater beam flexural capacity. Maximum flexural strength was also reported to be attained at 1.5 % volume fraction of steel fibers at aspect ratio 60, with a maximum increase in strength of 20.66 % when compared to standard concrete specimens.
D. The findings of this study also revealed that steel fibers concrete layers can be employed to strengthen reinforced concrete beams with confidence. When reinforced concrete beams were strengthened with a layer of FRC at the bottom of the beam, the ultimate load carrying capacity increased by 13.1 %.
E. Adding a coating of steel fibers concrete to reinforced concrete beams increased the structural behaviour of the beam. When reinforced concrete beams were retrofitted with a layer of FRC, a 5.35 % increase was recorded.
F. During beam testing, a cracking pattern was also detected. When reinforced concrete beams were strengthened and refitted with steel fibers concrete, the appearance and propagation of cracks was delayed.

REFERENCES

[1] Abo-alanwar, M.M., Elbatal, S.A. (2015) 'A smart reinforced steel wire mesh U-shape jacketing technique in strengthening and retrofitting RC beams', International journal of engineering research and technology, 4(12), pp. 46-55.
[2] Ashteyat, A.M., Mekhlafy, N.A., Haddad, R.H. (2010) 'Repair of heat-damaged reinforced concrete slabs using fibrous composite materials', Construction and building materials, 25, pp. 1213-1221.
[3] Ayubbi, J., Sharbatdar, M.K (2015) 'An Experimental Study on the Flexural Retrofitting of the Partial Damaged Reinforced Concrete Beams by using High Performance Fiber Reinforced Cement-Based Composite (HPFRCC)', International journal of engineering science and technology, 4(2), pp. 847-851.
[4] Choi, W.C., Yun, H.D., Cho, C.G., Feo.L. (2013) 'Attempts to apply high performance fiber reinforced cement composite (HPFRCC) to infrastructures in South Korea', Composite structures, 109(), pp.211-223.
[5] Ferrari, V.J., Hanai, J.B., Souza, R.A. (2013) 'Flexural strengthening of reinforcement concrete beams using high performance fiber reinforcement cement-based composite (HPFRCC) and carbon fiber reinforced polymers (CFRP)', construction and building materials, 48, pp. 485-498.



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