International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 10 | Oct - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Retrofitting Techniques: A Comprehensive Review

Sujal S. Nighot[1], Ayush D. Yerpude[2], Prachi H. Gandate[3], Tanmay L. Mendhule [4], Mr. Roshan H. Mohankar[5]

[1,2,3,4] Students, Department of Civil Engineering., Priyadarshini J.L. College of Engineering, Nagpur

[5] Asst. Prof., Department of Civil Engineering., Priyadarshini J.L. College of Engineering, Nagpur

---

Abstract - The need of improving the structural performance of old constructed structures has grown significantly as a result to increasing concerns over deteriorating infrastructure, changing building codes and natural calamities. Retrofitting is one of the best processes to make an existing building safe against future coming earthquakes or other environmental forces. Retrofitting is the process of adding new features to older buildings, bridges and many other structures. It aims to strengthen the structure, to satisfy the load carrying capacity of structure and seismic design. This paper includes study of research papers published in past years related to various methods of retrofitting such as seismic retrofitting, retrofitting by glass fibers, retrofitting by chemicals such as epoxy resin and many other methods. Structures lose their strength in some years, some structures are important in view of public, social or any historical. Retrofitting helps to increase the strength, resistivity and lifespan of structure.

Key Words: *Retrofitting, Strength, Safety.*

I. INTRODUCTION

Retrofitting of structures is essential for improving the lifespan and safety of old buildings, bridges, and other infrastructure. Numerous of the concrete structures throughout the world which are in critical need of rehabilitation, re-construction because of deterioration due to many factors like erosion, failure of bonding between beam and column joints, increase in service loads, etc. leading to cracking, spelling of concrete, loss of strength, etc. the need of effective recuperation and strengthening techniques of existing concrete structures has resulted in exploration and development of strengthening of structure. Although maturity of concrete structures has performed satisfactorily over the once times but numerous problems have raised due to inappropriate embellishments, incorrect specification, imperfect design and blunders in construction process or extreme environmental conditions. Cracks in concrete have many causes. They may indicate significant structural failure or lack of continuity, cracks may present. Their significance depended on the type of structure as well as the nature of the cracking. There are various building structures of public, private and historical importance. If these structures get damaged, in extreme cases they can be demolished. But in case of structures of historical importance, they cannot be demolished. And retrofitting is the only method to repair these structures. With the increasing recognition of climate change and urbanization pressures, retrofitting offers a sustainable alternative to demolition and reconstruction. To retrofit the cracks on the reinforced concrete structures there are many methods. Various approaches have been developed over the years, addressing specific challenges.

II. LITERATURE REVIEW

1. **"Retrofitting By Epoxy Resin" Ayush D. Yerpude, Varun A. Kalambe, Shweta H. Bhurle, Minakshi B. Kawale, (May 2023):** It is not cost-effective to reconstruct predamaged structure in a way that depletes our natural resources. A structure's lifespan can be increased through retrofitting while using little or no natural resources. Epoxy resins managed to increase strength while only slightly changing the global mass.

2. **"Shear Strength Study of RC Beams Retrofitted Using Vinyl Ester Bonded GFRP and Epoxy Bonded GFRP" Tara Sen, H.N. Jagannatha Reddy, Shubhalakshmi B.S., (Vol 2, No.2, 2012):** This paper have detailed study on shear behaviour of RCC beams and the Vinyl- Ester bonded GFRP and Epoxy bonded GFRP wrapped retrofitted RCC beams. Beams were retrofitted with Epoxy bonded GFRP sheets and Vinyl-Ester bonded GFRP sheets using epoxy resins. It was resulted that the wrapping of GFRP sheets increases the ultimate load carrying capacity of RCC beams.

3. **"Retrofitting of RC Beams using Glass Fiber Reinforced Polymer Sheets: An Experimental Study" Rohit Vasudeva, Mandeep Kaur, (Vol 9(44), November 2016):** In the current experimental investigation flexural and shear behavior of RC beams retrofitted with GFRP sheets in examined in sets. all beams of same grade of concrete where used but with different

structural detailing. In a set three beams (weak in flexure) were casted out of which one was controlled beam and other two beams were retrofitted using GFRP.

4. **"Retrofitting of Reinforced Concrete Beams Using Ferrocement & Epoxy Resin" C. Neeladharan, A. Muralidharan, P. Sathish, K. Mohan, (Vol. 6, Issue 11, November 2017):** The strengthened beam gives more strength when compared to the standard concrete beam. The flexural strength of the beams already having load are higher (70%,>80%,>85>90%). Hence the existing damaged beams can be strengthened upto 85% of the failure or collapse using Ferrocement and epoxy resin.

5. **"Retrofitting of Reinforced Concrete Beams Using Carbon Fiber Reinforced Polymer" Vanishri. A. Patil, Shruti Wadalkar, Vinayak Kale, (2023):** This study looks into the effects of Carbon Fiber Reinforced Polymer retrofitting on the compressive strength of reinforced concrete beams at different curing durations. Nine beam specimens were prepared and subjected to flexural strength testing after 7 days, 14 days, and 28 days of curing. The obtained results exhibit the effectiveness of the CFRP retrofitting. And a progressive increase in flexural strength over the curing period.

6. **"Repair and Retrofitting of Concrete Bridge Girder Using Epoxy, Micro Mortar, and CFRP Sheets" Khondaker Ahmed, Md Moniruzzaman, Kaniz Rupa, (September 2023):** In this study, a damaged cantilever concrete girder bridge has been tested to understand the effectiveness of strengthening work of its three girders. The strengthening of girders was conducted through a combined action of epoxy resin injection, micro mortars and externally bonded Carbon Fiber Reinforced Polymer (CFRP) sheets.

7. **"Retrofitting of Reinforced Concrete Beams Using Rubberized coir Fiber Sheets" Poorna Prasad Rao. O.L, RamaMohan Rao. P., (Volume 3 Issue 3–March 2016):** This paper studies the shear and flexural behavior of reinforced concrete beams retrofitted with RCFC sheets after preloading. The stiffness of the RCFS retrofitted beams are greatly increased when compared to the control beams. Also the deflection of retrofitted beams was reduced mostly at the early stages of loading.

8. **"Retrofitting of Reinforced Concrete Beams by using Carbon Fiber Reinforced Polymer Sheets" Mansoor Ahmad Bhat, (Volume 9, Issue 9, September 2018):** The flexural behaviour of reinforced concrete beams externally hardened by CFRP sheets having different thicknesses are studied in this experimental investigation Due to hardening of beams with CFRP sheets externally, the flexural strength and the ultimate load bearing capacity of the beams increased.

9. **"Retrofitting of RC Beam using Glass Fiber Reinforced Polymer Composite" Prof J. Jose Franklin, Catherine Mohanji Gera, (Vol-2, Issue-5 May- 2016):** In this paper the techniques of strengthening RCC structures is through restraint with composite enclosure. Fiber- reinforced polymer material, which are available in the form of sheet are used to increase the flexural, shear, and axial load carrying capacity of these structural members. The advance methods consist of wrapping Glass Fiber Reinforced Polymer composite mats on the shear and flexural zones of the RCC beams and studying their characteristics.

10. **"Retrofitting of Reinforced Concrete Structures" S. Karuppasamy, K. Shriram, S. Pradeep Kumar, K. Vijayakumar, D. Rohith babu, (Volume:06 Issue:03, Mar 2019):** The process of retrofitting a reinforced concrete structure is detailed and the experiment on beam before and after retrofitting is studied. The retrofitted beams have greater ultimate load capacity and flexural strength after external wrapping. The carbon fiber reinforced polymer remained unflawed even after the failure of beam.

11. **"Seismic Retrofitting of Structures by Steel Bracings" G Navyaa, Pankaj Agarwal, (2015):** This study proclaims a complete process of retrofitting on a building designed with two different IS codes, IS 456: 2000 and IS 1893 (Part 1): 2002 and retrofitted with steel bracing. The delicacy analysis was also carried out to indicate the probability of damage under different states which reduces after retrofitting of building.

12. **"Evaluation of severe damaged reinforced concrete beam repaired with epoxy injection and retrofitted with CFRP using acoustic emission technique" S N Mat Saliah, K Khairul Nizam, M M Muhammad Ariffaizad, N Abd Rahman and N Md Nor, (2019):** In this study, acoustic emission signal strength of extreme damaged RCC beams repaired with

epoxy injection and retrofitted with CFRP on the soffit subjected to monotonic loading are investigated. The crack progressions from tensile crack to shear crack were made and well matched to the illustrated crack pattern for beams.

13. **"Epoxy Resin Vs MBC Binder for GFRP Retrofit Structures" Raghavendra V, (2012):** The mix proportion of ingredients of MBC mortar with suitable examples are discussed in this paper. From the results obtained from this research, it is stated that MBC binder gives similar strength when compared with epoxy binder but results better at extreme temperatures, it has good insulation and resists acid attack making this process good for the structure.

14. **"Retrofitting Of Reinforced Concrete Beams Using GFRP" Riyaz J. Mulla, Vinit T. Avdut, Shivraj D. Bagal, Mohammad Fazal Bashir Dongare, Shubham D. Sarvade, (Volume 6, Issue 04 Apr. 2024):** This research shows that shear and flexural capacity of UW rapped specimens using stitched mat and woven roving increased, as the numbers of the mat increased. For both retrofitted heard efficient and retrofitted flexural deficient beams, triple layer of stitched mat has performed good. From this research, it is resulted that stitched mat is more effective material for retrofitting.

15. **"Retrofitting of RC Beams using Epoxy Injection and Epoxy Bonded Polyester Fiber" Jerry Emmanuel. V, (Issue - 2016):** This paper reviews work on repairing of damaged RCC beams. Every structural member should be designed for a particular type of loading and for adapting different types of environment. In this review, causes of damage of RCC beams as well as repairing by using epoxy, Polyester Reinforced Polymer and the techniques of applying these materials are studied.

16. **Rehabilitation of reinforced concrete beam: Sustainable restoration mortar with waste materials" Javad Sabzi, M. Reza Esfahani, Togay Ozbakkaloglu, Aliakbar Gholampour, Amir R. Masoodi, (December 2023):** The findings reveal that RCC beams gets strength with CFRP mesh-restoration mortar and GFRP rebar-restoration mortar exhibit load-carrying capacities 13% and 36% higher, respectively, compared to that reinforced with CFRP sheets. This study setup the foundation for future research by demonstrating, the superior performance of mortar-based restoration over epoxy resin.

17. **"Experimental Vacuum Process for Retrofitting Concrete Structures" A. Padilla- Ramírez, A. Flores Bustamante, M.I. Panamá Armendáriz & F. González Díaz, (2012):** As the study of this research shows that the, external reinforcing FRP has an important effect to control the structural damage on RCC structures. Moreover, the mechanical behaviour of retrofitted beams by external reinforcing FRP is better than the witness beams. In this way, load capacity of retrofitted beams is 10% higher than that present in witness beams.

18. **"Seismic Performance of Actual Members Retrofitted with Epoxy Resin Injection" H. Araki, Y. Segawa, (January 2017):** In this study unit weight of concrete was classified as lightweight concrete. In this research it was seen that the coarse aggregate was made from rhyolitic welded tuff from the component of concrete. By injecting Epoxy resin in RCC structure the seismic performance of the structure was improved. Although the crack of the retrofitted member of structure were similar to the member of structure without epoxy resin injection, the maximum strength of the retrofitted members increased to 1.3~1.6 times that of the members without epoxy resin injection.

19. **"Performance of Different Retrofitting Techniques on Existing RCC structures" Milind V. Mohod, (Volume-8 Issue-2, July 2019):** This paper shows effects of providing open ground storey and remedial measures of retrofitting among different methods of retrofitting techniques. To perform this task various retrofitting techniques namely infill walls, steel bracing and shear wall as showed in the paper were made in ETABS software.

20. **"Repair, Rehabilitation & Retrofitting of RCC For Sustainable Development With Case Studies" J. Bhattacharjee, (Vol.3, No.2, June 2016):** The paper brings out the present condition of concrete structures & the major areas where improvement is necessary during its service life for sustainable development & also the method of carrying out Repair & Retrofitting of structures. This has been shown in details in this paper along with case studies, where the author of the paper was directly involved in planning and execution of the jo

III. NEED OF STRENGTHENING

Following are reasons to strengthening a building:

a. Building which is designed considering gravity load only that is without considering gravity load only that is without considering earthquake force.

b. Do continuous exploration and development trouble in the field of earthquake resistant design of structure.

c. Analysis and design change in codes, practices, standards and etc. thus structure by be structurally.

d. Sometimes important existing structures in a particular locality may require to be strengthened to view of earthquake activity in an area.

e. The structure in which the earthquake resistance has failed due to the factor such as decrease in damage etc. Strength of construction material due the delay

IV. CONCLUSION

This study concludes that many RCC structures globally are getting deteriorated, and they lose their strength in some years due to aging, seismic activities, temperature effect and etc. Retrofitting is the method which is used to repair and strengthen these structures. It is the process of adding new features to older buildings, bridges, and many other structures. There are many techniques by which retrofitting can be done, such as seismic retrofitting, energy-efficient retrofitting, retrofitting by chemicals, and material-based retrofitting. Materials and chemicals, such as epoxy resin, Vinyl Ester Bonded GFRP, Glass Fiber Reinforced Polymer Sheets, Rubberized Coir Fiber Sheets, and many other materials, are used to retrofit the structures. Our review indicates that retrofitting techniques are essential for ensuring the safety, sustainability, and efficiency of these structures. With continued innovation and application, retrofitting can significantly contribute to safer, more energy-efficient, and cost-effective structures globally.

REFERENCES

1. **Ayush D. Yerpude, Varun A. Kalambe, Shweta H. Bhurle, Minakshi B. Kawale (2023),** "Retrofitting By Epoxy Resin".
2. **Tara Sen, H.N. Jagannatha Reddy, Shubhalakshmi B.S., (2012),** "Shear Strength Study of RC Beams Retrofitted Using Vinyl Ester Bonded GFRP and Epoxy Bonded GFRP".
3. **Rohit Vasudeva, Mandeep Kaur, (2016),** "Retrofitting of RC Beams using Glass Fiber Reinforced Polymer Sheets: an Experimental Study".
4. **C. Neeladharan, A. Muralidharan, P. Sathish, K. Mohan, (2017),** "Retrofitting of Reinforced Concrete Beams Using Ferrocement & Epoxy Resin".
5. **Vanishri. A. Patil, Shruti Wadalkar, Vinayak Kale, (2023),** "Retrofitting of Reinforced Concrete Beams Using Carbon Fiber Reinforced Polymer"
6. **Khondaker Ahmed, Md Moniruzzaman, Kaniz Rupa, (2023),** "Repair and Retrofitting of Concrete Bridge Girder Using Epoxy, Micro Mortar, and CFRP Sheets"
7. **Poorna Prasad Rao. O.L, RamaMohan Rao. P., (2016),** "Retrofitting of Reinforced Concrete Beams Using Rubberized coir Fiber Sheets".
8. **Mansoor Ahmad Bhat, (2018),** "Retrofitting of Reinforced Concrete Beams by using Carbon Fiber Reinforced Polymer Sheets".
9. **Prof J. Jose Franklin, Catherine Mohanji Gera, (2016)** "Retrofitting of RC Beam using Glass Fiber Reinforced Polymer Composite".
10. **S. Karuppasamy, K. Shriram, S. Pradeep Kumar, K. Vijayakumar, D. Rohithbabu, (2019),** "Retrofitting of Reinforced Concrete Structures".
11. **G Navyaa, Pankaj Agarwal, (2015),** "Seismic Retrofitting of Structures by Steel Bracings".
12. **SN Mat Saliah, K Khairul Nizam, M M Muhammad Ariffaizad, N Abd Rahman and N Md Nor, (2019),** "Evaluation of severe damaged reinforced concrete beam repaired with epoxy injection and retrofitted with CFRP using acoustic emission technique".
13. **Raghavendra. V (2012),** "Epoxy Resin Vs MBC Binder for GFRP Retrofit Structures".
14. **Riyaz J. Mulla, Vinit T. Avdut, Shivraj D. Bagal, Mohammad Fazal Bashir Dongare, Shubham D. Sarvade, (2024),** "Retrofitting of Reinforced Concrete Beams Using GFRP".
15. **Jerry Emmanuel. V, (2016),** "Retrofitting of RC Beams using Epoxy Injection and Epoxy Bonded Polyester Fiber".
16. **Javad Sabzi, M. Reza Esfahani, Togay Ozbakkaloglu, Aliakbar Gholampour, Amir R. Masoodi, (2023),** "Rehabilitation of reinforced concrete beam: Sustainable restoration mortar with waste materials".
17. **A. Padilla-Ramírez, A. Flores Bustamante, M.I. Panamá Armendáriz & F. González Díaz, (2012),**

"Experimental Vacuum Process for Retroffiting Concrete Structures".

18. **H. Araki, Y. Segawa, (2017),** "Seismic Performance of Actual Members Retrofitted with Epoxy Resin Injection".
19. **Milind V. Mohod, (2019),** "Performance of Different Retrofitting Techniques on Existing RCC structures".
20. **J. Bhattacharjee, (2016),** "Repair, Rehabilitation & Retrofitting of RCC For Sustainable Development with Case Studies".

BIOGRAPHIES

Sujal S. Nighot
B-Tech Student
Department of Civil Engineering,
Priyadarshini J.L. College of
Engineering, Nagpur

Ayush D. Yerpude
B-Tech Student
Department of Civil Engineering,
Priyadarshini J.L. College of
Engineering, Nagpur

Prachi H. Gandate
B-Tech Student
Department of Civil Engineering,
Priyadarshini J.L. College of
Engineering, Nagpur

Tanmay L. Mendhule
B-Tech Student
Department of Civil Engineering,
Priyadarshini J.L. College of
Engineering, Nagpur

Mr. Roshan H. Mohankar
Assistant Professor
Department of Civil Engineering,
Priyadarshini J.L. College of
Engineering, Nagpur