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A REVIEW ON RETROFITTING OF RC CIRCULAR COLUMN USING CARBON STRIPS

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Abstract—

The term "retrofit process" broadly encompasses various treatments such as preservation, rehabilitation, restoration, and reconstruction. Choosing the right treatment strategy is a significant challenge and must be determined on a project-by-project basis. Depending on the project's goals, the preservation and renovation of buildings may involve numerous technical considerations, including fire life safety, geotechnical hazards and their solutions, weathering and water infiltration, and structural performance under earthquake and wind loads. This paper discusses aspects of a research program examining the behavior of reinforced concrete slabs retrofitted with Fiber Reinforced Polymer composites. Theoretical and experimental investigations are underway to assess the effectiveness of these strengthening solutions. Eight specimens were tested, including two that were strengthened after being loaded to the yield level to simulate strengthening with some damage, and one strengthened under a sustained axial load to simulate strengthening under service conditions. These specimens were tested under constant axial load and lateral cyclic load to evaluate the seismic performance of RC columns reinforced with carbon fiber reinforced polymer (CFRP) sheets.
Keyword: *CFRP, Concrete, Suitability.*

I. INTRODUCTION

Nowadays, civil engineering increasingly incorporates composite materials, particularly Fiber Reinforced Polymers (FRPs). The properties of composite materials have proven to be highly successful in a range of applications, from localized strengthening to highly complex projects. The preference for composites over traditional steel or reinforced concrete (RC) strengthening solutions is supported by several factors. Among the most significant are the composites' exceptional corrosion resistance, the short construction time required, and their low weight.At the "Politehnica" University of Timisoara, one of the ongoing experimental programs focuses on retrofitting solutions using FRP for two-way RC slabs with cut-outs. Openings in slabs are often necessary in areas not originally considered during a building's design, primarily due to changes in functionality. Additionally, openings included in the design may need to accommodate higher loads than initially anticipated due to changes in usage. In either case, the slab's overall behavior may become inadequate, both in terms of stiffness and load-bearing capacity. This inadequacy is most pronounced around the cut-out areas where stresses are highly concentrated. Such situations can lead to significant changes in the overall failure mode, resulting in new and unexpected failures.

A. Necessity Of Strengthening Reinforced Concrete Elements

Nowadays, civil engineering increasingly incorporates composite materials, particularly Fiber Reinforced Polymers (FRPs). The properties of composite materials have proven to be highly successful in a range of applications, from localized strengthening to highly complex projects. The preference for composites over traditional steel or reinforced concrete (RC) strengthening solutions is supported by several factors. Among the most significant are the composites' exceptional corrosion resistance, the short construction time required, and their low weight.
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To consider the necessity of strengthening RC elements, we must analyze practical situations where existing concrete structures or their components may be inadequate and require repair or strengthening. The scenarios in which reinforced concrete slabs need intervention for repairs or strengthening include the following

a) Repairing damaged or deteriorated concrete slabs to restore their strength and stiffness.
b) Addressing corrosion of the reinforcement.
c) Limiting crack width under increased design/service loads or sustained loads.
d) Retrofitting concrete members to enhance the flexural strength and strain to failure under increased loading conditions, such as earthquakes or traffic loads.
e) Correcting design and construction errors, such as undersized reinforcement.
f) Extending the service life of the RC slabs.
g) Shear strengthening around columns to increase the perimeter of the critical section for punching shear.

II. STATE OF DEVELOPMENT

Abd El Rahman Megahid Ahmed et al. [1] This study explores the effects of varying aspect ratios (h/b=2, 2.5, 3, and 4), FRP confinement ratios (number of FRP layers), and FRP-wrapping configurations (full and partial systems). The experimental results indicated that the efficiency of the FRP confined system decreases with increasing aspect ratio. Confinement with CFRP sheets improves the performance of capsule-shaped RC columns under axial compressive loads, enhancing both strength and ductility regardless of the cross-sectional aspect ratio and confinement type. The authors proposed an analytical model to predict the axial load capacity of short capsule-shaped RC columns, which showed good agreement with experimental results and provided reasonable predictions of load capacity for FRP-confined columns. The study aimed to investigate the behavior of RC short capsule-shaped columns confined with CFRP sheets both experimentally and analytically. The efficiency of the FRP-confined strengthening system largely depends on parameters such as the FRP confinement ratio, cross-sectional shape and size, and the aspect ratio of non-circular columns.

K. Pradeeba et al. Concrete is extensively used in construction due to its ability to be cast into various shapes, although it has deficiencies that would limit its use without its qualities of resilience, flexibility, and stress redistribution. Plain concrete is weak in tension, has limited ductility, and little resistance to cracking. Micro-cracks in concrete propagate under load, leading to brittle fracture. Over the past two decades, CFRP has gained popularity for strengthening and repairing concrete structures. CFRP is favored in civil engineering due to its high strength, durability, corrosion resistance, and tensile strength. This paper presents experimental and analytical studies on concrete columns wrapped with CFRP. The investigations included wrap thickness (1 layer), fiber orientation, and combinations thereof. The results showed significant enhancements in compressive strength, stiffness, and ductility of CFRP-wrapped concrete columns compared to unconfined columns. An analytical model for ultimate stress and strain of confined concrete was proposed.

Renjith Raju et al. Reinforced concrete is known for its durability and structural performance, except in zones exposed to severe environmental conditions and high mechanical loading. Deterioration of structures can result from earthquakes, floods, pollution, faulty construction, chloride attack, and inadequate design. Retrofitting is a preferred solution over replacement for restoring the strength and load capacity of structures. Retrofitting techniques include concrete and steel jacketing and FRP jacketing. FRP offers advantages such as light weight, high strength, and good environmental resistance. This paper reviews the literature on Ferrocement and FRP jacketing for strengthening concrete columns, measuring axial load, lateral bulging, and crack patterns to assess effectiveness.

Evgenia Anagnostou et al. Older RC columns often have inefficiencies with lap-spliced longitudinal bars in the plastic hinge region, leading to inadequate force transfer and brittle failure during earthquakes. Existing RC structures designed to older seismic standards may require retrofitting to improve seismic behavior. This paper investigates the seismic strengthening of RC columns with lap-spliced bars, using FRP confinement. It evaluates the accuracy of KANEPE and EC8.3 equations for shear strength (VR) and ultimate chord rotation capacities (θu), proposing modifications to improve prediction accuracy.

Mohannad H. Al-Sherrawi et al. RC columns are primary load-bearing components that may need repair or strengthening over time. Common methods include concrete, FRP, and steel jacketing. Steel jacketing is widely used for non-ductile RC columns. This paper presents analytical models for the axial load-bending moment interaction diagram of RC columns strengthened with steel jackets, considering confinement by the steel jacket. The proposed models show good agreement with experimental data and design proposals.

Shubham S. Narwade et al. The need for rehabilitating, repairing, and strengthening concrete structures has increased globally. Techniques include concrete jacketing, retrofitting, and FRP composites. This project examines the effectiveness of CFRP wrapping in enhancing the strength of various building components. Concrete cubes and a column were tested before and after CFRP wrapping, showing increased strength and cost-effectiveness compared to concrete jacketing.

Sayed Behzad Talaeitaba et al. This experimental study investigates retrofitting RC columns under axial compression with different eccentricities using a hybrid technique combining near-surface-mounted longitudinal steel rebars and transverse CFRP straps. This method aims to prevent buckling, increase shear capacity, and improve concrete confinement. The study tested 20 small-scale circular columns, comparing control, repaired, and strengthened specimens. The results demonstrated enhanced structural performance in terms of load capacity, displacement, and ductility.

Stefan Kaeseberg et al. CFRP materials are recognized for enhancing the strength and ductility of confined RC columns. This paper reviews international standards and guidelines for designing CFRP-confined RC columns, highlighting differences in predictive models and loading conditions. Recent research from Leipzig University is discussed, comparing guideline predictive equations and proposing improvements based on new findings.

Hanan Suliman Al-Nimry et al. This study investigates the behavior of medium-scale circular RC columns wrapped with FRP sheets under concentric and eccentric axial loads. The experimental program assessed loading conditions and FRP wrapping systems. The results confirmed that FRP confinement enhances axial-flexural column resistance, with significant improvements under eccentric loading. Three stress-strain models were evaluated for axial-flexural interaction in FRP-jacketed columns, showing varying degrees of agreement with test results.

Saim Raza et al. Sustainability in infrastructure requires protecting RC structures from deterioration due to extreme loads, corrosion, or aging. This paper reviews jacketing techniques for strengthening and repairing RC columns, identifying research gaps and future directions.

Mahmod Samak et al. Strengthening concrete structures with FRP jackets is an alternative to traditional methods like steel and concrete jackets. This study tested six specimens, comparing FRP-wrapped columns to numerical models using ABAQUS. The results demonstrated significant improvements in strength and ductility with FRP wrapping, and a design equation was proposed for calculating the ultimate axial load of FRP-wrapped columns.

Yingwu Zhou et al. RC columns in bridges and frames often sustain damage from earthquakes and corrosion, leading to brittle failure. FRP has become popular for retrofitting to improve seismic performance, preventing concrete cover spalling and enhancing confinement. Recent studies show that LRS-FRP made from recycled PET fibers offers greater ductility and energy dissipation than traditional FRP. This paper reviews the effectiveness of FRP in improving seismic performance and proposes using LRS-FRP for better outcomes.

III. CONCLUSION & FURTHER STUDY

This paper focuses solely on the literature review of prior studies conducted on columns wrapped with FRP jackets. Previous research findings demonstrate that the effectiveness of confinement is notably influenced by various parameters including the type of fiber and resin, fiber volume and orientation, jacket thickness, concrete strength, cross-sectional shape and corner radius, slenderness ratio, and interface bond between the concrete core and jacket. For instance, the influence of corner radius on confinement was studied, revealing that FRP jackets provide no confinement effect when the corner radius is zero. To address this limitation, the authors proposed a simplified model for FRP systems that directly correlates strength enhancement, ultimate strain, and energy absorption capacity with a single parameter based on the relative stiffness of the jacket and concrete column, thereby avoiding the need for defining lateral confinement pressure. Analytical functions derived from the best fit of multiple experimental data enable the model's applicability to various FRP jacketing types. The project aims to increase column capacity through measures such as enlarging the cross-sectional area or enhancing concrete compressive strength via confining action. The study demonstrates that retrofitting techniques can achieve maximum strength at a low cost. Analytical investigation of CFRP columns under different conditions further supports these findings.

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