Shear behavior of RC Deep beams retrofitted with CFRP Sheets

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***Abstract*— RC deep beams are structural members widely used in numerous structural applications like bridges, water tanks, foundations, silos, bunkers, offshore structures, and tall buildings. Deep beams are beams having shear span to depth ratio less than 1. Carbon Fiber Reinforced Polymer (CFRP) is a strong and light fiber reinforced plastic containing carbon fibers. Shear behavior of RC deep beams retrofitted with CFRP Sheet enhances the load carrying capacity. The main concern of this paper is to investigate experimental behaviour of retrofitted reinforced concrete deep beams by CFRP sheets.**

***Keywords*— Deep beams, Carbon Fiber Reinforced Polymer (CFRP) Sheets, Retrofitting, Shear behavior**

I. INTRODUCTION

A beam is considered as deep beam, if the depth of beam is in relation to the span of the beam. For simply supported beams, it behaves as deep beam when the ratio of its effective length (L) to overall depth (D) is less than 2.0 and that for continuous beam is when the ratio is less than 2.5. In deep beams effective length is defined as the centre to centre distance between the supports or 1.15 times the clear span, whichever is less. Types of deep beams are classified as: (1)Simply Supported Deep Beams, (2)Continuous Deep Beam and (3)Deep Beams with and without openings. Deep beams can be widely used in many situations where ordinary beams or other structural members cannot be applied such as in bridges where long spans are required, in large halls or building where no column is to be used and in R. C. C. side walls of water tanks. Pile caps can also behaves as deep beams when the required span is lesser. In some cases; Raft foundation also contains deep beams: Bunkers and Silos of such structures may act as deep beam. For decades, methods of design and analysis for concrete members reinforced with normal strength steel have been developed. Lately reinforcing steel with enhanced strength than conventional steel has become commercially available.

The strut and tie modelling method is a widely accepted approach for R.C deep beams. However there are major differences among various design code Applications for this method with respect to reinforcement tie influences on the capacity of adjoining concrete struts. Furthermore, each design code provides altered limits on the maximum allowable stresses in the ties. Since high performance reinforcement continues to get wider reach in industry practices; it is necessary to validate existing design approaches for the mechanical properties of these new materials. The replacement of the smatched structural elements is very difficult and uneconomical process and the replacement of a particular structural element from an existing structure also creates hazard to the integrity of other connecting structural members. To reinstate the strength required of the smatched structure retrofitting is the solution. Retrofitting can be applied in two ways:

- Global Retrofitting
- Local Retrofitting

In Global Retrofitting, the entire structure is retrofitted to fulfil the serviceability requirements. It involves the design and analysis of the entire structure as per the specifications given in standard codes. In Local Retrofitting only selected member of the structure is either strengthened or replaced.

From the past studies conducted; it has been shown that externally bonded CFRP can be used to enhance the flexural, shear and tensional capacity of RC beams. The application of FRPs for the repair of accessible concrete structures has grown very speedily over the past few years. The CFRP can replace steel with overall cost savings in the order of 25%.

II.EXPERIMENTAL INVESTIGATION

A. Experimental Sample

Experimental study is done to examine the shear behavior of RC deep beams retrofitted with CFRP Sheets. Deep beams of size 450mm x 200mm x 1000mm is used and is designed for 280kN. M30 grade concrete is used and the grade of steel used is Fe500.

Details of the reinforcement in the deep beam are shown in Fig 1. 2 No.s of 16mm Φ TOR steel bars at the bottom and 2 No.s of 12mm Φ TOR steel bars at the top are given as main reinforcements. 2 legged 8mm Φ stirrups at 240mm centre to centre are given as vertical shear reinforcements and 2 No.s of 8mm Φ TOR steel bars are laid as horizontal shear reinforcements.

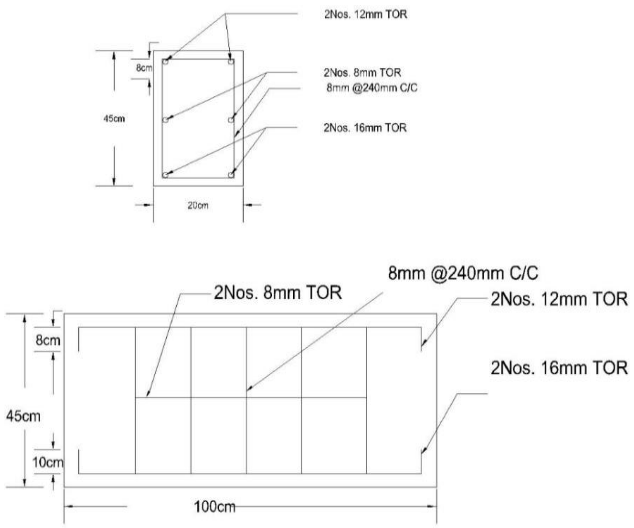

Fig 1.Reinforcement details

Fig 2. Casted Specimen

B. Material Characteristics

According to IS 10262:2009, mix proportion obtained for casting specimen is 1:1.97:3.84 by weight and water cement ratio was 0.38 by weight. Ordinary Portland cement, Msand and crushed gravel of 20mm maximum size are used. Ceraplast, a super plasticizer is used as admixture.
Carbon fiber reinforced polymer (CFRP) sheets with 0.10 mm thickness is used for wrapping as two layers. The mechanical properties of the CFRP material having elastic modulus of 230 GPa, tensile strength of 3500 MPa. The epoxy resin and hardener are used as adhesive.

C. Experimental Setup

Shear strength test of reinforced concrete deep beam is carried on loading frame of 50T capacity. Single point loading is applied. Dial gauges with 0.01mm and maximum range of 10mm were used to note the deflection values and a strain gauge is used to calculate the strain values.

Fig 3.experimental setup

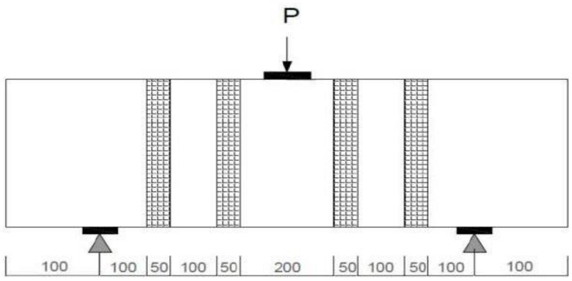

Fig 4. Retrofitted test beam Setup

III.RESULTS AND DISCUSSIONS

- Load v/s deflection of the beams are compared and is given in fig 9.
- The load v/s strain of the beam are also compared as shown in fig 14 and 15.
- The 28 days cube compressive strength obtained is 32.4MPa.
- Initial crack obtained is 182kN and the ultimate load obtained is 322kN. Mode of failure obtained is shear compression failure and is shown in the fig.5.
- Ultimate load of the retrofitted specimen obtained is 415kN

Fig.5. Failure Pattern

Fig 6.Retrofitted beam after failure

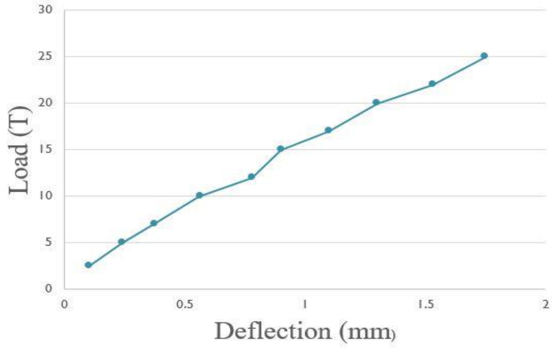

Fig 7.Load v/s deflection graph of control specimen

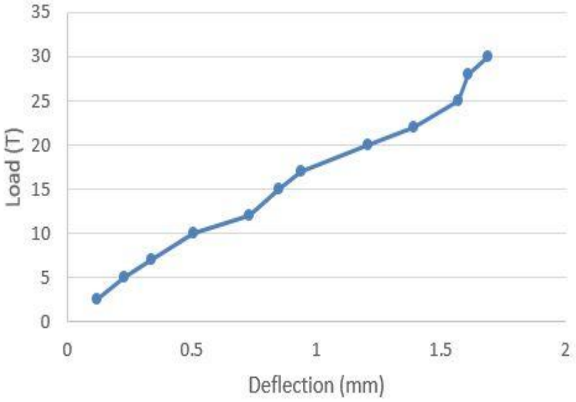

Fig8. .Load v/s deflection graph of retrofitted specimen

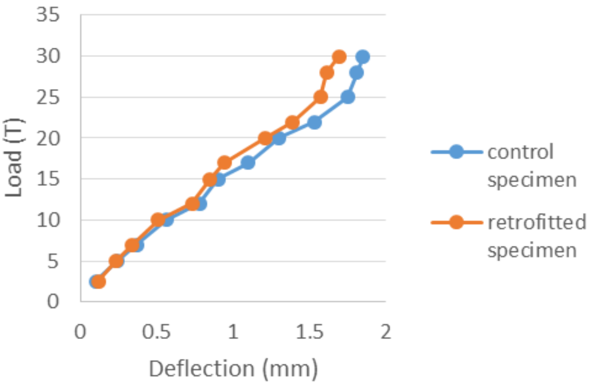

Fig 9.Combined Load v/s Deflection graph

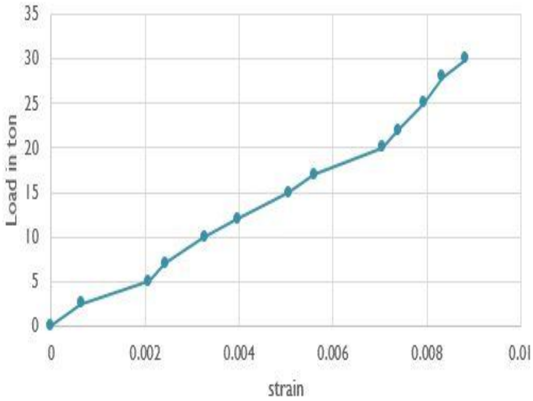

Fig 10.Load v/s Strain graph at the compression face

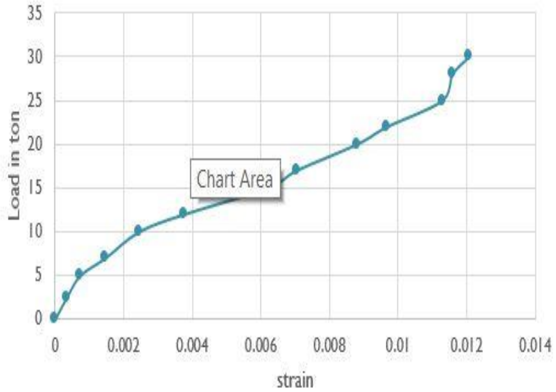

Fig 11. Load v/s strain graph at the tension face

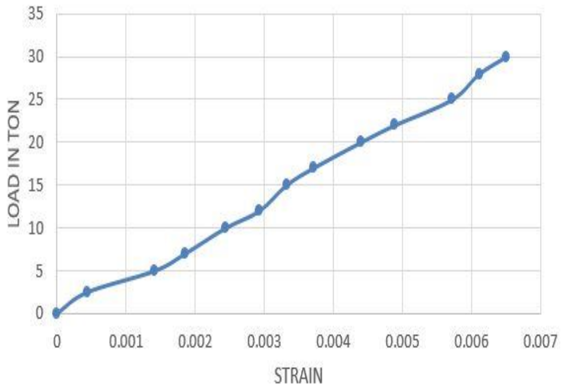

Fig 12. Load v/s strain graph of retrofitted specimen at the compression face

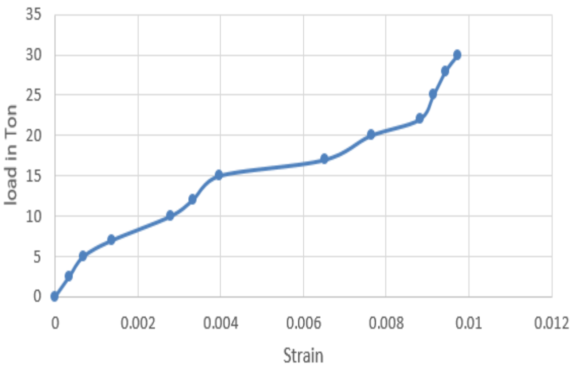

Fig 13. Load v/s Strain graph of retrofitted specimen at the tension face

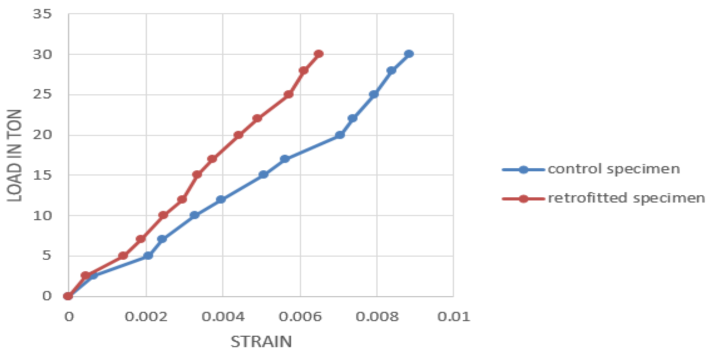

Fig 14.Load v/s Strain at the compression face

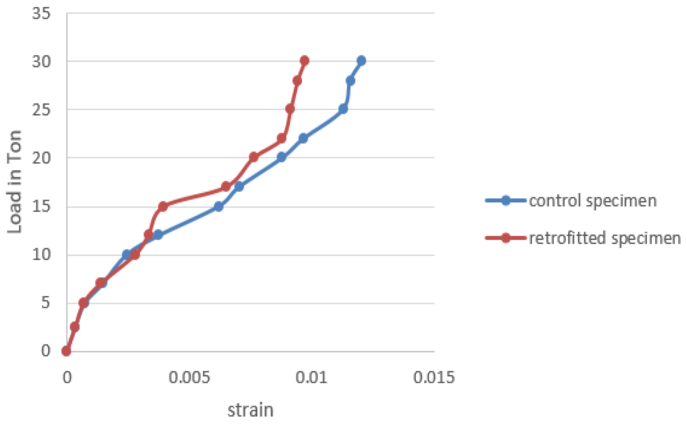

Fig 15. Load v/s strain at the tension face

IV.CONCLUSIONS

Based on experimental studies, the following can be concluded:

- Retrofitting the deep beams with CFRP sheets gives an 28.8% increase in the ultimate load carrying capacity.
- Retrofitted specimen gives deflection less compared to the control specimen.
- For ultimate load, retrofitted specimen shows less strain compared to the control specimen.

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