

Retrofitting Technique for Converting Commercial Building into Data Centre Building

Swaraj Korde¹, Yash Papalkar², Rushikesh Roy³, Rushikesh Ekapure⁴, Prof. P. P. Pande⁵

^{1,2,3,4}Students, Department of Civil Engineering, R. V. Parankar College of Engineering and Technology, Arvi

⁵Assitant Prof., Department of Civil Engineering, R. V. Parankar College of Engineering and Technology, Arvi

Abstract - Repair, rehabilitation, and retrofitting are vital practices in civil engineering that ensure the safety, durability, and functionality of reinforced concrete structures. Over time, buildings are exposed to environmental stress, overloading, and poor construction practices, leading to issues like corrosion, cracking, spalling, and degradation of structural integrity. Modern techniques such as fibre-reinforced polymers (FRPs), anti-corrosive coatings, self-healing concrete, and non-destructive testing (NDT) have been developed to address these problems. Retrofitting plays a crucial role in upgrading structures to enhance load capacity and resistance to natural disasters like earthquakes, floods, and high winds. In countries like India, where infrastructure is aging and rapidly expanding, these methods are essential for ensuring long-term safety, sustainability, and resilience. By adopting these modern techniques, engineers can extend structure lifespan, reduce maintenance costs, and ensure public safety, ultimately supporting economic development and maintaining infrastructure integrity. Effective repair, rehabilitation, and retrofitting strategies are critical for withstanding environmental challenges and ensuring the longevity of structures.

Key Words: optics, photonics, light, lasers, templates, journals

1.INTRODUCTION

Repair and rehabilitation are crucial in civil engineering, playing a vital role in extending the service life of structures, much like healthcare for aging humans. Reinforced Cement Concrete (RCC) structures, despite being valued for strength, versatility, and cost-effectiveness, face deterioration over time due to wear and tear, exposure to harsh environmental conditions, and increased loading. Many RCC structures can show signs of deterioration within relatively short periods, often within 15 years of construction. This is primarily due to inadequate construction practices, variability in material properties, fluctuations in service loads, and corrosive environmental effects like moisture, temperature changes, and chemical exposure.

Common issues include the corrosion of steel reinforcement, which is one of the most severe causes of deterioration in RCC structures. Corrosion occurs when moisture, oxygen, and chlorides or sulfates penetrate the concrete and react with the steel reinforcement. These corrosion products have a larger volume than the original steel, creating internal pressures that lead to cracking and spalling of the concrete cover, ultimately compromising the structural integrity and safety of the building or infrastructure. The consequence is a loss of strength and durability, making the element more vulnerable and potentially leading to catastrophic failure if unaddressed. Concrete's durability depends on its ability to withstand various stresses and environmental challenges without rapid deterioration. Deterioration results from the interaction between physical and chemical processes. Physical factors include mechanical stresses such as overloading, shrinkage, and thermal expansion, which can induce cracking and displacement.

Chemical factors include the ingress of aggressive substances like chlorides, sulfates, and carbon dioxide, which can react with the concrete matrix and embedded reinforcement, leading to corrosion and weakening of the material. Environmental factors, such as exposure to extreme temperatures, moisture, and pollution, also play a significant role in degradation.

To address these issues, repair and rehabilitation strategies are employed to restore or enhance the performance and safety of these structures. These strategies need to be tailored to address the specific needs of each structure. Advanced repair techniques and materials have emerged, including the use of fiber-reinforced polymers (FRPs) for strengthening, particularly enhancing tensile strength and resistance to corrosion. Anti-corrosive coatings are applied to steel reinforcement as a barrier against corrosive agents, while self-healing concrete contains microcapsules that release healing agents when cracks form to seal the damage. Surface treatments like hardeners and sealers can improve resistance to moisture and chemicals. Non-destructive testing (NDT) methods, such as ultrasonic testing, ground-penetrating radar (GPR), and radiography, help assess internal damage accurately without causing harm, allowing for more precise and targeted interventions.

Retrofitting, a subset of rehabilitation, involves modifying existing structures to improve their performance, safety, or resilience against natural hazards. It enhances the efficiency and safety of existing structures and can repair damage from bad construction methods or natural calamities. Retrofitting resolves structural concerns and improves safety for residents, and can drastically lower energy and water usage as technology advances. It refers to modifying an existing structure to safeguard it from risks such as flooding or high winds and is especially vital in disaster-prone areas to enhance seismic resistance. Methods include strengthening structural elements like beams, columns, and foundations by adding additional reinforcements or using advanced materials like FRPs. For flood resistance, retrofitting may involve elevating buildings, strengthening foundations, or adding waterproof barriers.

Retrofitting can significantly improve a building's energy efficiency by upgrading insulation, windows, lighting, and HVAC systems, leading to reduced energy use and a lower carbon footprint. It can also incorporate sustainable materials and renewable energy sources like solar panels. This practice supports extending the lifespan of the building, improving comfort and indoor air quality, increasing property value and compliance with modern codes, and enhances occupant safety through fire safety upgrades and improved accessibility.

In developing countries like India, where a significant portion of the built environment is aging or inadequately maintained, the adoption of new technologies and materials for repair and retrofitting is crucial for ensuring the safety and sustainability

of buildings, bridges, and other critical infrastructure. Regular maintenance and rehabilitation are essential as an integral part of the lifecycle of any structure, ensuring they remain safe, functional, and resilient for future generations. Using retrofitting to renovate a structure for changing its functional utility, such as converting a commercial building into a data centre, can be cost and time efficient, as well as sustainable due to energy conservation.

Objective

1. Accurate Structural Assessment.
2. Incompatibility of new materials with the existing structure.
3. Limited budget and resource constraints.
4. Structural overloading and safety concerns.
5. Compliance with current building codes
6. Minimizing disruption to occupants and operations.

PURPOSE AND IMPORTANCE: Repair and rehabilitation, which includes retrofitting, are essential aspects of civil engineering. Retrofitting is necessary to extend the service life of reinforced cement concrete (R.C.C.) structures. Structures deteriorate over time due to wear and tear, harsh environmental conditions, increased loading, and interactions between physical (mechanical stresses like overloading, shrinkage, thermal expansion) and chemical (aggressive substances like



chlorides, sulfates, carbon dioxide) processes. Retrofitting aims to restore or enhance the performance and safety of structures. It helps structures meet their intended purpose, adapt to new functional requirements, and address structural concerns, improving safety for residents. Retrofitting can repair damage from bad construction methods or natural calamities. It also extends the usable life of a structure.

Definition: Retrofitting involves modifying anything after it has been produced. In buildings, it means changing a building's systems or structure after it has been built and occupied. The process enhances the building's amenities. It is the method of treatment of a structure to increase its usable life. Retrofitting involves modifying or upgrading existing structures to improve their performance, safety, or resilience against natural hazards.

Types of Retrofitting: The sources mention several types of retrofitting:

Preservation Retrofitting: Treatment to prevent potential damage without affecting the originality, integrity, material, or value of the structure; a preventive method.

Rehabilitation Retrofitting: Required when the structure's usage changes and the initial design is not compatible with the new proposed usage.

Restoration Retrofitting: Bringing a deteriorated structure back to its original form.

Reconstruction: Creating a replica of a structure.

Methods and Materials: Retrofitting methods depend on the purpose. Local methods for concrete members include **Jacketing**, which provides extra strength by adding a casing (jacket) of fibre-reinforced plate or steel sheet, potentially covered with concrete/mortar or bonded with adhesive. Advanced materials and techniques include:

Fiber-Reinforced Polymers (FRPs): Lightweight, durable, corrosion-resistant, used for strengthening structures by increasing tensile strength and resisting seismic forces. Applied as sheets or wraps around elements like beams, columns, slabs. Examples include carbon fiber reinforced polymers (CFRP).

Anti-Corrosive Coatings: Applied to steel reinforcement to prevent ingress of moisture, oxygen, and corrosive agents, prolonging structure life.

Self-Healing Concrete: Contains microcapsules with healing agents that seal cracks.

Shear Bolts: Novel type of shear reinforcement for retrofitting existing slabs, enhancing strength and ductility of slab-column connections.

Fiber-Reinforced Concrete (FRC): Used to enhance durability and flexibility of concrete elements.

Base Isolators: Used for seismic retrofitting to protect the building from seismic forces.

Shear Walls and Cross-Bracing: Integrated to enhance the building's stiffness and strength against lateral forces.

Surface Treatments: Hardeners and sealers to improve resistance to moisture and chemicals.

Key Challenges and Problems: Retrofitting presents several challenges:

Accurate Structural Assessment: Difficulty in assessing existing conditions and hidden damage. Traditional methods only detect surface issues. Advanced diagnostics like NDT are needed.

Compatibility of Materials: Integrating modern materials (FRPs, high-performance concrete) with older materials (brick, stone, old concrete) due to differences in mechanical properties and thermal expansion.

Structural Overloading: Enhancing load-bearing capacity can overload the original structure if not properly analyzed.

Cost and Resource Constraints: Retrofitting can be expensive due to assessment, materials, labor, and complexity. Unexpected issues increase costs.

Minimizing Disruption: Retrofitting occupied buildings causes disruption (noise, dust, restricted access, temporary displacement) for occupants and logistical challenges for contractors.

Compliance with Updated Codes: Older buildings may not meet current codes (seismic, wind, fire safety, accessibility,

environmental). Integrating new standards without compromising functionality or aesthetics is challenging.

Environmental Impact: Retrofitting can generate waste and use non-sustainable materials, potentially containing hazardous substances.

Seismic Vulnerabilities: Many older buildings were not designed for seismic forces. Strengthening elements and load paths is complex.

Heritage Buildings: Balancing structural integrity upgrades with preserving architectural integrity and historical value.

Long-Term Durability: Predicting the performance and durability of retrofitting measures is difficult. Ongoing monitoring is essential.

Integrating Modern Technologies: Incorporating smart systems, energy-efficient technologies, and automation into older buildings can be technically challenging and costly.

BENEFITS AND ADVANTAGES: Despite the challenges, retrofitting offers significant benefits:

Enhanced Structural Integrity and Safety: Improved ability to withstand natural disasters like earthquakes and floods.

Improved Energy Efficiency: Lower energy consumption, reduced operational costs, and a smaller environmental footprint through upgrades to insulation, HVAC, lighting, and integrating renewables.

Increased Property Value: More attractive to buyers/tenants, higher market value.

Extended Lifespan: Prolongs the building's service life and reduces maintenance costs.

Environmental Benefits: More sustainable than demolition and new construction by minimizing waste, reusing structures, and reducing carbon emissions.

IMPROVED OCCUPANT COMFORT AND SAFETY: Better indoor air quality, consistent temperatures, fire safety upgrades, and accessibility features.

Compliance: Brings older buildings up to current codes and standards.

Adaptability: Makes buildings more flexible for future changes in needs or usage.

Preservation: Allows for the preservation of historic or cultural value.

Marketability: Increased competitiveness in the market, especially with sustainability features.

Tenant Satisfaction: Provides a more comfortable, efficient, and safer environment.

FACTORS CONSIDERED FOR RETROFITTING PROJECTS: Successful retrofitting requires considering:

Building Age and Condition: Materials degrade, and utility systems may be outdated.

Structural Integrity: Assessing existing strength and stability is crucial, especially for seismic safety and load changes.

Energy Efficiency: Assessing current performance and planning upgrades.

Building Code Compliance: Ensuring upgrades meet current standards.

Functionality and Occupant Needs: Tailoring retrofits to specific building types and user requirements.

Cost and Budget Constraints: Establishing a clear budget and conducting cost-benefit analysis, exploring financial incentives.

Building Occupancy and Disruption: Planning to minimize inconvenience and disruption to occupants and operations.

Sustainability and Environmental Impact: Integrating eco-friendly materials, energy efficiency, water conservation, and waste management.

Technological Integration: Incorporating smart systems and modern technologies.

Aesthetic and Architectural Integrity: Maintaining the visual appeal and heritage, especially for historic buildings.

Weather and Climate Resilience: Upgrading to withstand extreme conditions.

Time Constraints and Scheduling: Establishing timelines, phasing work, and managing external factors.

Stakeholder Involvement and Approval: Clear communication and coordination with all parties.

Future Adaptability: Designing for flexibility and easy integration of future upgrades and changes in usage.

2.LITERATURE REVIEW HIGHLIGHTS: The sources review studies on seismic performance analysis and retrofitting methods like shear walls, column jacketing, and steel bracing. They also discuss studies on improving the ductility and rotational capacity of slab-column connections, focusing on punching shear failure and the effectiveness of shear reinforcement, including novel shear bolts. The use of CFRP external strengthening for damaged slab-column connections is also discussed, including the investigation of multilayered CFRP and end anchorage. Studies using finite element analysis tools like ZEUS-NL and ABAQUS and models like the Concrete Damage Plasticity Model (CDPM) are mentioned. Research comparing flat slab and beam-supported slab buildings' seismic performance through pushover analysis indicates beam-supported buildings are effective at handling seismic loads on flat slabs.

3. CONCLUSIONS

This research project focused on the conversion of a commercial building into a data centre through the application of retrofitting techniques. The initial structural analysis revealed that the building was safe for its original commercial purpose, with its loading parameters falling within the maximum permissible limits for columns, beams, and slabs. However, when the structure was assessed for suitability as a data centre, it encountered significant issues. Severe column load was observed, particularly on the ground and first floors. Additionally, the slabs exhibited failure due to punching shear, and a section of the core wall beams also failed.

To address these structural deficiencies, column jacketing was implemented as a retrofitting technique to enhance the load-bearing capacity of the columns. Following the application of column jacketing (measuring 100 mm on each side), the columns were determined to be safe.

Nevertheless, a persistent problem remained, as the structure still experienced punching shear failure in the flat slabs. This issue was attributed to the absence of a drop panel in the existing flat slab design. To resolve this specific problem, a column capital of size 100 x 100 mm on each side was introduced. Subsequent analysis confirmed that, after this

addition, all measured values were well within their permissible limits.

Based on this analysis, it is understood that employing retrofitting techniques to renovate a structure offers an alternate approach for changing its functional utility. This method is described as being not only **cost and time efficient** but also **very sustainable** due to its capacity to conserve energy. This sustainability aspect is considered key as the construction industry increasingly focuses on sustainable development and is deemed pivotal for the future.

REFERENCES

1. H. A. Safarizkia, S. A. Kristiawan, and A. Basuki, Evaluation of the Use of Steel Bracing to Improve Seismic Performance of Reinforced Concrete Building, The 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering, Procedia Engineering 54, 2013, pp. 447-456.
2. S. S. Ramteke, S. P. Raut, Pushover Analysis and Seismic Retrofitting Using Shear walls and Bracing System of Frame Structure, International Journal of Modern Trends in Engineering and Research (IJMTER) Volume 02, Issue 04, April 2015, pp. 50-59.
3. M. Ghaderi, H. Ghafarzade, and J. Jamali, Evaluation of Seismic Performance of the Reinforced Concrete Buildings with Steel Bracing, Shear Wall and Column Jacketing, Technical Journal of Engineering and Applied Sciences 3 (23) pp. 3313-3324, 2013.
4. B. ShivakumaraSwamy, Dhananjaiah M, SEISMIC RETROFITTING OF R.C.FRAMES BY LINEAR STATIC METHOD AT SEVERE ZONE OF SOFT SOIL.
5. K. Suruthi, P. Shakivel, Seismic Qualification and Retrofitting Of Existing Structures, Vol. 4, Issue 1, pp: (174-187), Month: April 2016 - September 2016
6. Gattu Ashok Kumar, B. Harish Nayak, Seismic Retrofit of RC Building Using Jacketing A Review and Case Study, Vol. 5, Issue 10, October 2016. Certainly, here are four additional references related to retrofitting and structural analysis, drawn from the provided source material, to add to your list:
6. Hueste, M. B., and J. C. Kennedy, Seismic Retrofit Strategies for Existing Reinforced Concrete Frame Buildings with Flat Slabs, Earthquake Spectra, Vol. 23, No. 3, 2007, pp. 551-571.
7. Polak, M.A. Shear Reinforcement for Existing Concrete Slabs, Journal of Structural Engineering, Vol. 131, No. 9, 2005, pp. 1446-1454.
8. Silva, M. A. L., B. L. V. Pinho, H. C. E. Miranda, C. A. S. Rebelo, and L. C. A. D. Segurado, Retrofitting of Slab-Column Connections Using Externally Bonded CFRP Strips, Journal of Reinforced