A Review: Retrofitting Techniques for Reinforced Concrete Structural Members Using Different Materials"

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Abstract

In the current situation, concrete building deterioration is a global issue. There are numerous reasons for this, including the occurrence of natural hazards such as earthquakes, a lack of awareness of several critical and essential codal rules in construction, insufficient supervision, and so on. These factors result in structures that are weak. Overloading structures can result in significant deformations and corrosion, which require immediate treatment. Repair, retrofitting, and strengthening are periodically required actions in the construction business today to overcome all of these effects on reinforced concrete structures. Even newly constructed structures may require repair and strengthening in order to address faults caused by design or construction errors. Damaged structural elements caused by unexpected events such as fire, earthquake, foundation movement, impact, and overload require specialised strengthening, increasing the strength, and restoration techniques. Retrofitting is one of the most effective ways to make a current insufficient structure safe from future earthquakes or other natural disasters. Retrofitting decreases the risk of damage to an existing structure due to seismic activity in the near future. It tries to reinforce a structure in order to meet the requirements of contemporary seismic design codes. In recent years, a significant amount of research has been done to create various strengthening and rehabilitation procedures to improve structural seismic performance. This paper intends to provide an overview of many innovative and cost-effective local retrofitting strategies for strengthening damaged structures.
Keywords – Retrofitting, Strengthening, Restoration.

INTRODUCTION

1.1 General:

Any structures or buildings may show some sign of distress during their service period and also under the effect of natural calamity like earthquakes, etc. The safety of these buildings is of great concern especially because the loss of most of the lives during collapse of buildings has been reported in the past. The most of the old buildings made of stone masonry/ brick masonry are in existence and require adequate maintenance. At present, most of the buildings are being constructed in Reinforced Cement Concrete, which is assumed to be more durable and stable. The new materials and techniques in the field of construction and maintenance are developed and adopted in strengthening of existing buildings.

Many existing buildings do not meet the seismic strength requirements due to design inadequacy, material degradation over time or alteration carried out during the service life of the building. There may be some of the reasons for deterioration of buildings, for example, the construction of the buildings is never exactly as per designer's specifications and a number of defects and uncertainties crop up during the construction; the quality of the material deteriorates with time and the assessment of an existing building becomes a time dependent problem. It is, however, most important to ensure the safety of such buildings against various loads including loads of natural disasters like earthquakes, floods, cyclones and landslides etc. by applying appropriate retrofitting techniques. The term 'retrofitting' is mainly used in context with the strengthening of weak buildings to make them strong enough to withstand seismic forces through various repairing methods. The main purpose of retrofitting is to structurally treat the buildings with an aim to restore its original strength or more than that. The retrofitting may be adopted, if the cost of repair and strengthening of building is less than about 40% of the reconstruction cost.

The main types of damage in reinforced concrete structures are cracking in tension zone, diagonal cracking in the core and loss of concrete cover, stirrups bursting outside and buckling of main reinforcement. The complete replacement of such buildings is just not possible due to a number of social, cultural and financial problems. Therefore, strengthening of existing undamaged or damaged buildings is a definite requirement. It will involve actions for upgrading the seismic resistance of an existing building so that it becomes safer under the occurrence of probable future natural disasters.

Different Techniques have been used in the years to restore that structural integrity of the member by restoring or increasing its strength. Researchers across the globe are studying on the retrofitting techniques those are advantageous and most cost effective.

1.2. Objectives of the Project Report

I. To Study the Need for Retrofitting in RC Structures:
II. To Review Different Retrofitting Techniques:
III. To Assess the Structural Performance After Retrofitting:
IV. To Develop Guidelines for Material Selection and Technique Application:
V. To Suggest Recommendations for Future Research and Implementation:

2. Brief Literature Review

[1]T. P. Meikandaan, Dr. A. Ramachandra Murthy "Flexural Behaviour of RC Beam Wrapped with GFRP Sheets" (2017) conducted an investigation of the flexural behaviour of an RC beam wrapped in GFRP sheets, which included an experimental study using externally bonded GFRP sheets to the RC beam and testing under a two-point static loading system. They prepared six reinforced concrete beams for this, noted that all six are flexural weak and have the same reinforcement details. Three beams were isolated and used as control beams, while the other three were strengthened with GFRP in the tension zone. According to the findings, the bottom of GFRP sheet wrapping in a 70 percent preloaded beam can boost the beam's flexural capacity by 14 percent (on ultimate load) when compared to the control beam. According to the authors, strengthening the beam up to the neutral axis improves the beam's ultimate load carrying capacity. Since the earliest cracks generated by wrapping GFRP sheets on beams are not evident until they reach a higher load, this invisibility of initial cracks provides less warning than beams strengthened only at the soffit of the beam.

[2] Tahsiri, et al., (2015) observed in an experimental investigation that it improves energy dissipation capacity as well as ductility. They studied 12 reinforced and three reference specimens which were all subjected to three-point loading. For further strength, unidirectional carbon fibre reinforced polymer (CFRP) laminates were attached to the beam's soffit. For RCJ, ready-mix concrete was used. They also conducted an analysis to compare with the experimental programme.

[3] Ismail M.I. Qeshta et al., "The Use of Wire Mesh–Epoxy Composite for Enhancing the Flexural Performance of Concrete Beams" (2014) studied behaviour of a reinforced concrete beam strengthened using a new type of strengthening material of wire mesh-epoxy composite was compared to that of an RC beam reinforced with CFRP sheet. The findings of this tests showed that using a wire mesh-epoxy composite improves the performance of strengthened beams. These findings show that the applied approach improves initial crack load, stiffness, and yield strength; also, the usage of a hybrid wire mesh-epoxy-carbon fibre composite showed better post-yield behaviour and prevented CFRP sheet debonding. The authors conclude that specimens bonded with a hybrid wire mesh–epoxy–carbon fibre composite showed a significant increase in energy absorption. Specimens bonded with a hybrid composite had a 64% and 356% increase in flexural load capacity and energy absorption, respectively, as compared to control concrete specimens.

[4] N. F. Grace et al., "Strengthening Reinforced Beam Using Fibre Reinforced Polymer (FRP) Laminates" (2014) presents the various types of Fibre reinforced polymer laminates are tested with the 14 simply supported cross section beams. All of the beams were the same size and had the same flexural and shear reinforcements. Firstly, each beam was cracked by delivering a 44.8kN midspan force. Each beam was strengthened with a FRP material after it had cracked. The beams were then subjected to a concentrated force at midspan until they failed completely. In this study, five different FRP strengthening systems were used. These systems consist of two types of CFRP sheets, two types of GFRP sheets and CFRP plates. In these systems, four different types of epoxies were used. Each beam was reinforced with FRP laminates that were originally loaded higher than the cracking load and then tested till failure. The authors discovered beam deflection, strain, and ductile behaviour. The author found that using the right combination of vertical and horizontal sheets, as well as the right epoxy, the ultimate load carrying capacity of the beam can be doubled. To summarise, the behaviour of beam strengthening is expressed in a greater design factor of safety.

[5] ruiz-pinilla, pallarés, et al., "experimental tests on retrofitted rc beam column joints under designed to seismic loads-general approach" (2014) tested steel jacketing as a strengthening system for reinforced concrete framed structures on 20 full size interior beam column joints. The primary goal of this study was to examine the behaviour of strengthened beam column joints that were originally designed to withstand just gravity loads. The experiment was carried out with a strong beam and weak columns under gravity and cycle loads. To obtain this conclusion, the author created a load displacement envelope for each specimen. Steel jacketing prevents column failure, increases column bending strength, and transfers the failure section to the next weakest zone, as per the research.

[6] E. Chalioris and N. Pourzitidis (2012) introduced a new self-compacting RCJ method to repair a shear-damaged reinforced concrete beam. The jacket was 25 mm thick and encompassed the bottom section of the beam as well as the vertical side (U shaped jacket). Small diameter mild steel longitudinal rebar and U-shaped stirrups make up the jacket's steel reinforcement. They found that the load bearing capacity and overall structural performance of the jacketed beams were improved over the previously tested specimens

[7] Stephen Pessiki et al., "Axial Behaviour of Reinforced Concrete Columns Confined with FRP Jackets" (2012) investigated the performance of circular and square RC column jacketing with FRP and found that FRP jacketed concrete members have better axial load-carrying and deformation capacities than unjacketed concrete members, as well as factors influencing the axial stress-strain behaviour of FRP confined concretes. The jackets provided to specimens with square cross sections were not as successful as those provided to specimens with circular cross sections, according to the comparative study between square and circular columns, because square cross sections contain zones of ineffectively confined concrete.

[8].A Obaidat et al., "Retrofitting of reinforced concrete beams using composite laminates" (2011) investigated the results of an experimental study on the behaviour of structurally damaged full-scale reinforced concrete beams retrofitted with CFRP laminates in shear and flexure are presented in this work. Twelve beams were examined under four point bending after six months of curing for this experiment. The beams were separated into two categories. The focus of group RF was on flexural behaviour, while group RS focused on shear behaviour. Two beams were employed as control beams for group RF. The remaining six were preloaded until flexural cracks showed, then CFRP was installed. There were three distinct lengths of CFRP employed, each with two nominally equal beams. Finally, the retrofitted beams were loaded until they failed, with the results compared to the control beams. Two beams were used as control beams in group RS, while the other two were preloaded until shear cracks formed, then retrofitted and tested to failure. Internal reinforcement ratio, retrofitting position, and CFRP length were the important factors studied. The experimental results for the flexure group of beams indicate that they are similar to the control beams. The beam's crack propagation and final crack pattern differ significantly from that of the control beam.

The control beam had a few large flexural cracks, while the modified beam had many minor flexural cracks. This shows that the CFRP laminates acted as a barrier to crack propagation. The results for the shear beam clearly show that the control beam softens more due to crack propagation, but the cracks in the retrofitted beam are arrested by the CFRP, making the retrofitted beam curve slightly straighter than the control beam curve. The reinforced beam could withstand a maximum load of 270kN. When compared to the control beam, it can be shown that strengthening raises the maximum load by over 23%. Based on these findings, the authors concluded that the CFRPlaminated beams retrofitted in shear and flexure are structurally efficient, with stiffness and strength values almost equivalent to or greater than the control beams. The efficacy of the CFRP strengthening approach in flexure was discovered to vary depending on the length. Plate debonding in retrofitted beams was the most common failure mode in the experiments.

[9] Consuelo Beschi et al., "Beam-Column Joint Retrofitting with High Performance Fibre Reinforced Concrete Jacketing" (2011) investigated on retrofitting of beam column joints using high-performance fibre reinforced concrete jacketing. They started testing specimen on a column with cross section of 300×300 mm in the upper part and 400×400 mm in the lower part, and a beam cross section of 300×600 mm. The beam was 5 metres long and the column was 3.55 metres high. A R.C. corbel was put at the beam- column joint to replicate the presence of the transverse beam in the real construction. A static load is applied on this beam-column joint, followed by cyclic loading. The column is wrapped in FRP sheets that have been bent at a 90 degree angle. They were eventually wrapped in the HPFRC. During the test, a horizontal load was applied with increasing amplitude cycles till failure. The use of HPFRC jacketing improves the bearing capacity of the column, as well as its ductility and overall performance of the beam column junction. The results of the suggested technique can be used to strengthen existing RC structures with low concrete strength and low reinforcement ratios.

[10] Waghmare P.B. (2011) presented the material selection and processes that should be considered for Reinforced Concrete, steel, and FRP jacketing. He has mentioned the many technical features of beam, column, and beam-column joint jacketing, such as the width and thickness of the jackets, the minimum area of longitudinal reinforcement, the minimum area of transverse reinforcement, and so on.

[11]Halil Sezen and Eric Miller "Retrofit of Circular Reinforced Concrete Columns using FRP, Steel and Concrete Jackets" (2007) tested a circular column with concrete jackets reinforced with spiral rebar, welded wire fabric, and a new reinforcement called PCS (Pre-fabricated Cage System) under varied axial load conditions. The author evaluates the axial load-displacement relationships for the base specimen with seven other sample retrofitted specimens in this research. The welded wire fabric reinforced concrete jacketing and FRP composite retrofit methods have the lowest strength and deformation capacity, according to the experimental data. Both procedures produced similar results, with brittle failure occurring shortly after reaching maximum strength. The authors believe that steel tube jacketing was the most successful retrofit option for increasing strength and deformation capacity after comparing these results. Authors also highlighted that specimens with spiral rebar and Pre-fabricated Cage System reinforced concrete jackets behaved similarly, there was a significant difference in the post-cracking behaviour of concrete jackets with spiral rebar.

3.Conclusion

1. One of the most difficult challenges that structural engineers face in the outcome of an earthquake is retrofitting seismically inadequate or earthquake-damaged buildings. There are currently no seismic retrofitting codes of practise, but guidelines provided by various departments are available in the country. The paper provides up-to-date information about local retrofitting methods, as well as their advantages and disadvantages.

2. The paper gives the brief literature review of various retrofitting techniques with suitable methodologies and differentiation according to applications as well as limitations.

3. According to the comparison, study among various techniques of retrofitting jacketing is the most efficient technique for increasing member's strength.

4. However, before implementing any seismic retrofit approach on a damaged or inadequate structure, a thorough and accurate evaluation of the structure's seismic performance and current state is required.

5. The retrofitting of structural element is depend upon the assessment strategies which gives the condition index to select suitable technique for retrofitting.

6. A comparative examination of several retrofitting techniques based on effectiveness also been conducted in this paper.

4 References:

[1] Halil Sezen and Eric Miller (2007), "Retrofit of Circular Reinforced Concrete Columns using FRP, Steel and Concrete Jackets".

[2] Karayannis, C.G., Chalioris, C.E., Sirkelis, G.M., (2008), "Local retrofit of exterior RC beam– column joints using thin RC jackets - an experimental study".

[3] Consuelo Beschi, Alberto Meda and Paolo Riva, (ANIDIS RIVA-2011) "Beam-Column Joint Retrofitting with High Performance Fibre Reinforced Concrete Jacketing".

[4] A Obaidat, Y.T., Heyden, S., Dahlblom, O., Abu-Farsakh, (2011), "Retrofitting of reinforced concrete beams using composite laminates".

[5] Waghmare, P.B. (2011), "Materials and Jacketing Technique for Retrofitting of Structures".

[6] Stephen Pessiki, Kent A. Harries, Justin T. Kestner, Richard Sause, and James M. Ricles (2012), "Axial Behaviour of Reinforced Concrete Columns Confined with FRP Jackets".

[7] E. Chalioris and N. Pourzitidis (2012), "Rehabilitation of Shear-Damaged Reinforced Concrete Beams Using Self-Compacting Concrete Jacketing".

[8] Ismail M.I. Qeshta, Payam Shafigh, Mohd Zamin Jumaat, Aziz Ibrahim Abdulla, Zainah Ibrahim, Ubagaram Johnson Alengaram (2014), "The Use of Wire Mesh–Epoxy Composite for Enhancing the Flexural Performance of Concrete Beams".

[9] N. F. Grace, G. A. Sayed, A. K. Soliman and K. R. Saleh, (2014), "Strengthening Reinforced Beam Using Fibre Reinforced Polymer (FRP) Laminates".

[10] Ruiz-Pinilla, J.G., Pallarés, F.J., Gimenez, E., Calderón, P.A. (2014), "Experimental tests on retrofitted RC beam column joints under designed to seismic loads-General approach".

[11] Marlapalle, V.C., Salunke, P.J., Gore, N.G. (2014), "Analysis & Design of R.C.C. Jacketing for Buildings".

[12] Pankaj Agarwal and Manish Shrikhande (2014), "Earthquake Resistant Design of Structures".

[13] Hadi, M.N.S. & Tran, T.M. (2014), "Retrofitting Non seismically detailed exterior beam–column joints using concrete covers together with CFRP jacket".

[14] H. Tahsiri, O. Sedehi, A. Khaloo, E. M. Raisi (2015), "Experimental study of RC jacketed and CFRP strengthened RC beams".

[15] T. P. Meikandaan, Dr. A. Ramachandra Murthy (2017), "Flexural Behaviour of RC Beam Wrapped with GFRP Sheets".

[16] IS 13935, Repair and Seismic Strengthening of Buildings—Guidelines, Bureau of Indian Standards, New Delhi, 1993.