Retrofitting of RCC Beam in Flexure by External Cabling Method

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Abstract— In the world most of the RCC structures are damage before their service period due to several causes such as seismic forces like earthquakes, sudden impact load and improper structural design. Sometimes the whole replacement of structure is not possible because of high cost and time taking problem. In such a condition retrofitting technique for the damaged portion of the structure is more significant solution for strengthening the structures. Different retrofitting techniques are applied to strengthen the structure as their ease of uses. The retrofitting of RCC beam by external cabling method is very effective and rapid technique for strengthening the structure in both flexure and shear. In this investigation the external reinforcing steel bar as a cable was used for strengthening the RC beam in flexure only. Three number of RCC beam i.e. control beam of size 1800mm length, 100mm width and 150mm overall depth were casted for experimental study. The loads were applied at centre of each beam up to cracking and then up to failure point and load deflection for each beam were obtained. Then reinforcing steel bar was externally applied at top and bottom face of the each damaged beam. The effect of retrofitting by external reinforcing steel bar on RC beam was investigated.

Key words: Simply supported RCC beams, Retrofitting, External cable (reinforcing steel bar), Steel plate, Static load

I. Introduction

The addition of new technology or features to older systems is known as retrofitting. Retrofitting reduces the effect of damage of any structure. The vulnerability of existing reinforced concrete have exposed the earthquakes recently beam to seismic loading. Since many of the structures are varying quality and properties hence damaging over time. Steel jacketing and Concrete jacketing were the two common methods which is used for retrofitting of the reinforced concrete structures which results in increase of the cross sectional area and the self-weight of the structure. The retrofitting of reinforced concrete beam in flexure by EXTERNAL CABLING METHOD using reinforcing steel bar as a cable increases the beam strength and its stiffness and reduces the deflection capacity. Now days the external unbounded reinforcement is widely used for retrofitting technique to strengthening the RC beam due to its very effective, less cost and rapid installation techniques.

II. Experimental Investigation

The experimental study consist of three number of RCC beams each of length 1.8m and cross section size of 100mm width and 150mm overall depth according to IS Code 456:2000 known as control beam. These all beams are designed as singly reinforced balanced section. The beam is consisting of two numbers of 10mm diameter bars in tension zone and two numbers of 8mm diameter bars in compression zone as anchored bar. The vertical stirrups of 2-legged 6 mm Ø @ 100mm c/c spacing was used as per IS Code 456:2000. The mix design of concrete was done for target strength of 25 N/mm2. The experimental data based on load, deflection, crack and failure mode of each beams were recorded. Then these all beams are strengthening with external reinforcing steel bar and again experimental data based on load, deflection, crack and failure modes were recorded. And results of these two data of each beam were compared. The typical view of reinforcement detail is shown in figure1 and 2.

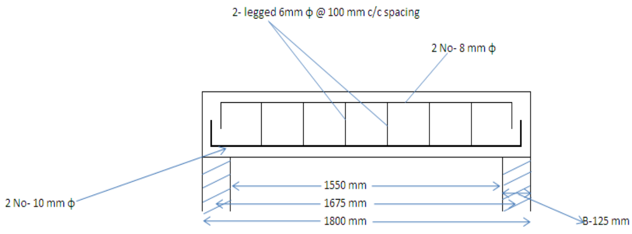

Fig. 1: Beam elevation

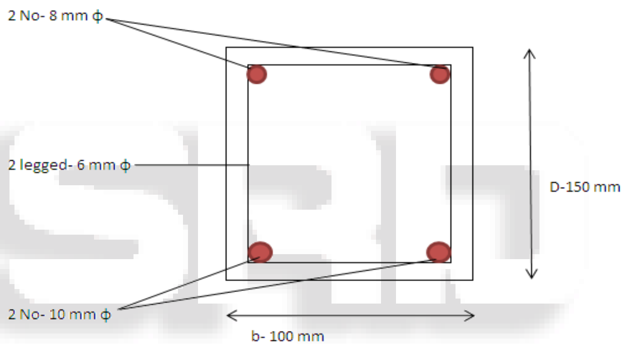

Fig. 2: Beam cross section

III. Preparation of Specimens

The concrete mix for casting of beam is prepared as per the design mix of M25. The form work of internal size of 1800mm x 150mm x 100mm was used. The form work of the beam is tightened with nut and bolt assembly at the ends of the mould. After tightening the inner walls of the form work is lubricated by lubricating oil then the reinforcement cage is kept in the form work with an effective cover of 20mm from the bottom and then the concrete mix is poured into the form work. All the nut bolt assembly of form work was opened after 24 hours of casting specimen. Then all specimens were cured in water tank for 28 days for proper curing. The control beams were tested up to ultimate load carrying capacity after 24 days of curing and then all the specimens were retrofitted (for strengthening purposes) by the external reinforcing steel bar of diameter 12mm. Two number of steel bar at top and bottom face of the beam was tightly held by nut bolt assembly with steel plate of size 100 mm width, 210 mm depth and 12 mm thickness. The typical view of both control and retrofitted RC beam is shown in figure 3 and 4.

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Fig. 3: Typical view of control Beam

Fig. 4: Typical view of retrofitted Beam

IV. DESCRIPTION OF TEST PROGRAMME

All the control and retrofitted specimen CRC1, CRC2, CRC3, RRC1, RRC2, and RRC3 were tested in General Testing Frame. All the beams were kept as simply supported. The point load was applied at the centre of each beam and deflection was recorded at centre and 200mm on both sides from centre using dial gauges. The load was gradually applied by hydraulic jack machine of capacity 100KN. The typical view of both control and retrofitted beam with loading is shown in figure 5 and 6.

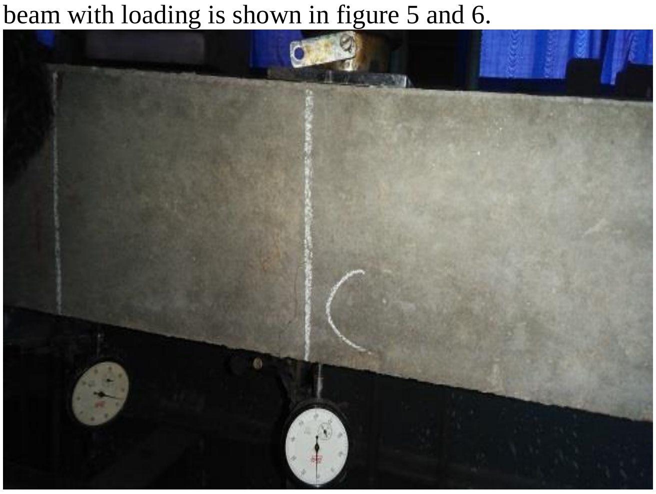

Fig. 5: Typical view of loaded control beam

Fig. 6: Typical view of loaded retrofitted beam

V. RESULTS AND DISCUSSION

In the case of control specimens CRC1, CRC2 and CRC3 beams it was found that the first crack formed at the centre of beam at a load of 25 KN, 25 KN and 28 KN respectively. The crack widened at a load of 28 KN, 29 KN and 30 KN respectively. The load was stopped when reaches at a load of 32 KN, 34 KN and 35 KN respectively for our convenience. The corresponding deflection of beam was found to be 7.85mm, 7.41mm and 7.60mm respectively. In the case of retrofitted specimens RRC1, RRC2 and RRC3 beams it was found that the max deflections achieved was 6.22mm, 4.98mm and 6.02mm at ultimate load carrying capacity of 25 KN, 25 KN and 28 KN respectively. The variations of deflection with load are given in table1.

Specimen	Load (at crack initiation) (in KN)	Load (at crack widened) (in KN)	Max Load (in KN)	Deflection (at crack initiation) (in mm)	Deflection (at crack widened) (in mm)	Max Deflection (in mm)
CRC1	25	28	32	4.98	6.62	7.85
CRC2	25	29	34	4.19	5.58	7.41
CRC3	28	30	35	4.51	5.5	7.60
RRC1	-	-	25	-	-	6.22
RRC2	-	-	25	-	-	4.98
RRC3	-	-	28	-	-	6.02

Table 1: Variations of deflection with load

The comparison of control and retrofitted beam between load and deflection are shown in figure7 and 8.

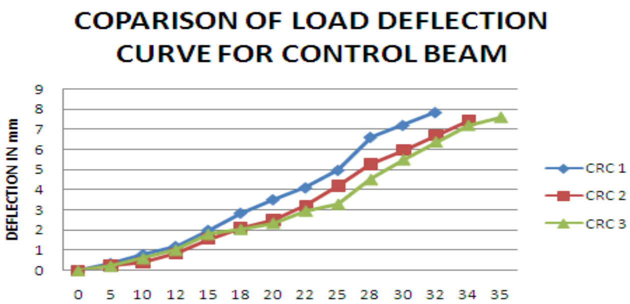

Fig. 7: Load deflection curve for control beam

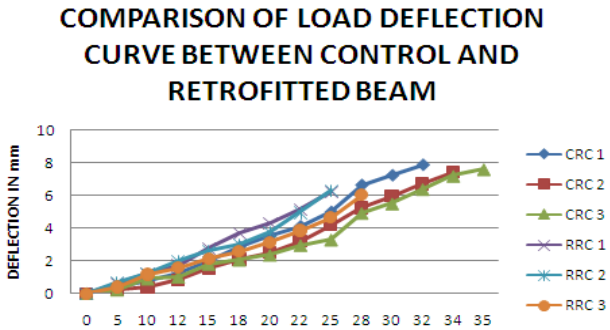

Fig. 8: Load deflection curve for control and retrofitted beam

VI. CONCLUSIONS

- In CRC 1, CRC2 and CRC3 beam, the initial cracks founded on higher loads.
- In this investigation it is found that the strengthening of beam by external cabling method using reinforcing steel bar achieve the 77% load carrying capacity of control RC beam.

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