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Strengthening and Retrofitting Reinforced Concrete Column Using Concrete Jacketing Method As External Confinement: An Overview

I'zaz Imtiyaz Shofa', Parmo*, Kusnul Prianto

Civil Engineering Engineering Department, Universitas Islam Negeri Sunan Ampel Surabaya, Surabaya
***Corresponding author**: parmo_99@uinsa.ac.id

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Abstract
Reinforced concrete (RC) jacketing is a universally recognized effective technique for strengthening and repairing structurally compromised columns. This paper integrates previous research to evaluate the effectiveness of RC jacketing in improving the axial and seismic performance of columns through external confinement. The literature review demonstrates that RC jacketing significantly improves the load-bearing capacity, ductility, and stiffness of columns. Key factors influencing performance are identified: surface preparation, use of mechanical connectors, adhesives, and the number of coated sides, with four-sided jacketing being particularly effective. The literature review also explores practical applications, such as partial jacketing at column corners and preload member jacketing, along with identifying their cost-effectiveness in economic terms compared to full renovation. Furthermore, innovative approaches such as the use of sustainable bamboo reinforcement and hybrid techniques combining jacketing with additional beams have the potential to improve efficiency and environmental sustainability. It can be demonstrated that RC jacketing has proven to be a reliable, economically and structurally viable solution for rehabilitation.
Keywords: *reinforced concrete jacketing, structural strengthening, seismic retrofitting, column confinement*

Abstrak
Pelapisan (*jacketing*) beton bertulang (RC) merupakan teknik yang secara luas diakui efektif untuk memperkuat dan memperbaiki kolom yang mengalami kerusakan struktural. Artikel ini mengintegrasikan penelitian-penelitian terdahulu untuk mengevaluasi efektivitas *jacketing* beton bertulang dalam meningkatkan kinerja aksial dan gempa kolom melalui pengekangan eksternal. Tinjauan literatur ini menunjukkan bahwa *jacketing* beton bertulang secara signifikan meningkatkan kapasitas beban, kelenturan, dan kekakuan kolom. Faktor-faktor kunci yang mempengaruhi kinerja diidentifikasi, seperti persiapan permukaan, penggunaan konektor mekanis, perekat, dan jumlah sisi yang dilapisi, dengan pelapisan empat sisi terbukti sangat efektif. Tinjauan literatur ini juga mengeksplorasi aplikasi praktis, seperti pelapisan sebagian di sudut kolom dan pelapisan elemen pra-muatan, serta mengidentifikasi efisiensi biaya mereka dalam hal ekonomi dibandingkan dengan renovasi penuh. Selain itu, pendekatan inovatif seperti penggunaan penguatan bambu berkelanjutan dan teknik hibrida yang menggabungkan pelapisan dengan balok tambahan memiliki potensi untuk meningkatkan efisiensi dan keberlanjutan lingkungan. Dari penelitian ini dapat dibuktikan bahwa pelapisan beton bertulang telah terbukti menjadi solusi yang andal, ekonomis, dan struktural untuk rehabilitasi.
Kata Kunci: *pelapisan beton bertulang, penguatan struktur, retrofit gempa, pengekangan kolom*

1. Introduction

Reinforced concrete columns play a crucial role in supporting structural buildings [1]. Yet, with increasing age, various factors such as changes in building function, earthquake damage, or weaknesses in the design or construction process can cause the strength and ductility of the columns to no longer be able to meet the load demands and current standards [2]. Column failure, especially a brittle failure, can trigger partial or total collapse of the structure. Therefore, the need for structural strengthening and retrofit is highly important to ensure the safety and functional sustainability of the building.

Among various strengthening methods, the technique of concrete jacketing has long been recognized as an effective and economical solution. Reinforced concrete is a structural rehabilitation and strengthening technique used primarily on columns. It involves encasing an existing concrete column with a new layer of reinforced concrete to enhance its strength, stiffness, and ductility. In order to increase the load-bearing

capacity of the column and improve the column's ability to deform without sudden failure, the concrete jacketing technique was developed failure [3].

This study broadly categorized the strengthening and repair techniques for Reinforced Concrete (RC) columns into six main types: reinforced concrete/mortar jacketing, steel jacketing, externally bonded fiber-reinforced polymer (FRP) jacketing, near-surface mounted FRP jacketing, shape memory alloy (SMA) jacketing, and hybrid jacketing. This comprehensive review included 99 studies focusing on the strengthening of RC columns conducted over the last two decades [4]. Occupying a middle ground in this spectrum is reinforced concrete (RC) jacketing. Engineers and the construction industry are generally well-acquainted with the on-site use of structural concrete. In rehabilitation projects, particularly those involving the modification of existing components, prefabrication is often impractical, making structural concrete the main material used for on-site fabrication and application.

Concrete jacketing is a strengthening technique that involves adding a new layer of concrete along with supplementary reinforcement to an existing structural element. The major purpose of this method is to enhance the load-bearing capacity of structural elements and improve their ductility, while increasing their resistance to seismic forces [5]. Concrete jacketing techniques have been strongly applied following major earthquakes in regions such as Mexico, the Balkans, and many Asian countries. In order to improve the nominal moment of the RC column, Parmo (2024) [6] applied concrete jacketing to the RC column of the existing Islamic Center building. To achieve optimal structural performance from these composite elements, monolithic behavior is essential. This requires a complete and effective bond (adhesion) between the original column and the new concrete jacket [7].

Although this method is not without its limitations. The application of the Reinforced Concrete (RC) Jacketing technique has several significant drawbacks that limit its application efficiency and encourage the need for alternatives such as Fiber-Reinforced Polymer (FRP) Jacketing. The main drawback is the significant increase in the cross-sectional dimensions of the structural elements, which can be a critical problem in spaces with limited floor space. In addition, the implementation process of this technique is highly invasive because it disrupts the building's occupancy, produces high levels of dust, waste materials, and noise pollution, thus increasing the health and safety risks of workers [8].

The author has reviewed various studies related to the effectiveness of the RC jacketing method. This paper focuses on providing a comprehensive review of the RC jacketing method, offering a detailed analysis of its structural behavior and construction techniques based on a comprehensive survey of experimental and numerical studies.

2. Research Methods

This research recruits a relevant literature review method through the collection, synthesis, and evaluation of data from scientific publications and research studies spanning the past two decades. The approach employed includes analysis of laboratory experimental results and numerical modeling studies to develop practical recommendations for the design and implementation of RC jacketing techniques.

3. Literature Review

The Reinforced Concrete (RC) jacketing method is applied by expanding the column cross-sectional dimensions to significantly increase structural stiffness and strength. This intervention allows for global modifications of the structure's behavior, such as changing the collapse mechanism from 'weak column-strong beam' to the more stable 'strong column-weak beam', although this impacts changes in the structure's dynamic characteristics.

General Concepts of Structural Strengthening and Retrofitting

In civil engineering, the need for strengthening and retrofitting reinforced concrete (RC) structures presents a significant challenge. Critical intrusions frequently focus on column retrofits, which are technically defined as increasing the capacity of a structure to safely support its design loads. It's important to distinguish this concept from structural repair, which simply aims to restore the element's original function and condition after damage [9].

Basic Principles of Reinforced Concrete Coating Jacketing

Reinforced concrete jacketing is a structural method that can be applied in a variety of techniques, including single-sided, double-sided, triple-sided, or quadruple-sided coating for columns. The choice depends on architectural and space constraints. Nonetheless, four-sided plating proved to be most effective in wrapping around the core column, with increased capacity in holding its load and durability. But actually,

in many actual cases, jacketing with fewer sides is often applied because it saves space and minimizes repairs.

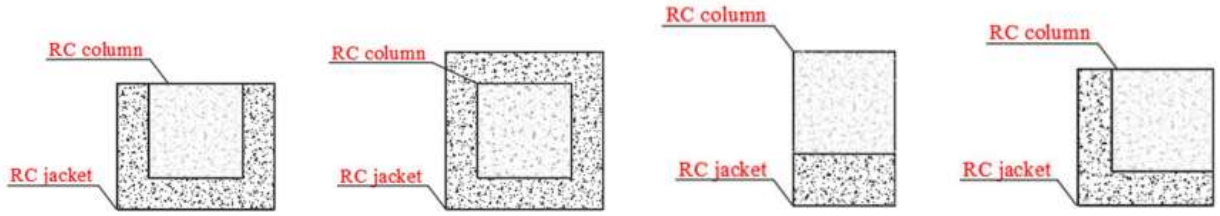

Fig. 1: Types of RC Jacketing in Column
Source: Habib et al., 2020

The RC Jacketing technique works by breaking up the old concrete column with a new layer of concrete, complete with additional longitudinal steel reinforcement. One of the most crucial aspects of this method is the installation of stirrups or ties that connect the new reinforcement to the old reinforcement to ensure both work as a unified composite structural unit. In practice, this procedure enlarges the cross-sectional dimensions and provides much stronger confinement to the original concrete core [10]. The retrofitting process starts with surface preparation of the existing column, often combined with dowel bars and bonding agents to ensure good load transfer. New longitudinal and transverse reinforcements are then installed, followed by casting a concrete jacket (typically using conventional concrete for thicker jackets due to its cost efficiency) [11].

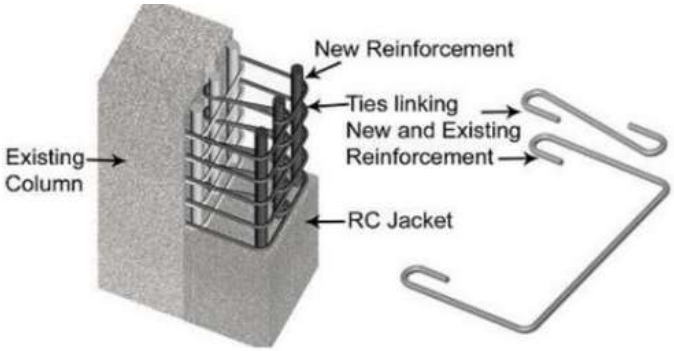

Fig. 2: RC Jacketing of Existing Column
Source: Michael N. Fardis, 2009

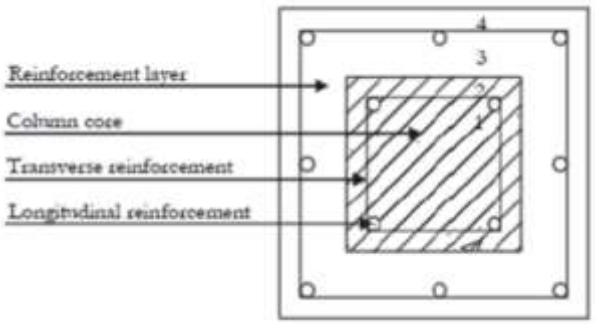

Fig. 3: RC Jacketed Column Cross-Section Jacketed Column Cross-Section
Source: Rodrigues & Araújo, 2018

Experimental Studies on Structural Elements

The study with the titled "*Effectiveness of Various Methods of Jacketing for RC Beams*" [12] experimentally evaluates the effectiveness of RC beam jacketing by focusing on surface preparation and the use of mechanical and chemical bonding. To address structural weaknesses and material aging, this research compares 4 jacketing techniques involving the use of dowel connectors, bonding agents, a

combination of both, and micro-concrete alone. The results of this study indicate that the effectiveness of this method is highly dependent on the concrete surface preparation. On smooth surfaces, optimal performance requires a combination of dowel connectors, adhesive, and micro-concrete. Yet, the best results were consistently obtained on blocks with roughened surfaces, where the use of micro-concrete alone was sufficient. Consequently, the study strongly recommends roughening the block surface before coating for improved performance.

The research "*Concrete Jacket Construction Detail Effectiveness when Strengthening RC Columns*" [13] also proved that RC jacketing increases column strength by over 3 times. Their key finding was that connection details are critical; welded stirrups and mechanical connectors (dowels, bent-down bars) are essential to prevent buckling and achieve near-monolithic behavior, governing the technique's success.

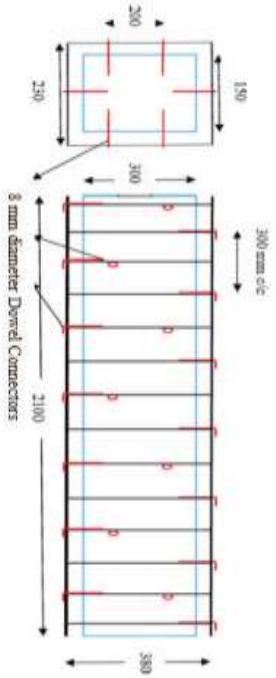

Fig. 4: Location of dowel connectors on beams
Source: Vandoros & Dritsos, 2008

The experimental investigation into RC jacketing has also been extended to explore the use of alternative, non-conventional materials. A notable study by Surya & Sunarwadi [14] demonstrated the viability of using bamboo reinforcement within the concrete jacket. Testing columns under quasi-static loading, the research found that jacketing with bamboo reinforcement significantly enhanced the structural performance of both damaged and undamaged columns. The technique successfully restored and even exceeded the original lateral load capacity, while also providing substantial improvements in ductility (40-80%) and energy dissipation. This study is significant, suggesting that the effectiveness of the RC jacketing method is rooted in the composite section's increased dimensions and confinement, which can be achieved even with sustainable reinforcement materials.

Mahmoud in his study [15] specifically investigated partial jacketing for corner and edge columns, where a full jacket is architecturally impossible. Their experimental results show that jacketing two sides can increase capacity by 106-133%, while jacketing three sides can increase it by 153-249%. Crucially, they identified that welding the stirrups of the jacket to those of the existing column is the most effective connection method.

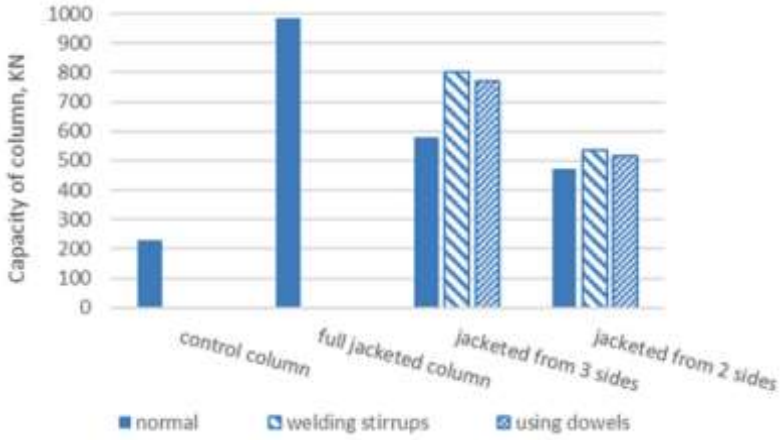

Fig. 5: Ultimate load capacity
Source: Mahmoud et al., 2022

Furthermore, the application of jacketing to columns under load, a common real-world constraint, has been validated. Ong & Kang [16] investigated the jacketing of preloaded steel columns and found that while initial stresses and deformations from preloading can reduce the ultimate strength (e.g., a 9% reduction for a 300 kN preload) and ductility, the jacketing process remains highly effective in enhancing overall structural performance. Their use of a fiber element analysis method proved more accurate than standard code (Eurocode 4) calculations, accurately modeling the effects of initial stresses.

System-Level Application and Economic Efficiency

The study titled *"Optimal design algorithm for seismic retrofitting of RC columns with steel jacketing technique"* [17] presents an optimization framework aimed at minimizing the cost of seismic retrofitting in reinforced concrete (RC) structures using the steel jacketing method. Since many existing RC buildings were not originally designed for seismic loads, steel jacketing is often employed to enhance strength and ductility, though it is costly and intrusive. The proposed approach integrates a genetic algorithm with nonlinear static (pushover) analysis in OpenSEES to identify the optimal configuration of retrofitted columns and batten spacing. Applied to a five-story RC frame in Italy, the method successfully reduced retrofitting costs by around 40% while maintaining a sufficient safety level (capacity-demand ratio ≈ 1.01). The findings demonstrate that combining optimization algorithms with structural analysis tools can effectively balance safety and cost-efficiency in seismic rehabilitation projects.

In another study, Huang et al (2015) [18] demonstrated that combining RC column jacketing with supplemental beams significantly enhances seismic performance. While traditional column jacketing alone (Plan A) increased lateral strength by 16%, adding supplemental beams (Plan B) boosted strength by 46%, achieving 194% greater retrofit efficiency. The supplemental beams work by generating additional resisting moments at beam-column joints, reducing bending moments at column bases, and enabling higher lateral load capacity. The study titled "Seismic Retrofitting of an Existing Structure & its Cost-Effectiveness" [19] proves that Reinforced Concrete (RC) jacketing is a highly efficient method for seismic retrofitting. Analysis of a G+1 building showed the technique successfully restored structural safety by reducing critical Demand-Capacity Ratios (DCR) from above 1.0 to safe levels. Furthermore, the approach proved to be highly cost-efficient, requiring only a fraction of the cost and a significantly shorter construction time (2-3 months) compared to complete demolition and reconstruction (1-2 years), establishing it as an optimal solution for enhancing seismic resilience economically.

4. Summarizes The Review

In summary, this literature review highlights several key points regarding RC jacketing as a structural strengthening method in civil engineering. Numerous studies were reviewed and summarized in the following table (**Table 1**).

Table 1. Summary of Literature Review

Authors & Year	Applied Retrofitting Technique	Main Performance Findings
(Vandoros & Dritsos, 2008)	Concrete jacketing with end-welded stirrups and dowel placement.	Strength & Ductility: Enhanced (over 3x strength increase) Initial Stiffness: Enhanced
(Raval & Dave, 2013)	RC beam jacketing with varied surface treatments (dowels, bonding agents, micro-concrete).	Critical Finding: Surface preparation is key. Roughened (chipped) surfaces with micro-concrete alone showed optimal performance.
(Anika et al., 2023)	RC jacketing of columns in a G+1 building.	Key Finding: Technique successfully reduced critical Demand-Capacity Ratios (DCR) to safe levels and was highly cost-efficient compared to reconstruction.
(Trapani et al., 2020)	Steel jacketing with an optimal design algorithm (Genetic Algorithm).	Key Finding: Optimization framework reduced retrofitting costs by around 40% while maintaining safety.
(Huang et al., 2015)	Combining RC column jacketing with supplemental beams.	Key Finding: Combination boosted lateral strength by 46% and achieved 194% greater retrofit efficiency compared to jacketing alone.
(Surya & Sunarwadi, 2021)	Concrete jacketing with bamboo reinforcement	Restores/exceeds original capacity; 40-80% ductility increase. Sustainable alternative.
(Habib et al., 2020)	Review of RC jacketing	Four-sided jacketing is most effective; partial jacketing preserves space but is less effective.
(Nechevska-Cvetanovska et al., 2019)	Seismic strengthening with RC/FRP	Both methods effective; choice depends on specific project requirements.
(Zaiter & Lau, 2020)	Literature review of RC jacketing design considerations	Emphasizes surface prep, dowel bars, and bonding agents for composite action.
(Mahmoud et al., 2022)	Partial RC Jacketing (from two or three sides of the perimeter) for corner and edge columns, investigating surface bonding (friction, dowels) and stirrup connection methods (welding)	Partially jacketed columns showed a significant and acceptable increase in capacity. Welding the jacket stirrups to the existing column's stirrups was the most effective connection method, increasing capacity by up to 249% (three sides) and 133% (two sides) compared to the control column.
(Ong & Kang, 2004)	Reinforced concrete jacketing of preloaded steel columns with shear studs and longitudinal reinforcement.	Strength & Stiffness: Jacketing significantly enhances both, and higher preload (300 kN) reduced ultimate strength by ~9% and decreas.

Source: Summarized by Authors

5. Conclusion

Based on the statements that have been researched in the previous chapter, the following conclusions can be drawn:

- Reinforced Concrete (RC) jacketing has proven to be an effective method for rehabilitating concrete columns experiencing quality degradation, damage, or insufficient load-bearing capacity and ductility.

- The effectiveness of this method heavily depends on meticulous field execution. Key factors include thorough surface preparation (such as roughening), the use of mechanical connectors (dowels and welded stirrups), and bonding agents.
- This technique can restore the Demand-Capacity Ratios to safe levels, making it a cost-effective solution for seismic retrofitting of buildings.
- The use of sustainable materials such as bamboo, or combining jacketing with additional beams, shows significant potential. These integrated strategies can even enhance strengthening efficiency by more than 190% compared to conventional jacketing alone.
- The method remains effective even when applied to columns under active loading (preloaded columns). Although there is a potential reduction in ultimate strength of about 9% due to the existing load, this can be adequately addressed through proper design planning.

6. References

[1] M. A. M. Amin, M. M. El Hawary, A. Shaheen, and I. M. Mashhour, "Structural behavior of reinforced concrete columns under eccentric loads strengthened by steel jackets filled with normal and high-strength concrete," *HBRC Journal*, vol. 21, no. 1, pp. 376–403, 2025, doi: 10.1080/16874048.2025.2506908.

[2] C. Chen, K. Zhang, and L. Ye, "Influence of Freeze–Thaw Cycles and Sustained Load on the Durability and Bearing Capacity of Reinforced Concrete Columns," *Materials*, vol. 17, no. 24, Dec. 2024, doi: 10.3390/ma17246129.

[3] E. S. Júlio, F. Branco, and V. D. Silva, "Structural rehabilitation of columns with reinforced concrete jacketing," *Progress in Structural Engineering and Materials*, vol. 5, no. 1, pp. 29–37, Jan. 2003, doi: 10.1002/pse.140.

[4] S. Raza, M. K. I. Khan, S. J. Menegon, H. H. Tsang, and J. L. Wilson, "Strengthening and repair of reinforced concrete columns by jacketing: State-of-the-art review," Jun. 01, 2019, *MDPI*. doi: 10.3390/su11113208.

[5] L. F. Tjong and A. Singh, "Retrofit Kolom Menggunakan Concrete Jacketing dan Steel Jacketing Pada Gedung Beton Bertulang Dengan Soft Story," *Journal of Sustainable Construction*, vol. 4, no. 2, pp. 15–24, Apr. 2025, doi: 10.26593/josc.v4i2.9220.

[6] P. Parmo, A. Hakim, Y. Yusrianti, and B. G. A. Wicaksono, "Strengthening of Reinforced Concrete Structure Using FRP and Concrete Jacketing Methods," *Media Komunikasi Teknik Sipil*, vol. 31, no. 1, pp. 149–159, Aug. 2025, doi: 10.14710/mkts.v31i1.72695.

[7] E. N. Brito, S. Júlio, and F. A. Branco, "Reinforced Concrete Jacketing-Interface Influence on Cyclic Loading Response ACI Structural Journal." [Online]. Available: https://www.researchgate.net/publication/268223250

[8] Bousias, Stathis N., Alexis-Loukas Spathis, and Michael N. Fardis. "Concrete or FRP jacketing of columns with lap splices for seismic rehabilitation." *Journal of Advanced Concrete Technology* 4.3 (2006): 431-444.

[9] T. P. Artiningsih, "Kajian Penggunaan Ferro-Cement Untuk Retrofit Kolom Beton Bertulang Dengan Variasi Tingkat Pembebanan," *Jurnal Teknik Sipil*, vol. 14, no. 3, pp. 170–181, Oct. 2017.

[10] G. Nechevska-Cvetanovska, A. Roshi, and J. Bojadjieva, "Seismic Strengthening Of Existing Rc Buildings Structures Using Concrete Jacketing And FRP Materials," *Elektronički časopis građevinskog fakulteta Osijek*, pp. 68–80, Dec. 2019, doi: 10.13167/2019.19.7.

[11] A. Zaiter and T. L. Lau, "Review on Strengthening Reinforced Concrete Columns Using Reinforced Concrete Jackets," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing Ltd, Dec. 2020. doi: 10.1088/1755-1315/614/1/012063.

[12] S. S. Raval and U. V. Dave, "Effectiveness of Various Methods of Jacketing for RC Beams," in *Procedia Engineering*, Elsevier Ltd, 2013, pp. 230–239. doi: 10.1016/j.proeng.2013.01.032.

[13] K. G. Vandoros and S. E. Dritsos, "Concrete Jacket Construction Detail Effectiveness when Strengthening RC Columns," *Constr Build Mater*, vol. 22, no. 3, pp. 264–276, Mar. 2008, doi: 10.1016/j.conbuildmat.2006.08.019.

[14] H. Surya and W. Sunarwadi, "Performa Struktur Kolom Pasca Perkuatan Dengan Metode Concrete Jacketing BertulangBambu," *Jurnal Teoritis dan Terapan Bidang Rekayasa Sipil*, vol. 9, no. 1, pp. 47–54, 2021, [Online]. Available: http://jurnal.unismabekasi.ac.id/index.php/bentang

[15] K. M. Mahmoud, E. A. Sallam, and H. M. H. Ibrahim, "Behavior of partially strengthened reinforced concrete columns from two or three sides of the perimeter," *Case Studies in Construction Materials*, vol. 17, Dec. 2022, doi: 10.1016/j.cscm.2022.e01180.

[16] K. C. G. Ong and J. H. Kang, "Jacketing of Preloaded Steel Columns," *J Constr Steel Res*, vol. 60, no. 1, pp. 109–124, 2004, doi: 10.1016/j.jcsr.2003.08.001.

[17] F. Di Trapani, M. Malavisi, G. C. Marano, R. Greco, and M. F. Ferrotto, "Optimal design algorithm for seismic retrofitting of RC columns with steel jacketing technique," in *Procedia Manufacturing*, Elsevier B.V., 2020, pp. 639–646. doi: 10.1016/j.promfg.2020.02.245.

[18] C.-H. Huang, M.-L. Lin, and D.-J. Cheng, "Seismic Retrofit of Reinforced Concrete Buildings using Combination of Column-Jacketing and Supplemental Beams," *International Conference on Architectural, Civil and Hydraulics Engineering (ICACHE 2015)*, Nov. 2015.

[19] Anika, F. R., et al. "Seismic Retrofitting of an Existing Structure & its Cost-Effectiveness." *4th International Conference on Planning, Architecture & Civil Engineering, RUET, Rajshahi*. 2023.