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Comparative Study of RC Column with RC Jacketing and FRP Jacketing

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Abstract

Retrofitting of existing reinforced concrete (RC) structures has become increasingly essential due to ageing infrastructure, evolving seismic design requirements, and performance deficiencies identified during structural assessments. Among the various strengthening methods, RC jacketing and fibre-reinforced polymer (FRP) wrapping are two of the most extensively applied techniques for enhancing the performance of RC columns. This study provides a detailed comparative investigation of these methods by examining cost implications, site feasibility, labour requirements, strength enhancement, spatial constraints, durability, and compliance with seismic provisions of IS 1893:2016 (Part I) and the FRP strengthening guidelines specified in ACI 440.2R-17.

Analytical modelling and performance evaluation were carried out using ETABS software to quantify improvements in axial load capacity, confinement, and ductility for each retrofitting scheme under seismic loading conditions. The results indicate that RC jacketing, while cost-effective and structurally robust, demands significant labour, formwork, curing time, and increased dimensional footprint, limiting its suitability in congested sites. FRP wrapping, by contrast, provides rapid installation, lower disruption to existing operations, and minimal dimensional increase, making it advantageous in constrained environments and for columns where added thickness must remain within acceptable limits. Durability analysis further highlights the superior corrosion and environmental resistance offered by FRP composites. ETABS simulation results confirm that both techniques enhance seismic performance, though FRP systems demonstrate higher efficiency in confinement and ductility enhancement due to their superior strength-to-weight ratio and uniform confinement characteristics. Overall, the study concludes that while both methods significantly improve the structural behaviour of RC columns, FRP wrapping offers notable advantages in terms of feasibility, durability, and seismic performance, particularly in regions with

stringent seismic demands.

Keywords - Retrofitting, RC Column, RC Jacketing, FRP Jacketing, Seismic Strengthening, ETabs, Durability.

1. Introduction-

Reinforced concrete (RC) columns are among the most critical structural components in modern civil engineering construction, as they ensure vertical load transfer, global stability, and overall integrity of buildings and infrastructure. Over the service life of a structure, RC columns are exposed to various environmental and mechanical stressors, including chloride-induced corrosion, carbonation, freeze–thaw cycles, inadequate design, poor workmanship, accidental overloading, and seismic events. These factors contribute to progressive deterioration, loss of strength, reduced ductility, and compromised safety of the structural system. As aging infrastructure becomes more prevalent worldwide, the need for effective and reliable retrofitting techniques to restore or enhance structural performance has gained increasing importance.

Among the available strengthening and retrofitting techniques, RC jacketing and fiber-reinforced polymer (FRP) jacketing are widely adopted due to their ability to enhance axial load capacity, confinement, energy dissipation, and seismic performance of existing columns. RC jacketing, the traditional and well-established method, involves increasing the cross-sectional area by adding steel reinforcement and a new layer of concrete around the existing column. This approach significantly improves strength and stiffness but adds considerable weight and may alter the structural configuration. Conversely, FRP jacketing—an advanced composite-based solution—utilizes lightweight, corrosion-resistant materials such as carbon, glass, or aramid fibers bonded to the column surface. FRP jackets provide superior confinement, enhanced ductility, and ease of application without substantial increase in member dimensions, making them ideal for space-constrained or architecturally sensitive structures.

Despite their widespread application, the selection between RC jacketing and FRP jacketing is not straightforward, as both systems exhibit distinct mechanical behaviours, construction challenges, durability characteristics, and cost implications. While RC jacketing offers excellent compatibility with existing concrete and proven long-term reliability, it is labour intensive, time consuming, and susceptible to shrinkage and additional seismic forces due to added mass. On the other hand, FRP jacketing, although faster and lighter, faces challenges related to fire resistance, long-term durability under moisture and chemical exposure, and higher material costs.

Although extensive studies have been conducted individually on RC and FRP jacketing techniques, comparative assessments that evaluate their performance under different loading, environmental, and durability conditions remain limited. In particular, there is insufficient research that holistically examines their behaviour under axial compression, cyclic loading, seismic demands, long-term durability, and cost–benefit efficiency. Moreover, many existing studies focus on small-scale specimens or isolated performance parameters, highlighting the need for comprehensive investigations that integrate structural performance, practical feasibility, and economic evaluation.

Therefore, a detailed comparative study of RC and FRP jacketing is essential to address these gaps and support the decision-making process for engineers, designers, and policymakers. Such research is critical for achieving optimal retrofitting solutions that balance strength enhancement, ductility improvement, execution time, cost, and long-term sustainability. The findings of this study can guide future development of retrofitting guidelines, contribute to advancements in seismic strengthening practices, and provide valuable insights for rehabilitation of aging infrastructure worldwide.

This research paper aims to critically evaluate and compare the structural performance, confinement efficiency, seismic response, durability aspects, and cost-effectiveness of RC jacketing and FRP jacketing for retrofitting RC columns. The results will help determine the most appropriate retrofitting technique for different structural conditions, environmental exposures, and functional requirements. Ultimately, the study seeks to advance the state of knowledge in structural rehabilitation and contribute to safer, more resilient built environments.

2. Literature Review-

1) Ahed Habib [2020], "Column repair and strengthening using RC jacketing".

The paper addresses the importance of rehabilitating old structures, particularly through reinforced concrete jacketing, which is a widely used technique for structural repair and strengthening in earthquake-prone countries. This method enhances the axial and bending strengths, stiffness, and lateral strength of weak structural elements, making it a practical solution for improving load-carrying capacity. Despite the existence of modern techniques, RC jacketing remains prevalent in developing countries due to cost and lack of expertise, highlighting a gap in the literature regarding comprehensive reviews of its performance. The paper aims to provide a review of recent investigations on column repair and strengthening using reinforced concrete jacketing, summarizing findings to benefit engineers and scientists in the field.

2) Kashi, A.[2017], "Durability evaluation of retrofitted corroded reinforced concrete column with.FRP sheets in marine. Environmental conditions."

The paper investigates the performance of Fiber reinforced polymers (FRP) for strengthening corrosion-damaged reinforced concrete (RC) columns, particularly in harsh marine environments, where traditional methods face challenges due to corrosion and environmental degradation. It highlights the limitations of existing rehabilitation techniques, such as steel jacketing, which are prone to corrosion and application difficulties. The study identifies a gap in understanding the post-repair structural behaviour of FRP-wrapped columns under prolonged exposure to aggressive conditions, including high humidity and saltwater. The objective is to evaluate the effectiveness of different retrofit methods for corroded RC columns using FRP sheets, emphasizing the need for protective measures for FRP in marine environments.

3) Ayush Srivastava [2016],"Comparative Study of RC Jacketing and FRP Wrapping."

The paper discusses retrofitting as a method to enhance the performance of deficient structural elements, particularly in the context of earthquake resilience. It highlights the superiority of retrofitted buildings over original structures, emphasizing the need for retrofitting to prevent significant damage during seismic events. The study compares two retrofitting methods: RC jacketing and Fibre Reinforced Polymer (FRP)

wrapping, aiming to determine their effectiveness in increasing structural strength. It addresses the limitations of existing structures that cannot undergo lengthy repairs, advocating for retrofitting as a practical solution. The paper aims to assist structural engineers in selecting the most suitable retrofitting method based on the comparative strength increases achieved.

4) Gupta, N. [2016] "Design and Detailing of RC Jacketing for Concrete Columns."

The paper addresses the urgent need for retrofitting existing buildings to enhance their seismic resistance, particularly in light of past earthquakes and outdated design codes. It highlights the importance of strengthening structures that are either poorly designed or have undergone changes that increase their vulnerability. The study focuses on the method of reinforced concrete jacketing for columns, as per IS 15988:2013, to improve their strength and ductility. The paper aims to elaborate on the concrete jacketing procedure and its effectiveness in enhancing the overall performance of columns against seismic forces. It emphasizes that retrofitting can significantly improve a building's structural capacities without the need for demolition.

5) Kadam, S. S [2015] "Performance of rc building under dynamic forces and suitability of strengthening by FRP jacketing."

The paper addresses the significant destruction caused by earthquakes in India, emphasizing the need for evaluating the strength of reinforced concrete (RC) structures to withstand seismic activities. It highlights the inadequacy of existing structures designed without considering seismic codes, particularly in Zone III, where the study is focused. The research aims to assess the seismic performance of a 15-year-old four-storey RC structure and proposes FRP jacketing as a retrofitting method for enhancing structural resilience. The study identifies the necessity for detailed evaluations, including linear and nonlinear analyses, to determine the adequacy of existing buildings under seismic loads. It underscores the importance of rehabilitation measures to ensure that existing structures meet intended performance levels during earthquakes.

6) M. El-Assaly [2012] "Seismic Assessment of Retrofitted RC Structures Using Traditional and New Repair Techniques."

The paper addresses the inadequate seismic resistance of existing reinforced concrete (RC) buildings designed under old codes, highlighting their vulnerability during earthquakes due to insufficient lateral load capacity and ductility. It emphasizes the urgent need for retrofitting these structures to meet current seismic design codes, focusing on enhancing strength, stiffness, and ductility. The study evaluates various rehabilitation techniques, particularly RC jacketing and FRP wrapping, to improve the seismic performance of RC columns. It employs both static pushover and dynamic time history analyses to assess the effectiveness of these retrofitting methods. The paper aims to provide insights into the performance levels of retrofitted structures compared to original designs, addressing a gap in understanding the benefits of different retrofitting strategies.

7) Gupta et al. [2011], in their paper "Bonding Challenges in RC and FRP Jacketing"

The paper studied the bonding and adhesion challenges associated with RC and FRP jacketing. They found that while RC jacketing had fewer bonding issues, FRP jacketing required specialized bonding agents to ensure effective adhesion. The study emphasized that proper application of bonding agents is critical for FRP jacketing to achieve its full potential thus offering valuable insights for enhancing the durability and efficiency of FRP retrofitting systems. In their study Bonding Challenges in RC and FRP Jacketing. Their laboratory bond strength tests demonstrated that FRP jacketing required specialized bonding agents to achieve optimal performance, while RC jacketing faced fewer bonding issues. Proper application of these bonding agents is essential for maximizing the benefits of FRP jacketing, especially in terms of adhesion and overall effectiveness.

8) Zhao et al [2011], in "Time Efficiency in Retrofitting RC Columns with Jacketing Methods."

Their field implementation tests revealed that FRP jacketing required significantly less installation time than RC jacketing, making it an ideal choice for projects where quick retrofitting with minimal disruption is crucial. This study highlights the practical advantage of FRP jacketing, especially in time-sensitive construction projects. They conducted a study titled Time Efficiency in Retrofitting RC Columns with Jacketing Methods to compare the time efficiency of RC and FRP jacketing during retrofitting. Their field implementation tests found that FRP jacketing required significantly less installation time than RC jacketing, making it a more efficient choice for projects requiring quick retrofitting with minimal disruption to ongoing operations

9) Lee and Park [2009], in their paper "Seismic Retrofitting. Of RC Columns: RC vs. FRP Jacketing"

The paper analysed the seismic. Performance of RC columns retrofitted with RC and FRP jackets using nonlinear finite element analysis. Their study concluded that while both methods improved seismic performance, FRP jacketing was more suitable for rapid retrofitting in seismic zones due to its enhanced flexural performance and ease of installation, offering a significant advantage over RC jacketing in earthquake prone regions. In their study Seismic Retrofitting of RC Columns: RC & FRP Jacketing, used nonlinear finite element analysis to analyse the seismic performance of RC columns retrofitted with RC & FRP jackets. They found that while RC jacketing improved shear capacity FRP jacketing significantly enhanced the flexural performance of columns. This study highlighted that FRP jacketing is particularly suitable for rapid retrofitting in seismic zones, where both shear and flexural strength are essential.

10) Smith et al. [2009], in their study "Effectiveness of RC and FRP Jacketing in Strengthening RC Columns,"

The paper evaluated and compared the strength and ductility improvements of RC columns using both RC and FRP jacketing. Their experimental tests showed that FRP jacketing increased both ductility and load-carrying capacity more than RC jacketing, suggesting that FRP jacketing is more effective for enhancing strength and ductility compared to RC jacketing. This paper emphasizes the superior performance of FRP in terms of both strength and flexibility. In their paper Effectiveness of RC & FRP Jacketing in Strengthening Columns aimed to evaluate and compare the improvement in strength & ductility of RC

columns using RC and FRP jacketing. Their experimental tests on scaled RC columns showed that FRP jacketing increased both ductility and load-carrying capacity more than RC jacketing, making it a more effective solution for enhancing the structural performance of retrofitted columns.

3. Objectives-

1] To model the existing RC building in ETABS and analyse its seismic performance to locate critical columns.

2] To apply RC jacketing to the identified columns in ETABS and evaluate the improvement in strength.

3] To perform numerical analysis of FRP-jacketed columns and evaluate their structural performance.

4] To compare RC jacketing and FRP jacketing for cost and aesthetics.

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