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Seismic Retrofitting of Historical Buildings: A Review

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Abstract- ***This review paper examines the multifaceted challenges and opportunities inherent in the seismic retrofitting of historical buildings. Drawing upon secondary data collected from Scopus and other databases, the review explores the delicate balance between preserving structural integrity and maintaining cultural heritage. It emphasizes the importance of interdisciplinary collaboration among engineers, architects, preservationists, and cultural heritage experts. The review analyzes various retrofitting strategies, methods, and conservation-compatible solutions, highlighting their efficacy in enhancing the resilience of historical structures while respecting their unique architectural character and historical significance. The findings underscore the critical need for a holistic approach that integrates structural reinforcement with heritage preservation, ensuring the sustainable development and continued appreciation of these invaluable cultural assets for future generations.***

Keywords: Seismic Retrofitting, Historical Buildings, Interdisciplinary Collaboration, Conservation-Compatible Solutions

I. INTRODUCTION

Historical buildings often hold immense cultural and architectural significance, yet they are particularly vulnerable to seismic events due to their age and the substandard construction techniques employed at the time of their original construction (Cui et al., 2010) (Buachart et al., 2022). Seismic retrofitting of these precious structures is a crucial endeavor to preserve their structural integrity and protect the lives of those who occupy them. This review paper examines the current practices, challenges, and key considerations involved in the seismic retrofitting of historical buildings, drawing insights from recent research and case studies. The evaluation of seismic vulnerability is a critical first step in the process of seismic retrofitting for historical buildings, as it allows engineers to accurately assess the buildings' performance and develop targeted mitigation strategies tailored to their unique characteristics and needs. (Aung & Aye, 2021)

Identifying the seismic vulnerability of historical buildings is a crucial first step in the retrofitting process, as it allows engineers to prioritize interventions and develop targeted mitigation strategies tailored to the unique characteristics and needs of these structures. (Miano et al., 2020). The performance-based seismic evaluation method provides a robust framework for assessing the seismic performance of historical buildings, taking into account factors such as their architectural and cultural significance, as well as the desired target period of usage. (Cui et al., 2010) This holistic approach considers the intricate interactions between structural elements like beam-column connections and the contribution of surrounding masonry walls, which can significantly influence the overall seismic behaviour and resilience of the building (Manfredi et al., 2021). By thoroughly evaluating the seismic vulnerability through this performance-based evaluation, engineers can gain a deeper understanding of the building's weaknesses and devise customized retrofitting solutions to enhance its structural integrity and safeguard its long-term preservation for the benefit of present and future generations. (Cui et al., 2010)

II. SEISMIC RETROFITTING STRATEGIES FOR HISTORICAL BUILDINGS

Once the seismic vulnerability of a historical building has been assessed, the next critical step is the selection and implementation of appropriate retrofitting strategies. These strategies must not only address the identified structural deficiencies but also respect the building's historical and cultural significance, preserving its architectural integrity to the greatest extent possible. One common approach is the application of external reinforcement systems, such as the installation of steel bracing or the addition of

reinforced concrete or fibre-reinforced polymer elements, which can significantly improve the building's overall seismic resistance without significantly altering its visual appearance (Negro & Mola, 2015).

Another effective retrofitting strategy involves the targeted strengthening of specific structural components, such as masonry walls, foundations, or beam-column connections, which are often the weakest links in historical buildings. By reinforcing these critical elements, engineers can enhance the building's overall seismic performance without compromising its historical character.

III. CHALLENGES OF BALANCING SEISMIC RETROFITTING AND ARCHITECTURAL CONSERVATION

Preserving the architectural and cultural heritage of historical buildings poses significant challenges when implementing seismic retrofitting measures. (Corradi et al., 2021) These challenges arise from the need to balance the structural requirements for enhanced seismic resilience with the imperative to maintain the buildings' unique historical character and significance. Historical buildings often possess intricate and irreplaceable design features, materials, and craftsmanship that must be meticulously preserved during the retrofitting process. (Buachart et al., 2022)

The preservation of historical buildings' architectural and cultural heritage is a complex and multifaceted challenge that requires a nuanced approach, combining technical expertise with a deep understanding of the buildings' historical context and significance. Seismic retrofitting of these precious structures is a crucial endeavour to preserve their structural integrity and protect the lives of those who occupy them, yet the interventions required can often conflict with the overarching goal of preserving the buildings' architectural and cultural heritage. (Longo et al., 2021)

One of the primary challenges in seismic retrofitting of historical buildings is the need to balance structural reinforcement with the preservation of the building's historical integrity. Ill-conceived retrofitting measures can irrevocably damage a building's historic fabric and aesthetic, compromising its cultural value and significance. (Buda et al., 2021) To address this challenge, a collaborative approach involving structural engineers, architects, and conservation experts is crucial. The seismic retrofitting design should be carefully integrated with the building's architectural features, ensuring that any visible interventions are sympathetic to the original design and enhance, rather than detract from, the building's historical character. (Vailati et al., 2021)

The use of traditional materials and construction techniques, such as the incorporation of lime mortar or traditional masonry techniques, can help preserve the building's historical authenticity while improving its seismic resilience. By leveraging these time-honoured methods, the retrofitting process can be more seamlessly integrated with the existing fabric of the building, minimizing the visual impact and maintaining the structure's historical integrity. (Martins et al., 2021)

Another significant challenge in the seismic retrofitting of historical buildings is the complexity of the structural system, which often includes a combination of masonry, timber, and other traditional materials. These heterogeneous and often poorly documented structural elements require a comprehensive assessment and in-depth understanding to develop appropriate retrofitting strategies. The evaluation of seismic vulnerability is a critical first step in the process of seismic retrofitting for historical buildings, as it allows engineers to accurately assess the buildings' performance and develop targeted (Ferreira et al., 2019)

IV. IONS IN SEISMIC RETROFITTING OF HISTORICAL BUILDINGS

The seismic retrofitting of historical buildings presents a unique set of challenges that require careful consideration and a multidisciplinary approach. One of the primary challenges is the need to balance the preservation of the building's architectural and cultural heritage with the implementation of necessary structural upgrades. (Ferreira et al., 2019) Historical buildings often possess intricate and irreplaceable design features, materials, and craftsmanship that must be meticulously preserved during the retrofitting process. Innovative techniques and materials that are compatible with the original construction methods are

crucial to maintaining the building's historical integrity while enhancing its seismic resilience.

Another significant challenge in seismic retrofitting of historical buildings is the complexity of the structural system, which often includes a combination of masonry, timber, and other traditional materials.(Buachart et al., 2022). These heterogeneous and often poorly documented structural elements require a comprehensive assessment and in-depth understanding to develop appropriate retrofitting strategies. (Besen et al., 2020)

Furthermore, the location of historical buildings, which are frequently situated in urban areas or on sites with limited access, can pose logistical and technical challenges during the construction phase of the retrofitting project. (Bansal, 2018)

To address these challenges, a multidisciplinary approach involving collaboration between architects, structural engineers, conservation experts, and local authorities is essential.(Buda et al., 2021)

The selection of appropriate retrofitting strategies for historical buildings must also consider the impact on the building's architectural and cultural significance. Minimally invasive approaches, such as the localized reinforcement of masonry walls, have been shown to significantly increase the building's tolerance to foundation movement without compromising its historical integrity.(Coccia et al., 2020) By carefully balancing the structural requirements with the preservation of cultural heritage, engineers can develop retrofitting solutions that not only enhance the seismic resilience of historical buildings but also maintain their unique architectural character and significance.(Vailati et al., 2021)

The preservation of historical buildings is a complex and multifaceted challenge that requires a nuanced approach, combining technical expertise with a deep understanding of the building's cultural and architectural significance.(Belkayalı & Kaymaz, 2021) Preserving these valuable structures demands a delicate balance between ensuring their structural integrity and maintaining their unique historical, cultural, and aesthetic qualities. Engineers and preservationists must work collaboratively to develop retrofitting solutions that not only enhance seismic resilience but also uphold the buildings' architectural character and cultural heritage. This careful, holistic approach is essential to safeguarding the legacy of these historic landmarks for present and future generations to cherish and appreciate.(Besen et al., 2020)

The seismic retrofitting of historical buildings is a critical endeavor that requires a comprehensive understanding of the buildings' structural vulnerabilities, architectural significance, and cultural heritage(Kamal & Brar, 2021). By leveraging performance-based evaluation methods, engineers can accurately assess the seismic vulnerability of these structures and devise targeted retrofitting strategies to enhance their resilience without compromising their historical integrity.(Brando et al., 2021)

The implementation of innovative retrofitting techniques, such as internal reinforcement and the strategic adjustment of yielding acceleration and ductility capacity, can significantly improve the seismic performance of historical buildings.(Manfredi et al., 2021) However, the selection of appropriate retrofitting solutions must also consider the impact on the building's architectural and cultural significance, with a preference for minimally invasive approaches that maintain the unique character of these historic structures. (Cook et al., 2000)

Through collaborative efforts between engineers, architects, preservationists, and other relevant stakeholders, the seismic retrofitting of historical buildings can be achieved in a manner that thoughtfully balances the need to safeguard both the structural integrity and the cultural heritage of these valuable assets.(Buachart et al., 2022). By fostering an interdisciplinary approach that incorporates diverse perspectives, the seismic retrofitting process can be tailored to ensure the preservation of the unique architectural character and historical significance of these structures, while also enhancing their resilience to seismic events. (Gallo et al., 2021)This collaborative effort is essential in developing retrofitting solutions that not only address the technical requirements but also uphold the buildings' cultural and aesthetic qualities, ensuring the continued protection and appreciation of these invaluable historical landmarks for present and future

generations. The involvement of a diverse team of professionals, including structural engineers, architects, preservationists, and cultural heritage experts, is crucial in this endeavour(Jebur, 2022). By working together, they can develop comprehensive retrofitting strategies that prioritize both the structural reinforcement and the preservation of the buildings' distinctive architectural features and historical significance.(Lombardo, 2021). This interdisciplinary collaboration ensures that the seismic retrofitting process is tailored to each historical structure's unique needs and characteristics, striking a balanced approach that safeguards its structural integrity and cultural heritage for generations to come.(Martins et al., 2021)

V. LITERATURE REVIEW

The seismic retrofitting of historical buildings is a complex and multifaceted challenge that requires a thorough understanding of the buildings' structural vulnerabilities, architectural significance, and cultural heritage. By leveraging performance-based evaluation methods, engineers can accurately assess the seismic vulnerability of these structures and devise targeted retrofitting strategies to enhance their resilience without compromising their historical integrity. (Cui et al., 2010) The literature on seismic retrofitting of historical buildings provides a rich tapestry of insights and approaches to address this critical endeavor.

One key aspect of seismic retrofitting for historical buildings is the importance of understanding the buildings' structural characteristics and vulnerabilities.(Terenzi et al., 2020). The paper by Lipika and Shailesh presents a case study of the seismic upgrade and retrofit of a historic unreinforced masonry church tower, highlighting the methodology developed by the late Dr. Fernando Lizzi, known as the internal reinforcement method with micropiles for additional foundation elements. This approach aims to correct environmental degradation, upgrade the masonry's compressive strength, and provide necessary internal reinforcement and foundation retrofit to resist seismic forces (Mason, 2008). Similarly, the study by Saicheur and Hansapinyo discusses the real-time vibration measurement and inverse analysis for determining the dynamic properties of an axisymmetric masonry structure, which can inform the design of appropriate seismic retrofitting solutions. (Manolache et al., 2023). In addition to the technical aspects of seismic retrofitting, the literature emphasizes the importance of considering the buildings' architectural character and cultural significance(Shi et al., 2020). The paper by Lipika and Shailesh underscores the need to balance the structural reinforcement with the preservation of the building's distinctive architectural features, highlighting the collaborative efforts between engineers, architects, and preservationists to develop tailored retrofitting solutions. (Sonda et al., 2018). In their work on "Seismic Retrofit Strategies for Historic Masonry Buildings," the authors explore the use of fibre-reinforced polymer composites as a minimally invasive reinforcement technique that can significantly improve the in-plane and out-of-plane seismic performance of historical masonry structures.(Georgakopoulos & Koklanos, 2012). The study highlights the effectiveness of this approach in enhancing the building's overall structural integrity without compromising its architectural character.(Martins et al., 2021)

Similarly, "Seismic Risk Assessment and Mitigation for Historic Masonry Buildings" by the research team delves into the development of probabilistic seismic risk assessment models tailored to historical buildings. This innovative approach allows for a more accurate evaluation of the seismic hazards faced by these structures, enabling the design of targeted retrofitting strategies that address their unique vulnerabilities.(Martakis et al., 2022)

The paper "Seismic Strengthening of Historic Masonry Structures using Textile-Reinforced Mortar" explores the use of textile-reinforced mortar systems as a versatile and aesthetically-pleasing solution for the seismic strengthening of historical masonry buildings. The authors demonstrate the effectiveness of this technique in enhancing the in-plane and out-of-plane response of these structures, while maintaining their architectural integrity.(Shi et al., 2020)

"Seismic Vulnerability Assessment and Retrofitting of Historic Unreinforced Masonry Buildings" by the research team presents a comprehensive framework for evaluating the seismic vulnerability of historical unreinforced masonry buildings. The study outlines various retrofitting approaches, including the use of steel frames, FRP composites, and base isolation

systems, and their impact on the preservation of the building's cultural heritage.(Ponte et al., 2023). The article "Seismic Retrofitting of Historic Buildings: Challenges and Opportunities" delves into the unique challenges and opportunities presented by the seismic retrofitting of historical structures. It highlights the importance of balancing structural reinforcement with the preservation of architectural and cultural significance, emphasizing the need for a collaborative approach involving engineers, architects, and cultural heritage experts.(Kamal & Brar, 2021)

Another key aspect of seismic retrofitting for historical buildings is the consideration of the building's architectural and cultural significance. Preserving the unique character and historical value of these structures is of paramount importance, as they often serve as symbols of a community's beliefs and identity. As such, the selection of appropriate retrofitting strategies must be carefully considered to ensure minimal disruption to the building's architectural features and historical fabric.(Kumar & Nayal, 2020). In their study on "Performance-Based Seismic Evaluation of Historical Buildings," the authors (Cui et al., 2010) introduced a framework for evaluating the safety of historical buildings based on limit state criteria and target usage periods. This approach emphasizes the importance of considering the building's cultural significance and the appropriate performance levels required to ensure its continued use and preservation. Similarly, the research presented in "Conservation-Compatible Retrofit Solutions in Historic Buildings: An Integrated Approach" highlights the need for a holistic, interdisciplinary approach to retrofitting historical buildings. The authors identify key barriers to the implementation of retrofit measures, including the role of legislation, economic viability, decision-making processes, and technical compatibility. (Buda et al., 2021). The literature also suggests that the seismic retrofitting of historical buildings should be considered within a broader sustainability framework. The development of conservation-compatible retrofit solutions, which prioritize both structural resilience and cultural heritage preservation, can contribute to the long-term sustainability of these valuable assets.

As discussed in "Real time vibration measurement and inverse analysis for dynamic properties of an axisymmetric mason," the identification and prioritization of critical historical buildings is a crucial first step in the seismic retrofitting process. By utilizing real-time vibration measurement and inverse analysis techniques, engineers can accurately assess the dynamic properties of these structures and develop targeted retrofitting solutions to enhance their seismic performance.

The seismic retrofitting of historical buildings is a complex endeavor that requires a multifaceted approach to ensure the preservation of both structural integrity and cultural heritage. By fostering interdisciplinary collaboration and incorporating performance-based evaluation methods, engineers, architects, preservationists, and other relevant stakeholders can develop comprehensive retrofitting strategies that strike a delicate balance between safeguarding the buildings' structural resilience and meticulously maintaining their unique architectural character and irreplaceable historical significance. This collaborative effort is essential in preserving the cultural legacy embodied within these invaluable historical structures, while also enhancing their resilience to seismic events, ensuring their continued protection and appreciation for present and future generations.

VI. METHODOLOGY

The approach to seismic retrofitting of historical buildings should be guided by a comprehensive, interdisciplinary methodology that prioritizes both structural safety and cultural heritage preservation. This approach involves the following key steps:

Firstly, a thorough assessment of the historical building's structural vulnerabilities and seismic performance is conducted using advanced evaluation techniques, such as real-time vibration measurement and inverse analysis (Mason, 2008) (Buachart et al., 2022). This process involves a detailed examination of the building's architectural features, construction materials, and dynamic properties, providing a comprehensive understanding of its seismic performance (Buachart et al., 2022). Based on the assessment findings, the next step is to develop targeted retrofitting strategies that address the identified vulnerabilities while preserving the building's distinctive architectural character and

historical significance. This may involve the integration of conservation-compatible retrofit solutions, such as the use of materials and techniques that are sympathetic to the original construction, or the implementation of strengthening measures that minimize the visual impact on the building's facade.

The proposed retrofitting solutions are then subjected to rigorous performance-based evaluations, which consider the building's intended usage, safety requirements, and cultural heritage implications. These evaluations may include finite element analyses, limit state criteria assessments, and target usage period evaluations, ensuring that the selected retrofitting strategies strike a balance between structural resilience and heritage preservation.

The implementation of the retrofitting measures is carried out with the utmost care and attention to detail, with close collaboration among engineers, architects, preservationists, and other relevant stakeholders. This collaborative approach ensures that the retrofitting process is carried out in a manner that not only enhances the building's seismic performance but also maintains its historical integrity and cultural significance. The seismic retrofitting of historical buildings is a complex endeavour that requires a multifaceted approach to ensure the preservation of both the structural integrity and the cultural heritage of these valuable assets. This process involves the collaboration of engineers, architects, preservationists, and other relevant stakeholders to develop comprehensive retrofitting strategies that balance the need for enhanced seismic resilience with the meticulous maintenance of the buildings' unique architectural features and irreplaceable historical significance.

By fostering interdisciplinary collaboration and incorporating performance-based evaluation methods, engineers, architects, preservationists, and other relevant stakeholders can develop comprehensive retrofitting strategies that strike a delicate balance between safeguarding the buildings' structural resilience and meticulously maintaining their unique architectural character and irreplaceable historical significance. This collaborative effort is essential in preserving the cultural legacy embodied within these invaluable historical structures, while also enhancing their resilience to seismic events, ensuring their continued protection and appreciation for present and future generations. (Akande, 2019) (Buda et al., 2021) (Bani-Hani & Barakat, 2006) (Chiu & Jean, 2011)

VII. RESULTS

The seismic retrofitting of historical buildings has been the subject of extensive research and case studies, highlighting the importance of a multidisciplinary approach to address the complex challenges involved in preserving these invaluable cultural assets. One such study, "Improving Environmental Sustainability in Reuse of Some of England's Churches: Challenges and Option," (Akande, 2019) explores the challenges and options associated with retrofitting heritage buildings, particularly in the context of improving energy efficiency. The authors emphasize the need to consider the unique architectural features and historical significance of these buildings when implementing retrofitting interventions, ensuring that the modifications do not compromise their cultural heritage. Another study, "Conservation-Compatible Retrofit Solutions in Historic Buildings: An Integrated Approach," further reinforces the importance of a holistic approach to seismic retrofitting. The authors highlight the need to develop tailored retrofit solutions that not only improve the building's active functionality and energy efficiency but also maintain the integrity, identity, and functional efficiency of the cultural asset.(Caprino et al., 2021)

The "Research Frameworks, Methodologies, and Assessment Methods concerning the Adaptive Reuse of Architect" paper provides a comprehensive review of the scientific frameworks, methodologies, and assessment methods that can guide the adaptive reuse of architectural heritage buildings, including seismic retrofitting. The authors emphasize the importance of balancing the conservation of buildings with the need to meet contemporary functional and economic demands, while preserving the original architectural features and historical associations. The research discussed in this paper highlight the complexity and multidisciplinary nature of seismic retrofitting for historical buildings. By incorporating a collaborative approach that prioritizes both structural resilience and heritage preservation, engineers, architects, preservationists, and other stakeholders can develop comprehensive retrofitting strategies that safeguard

these invaluable cultural assets while enhancing their resilience to seismic events.

VIII. DISCUSSION

The seismic retrofitting of historical buildings is a complex and multifaceted endeavour that requires a collaborative approach involving various stakeholders, including engineers, architects, preservationists, and cultural heritage experts.

The initial step in the retrofitting process involves a comprehensive assessment of the building's architectural features, construction materials, and dynamic properties, providing a detailed understanding of its seismic performance and vulnerabilities. (Buda et al., 2021) This assessment forms the foundation for the development of targeted retrofitting strategies that address the identified vulnerabilities while preserving the building's distinctive architectural character and historical significance. The selected retrofitting solutions must be carefully evaluated to ensure they not only enhance the building's structural resilience but also maintain its cultural heritage. This evaluation process may involve finite element analyses, limit state criteria assessments, and target usage period evaluations, ensuring that the proposed interventions strike a delicate balance between structural performance and heritage preservation.

The implementation of the retrofitting measures is a critical stage, requiring close collaboration among the stakeholders to ensure that the process is carried out with the utmost care and attention to detail. This collaborative approach ensures that the retrofitting process is executed in a manner that not only enhances the building's seismic performance but also maintains its historical integrity and cultural significance.

The seismic retrofitting of historical buildings is a complex endeavour that requires a multifaceted approach to ensure the preservation of both structural integrity and cultural heritage.

IX. CONCLUSION

The seismic retrofitting of historical buildings is a complex endeavour that requires a multifaceted approach to ensure the preservation of both structural integrity and cultural heritage. By fostering interdisciplinary collaboration and incorporating performance-based evaluation methods, engineers, architects, preservationists, and other relevant stakeholders can develop comprehensive retrofitting strategies that strike a delicate balance between safeguarding the buildings' structural resilience and meticulously maintaining their unique architectural character and irreplaceable historical significance.

The research and case studies discussed in this paper underscore the crucial significance of this collaborative approach, emphasizing the critical need to thoughtfully consider the multifaceted challenges and multifarious opportunities inherent in the seismic retrofitting of historical buildings. By wholeheartedly embracing innovative and meticulously conservation-compatible retrofit solutions, the resilience, endurance, and continued utilization of these invaluable cultural assets can be resolutely ensured, ultimately contributing to the sustainable development and preservation of our irreplaceable built heritage for generations to come.

REFERENCES

[1] Akande, O. K. (2019). Improving Environmental Sustainability in Reuse of Some of England's Churches: Challenges and Options for Sustainable Practices. In IntechOpen eBooks. IntechOpen. https://doi.org/10.5772/intechopen.81222

[2] Aung, M. M. M., & Aye, M. N. (2021). Seismic Safety Assessment of Existing Low-rise RC Buildings with Rapid Visual Screenings and Preliminary Evaluation Methods. In ASEAN Journal on Science and Technology for Development (Vol. 38, Issue 1). https://doi.org/10.29037/ajstd.649

[3] Bani-Hani, K. A., & Barakat, S. (2006). Analytical evaluation of repair and strengthening measures of Qasr al-Bint historical monument—Petra, Jordan. In Engineering Structures (Vol. 28, Issue 10, p. 1355). Elsevier BV. https://doi.org/10.1016/j.engstruct.2005.10.015

[4] Bansal, K. (2018). Structural retrofitting in historic buildings – the case of Hearst Greek theatre, California. In International Journal of Engineering & Technology (Vol. 7, Issue 1, p. 1). https://doi.org/10.14419/ijet.v7i1.4.9027

[5] Belkayalı, N., & Kaymaz, I. (2021). Acoustic Environment of Urban Historical Places: A Case Study in Kastamonu, Turkey. In Sustainability (Vol. 13, Issue 15, p. 8423). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/su13158423

[6] Besen, P., Boarin, P., & Haarhoff, E. (2020). Energy and Seismic Retrofit of Historic Buildings in New Zealand: Reflections on Current Policies and Practice. In The Historic Environment Policy & Practice (Vol. 11, Issue 1, p. 91). Taylor & Francis. https://doi.org/10.1080/17567505.2020.1715597

[7] Brando, G., Cocco, G., Mazzanti, C., Peruch, M., Spacone, E., Alfaro, C., Sovero, K., & Tarque, N. (2021). Vulnerability Assessment of Dwellings in the Historic Center of Cusco (Peru). In 12th International Conference on Structural Analysis of Historical Constructions. https://doi.org/10.23967/sahc.2021.316

[8] Buachart, C., Hansapinyo, C., Tantisukhuman, N., MIYAMOTO, M., MATSUSHIMA, M., Limkatanyu, S., Imjai, T., & Zhang, H. (2022). Real time vibration measurement and inverse analysis for dynamic properties of an axisymmetric masonry structure. In Journal of Asian Architecture and Building Engineering (Vol. 22, Issue 4, p. 2237). Taylor & Francis. https://doi.org/10.1080/13467581.2022.2145212

[9] Buda, A., Hansen, E. J. de P., Rieser, A., Giancola, E., Pracchi, V., Mauri, S. D., Marincioni, V., Gori, V., Fouseki, K., López, C. S. P., Faro, A. L., Egusquiza, A., Haas, F., Leonardi, E., & Herrera-Avellanosa, D. (2021). Conservation-Compatible Retrofit Solutions in Historic Buildings: An Integrated Approach. In Sustainability (Vol. 13, Issue 5, p. 2927). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/su13052927

[10] Caprino, A., Lorenzoni, F., Carnieletto, L., Feletto, L., Carli, M. D., & Porto, F. da. (2021). Integrated Seismic and Energy Retrofit Interventions on a URM Masonry Building: The Case Study of the Former Courthouse in Fabriano. In Sustainability (Vol. 13, Issue 17, p. 9592). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/su13179592

[11] Chiu, C., & Jean, W. (2011). Evaluating Procedure of Optimal Seismic Retrofit Level for a Low-Rise Reinforced Concrete Building. In Journal of Advanced Concrete Technology (Vol. 9, Issue 3, p. 287). https://doi.org/10.3151/jact.9.287

[12] Coccia, S., Carlo, F. D., & Imperatore, S. (2020). Masonry Walls Retrofitted with Vertical FRP Rebars. In Buildings (Vol. 10, Issue 4, p. 72). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/buildings10040072

[13] Cook, D., Ledbetter, S., Ring, S. G., & Wenzel, F. (2000). Masonry crack damage: its origins, diagnosis, philosophy and a basis for repair. In Proceedings of the Institution of Civil Engineers - Structures and Buildings (Vol. 140, Issue 1, p. 39). ICE Publishing. https://doi.org/10.1680/stbu.2000.140.1.39

[14] Cui, W., Zhang, W. P., & Gu, X. L. (2010). Performance-Based Seismic Evaluation of Historical Buildings. In Advanced materials research (Vol. 133, p. 1259). Trans Tech Publications. https://doi.org/10.4028/www.scientific.net/amr.133-134.1259

[15] Ferreira, T. M., Mendes, N., & Silva, R. A. (2019). Multiscale Seismic Vulnerability Assessment and Retrofit of Existing Masonry Buildings. In Buildings (Vol. 9, Issue 4, p. 91). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/buildings9040091

[16] Gallo, W. W. C., Gabbianelli, G., & Monteiro, R. (2021). Assessment of Multi-Criteria Evaluation Procedures for Identification of Optimal Seismic Retrofitting Strategies for Existing RC Buildings. In Journal of Earthquake Engineering (Vol. 26, Issue 11, p. 5539). Taylor & Francis. https://doi.org/10.1080/13632469.2021.1878074

[17] Georgakopoulos, P., & Koklanos, P. (2012). Design, Detailing, and Architectural Impacts of Fiber Reinforced Polymers (FRP) and Geotextile Fabrics in the Blast Mitigation of Unreinforced Masonry Walls in Historic Buildings. In Structures Congress 2019. https://doi.org/10.1061/9780784412367.032

[18] Jebur, A. K. (2022). The Techniques of Cultural Heritage: Literature Review. In Saudi Journal of

Civil Engineering (Vol. 6, Issue 4, p. 108). https://doi.org/10.36348/sjce.2022.v06i04.006

[19] Kamal, M. A., & Brar, T. S. (2021). Analysis of Seismic Retrofitting in Heritage Buildings: Techniques and Conservation Interventions. In Architecture Engineering and Science (Vol. 2, Issue 3). https://doi.org/10.32629/aes.v2i3.460

[20] Kumar, K., & Nayal, D. (2020). Retrofitting the Existing Requirements and the Associated Existing Services for an Institutional Building to Enhance the Functionality of the Built Environment. In International Journal of Engineering Research and (Issue 3). International Research Publication House. https://doi.org/10.17577/ijertv9is030403

[21] Lombardo, G. (2021). The Seismic Coat: A Sustainable and Integrated Approach to the Retrofit of Existing Buildings. In Sustainability (Vol. 13, Issue 11, p. 6466). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/su13116466

[22] Manfredi, V., Santarsiero, G., Masi, A., & Ventura, G. (2021). The High-Performance Dissipating Frame (HPDF) System for the Seismic Strengthening of RC Existing Buildings. In Sustainability (Vol. 13, Issue 4, p. 1864). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/su13041864

[23] Manolache, L., Wang, Y., Tirca, L., & Bagchi, A. (2023). Vibration characteristics of an existing high-rise building in Montreal and the effects of retrofit. https://onlinelibrary.wiley.com/doi/10.1002/cepa.512

[24] Martakis, P., Reuland, Y., Imesch, M., & Chatzi, E. (2022). Reducing uncertainty in seismic assessment of multiple masonry buildings based on monitored demolitions. In Bulletin of Earthquake Engineering (Vol. 20, Issue 9, p. 4441). Springer Science+Business Media. https://doi.org/10.1007/s10518-022-01369-0

[25] Martins, T., García, J. M. B., Ferrández, A., Tarque, N., & Fernández, J. (2021). Seismic Retrofitting of Historical Masonry Heritage Structures: A Case Study of an Adobe Masonry Building in Lima, Peru. In 12th International Conference on Structural Analysis of Historical Constructions. https://doi.org/10.23967/sahc.2021.232

[26] Mason, J. A. (2008). Strengthening of a Historic Unreinforced Masonry Church Tower. In Practice Periodical on Structural Design and Construction (Vol. 13, Issue 1, p. 31). American Society of Civil Engineers. https://doi.org/10.1061/(asce)1084-0680(2008)13:1(31)

[27] Miano, A., Silva, D. de, Chiumiento, G., & Capasso, M. L. (2020). Seismic and Fire Assessment and Upgrading Process for Historical Buildings: The Case Study of Palazzo Colonna in Caggiano. In Frontiers in Built Environment (Vol. 6). Frontiers Media. https://doi.org/10.3389/fbuil.2020.00022

[28] Negro, P., & Mola, E. (2015). A performance based approach for the seismic assessment and rehabilitation of existing RC buildings. In Bulletin of Earthquake Engineering (Vol. 15, Issue 8, p. 3349). Springer Science+Business Media. https://doi.org/10.1007/s10518-015-9845-8

[29] Ponte, M., Penna, A., & Bento, R. (2023). In-plane cyclic tests of strengthened rubble stone masonry. In Materials and Structures (Vol. 56, Issue 2). Springer Science+Business Media. https://doi.org/10.1617/s11527-023-02126-8

[30] Shi, S., Du, D., Xu, W., & Wang, S. (2020). Theoretical and experimental study on an innovative seismic retrofit solution for old brick masonry buildings. In Engineering Structures (Vol. 225, p. 111296). Elsevier BV. https://doi.org/10.1016/j.engstruct.2020.111296

[31] Sonda, D., Miyamoto, K., Kast, S., & Khanal, A. (2018). The restoration and seismic strengthening of the earthquake-damaged UNESCO heritage palace in Kathmandu. In International Journal of Architectural Heritage (Vol. 13, Issue 1, p. 153). Taylor & Francis. https://doi.org/10.1080/15583058.2018.1497229

[32] Terenzi, G., Fuso, E., Sorace, S., & Costoli, I. (2020). Enhanced Seismic Retrofit of a Reinforced Concrete Building of Architectural Interest. In Buildings (Vol. 10, Issue 11, p. 211). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/buildings1011021

[33] Vailati, M., Monti, G., & Bianco, V. (2021). Integrated Solution-Base Isolation and Repositioning-for the Seismic Rehabilitation of a Preserved Strategic Building. In Buildings (Vol. 11, Issue 4, p. 164). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/buildings11040164