

Extending Reinforced Concrete Structures: A Comparative Retrofitting Approach

Vivek Kumar Singh^{1, 2, ✉}, Kunal Bharali²

1. Department of Civil Engineering, Galgotias University, Greater Noida, IND

2. Department of Civil Engineering, National Institute of Technology Silchar, Silchar, IND

Received: May 23, 2026 | Review began: June 09, 2026 | Review ended: June 16, 2026 | Published: August 05, 2026

© Copyright 2026

This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

In densely populated urban regions, vertical extension of existing reinforced concrete (RC) buildings provides an efficient solution to land scarcity and urban expansion challenges. This study investigates the structural feasibility of upgrading an existing G+3 RC building to G+4 using two retrofitting techniques: concrete jacketing and steel jacketing. Numerical modeling and nonlinear seismic analysis were carried out using SAP2000 under gravity and seismic loading conditions in accordance with IS 1893 (Part 1): 2016 and ATC-40 guidelines. The study evaluated structural performance through modal analysis, pushover analysis, and nonlinear time-history analysis. The addition of the extra story increased the structural mass by approximately 22%, causing the natural period of the original structure to increase from 0.98 s to 1.14 s. After retrofitting, the natural period reduced to 0.95 s for concrete jacketing and 0.91 s for steel jacketing, indicating improved structural stiffness. Pushover analysis revealed that steel jacketing achieved nearly 15% higher base shear capacity than concrete jacketing, while time-history analysis demonstrated 10%-12% lower interstory drift and reduced residual displacement in the steel-jacketed model. Concrete jacketing improved stiffness significantly but resulted in comparatively lower ductility. The study further compares both retrofitting methods in terms of constructability, durability, seismic performance, and serviceability. Validation of analytical results with published experimental and analytical studies confirmed that the obtained numerical trends were consistent with previous research findings. The results indicate that steel jacketing provides superior seismic performance and ductility for vertical extension projects, whereas concrete jacketing remains an economical and structurally compatible strengthening technique.

Categories: Structural Engineering

Keywords: vertical extension, seismic retrofit, concrete jacketing, steel jacketing, pushover analysis

Introduction

Urban densification and land scarcity in major cities demand innovative approaches to space optimization. Vertical extension means adding new storeys to the existing structures, which presents a sustainable solution, provided that the existing framework can safely accommodate the increased loads. However, older reinforced concrete (RC) buildings often lack sufficient seismic detailing or strength for additional storeys without structural enhancement.

Retrofitting techniques are therefore essential to improve the structural capacity and seismic performance of such buildings before vertical expansion. Among the available strengthening methods, concrete jacketing and steel jacketing are widely used because of their effectiveness, practical implementation, and compatibility with existing RC systems.

How to cite this article:

Singh V, Bharali K (August 05, 2026) Extending Reinforced Concrete Structures: A Comparative Retrofitting Approach. Cureus J Eng 3 : es44388-026-00207-2. DOI <https://doi.org/10.7759/s44388-026-00207-2>

Concrete jacketing enhances stiffness, load-carrying capacity, and confinement by enlarging the member section with additional RC. Steel jacketing, on the other hand, improves ductility and confinement while adding minimal additional weight and section size.

Several researchers have investigated the behavior of retrofitted RC structures under seismic loading conditions. Previous studies have reported that RC jacketing significantly improves axial load capacity and flexural strength, while steel jacketing offers superior ductility and energy dissipation characteristics. Experimental investigations on steel-confined concrete members demonstrated considerable improvement in seismic resistance and delayed in brittle failure mechanisms. Nonlinear pushover and time-history analyses have also been extensively used for evaluating seismic retrofit strategies and performance-based design of RC buildings. Earlier studies also focused on durability improvement and structural monitoring of retrofitted concrete systems. Fiber optic crack monitoring techniques and fracture analysis methods developed in previous research provided an improved understanding of damage progression and retrofit effectiveness. Experimental studies on high-performance concrete jackets, steel jackets, and composite retrofitting systems confirmed significant enhancement in stiffness, ductility, and seismic performance.

Despite extensive research on seismic retrofitting, limited studies have comparatively evaluated the suitability of concrete and steel jacketing specifically for vertical extension of existing RC buildings using nonlinear seismic analysis procedures. Therefore, this study investigates the structural feasibility of upgrading an existing G+3 building to G+4 through concrete and steel jacketing retrofits using SAP2000. Modal analysis, nonlinear pushover analysis, and nonlinear time-history analysis were performed to compare structural behavior under seismic loading conditions.

The primary objective of this research is to evaluate the comparative effectiveness of concrete jacketing and steel jacketing in improving stiffness, ductility, displacement control, and seismic performance for vertical building extensions.

Materials And Methods

Structural performance and durability of RC systems

Research into concrete material behavior has emphasized the importance of ductility and fracture control for long-term performance. Previous studies introduced pseudo-ductile permanent formwork concepts for durable concrete structures and highlighted the importance of improved toughness in structural retrofits [1]. Structural renovation methods for deteriorated concrete buildings established the theoretical basis for modern retrofit strategies [2]. Monitoring and assessment of crack propagation are essential for evaluating retrofit effectiveness. Earlier studies demonstrated that fiber-optic sensing techniques can effectively monitor mixed-mode crack behavior in RC members and provide reliable nondestructive evaluation methods for retrofitted structures [3,4]. Fracture parameter evaluation through inverse analysis techniques also contributed to more accurate numerical modeling of rehabilitated RC members [5].

Column and steel jacketing methods

Previous review studies summarized the effectiveness of RC, steel, and fiber-reinforced polymer jacketing techniques for strengthening RC columns [6]. These studies concluded that both RC and steel jacketing significantly improve column strength and seismic resistance, although the final selection depends on cost, constructability, and ductility requirements.

Experimental investigations confirmed that concrete jacketing considerably improves axial load-carrying capacity and stiffness of RC columns [7,8]. Steel jacketing techniques demonstrated improved confinement, ductility, and energy dissipation under cyclic loading conditions [9]. More recent studies investigated high-performance concrete jackets, ultra-high-performance concrete jackets, and hybrid steel-concrete systems for enhanced seismic behavior and durability [10-12].

Seismic retrofit approaches

Performance-based seismic retrofit methods using nonlinear pushover analysis have been widely adopted for evaluating RC structures [13-15]. Earlier research demonstrated that pushover analysis effectively predicts displacement demand, base shear capacity, and structural performance levels under seismic loading.

Comparative studies on different retrofit systems revealed that seismic retrofit effectiveness depends on stiffness enhancement, deformation control, and ductility improvement. Previous experimental and analytical investigations showed that steel-based confinement systems provide improved seismic resilience and energy dissipation compared to conventional retrofitting methods.

Building description and modeling

A four-storey (G+4) RC framed structure was modeled in SAP2000 to represent the vertical extension of an existing G+3 building. The original structure was assumed to have been designed according to conventional 1980s construction practices without modern ductile detailing provisions.

The building was modeled using M25 grade concrete and Fe415 reinforcement steel. Fixed supports were considered at the base, and mass and stiffness distributions were updated to incorporate the additional storey. Figure 1 illustrates the three-dimensional model of the original building, while Figure 2 presents the retrofitted model after vertical extension. The mechanical properties of the materials used in the SAP2000 model are summarized in Table 1. Figure 3 and Figure 4 present the stress-strain relationships adopted for concrete (M25) and mild steel (Fe250), respectively.

Mechanical properties	Concrete (M25)	Mild steel (Fe250)
Modulus of elasticity (E)	25000 MPa	210000 MPa
Poisson's ratio (μ)	0.2	0.3

TABLE 1: Mechanical properties of isotropic materials

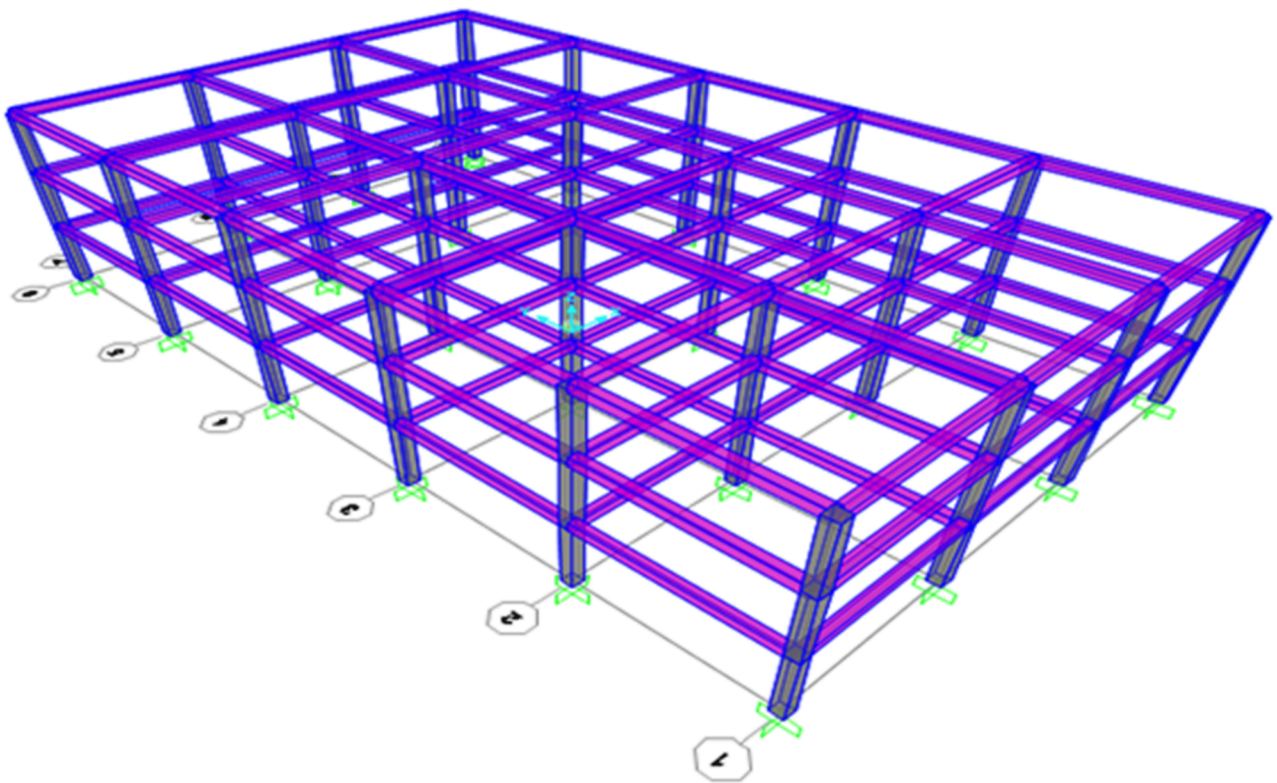


FIGURE 1: 3D view of original building

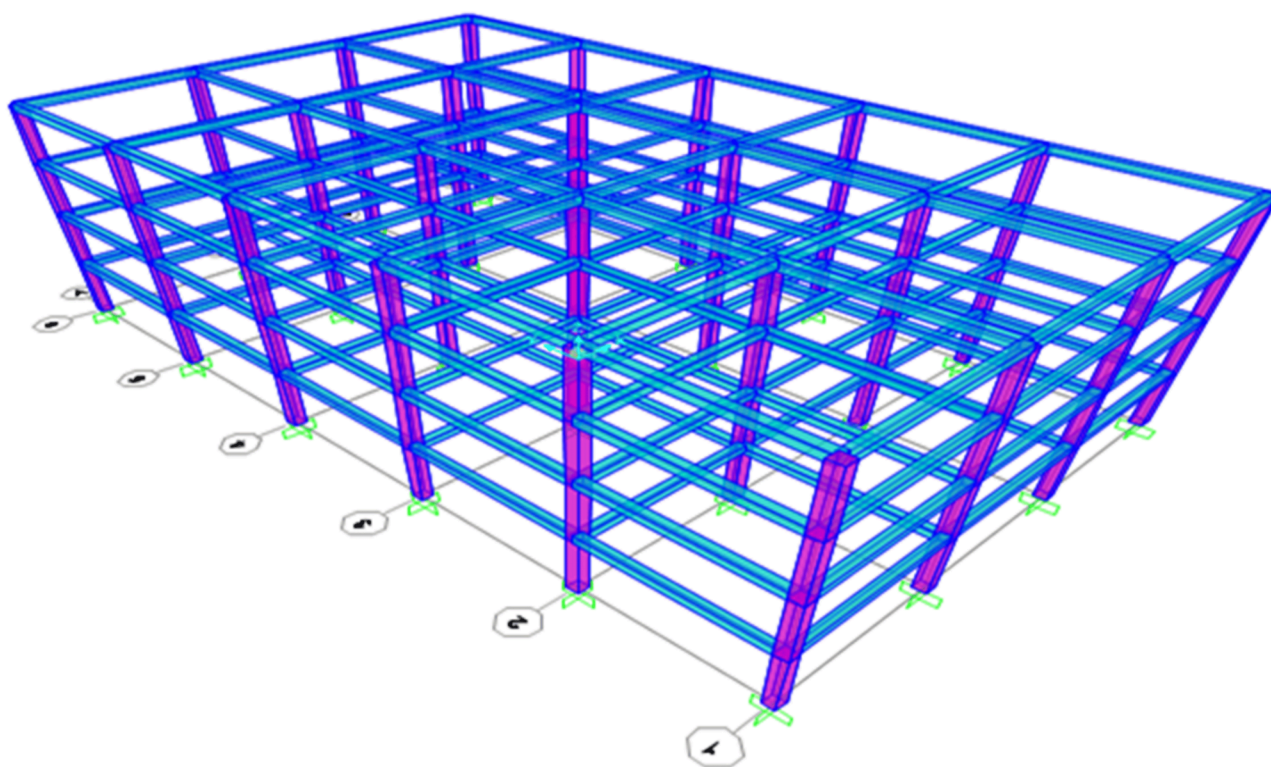


FIGURE 2: 3D view of building after vertical extension

Retrofitting schemes

Two retrofitting schemes were investigated in this study.

Concrete Jacketing

Concrete jacketing was implemented by enlarging the existing RC columns with a 50 mm thick M25 concrete jacket reinforced with additional longitudinal and transverse reinforcement. Shear connectors and bonding agents were used to ensure composite action between the existing and new concrete. This retrofit method significantly increased section stiffness, axial load capacity, and confinement. The concrete jacketing retrofit configuration adopted in the study is illustrated in Figure 5.

Steel Jacketing

Steel jacketing was implemented using 20 mm thick Fe250 steel plates surrounding the existing RC members. The steel plates were connected through welding and bolting techniques to ensure proper confinement and load transfer. Non-shrink grout was introduced between the steel jacket and the existing concrete surface.

Steel jacketing improved axial load capacity, ductility, and energy dissipation while minimizing additional dead load and dimensional increase. The steel jacketing configuration used in the study is shown in Figure 6.

Loading and seismic input

The building was analyzed under dead load, live load, and seismic loading conditions according to IS 1893 (Part 1): 2016 for Zone IV seismic parameters. Modal analysis was performed to determine the fundamental time period and modal participation.

How to cite this article:

Singh V, Bharali K (August 05, 2026) Extending Reinforced Concrete Structures: A Comparative Retrofitting Approach. Cureus J Eng 3 : es44388-026-00207-2. DOI <https://doi.org/10.7759/s44388-026-00207-2>

Figure 3 and Figure 4 present the stress-strain relationships adopted for concrete (M25) and mild steel (Fe250), respectively.

Validation of numerical results

To validate the SAP2000 analytical results, the obtained seismic performance trends were compared with previously published experimental and analytical studies related to RC and steel jacketing retrofits [8,9,13]. Validation was primarily based on comparison of stiffness enhancement, base shear capacity, ductility improvement, and displacement response.

The SAP2000 simulations predicted approximately 15% higher base shear capacity for steel jacketing compared to concrete jacketing. Similar trends were reported in experimental investigations conducted in previous literature, where steel confinement systems demonstrated improved ductility and seismic resistance [9,12,13].

Furthermore, the reduction in inter-storey drift obtained from nonlinear time-history analysis was found to be consistent with previously published analytical studies on steel-jacketed RC frames [14,16-19]. The observed increase in stiffness due to concrete jacketing also aligned with earlier experimental findings reported for RC jacketed columns [8].

A comparison between the present SAP2000 results and previously published experimental and analytical studies is presented in Table 2 to validate the numerical model.

Parameter	Present Study	Published Literature Trend
Increase in base shear capacity using steel jacketing	~15%	Similar improvement reported in [9,13]
Reduction in inter-storey drift	10–12%	Comparable drift reduction observed in [14,16]
Stiffness enhancement using concrete jacketing	Significant	Consistent with experimental studies [8]
Ductility improvement using steel jacketing	High	Reported in previous investigations [7,9]

TABLE 2: Validation comparison with published studies

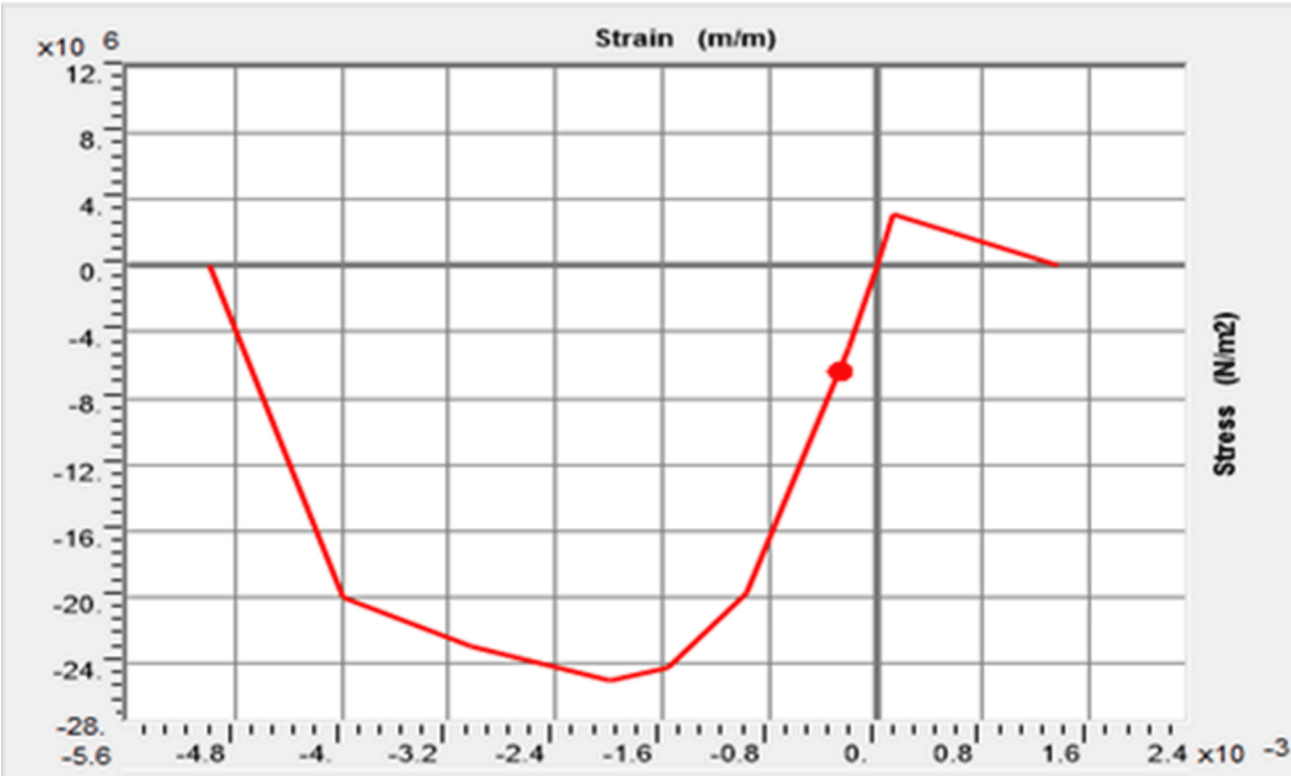


FIGURE 3: Stress-strain plot of concrete (M25)

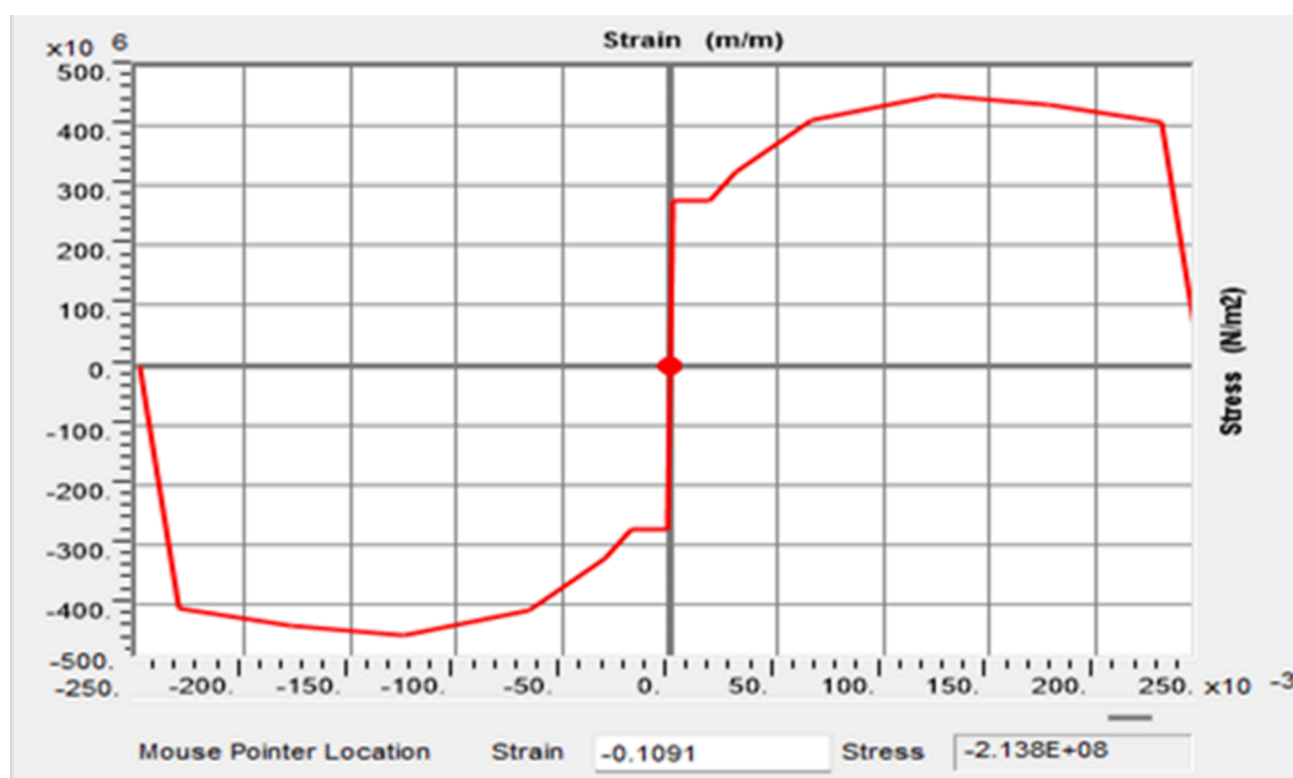


FIGURE 4: Stress-strain plot of mild steel (Fe250)

The validation results confirmed that the SAP2000 analytical model reasonably captured the seismic behavior of retrofitted RC buildings and produced results consistent with experimental and analytical findings available in the literature.

AI usage declaration

Artificial Intelligence (AI) tools and Large Language Models (LLMs) were used only for limited language refinement and paraphrasing assistance during manuscript preparation. All technical analysis, numerical modeling, interpretation of results, figures, tables, and conclusions were independently developed, verified, and approved by the authors.

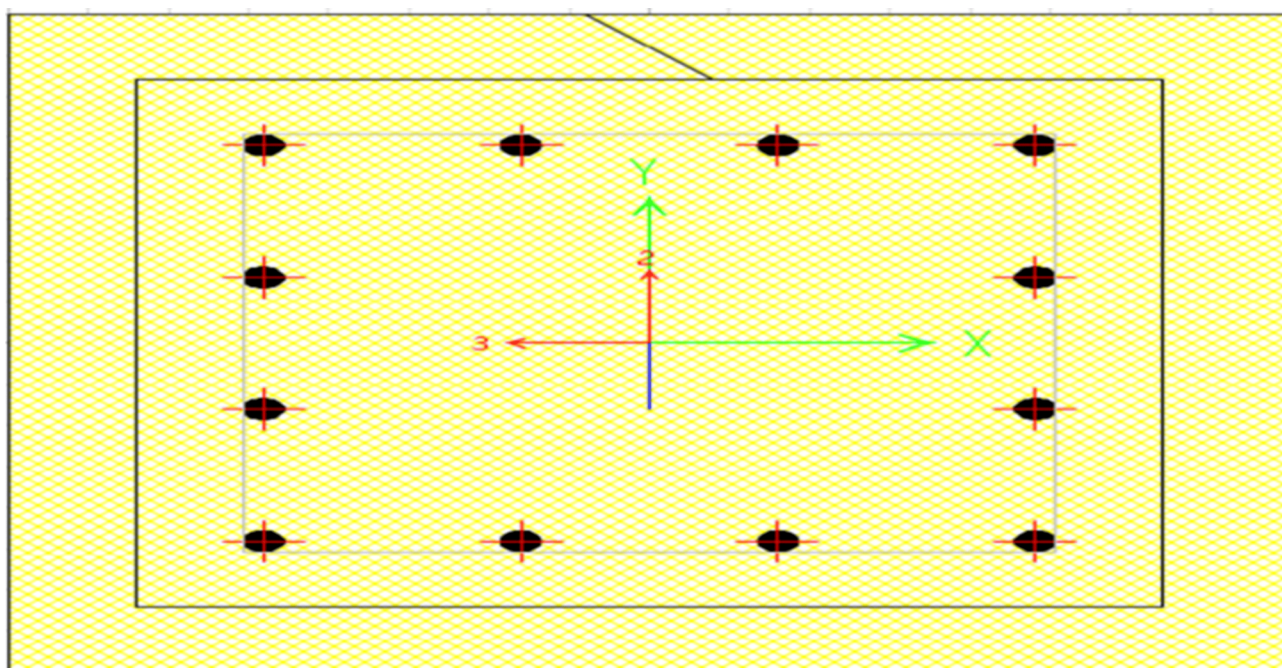


FIGURE 5: Concrete jacketing retrofitting technique

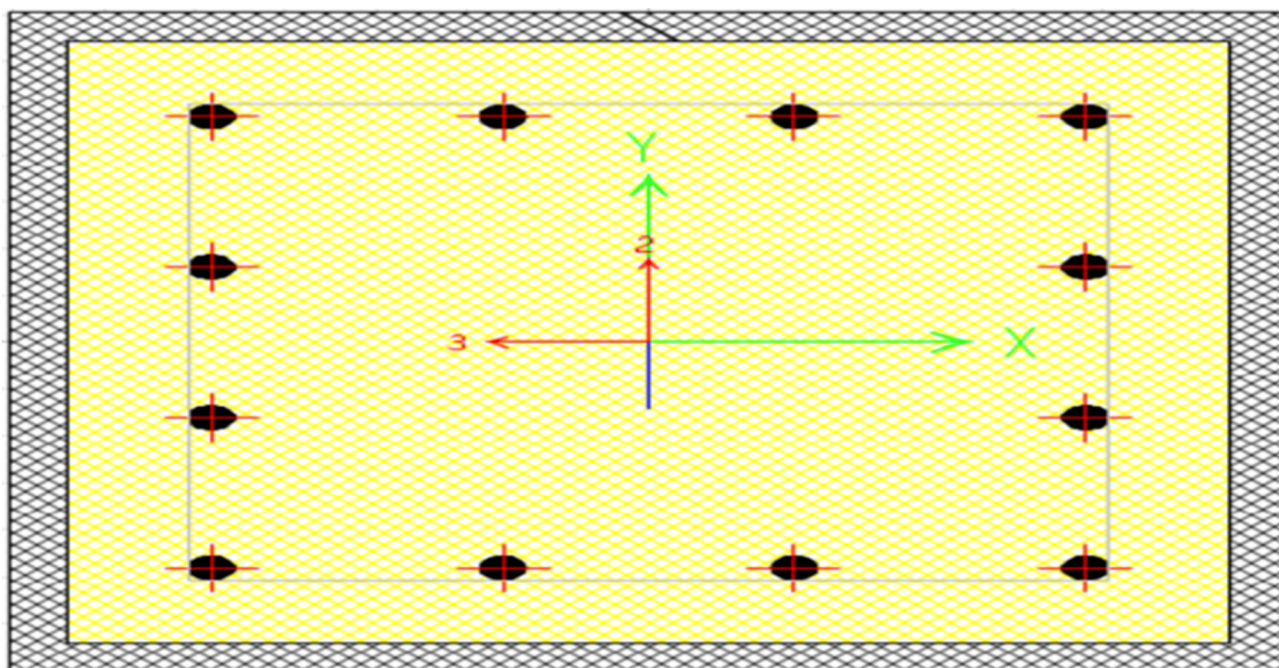


FIGURE 6: Steel jacketing retrofitting technique

Results And Discussion

Modal and seismic performance

The addition of the extra storey increased the total structural mass by approximately 22%, which caused the natural period of the unretrofitted building to increase from 0.98 s to 1.14 s. This increase indicated greater seismic vulnerability due to reduced global stiffness.

After retrofitting, the natural period reduced to 0.95 s for the concrete-jacketed model and 0.91 s for the steel-jacketed model, demonstrating enhanced stiffness and improved lateral resistance. Steel jacketing provided better dynamic performance because of improved confinement and energy dissipation characteristics.

Time-history response

Nonlinear time-history analysis was performed using four real earthquake records: El-Centro (1940), Chi-Chi (1999), Kobe (1995), and Northridge (1994). The objective was to evaluate displacement response, inter-storey drift, and residual deformation characteristics.

Figure 7 to Figure 10 present the displacement response histories obtained under different earthquake records. The red color represents the original building, the blue color indicates the concrete-jacketed building, and the green color represents the steel-jacketed building.

The steel-jacketed structure exhibited 10-12% lower maximum inter-storey drift and significantly reduced residual displacement compared to the concrete-jacketed structure. The improved performance resulted from enhanced confinement, ductility, and energy dissipation capacity provided by steel jacketing.

Concrete jacketing reduced displacement response primarily through stiffness enhancement. However, steel jacketing demonstrated superior seismic resilience due to its improved deformation capacity and confinement behavior.

Pushover analysis results

Nonlinear static pushover analysis was carried out according to ATC-40 and FEMA 356 recommendations. Plastic hinge properties were assigned for beams and columns using default hinge definitions available in SAP2000.

The resulting pushover curves are presented in Figure 11. The analysis demonstrated that steel jacketing achieved approximately 15% higher base shear capacity compared to concrete jacketing. Concrete jacketing provided greater initial stiffness but comparatively lower ductility.

The hinge formation sequence revealed that the steel-jacketed structure maintained the Life Safety performance level up to nearly 1.2% roof drift, whereas the concrete-jacketed model approached Collapse Prevention at the same displacement level. These observations were consistent with previously reported experimental studies on confined RC systems.

Pushover analysis also showed that retrofitting significantly improved the inelastic deformation capacity of the building. The retrofit methods delayed hinge formation and reduced the likelihood of brittle failure mechanisms under seismic loading [20].

How to cite this article:

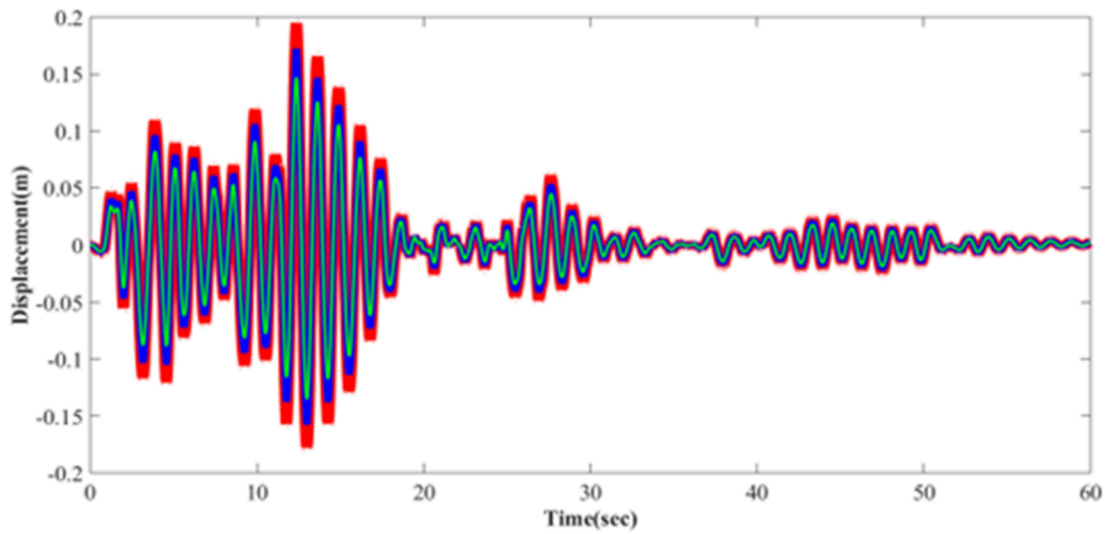


FIGURE 7: Time history displacement response under El-Centro earthquake (1940)

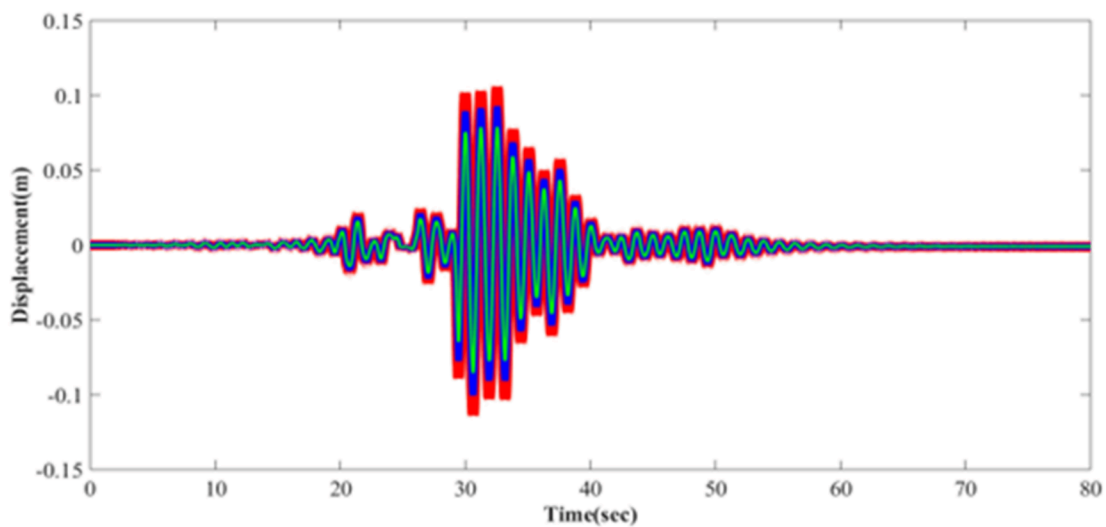


FIGURE 8: Time history displacement response under Chi-Chi earthquake (1999)

How to cite this article:

Singh V, Bharali K (August 05, 2026) Extending Reinforced Concrete Structures: A Comparative Retrofitting Approach. Cureus J Eng 3 : es44388-026-00207-2. DOI <https://doi.org/10.7759/s44388-026-00207-2>

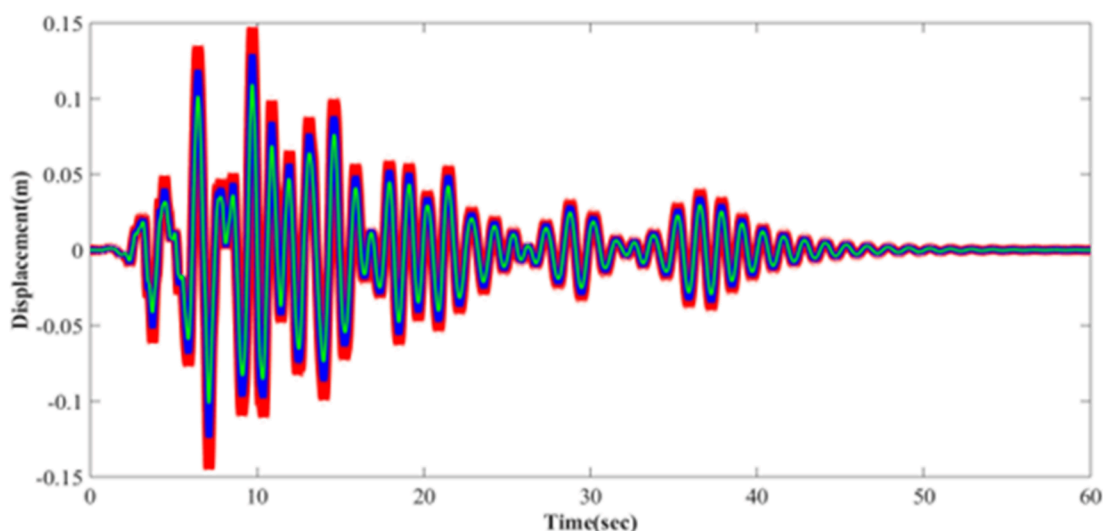


FIGURE 9: Time history displacement response under Kobe earthquake (1995)

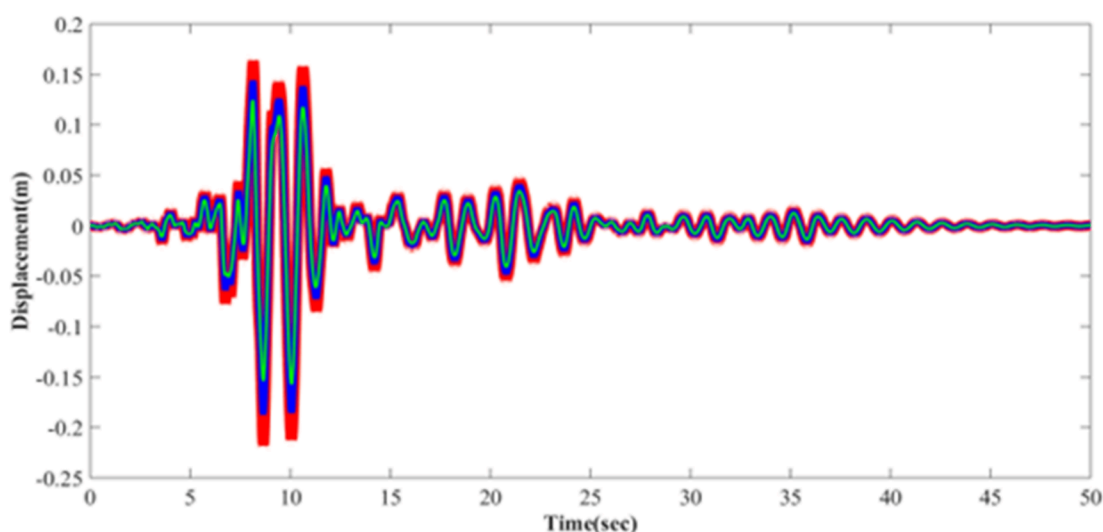


FIGURE 10: Time history displacement response under Northridge earthquake (1994)

Constructability and serviceability

Concrete jacketing increased member dimensions and added considerable dead load to the structure. Although it is cost-effective and structurally compatible with existing RC systems, the retrofit process is labor-intensive and may obstruct usable floor space.

Steel jacketing required comparatively faster installation and caused minimal dimensional increase. It also provided better confinement and seismic performance. However, corrosion protection and skilled fabrication are necessary to ensure long-term durability.

How to cite this article:

Singh V, Bharali K (August 05, 2026) Extending Reinforced Concrete Structures: A Comparative Retrofitting Approach. Cureus J Eng 3 : es44388-026-00207-2. DOI <https://doi.org/10.7759/s44388-026-00207-2>

A comparative assessment of the performance characteristics of concrete and steel jacketing is presented in Table 3. The comparative analysis indicated that steel jacketing is more suitable for seismic retrofitting and vertical extension applications where ductility, rapid installation, and reduced structural weight are important considerations [21-23].

Parameter	Concrete Jacketing	Steel Jacketing
Base shear capacity	Moderate	High
Ductility	Moderate	Excellent
Stiffness increase	High	Moderate
Constructability	Labor-intensive	Easier
Durability	High	Needs coating
Space requirement	Increases member size	Minimal change in dimension
Added mass	High	Low
Cost	Moderate to low	High material cost

TABLE 3: Performance comparison between concrete and steel jacketing

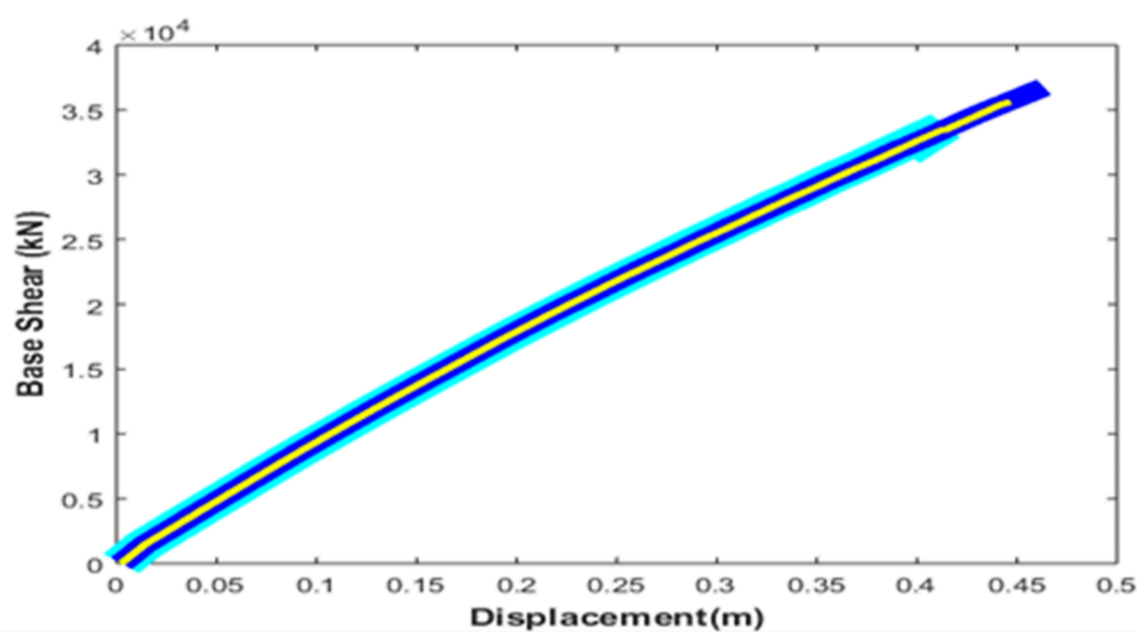


FIGURE 11: Pushover curves of original, concrete jacketing and steel jacketing retrofitted buildings

The combined analytical and literature-based evidence [6-9] suggests that while concrete jacketing ensures stiffness and integration, steel jacketing offers superior seismic performance and practicality for vertical extensions.

Conclusions

This study investigated the structural feasibility of extending an existing G+3 RC building to G+4 using concrete jacketing and steel jacketing retrofit techniques through nonlinear seismic analysis in SAP2000.

The major findings of the study are summarized as follows:

The additional storey increased the structural mass by approximately 22%, causing the natural period of the original structure to increase from 0.98 s to 1.14 s.

Retrofitting improved the dynamic characteristics of the structure, reducing the natural period to 0.95 s for concrete jacketing and 0.91 s for steel jacketing.

Steel jacketing achieved nearly 15% higher base shear capacity compared to concrete jacketing during pushover analysis.

Time-history analysis indicated that steel jacketing reduced maximum inter-storey drift by approximately 10-12% compared to concrete jacketing.

Concrete jacketing significantly improved stiffness and load-carrying capacity but resulted in larger member dimensions and additional dead load.

Steel jacketing provided superior ductility, energy dissipation, and seismic resilience while minimizing dimensional increase and structural weight.

Validation with previously published experimental and analytical studies confirmed that the SAP2000 simulation results were consistent with established seismic retrofit behavior reported in the literature.

Based on the obtained analytical results, steel jacketing is recommended for vertical extension projects in seismic regions where improved ductility, rapid installation, and enhanced seismic performance are critical requirements. Concrete jacketing remains a practical and economical alternative for projects emphasizing stiffness enhancement and structural compatibility.

Future research may focus on hybrid retrofitting systems, advanced materials such as ultra-high-performance concrete, and integration of structural health monitoring techniques for improved retrofit optimization.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Vivek Kumar Singh, Kunal Bharali

Acquisition, analysis, or interpretation of data: Vivek Kumar Singh, Kunal Bharali

Drafting of the manuscript: Vivek Kumar Singh, Kunal Bharali

Critical review of the manuscript for important intellectual content: Vivek Kumar Singh, Kunal Bharali

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors

How to cite this article:

Singh V, Bharali K (August 05, 2026) Extending Reinforced Concrete Structures: A Comparative Retrofitting Approach. Cureus J Eng 3 : es44388-026-00207-2. DOI <https://doi.org/10.7759/s44388-026-00207-2>

have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Data Availability Statements

The datasets (and/or code) supporting this study are available from the corresponding author upon reasonable request.

Acknowledgements

The authors acknowledge the Civil Engineering Department at Galgotias University for its support of this research and access to structural software and computational facilities.

References

1. Leung CKY, Cao Q: [Development of pseudo-ductile permanent formwork for durable concrete structures](#). Materials and Structures. 2009, 43:993-1007. [10.1617/s11527-009-9561-4](#)
2. Li Z, Leung CKY, Xi Y: [Structural Renovation in Concrete](#). Taylor and Francis, 2009. [10.1201/9781482265972](#)
3. Wan KT, Leung CKY: [Fiber optic sensor for the monitoring of mixed mode cracks in structures](#). Sensors and Actuators A: Physical. 2007, 135:370-380. [10.1016/j.sna.2006.08.002](#)
4. Wan KT, Leung CKY: [Applications of a distributed fiber optic crack sensor for concrete structures](#). Sensors and Actuators A: Physical. 2007, 135:458-464. [10.1016/j.sna.2006.09.004](#)
5. Zhang J, Leung CKY, Xu S: [Evaluation of fracture parameters of concrete from bending test using inverse analysis approach](#). Materials and Structures. 2010, 43:857-874. [10.1617/s11527-009-9552-5](#)
6. Habib A, Yildirim U, Eren O: [Column repair and strengthening using RC jacketing: a brief state-of-the-art review](#). Innovative Infrastructure Solutions. 2020, 5:75. [10.1007/s41062-020-00329-4](#)
7. Raza S, Khan MKI, Menegon SJ, Tsang HH, Wilson JL: [Strengthening and repair of reinforced concrete columns by jacketing: State-of-the-art review](#). Sustainability. 2019, 11:3208. [10.3390/su11113208](#)
8. Campione G, Fossetti M, Giacchino C, Minafò G: [RC columns externally strengthened with RC jackets](#). Materials and Structures. 2014, 47:1715-1728. [10.1617/s11527-013-0146-x](#)
9. Thermou GE, Papanikolaou VK, Hajirasouliha I: [Structural performance of RC columns retrofitted with steel-reinforced grout jackets under combined axial and lateral loading](#). Engineering Structures. 2021, 245:112946. [10.1016/j.engstruct.2021.112946](#)
10. Meda A, Mostosi S, Rinaldi Z, Riva P: [Corroded RC columns repair and strengthening with high performance fiber reinforced concrete jacket](#). Materials and Structures. 2016, 49:1967-1978. [10.1617/s11527-015-0627-1](#)
11. Chen J, Wang Z, Xu A, Zhou J: [Compressive behavior of corroded RC columns strengthened with ultra-high performance jacket](#). Frontiers in Materials. 2022, 9:859620. [10.3389/fmats.2022.859620](#)
12. Waenpracha A, Pannachet T, Boonpichetvong M: [Experimental investigation on axial strength improvement of cold-formed steel jacketed concrete stub columns](#). International Journal of Concrete Structures and Materials. 2024, 18:64. [10.1186/s40069-024-00706-8](#)
13. Landović A, Bešević M: [Experimental research on reinforced concrete columns strengthened with steel jacket and concrete infill](#). Applied Sciences. 2021, 11:4043. [10.3390/app11094043](#)
14. Hsiao FP, Oktavianus Y, Ou YC, Luu CH, Hwang SJ: [A pushover seismic analysis and retrofitting method applied to low-rise RC school buildings](#). Advances in Structural Engineering. 2015, 18:311-324. [10.1260/1369-4332.18.3.311](#)
15. Koutromanos I, Stavridis A, Shing PB, Willam K: [Numerical modeling of masonry-infilled RC frames subjected to seismic loads](#). Earthquake Engineering & Structural Dynamics. 2011, 39:1026-1037. [10.1016/j.compstruc.2011.01.006](#)
16. Ahmed HA, Tanoli WA: [Seismic retrofitting of RC buildings using a performance-based approach for risk resilience and vulnerability assessment](#). Buildings. 2025, 15:1333. [10.3390/buildings15081333](#)

How to cite this article:

Singh V, Bharali K (August 05, 2026) Extending Reinforced Concrete Structures: A Comparative Retrofitting Approach. Cureus J Eng 3 : es44388-026-00207-2. DOI <https://doi.org/10.7759/s44388-026-00207-2>

17. Umwi D, Alex J: [Seismic performance assessment of reinforced concrete frames: Insights from pushover analysis](#). Lecture Notes in Civil Engineering,. 2024, 607:979-987. [10.1007/978-3-031-70431-4_72](#)
18. Krawinkler H, Seneviratna GDPK: [Pros and cons of a pushover analysis of seismic performance evaluation](#). Engineering Structures. 1998, 20:452-464. [10.1016/s0141-0296\(97\)00092-8](#)
19. Almusallam TH, Elsanadedy HM, Al-Salloum YA, Alsayed SH: [Experimental and numerical investigation for the flexural strengthening of RC beams using near-surface mounted steel or GFRP bars](#). Construction and Building Materials. 2013, 40:145-161. [10.1016/j.conbuildmat.2012.09.107](#)
20. Mwafy AM, Elnashai AS: [Static pushover versus dynamic collapse analysis of RC buildings](#). Engineering Structures. 2001, 23:407-424. [10.1016/s0141-0296\(00\)00068-7](#)
21. Zhao J, Shen F, Si C, Sun Y, Yin L: [Experimental investigation on seismic resistance of RC shear walls with CFRP reinforcement in boundary elements](#). International Journal of Concrete Structures and Materials. 2020, 14:4. [10.1186/s40069-019-0377-5](#)
22. Liu S, Ding X, Li X, Liu Y, Zhao S: [Behavior of rectangular-sectional steel tubular columns filled with high-strength steel fiber reinforced concrete under axial compression](#). Materials. 2019, 12:2716. [10.3390/ma12172716](#)
23. Han LH, Yao GH, Tao Z: [Performance of concrete-filled thin-walled steel tubes under pure torsion](#). Thin-Walled Structures. 2007, 45:24-36. [10.1016/j.tws.2007.01.008](#)

How to cite this article:

Singh V, Bharali K (August 05, 2026) Extending Reinforced Concrete Structures: A Comparative Retrofitting Approach. Cureus J Eng 3 : es44388-026-00207-2. DOI <https://doi.org/10.7759/s44388-026-00207-2>