EXPERIMENTAL STUDY ON CRACK PATTERN OF RC BEAM UNDER FLEXURAL LOADING CONDITION

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Abstract : In current days the problem faced by the construction industry is acute shortage of raw materials. We have responsibility to reduce the effect the application of concrete materials to environmental impact. The concrete should be used as efficiently as much as possible. In structural design, an ideal situation in material saving is to reduce the weight of the structure without having to compromise on its strength and serviceability. This paper present literature review on adding the steel fiber in concrete which includes current and future trends of research. It is inhance the property of flexural strength and reduce the crack width.

IndexTerms **- Steel fiber, Conventional Beam, Flexural loading, SFRC Beam , Mix Design, Crack Pattern**

I. INTRODUCTION

Reinforced cement concrete is one of the main component in the construction industry. Now a days, the use of concrete increased very much. In this paper an attempt is made for reduction of concrete and self-weight of the beam by replacing the concrete below neutral axis. However, concrete have low tensile strength and when a concrete member is subjected to flexure, the region under the neutral axis of the cross-section is considered ineffective when it is in tension at ultimate limit states. The behaviour of brick and RCC composite beams is same to that of reinforced concrete beams. Therefore, bricks are used within the un-utilized area. Steel bars are good for tension, so placing steel bars at bottom of beams will resist the tensile bending stresses and also overcome the tensile weakness of the bricks. It should be noted that the bonding between the steel bar, brick and concrete should be good for avoiding the slip between them. In this study by reducing weight of the beam and saving quantity of concrete by saving cement reduced the greenhouse gasses emissions. So it is environmental friendly.

A building component develops cracks whenever the stress in the components exceeds its strength. Stress in the building component is caused by externally applied forces or loads Almost all the types of cracks in Reinforced Concrete Beams are fundamentally defined by the principle cause or mechanism associated with the function of cracks. Allowable crack width as per IS: 456 - 2000 varies according to climatic conditions from 0.1 mm to 0.3 mm. Cracking is one of the common problems in the concrete structure. Structural members which are subjected to bending moment such as slabs and beams will develop flexural cracks. Flexural cracks occur when the stresses in the tension zone exceed the bending strength of the concrete. Flexural cracks on the sides of a beam start at the tension face and will extend, at most. In general, the cracks will be uniformly spaced along the most heavily loaded portion of the beam.

II. LITERATURE REVIEW

T Krishna Thulasi et.al (2018): Worked an experimental study of crack pattern on reinforced concrete beam is studied in this experiment, around 6 beam specimens of M20 is cast, Beam size of 1500 x 100 x 200 mm. During loading the pattern of cracks i.e., initial cracks and the crack propagation, Flexure and Shear crack is studied. The ultimate load carrying capacity & crack patterns of RC Beams has been analyzed. In order to increase the load carrying capacity of beam we can also use wraps of like GFRP, FRP etc.(1)

Piyush Kumar et.al (2015): Has studied the Comparative Study on Crack Pattern of RCC and Brick & RCC Composite Beams. In this experimental program is conducted on six simply supported concrete beams. All six beams cast in 2 different groups and every group having 3 beams. The first group of beams is of reinforced concrete beams and second group of beams are composite beams. The Crack Pattern of both groups of beam compare with each other. The comparative study result on Crack Pattern is taken with the help of load deflection reading by using dial gauge. The dial gauge are at position L/6, L/3, L/2, 2L/3 and 5L/6, where L is the length of beam. Reinforced Masonry, Deflection The most of the cracks are being seen at point L/3 and 2L/3 where load is also applied and small cracks appear near L/3 and 5L/6 of beams for both RCC and composite beams All the beams of composite shows large deflection and cracks with respect to the RCC beam. RCC beams shows a little bit more ultimate load as compare to composite beams. So composite beam has desired strength RCC beam. It has been observed that RCC beam has more first hair crack strength as compared with composite beams Behavior of composite beams is similar to that of reinforced concrete beams. By reducing concrete we have to save cement and also reduced the greenhouse gases emissions. So we can say that it is environment friendly.(2)

Mita Ann Zachariah et.al (2016): Has studied the Experimental Analysis of Flexural Behavior and Crack Pattern of RCC Composite Beam In this paper, an experimental investigation is on partial replacement of concrete below the neutral axis by placing bricks with spacing and without spacing. Specimens of solid RC beams and two composite beams with different variations are casted and tested under two-point flexure loading. is the results obtained are the Flexural behavior of the composite beam having bricks below the neutral axis shows very close to the conventional beam. Composite beam has withstood the same quantity of load as like the normal beam. Composite beam without spacing for bricks have saved 10.4% of concrete in casting similarly spacing for bricks have saved 7.43% of concrete in casting Self weight of the composite beam got reduced 3.28% for brick without spacing Similarly, 2.34% for brick with spacing. Thus, behavior of composite beams has shown similar strength and characteristics to that of reinforced concrete beams. Therefore, Brick reinforced

concrete beams can be used for environment friendly construction work as it reduces the consumption of cement and also reduces the dead load.(3)

S Tejaswi et.al (2015):Worked on Flexural Behavior of RCC Beams in this experiment analysis the simply supported beams of under reinforced, balanced and over reinforced sections are considered. When the beam is simply supported and is subjected to some external loading the corresponding deflections are examined such that the flexural behavior of the RCC beams of under reinforced, balanced and over reinforced sections analyzed. in this experiment is carried out the ultimate load carrying capacity of Plane concrete beam is 0.14 times the under reinforced beam. In under reinforced beam reach maximum ultimate stress as compare to over reinforced concrete beam. From the analytical investigation it was observed that under reinforced ratio is the best type of reinforcement ratio among the others it shows greatest warning zone before failure.it was also observed that under reinforced section reinforcement reaches ultimate stress and over reinforced section reach 87% of ultimate stress.(4)

Prasad Karunakaran et.al (2017): Has done on Experimental Study on Behavior of Steel Fiber Reinforced Concrete in This paper deals with experimental study on Behavior of steel fiber reinforced concrete for M25 grade having mix proportion of 1:1:2 with 0.44 water cement ratio to study the Compressive strength, Split tensile strength, Flexural strength of steel fiber reinforced concrete (SFRC) containing fibers of 0.5% volume fraction of hook end Steel fibers of 50 aspect ratio were used. also found that Addition of steel fibers to concrete increases the compressive strength of concrete marginally. The addition of steel fibers increases the tensile properties of concrete and improves resistance to cracking. Addition of steel fiber increase the flexural strength. Increase the volume of fraction of fiber and get good strength.(5)

Manish Kumar et.al (2019): Studied the flexural behavior of RCC beam with partially replaced concrete below neutral axis. For this experiment six group of beam have been casted. First three groups comprise of M-25 concrete, above neutral axis (N.A)and lower grade concrete below N.A. zone, and remaining three group is same as first three group except that zone below N.A. is also partially replaced with a hollow void in longitudinal direction. Flexural behavior has been studied for the above cases. Control beam is of M-25 grade and low grade concrete used are of M-20 and M-15 grade. Hollow UPVC pipe (diameter=63mm/2.5") were used to replace concrete and to create hollow void throughout the length of concrete. Dimension of beam specimen is 150x150x700 mm and flexural test has been carried out with three-point loading using Universal Testing Machine. From experiment it is found that in heterogeneous solid beams with lower grade concrete below N.A. reduction in ultimate load is about 15% to 25% whereas for hollow beams reduction is about 25% to 40%.In case of solid heterogeneous beams deflection increases by 80% to 100%. From this experimental it has been observed that the replacement of concrete with lower grade of concrete below neutral axis does not significantly affect flexural capacity of beam, also reduces cost and weight of beams. Such beams can be used in precast construction, lightweight and elevated structure, plinth beams, raft foundation etc.(6)

Ashraf Abdalkader et.al (2017): Worked on Flexural Cracking Behavior of Steel Fiber Reinforced Concrete Beams. In this experimental work, flexural cracking behavior of reinforced concrete beams contains different percentage of hooked-end steel fibers with length of 50 mm and equivalent diameter of 0.5 mm was studied. The beams were tested under third-point loading test at 28 days. First cracking load, maximum crack width, cracks number, and load-deflection relations were investigated to evaluate the flexural cracking behavior of concrete beams with 34 MPa target mean strength. Workability, wet density, compressive and splitting tensile strength were also investigated. The results showed that the addition of steel fiber caused a slight increase in wet density, and clear reduction in slump Compressive strength does not show a clear improvement due to the addition of steel fiber, but significantly increase the splitting tensile strength. It may be related to control cracks by the addition of steel fiber. Maximum crack width of FRC beams is clearly reduced. The addition of fiber 1.0% resulted in about 81 % reduction in maximum crack width compared to concrete beam without fiber. The addition of low steel fiber fraction is also found to be effective in controlling maximum crack width. The number of cracks increased by two times when 1.0% fiber was added But reduce the crack width.(7)

S. B. Kandekar et.al (2013): Studied the concrete grade variation in tension and compression zone of RCC beam, is the ultimate bending moment remains same whereas bending moment at first crack varies. The reinforcement provided at compression side has shown sufficient contribution, where theory does not permit to account the same for diameter less than 12mm As the depth of higher grade concrete increases in compression zone, resistance to first crack development also Increases. all type of beams have shown flexural failure, no shear cracks were seen. This only may be because of large span of the test specimen.(8)

Patil Shweta et.al (2014): Has done Study of Flexural Strength in Steel Fiber Reinforced Concrete In the present investigation properties of steel fiber reinforced concrete like flexure and compressive strength are studied. Tests were conducted to study the flexural and compressive strength of steel fibre reinforced concrete with varying aspect and varying percentage of fiber. In the experiments conducted four aspect ratio were selected i.e. 40,50,60,70 and percentage of steel in each case varied from 0.5% to 2.5% at interval of 0.5%. The various strength parameters studied are compressive strength and flexural strength as per the relevant IS standards. The addition of binding wire or a steel fibre into the concrete significantly increases the flexural strength. At constant percentage of fibre=1.5%& by increasing aspect ratio of fiber from 40 to 70, it is observed that the flexural strength is increased from 36.7% to 58.65% as compared to plain concrete strength. At constant aspect ratio of fibre is 70 and by increasing percentage of fibbers from 0.5% to 2.5%, it is observed that the flexural strength is significantly increased from 29.2% to 119.69% as compared to plain concrete. it is observed that the compressive strength slightly decreased. it is observed that as the percentage of fibre increases with constant aspect ratio, the deflection of the beam is also increased before failure. The maximum deflection is observed with 2.5% fiber and 70 aspect ratio and it was 3.2mm.(9)

Markandey arajuponnada et.al (2015): In this experiment performance of RCC beams with and without curtailment the study was conducted on 2 RCC beams of 0.23 m x 0.23 m x 1.5 m size with same Ast corresponding to Moment of Resistance of 40 Knm. From the study, it was observed that curtailment improved the Moment carrying capacity and displacement ductility. In spite of having same reinforcement, the beam with curtailment of Flexure reinforcement i.e., B2, showed increased Moment carrying capacity than beam B1. It deflected more than B1 before failure. Although both the beams have the same Ast, the number of bars are high in B2 than in B1 resulting in high steel- concrete contact area. This may be a factor for enhanced performance of Beam B2.(10)

Vinay N et.al (2015): In this work Experimental Investigation on the Flexural Behavior of the Steel-Concrete Composite Beams it was carried out on 8 simply supported beam specimens to understand the flexural performance. Two beams were control beams and the remaining six beams were composite beams. Six composite beams were provided with different configuration of the shear transfer mechanism. The cross section of the beams were kept such that, span to depth ratio varied from 6 to 9 and shear span to depth ratio varied from 2.5 to 3. The grade of concrete was M30 and the grade of steel was kept Fe415. Composite action is predominant over the fundamental mechanism of load slip, load transfer and shear transfer. Sound bond between the two materials under flexure-shear is to be achieved during the design and construction of composite structures. The connection between the steel and the concrete section of this work was established using T-shear connectors. T-shear connectors were used in three different configurations. The beam specimens were tested by subjecting them to two point loading. The cracking load, load-deflection behavior, ultimate load and failure pattern of the beam specimens were studied. The experimental results indicate that, the load carrying capacity of the composite beams were increased by 38.09% to 214.28%.It is observed that, cracking load for composite beams is thrice more than the cracking load for control beams for both beams having span to depth ratio of 6 and shear-span to depth ratio of 2.5 and span to depth ratio of 9 and shear-span to depth ratio of 3.(11)

Kamal G.Sharobim et.al (2019): In This paper presents experimental investigation for eight beams in two sets each one component of control beam and three beams strengthened by the three different methods without changing its dimensions. The beams were tested under four point loads. Ultimate loads, load-deflection curves, cracking and crushing patterns for strengthening beam had been compared with those of the RC beams without strengthening in shear and flexure stresses. The beams strengthened by CFRP increased load capacity by 24% in shear and 22% in flexure, and The deflection at failure approximately increased by 35% in shear and 21% in flexure than the control beam. The beams strengthened by EX steel increased load capacity by 12% in shear and 14% in flexure and the deflection at failure approximately increased by 20% in shear and 13% in flexure than the control beam. the beams strengthened by CFRP increased load capacity by 11% in shear and 7% in flexure, while the deflection at failure approximately increased by 13% in shear and 8% in flexure than Beams strengthened by EX. steel.(12)

Vinu R. Patel et.al (2012): In This experimental study for behavior of crack and modes of failure of SFRC (Steel Fiber Reinforced Concrete) deep beams & Moderate deep beams without stirrups having various shear span (a) to overall depth ratio (D). Eight nos. of SFRC simply supported beams having different depths of 300 mm, 400 mm, 500 mm and 600 mm were tested. We have used CCT (circular corrugated type) fibers in four beams and FCT (fibrillated corrugated type) fibers in another four beams. The span (overall span of 1300 mm, effective span of 1200 mm) and width (150mm) of all the beams were kept constant. Three cubes & three cylinders were cast as control specimen. Initiation or appearance and proportion of behavior of crack and mode of failure of beams were noted. We conclude that SFRC moderate deep beams with a/D ratio<1and were failed in shear mode so they are shear predominant members which is brittle in nature. The beams having a/D ratio ranging from 1to2.5 were failed in both shear and flexure. The beams having a/D ratio more than 2.5 failed in pure flexure. The evaluation indicated that SFRC beams with a/D ratio less than 1 are shear predominant members and generally fails in shear mode which is brittle in nature and having a/D ratio between 1 to 2.5 are failing due to both flexure and shear. SFRC Beams with a/D ratio greater than 1 are flexure predominant member and fails in flexure mode.(13)

P. Rama Mohan Rao et.al (2018): In this experiment The bamboo can be replaced in structural member with certain percentages such as 25 %, 50 %, 75 % and 100% as a main rebars. The bamboo rebars were placed in both tension and compression zone on 0.7 m beams. The beams are tested under loading frame and test results are obtained. In loading frame, two-point loads were given in one- third of position on both ends in beam. The beams are tested in loading frame to obtain flexural strength and deflection with loads applied on one- third of its position from both ends. From results, we obtain that 25 % bamboo beam attain strength which is slightly less than conventional beam but it is higher than other percentages of beam such as 50 %, 75 % and 100%.(14)

Umesh Sharma et.al (2015): Has studied on Evaluation of Workability and Cracking Pattern in Flexure of Steel Fiber Reinforced Concrete (SFRC) Beam In this paper, workability characteristics and cracking patterns formed in different proportions of SFRC beam samples with varying proportion of Steel Fiber content have been analyzed. Many attempts have been previously made towards making concrete composite, more homogeneous and ductile material in order to decrease the problem of visible cracks. Using Fibbers in concrete has significantly reduced the problem of sudden failure. It also works towards enhancing flexure strength in concrete composite From cracking patterns it's observed that increasing the Fiber content increases the crack arrest mechanism in concrete composite even after failure. but concrete with higher volume of Fiber content becomes difficult to work with due to reduced workability.(15)

ShivandJalade et.al (2013): Worked on Comparative Study on Behavior of Medium and High Strength Concrete Beam With and Without Fiber under Flexure in this experiment program consisting of tests on steel fiber reinforced concrete (SFRC) beams with conventional reinforcement and reinforced concrete (RC) beams was conducted under flexural loading. SFRC beams include two types of beams containing steel fibers in two different volume fractions i.e. 1% and 1.5%. The cross sectional dimensions and span of beams were fixed same for all types of beams. The dimensions of the beams were 125mm x 150mm x11000mm. The percentage increase compression strength for M25 concrete with 1% and 1.5% were found to be 13.44%, and 32.54% respectively The percentage increase compression strength for M50 concrete with 1% and 1.5% were found to be 16.03%, and 33.33% respectively. And percentage of fibers increased from 0%, 1% and 1.5% the load as well as the deflection of the beam increased. There is also further increase in load capacity and deflection from M25 to M50 grade concrete.(16)

MohdYuasrizamet.al(2016): In this experiment Steel Fibers as Flexural Cracks Inhibitor in Reinforced Fibrous Concrete Beams under Static Loading in this work Seven sets of 150×250×1000mm concrete beams consists of three RC beams with full steel fibrous concrete (SFRC), three RC beams with steel fiber placed within tension zone of the beam, three RC beams with steel fiber placed at the half of beam's tension zone, two conventional RC beams as control sample, one unreinforced concrete beam with full steel fiber, one unreinforced concrete beam with steel fiber at tension zone only and one unreinforced concrete beam with steel fiber at half of tension zone. The addition of steel fiber in the conventional RC beam showed that it inhibits the flexural cracks. Based on this research study, it can be concluded that when the reinforced concrete beam subjected to flexural load, the addition of 1.0% steel fiber in reinforced concrete beam has increased the ultimate load, improved deflection and reduced crack. The presence of steel fiber in concrete matrix also can provide better performance in carrying high stress compare to steel fibrous reinforced concrete (tension zone) beam, steel fibrous reinforced concrete (half tension

zone)beam and reinforced concrete beam. To be conclude in terms of crack propagation and economy, steel fibrous reinforced concrete (tension zone) beam is a most suitable option to incorporate steel fiber in conventional reinforced concrete beam. The flexural strength of steel fibrous reinforced concrete (tension zone) beam is slightly low than flexural strength of steel fibrous reinforced concrete beam, but, the cracks width and cracks pattern is almost similar. All beams failed under flexural cracks. SFRC (TZ) is an economical solution to inhibit flexural cracks.(17)

Rakendu K et.al (2017): This work deals with the flexural behavior of plain cement concrete beams reinforced with biaxial geo grid in one, three and five layers for three different mixes. The experimental program consisted of testing thirty four geo grid concrete beams and six control beam specimens under two-point loading. The test results are presented in terms of ultimate load carrying capacity, flexural strength behavior, load deflection behavior and crack patterns. The two point bending test on geo grid beams reveals that strength of geo grid and number of layers plays a crucial role in enhancing load carrying capacity and flexural strength. Beams reinforced with more number of layers of geo grid exhibits a good result in load carrying capacity and provide a flexural strength which is only 2.6% less than the control beams. Load carrying capacity is more when five layers of geo grid is used in plain cement concrete beams In case of load carrying capacity an average of 4.4% increase is shown by the geo grid beams reinforced with 100G5. Geo grid can take tensile forces when these are kept in plain cement concrete beams. Deflection can be reduced by the use of geo grid in beams Cracks appeared only in the middle section of the beam i.e. only flexural cracks are formed for all the beams reinforced with geo grid. The confining effect of geo grid plays a major role in the properties of concrete. The variation in flexural strength may be due to experimental errors like improper compaction which might have lead to weak bonding between aggregate and geo grid.(18)

Dhinesh.N.Pet.al (2017): This experimental program consists of casting and testing of RC beams of size 1000mm x150mm x 150mm with hollow core in different zone. To study the flexural behavior, all beams are tested by three points loading. The performance of experimental Hollow Core Beams under flexure shows better when compared with theoretical hollow core beam. It is found that the ultimate load carrying capacity of the beam is high in tensile zone of hollow core when compared to other zones of hollow core. First crack was observed at 80-90% of the ultimate load. Actual experimental results are match with the theoretical calculations as per IS code. The hollow core can be used as Duct The strain values are optimum depth of hollow core is 116 mm from tension zone.(19)

Laya A et.al (2019): This project deals with the experimental investigation for enhancing the flexural strength capacities of steel fiber reinforced concrete (RC) beams using BFRP rods. A control specimen is prepared without adding steel fiber and BFRP rod. RC beam reinforced with BFRP rod alone is then casted and cured, after that three beam specimens with different lengths of steel fibers is casted. The ultimate loads, load-deflection curves, cracking and crushing patterns of BFRP reinforced concrete beam have been compared with that of steel fiber RC beam using BFRP rods. The critical load for tested beams reinforced with BFRP bars was much greater than the carrying capacity of beams with conventional steel reinforcement .In comparison with the control beam, the ultimate load was found to be increased by 27.1% for the basalt reinforced beam. It is observed that ultimate loads of beam increases from 50.8% to 61.5% for basalt reinforced beam with steel fibers. Basalt reinforced beam with steel fibers of length 30mm showed greater ultimate load value up to 61.5% increase. behavior of BFRP RC beams. An optimum value of 30mm of the fiber length is obtained from the experiment. The central deflection of basalt reinforced beam is 4.7 times greater than control beam. As the length of the steel fiber increases, the deflections corresponding to the ultimate load also increases.(20)

D.Shantha Kumar et.al (2016): In this, present study the results and comparative discussion is carried on an experimental programme concerning concrete beam reinforced with both steel bars, GFRP bars and partially under varying concrete grade and diameter of GFRP bars. This paper investigate the flexural behavior of concrete beam reinforced with steel bars and GFRP bars under two-point loading designed based on code of IS 456: 2000 and ACI 440-1R. The parameters inspected in this study are flexural behavior, load- deflection, crack pattern and width. From this work it is observed that the results satisfy expectation. The beam specimen reinforced with both steel bar and GFRP bars as good flexural behavior over other beam specimen. Since, GFRP bars offer high strength performance and a steel bar offers a good ductility which in turn observed that it has good behavior over all parameter took in account like, load-deflection behavior, strain distribution and crack pattern.(21)

III. CONCLUSION

From the above literature Review it is generally find that For Load act at various location of beam mostly crack appears at L/3 & 2L/6.Crack width reduced up to 81% by addition of fiber up to 1%, and Flexural strength increased from 29.2 % to 119.69% as compared with plane concrete when fiber is added, strength of beam increased by using CFRP by 24% in shear and 22% in flexure. the addition of 1.0% steel fiber in reinforced concrete beam has also increased the ultimate load, improved deflection and reduced crack. All beams failed generally under flexural cracks. The maximum deflection is observed with 2.5% fiber and 70 aspect ratio and it was 3.2mm. it was also observed that curtailment improved the Moment carrying capacity and displacement ductility of Beam

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