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Editorial

Special Issue: Advances in Structural Analysis and Rehabilitation for Existing Structures

Alessio Cascardi

Department of Civil Engineering, University of Calabria, Via P. Bucci Cube 45B, 87036 Arcavacata di Rende, Italy; alessio.cascardi@unical.it

1. Introduction

In the dynamic realm of civil engineering, the principles of structural analysis and rehabilitation are pivotal in extending the lifespan and enhancing the performance of existing structures. The following Special Issue, entitled "*Advances in Structural Analysis and Rehabilitation for Existing Structures*", delves into the forefront of research and innovation in the field. It explores the evolving methodologies, technologies, and strategies that engineers and researchers worldwide are employing to address the challenges posed by aging infrastructure. As populations grow and urbanization intensifies, the demand for sustainable infrastructure becomes increasingly urgent. Existing structures, whether historic landmarks or essential infrastructure, require continuous assessment and maintenance to ensure safety, functionality, and longevity. This collection of contributions aims to illuminate the latest advancements that enable engineers to analyze, diagnose, and rehabilitate structures with precision and efficiency. From advanced computational models and non-destructive testing techniques to innovative materials and retrofitting strategies, the chapters in this Special Issue encompass a broad spectrum of approaches. Each article offers insights into how these advancements are reshaping the practice of structural engineering, paving the way for more resilient and sustainable built environments.

Moreover, the following Special Issue serves as a platform for collaboration and knowledge exchange among researchers, practitioners, and academicians. By sharing cutting-edge research and practical applications, we aim to inspire further innovation and foster a deeper understanding of the complexities involved in maintaining and upgrading our infrastructure. Through this compilation, we invite readers to explore the frontiers of structural analysis and rehabilitation, where theory meets practice and where the future of sustainable infrastructure is being defined. Whether you are a seasoned professional, a budding researcher, or simply curious about the evolving landscape of civil engineering, we hope that this collection sparks new ideas and insights that contribute to the ongoing evolution of our built environment.

Welcome to "*Advances in Structural Analysis and Rehabilitation for Existing Structures*"—a testament to the ingenuity and dedication driving the advancement of structural engineering worldwide.

2. Overview of the Published Articles

This Special Issue contains eleven papers, including eight reviews, published by a number of authors interested in cutting-edge developments in the field of engineering. The authors hail from 12 countries, including Germany, France, Portugal, Canada, the UK, the USA, Singapore, Brazil, China, Malaysia, Iran, and Iraq.

The authors of the paper "Carbon Fiber-Reinforced Polymer Composites Integrated Beam–Column Joints with Improved Strength Performance against Seismic Events: Numerical Model Simulation" explore the use of carbon fiber-reinforced polymer (CFRP) composites in beam–column joints to enhance their strength and resilience during seismic

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events. The study authors utilize numerical simulations to investigate how CFRP can effectively reinforce these critical structural connections, offering insights into its performance and potential benefits in seismic-resistant design. Key findings highlight the improved strength and durability of CFRP-integrated joints, suggesting promising applications for enhancing structural safety in earthquake-prone regions.

The authors of the paper "Performance Evaluation of Self-Compacting Glass Fiber Concrete Incorporating Silica Fume at Elevated Temperatures" examine the behavior of self-compacting concrete (SCC) reinforced with glass fibers and silica fume when subjected to high temperatures. Through a series of experimental tests, the study authors evaluate the concrete's mechanical properties, including its strength, workability, and durability under elevated temperature conditions. The results indicate that the addition of glass fibers and silica fume enhances the thermal resistance and overall performance of SCC, making it a viable option for construction applications where high-temperature exposure is a concern.

The authors of the paper "Minimum Shear Reinforcement for Reactive Powder Concrete Beams" investigate the requirements for shear reinforcement in reactive powder concrete (RPC) beams. Through experimental testing and analysis, the study authors determine the optimal amount of shear reinforcement needed to ensure structural integrity and prevent failure. Findings suggest that RPC beams, known for their high strength and durability, require less shear reinforcement compared to conventional concrete beams, due to their superior material properties. The research provides guidelines for the design of RPC beams, aiming to improve efficiency and safety in structural engineering applications.

The authors of the paper "Numerical Investigation of the Seismic Performance of an Innovative Type of Buckling-Restrained Brace (BRB)" explore the effectiveness of a newly designed buckling-restrained brace in enhancing the seismic performance of structures. Using numerical simulations, the study assesses the brace's ability to withstand seismic loads and prevent buckling under stress. Their study results indicate that the innovative BRB design significantly improves energy dissipation and overall structural resilience during earthquakes. The findings highlight the potential of this new BRB type to provide superior seismic protection, offering valuable insights for improving earthquake-resistant building design.

The authors of the paper "Assessment of Groundwater Contamination in the Southeastern Coast of Brazil: A Potential Threat to Human Health in Marica Municipality" investigate the quality of groundwater in Marica Municipality, Brazil, and its implications for human health. Through comprehensive water quality testing and analysis, the study authors identify various contaminants present in the groundwater, including heavy metals and microbial pollutants. The findings reveal significant levels of contamination, posing potential health risks to the local population. The research underscores the urgent need for effective groundwater management and pollution mitigation strategies to protect public health in the region.

The authors of the paper "A Parametric Study on the LDB Strength of Steel-Concrete Composite Beams" examine the lateral–distortional buckling (LDB) strength of steel-concrete composite beams through a series of parametric analyses. By varying key parameters such as beam geometry, material properties, and loading conditions, the study authors evaluate their impact on the LDB behavior and strength of these composite structures. The results provide a deeper understanding of the factors influencing LDB strength and offer guidelines for optimizing the design of steel-concrete composite beams to enhance their stability and performance in structural applications.

The authors of the paper "Insight into the Optimization of Implementation Time in Cob Construction: Field Test and Compressive Strength Versus Drying Kinetics" explore the optimal timing for implementing cob construction to balance compressive strength and drying kinetics. Through field tests, the study authors examine how different implementation times affect the drying process and the resulting compressive strength of cob materials. Findings indicate that optimizing the implementation time is crucial for achieving desirable strength characteristics while ensuring efficient drying. The research provides practical recommendations for enhancing the durability and performance of cob structures, contributing to more effective and sustainable building practices.

The authors of the paper "Seismic Resilience and Design Factors of Inline Seismic Friction Dampers (ISFDs)" investigate the effectiveness of ISFDs in enhancing the seismic resilience of structures. By analyzing various design factors, the study authors evaluate how these dampers perform under seismic loading conditions. The results show that ISFDs significantly improve energy dissipation and structural stability during earthquakes. Key design factors such as damper configuration, material properties, and installation methods are found to influence the overall performance of ISFDs. The research offers valuable insights and guidelines for incorporating ISFDs into building designs to achieve superior earthquake resistance.

The authors of the paper "Improved Structural Health Monitoring Using Mode Shapes: An Enhanced Framework for Damage Detection in 2D and 3D Structures" present a novel approach to structural health monitoring that leverages mode shapes for more accurate damage detection. The enhanced framework is designed to identify and locate damage in both two-dimensional and three-dimensional structures. Through numerical simulations and experimental validation, the study authors demonstrate that using mode shapes improves the sensitivity and reliability of damage detection methods. The findings suggest that this advanced monitoring technique can significantly contribute to maintaining the safety and integrity of various structural systems.

The authors of the paper "Chemo-Thermo-Mechanical FEA as a Support Tool for Damage Diagnostic of a Cracked Concrete Arch Dam: A Case Study" explore the use of finite element analysis (FEA) incorporating chemical, thermal, and mechanical factors to diagnose damage in a cracked concrete arch dam. The case study demonstrates how this comprehensive FEA approach can effectively simulate the complex interactions and stressors affecting the dam's integrity. Their study results highlight the method's ability to accurately identify damage locations and assess the severity of cracks. The research supports the use of chemo-thermo-mechanical FEA as a valuable tool for enhancing the precision of structural diagnostics and maintenance strategies for concrete arch dams.

The authors of the paper "Surface Waterproofing Techniques: A Case Study in Nova Lima, Brazil" investigate various surface waterproofing methods applied to structures in Nova Lima, Brazil. The study authors evaluate the effectiveness of different techniques in preventing water infiltration and mitigating related damage. Through field experiments and performance assessments, the authors identify which waterproofing strategies provide the best protection under local environmental conditions. The study findings suggest that certain techniques significantly enhance the durability and lifespan of the structures. The study offers practical insights and recommendations for selecting and implementing surface waterproofing solutions in similar climatic regions.

3. Closing Remarks

In editing the eleven papers comprising the herein-presented Special Issue, several key insights and conclusions emerge, highlighting the evolving landscape of structural engineering and materials science.

The integration of advanced materials and innovative design approaches plays a crucial role in improving structural resilience. For instance, carbon fiber-reinforced polymer (CFRP) composites have been shown to enhance the strength and seismic performance of beam–column joints, offering a promising solution for earthquake-resistant structures. Similarly, the use of glass fibers and silica fume in self-compacting concrete has demonstrated significant improvements in thermal performance and mechanical properties, indicating their potential for high-temperature applications.

Recent research on reactive powder concrete (RPC) beams reveals that their superior properties allow for reduced shear reinforcement compared to traditional concrete, optimizing material use without compromising structural integrity. The above aligns with findings on buckling-restrained braces (BRBs), where innovative designs have been found to significantly improve energy dissipation and stability during seismic events, underscoring the importance of advanced seismic protection technologies.

Groundwater contamination studies in Nova Lima, Brazil, highlight a critical public health concern, emphasizing the need for effective water management and pollution mitigation strategies. This concern extends to the structural domain as well, where optimizing design parameters for steel–concrete composite beams can enhance their lateral–distortional buckling strength, contributing to more stable and efficient construction practices.

In the realm of construction techniques, the optimization of implementation time in cob construction has been shown to affect both compressive strength and drying efficiency, illustrating the importance of precise timing for material performance. This principle of optimization extends to the use of inline seismic friction dampers (ISFDs), which offer improved seismic resilience through enhanced energy dissipation.

Structural health monitoring benefits from the use of mode shapes, which provide more accurate damage detection in both two-dimensional and three-dimensional structures. This method's reliability is further supported by advanced chemo-thermo-mechanical finite element analysis (FEA) techniques, which have proven effective in diagnosing damage in concrete arch dams by considering a comprehensive range of factors.

Lastly, the evaluation of surface waterproofing techniques in Nova Lima, Brazil, underscores the variability in effectiveness based on environmental conditions, stressing the importance of selecting appropriate methods to prevent water damage and extend the lifespan of structures.

Together, these studies reflect a growing emphasis on integrating advanced materials, innovative designs, and precise monitoring techniques to enhance the performance, safety, and longevity of structures across diverse applications and environments.

In addition, a valuable short references list is reported herein in order to make the present section as comprehensive as possible. In their study, Cascardi et al. (2024) [1] explore the use of carbon fabric-reinforced cementitious mortar (CFRCM) for enhancing the confinement of concrete cylinders. The study authors focus on evaluating the effectiveness of multi-ply wrapping configurations in improving the mechanical properties and structural performance of concrete under different loading conditions. Key findings from the research highlight the influence of the mortar matrix in CFRCM on overall performance, particularly in terms of strength enhancement and ductility. The authors experimentally investigate various parameters such as ply orientation, number of layers, and mortar composition to determine their impact on confinement efficiency. The results suggest that the matrix composition significantly affects the confinement effectiveness of CFRCM, with implications for optimizing design and application in structural engineering. The study provides valuable insights into the mechanics of composite materials and offers practical guidelines for utilizing CFRCM in enhancing the resilience and durability of concrete structures. Overall, Cascardi et al. contribute to the understanding of CFRCM technology by emphasizing the importance of mortar matrix properties in achieving enhanced performance of reinforced concrete elements through multi-ply wrapping techniques.

The authors of [2] investigate the application of fiber-reinforced polymers (FRP) as a removable method for confining and reinforcing heritage masonry columns. The study aims to address the need for reversible strengthening techniques in the preservation of historical structures. The authors propose a novel approach that allows FRP materials to be used temporarily, ensuring that the original state of the masonry columns can be restored when necessary. This method balances the preservation requirements of heritage structures with the need for structural enhancement to improve their load-bearing capacity and stability. Key aspects of the research include experimental tests on masonry columns confined with removable FRP wraps. The results demonstrate that the FRP confinement significantly enhances the mechanical performance of the columns, increasing their strength and ductility. Additionally, the reversibility of the FRP application is confirmed, making it a viable solution for temporary strengthening. The study provides detailed insights into the behavior of FRP-confined masonry columns, including the effects of various confinement configurations and materials. The authors also discuss the practical implications of their findings for the conservation of heritage buildings, emphasizing the potential for FRP technology to offer both structural benefits and compliance with preservation standards.

A further contribution is [3], whose authors address the critical issue of evaluating the seismic performance of existing reinforced concrete (RC) structures. The study authors provide a comprehensive framework for assessing the vulnerability of such structures to seismic events and propose methodologies for their evaluation and retrofitting. Key elements of the research include:

- The authors outline systematic procedures for the seismic assessment of existing RC structures. These procedures incorporate both qualitative and quantitative evaluations, considering factors such as structural design, construction quality, material properties, and the current state of the structure.
- Ghobarah discusses various performance criteria that should be met to ensure the safety and functionality of RC structures during and after seismic events. These criteria include maintaining structural integrity, minimizing damage, and ensuring the safety of occupants.
- The authors review different methods for evaluating seismic performance, including linear and nonlinear analysis techniques. Ghobarah emphasizes the importance of accurate modeling and analysis to predict the behavior of RC structures under seismic loads.
- The authors also explore various retrofitting strategies to enhance the seismic performance of RC structures. These strategies range from local strengthening techniques, such as the addition of shear walls and steel bracings, to global approaches like base isolation and energy dissipation devices.
- To illustrate the practical application of the proposed assessment and retrofitting methodologies, the paper includes case studies and examples of existing RC structures that have undergone seismic evaluation and strengthening.

In conclusion, Ghobarah's research offers a valuable contribution to the field of structural engineering by providing a detailed and practical framework for the seismic assessment and retrofitting of existing RC structures. The study emphasizes the importance of a thorough evaluation to ensure that these structures can withstand seismic events, thereby safeguarding lives and reducing economic losses.

Lastly, in the paper by Mesquita et al. (2016) [4], the authors provide a comprehensive review of the advancements in structural health monitoring (SHM) technologies. The study focuses on the development and implementation of SHM platforms to enhance the safety and longevity of civil infrastructure. Key aspects of the research include:

- The paper begins with an overview of the current state of SHM technologies, highlighting their importance in detecting damage, assessing structural integrity, and ensuring the safety of civil structures.
- The authors discuss various sensor technologies used in SHM, including traditional sensors such as strain gauges and accelerometers, as well as advanced optical fiber sensors and wireless sensor networks. These technologies are evaluated based on their accuracy, reliability, and ease of deployment.
- The authors examine the methods for data acquisition and processing, emphasizing the role of real-time monitoring and data analytics in providing accurate and actionable information about structural health. The use of machine learning and artificial intelligence in SHM data processing is also explored.
- The authors review the integration of SHM systems with communication platforms, enabling remote monitoring and analysis. The authors also highlight the importance of robust and secure communication channels for the effective implementation of SHM systems.
- To demonstrate the practical applications of SHM technologies, the study includes several case studies showcasing successful implementations in bridges, buildings, and

other civil structures. These examples illustrate the benefits of SHM in extending the service life of structures and reducing maintenance costs.

- ➢ The authors identify the challenges faced in the field of SHM, such as the need for standardized protocols, the high cost of advanced sensor technologies, and the integration of diverse data sources. They also discuss future directions, including the development of more cost-effective solutions and the incorporation of emerging technologies such as the Internet of Things (IoT) and cloud computing.

In conclusion, Mesquita et al. provide a detailed and insightful overview of the advancements in SHM platforms, highlighting their critical role in the maintenance and safety of civil infrastructure. Their paper underscores the need for continuous innovation and integration of new technologies to address the challenges in SHM and to enhance the effectiveness of monitoring systems.

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Conflicts of Interest: The author declares no conflicts of interest.

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