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Original Article

Comparative Study of the Interaction Diagrams before and after Retrofitting the Existing Reinforced Concrete Columns of the National Gallery of Arts Building in Tirana

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Abstract *- This study presents a comprehensive analysis of the structural integrity and performance of Reinforced Concrete (RC) columns in the National Gallery of Arts in Tirana before and after undergoing retrofitting procedures. The focus is on the interaction diagrams, crucial for understanding the axial load-bending moment relationship in RC columns. The retrofitting process must use contemporary techniques suitable for historical and culturally significant buildings. This study's chosen retrofitting approach involved applying concrete jacketing and steel rebars. This strategy aimed to bolster the columns' structural stability and seismic resilience while meticulously preserving the building's architectural essence. The comparison between the pre- and post-retrofitting diagrams provided a valuable understanding of the effectiveness of the retrofitting techniques. Significant improvements were observed in the load-bearing capacity and flexibility of the columns, bolstering their ability to resist axial forces and bending moments. The columns' axial force-bearing capacity increased by more than four times, and the capacity against bending moments increased by 5.8 to 8.6. Furthermore, the findings contribute helpful insights to the field of structural engineering, particularly in the context of retrofitting and conserving ageing structures in urban environments, offering a methodological approach for enhancing the structural integrity of RC columns in heritage buildings. This paper explores the impact of retrofitting reinforced concrete columns with reinforced substantial jackets on their interaction diagrams.*

Keywords *- Reinforce Concrete structures, Structural Retrofitting, Columns interaction diagrams, FRP, NGA.*

1. Introduction

The research involved a detailed examination of the existing condition of the building's RC columns, considering factors such as age, material degradation, and previous exposure to environmental and loading conditions. Significant civil and earthquake engineering advancements have been made since the current building typologies were designed and built. In Albania, the Technical Design Conditions (KTP-78 and KTP-N.2-89) were established in 1978 and 1989, respectively, making them 46 and 35 years old. While these design codes aligned with the standards of their respective times, they did not meet modern design requirements. Strengthening the columns would increase their load-bearing capacity and align their structural characteristics with the Eurocodes.

This study was initiated primarily because the focus has been on the behaviour of columns reinforced with Fiber Reinforced Polymer (FRP), while the examination of columns strengthened with a reinforced concrete jacket layer, especially the impact of such reinforcement on their interaction diagrams, remains underexplored in both Albanian and international literature.

Studying the interaction diagram of columns is an essential tool in structural engineering, aiding in understanding and designing strengthened slender concrete columns under different loading conditions. Recent studies have focused on improving methods for creating these diagrams, comparing different column shapes, and integrating computer-aided design for more efficient and accurate results. An interaction diagram of concrete retrofitted columns typically represents the relationship between axial load and bending moment for a column that has been strengthened or upgraded. This type of diagram is crucial in structural engineering to understand the performance of retrofitted columns under various loading conditions. It compares the capacity of a column before and after retrofitting,

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demonstrating how retrofitting materials like concrete and steel reinforcements or other advanced composites enhance the column's load-bearing capacity and flexibility [8].

The study will focus on two NGA building columns: one along its perimeter and the other in the centre. Given that previous studies mainly discuss the advantages of strengthening the reinforced concrete columns with steel jacketing, carbon fibre jackets, or glass fibres, this work focuses on retrofitting reinforced concrete columns with a reinforced concrete jacket layer. Through conducting an in-depth examination and simulation of columns K-2 and K-6 situated on the first and second floors, measuring 30x50 cm, an observation can be made about the effect of retrofitting with reinforced concrete jackets.

Constructed in the 1970s, the National Gallery of Arts (NGA) in Tirana is a testament to the architectural norms of that era that defined the period. Today's building has three levels above the ground and an underground floor. It primarily utilizes reinforced concrete for its structural integrity, enhanced by the aesthetic inclusion of non-load-bearing masonry walls. Originating in 1974, the structural concept of the National Gallery of Arts was crafted in alignment with the Albanian Technical Design Conditions (KTP), the foremost design standards of that period.

For a thorough structure analysis, compiling an extensive data set is crucial. This should encompass in-depth historical information about the structure, particularly noting any prior structural damage and subsequent repair efforts. Furthermore, precise identification and documentation of the structure's geometric details are essential. This includes the classification and characteristics of various structural elements, exact measurements of components like foundations, reinforced concrete walls, slabs, beams, and columns, and comprehensive information on their reinforcement. This should cover longitudinal and transverse reinforcement specifics to ensure a complete understanding of the structural integrity.

Fig. 1 Existing conditions of columns K-2 and K-6 in the NGA building

This study is dedicated to preserving the National Gallery of Arts building in Tirana, targeting the existing columns that do not meet Eurocode standards. The objective is to accomplish this with minimal structural interventions that maintain the building's architectural integrity while enhancing its vertical elements' resistance. This improvement is crucial to guarantee that the building can effectively withstand everyday serviceability loads and seismic forces.

This paper is structured into well-defined sections, providing a comprehensive analysis of the interaction diagrams of both the existing and retrofitted columns of the building. It begins by establishing the literature and theoretical framework, introducing the foundational concepts and the ecosystem approach that form the backbone of the study. Subsequently, the methodology section provides a detailed exposition of the research design, meticulously describing the structural analysis conducted on the columns and the analytical techniques employed throughout the investigation. The results section presents and interprets the study's outcomes in-depth, thoroughly examining their implications. The paper culminates with the Conclusion, consolidating the principal insights derived from the research, highlighting its significant contributions to the structural reinforcement of existing buildings in Albania.

2. Literature Review

The literature regarding this study on the change in interaction diagrams of columns reinforced with a concrete jacket layer is not extensive. The main focus of previous works has been the study of column interaction diagrams. Also, column behaviour strengthened with FRP and steel plates, but not with reinforced concrete jacket layer, has been part of previous studies presented below.

Bhairav K. Thakkar (2012) notes that the analysis of RCC column sections usually involves the determination of the moment capacity of the section for a given value of axial compression or vice versa. Since the section is under the effect of direct compression along with bending, the capacity of the section is a function of both actions. An interaction curve shows the relation between the section's moment carrying capacity for varying axial compression values [8]. Park and Pauley [9] give interaction curves for regular channel sections.

Bažant, Cedolin, & Tabbara (1991) presented a new method to calculate column-interaction diagrams, accounting for slenderness effects. This method substantially agrees with the CEB Model column method based on moment-curvature relations [10].

An experimental and analytical study on fifteen RC columns retrofitted with Near Surface Mounted-Carbon Fiber Reinforced Polymer (NSM-CFRP) showed a significant increase in axial capacity and enhancement in the interaction diagrams across different retrofitting configurations. The study highlighted the improvement in tension and compression control regions, significantly when columns were strengthened in transverse and longitudinal directions [16].

Research on improving the strength and ductility of rectangular RC columns through composite partial interaction, such as bolting steel plates to compression faces, confirmed that this approach could delay concrete crushing and enhance strength and ductility [17].

An analytical model proposed to estimate the ductility of potential plastic hinge regions of RC columns after an FRP retrofit offered a simplified seismic retrofit design procedure. Results presented in non-dimensional plots aid engineers in FRP retrofit design for ductility enhancement, highlighting the model's accuracy against sectional analysis and test results [18].

Kuchhadiya (2016) discussed the computerization of design for rectangular and square column sections, which includes the development of interaction diagrams [11]. Oad, Shaikh, & Laghari (1995) developed a computer program for designing RC columns using interaction diagrams from the ACI strength design handbook, aiming to overcome the limitations and inaccuracies of manual methods [12].

3. Methodology

3.1. Determine the Structural Factors

Various design factors significantly affect the performance of RC frame buildings designed according to Eurocodes. A detailed evaluation of individual factors on global structural performance is essential [2]. The structure factors are determined based on the structural system and detailing according to EC8, as shown in Table 3 in Appendix 1, taking into account the type of the structure. The importance factor adjusts the loads based on the importance of the structure.

In contrast, a higher importance factor is used for critical structures like hospitals, service buildings, and crowded buildings, reflecting the need for enhanced safety and performance under loads. The behaviour factor (q) approach (see 2.2.1(4)P), the design spectrum for linear analysis is obtained from EN 1998-1: 2004, 3.2.2.5.

A value of q = 1.5 and 2.0 for reinforced concrete and steel structures may be adopted regardless of the structural type. Higher values of 'q' may be adopted if suitably justified concerning the local and global available ductility, evaluated by the relevant provisions of EN 1998-1: 2004. Referring to Eurocodes, for the behaviour factor q, the value of q =2.0 [1].

Eurocode 8's ductility classes have implications for the design of RC frame structures. The study provides a complete analysis of the impact of the ductility class on design, showing that the Ductility Class Medium (DCM) has high performance close to the Ductility Class High (DCH) even in high-hazard seismic zones [3].

3.2. Load Combination

Loads and their combinations are meticulously applied following the standards set by the Eurocodes.

Dead (Permanent) loads include the self-weight of all supporting elements of the masonry and reinforced concrete structure (foundations, beams, columns, walls, self-weight of slabs, floor layers, self-supporting partition walls with bricks, and parapets of balconies, stairs, etc.).

Live loads are not constant and are associated with the structure's intended use. Live loads include the weight of people, furniture, vehicles, equipment, and other movable objects that may be present on or within a structure and are considered in Table 5 in Appendix 1:

The design load will be applied in the finite element model. The KTP-N.2-89 regulations represented a more rigorous approach than their predecessors. However, Albania is transitioning to the Eurocodes, which provide even more comprehensive and stringent criteria for building design, aligning with the latest developments in engineering.

The building belongs to category C-3, according to Eurocode (EN 1991-1-1:2002) [2], with a design load of 300-500 kN/m^2. According to the Albanian Technical Design Code, it is not less than 500 kg/m^2. The values considered for the calculated loads are more or less the same as for the Eurocodes above for KTP. However, the difference lies in the load safety factor, where the coefficients according to the Eurocode are higher.

The Eurocodes include three combination rules. One of these (8.12), i.e., 1.35G + 1.5Q, utilizes the DLC, and the other two (8.13a, b), max (1.15G + 1.5Q, 1.35G + 1.05Q) and (8.14a, b), max (1.35G, 1.15G + 1.5Q) correspond to the ILC [13].

Also, according to the Albanian Technical Design Code, the design loads are calculated using different safety factors, which are smaller than those in the Eurocode, where for live load $\gamma_Q = 1.3$ and dead load $\gamma_Q = 1.2$, presented in Table 4 in the Appendix 1.

Table 1. Difference between eurocode and KTP load safety factors

Load	Euorcode	KTP-N.2-89
Live Loads	1.5	1.3
Dead Loads	1.35	1.2

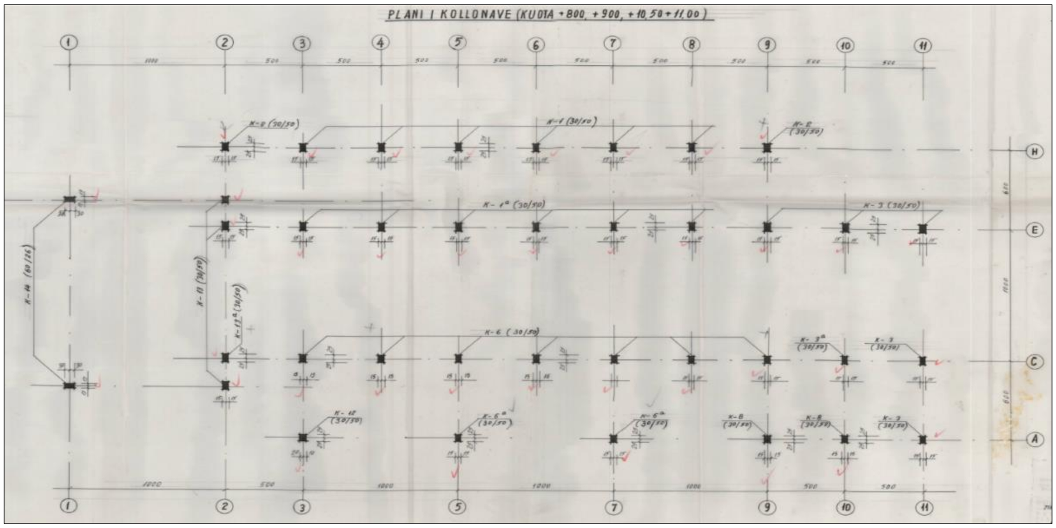

Fig. 2 The layout of the building columns and the position of the studied columns K-2 and K-6 [6]

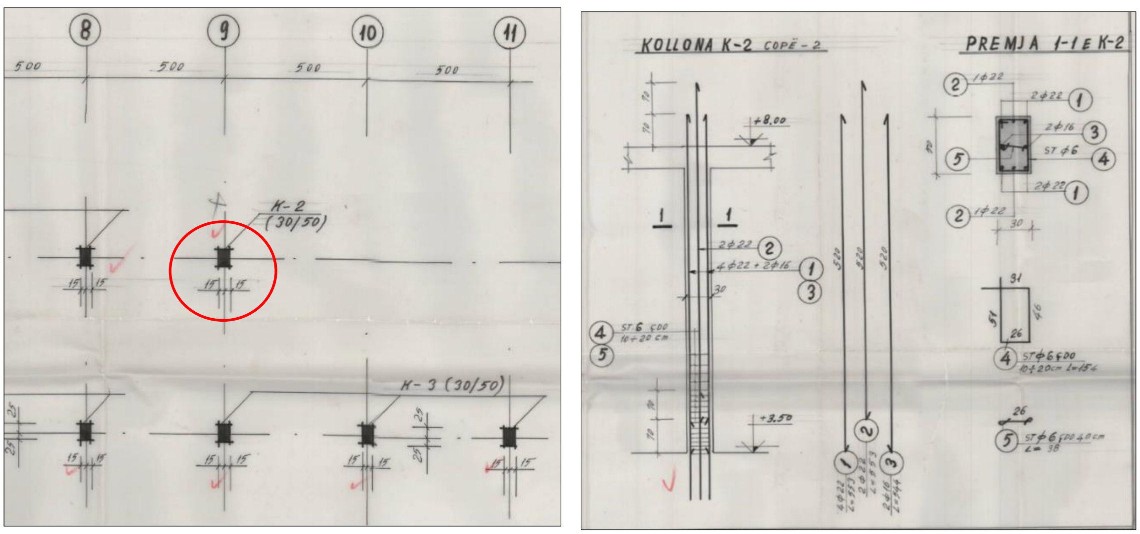

Fig. 3 Section, longitudinal and transverse reinforcement of column K-2 [6]

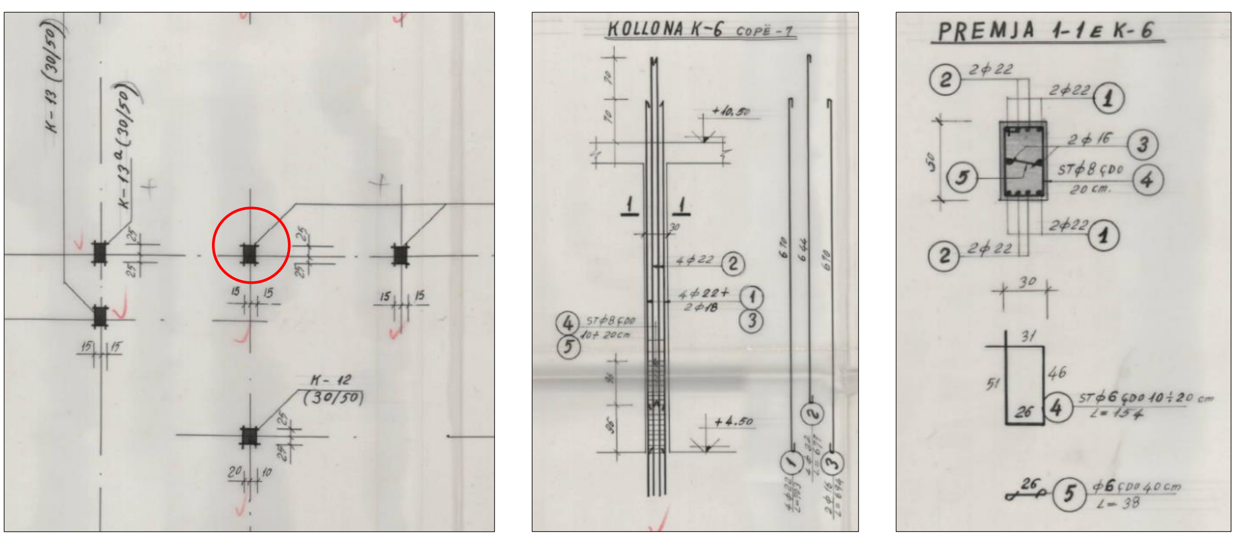

Fig. 4 Section, longitudinal and transverse reinforcement of column K-6 [6]

When designing in compliance with Eurocode standards, also it is essential to incorporate the partial factor of materials γc and γs, for concrete and reinforcing steel, as shown in Table 2.1N of the Eurocode (EN 1991-1-1:2002) [2]. The rated loads (dead, live) and load combinations considered for the above columns analysis are shown in Appendix 1(Tables 5, 6, 7, and 8).

3.3. Assessment of the Condition of the Existing Columns

The general methodology for assessing the structural capacity of existing columns is a detailed process that involves the following steps [4]:

3.3.1. Collection of Existing Data on the Structure

This phase involves gathering information about the building's history, construction, design methods used during its construction, typology, classification, and a preliminary assessment of the structure (Figure 2).

3.3.2 Identification of Characteristic Geometric Data

This includes detailed data of columns K-2 and K-6, covering their type and typology, dimensions and characteristics, and reinforcement details. These data are gained from the old designs of the 1970s and are shown in Figure 3 and Figure 4. As shown in the figure, the existing section of column K-2 is 30x50 cm, and the longitudinal reinforcement consists of 4 bars of Ø22 and 2 bars of Ø16. Meanwhile, the transverse reinforcement is made of Ø6 bars/10÷20 cm. The section of column K-6 is the same as column K-2, 30x50 cm, but the reinforcement characteristics of column K-6 are not the same as column K-1. As can be seen from the pictures, the longitudinal reinforcement of columns K-6 consists of 8 bars of Ø22, 2 bars of Ø16. And the Ø6 bars/10÷20 cm as transverse reinforcement.

3.3.3. Identification of Material Characteristics

This step involves analyzing the materials through the existing design and detailed studies to determine their strength and level of degradation. The concrete characteristics of the existing columns are R_{ck} = 17 Mpa, and the rebar's characteristics are $S_{T\text{-}5}$, with $f_{yk} = 2500$ kg/cm^2 [6].

3.3.4. Reassessment of Applied Loads

This stage involves revisiting the loads on the building, especially if some parts are used for different purposes than originally intended, taking into account the building's importance class.

3.3.5 Collection of Data on Structural Damages (If any)

This includes identifying current or past damages to the structure, as well as any repairs that have been made. The building's history and current condition are also considered. From the checks carried out, the columns on all floors had no damages or various vertical, transverse, or diagonal cracks. Additionally, the protective concrete layer remains undamaged by atmospheric agents, as it was covered with mortar, as illustrated in Figure 1.

3.4. Structural Modeling

A detailed 3D model of the structure of NGA with finite element software ETABS 19 will be used to perform static and dynamic analysis of the structure and obtain results concerning the comparative study of the interaction diagrams before and after retrofitting of the columns. The material characteristics, the dimensions, and the existing reinforcement of the two columns have been set according to the current designs, which have been obtained from the Designs of the "Construction of The National Gallery of Arts in Tirana", Author: "Urban Planning and Design Bureau (1974) [6]". The figure below shows the structure layout, including modelling existing columns, slabs, and beams.

Fig. 5 Existing column and structure layout of NGA building modelled in FEM software

3.4.1. Modeling the Existing Columns K-1 and K-6

The loads are applied according to the tables shown in Appendix 1. Also, the concrete characteristics of the existing columns K-2 and K-6 are R_{ck} = 17 Mpa, the rebar's characteristics are ST-5, with $f_{yk} = 3500$ kg/cm^{2,} and the reinforcement is as mentioned on pages 6 and 7 in this paper [6].

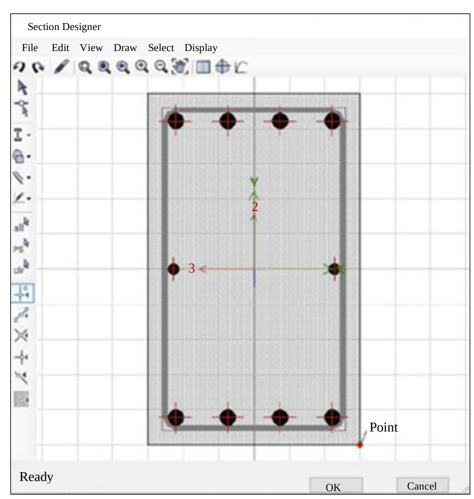

Fig. 6 Modeling the existing section and rebars in FEM software of column K-6

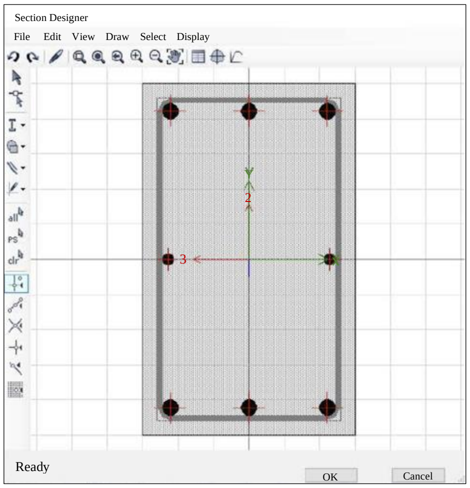

Fig. 7 Modeling the existing section and rebars in FEM software of column K-2

3.4.2 Modeling the Retrofitted Columns of the NGA Building

Based on preliminary calculations, concrete's characteristic cylindrical and cubic resistance has been chosen as f_{ck} = 35 Mpa and R_{ck} = 45 Mpa (C35/45). In contrast, the characteristic yield strength of steel has been selected as f_{yk} = 550 Mpa, and the calculated resistance of steel is $f_{yd} = f_{yk} / \gamma_s$ = 215 Mpa [5]. The figure below shows the structure layout, including the modelling of retrofitted columns.

Fig. 8 The plan for the reinforced columns and new five R/C concrete walls

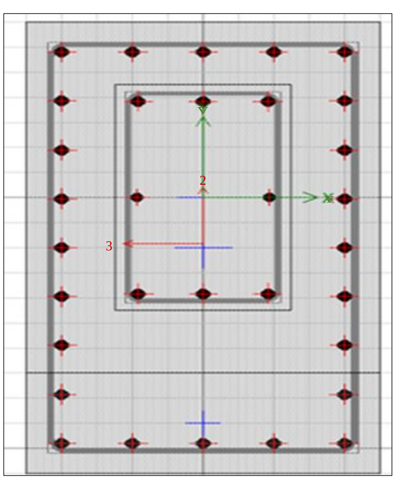

Fig. 9 Modeling of the reinforced concrete jacketing layer and rebars of the columns K-2

The column K-2 longitudinal reinforcement is designed with Φ22 rebars at a maximum distance of 100cm from each, while the columns transverse reinforcement (stirrups) is designed with Φ 10/10cm and Φ 12/ 10 cm. The reinforcing steel used is of Class S500 grade, characterized by high strength and durability. For this column, the offset of the concrete layer will be t=10 cm from three sides, whereas from one side, it will be expanded by t=40 cm.

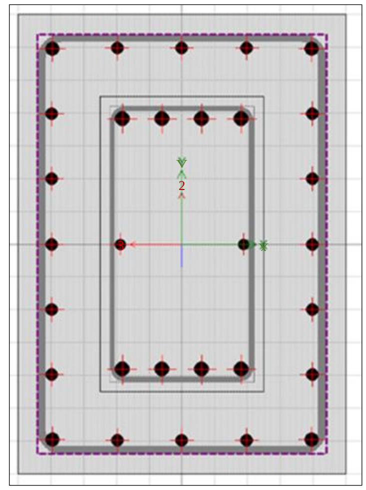

Fig. 10 Modeling of the reinforced concrete jacketing layer and rebars of the columns K-6

The column longitudinal reinforcement is designed with Φ20 rebars at a maximum distance of 100cm from each, while the column's transverse reinforcement (stirrups) is designed with Φ 10/10cm and Φ 12/ 10 cm. The reinforcing steel used is of Class S500 grade, characterized by high strength and durability.

The new reinforced concrete walls are designed with C35/45 concrete like the columns, and the longitudinal reinforcement is designed with Φ16 rebars, while the transverse reinforcement (stirrups) is designed with Φ12/10 cm [5]. The offset of the additional concrete jacket will be 10 cm.

4. Results

After completing the structural analysis with finite element software, the study derived the following results as part of a comparative study of the interaction diagrams before and after retrofitting the existing reinforced concrete columns of the National Gallery of Arts Building in Tirana.

4.1. Columns K-2 Comparative Analysis of the Interaction Diagrams before and after Retrofitting

The following section presents the results obtained for column K-2 of the National Gallery of Arts using finite element software. It includes detailed data on the interaction diagram of the existing and the retrofitted columns, comprehensively documented in the charts below.

Table 2. K-2 column characteristics before and after retrofitting

Column K-2, Existing State			
Concrete			
b (mm)	h (mm)	sip (mm^2)	0.002Ac
300	500	150000	300
Rebars			
ø (mm)	Section (mm^2)	Quantity (Pcs)	As (mm^2)
22	383	6	2298
16	201	2	402
Total			2700
% of Reinforcement		0.018	>0.002Ac
Column K-2, Retrofitted			
Concrete			
b (mm)	h (mm)	sip (mm^2)	0.002Ac
500	1000	500000	1000
Rebars			
ø (mm)	Section (mm^2)	Quantity (Pcs)	As (mm^2)
22	383	6	2298
16	201	2	402
20	314	24	7540
Total			10 240
% of Reinforcement		0.0205	>0.002Ac

After conducting several simulations with a finite element program, it was concluded that the optimal reinforced section and rebar for column K-2, which significantly enhances the column's load-bearing capacity against axial forces and bending moments, is shown in the Table 2.

As observed from the Table 2, the section size of the retrofitted column increased from 150,000 mm² to 500,000 mm², more than tripling in size, without affecting the functionality and architecture of the existing building. Additionally, the number of rebars used increased from 8 to 32, while the reinforcement area grew approximately four times.

The results regarding the interaction diagram of the existing column K-2 are presented in Figure 13. As observed from the Table 2 and the graph generated by the finite element program, the maximum axial load that the column can withstand is 2252.81 Kn. At the same time, the maximum bending moment that the un-retrofitted column K-2 can resist is 207.08 kN•m.

Meanwhile, Figure 14 presents the interaction diagram of retrofitted column K-2, where the maximum axial load the column can withstand is 10911.05 Kn. At the same time, the maximum bending moment that the un-retrofitted column K-2 can resist is 1788.48 kN•m.

The Figure 15 illustrates a schematic comparison between the interaction curves of the un-retrofitted and the retrofitted K-2 column. The graph shows that the axial force-bearing capacity of the retrofitted column, with an additional reinforced concrete layer, increases by more than four times. Meanwhile, the load-bearing capacity against bending moments increases by 8.6 times.

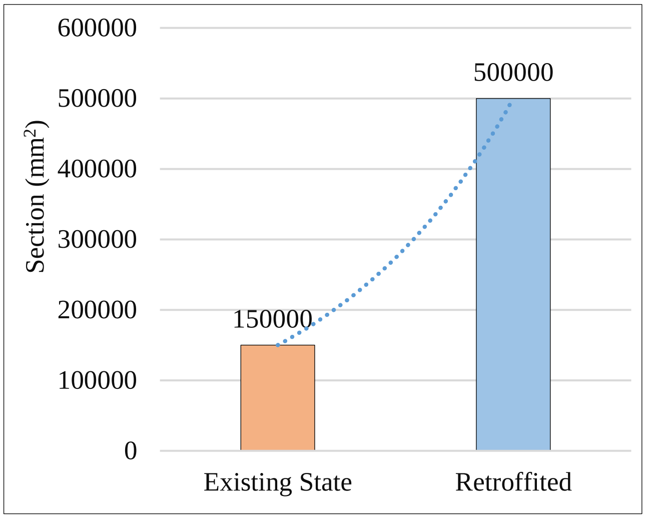

Fig. 11 Comparison between existing and retrofitted K-2 column section

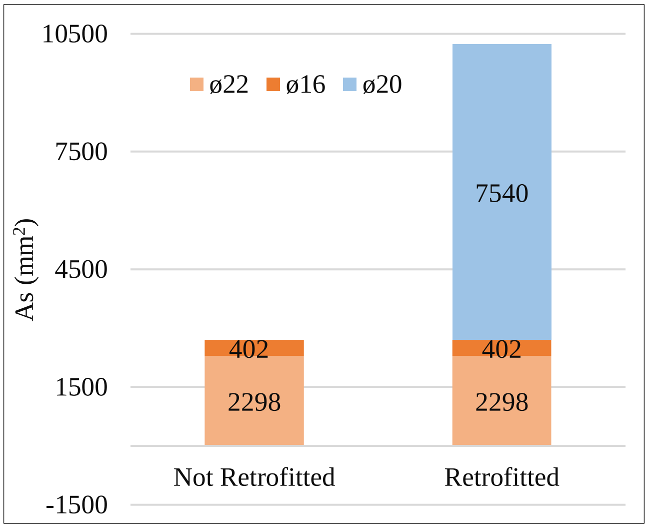

Fig. 12 Comparison between existing and retrofitted K-2 column reinforcement

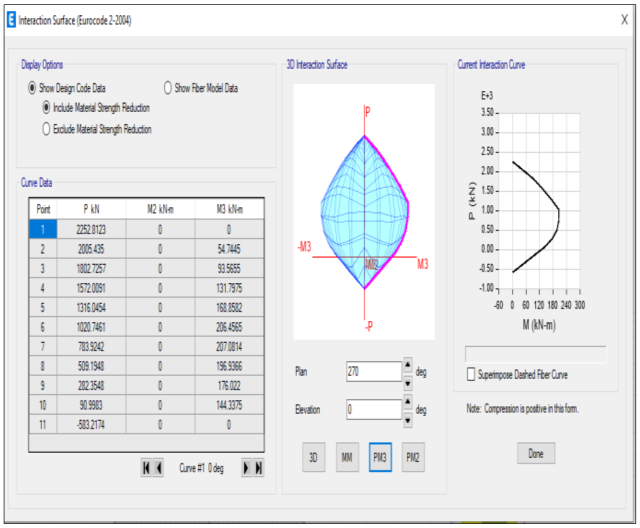

Fig. 13 Existing column K-2 interaction diagram calculated with FEM software

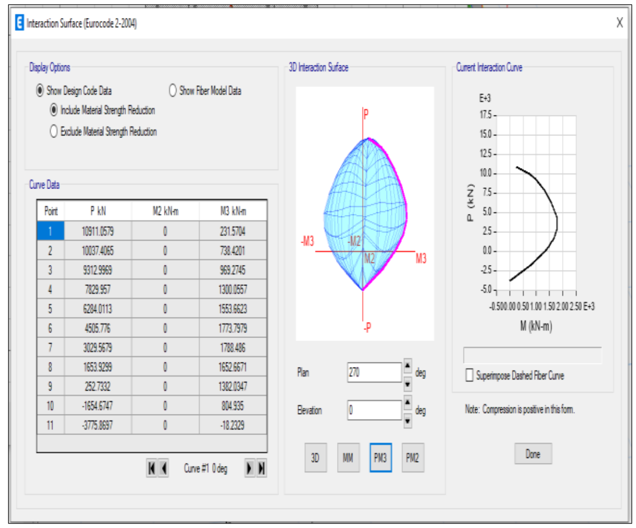

Fig. 14 Retrofitted column K-2 interaction diagram calculated with FEM software

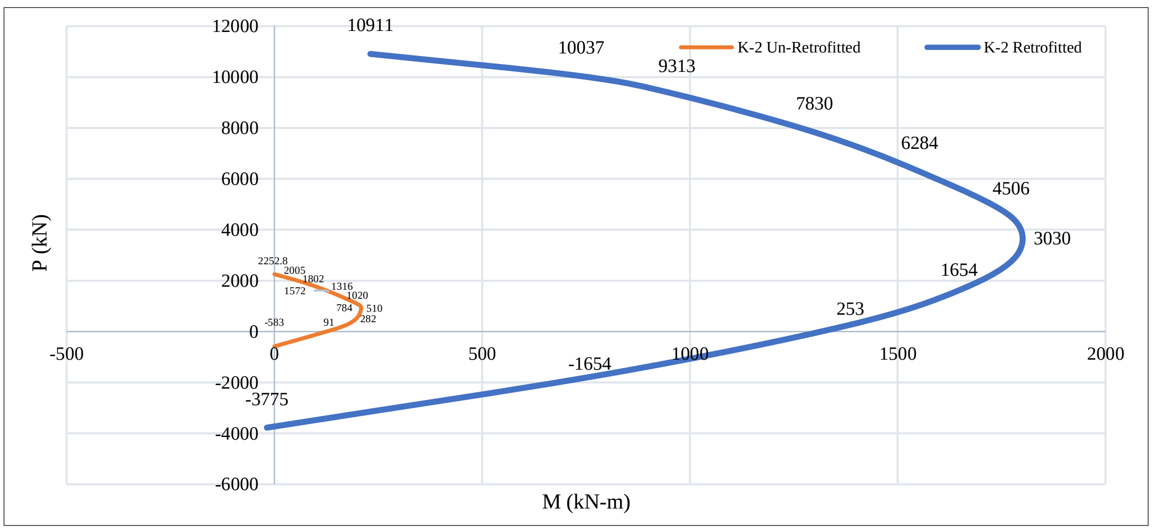

Fig. 15 Comparison between interaction diagrams of the K-2 column before and after retrofitting

4.2. Columns K-6 Comparative Analysis of the Interaction Diagrams before and after Retrofitting

The following section presents the results obtained for column K-6 of the National Gallery of Arts using finite element software. It includes detailed data on the interaction diagram of the existing and the retrofitted columns, which are comprehensively shown in the Table 3.

The Table 3 illustrates that the retrofitted column's section size expanded significantly from 150,000 mm² to 350,000 mm², increasing thrice while maintaining the building's functionality and architectural integrity.

Furthermore, the number of rebars used in the column rose from 10 to 28, resulting in an approximately 2.6-fold increase in the reinforcement area. This section size and reinforcement enhancement implies considerably improving the column's structural strength.

The dotted line connecting the two bars suggests a comparison or a transition from the not retrofitted to the retrofitted state, indicating a substantial increase in section size after retrofitting. After retrofitting, the significant increase in the cross-sectional area suggests a significant strengthening of the columns (Figure 16).

In the "Retrofitted" state, the total reinforcement is substantially increased to a single value of 5655 mm², shown by a single blue bar. This suggests that after retrofitting, the column's reinforcement area is almost twice the size of the original state (Figure 17).

Table 3. Column K-6 characteristic before and after retrofitting

Column K-6, Not Retrofitted			
Concrete			
b (mm)	h (mm)	sip (mm^2)	0.002Ac
300	500	15 000	300
Rebars			
ø (mm)	Section (mm^2)	Quantity (Pcs)	As (mm^2)
22	383	8	3 064
16	201	2	402
Total			3466
% of Reinforcement		0.018	>0.002Ac
Columns K-6, Retrofitted			
Betoni			
b (mm)	h (mm)	sip (mm^2)	0.002Ac
500	700	350 000	700
Concrete			
ø (mm)	Section (mm^2)	Quantity (Pcs)	As (mm^2)
22	383	8	3 064
16	201	2	402
20	314	18	5 655
Total			9 121
% of Reinforcement		0.0217	>0.002Ac

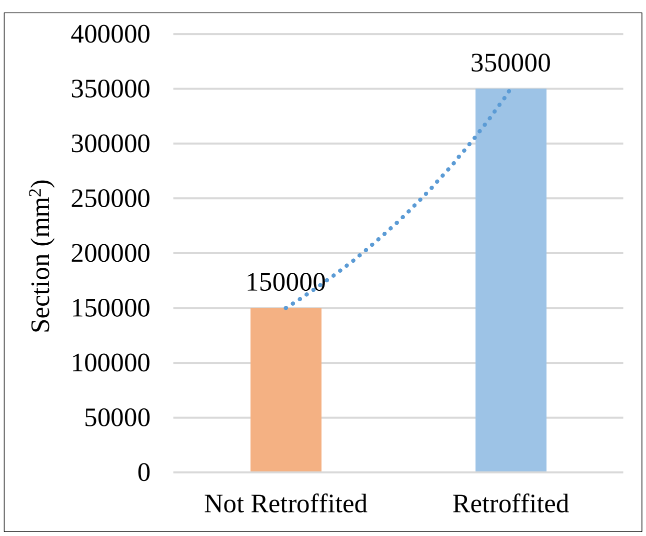

Fig. 16 Comparison between existing and retrofitted column K-6 section

Fig. 17 Comparison between existing and retrofitted column K-6 reinforcement

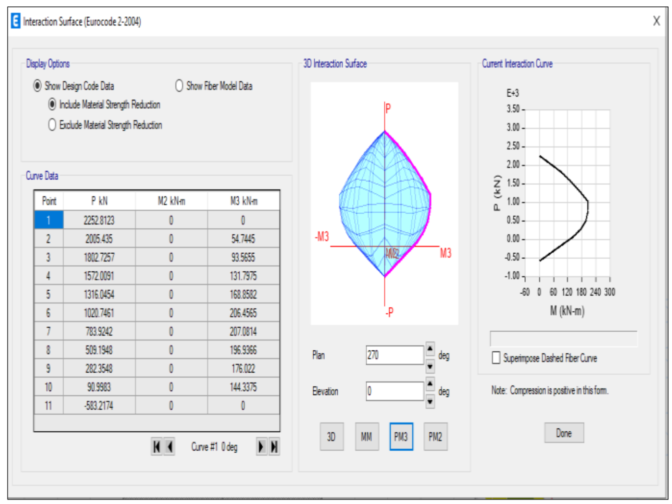

Fig. 18 Existing column K-6 interaction diagram calculated with FEM software

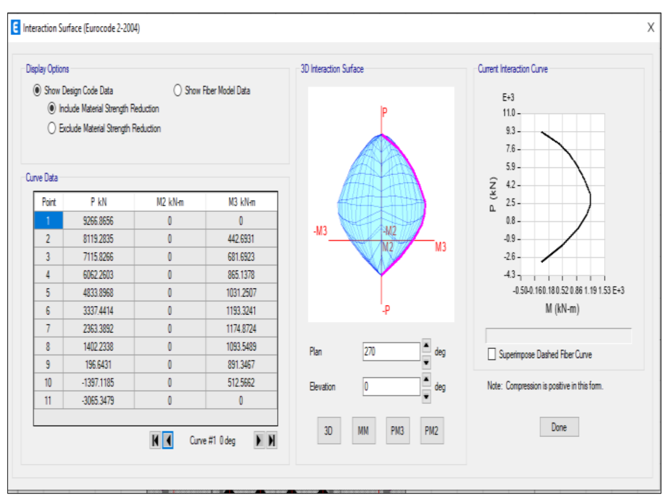

Fig. 19 Retrofitted column K-6 interaction diagram calculated with FEM software

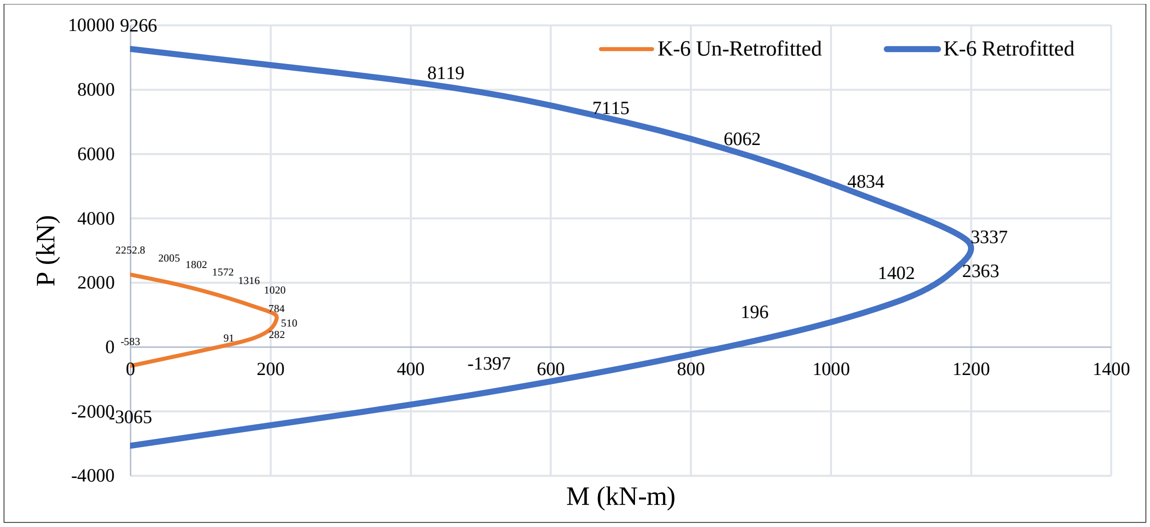

Fig. 20 Comparison between interaction diagrams of columns K-6, before and after retrofitting

The figure illustrates a schematic comparison between the interaction curves of the un-retrofitted and the retrofitted K-6 column. The graph shows that the axial force-bearing capacity of the retrofitted column, with an additional reinforced concrete layer, increases by more than four times. Meanwhile, the load-bearing capacity against bending moments increases by 5.8 times.

Experimental investigations showed that steel jacketed short RC columns with specific longitudinal and strengthening steel percentages exhibit a considerable increase in ultimate capacity under concentric loading - 240% higher than an un-strengthened RC column. With rising eccentricity, this increase varies from 330% to 850%. The early activation of confinement, which increases by 39% as eccentricity rises, contributes to this enhancement. The finite element model developed could accurately predict the load-moment failure surface. The experimental to numerical ultimate load capacity ratio averaged 0.94 [14].

About [15] studied the behaviour of beam-columns wrapped with GFRP and CFRP. One specimen without FRP wrapping, three specimens with 2, 4, and 6 layers of GFRP, and two specimens with one layer of CFRP were tested. The column specimens wrapped with two layers, four layers, and six layers of GFRP show an 8%, 28%, and 32% increase in load-carrying capacity compared to the specimen without wrapping. The specimens covered with CFRP have an average of 98.3% increase in strength capacity compared to those without CFRP wrapping.

Comparing the results of this paper with previous papers on column retrofitting with steel jackets, carbon, and glass fibre reinforced polymer, it's evident that retrofitting columns with a reinforced concrete jacket is much more effective in increasing the load-bearing capacity of reinforced concrete columns.

5. Conclusion

The study concluded that retrofitting existing reinforced concrete columns in the National Gallery of Arts Building in Tirana with reinforced substantial jackets significantly improved their structural integrity. The retrofitting substantially increased the columns' load-bearing capacity against axial forces and bending moments, enhancing their stability and seismic resistance.

The results underscored the effectiveness of the reinforced concrete jacket retrofitting techniques, demonstrating their potential for preserving and strengthening ageing structures in urban environments. This enhancement is visually represented and quantified through changes in the interaction diagrams of the columns. The axial force bearing capacity increased by more than four times, and the capacity against bending moments increased by 5.8 to 8.6 times for different columns.

Specifically, for column K-2, the retrofitting process increased the column's cross-sectional area, with the number of rebars used also increasing, resulting in a considerable enhancement in axial load-bearing capacity and resistance to bending moments.

Similar improvements were observed for column K-6, with substantial increases in section size and reinforcement area, leading to a marked improvement in load-bearing capacities. The improvement in the interaction diagram reflects an overall increase in the structural integrity and safety of the building, demonstrating the efficacy of such retrofitting in strengthening ageing or vulnerable structures.

It becomes clear that applying a reinforced concrete jacket significantly surpasses other methods in enhancing the load-bearing capacity of reinforced concrete columns. This approach not only reinforces the structural strength but also demonstrates superior effectiveness in bolstering the overall stability of the columns. Also, the retrofitted columns with reinforced concrete jackets can absorb and dissipate more energy during seismic events.

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Appendix

Table 4. Design load and safety factors according to Albanian Design Codes

No.	The name of the building and the department	Rated load in kg/m²	Coefficients
1	Residential apartments, hospitals (with the exception of halls and entrances where people can gather).	150	1, 4
2	Collective rooms, hotels, administrative and educational offices, service facilities of industrial enterprises, classrooms, reading room (1).	200	1, 4
3	Corridors, entrances and stairs contained in the points above, with the exception of educational institutions.	300	1, 3
4	Auditor, mensash room, kafene, restaurant	300	1, 3
5	Halls of educational, administrative and scientific institutions, stations, theaters, cinemas, clubs, concert and sports halls, tribunes with fixed seats.	400	1, 3
6	Hall of MaPo, museums, exhibitions	According to the cases, but not less than 500 kg/m^2	1, 3
7	Warehouse for storing books, archives.	According to the actual load, but not less than 500 kg/m²	1, 2
8	Vestibules, corridors and stairs of cafeterias, cafes, restaurants, educational institutions, stations, theaters, cinemas, clubs, sports and concert halls, warehouses, museums, exhibition halls and pavilions, libraries and archives.	400	1, 3

Table 5. Structure factors [5]

Importance factor:	kr (ɤ) = 1.2	Accidental alienation:	5%
Structure recognition factor:	CF = 1.2	Critical Damping Factor:	ζ=5%
Behaviour factor:	2	Spectral Amplification Factor:	η=1
Type of structure:	DCM	Foundation's factor:	β=2.5

Table 6. Dead Loads (Permanent loads) [5]

Concrete, specific gravity:	25.00	kN/m^3	Slab coating:	1.50	kN/m²
Steel specific weight:	78.00	kN/m^3	Room tiling:	1.50	kN/m²
Header wall weight:	3.60	kN/m²	Staircase tiling:	1.30	kN/m²
Stretcher wall weight:	2.10	kN/m²	Soil specific gravity:	18.00	kN/m^3

Table 7. Live Loads [5]

Museum floors:	5.00	kN/m²	Offices floors:	2.00	kN/m²
Balconies floors:	5.00	kN/m²	Staircase floors for residences:	3.50	kN/m²
Stores floors:	5.00	kN/m²	Staircase floors for offices:	3.50	kN/m²

Table 8. Load combinations [5]

A	1.35G + 1.50(Q+Qshkalleve)
1B	1.00G + 0.60(Q+Qshkalleve) + 1.00Ex + 0.30Ey
1D	1.00G + 0.60(Q+Qshkalleve) + 0.30Ex + 1.00Ey
1F	1.00G + 0.60Q - 1.00Ex+eccy - 0.30Ey+eccx
1H	1.00G + 0.60Q - 0.30Ex+eccy - 1.00Ey+eccx
2B	1.00G + 0.60Q + 1.00Ex-eccy + 0.30Ey+eccx
2D	1.00G + 0.60Q + 0.30Ex-eccy + 1.00Ey+eccx
2F	1.00G + 0.60Q - 1.00Ex-eccy - 0.30Ey+eccx
2H	1.00G + 0.60Q - 0.30Ex-eccy - 1.00Ey+eccx
3B	1.00G + 0.60Q + 1.00Ex+eccy + 0.30Ey-eccx
3D	1.00G + 0.60Q + 0.30Ex+eccy + 1.00Ey-eccx
3F	1.00G + 0.60Q - 1.00Ex+eccy - 0.30Ey-eccx
3H	1.00G + 0.60Q - 0.30Ex+eccy - 1.00Ey-eccx
4B	1.00G + 0.60Q + 1.00Ex-eccy + 0.30Ey-eccx
4D	1.00G + 0.60Q + 0.30Ex-eccy + 1.00Ey-eccx
4F	1.00G + 0.60Q - 1.00Ex-eccy - 0.30Ey-eccx