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SFRC used RC Beam and its Increasing Torsional Strength

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Abstract: *Steel Fiber Reinforced Concrete (SFRC) is the most often employed method for improving the flexural, shear, and torsional properties of concrete in the modern era. It is capable of withstanding cracks and crack propagation. As a consequence of this capacity to arrest fractures, fiber composites may improve extensibility and tensile strength, both at the initial crack and at the final load, and fibers can help keep the matrix together after significant cracking. Steel fibers are short in length and are employed in concrete in proportion to their aspect ratio (i.e., the ratio of length to diameter); this ratio ranges from 20 to 100. Torsion is often associated with bending moment and shear force, and so the interplay of these forces is critical. Torsion occurs when a slab or beam is supported on just one side or when stresses acting transverse to the beam's longitudinal axis are applied. Numerous researchers have worked with SFRC to boost the flexural and shear capacities of the material, but the amount of work done on torsional strengthening is insignificant. This article introduces steel fiber, reviews prior experimental investigations on torsional strengthening, and compares the torsional strength and angle of twist of normal concrete and SFRC beams when varying percentages of steel fiber used.*

Keywords: Steel Fiber Reinforced Concrete, Cracks, Torsion

I. INTRODUCTION

Steel Fiber Reinforced Concrete is a mixture of cement, aggregates, water, and steel fiber. In the concrete mixture, fibers are evenly dispersed and randomly orientated. Concrete is a brittle material that works well in compression but poorly in tension, with a tensile strength around one-tenth that of its compressive strength. Steel reinforcement is employed to absorb these tensile stresses and, to a certain degree, prevent cracking. While adding steel reinforcement to concrete may greatly enhance its strength, in order to create concrete with homogenous tensile characteristics, micro-cracks must be addressed.

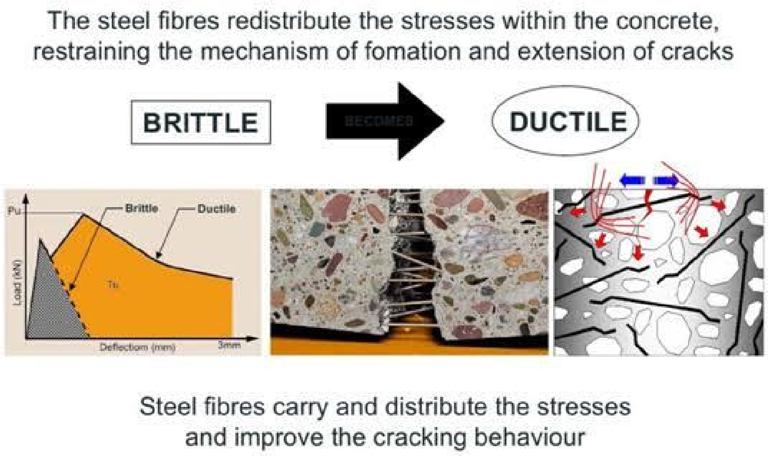

Figure 1: Crack arresting mechanism of Steel Fiber Reinforced Concrete

Steel Fiber is a widely used material for improving the mechanical properties of concrete, such as flexural strength, fatigue resistance, and impact resistance. The true benefit of randomly oriented, discontinuous steel fiber is its ability to span concrete fissures. Following matrix cracking, fibers arrest and confine these fractures. Additional forces and energy are necessary to take out or shatter the fibers in the event of further bending of the concrete. This increases concrete's load-bearing capability. Thus, the presence of steel fibers in concrete components enhances tensile strength, toughness and ductility as well as flexural and torsional strength.

II. Beam and Torsional Strengthening

Torsional moments are often increased in reinforced concrete beams by bending moments and shearing stresses. Torsion is used to structural elements such as curved girders, space frames, eccentrically loaded beams, spandrel beams in structures, and spiral staircases. Apart from flat rectangular forms, structural members may be T, L, or box shaped. These disparate forms complicate the understanding of torsion in RC members. No construction, including beams, is likely to be exposed to pure torsion or pure bending. When a beam is loaded transversely and the resultant forces pass through the longitudinal shear centre axis, the beam bends but does not twist; however, when the resultant operates eccentrically from the shear centre axis, the beam experiences a combination of bending and twisting. When a reinforced concrete (RC) beam without transverse reinforcement is exposed to a torsional moment, it might break prematurely in torsion before reaching its appropriate flexural strength. This breakdown occurs quickly and without any notice to people; as a result, it is often devastating. While both shear and torsion cause diagonal fractures in RC beams, the behaviour of RC beams exposed to torsion is distinct. Cracks propagate in the same direction on both sides of the beam owing to shear, while spiral cracks propagate in the opposite direction on both sides of the beam due to torsion.

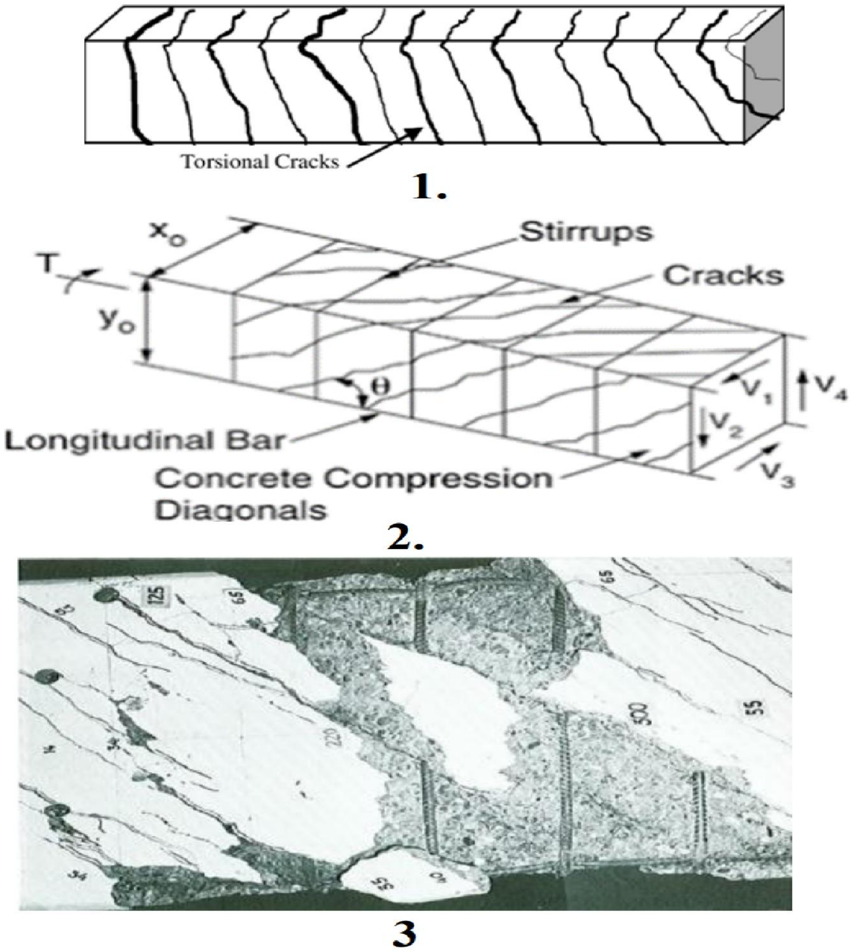

Figure 2: Torsional Cracks

III. STEEL FIBER REINFORCED CONCRETE (SFRC)

SFRC is a composite material composed of concrete, aggregates, water, and steel fiber. Its primary benefit is that it may enhance the mechanical properties of concrete. According to ASTM A820, steel fibers are classified into four categories.

Those are:

1. Cold-drawn wire
2. Cut sheet
3. Melt-extracted
4. Other fibers

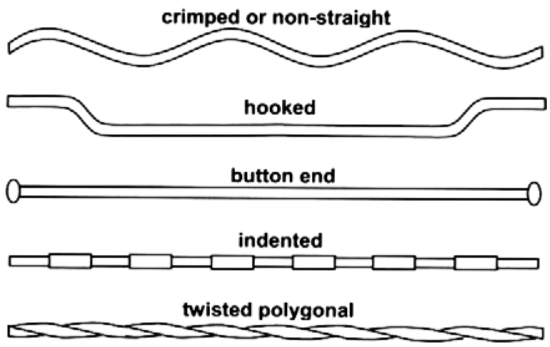

Figure 3: Various steel fiber geometrics

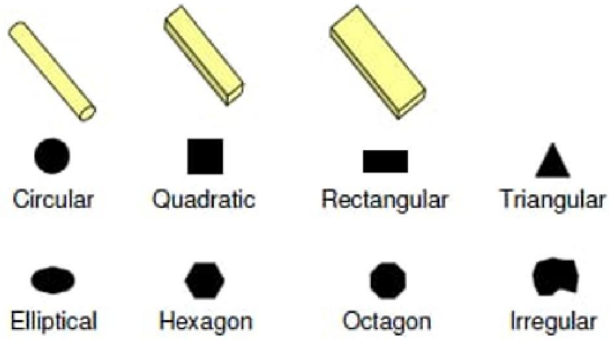

Figure 4: Various Cross sections of steel fibers used in FRC

Steel fibers may have circular, rectangular, or triangular cross sections. The primary objective of steel fiber reinforced concrete is to improve the mechanical and ductility properties of the material. Steel fibers are often used to increase the ductility of fragile plain concrete. Increased ductility and energy dissipation are especially advantageous for constructions subjected to earthquake loads. By converting brittle to ductile material, the energy absorption qualities of the fiber composite are significantly improved, as is its capacity to endure repeated shock or impact loading. When no steel fiber is introduced to the concrete, the failure will be severe, but when steel fiber is added, the fibers will disperse energy after post pick, converting the concrete to a ductile material.

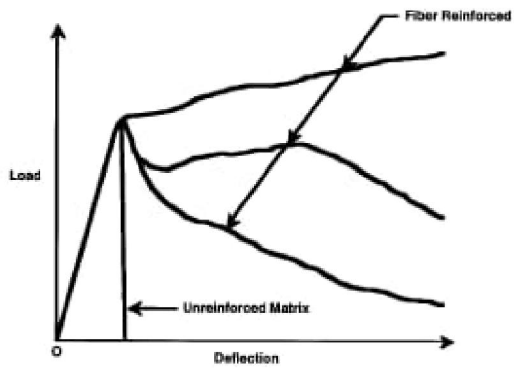

Figure 5: Load-deflection between plain and steel fiber concrete

IV. Literature Review and Experimental Study

Rautand Kulkarni examined the torsional behaviour of Steel Fiber Reinforced Concrete (SFRC) beams in comparison to conventional reinforced concrete (NRC) beams. Under pure torsion, the torsional moment and twist angle of steel fiber reinforced concrete and standard reinforced concrete beams were investigated. The proportion of fibers added to the concrete ranged between 0% and 1% by volume. Steel fiber's aspect ratio was maintained at 38. A total of fifteen beams were cast. All beam specimens have been subjected to two-point loading until the beam failed due to twisting. They discovered that the torsional strength of SFRC beams improved by 47.27 percent, a considerable improvement in concrete strength when compared to ordinary RC beams. Additionally, the steel fiber reinforcement succeeded in increasing the beam's stiffness by reducing the angle of twist of the strengthened beam as compared to a straight RC beam.

Arvind et al. and Kanase Jayant S [1] conducted an experiment in which they used three different fiber percentages: 0.5 percent, 1%, and 1.5 percent. Their experiment included the use of glass fibers. The experimental programme will include the casting of five reinforced concrete beams with dimensions of 150mm X 150mm and a length of 2m. The longitudinal reinforcement and shear stirrup spacing were maintained constant. Their investigation revealed that the use of fiber significantly improved the torsional strength of an RC beam exposed to pure torsion. The maximum breaking torsional strength of was 1.5 percent fiber, which represents a considerable improvement in concrete strength as compared to traditional RC Beams. Twist angle was also reduced when fiber was used.

Sameera Khan [4] studied the behaviour of cylindrical composite beams made of M20 grade concrete with a cross sectional area of 100 cm2 and a length of 50 cm with a fiber content of different percentages under combined flexure, torsion, and shear states. Straight fibers with an aspect ratio of 100 were employed with a length of 28 mm and a diameter of 0.28 mm. Twelve cylindrical beams were produced with fiber percentages of 0, 0.5.0.75, and 1% by weight. It had been noticed that when torsion increased, the value of ultimate bending strength and deflection dropped. For a fiber content of 1.00 percent, the maximum bending stress decreased by a maximum of 26.66 percent from 7.095 N/mm2 to 5.203 N/mm2, as the torsion applied rose from 0 Nm to 320.44 Nm.

S. B. Kandekar and R. S. Talikoti [24] strengthened reinforced concrete (RC) beams with aramid fiber strips to improve their torsional behaviour. Different patterns of aramid fiber strips were chosen to wrap around RC beams, and the wrapped beams' torsional behaviour was investigated. The beam measured 150 mm 300 mm in diameter and 1.3 m in length. A total of 21 rectangular reinforced concrete beams were cast. They discovered that reinforced beams had a greater capability for bearing torsional moments than regulated beams. In the case of wrapped beams, first fractures emerge at higher times. The reinforced beam wrapped in 150 mm aramid fiber strip with a 100 mm spacing was determined to have the highest moment bearing capability of all the beams. Wrapping all samples with aramid fiber strips enhances the ability of the samples to carry torsional moments. When the strip spacing was increased, the ability to transport torsional moments diminished with slight fluctuations in the angle of twist.

Karim et al. [21] studied the influence of concrete cover on the behaviour of rectangular solid beams made of ultra-high performance fiber reinforced concrete in pure torsion. The primary restriction in this study was the thickness of the concrete cover, which ranged from 21 to 52 mm. Four rectangular solid beams under-reinforced with ultra-high performance fiber reinforced concrete were cast and tested in pure equilibrium torsion. The test findings verified that the torsional resistance at peak and fracture loads were increased to 113 and 134 percent, respectively, of the value calculated using thin-walled tube theory. Additionally, it was shown that the twisting angle at maximum load and shear strain in concrete decreased by up to 64.9 percent and 40.1 percent, respectively. Additionally, both longitudinal reinforcement and stirrup strain were decreased by up to 50%.

Hameed et al. [3] investigated the torsional behaviour of reinforced beams reinforced with steel fibers when subjected to pure torsion. A total of four beams includes one conventional beam and three steel fiber-reinforced beams. The beams cast were 0.15m 0.20m 2.00m in size. The percentage volume of hooked steel fiber in the concrete was changed between 0.0 percent, 0.5 percent, 0.75 percent, and 1%. The experimental results indicate that when steel fibers are added to normal reinforced concrete beams, the ultimate Torsional strength increases by (28.55 percent), (38.09%), and (49.46 percent) for specimens with (0.5 percent, 0.75 percent, and 1%) volume fraction of steel fiber, respectively, when compared to the control beam. Additionally, the data indicate that the angle of twist reduced by (35.17%), (60.88%), and (52.62%), correspondingly.

Mohammad Rashidi and Hana Takhtfiroozeh [25] examined the torsion strength effects of transverse and longitudinal reinforcement. Four beams of identical length and concrete mix design were tested. Each beam had been reinforced with a variety of various methods of reinforcement. The ductility factor was shown to rise as the percentage reinforcement from the test findings increased. Torsional strength and ductility of beams reinforced with transverse and longitudinal bars were enhanced by 95% and 50%, respectively, in comparison to unreinforced beams.

Naveen Sure [27] investigated the torsional strengthening behaviour of solid RC flanged T-beams. The purpose of this research is to determine the efficiency of using epoxy-bonded GFRP textiles as external transverse reinforcement in torsion-resistant reinforced concrete beams with flanged cross sections (T-beam). Eleven medium-scale reinforced concrete beams with a total length of 1900 mm were fabricated for this study. The shaped beams were subjected to combined bending and torsional pressures. Three beams were evaluated without torsional reinforcement as control specimens, and eight beams were reinforced externally using epoxy-bonded glass FRP textiles. The investigation revealed a substantial influence of flange width on the torsional capacity of GFRP reinforced RC T-beams. For 900 totally wrapped arrangements, the highest torque gain was achieved. Increase in strength was determined to be 13% for 250 mm wide flanges, 29% for 350 mm wide flanges, and 69% for 450 mm wide flanges. Beams clad with 900-oriented GFRP stripes demonstrated the least torsional resisting ability. Torsion would be poorly resisted in the case of U-jacketing strengthening, since shear flow stresses follow a tight route under torsional loading.

C. E. Chalioris [26] investigated the torsional response of reinforced concrete (RC) beams modified with external transverse carbon fiber-reinforced polymer (FRP) strips. The experimental programme consists of eight rectangular cross-section beams subjected to pure torsion. The torsional moment at cracking and ultimate strength, as well as the behavioural curves of the beams, are used to draw meaningful inferences about the success of the FRP strengthening approach. Each group consists of four individuals. Two of the beams were reinforced externally transversely using epoxy-bonded carbon FRP strips wrapped around the rectangular cross-section of the beams. All specimens examined had the same longitudinal reinforcement. It was noticed that the torsion and angle of twist of the retrofitted beam always enhanced the control beam.

V. RESULTS

The results obtain from [2] are:

TABLE I: TEST RESULTS

Beam Type	Fiber Fraction (%)	Ultimate Load (kN)	Torsional Moment (kN.m)	Angle of Twist (rad/m)
CB	0	5.50	1.826	0.03333
SFRC 1	0.25	5.70	1.892	0.0364
SFRC 2	0.50	6.75	2.241	0.0349
SFRC 3	0.75	8.10	2.689	0.0616
SFRC 4	1	7.05	2.341	0.0540

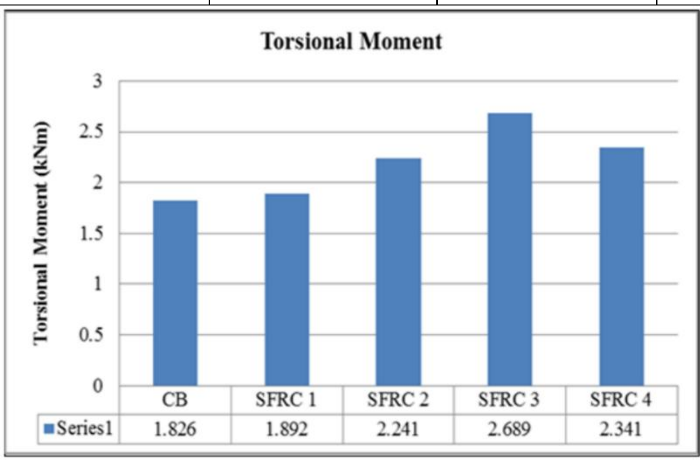

Figure 6: The torsional strength for steel fiber reinforced strengthened beam with respect to the control beam

They had found out that the torsional strength of SFRC beams had increased up to 47.27% which was very significant increase in the strength of concrete compared to conventional RC Beam. The 0.75% of steel fiber fraction gives the more comprehensive results in terms of strength and twisting angle over other percentage of fiber fractions.

The results obtain from Karim et al. [21] are:

TABLE III: Results of pure Tortional Test in UHPFRC Beams

Beam	Concrete cover, mm	Torsional resistance at crack load, kN.m	Twisting angle at crack load, rad/m X 10-3	Torsional resistance at peak load, kN.m	Twisting angle at peak load, rad/m X 10-3	Inclination of crack at failure, degree
B-1-UH	21	12.11	5.655	24.96	37.28	42
C-1-UH	21	15.329	2.163	25.287	30.636	46
C-2-UH	31	12.803	1.831	28.678	26.146	50
C-3-UH	52	28.337	0.645	53.351	10.733	52

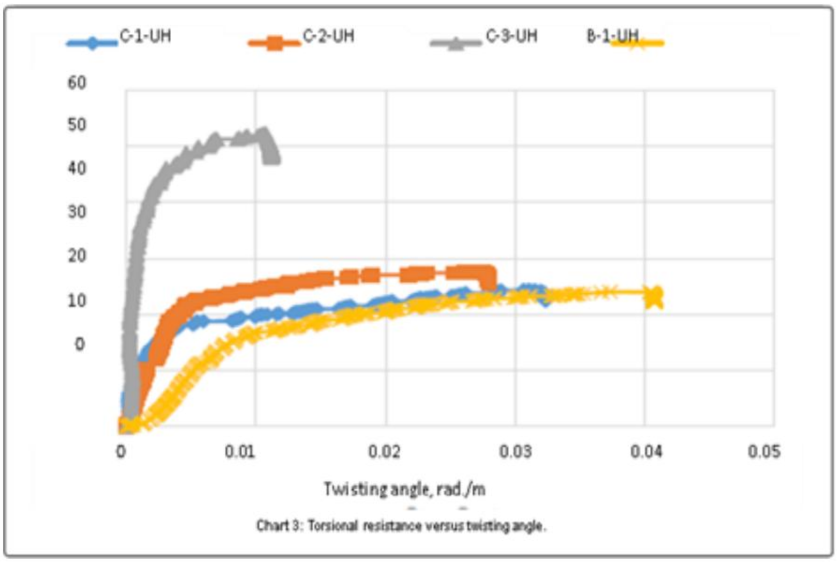

Figure 7: Torsional resistance versus twisting angle

VI. Conclusion

The Following observations has been drawn from these studies:

- It was noticed that when fiber percentages increased, the cracking torque capability increased as well.
- The energy dissipation property of steel-fiber is the primary reason for absorption of the increased torsional moment in order to increase the beam's torsional strength.
- Steel Fiber reinforcing has also been successful in increasing the beam's rigidity by reducing the angle of twist.
- Torsion spiral fractures propagate perpendicular to the path of propagation on opposing sides of the beam.
- As the percentage of fiber in the concrete increases, the workability of the concrete diminishes.
- Ductility also rose as the fiber fraction increased.

REFERENCES

[1]. Kumar, A., Mohan, M., Rajesh, D. V. S. P., &Kulkarni, P. (2015). Behaviour of Fiber Reinforce Concrete Beam in Pure Torsion. International Journal of Research in Engineering and Technology, 4(5), 551-556.

[2]. Raut, L. L., &Kulkarni, D. B. (2014). Torsional strengthening of under reinforced concrete beams using crimped steel fiber. International Journal of Research in Engineering and Technology, 3(6), 466-471.

[3]. Hameed, A. A. (2018). Torsional strength of steel fiber reinforced concrete beams. Technology, 9(6), 1388-1396.

[4]. Khan, S. (2017). Performance of steel fiber reinforced concrete specimens under the combined state of flexure, torsion and shear, varying its geometry. Int. J. Civ. Eng. Technology, 8, 1034-1043.

[5]. Rao, T. G., &Seshu, D. R. (2006). Torsional response of fibrous reinforced concrete members: Effect of single type of reinforcement. Construction and Building materials, 20(3), 187-192.

[6]. Ramadevi, K., &Venkatesh Babu, D. L. (2012). Flexural Behavior of Hybrid (Steel-Polypropylene) Fiber Reinforced Concrete Beams. European Journal of Scientific Research, 70(1), 81-87.

[7]. Raut, L. L., &Kulkarni, D. B. (2014). Torsional strengthening of under reinforced concrete beams using crimped steel fiber. International Journal of Research in Engineering and Technology, 3(6), 466-471.

[8]. Senthuran. T & Sattainathan S. (2016). Experimental Study on Torsional Behaviour of Crimped Steel Fiber Reinforced Beam, International Journal of Engineering Science and Computing, 6(4), 3950- 3953.

[9]. Ismail, M., & Fehling, E. (2016, July). On the Steel Fiber Efficiency of UHPC Beams Subjected to Pure Torsion. In International Interactive Symposium on Ultra-High Performance Concrete (Vol. 1, No. 1). Iowa State University Digital Press.

[10]. ACI Committee. (2008). Building code requirements for structural concrete (ACI 318-08) and commentary. American Concrete Institute.

[11]. Ghobarah, A., Ghorbel, M. N., &Chidiac, S. E. (2002). Upgrading torsional resistance of reinforced concrete beams using fiber-reinforced polymer. Journal of composites for construction, 6(4), 257-263.

[12]. Chalioris, C. E. (2008). Torsional strengthening of rectangular and flanged beams using carbon fiber-reinforced-polymers–Experimental study. Construction and building materials, 22(1), 21-29

[13]. Gupta, S., Kumar, V., &Jaisawal, A. Investigation of Incompressible Flow Past Two Circular Cylinders of Different Diameters.

[14]. Qasim, O. A. (2018). Perlite Powder and Steel Fiber Effects on Properties of Light Weight Concrete. Technology, 9(1), 371-387.

[15]. ASTM, A. (2006). Standard specification for steel fibers for fiber-reinforced concrete.

[16]. ASTM, S. (2009). Standard specification for deformed and plain carbon-steel bars for concrete reinforcement. ASTM A615/A615M-09b.

[17]. Shafiq, N., & Akbar, I. A Review of Combined Flexure, Shear & Torsion Strengthening of Reinforced Concrete Beam.