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Strength Improvement with Different Retrofitting Methods for RCC Structure

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***Abstract*: Reinforced concrete is the main material which is being used in major construction projects. However, the deterioration of reinforced concrete structures is the serious problem worldwide. Apart from regular maintenance, many structures require extensive repair and strengthening.**
The researchers have studied three different methods of retrofitting considering the strength and cost aspects.
In this study, Ferro-cement, Carbon Fiber Reinforced Polymer (CFRP) and Plate Bonding method are used for retrofitting deteriorated beams. Flexural strength of the retrofitted beams are tested and compared.

***Keywords*: Ferro-cement, Carbon Fiber Reinforced Polymers (CFRP), Plate Bonding Method, Compressive Strength, Flexural Strength**

I. INTRODUCTION

The existing infrastructure now a day is subjected to overuse and hence degradation or deterioration is taking place.
In India, it has been seen that many old structures are in very unsafe structural condition due to negligence of timely repairs and maintenance. Due to which they need major repairs. In many places, where constructions are very old but still, they are occupied for residential purpose. In Rajasthan region most of the constructions are old and such buildings occupied for residency. This can be led to serious accidents. If a building is not maintained or repaired for about 25 to 30 years of its service life span, then it is reasonable to expect that it would need some major structural repair soon.
There are many causes which lead to dilapidation condition of a building such as ageing effect, inadequate maintenance, weathering, overloading the structure, poor quality of material for construction and poor design of structure.

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Retrofitting is nothing but repairing the deteriorated structure and increasing its life span. Use of ferrocement, CFRP sheets and steel plate bonding are some of the methods of retrofitting the structural members and increase its load carrying capacity. Carbon Fiber Reinforced Polymer (CFRP) is a composite material made from Carbon Fiber and Polymers. Carbon fibers are responsible for good strength and stiffness and polymers hold the fibers together and provides cohesiveness and toughness to the material.
Ferrocement is combination of a thin reinforcement layer and a plaster mortar. A mesh of thin, well distributed reinforcement is applied with a plaster mortar on its both sides to make ferrocement. Steel Plate Bonding is a technique in which steel plates are bonded to the concrete member using some adhesives. These steel plates serve as a new reinforcement and takes active part in taking loads.

II. METHODOLOGY

A. Specimen of Deteriorated Beams

Original deteriorated beams are of length 700mm and cross section 150mm^2 reinforced using 2 bars of 10mm diameter at bottom.

It is observed that the average compressive strength of virgin beams is 4.566 MPa.

B. Surface Preparation for Application

Existing surface of beam is firstly prepared by removing the unwanted particle to give hard surface.

C. Application of Retrofitting Techniques

C.1 Application of Carbon Fiber Reinforced Polymer

Bonding agent is first applied evenly on the cleaned surface of beam. This bonding agent (Epoxy) is prepared by mixing resin and thinner.CFRP sheets are cut in the required shape and size and then placed on a thin layer of bonding agent which was applied previously on the clean surface of member. The CFRP sheets are pressed equally all over the surface. Cut the extra portion of sheet.


a. Application of Epoxy


b. Layer of CFRP Sheet

Fig. 1. Application of CFRP

C.1 Application of Ferro-cement.

Wire meshes are fixed on the cleaned surface using anchorages. One-inch deep holes are drilled in two lines on three sides of beam.

Cement slurry is prepared and poured into the holes to fix the nail into the holes.

Fix a single layer of mesh accurately and tightly wrapped around three sides of the beam. After application of the first layer of mesh, two 6mm diameter bars are placed on each working faces of beam ie. Six numbers of bars are required for one beam. Bars are placed near the nail lines.

The second layer of mesh is now tightened using the nails. Prepare a micro concrete of grade M40 having proportion 1:1 (Cement: Fine sand passing through 2.36mm sieve). Apply this mortar on the tightened mesh evenly and level the surface. Cure the member for 28 days.

a. Layer of Mesh

b. Preparation of Mortar c. Application of Mortar

Fig. 2. Application of Ferro-cement

C.3 Application of Steel Plate Bonding Method

Bonding agent (Epoxy) is first applied evenly on the cleaned surface of beam. Avoid excessive use of agent.

The Steel plates are placed on the layer of epoxy and pressed by keeping heavy weight on it for 24 hrs. Props are used on site for supporting the steel plates.

a. Application of Bonding Agent on the Surface. b. Steel plates bonded to the Surface

Fig. 3. Application of Steel Plate Bonding Method

III. EXPERIMENTATION

The beam specimens are tested against standard specification given by IS: 516(1959) for flexural strength. Four specimens are used for every retrofitting method. For finding the final value of flexural strength average value of three specimens are considered.

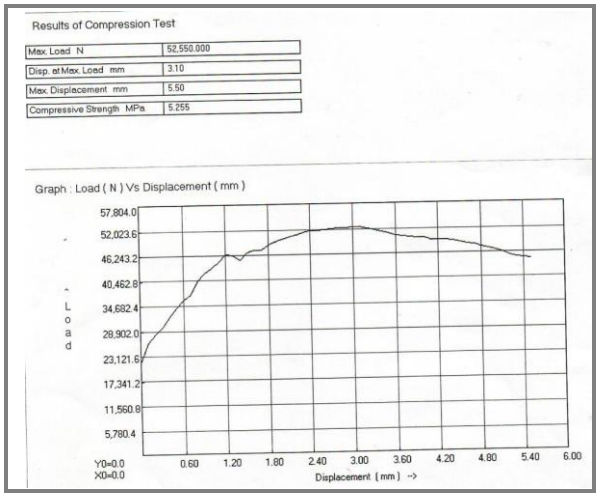
a. Beam with CFRP b. Beam with Ferro- cement

c. Beam with Steel Plate Bonding

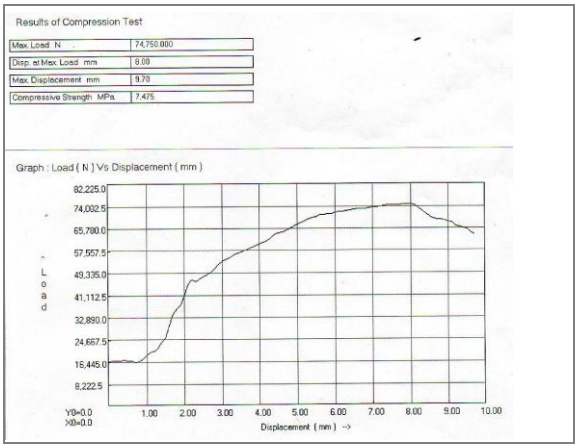
Fig. 3. Testing of Retrofitted Beams

IV. RESULT AND DISCUSSION

A. Compressive Strength and Flexural Strength

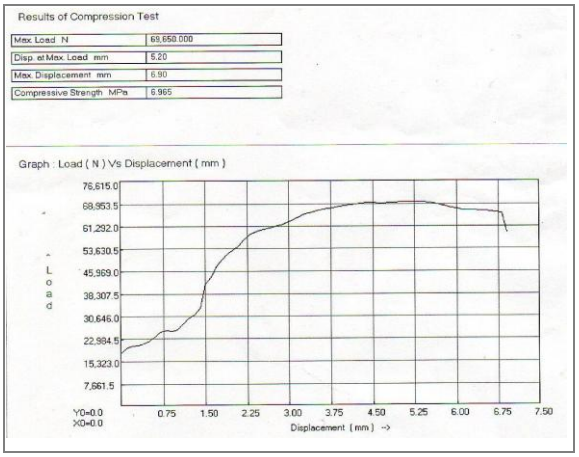


a. Result for Virgin Beam Sample 2



b. Result for CFRP Beam Sample 2

c. Result for Ferro-cement Beam Sample 2



d. Result for Steel Plate Bonded Beam Sample 2

Fig.4. Results on Virgin and Retrofitted Beams for Sample no. 2

It is observed from the experimental results that the average compressive strength of virgin beams is 4.566 MPa, beams wrapped with CFRP sheet is 7.721Mpa, beams fitted with Ferro-cement sheet combined bars with 6 mm diameter bar is 10.278 MPa and beams retrofitted with Steel Plate Bonding is 5.470 MPa. Comparison is shown in Fig 5.

From the compression load taken by the beams, average value of flexural strength is calculated. Flexural strength of virgin beams is 6.760 MPa, beams wrapped with CFRP sheet is 11.438 Mpa, beams fitted with Ferro-cement sheet combined bars with 6 mm diameter bar is 15.220 MPa and beams retrofitted with Steel Plate Bonding is 8.103 MPa.

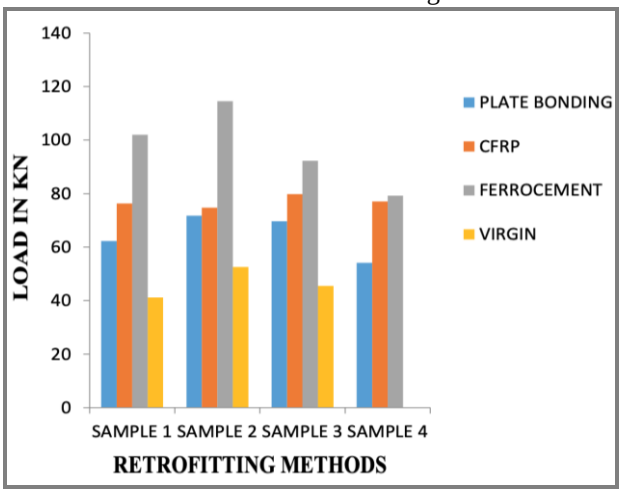


Fig.5. Comparison of Load Carrying Capacity

B. Cost Calculation

The total cost of material, workmanship, equipment is worked out and cost comparison is done.

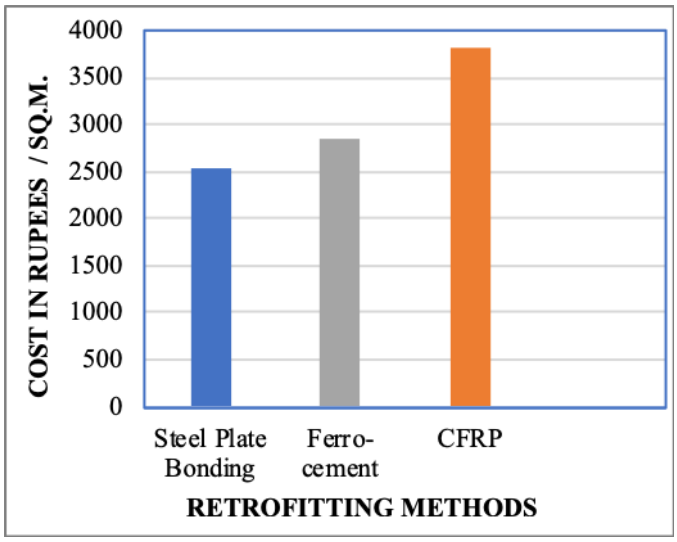


Fig.6. Cost Comparison for Retrofitting Methods

C. Comparative Results

Following results are observed considering the average flexural strength of all three methods:

1) Beams retrofitted with Steel Plate Bonding method shown 1.198 times increase in strength.
2) Use of Carbon Fiber Reinforced Polymers (CFRP) for retrofitting of beams enhances the strength by1.69 times.
3) Ferro-cement wrapping combined with two bars of mild steel has drastically increased the strength by 2.25 times.
4) The cost comparison chart (Fig. 6.) shows that Carbon Fiber Reinforced Polymers (CFRP) requires highest cost.

V. CONCLUSION

The experimental results and the cost comparison showed a promising potential of Ferro-cement wrapping used with a combination of mild steel bars. This combination has given higher strength as compared to CFRP in much lesser cost.
It is also observed that the Steel Plate Bonding is economical to adopt but the strength gained is very less compared to other two methods.

REFERENCES

1. Masood Montevallo, Christoph Czaderski, and pfyl-Lang Kerstin."Pre-stressed CFRP for strengthening of reinforced concrete structure: Recent development at Empa". ASCE, 2010.
2. Garden, H. N and Hollaway L. C, Thorne L. M. "An Experimental study of the failure modes of reinforced concrete beams strengthened with prestressed carbon composite plate". ASCE, 1998.
3. L.kostas, T. C.Triantafillous. "Uses of Anchors in shear strengthening of reinforced Concrete T-Beams with FRP". ASCE, 2013.
4. Mohammad Hussein, Hamdy Mohy EI-Din Afefy and Abdel Hakim. "Innovation Repair Technique for RC Beams predamaged in shear". ASCE, 2013.
5. Ke Li, Shuangyin Cao, Yue Yang and Juntao Zhu. "Bond slip relationship for CFRP sheets externally bonded to concrete under cyclic loading". ASCE, 2018.
6. Ahmed W. Al Zand, Wan Hamidon, W. Badaruzzaman Azrul, A. Mutalib and Salam J. Hilo. "Flexural behavior of CFST beams partially strengthened with unidirectional CFRP sheets". ASCE, 2015.
7. Tamer El Maaddawy and Khaled Soudki. "Carbon-Fiber-Reinforced Polymer repair to extend service life of corroded reinforced concrete beams". ASCE, 2015.
8. .Jawdhari, A.M.ASCE, A. Peiris, M.ASCE, and I. Harik. "Bond study on CFRP rod panels externally adhered to concrete". ASCE, 2016.
9. Marco Arduini and Antonio Nanni. "Behaviour of precracked RC beams strengthened with carbon FRP sheets". ASCE, 2015.
10. Mohammed A. Al-Saa wani, Ahmed K. El-Sayed and Abdulaziz I. Al-Negheimish. "Crack width prediction for concrete beams strengthened with carbon frp composites". ASCE, 2017.
11. Tohid Ghanbari Ghazijahani, Hui Jiao, and Damien Holloway. "Composite timber beams strengthened by steel and CFRP". ASCE, 2016.
12. Neil A. Hoult and Janet M. Lees. "Efficient CFRP strap configurations for the shear strengthening of reinforced concrete T-beams". ASCE, 2009.
13. Moataz Badawi and Khaled Soudki. "Fatigue behaviour of RC beams strengthened with NSM CFRP rods." ASCE, 2009.
14. Cheng Chen, and Lijuan Cheng. "Fatigue behaviour and prediction of NSM CFRP-strengthened reinforced concrete beams". ASCE, 2016.
15. Li Li Hu, Xiao Ling Zhao, and Peng Feng. "Fatigue behaviour of cracked high- strength steel plates strengthened by CFRP sheets". ASCE, 2016.
16. Rizwan Azam, Khaled Soudki, Jeffrey S. West and Martin Noë. "Behaviour of shear-critical RC beams strengthened with CFRCM". ASCE, 2017.
17. Yousef A. Al-Salloum, Hussein M. Elsanadedy Saleh H. Alsayedand Rizwan A. Iqbal. "Experimental and numerical study for the shear strengthening of reinforced concrete beams using textile-reinforced mortar". ASCE, 2012.
18. Chetan Yalburgimath, Akash Rathod, S Bhavanishankar. "Retrofitting of reinforced concrete beam using Carbon Fiber Reinforced Polymer (CFRP) Fabric". IRJET, 2018
19. Prabhjot Singh.. "A case study on rehabilitation and retrofitting of cheetal marriage accommodation of Indian army Hissar". IRJET, 2018.
20. Moataz Badawi and Khaled Soudki. "Control of corrosion-induced damage in reinforced concrete beams using Carbon Fiber-Reinforced Polymer Laminates". ASCE, 2015.
21. Bimal Babu Adhikary, and Hiroshi Mutsuyoshi. "Behaviour of concrete beams strengthened in shear with carbon-fiber sheets". ASCE, 2015.
22. H. Toutanji, L. Zhao,Y. Zhang. "Flexural behaviour of reinforced concrete beams externally strengthened with CFRP sheets bonded with an inorganic matrix". ELSEVIER, 2005.
23. Oluwa funmilayo Awani, Tamer El-Maaddawy, Najif Ismail. "Fabric-reinforced cementitious matrix: A promising strengthening technique for concrete structures". ELSEVIER, 2016.
24. Jacopo Donnini,Valeria Corinaldesi,Antonio Nann. "Mechanical properties of FRCM using carbon fabrics with different coating treatments". ELSEVIER, 2015.
25. Jacopo Donnini, Valeria Corinaldesi. "Mechanical characterization of different FRCM systems for structural Reinforcement". ELSEVIER, 2017.

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