12. DISCUSSION OF TEST RESULTS

From Experiments the various observations are observed and discussed here

1. From the graphs (No. 5-1 to 5-85) of Load vs. Deflection, it is observed that during the Elastic stage the curve is almost linear and can be approximated by a straight line. After yielding of steel the curve changed its slope and it becomes nonlinear. There was a considerable deviation in load deflection curve after the yielding of steel, which can be attributed to the first cracking and yielding of beam which caused a sudden increase in deflection. Generally during elastic stage, the central deflection was slightly more than the left and right deflections. In some of the beams in which major cracks appeared in Shear zones suddenly, the corresponding side of the deflection increases slightly more than the central deflection.
2. Graph 5-44 to 5-85 reveals that the Left and right supports dial gauge readings were almost same. In some cases on one side dial gauge pointer moved faster, it indicates slip of load in that direction. The reason of slipping due to not proper leveling and rough surface between loading frame and supporting arrangement.
3. Fibrous beam has good control of deflection and crack width, compare to RCC series. It is also observed that in Fibrous beam series Deflection and crack width were reduce at any given level compare to RCC series. The tensile stresses across diagonal crack increase in Fibrous beam compare to RCC beams as shown in Graph 5-1 to 5-43.
4. It reveals from Table 7-4 that the comparisons of test results and theoretical values for RCC series of beams. RCC Beams R (D10 to D40) were tested. Its Ultimate load were compared with Nehdi-Optimized Equation, Cheng and Tang Equation, Original Equation and Modified Equation. Average error between Experimental results and Modified Equation is 1.44%. While between Nehdi-Optimized Equation, Cheng and Tang Equation, Original Equation and Experimental results shows 22%, -33 % and -21% error respectively. Modified equation result considers as datum. + percentage when value is higher than modified equation and – percentage when value is lower than modified equation.

5. It reveals from Table 7-6 that the comparisons of test results and theoretical values for Layered RCC series of beams. Layered RCC Beams (D20 to D40) were tested and its Ultimate load were quantified with Nehdi-Optimized Equation, Cheng and Tang Equation, Original Equation and Modified Equation and compared with test results. Average error given by Modified Equation is -9 % to the test results. Whereas Nehdi-Optimized Equation, Cheng and Tang Equation, Original Equation shows 16 %, -44% and -40 % error, respectively.

6. It reveals from Table 7-8 that the comparisons of test results and theoretical values for Fibrous RCC series of beams. Fibrous RCC Beams RF (D10 to D40) were tested, and its Ultimate load were quantified with Nehdi-Optimized Equation, Cheng and Tang Equation, Original Equation and Modified Equation and compared with test results. Average error given by Modified equation is 2% to the test results. Where Nehdi-Optimized Equation, Cheng and Tang Equation, Original Equation shows 22 %, -29% and -36% error respectively.

7. It reveals from Table 7-10 that the comparisons of test results and theoretical values for Fibrous Layerd RCC series of beams. Fibrous Layered RCC Beams RLF (D20 to D40) were tested and its Ultimate load were quantified with Nehdi-Optimized Equation, Cheng and Tang Equation, Original Equation and Modified Equation and compared with test results. Average error given by Modified Equation is -2 % to the test results. While Nehdi-Optimized Equation, Cheng and Tang Equation, Original Equation shows 38 %, -34 % and -30% error respectively.

8. It reveals from Table 7–11 that the comparisons for ratios of test results to theoretical values of Ultimate shear strength for RCC series of beams R (D10 to D40). Average of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 1.00. The values obtained for Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 1.25, 0.69 and 0.81 respectively. Average of absolute Deviation of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 0.07. While

The values obtained for Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 0.37, 0.15 and 0.22 respectively.

9. It reveals from Table 7-12 that the comparisons for ratios of test results to theoretical values of Ultimate shear strength for Layerd RCC series of beams RL (D20 to D40). Average of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 0.91. The values obtained for Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 1.16, 0.56 and 0.60 respectively. Average of absolute deviation of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 0.10. The values obtained for Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 0.18, 0.07 and 0.08 respectively.

10. It reveals from Table 7-13 that the comparisons for ratios of test results to theoretical values of ultimate shear strength for FIBEROUS RCC series of beams RF (D10 to D40). Average of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 1.10. The values obtained for Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 1.57, 0.88 and 0.80 respectively. Average of Absolute Deviation of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 0.06. The values obtained for Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 0.53, 0.24 and 0.23 respectively.

11. It reveals from Table 7-14 that the comparisons for ratios of test results to theoretical values of Ultimate Shear strength for FIBEROUS LAYERED RCC series of beams RLF (D20 to D40). Average of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 0.98. The values obtained for Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 1.38, 0.67 and 0.7 respectively. Average of absolute deviation of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 0.03. The values obtained for Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 0.25, 0.09 and 0.12 respectively.

12. It reveals from Table (7-15) that the comparisons for ratios of test results to theoretical values of Ultimate shear strength for All series of beams i.e. RCC Beam, RL RCC Layered Beam, RF RCC Fibrous Beam and RLF RCC Layered Fibrous Beams. Average of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 1.01. The values obtained form Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 1.35, 0.71 and 0.74 respectively. Average of absolute deviation of Ultimate shear strength ratio (Wu test/ Wu theo) for Modified Equation is 0.09. The values obtained for Nehdi-Optimized Equation, Cheng and Tang Equation and Original Equation are 0.37, 0.17 and 0.19 respectively.

13. It reveals from Table 7-16 that the comparisons of test results and theoretical values for All series of beams i.e. RCC Beam, RL RCC Layered Beam , RF RCC Fibrous Beam and RLF RCC Layered Fibrous Beams. Overall average of average error given by Modified Equation is -0.79% to the test results. While for Nehdi-Optimized Equation, Cheng and Tang Equation, Original Equation show 26.87%, -34.07% and -30.49% error respectively.

14. It reveals from RCC specimen (Graph 8-1), PFRC specimen (Grpah 8-2) and SFRC specimen (Graph 8-3) that the Nominal shear stress is almost linear while the Ultimate shear stress is decreasing with increasing the depth of the beam.

15. It reveals that Ultimate load carrying capacity increases as the size of beam increases and when compared with fibrous concrete, steel fibers show highest capacity amongst normal concrete and polypropylene mixed concrete.

16. It was observed that Ultimate load of RCC and PFRC beams were almost in the similar range but in SFRC series Ultimate loads increases up to 25 %. This is because steel fiber which has large strength. It resists the propagation of crack, absorb energy and avoid the catastrophic failure.

17. It was observed that PFRC series Ultimate loads were varying from RCC about 2 to 5 % so it is concluded that fiber content 0.7 % were not

optimum dosage. Fiber content must be increases in concrete to increase the Ultimate shear strength.

18. It reveals that The Nominal shear stress mention for RCC beam (Table 9-2), For PFRC beam (Table 9-3) and for SFRC beam (Table 9-4). The Graph 9-2 shows the Nominal shear stress is decreasing with Depth of the beam increasing. The variation of stresses mainly due to size effect parameter.
19. As per Kani for slender beam (a/D)>2.5 without shear reinforcement the Nominal shear strength decreases as the Member depth increases. Graph 9-3 shows that Similar nature of reduction in Nominal shear strength observed as depth varying from 225 mm to 425 mm strength reduced to 32 % in RCC, 34 % in PFRC and 33.86 % in SFRC beams.
20. The Graph of Ultimate load v/s Depth for RCC (Graph9-4), PFRC (Graph 9-5) and SFRC (Graph 9-6) have plotted. From all graphs it reveals that the Experimental shear strength and Modified shear strength of CSA code almost in the close-range results.
21. It was observed that the Table 9-6 shows that the Wexp / Wtheo is almost unity for RCC Beams, PFRC Beams and SFRC Beams.
22. Experimental results of the present work were compared with the existing Original CSA-A23.3-04 formula. The size effect proposed by various researchers as APPA RAO (2012) and Modified IS 456-2000 formula. All the results of RCC series are nearer with G. APPA RAO'S proposed formula but in the cases of Fibrous concrete results are differ by 10 to 12%. All the beams' results predicated by Modified IS 456 2000 varying by 40-54 % from experimental results. (Table 9-7). All the beams result of Original CSA-A23.3-04 varying by 84-87 % from experimental results. After Applying size effect parameter all results are varying by 4 – 20 % from experimental results.
23. In experimental sequence it shows that cracks were generally initiated from the flexure zone than it transfers from flexure to shear zone and widening of cracks occurs in shear at D/3 of beam in shear span.
24. First Cracking load increase in PFRC material then RCC material. Frist cracking load more in SFRC material compare to PFRC material of the

beam. The Increase in load is due to increase in fiber volume.

25. Comparing the graphs (11-1 to 11-4) it is observed that RCC and PFRC follows nearly equal pattern of First crack load and Ultimate load in central point load and two-point load. Graph 11-3 and 11-4 SFRC specimens gives higher value of Ultimate load than RCC and PFRC.
26. Addition of fibers in a concrete mix gives better results for first crack load. Fibrous concrete resist heavier load to create first crack compare to normal concrete. In Fibrous concrete Steel fiber dosage 0.7 % is more effective than the polypropylene fiber.
27. Polypropylene (monofilament) fibers used with 0.7% volume of fibers in concrete increases the value of first crack load than Normal concrete. It reduces the widening of crack and increases crack propagation time leading to ductile nature of failure.
28. End hook type steel fibers used with 0.7% volume of fiber in concrete improves both loading capacity and cracking characteristics. Initial and Ultimate load carrying capacity of steel fibers are much higher than Normal concrete and Polypropylene fiber mixed concrete. Cracking characteristics like widening, spacing, pattern shows better results than other two. Reduction in significant crack width was observed. when it compared with RCC and PFRC specimens at the Ultimate load of RCC specimens. A significant gap was observed in values which leads towards a beneficiary usage of steel fibers in structural members.
29. A noticeable reduction of crack width and crack spacing observed in steel fiber Reinforced concrete. The steel fiber absorbs more energy and extends the time of cracking and increase the load carrying capacity.
30. As fibers play important role in delay of the first crack, In some specimen ineffective after development of crack in PFRC Moderate Deep Beam. This is due to rupture of fibers, orientations and its embedded length. To avoid this type of behavior, volume of fibers should be increased and Aspect ratio should be decreased to have better performance in post cracking behavior.
31. The Ultimate load causing the failure of RCC beam also leads to the development of measurable cracks in the SFRC beam. It is observed that

the sudden diagonal shear cracks were formed approximately at the 65% of Ultimate load of SFRC.

32. All Plain concrete beam (photo 14-1 to 14-7 and 14-22 to 14-28) fails in Flexure mode. Crack starts in Flexure zone and propagate vertically upward in most of the specimens.
33. From the observation and photographs Annexure 14 Photo R 150 (14-8), R 300 (14-10), F 150 (14-15), F300 (14-17), F375 (14-18), F-450 (14-19), F-10 (14-54), RF300 (14-58) specimens show that beam were failed in flexure. The first crack was observed at mid span in flexure zone. During further increasing loading the crack widen and propagated upward towards loading point. During this process few shear cracks developed in shear zone. however, such cracks were not significantly widen. The predominant failure of beam occurs due to widening of flexural cracks. At the Failure of beam Dial gauge shows more rotation. Crack develop suddenly, propagate faster leads to failure of specimen.
34. Beam of R450 (14-33) R15 (14-43) F RCC (14-66) PFRC BEAM (14-71 to 14-75) were failed in flexure shear mode. This result reveals the transitions of failure mode from flexure to flexure shear.
35. The photograph of beam F450 (14-39) which was failing in flexure mode. it reveals that addition of fiber in the beam changed mode of failure from flexure to flexure shear mode. i.e. in Fibrous Concrete Moderate deep beam Ductility increases compare to RCC moderate deep beam.
36. For RCC beams and Fibrous Beam having a depth of 525 and 600 (14-34, 14-35, 14-40, 14-41) series it was observed from the photograph that predominant crack occurs at D/3 of beam in shear zone. The flexure cracks were formed prior to the shear crack. Flexure cracks were found to be very thin and hardly reach up to the mid height of the beam. This shows that flexure strength considerably higher than shear strength due to high moment of inertia. In this series of beams were failed in shear because shear cracks were wide and predominant.
37. For RCC beams and Fibrous Beam having a depth 525 and 600 series (14-34, 14-35, 14-40, 14-41) major diagonal shear cracks were appeared. These cracks were initiated by splitting action. This phenomenon of

failure was similar to that of compression test on concrete cylinder. The diagonal shear crack appeared along the line joining the loading point and support point. It reveals the elliptical pattern of strain distribution.

38. In case of R 600 (14-35) premature failure was observed near to bearing plate at support. It seems that bearing stresses significantly larger than crushing stress in concrete. It may be due to inadequate compaction near bearing plate or arch action. Arch action might have generated in the beam resulted into axial thrust in the section. It may be also due to inadequate length of bearing plate provided in the beam section.