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Shear Strengthening of R.C Deep Beam using Carbon Fibre Reinforced Polymer Strips

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Abstract: ***The carbon fibre reinforced polymer fabric (CFRP) is an internal reinforcement is used to extensively enhance the strength required to shear and flexure in the structural system. This project represent experimental data casting of R.C deep beam on the behavior and shear strength with carbon fibre reinforced polymer strips. A total Eleven R.C deep beam where casted. The length of beam was 1000mm where constructed and test up to failure. The size of R.C deep beam was 150mm*300mm*1000mm length. In which Eleven beam one beam was control beam, five beam was 10mm strips and remaining five beam was 20mm strips. The wrapping patterns of CFRP strips was as per as design,0.75d or 300mm whichever is less,L/3 ratio, spiral in shape and plus sign in shape.***
Keywords: Shear Strengthening, CFRP Fabric. CFRP strips, FRP, Avg crack load, ultimate load, CFRP wrapping patterns.

I. INTRODUCTION

The strengthening of R.C deep beam using internally reinforcement of carbon fibre reinforced polymer (CFRP) fabric it is an effectively method to improving shear strength of R.C deep beam [19]. The CFRP fabric use under increase in load condition and also decrease the deflection and small crack [6]. Also it has use a several advantage like it can be easy in bonding for light weight structure, irregular structure curved etc [19].

The tensile strength of GFRP is 3000-4800 mpa where as CFRP is 2400-5100 mpa. In the various RC structure such as column, slab, beam can be strengthened using FRP.A vast amount of literature on the structure including flexure and torsion is available [1]. Still the R.C deep beam with CFRP strips is open for research. In reinforced structure (RC) structure the corrosion of steel reinforcement is a major cause of deterioration [6]. Since the use of FRP (Fibre Reinforced Polymer) material is improving to solve the major problem for increase the service life of structure.

It can be also used for repair and damage structure it is called as retrofitting [1]. There may be reason for deterioration of structure such as error in design and construction, environmental, corrosion in steel, earthquake, accidental event or it may be error caused due to time of construction [6]. So for this purpose the strengthening technique has developed to get strength requirement. There are various FRP materials available in market such as CFRP, GFRP and Aramid etc [8].The FRP material is widely used but more research is required to be carried out for strengthening [5]. From IS-456 2000 clause 29.simply supported beam consider as deep beam if the ratio to effective span i.e. L/D is less than 2.0 and for continuous beam the ratio to effective span i.e. L/D is less than 2.5 If we consider a normal beam with steel stirrups it has more width of crack and has less avg.ultimate load.So in this paper we exactly solve how to increase a load capacity on it so that it can carry shear. In this paper we are going to increase the shear strength with CFRP fabric strips of 10mm and 20mm with various wrapping pattern.

II. REVIEW OF LITERATURE

The shear strengthening of R.C deep beam conduct with various wrapping patterns as different configuration of FRP, thickness varying FRP, applying different glue epoxy resin used as bonding materials etc. some of the different literature studies are shown below: Ehab. A. Ahmed et.al. Where focused on CFRP stirrups on the bridge girder as experimental data on the behavior and shear strength of concrete bridge girder.

The CFRP stirrups of 9.5mm diameter was spaced at different spacing of d/2,d/3 and d/4.Shraddha.B.Thibe and Vijaykumar. R. Rathi where focused on torsional behavior of R.C beam with externally wrapping of CFRP and GFRP fabric. Total 39 rectangular beam of size 150mm*300mm*1200mm length. Out of 39 beam 36 were classified into two groups as GFRP and CFRP remaining three beam were control beam. Sandeep Agharal studied on torsional strengthening of R.C beam with GFRP laminations. Six beam were casted of size 180mm*210mm*1500mm length in which one beam was control beam and remaining beam were wrapped by GFRP.

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III. EXPERIMNAL WORK

Total Eleven R.C deep beam were casted in which one beam was control beam and remaining ten beam was wrapped by CFRP fabric strips of 10mm and 20mm having different wrapping patterns and adhesive is prepared by mixing two solution i.e. epoxy resin and hardener in proportion 1:3

A. Specimen Characteristics

Total Eleven R.C deep beam of size of 150mm*300mm*1000mm length were casted by using 2-10mm diameter bar at top reinforcement and 2-10mm bottom reinforcement. Shear reinforcement i.e. spacing of CFRP fabric strips was spiral in shape, L/ 3 ratio, 0.75d or 300mm whichever is less, plus sign in shape and as per as design. As per as design the spacing was 2 legged 8mm bars @20mm c/c.

B. Material Properties

1) Concrete Properties: The R.C deep beams were casted by using M25 grade of concrete 53 grade ultratech OPC cement. The size of coarse aggregate was taken as 20mm throughout this investigation. The specific gravity of coarse aggregate is 2.75 and fine aggregate used for casting is clean river sand locally available. Specific gravity of fine aggregate is 2.6

2) Fibre Reinforced Polymer Properties

a) 3k carbon-k/38000

b) Adhesive-Resin + hardner

Mixing ratio were taken as 1:3 propertion. Time required for harden 28^{o}C is 45 min.

Table 1-Properties of FRP

Types of FRP	Ultimate tensile strength (mpa)	E-modulus (Gpa)
GFRP	2900-4800	390-760
CFRP	2500-5100	60-80
AFRP	2800	120

Figure- 1 CFRP fabric.

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C. Carbon Fibre Reinforced Polymer Fabric (CFRP) Strips

Ten beam of size 150mm*300mm*1000mm length in which five beam was casted of 10mm strips and remaining five beam was 20mm strips. One beam was control beam as per as design and reinforcement.

Figure-2. 10mm CFRP strips.

Figure-3. 20mm CFRP strips.

IV. TEST SET-UP

From the review of paper study the shear test is conducted on universal testing machine as shown in fig. Two point load is conducted at 300mm and 700mm.

Figure-4.Two point loading test set-up.

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V. METHODOLOGY

A. Casting Process

The R.C deep beam was casted with top reinforcement 2-10 and 2-10 for M25 grade of concrete 53 grade ultratech OPC cement. One beam was control beam as per as design five beam was 10mm CFRP fabric strips and remaining five beam was 20mm strips with different wrapping patterns.

B. CFRP fabric Strips Wrapping Patterns

Figure-5.20mm CFRP strips.

Figure-6.10mm CFRP strips.

The CFRP strips was used for stirrups is 10mm and 20mm with different patterns such as spiral in shape, L/3 ratio, 0.75d or 300mm whichever is less, plus sign in shape and as per as design.

Figure-7. Test beam fixed on UTM assembly.

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VI. TEST RESULT AND DISCUSSION:

Below tables shows the result of all wrapping patterns of CFRP 10mm and 20mm strips.

Table-2 Test result of all CFRP 10mm and 20mm strips

Sr.no	Test Beam	Avg. Crack load	Avg. Ultimate load	Percentage increase in load
1	Control beam	20	26.500KN	-
2	L/3 10mm	31.24KN	39.700KN	49.81
3	L/3 20mm	44.29KN	60.950KN	130
4	0.75d 10mm	20.31KN	24.350KN	-8.11
5	0.75d 20mm	32.65KN	36.500KN	37.92
6	Plus sign 10mm	22.19KN	26.500KN	0
7	Plus sign 20mm	29.36KN	36.650KN	38.30
8	As per design 10mm	32.63KN	35.850KN	35.28
9	As per design 20mm	46.85KN	60.950KN	130
10	Spiral shape 10mm	32.69KN	34.350KN	29.62
11	Spiral shape 20mm	39.72KN	44.200KN	66.79

1) The shear strengthening is done by using internal reinforcement of CFRP strips of 10mm and 20mm with various wrapping pattern and on the basic of test result it has seen that L/3 ratio 20mm strips and as per as design 20mm strips has maximum strength than control beam.

2) The Average ultimate load of control beam, L/3 ratio 20mm strips and as per as design 20mm strips is 26.500 KN, 60.950KN and 60.950 KN which is greater than all.

3) The percentage increase in shear strength for L/3 ratio and as per as design 20mm strips is 130%

4) We will make the comparison of third wrapping pattern of L/3 10mm, as per as design 10mm the avg.ultimate load are 39.700KN and 35.850KN.

5) The first crack load of control beam is 20KN which is less in all above wrapping patterns.

6) L/3 ratio and as per as design for both 20mm strips first crack load is highest i.e. 44.29 KN and 46.85KN.

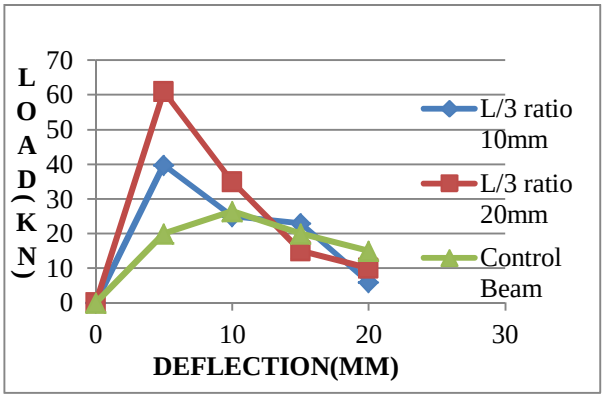

Figure-8 Load vs. deflection for L/3 ratio 10mm and 20mm strips

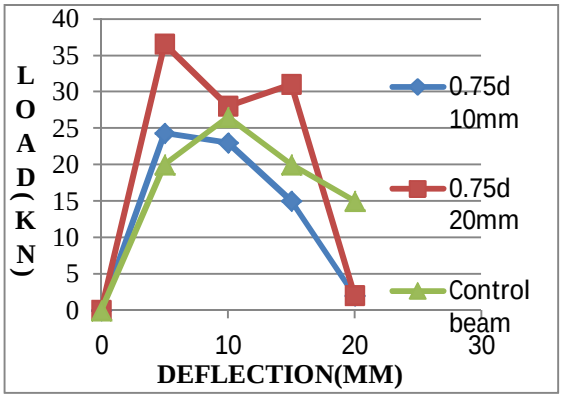

Figure-9 Load vs. deflection for 0.75d for 10mm and 20mm strips

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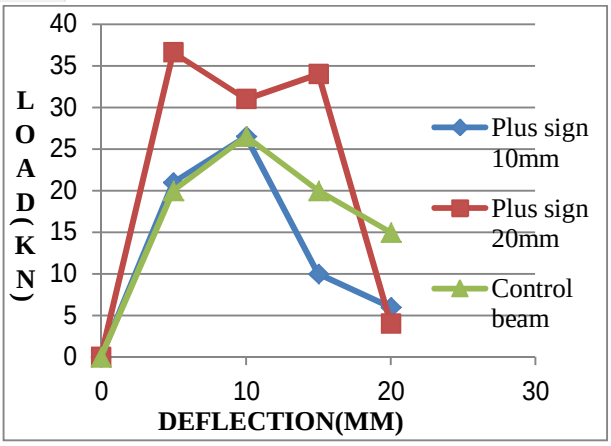

Figure-10 Load vs. deflection for Plus sign on 10mm and 20mm strips

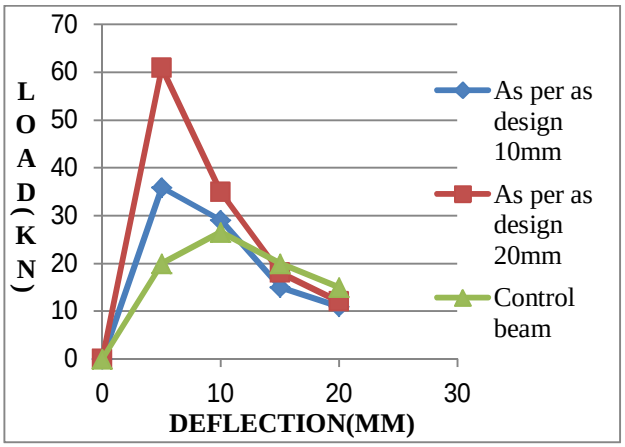

Figure-11 Load vs.deflection for as per as design staad pro 10mm and 20mm strips

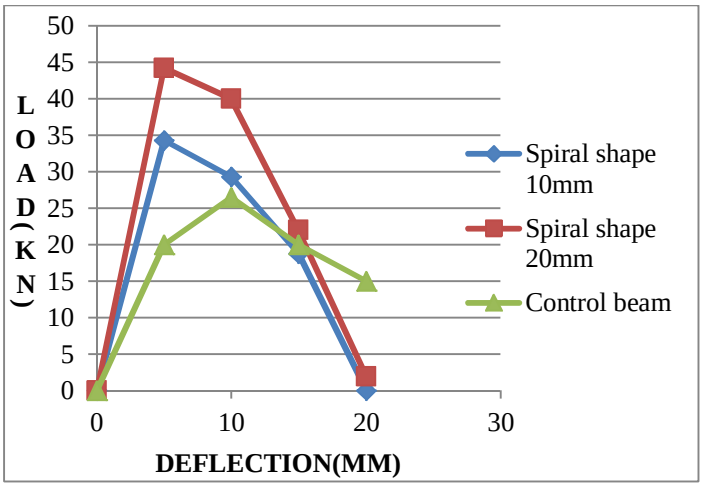

Figure-12 Load vs. deflection for spiral 10mm and 20mm strips

Figure-13 Crack width of control beam.

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Figure-14 CFRP R.C deep beam before testing

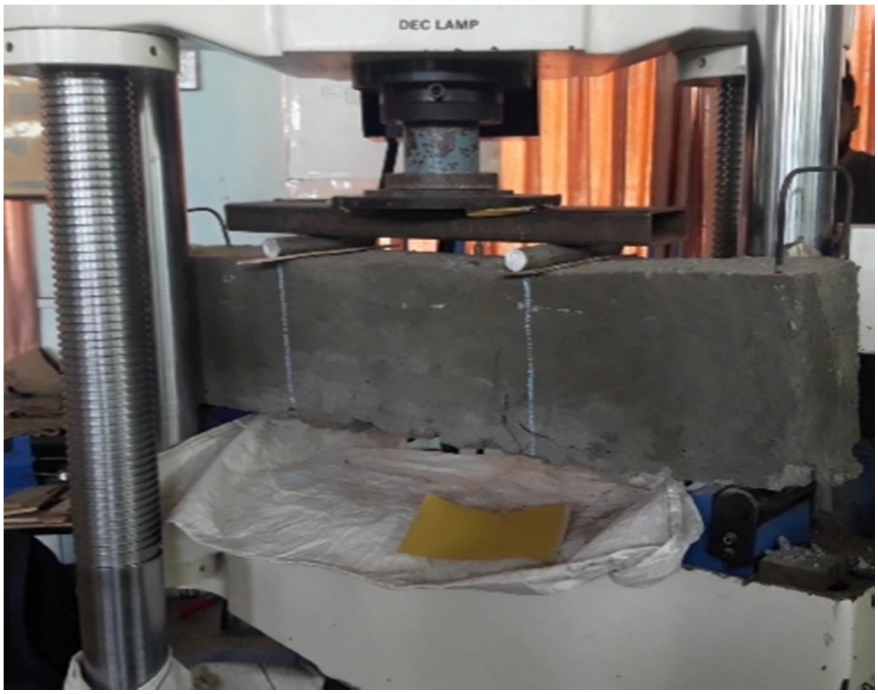

Figure-15 CFRP wrapping RC deep beam after testing.

VII. CONCLUSION

A. It is observed that shear strength taking capacity of L/3 ratio 20mm and as per design 20mm strips has highest value.
B. Where as spiral shape 20mm and L/3 ratio 10mm has increase by 66.79% and 49.81% with respectively to control beam.
C. The maximum increase in shear strength is about 130% for both 20mm strips L/3 ratio and as per as design.
D. As we compared a normal control beam with CFRP strips, it has proved that CFRP strips having maximum shear strength than steel stirrups.
E. We can also say that crack width decrease due to the CFRP fabric strips.
F. Hence, we can conclude that the shear strength has maximum value for CFRP fabric strips than control beam.
G. As we consider the wrapping patterns of CFRP fabric 10mm and 20mm strips both are proved to more efficient in shear strength.

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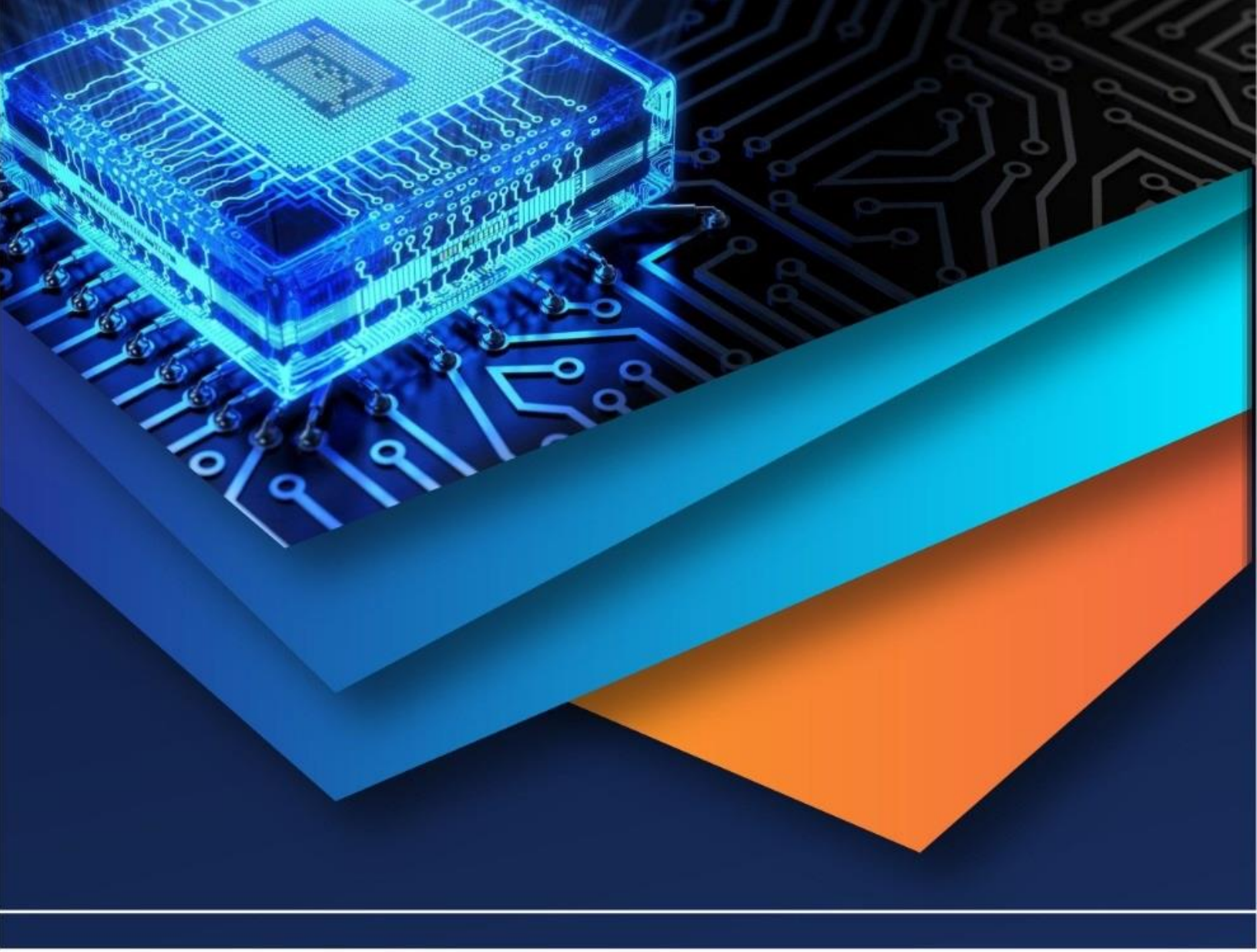

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