Review Paper on to Investigate the Experimental and Analytical Study on Shear Strength of R.C Deep Beam using fibers.

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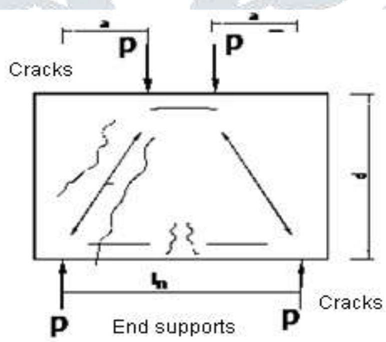
***Abstract*: This paper provides a review of some of the progress in the area of Shear strength of R.C Deep Beam using fibers. The addition of fibers in R.C Deep beam improves its shear strength and replace shear reinforcement of R.C Deep Beam. The addition of fibers not only improve compressive strength but also improves the tensile strength of R.C Deep Beam.**

***Index* Terms– R.C. Deep Beam, shear span, shear strength, steel fibers, polypropylene fibers, glass fibers, volumetric fraction** (Vf)

I INTRODUCTION:

- The Beam is considered as deep, if the depth of beam is comparable to the span of the beam. According to IS-456 (2000) Clause 29, a simply supported beam acts as a deep beam when the ratio of its effective span (L) to overall depth (D) is less than 2.0 and that for continuous beam this ratio is less than 2.5. The effective span is defined as the centre to centre distance between the supports or 1.15 times the clear span whichever is less. ACI code 318 classifies the beam as a deep beam for flexural if the clear span / Overall-depth ratio is less than 1.25 for simply supported beams and 2.5 for continuous beams. Deep beams with a small shear span to effective depth ratio could carry much greater shear force. These beams are used in building structures, such as transfer girders, folded plates and cap beams. The failure mode of deep beams is usually shear failure rather than flexure failure. It has been widely shown that the shear capacity of RC deep beams increased as the strength of the concrete increased. Because of their proportions i.e. span to depth ratio and shear span to depth ratio, they are likely to have strength controlled by shear. For deep beams a significant part of the load is transferred directly from the point of application to the supports by diagonal compression strut.(Ref Figure 1)



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Where d is depth of beam and P is the point load acting at a distance ‘a’ from the support.ln is the centre to centre distance between the supports.

- In this review paper, review of an experimental study will be carried out different authors for investigating the increase in shear strength of R.C, Deep Beam using fibers.

II. LITERATURE REVIEW

Abolfazl Arabzadeh (2020) investigates experimental and analytical results of 43 deep beams with span -to -depth ratio of less than 3,with different reinforcement arrangements and boundary conditions. Results indicated that, boundary conditions have important effects on ultimate loads, modes of failure and deflections; but crack formation and their patterns are almost the same irrespective of applied boundary conditions. Furthermore, the ultimate loads of the beams with fixed ends are 1.2–6 times of simply supported and continuous deep beams, depending on amount of main bottom and top reinforcements. Furthermore, in fixed -end deep beams, modes of failure and ultimate loads mostly depend on top main reinforcement whereas in continuous and simply supported beams both modes of failure and ultimate strength depends on bottom main reinforcement. However, the methods proposed by ACI 318–14 and CIRIA Guide 2 yielded very conservative results for simply supported deep beam. Results indicated that, none of existing methods is suitable for fixed- end deep beams, except proposed method.

Bantumilli Satya& et. al (2020) investigates the behavior of 4 deep beams prepared by varying the percentages of horizontal and vertical shear reinforcement. Different parameters like percentage of horizontal shear reinforcement, vertical shear reinforcement, and shear span depth ratio, web reinforcement was studied and validated analytically through ABAQUS software. The load-carrying capacity of fiber-reinforced deep beam is comparatively greater than the first conventional deep beam. STM reinforced deep beam has more load-carrying capacity than that of the second conventional deep beam. The Von mises stress, it can be implied that fiber reinforced and STM reinforced deep beams withhold more stresses along with inclined stress path.The amount of fibers added is 1% of steel fibers and 0.25% of polypropelene fibers to the total volume of concrete.

R.Yuvanesh Kumar et.al (2020) studied the deep beam using three different types of fibers such as glass 0.3%, steel 0.75% & 1% and polypropylene fibers 0.3% were added to volume of concrete. The mix design has been arrived based on IS code method for M20 grade of concrete. An investigation is carried out to evaluate the fresh Properties and mechanical Properties of Hybrid Fiber Reinforced Concrete (HFRC). The result shows that hybrid fiber reinforced deep beams achieved better performance than the ordinary RC deep beam under application of load. It is found that the deep beam with glass fiber of 0.3 % and steel fiber with 1% proportion by volume of concrete gives better bearing load and reducing the bending moment when compared with other proportions.

Payal Kotecha⁎ , Ali AbolmaaliMacro (2019) had done work on Macro synthetic fibers which enhance the response of concrete in tension, ultimately improving its structural behavior, which leads to fully or partially replacing the conventional reinforcements in structural members. However, their applicability in shear predominant critical structural members that have complex stress fields and congested reinforcements have not been investigated. The objective of this paper is to evaluate the performance of macro synthetic fibers in critical structural applications with plausibly reduced conventional reinforcements by comparing the structural response of macro-synthetic-fiber reinforcement with that of conventional reinforcement and steel-fiber-reinforcement from available literature in order to gain perspicacity on different fiber types, fiber dosages, and congestion of reinforcements. An experimental program was conducted on three quarter-scale deep beams with discontinuity regions having reduced reinforcements. Macro-synthetic fibers were added at volume fractions (Vf) of 1% and 2%, and their performance was compared with that of the specimen without fibers. The applied load versus deflection of the beams, failure modes, cracking patterns, and strain in reinforcements were monitored during the tests until failure. The experimental results revealed that the inclusion of 2% Vf of macro synthetic fibers significantly increased the ultimate strength and post-cracking resistance of deep beams.

Prakash Appasaheb Nayakar (2019) investigate the crack width in reinforced concrete beams. In practice, the propagation of concrete crack width is seen as one of the most significant benchmarks for the designing and investigation of the long term amenity of the reinforced concrete structures. It is therefore beneficiary and necessary to gain full understanding of the process of growth of crack width over time. This paper attempts to assess the phenomenon of concrete cracking and estimate the concrete surface crack width under the action of applied loads. This assessment is carried out by analytical methods. In the analytical method, the experimental RC beams were taken as examples for the computation of the crack width by using the simplified methods as given in the standard design codes of reinforced concrete structures (IS: 456-2000).The codes used for comparison are Eurocode, national code of Finland, German Institute for standardization and IS code. The crack width is compared for different cases like clear cover, diameter of reinforcement's etc.It was observed that the crack width increases as the clear cover increases and all the codes estimate nearly the same results. As the diameter of reinforcement bars increase the crack width decreased and this trend is followed from all the codes. As the load gets increased the crack width increases in all the cases.

Kaize Ma et.al (2018) investigatesexperimentally the mechanical performance of HFRC(Hybrid fiber reinforced concrete) with two types of steel fibers. The investigated parameters were the volume fractions of the short steel fibers and long steel fibers. The compressive strength, tensile strength, and flexural strength of the HFRC were researched. The group with volume fractions of 1.5% for the long steel fibers and 0.5% for the short steel fibers exhibited the best flexural strength. The results indicated that hybrid fibers contribute greatly to the shear behavior of deep beams. The hybrid fibers led to the formation of multiple diagonal cracks in the deep beams and enhanced the damage tolerance.The HFRC had high tensile strength and flexural toughness as the steel volume fractions up to 2%.

Kulkarni S.K. et.al, (2017) Carried out experimental test results of M20 Gr. concrete mix by inclusion of polypropylene and hooked end steel fibers in it. Fibers were added in predefined proportions in concrete. Hooked end steel fibers from 0.5% to 2% by volume of concrete were used in the investigation. Also for each percentage of steel fiber, polypropylene fiber (PP) from 0.1% to 0.3% was added in concrete. For 1.1% & higher steel fiber percentages, super plasticizers were used in order to improve the workability of concrete. Test results show that combination of these fibers boosts the impact strength, split tensile strength and pull out strength of fibers. Only marginal improvement was found in case of compressive strength. For mixes without any super plasticizers, concrete mix with 0.8% steel fiber and 0.3% polypropylene fiber was observed to be optimum mix from workability and strength point of view. For mixes with super plasticizers, concrete mix with 1.4% steel fiber and 0.3% PP fiber was observed to be optimum mix

M. Shariat et.al (2017) studied shear capacity and failure load capacity of rectangular concrete deep beams are computed using strut and tie model (STM), and the results were compared with experimental results which were derived using ACI and AASHTO regulations. Finite element numerical model was utilized for analyzing these beams and the results of which reveals acceptable congruency.

This study has utilized experimental data of former researchers for data analysis and determination of shear capacity of deep beams. Validity measurement of results was carried out with the aid of finite element modeling through ABAQUS software. The mode of failure in deep beams depends on beams dimension and the percentage of available flexural and shear reinforcement. Also, as bending longitudinal reinforcement decrease, the beam will expose bending failure.

S.K.Kulkarni et. al (2017) presented data obtained from experiments carried by using combination of hooked end steel fiber and glass fiber. They took two fibers in predefined proportions in the concrete and its effect on strength characteristics of HFRC deep beam is studied. The deep beams cast & cured were tested using 1000 kN capacity loading frame. The two-point loading is applied on simply supported beam. During experiment, first crack load, deflection at first crack load and load at permissible deflection of deep beams are recorded. It is observed that, in comparison with conventional deep beams with shear span to depth ratio 0.5, there is improvement of 14% in first crack load and 11% in load at permissible deflection of HFRC deep beams,casted with optimum mix containing 0.7% steel fiber and 0.3% glass fiber by volume of concrete. However workability of concrete with steel & glass fiber is observed to be lower than concrete with steel & Polypropylene fiber, whereas the strength acquired is higher by 13% in comparison with steel & PP fiber.

Vijay M. Mhaskeet.al (2016) conducted experimental study for the assessment of mechanical properties of high strength fiber reinforced concrete (HSFRC) for M90 grade. High strength concrete (HSC) is made with appropriate cementitious materials i.e. cement fly ash and silica by DOE mix design method. The fiber volume fraction is used 0 to 4 % at 0.5% interval. Total 54 members were casted and tested for cube (100 X 100 X 100) mm and cylinder (150 X 300) mm each. Total members cured for 7 days and 28 days in curing tank of civil engineering concrete technology laboratory.The maximum percentage increase in compressive strengths is at 3.5% of fiber volume fractions and Split tensile strength is achieved at 3% of fiber volume fractions. The fibers observed on the failure section of the cylinder in split test are found to be aligned along the length of the cylinder.

Kumbhar A. N. & Kadam S. S. (2015) studied the effect of addition of mixed (Crimped steel – Polypropylene) fibers on shear strength reinforced concrete deep beams without any shear reinforcement. Results of an experimental investigation on the behavior and ultimate shear strength of 27 reinforced concrete deep beams are summarized. In this the main variables are percentage of mixed (Crimped steel – Polypropylene) fibers (0%,1.5% & 2.5%)and clear span to depth ratios (1.87, 1.76 & 1.66) by keeping compressive strength (35 Mpa)and do tensile reinforcement make constant. All the beam specimens are tested under two point loading test set-up up to failure and record the first crack load, failure load and central deflection. The obtained test results are compared with the equations proposed by different codes and author's in past years to find which equation gives accurate results. From the experiments present that the mixed (crimped steel – Polypropylene) fibers have great influence on the shear strength of longitudinal reinforcement concrete deep beams. It also observes that shear strength increased with increase in fiber volumes (%) and decreasing a clear span to depth ratio (l/D). Mixed fibers in concrete deep beams provide better crack control and deformation characteristics of beam.

Nabeel A.M. et.al [18](2015) studied experimental investigations behavior of simply supported fully encased composite deep beams. Eight simply supported deep beams were tested up to failure under the action of two point loads. The variables included are the compressive strength of the concrete (f ′c), shear span to depth ratio a/d and web plate thickness. They focused on determining overall deformation and behavior on the concrete surface, strain measurement, inclined cracking and ultimate strength. The results show that the variation of the type of steel reinforcement from steel bars to steel plate, the ultimate strength decreased by 9.13%. In addition, the ultimate strength and mid-span vertical deformation were significantly affected by the variations in (f ′c) and changing of the steel plate web thickness on the behavior of tested beams.

Giuseppe Tiberti et.al[6](2015) done a broad investigating on the ability of fibers in controlling cracks by discussing more than ninety seven tension tests on Reinforced Concrete (RC) prisms.The beams having different sizes, reinforcement ratios, amount of fibers and concrete strengths. In particular the influence of FRC in reducing the crack spacing and the crack width is evaluated as a function of the FRC toughness. A crack spacing reduction of around 30% was seen in SFRC elements with concrete volume fraction of 0.5 % steel fibers and 37 % reduction in crack spacing with concrete volume fraction of 1% steel fibers .

Emma Slater et.al (2012) predicts the shear strength of steel fiber reinforced concrete (SFRC) beams based on existing experimental results. A large database containing 222 shear strength tests of SFRC beams without stirrups was divided into six different groups based on their span-depth ratio (a/d P 3 or a/d < 3), concrete compressive strength (fc P 50 or f c < 50) and steel fiber shapes (hooked, crimped and plain) and was used to develop separate equations for predicting their respective shear strength.The proposed equations were obtained by performing both linear and non-linear regression analysis on each database. Overall, it was observed that the linear regression equations developed from this research for SFRC database could accurately predict the shear strength compared to the other previously proposed models.The parameters which affect shear strength of of SFRC beams are the concrete compressive strength (f'c), tensile reinforcement ratio (ρ), span-depth ratio a/d , fiber aspect ratio (lf/ df) and the amount of fiber in concrete (Vf) where studied.They took fiber factor proposed originally by Narayanan and Darwish as F =(lf/ df) Vf Df where Df is bond factor .The fiber aspect ratio alone is not a large influencing factor on the shear strength of SFRC beams; however, its combination with the fiber volume has a greater influence on its shear strength. They proposed equations for shear strength of SFRC beams from linear regression for a/d >= 3 and a/d<3 for all types of fibers, hooked fiber and plain or crimped steel fiber.

Vinu R. Patel& I.I. Pandya (2012) :- investigates the shear strength of Polypropylene Fiber Reinforced Concrete (PPFRC) with 1 % volume fraction of concrete for moderate deep beams without stirrups having span to depth ratio 2.0, 2.4, 3.0, 4.0. The 16 numbers of beams were tested. 4 numbers of beams were tested to failure under two point symmetrical loading and 12 numbers of beams were tested to failure under central point loading. A complete shear deformational behavior along with load-deflection response, crack patterns and modes of failure is studied experimentally. Shear strength is evaluated using empirical equations proposed for estimation of ultimate shear strength of moderate deep beams without stirrups. Experimental results of ultimate shear strength are compared with theoretical results calculated from proposed equation proposed. The comparison shows that the equation proposed (refer equation 1and equation 2) provides the most accurate estimates of shear strength. In addition to concrete strength, the influence of other variation such as fiber factor, span to depth ratio, longitudinal steel ratio and size effect is considered in the proposed equation.

$$V_u = V_{uc} + V_{ufrc};$$

$$V_{uc} = \tau_c Bd \; ; F = (\rho f l f \beta)^{df} \qquad \text{-------(1)}$$

$$Vufrc = 13.3\left[\frac{Ast}{bD}\left\{Fspf^{\frac{D}{L}}\right\}Fcr\left\{L^{\frac{a}{D}}\right\}\right] + \frac{7}{6}\left[Vf^{\,2.59}F^{\,0.5}\right]\times 10^{-6} \qquad \text{-----(2)}$$

Vengatachalapathy.V. & Ilangovan.R. (2010) studied Steel Fiber Reinforced Concrete Deep Beams with and without web openings. The percentage of steel fiber was varied from 0 % to1.0%.The influence of fiber content in the concrete deep beams has been studied by measuring the deflection of the deep beams and by observing the crack patterns. The investigation also includes the study of steel fiber reinforced concrete deep beams with web reinforcement with and without openings. The ultimate load obtained by applying the modified Kong and Sharp's formula of deep beams are compared with the experimental values. The above study indicates that the location of openings and the amount of web reinforcement, either in the form of discrete fibers or as continuous reinforcement are the principal parameters that affect the behaviour and strength of deep beams. The observations shows that optimum percentage of 0.75 % by volume , gives maximum ultimate load for the deep beam.

Giuseppe Campione & Maria Letizia Mangiavillano (2008) studied the flexural behavior of plain and fibrous reinforced concrete (FRC) beams under monotonic and cyclic actions. Twelve beams were reinforced with top and bottom longitudinal deformed steel bars and transverse steel stirrups. Concrete, having 30 MPa cylindrical strength, was reinforced with hooked steel fibers at a volume percentage of 1%. Beams, 600 mm in length and with a square side cross section of 150 mm, were tested in flexure using a three point bending test, adopting three different cover thicknesses of 5, 15 and 25 mm, respectively. The results obtained show that the addition of fibers increases the bearing capacity of the beams and ensures more ductile behavior, at the same time reducing degradation effects under cyclic reversal loads. Moreover, the presence of fibers reduces the cover spalling process, also in the presence of high cover thicknesses. Shear strength of the beams was calculated using an analytical expression given in literature for plain concrete beams and here extended to the case of fibrous concrete beams of hooked steel fibers on the subject, while the analytical results in terms of load–deflection curves, under monotonic actions, were generated using a nonlinear finite element program (DRAIN-2DX). This programme was calibrated on the basis of constitutive laws in compression and in tension capable of taking FRC properties into account, and verified against experimental data.

Wen-Yao Lu (2006) proposes an analytical method for determining the shear strengths of steel reinforced concrete deep beams under the failure mode of concrete crushing originally based on the softened strut-and-tie model. An analytical method for determining the shear strengths of SRC deep beams under the failure mode of concrete crushing based on the SST model is proposed. The predicted shear strengths of the SRC deep beams can be Vbv, calc = min (VDC, VB) where Vbv, calc is the predicted shear strengths of the SRC deep beams, VDC is the shear strength due to diagonal compression failure, and VB is the shear strength due to bearing failure.

The proposed method is a good physical model that can correlate well with the observed failure phenomenon of steel reinforced concrete deep beams. By comparing the predictions of the proposed method with the available test results from the literature, it was found that the proposed method is capable of predicting the shear strengths for steel reinforced concrete deep beams with sufficient accuracy. The shear-carrying behavior of steel reinforced concrete deep beams is highly influenced by the ratios of flange width to gross width, the shear span-to-depth ratios, and the concrete strengths. When the ratio of flange width to gross width is low, the shear-carrying capacities of steel reinforced concrete deep beams increase with the increasing ratio. However, if the ratio of the flange width to gross width is higher than a critical value, then the failure mode of steel reinforced concrete deep beams will be converted from diagonal compression failure into bearing failure.

A total of 16 test specimens and their results in the available literature are used to verify the proposed method. The major factors influencing the shear-carrying behavior of SRC deep beams have been found to be the ratio of the flange width to the gross width (b f /b), shear span-to-depth ratio (a/d), and the compressive strength of concrete (f c). Bearing failure is likely to occur in SRC deep beams with high a/d and low fc . On the contrary, diagonal compression failure is likely to occur in SRC deep beams with low a/d and high fc.

K. Sachan & C. V. S. Kameswara Rao (1990) describes an experimental investigation to study the strength and behaviour of steel fiber reinforced concrete deep beams. In total 14 beams were tested. The effects of fiber content, percentage reinforcement and type of loading were studied. The ultimate load-carrying capacity, mode of failure and load-deflection behavior are reported. A simple model is proposed to predict the load carrying capacity of the beams.

The addition of steel fibers to concrete results in a significant increase in ultimate strength of deep beams. It is also observed that the failure of fiber reinforced concrete beams was more ductile and gradual compared with the failure of plain and reinforced concrete beams. Calculation of ultimate load on the basis of a model suggested in this investigation, for beams failing in shear, is in good agreement with the experimental observations

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XV.Future work:

In summary Many researchers have used single fiber and combination of two fibers to improve shear strength of R.C Deep Beam and also tensile strength of concrete. However, little study is carried out on more than two fibers; hence it is necessary to carry more investigations on use of three hybrid fibers in concrete mix which shows shear strength improvement of R.C Deep Beams.The addition of hybrid fibers will also help in replacement of regular shear reinforcement.

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