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Retrofitting of Reinforced Concrete Beams using MS Steel Plates And Modelling using Finite Element Approach

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***Abstract*: Many of the reinforced concrete structures are being damaged by the frequent earthquakes and they need to be retrofitted using external retrofitting materials. Finite element method (FEM) has become a source for analysing by simulating a model and predicting the physical behaviour of complex engineering models. ANSYS is one such commercial finite element programs had been accepted by engineers in industry and research. The first specimen is the control specimen, which is designed as per IS 456:2000. The second and third specimens are also the same control specimen which is retrofitted using 2 and 3 layers of MS steel plates. Static load was applied at the center of the beam upto a controlled load. Non linear analysis was performed. The performances of the retrofitted beams were compared with the control specimen both experimentally and in ANSYS and the results are presented in this paper.**

Keywords - Simply supported beam, Retrofitting, MS steel plates, FEM

I. INTRODUCTION

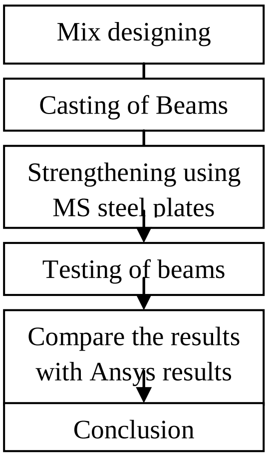
Reinforced concrete structures deteriorate due to many factors such as improper maintenance, increasing service loads, concrete related problems and natural disasters like earthquakes. Rehabilitation and retrofitting is necessary in high seismic regions. Seismic retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground motion and soil failure due to earthquakes. With better understanding of seismic demand on structures and with our recent experiences with large earthquakes near urban centers, the need of seismic retrofitting is well acknowledged. Thus, retrofitting became an important challenge to civil engineers. Complete replacement of an existing structure may not be possible and not cost-effective solution. In such cases repair and rehabilitation is a best possible solution. There are different techniques in retrofitting such as steel jacketing, providing additional reinforcement and increasing the section dimensions, strengthening using fiber reinforced polymers etc. Each of these methods has their own importance and is opted based on the requirement and ease of application.

The above techniques are expensive, require skilled labour and take more duration for application. Mild steel plates will be one of the alternatives for retrofitting the existing structure, which has high young's modulus and is ductile, malleable. They are economical in cost and easy to install. They will be available in required thickness. They can be painted along with the specimen, so that it won't appear as retrofitted specimen.

In this paper, the behaviour of a simply supported retrofitted reinforced concrete beam with MS steel plates under static load is studied. It should be ensured that, there are no irregularities between surface of the beam and MS sheets and rivets should be driven at regular intervals. If there are any irregularities between the surfaces, MS plates will not resist the deformation properly. The specimen may fail at less load than the expected or original load. So the plates are to be riveted tightly.

Fig 1 RCC Beam retrofitted with MS plates

II. METHODOLOGY



A. MATERIALS

Ordinary Portland cement of grade 53 was used. The initial setting time of cement is 30 minutes and the specific gravity of cement is 3.15. Fine aggregate used was clear sand passing through 4.75mm sieve with a specific gravity of 2.64. The grading zone of aggregate was zone III. Coarse aggregate used was angular crushed aggregate with a specific gravity of 2.8. Design concrete mix of 1:1.56:3.08 is adopted to attain 30N/mm^2. The water cement ratio of 0.47 is used. After several trails this mix design was finalised. Six cube specimens were casted and tested after curing for 28 days. The average compressive strength of 38.5N/mm^2 is achieved. HYSD bars of 12mm and 10mm diameters are used as longitudinal reinforcement and mild steel bars of 6mm diameter are used for shear reinforcement. MS steel plates of 2mm thickness are used for retrofitting the beams.

B. CASTING OF BEAMS

The moulds were prepared using teak wood, since we need stronger moulds for casting more cycles. The dimensions of all the specimens are identical. The length of beams was 1060mm and the cross sectional dimensions were 150mm x 150mm. Nine under reinforced beams were cast, three as control specimens and six for retrofitting. Two bars of 12mm diameter were provided as tension reinforcement at the soffit of the beam and two bars of 10mm diameter were provided as hanger bars at the top of the beam and bars of 6mm diameter were provided as shear reinforcement at a distance of 200mm c/c. The beams were casted and de-moulded after one day and are allowed to cure in water.

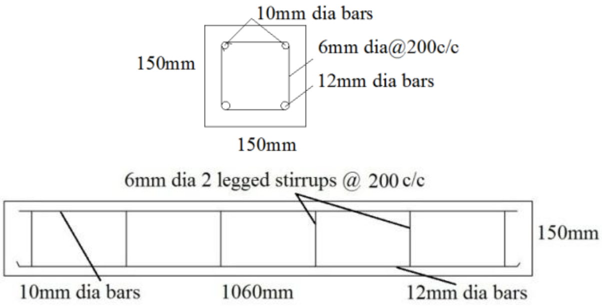


Fig 2 Reinforcement detailing of the beam

C. RETROFITTING OF BEAMS

The beams are cured for 28 days and then are removed from water. The surfaces of the beams are cleaned with water to remove dirt and for the visibility of the cracks. They are allowed to dry completely. The surface of the beams is cleanly scrubbed and groves were drilled using drilling machine at marked points. The MS steel plates are cut into the required dimensions and holes were drilled at required points. Using rivets, the steel plates were attached to the bottom surface of beams

D. TESTING OF BEAMS

The beams were properly set one after another on the universal testing machine. Single point loading is applied on the beam at the center of the beam. The load is transmitted through a load cell. The load is applied until the beams fails at ultimate loads. Load vs deflections graphs have been plotted

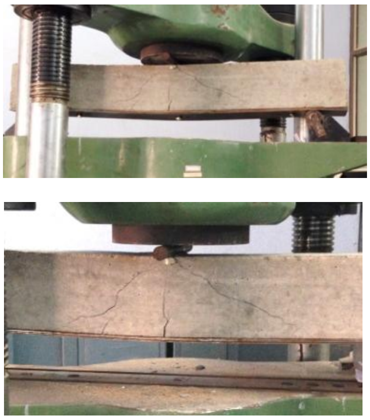


Fig 3 Experimental Test setup and Crack pattern

III. MODELLING

The concrete was modelled using Concrete 65 element. The steel plates were modelled using Solid 45 element. The reinforcement was modelled using Beam 188 element. In the past, many researchers used Link 8 element for modelling reinforcement, but in ANSYS 14.5 version Link 8 element is not supported. Before modelling the reinforcement, different circular sections are defined according to the diameters of bars. Meshing was done for both control and retrofitted specimens using ANSYS. One

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end of the beam is hinged and other end is provided with a roller support. The static load was applied at the centre of the beam at a regular interval of 5kN for the control beam and retrofitted beams. The performances of the retrofitted beams were compared with control beam specimen.

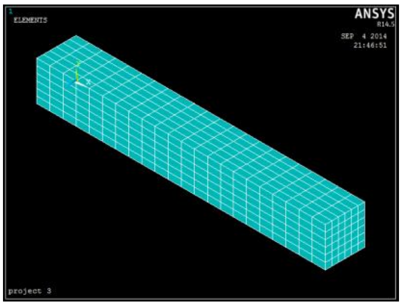


Fig 4 (a) Typical Control specimen

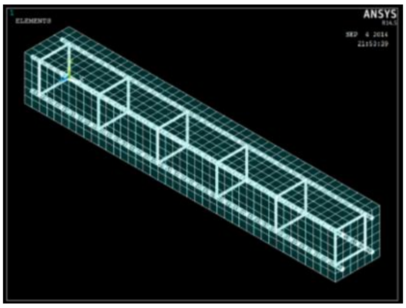


Fig 4 (b) Translucent view of control specimen

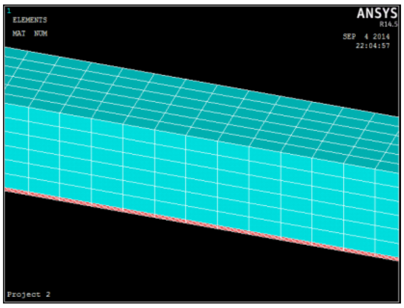


Fig 4 (c) Control specimen retrofitted with 3 layers of MS steel plates

Non linear analysis was done by choosing load interval of 5kN. Graphs were plotted according to this load interval. Load vs. deflection graph is plotted for each specimen using Ansys software. Figure 5(a) and 5(b) represents the deflected control beam and retrofitted beam.

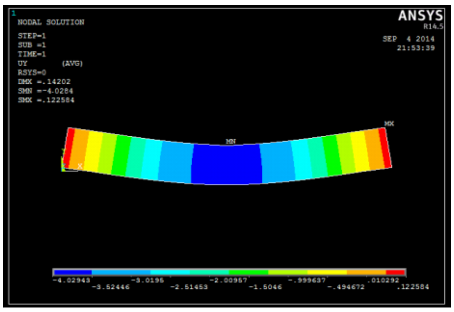


Fig 5 (a) Deflected control beam

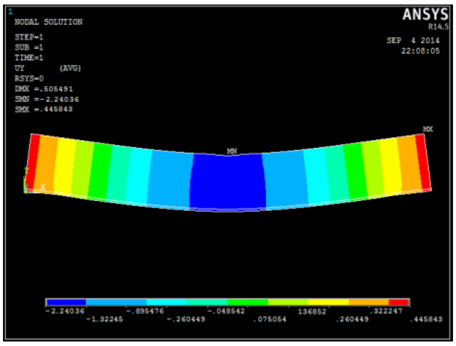


Fig 5 (b) Deflected retrofitted beam

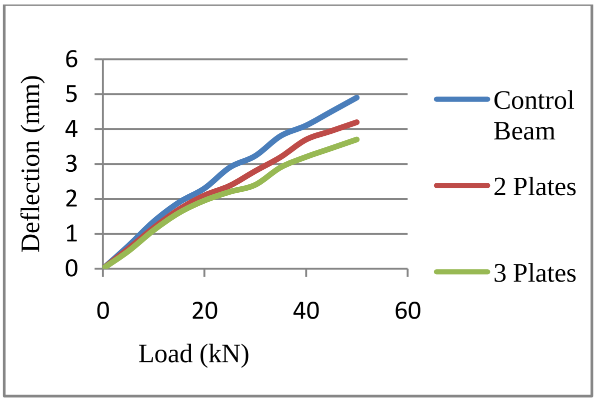
IV. RESULTS

The beams are subjected to single point static load at the center in UTM and load vs deflection graphs are plotted. The ultimate loads and deflections were obtained experimentally. Load vs deflection graphs obtained for three specimens when it is subjected to non linear analysis in Ansys software. The obtained results are tabulated and graphs were plotted below.

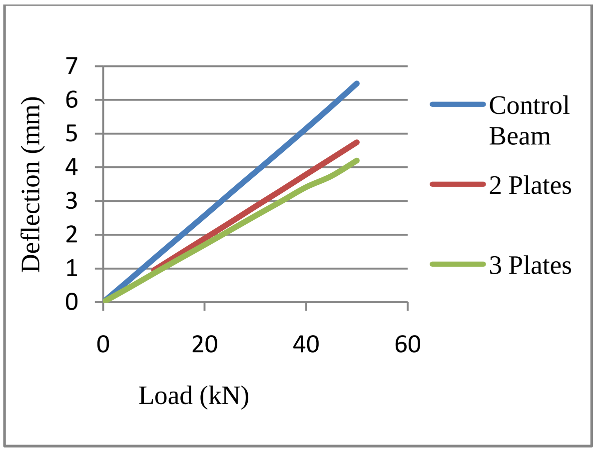
TABLE 1 Ultimate Loads and deflections (experimental)

Specimen	Ultimate Load KN	Deflection at Ultimate Load mm
Control Beam	53.250	6.8
2 Plates	60.850	7.3
3 Plates	73.350	10.5

Graph 1 Load vs Deflection (experimental)



Graph 2 Load vs Deflection (Ansys)



V. CONCLUSIONS

The following conclusions can be obtained from the study:

- It was observed that all the beams were failed due to shear
- Ultimate load of retrofitted beam with 3 Ms plates is relatively high compared to the control beams.
- Retrofitted beams showed lesser displacement compared to control beam at similar load intervals.
- Load vs displacement results obtained from the finite element analysis is similar to the experimental results.

VI. REFERENCES

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