

Upgradation of Retrofoting Techniques Using Software Implementation on Live Projects A Review

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Abstract- *Retrofitting is growing more and more popular worldwide these days because most significant structures, such as historical buildings or other old structures, deteriorate with time. For existing structures, retrofitting is the greatest way to protect them from future earthquakes and other environmental conditions. Retrofitting reduces the vulnerability of an existing structure to damage during future seismic activity. It intends to reinforce a structure in order to meet the requirements of the current seismic outline codes. Retrofit is preferable and more practical than traditional repair and rehabilitation. The strength, resistivity, and general longevity of the structure are all improved by retrofitting.*

In this paper presenting review of literature.

Keywords- seismic load, retrofitting techniques, seismic vibrations, ETABS 16

I. INTRODUCTION

At a specific safety level and degree of dependability, RCC structures are made to support combined loads, including dead, live, and seismic loads. The anticipated performance of the structural building should be met when this design is ultimately implemented during the building process. This ideal state isn't always reached, though. Despite being an excellent building material, R.C.C. is used to build almost all of the structures, and once it is set, it is very difficult to improve its strength. A number of factors, including concrete deterioration, inexperienced labour, building unit modifications, increased loads from structural extensions, etc., can cause a building's performance to decline in terms of safety level, strength, or capacity. When these structures reach the end of their design period, they may not be able to support the current loads and, of course, will not be able to support additional loads. During this time, they behave or act normally. A structural engineer would find this more challenging than planning and building a new structure. By strengthening the structure, which can be accomplished through retrofitting, the performance of such a compromised building can be improved.

II. LITERATURE REVIEW

REVIEW OF LITERATURE SURVEY

Naser Kabashi et.al (2025) investigated three different situations from Albanian post-earthquake assessments, focussing on the effects of subpar concrete and insufficient detailing on structural performance. Nonlinear finite element analysis (NLFEA) was utilised for localised analysis to observe the impact of FRP strengthening on critical joints, and finite element modelling (FEM) was utilised for global analysis to illustrate the behaviour at the structural level in order to fully capture the behaviour of FRP-strengthened RC structures. Through a combination of material quality and detailed scenarios, the combined approach assesses how well FRP reinforcement mitigates vulnerabilities such brittle failure modes and shear deficits.

The findings demonstrated improved ductility and seismic resilience, with FRP retrofitting techniques leading to a 20% increase in displacement capacity and a 25% increase in peak shear force. When compared to experimental data, the finite element analysis showed highly accurate predictions with error margins less than 5%. With regard to improving seismic resistance, these findings highlight the need of customised FRP retrofitting techniques and provide important information for future retrofitting procedures in seismically active areas.

Idlir Dervishi and Arlind Hasalami (2024) provided a thorough evaluation of the performance and structural soundness of the reinforced concrete (RC) columns of the National Gallery of Arts in Tirana both before and after they underwent retrofitting. The research also sought to strengthen the seismic resistance and structural stability of the columns while carefully maintaining the architectural character of the structure. An important insight into the efficacy of the retrofitting methods was given by comparing the schematics before and after the modification.

The results demonstrated the ability of the reinforced concrete jacket retrofitting approaches to preserve and

strengthen ageing structures in urban settings, highlighting their effectiveness. Variations in the column interaction diagrams serve both a visual representation and a quantitative measure of this improvement. The capacity to withstand bending moments rose by 5.8 to 8.6 times for various columns, while the axial force bearing capacity increased by more than four times. In particular, the retrofitting operation for column K-2 increased the cross-sectional area of the column and increased the number of rebars utilised. This led to a significant improvement in the column's resistance to bending moments and axial load-bearing capacity. With significant increases in section size and reinforcement area, column K-6 also showed improvements, resulting in a noticeable rise in load-bearing capacity. The interaction diagram's enhancement shows a general improvement in the building's safety and structural stability, proving how effective such retrofitting is at fortifying ageing or susceptible structures.

Aayush Gautam et.al (2023) The goal was to compare and assess popular retrofit methods according to their cost and design factors. First, the seismic evaluation is carried out. After the reactions of the system have been determined, the study's scope is broadened to include specific retrofit methods that are intended to fix the structure's flaws. Two retrofitting options that are evaluated in the building include shear walls and column and beam jacketing. The seismic reaction of the structure is examined using reaction Spectrum Analysis and Linear Static Analysis.

A comparison is made between the outcomes of the retrofitted scenarios and the original, unaltered layout of the structure. Different approaches are compared according to their seismic performance and cost after the seismic retrofitting analysis is completed. In the X and Y directions, the drift ratios decreased from 0.91% and 1.85% to 0.17% and 0.35%, respectively, demonstrating the improvement in the structure. The retrofit expenses don't surpass thirty percent of the building's overall cost. In order to get a deeper understanding of seismic retrofitting applications and procedures, this study lays the groundwork for future research.

M Mohammad Roshan Zameer and Dr. E Arunakanthi (2023) A range of retrofitting methods, such as shear walls, steel bracing, and friction dampers employing ETABS, were taken into consideration when analysing the g+20 structure. The pushover and structural reaction analyses were conducted in Zone V. According to IS: 1893-2016, seismic analysis was carried out, and the models' response was assessed in terms of performance, lateral displacement, drift, and storey shear. This study's Pushover Curves show that the friction damper structure's response is not much different from the

conventional structure's, but it is still more efficient to use the friction damper structure because the performance point is much closer, reaching 147.838 mm for Zone V, and the response spectrum analysis results are far superior to those of the conventional structure. In Zone V, the maximum story displacement, story drift, and base shear were all considerably lower in retrofitted structures than in traditional structures. Consequently, there were lower seismic stresses applied to the multi-story structures. The way the buildings react to earthquakes is also affected by the steel bracings that are installed. Similar to a shear wall design, models with steel bracing systems showed satisfactory response for all parameters.

Rahul S. Pardeshi and Shyambhau G. Ban (2023) examined how long retrofitted buildings last in comparison to new construction, examined how stable existing structures are, and assessed how well retrofitting techniques increase structural strength. A decision-making process for deciding whether to retrofit or demolish buildings damaged by earthquakes was proposed by the author. The approach contrasts the strength of retrofitting with the strength of developing a new structure with the same level of usefulness. Through the consideration of elements including capital depreciation, new construction capacity, and retrofit strength, this method offers a structural safety viewpoint. Finding structural damage, assessing retrofit strength, and contrasting it with the ability to remove the existing structure and build a new one are all part of the technique. Additionally, the anticipated lifespan of both new and modified buildings is taken into account in the research.

According to the findings, retrofitting is an affordable option for both historic and earthquake-prone buildings. There are financial benefits to retrofitting an existing structure over building a new one since it can save a lot of money. Nonetheless, it is crucial to take into account the building's particular needs and functions while making decisions. By considering these elements, one can make a better decision on whether new building or retrofitting is the better course of action. Existing structures' stability strength and the degree to which retrofitting procedures improve structural strength.

Mirzagalib Sande and Trupti Narkhede (2022) performed a nondestructive testing (NDT) test on a G+4 building located in Aurangabad. The structure was simulated using ETABS software in order to determine the bending moment, shear force, and axial force as well as to further analyse its static structural behaviour. Determine which column is critical for retrofitting based on the findings of the NDT test. That column was simulated using ANSYS software, and it was connected to the CFRP sheet using a variety of techniques. The forces

that are discovered in the ETABS model analysis are then analysed in ANSYS.

It was found that double and triple layer wrapping produced satisfactory results under full wrapping conditions. However, when the economy is taken into account, it is found that CFRP material is expensive. Therefore, employ CFRP sheets with a thickness of 2 mm in two layers for this complete wrapping situation. Thus, both economic and strength-related requirements are met. Double layer and triple layer wrapping are observed to yield satisfactory outcomes under strip wrapping conditions. However, it is noted that CFRP material is expensive when taking the economy into account. Therefore, in this strip wrapping scenario, employ CFRP sheets that are 150 mm wide and 2 mm thick in two layers. Thus, both economic and strength-related requirements are met. Full wrapping consistently provides more strength than strip wrapping when the two circumstances are compared. Therefore, the results showed that CFRP sheet with triple-layered strip wrapping improves column strength and is cost-effective to use. The building retrofitted with CFRP sheet and strip wrapping in triple layer is validated to stand effectively against deformation based on the finite element analysis conducted with ANSYS.

M.V. Requena-Garcia-Cruz et.al (2022) intended to use a logical MCDM method called TOPSIS to rank and compare various seismic retrofitting methodology. The relative closeness assessment method to both positive and negative ideal solutions serves as its foundation. The primary innovation of this work is the comparison of ground-improvement and structural methods using various and extra criteria to the existing literature, including damage reduction, ductility improvement, social impact, and architectural impact. Due to its moderate construction costs and minimal architectural influence, the results indicated that confining columns with FRP is the best option. Addition of steel X bracings in both directions has come after this. Despite having the greatest architectural impact, this option also offers the lowest construction costs and the highest structural performance improvement ratios. Adding single steel bracing to 50% of the beam-column junctions has been the recommended approach. Basically because of its high maintenance expenses, it has not been the greatest solution because it is far from the best-ideal choice. One could argue that the best solutions would arise if these components were stainless steel, as they would require no maintenance. Consequently, it was determined that more effective solutions may result from raising installation expenses in order to lower maintenance ones.

Rohit R. Borse and Dr. Satish S. Deshmukh (2022) Examining the retrofitting of reinforced concrete structures while taking into account a 19-year-old structure was the aim of this study. Through retrofitting, the deteriorating building structure gained strength, increasing its efficiency and ability to support both static and dynamic loads. Enough seismic structural strength can be achieved by retrofitting a pure masonry structure. The market is estimated to be worth around Rs. 7,26,827. This indicates that the retrofitting will cost Rs. 1219.78/-per square metre. Therefore, the least expensive method of enhancing the structural quality of a structure is retrofitting. The building's lifespan is approximately forty-five years.

According to the results of the rebound hammer experiment, upgrading an old building can increase its strength. Additionally, the building's concrete quality ranges from Fair to Good. The building's strength increased by 57.75% between before and after retrofitting. This project described a structural experiment that was carried out to confirm the efficacy of a retrofitting technique for reinforced concrete buildings that makes use of the section-enlarging reinforcing method and the jacketing method. It takes less time to retrofit than other necessary operations. Buildings that have undergone retrofitting are more adaptable and suitable for both present and future uses, and they are also more comfortable to withstand loads. Getting a certain level of performance at a reasonable price was the main obstacle, which could be solved with careful analysis. The most cost-effective retrofit for a particular building must be determined using optimisation techniques. The publication of appropriate design codes as a code of practice is required by professionals in this field.

S.Mahesh et.al (2022) outlined a thorough investigation, including its steps, process, and applications in a variety of industries. It is possible to increase retrofitting innovation through a combination of design, machinery, and years of experience. On showcase day, retrofitting has a very profitable business in both developed and developing countries. It provides a range of methods to repair damaged structures and extends their lifespan, improving their functionality and safety. Retrofitting may differ from location to location and primarily depends on contemporary technology and the innovative ideas of the engineers.

Abrar Ahmed and U. J. Phatak (2021) In order to reduce retrofitting costs and waste without compromising production or quality, as well as to minimise environmental effects, the goal was to examine different approaches used for rehabilitation repairs and retrofitting in the construction industry, including both new and traditional construction

techniques. Visual inspection and advanced techniques for rehabilitation repairs and retrofitting surveys were part of the methodology, which allowed us to determine the factors influencing repair costs that were directly related to the materials used in the retrofit. Based on earlier studies, the literature was used to identify the elements influencing the retrofitting time and cost. The most appropriate substitute for the current conventional approach, such as cement slurry, is the material that incorporates new techniques, advanced methods, and installation procedures, according to the time comparison of the two materials used in the retrofitting job.

The most appropriate substitute for the current conventional approach, such as cement slurry, is the material that incorporates modern methods, new techniques, and an installation procedure, according to the time comparison for the two materials used in the retrofitting operation. Additionally, in order to determine the economic viability of implementing various materials, an integrated cost-benefit analysis would require the computation of benefits. The net profit of each management option can therefore be ascertained by comparing the advantages and disadvantages.

Shubham Velani et.al (2021) examined abnormalities in the frame structure, particularly torsional irregularities and re-entrant corners. These discrepancies were created using the IS 1893:2016 (part 1) code. In order to see the unstable reaction of the structure, the regular and irregular models were examined using ETABS 2018. The models were analysed using both static and dynamic methods, including displacement, storey drift, and torsional irregularity as considerations for the parameters.

The findings showed that during earthquakes, floating column structures do not function well. During major earthquake shaking, RC outline constructions with open first stories exhibit noteworthy performance. For buildings with sensitive ground levels, the major level columns must have extremely high float and strength requirements. Providing such capacities in the main floor columns is challenging. It follows that such designs will be unsuccessful in the event of a large earthquake. It is imperative that this dangerous area of Indian RC outline buildings be immediately recognised and that the required improvements be made to enhance the building's display. The floating column exhibits a greater storey drift in both X and Y directions than the soft storey structure in both the RSA and ESA cases. In the case of RSA, the shear, bending, and torsion values are higher for soft-storey structures than for floating-column buildings, and they are about equal for both buildings in the ESA analysis.

SM Kamalakannan et.al (2021) Through the use of retrofitting techniques, the research aimed to transform a

commercial facility into a data centre. In order to change a structure's functional use, retrofitting techniques were used. Specifically, the goal is to convert a commercial 10-story building into a data centre. To account for the new load requirements, retrofitting solutions—which are very energy and environmentally careful and save money and labor—should be used rather than rebuilding the entire structure. The analytical tool ETABS was used to model and analyse the structure.

According to a commercial utility analysis, the construction is safe. Its loading parameters fall well within the upper limit of what can be loaded onto the slabs, beams and columns. According to an analysis of the construction as a data centre building, the ground and ground floors are subject to significant column load. Punching shear is a factor in the slabs' collapse. Additionally, a portion of the core wall beams fails. The findings indicated that renovating a facility through retrofitting would be an alternative strategy for altering its functional utility. In addition to being economical and time-efficient, this type of technique is highly sustainable due to its capacity to conserve energy, which is crucial given that the construction sector is achieving sustainable development and will play a significant role in the future.

Syeda Sakina Mustafa et.al (2021) focused on using the structural engineering software ETABS version 16 to analyse multi-story buildings against seismic loads and recommend retrofitting methods to reduce the building's overall displacement and raise the frequency of seismic vibrations. The process for implementing a seismic retrofitting approach was encountered.

According to the results, the model with the shear wall produces the best outcomes. Since it tends to shorten the building's lifespan by 80.54% and decrease the lateral displacement in the X and Y directions by a significant amount.

Pratik D Akarte and G.B. Bhaskar (2019) NDTs were used to evaluate the current structure's state, and it was suggested that the structure be extended and that a new building design be created that would allow it to support additional floor loads that would otherwise be placed on the same column by retrofitting it with jacketing procedures.

The concrete condition of the R.C.C. structure was assessed using the Ultrasonic Pulse Velocity test, and tests with rebound hammers were conducted on a variety of R.C.C. members. The results of the Ultrasonic Pulse Velocity tests using direct, semi-direct, and indirect methods showed that the maximum readings were less than 3 km/sec and between 3.0

and 3.5 km/sec. Furthermore, according to the Rebound Hammer measurements, the concrete's likely compressive strength ranges from M18 to M22. Therefore, the structure must be strengthened for the new G + 5 because the existing column's real load carrying capacity is less than what the new column needs.

Simran Pathan et.al (2019) analysed and designed an old, existing building in SAP2000.V20 to strengthen its strength and stability, as well as to give the structure uniformity and extend its lifespan. The behaviour of the structure was noted after applying some retrofitting techniques, such as shear walls, bracings, and column jacketing.

After researching several retrofitting methods, including shear wall, bracing, and column jacketing, it was determined that the shear wall method was the most practical for the current nine-story reinforced concrete building. Instead of using bracing and column jacketing retrofitting techniques, the structure has become more rigid due to the shear wall, which makes the collapse of the columns and beams in the current building insignificant. Using the SAP2000.V20 software, we came to the conclusion that applying shear walls may control seismic activity.

Ashhar Husain et.al (2018) The proposed Aerocon AAC (autoclaved, aerated concrete) blocks (size 800mmx600mmx200mm) for the walls of the stilt floor, ground floor and upper four floors of the S+G+4 building under consideration are lightweight (dry density of 550–700 kg/m³, or roughly one-third that of clay bricks), environmentally friendly and have the advantage of being able to be constructed more quickly. This building will now have two more storeys added, and for improved aesthetics and thermal insulation, Porotherm clay blocks with a dry density of 1800 kg/m³ are suggested for the additional floors. It is necessary to verify the structure's safety because of this increase in weight. This project's structure was analysed and designed using the software program STAAD-Pro, which employs limit state design techniques that adhere to the Indian Standard Code of Practice.

The results showed that the additional storeys in the second model made the existing footing and column diameters insufficient to support the additional loads. The reason for this is that the members' load-bearing capability becomes inadequate due to the increased loads placed on the structure. Two stories are added on top of the existing S+G+4 building, necessitating the modification of the footing and column. Retrofitting improves the structure's performance and strengthens the members' ability to support more weight.

Abdul Kalam et.al (2017) emphasised the fundamentals of evaluating and renovating buildings to withstand seismic activity. Investigating the building's performance during the earthquake and assessing the structure's behaviour following the application of retrofitting techniques were done using the Finite Element Method. Techniques like shear walls and shear cores that can be used to increase overall stability were examined, as well as techniques like steel and concrete jacketing and the use of fibre reinforced polymer (FRP) composites that were utilised to increase the load bearing capacity of individual structural elements.

A thorough nonlinear analysis can be used to accomplish the primary challenge of achieving the required performance level at the lowest possible cost. The most effective retrofit for a given structure requires optimisation techniques. As a code of practice for professionals working in this industry, proper design codes must be published. Bridge and building structures have benefited from FRP retrofitting for both static and quasi-static loads (improving dead or live load in a bridge or building structure) and dynamic loads (improving seismic or blast response in a bridge or building structure). Shear strengthening of concrete beams, axial strengthening and ductility improvement of concrete columns, and flexural strengthening of concrete beams and slabs have all been accomplished with success using FRP composites.

Garaga Jyothi and Chalumuri Bhaskar Rao (2017) One of the Hyderabad city buildings was reanalysed for the higher applied loads as part of the study. Using the sophisticated structural engineering software ETABS, the building was reanalysed, and appropriate retrofitting methods were recommended. Techniques such as the concrete jacketing method for the columns and beams, the steel beam fixing for the slabs, and the area expansion for the footings were all covered in this examination.

The size and depth of the footings rose by 26.17% and 26.66%, respectively, according to the results. With the use of retrofitting techniques, these deficiencies were filled by adding the necessary extra concrete and steel regions. The reinforcement in columns rose by 64.34%. The concrete jacketing approach has been used to address this shortcoming. There was a 27.31% rise in top reinforcement and a 30.63% increase in bottom reinforcement in beams. The appropriate retrofitting techniques have been used to address these shortcomings. The old slab was reinforced for the additional applied loads by adding steel beams at appropriate intervals, negative reinforcement, and the required shear connectors.

III. CONCLUSION

A comprehensive review of existing literature reveals a growing emphasis on the use of Non-Destructive Testing (NDT) techniques for the assessment and diagnosis of high-rise structures. Researchers and practitioners increasingly rely on NDT methods—such as Ultrasonic Pulse Velocity (UPV), Rebound Hammer Test, Ground Penetrating Radar (GPR), and Infrared Thermography—to evaluate the in-situ condition of aging or distressed buildings without causing damage. Among the most widely adopted techniques, UPV has gained prominence for its ability to detect internal flaws, estimate concrete quality, and assess uniformity across structural elements.

Recent studies by Patel and Joshi (2021) emphasize the integration of NDT data with Building Information Modelling (BIM) environments to visualize damage zones and streamline maintenance planning. In summary, literature confirms the pivotal role of NDT in assessing the integrity and durability of high-rise structures. These methods enable detailed condition surveys, support retrofit planning, and offer a cost-effective means of maintaining structural performance throughout the lifecycle of tall buildings.

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