ABSTRACT

In General, Reinforced Cement Concrete (RCC) Beams are classified into three categories, on the basis of span to depth (L/D) ratios. Namely Shallow Beam, Moderate Deep Beam, and Deep Beam. According to as per IS 456:2000 clause 29.1 (Page 51). Deep Beam ratio of Effective span (Le) to overall Depth (D) 2 for Simply supported beam and 2.5 for Continuous Beam. In General, it can be classified as (**1**) Shallow Beams ($L/D \geq 6.0$) or ($a/D \geq 2.5$), (**2**) Moderate Deep Beams ($2.0 < L/D < 6.0$) or ($1 \leq a/D < 2.5$), (**3**) Deep Beams ($0.5 < L/D \leq 2.0$) or ($a/D < 1.0$).

In Ancient Egyptian construction work, Animal hairs and straws were used in mud bricks in house wall. Since last two decade the various types of Fibers used in Civil construction as per the requirement of structural members. The Fibers imparts Ductility to the concrete. In Fibrous concrete, Fiber arrest crack and reduce rate of propagation. Fiber helps in controlling the catastrophic failure of the structure. The process of Fiber pulls out absorbs lot of energy. It imparts higher toughness and impact resistance to the concrete. By adding fibers in concrete, it improves the Tensile strength, Fatigue resistance, Resistance to abrasion, Resistance to cracking in RCC beams. From Durability aspect Fiber Reinforced concrete proved to be most cost effective and innovative construction material. The types of synthetic fibers such as Acrylic, Carbon, Nylon, Polyester, Polypropylene and Steel are used in construction. In Present Research work the Steel Fibers and Polypropylene are used in casting of test specimens of Moderate Deep Beams.

To achieve the accurate and more realistic result of Shear strength of Moderate Deep Beam, the innovative parameter as "Size Effect" is incorporate in Theoretical Equation developed by several Researchers. The Ultimate shear stress decreases, when Depth of the beam increases. It happens due to size effect parameter present in structures. When load applied to beam the Shallow beam fails in Flexure mode. The Moderate deep beam fails in Flexure-shear mode and Deep beam fails in Shear mode. Moderate Deep Beams are widely used in various

important structures such as Nuclear Reactors, Water tanks, Halls, Hotels, Complex foundation, Offshore structures and Corbels.

In Present Research work, during testing various data were recorded related to Deflection of Beam, First Cracking load, Crack patterns and Crack width and Shear strength of Beam to understand the Influence of Size effect parameter in concrete. The Size effect parameter such as Longitudinal reinforcement ratio (ρt), Shear reinforcement ratio (ρw), Steel rebar arrangement, Grade of steel (fy), Grade of concrete (fck), Steel stress (fs), Strain in rebar (εs), Strain in concrete at level of reinforcement (εc),Concrete cover (Cc), Bond factor between steel and concrete at the level of reinforcement, Duration of load application, Modular ratio (m), Diameter of bar to Percentage of Reinforcement (Φ/ρ), Strain distribution factor, Shear span to Depth ratio (a/d), Effective length to overall depth ratio (Le/D), Modulus of Elasticity of steel (Es), Fiber Aspect ratio (diameter/length), % of Fiber reinforcement, Depth of neutral axis (xu), Maximum bar spacing (s) etc.

Generally, the Shear failure of a Reinforced concrete Moderate beam is directly related to the Diagonal Tensile crack. The crack develops in the direction perpendicular to the Principal Tensile Stress axis. Concrete has low tensile strength. Crack occurs in tension zone of concrete section. This significantly reduces the shear strength of the Moderate Deep beam. According to various Researchers' experimental test results, the addition of fibers effectively improves the shear strength of concrete. It was observed that the Fibers can transfer tensile stress effectively across crack surface by generating crack tip forces, which is called the crack bridging stress.

Total 75 beams had been casted and tested under central point load and two-point load to find the shear strength of the Moderate Deep beam. The test specimen consists of 21 number Moderate Deep beam having effective span to overall depth ratio 2 (i.e. L/d =2). All these 21 numbers of beams having three series of beams. Each series consist of 7 beam having depth ranging from 150 mm to 600 mm and span 300 mm to 1200 mm. Plain concrete (R), Reinforced cement concrete (RL) and Fibrous concrete (RLF).Each beam having reinforcement ratio

0.3 % and anchored at end with the length of 0.8 Ld. Beam sizes are selected as per Bazant 's size effect laws, which are given as, Minimum Width(b) and Depth (d) > 3 x da.(da = size of aggregate) Provided Width(b) = 75 mm >(3 x da = 3 x 20 = 60mm), Provided Depth(D) = 150 mm >(3 x da = 3 x 20 = 60mm), Largest Depth(D) $\nless$ 10 x da,Provided Largest Depth (D) = 600 mm> (10xda= 10 x 20 = 200mm) The ratio $\frac{\text{Largest Depth}}{\text{Smallest Depth}} = 4$ Provided Ratio = $\frac{600}{150}$ =4 d/da = 4,8,16 Acceptable and d/da = 3,6,12,24 Preferable. All specimen should be Geometrical similar in two direction with third dimension kept constant. Span = Varying, Depth = Varying and Width = Constant. Width of all the beams (b) were kept constant as 75mm. That means L/d and a/d ratio remain same for all specimens.

The test specimen consists of 24 number Moderate Deep Beam having effective span to overall depth ratio 3 (i.e. L/D =3). The test specimen consists of Fibrous RCC (10 number) and Fibrous Layered RCC (14 number). Beams have depth ranging from 100 mm to 400 mm and effective span ranging from 300 mm to 1200 mm. Each series having different types of concrete Moderate Deep beam i.e. Fibrous RCC and Fibrous Layered RCC Beam.

An experimental work was tested on 30 number of Moderate Deep beams which were divided in 3 series i.e. RCC Moderate deep beams (10 Number), PFRC (Polypropylene Fiber Reinforced concrete) Moderate deep beams (10 Numbers) and SFRC (Steel Fiber Reinforced Concrete) Moderate deep beams (10 Numbers). In each group, size differs from 700mm to 1500mm in span and 150mm to 400mm in depth. Bearing plates having size 75 mm length x 75 mm width x 6 mm thickness for a/d ratio 1 and100 mm length x 75 mm width x 6 mm thickness plates For a/d ratio of 2 placed at the loading points and at the supports. Concrete cover to reinforcement provided as 25 mm.

The aim of the present Research work is to Evaluate the size effect parameter. The Size effect parameter is incorporated in Shear Strength Equation by using statistical data and Regression Analysis. In course of investigations, Five Empirical Equations are modified by incorporating Size effect parameter for RCC and Fibrous Moderate Deep Beam. The Size effect parameter terms as constant

lemada (λ) and d/da incorporate in Prof. P. J. Robbins shear strength formula. After incorporating the Size effect parameter, the Ultimate shear strength is almost nearer to with the experimental results. The Ultimate shear strength v/s Depth graphs were plotted to compare the test results. Similarly, the Depth(d) and Characteristic Compressive Strength (fck) parameter incorporate in S. N. Patel and S. K. Damale 's equation.

The Size effect parameter in terms of Shear span to Depth ratio (a/d), Compressive strength of concrete (fck) for RCC beams and Volume of Fiber (V_f) and Aspect ratio (lf/df) for PFRC and SFRC beams incorporate in Original equation given by Eurocode-02:2004. The Size effect parameter as Shear span to depth ratio (a/d), Longitudinal reinforcement ratio (ρ), and Effective length to overall depth ratio (le/D) incorporate in Canadian Structural Association code formula (CSA A23.3-04). In Modified shear strength equation Size Effect parameter incorporate by using Regression Analysis. Finally, The Modified Shear strength results compares with experimental results. The experimental load and theoretical load are almost in close range and its ratio is nearer to unity.

In all the test Beam specimens, Initiation of flexure crack was from the soffit of the beam. In most of the cases, All the flexure cracks were almost vertical in flexure zone. Most of the shear cracks were developed at D/3 depth of the beam along the load path line joining the application of load point and support point. It propagates along this inclined path in shear zone. The shear strength of concrete improves by adding fibers in concrete.

Gergly and Lutz formula used to find crack width. Size effect parameter in terms as Le/D (effective length to Depth ratio), Percentage of Fiber reinforcement and Ratio of Diameter of reinforcement to Percentage reinforcement Φ/ρ were incorporate in Gergly and Lutz formula and compare the crack width experimentally and theoretically in RCC, PFRC and SFRC Beams. By incorporating Size effect parameter in Modified Gergly and Lutz equation crack width almost in close range with experimental crack width for RCC, PFRC and SFRC Moderate Deep Beams. Size effect parameter play the vital role in Design work.