ABSTRACT

The concept of using fibers in a brittle matrix was first observed with the ancient Egyptian work. Animal hairs and straw were used as reinforcement for mud bricks and walls in housing. In the past two decades serious consideration has been given to use of fibers in the conventional moldable construction materials like asbestos gypsum plasters, cement plasters and concretes to improve performance. The use of fibers imparts ductility to the concrete and delays its catastrophic nature of failure. The process of fiber pull out absorbs lot of energy and imparts higher toughness and impact resistance of concrete. Remarkable improvements in tensile strength, cracking characteristics, fatigue resistance and abrasion resistance are observed in RCC beams due to addition of fibers. In last decade, FRC has proved its worth as a cost effective and innovative construction material for large durability. Various types of synthetic fibers, acrylic, carbon, nylon, polyester, polyethylene, and polypropylene fibers apart from steel have found their way in forming vibrant FRC. Polypropylene, Steel and Hybrid (Steel & Polypropylene mix) Fibers are used in the present research work.

Generally, the shear failure of a Reinforced concrete beam is directly related to the diagonal tensile cracking that develops in the direction, perpendicular to the principal tensile stress axis. Once tensile cracking occurs, the tensile stress at the crack surface rapidly softens the concrete. This significantly reduces the shear strength of the beam. According to existing experimental results, the addition of fibers effectively improves the shear strength of concrete. This is because the fibers can transfer tensile stress effectively across crack surfaces by generating crack tip forces, which is called the crack-bridging stress.

IS 456: 2000, along with other various codes of different countries, classifies the beam into three categories; namely Shallow Beam, Moderate Deep Beam, and Deep Beam, according to their effective span (L) or shear span (a) to overall depth (D) ratio. In general, it can be classified as 1) Shallow Beams (L/D ≥ 6.0) or (a/D≥2.5), 2) Moderate Deep Beams (2.0 ≤ L/D ≤ 6.0) or (1 ≤ a/D < 2.5), 3) Deep Beams (0.5 ≤ L/D ≤ 2.0) or (a/D < 1.0).

Moderate Deep Beams are widely used in various important structures such as nuclear reactors, water tanks, halls, hotels, complex foundations, offshore structures, corbels. Therefore an attempt has been made through the experimental study to understand the complex but most significant shear response and cracking characteristics such as crack patterns & crack width profile of such beams under fibrous matrix.

Total eighty eight (88) numbers of Fiber Reinforced Cement Concrete beams were tested with simply supported conditions having an effective span of 1200 mm. The Length of the beams (1300 mm) and width of the web (150 mm)
were kept constant. The beams were divided into four series having depths of 300 mm, 400 mm, 500 mm and 600 mm respectively. Forty eight (48) numbers beams of were tested under symmetrically placed two point loading and Forty (40) numbers of beams were tested under single central point loading.

The aim of the present investigation is to provide a systematic and comprehensive study on the cracking characteristics with respect to crack width & crack patterns as well as shear strain distribution in Fiber Reinforced Cement Concrete Moderate Deep Beams. In course of investigations, three empirical equations are suggested to estimate the shear strength of Fibrous Moderate Deep Beams using different types of fibers and four empirical equations are suggested to calculate the maximum crack width for different Fibrous Moderate Deep Beams.

The graphs plotted for the variation of shear strain at top surface and at in-depth surface along the vertical axes in shear zone show D shape of strain distribution. This is in good agreement with the theoretical shear stress distribution of parabolic nature along the vertical axes of the beam.

In all the beam specimens, initiation of flexure cracks was from the bottom of the beams. In most of the cases, all the flexure cracks were almost vertical in flexure zone. The most of the shear cracks were inclined in shear zone and their direction of propagation was towards the nearest load point irrespective of its place of origin. Beams of series D30 and D40 (having L/D ratio 3 & more) failed in pure flexure failure by yielding of longitudinal tensile reinforcement. Beams of series D50 (having L/D between 2 to 3) failed in flexure-shear mode. Beams of series D60 (having L/D less than 2) failed in pure shear failure. It is observed that the inclination of predominant crack has been changed from 60° to approximately 45° due to increase in a/D ratio by 50%.

By the detailed analysis and its results, it can be concluded that fibers can be the best alternative solution to avoid congestion of reinforcement along with crack arresting mechanism especially at the beam-column junctions where more shear reinforcement is required.

In the present investigation, it is observed that Ultimate shear strength of Fibrous Moderate Deep Beams without web reinforcements (stirrups) is 70 to 75 % more than that of the RCC Moderate Deep Beams without web reinforcements. This shows that shear reinforcement in the form of stirrups can be effectively partially replaced by fibers with proper design.

The Ultimate Shear load and maximum crack width calculated by the proposed empirical formulas shows good agreement with the test results of the Fibrous Moderate Deep Beams.