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Special Issue

Earthquake Engineering

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INTRODUCTION BY GUEST EDITORS

Earthquakes remain among the most unpredictable and destructive natural hazards, capable of causing widespread human suffering and extensive material damage. Recent seismic events in Türkiye, Syria, and Morocco have once again underscored the devastating consequences of inadequate structural resilience, highlighting the urgent need for improved seismic risk mitigation. Closer to home, the ongoing subduction of the Adriatic microplate beneath the Eurasian Plate continuously stresses the crust of the Western Balkans, generating persistent seismicity across the region. The 2020 Petrinja earthquake in Croatia serves as a stark reminder that our own terrain is not exempt from such hazards. In this context, the imperative to design and construct seismically resilient infrastructure emerges as both a scientific responsibility and a societal necessity.

Developing such resilience demands more than strict adherence to seismic design codes; it requires continuous refinement of national regulations and engineering methodologies, aligned with European frameworks—particularly the Eurocodes. This effort must be underpinned by reliable site-specific seismic inputs, comprehensive geotechnical and structural databases, accurate typology classifications, and the integration of advanced modeling techniques.

This special issue presents six contributions from the fields of civil engineering and geodesy, each addressing seismic hazard from a distinct yet complementary perspective. Together, they illustrate the value of interdisciplinary cooperation in confronting seismic vulnerability with both computational innovation and empirical precision.

In the article “On Simplified Approaches of Seismic Analysis of Tunnels,” E. Zlatanović et al. assess widely used free-field deformation methods alongside Wang’s soil–structure interaction formulations for tunnel design under seismic loading. Through comparative 1D and 2D simulations, the study finds that although these simplified methods tend to conservatively overestimate shear strains and internal forces, they nonetheless provide a transparent and dependable foundation for practical engineering design.

The paper “Numerical Modeling of Tunnel Excavation and Support Using the Deconfinement Method for Static and Seismic Conditions,” by Z. Zafirovski et al., applies the (1–β) deconfinement technique within PLAXIS 2D to simulate staged excavation and support performance under combined loading conditions. Their parametric study confirms a direct relationship between increased deconfinement ratios and rising displacements and internal forces, supporting the method’s reliability for tunnel lining design.

In “The Effect of Masonry Infill Model Selection on the Seismic Response of Reinforced Concrete Frame Structures,” A. Cumbo et al. compare bare frames and various infill configurations to assess seismic response. The findings reveal that non-isolated infill significantly modifies dynamic behavior, introducing soft-story mechanisms and amplifying base shear forces. The authors advocate for updated code provisions and design simplifications using diagonal strut models to ensure both safety and practical implementation.

The study “Environmental Impact Assessment and Seismic Hazard Analysis: Petrinja 2020 Experience,” by B. Kordić et al., synthesizes field observations, GNSS data, InSAR imagery, and paleoseismic trenching to characterize the surface rupture features of the 2020 Mw 6.2 Petrinja earthquake. By identifying the Petrinja–Pokupsko Fault as the principal seismogenic structure, the authors emphasize the necessity of regionally coordinated geological and geophysical investigations to refine hazard models across national borders.

The paper “Modeling Tectonic Movements Using the Kalman Filter on GNSS Coordinate Time Series,” by V. Janković et al., integrates Kalman filtering with seasonal-trend models to analyze GNSS time series from Japan. Capturing complex horizontal displacements and coseismic offsets during the 2011 Tōhoku earthquake, the study demonstrates the robustness of filtered GNSS trajectories in mapping crustal deformation and informing seismic risk assessments.

Finally, “Tectonic Geodesy as Supplement Data in Seismology,” by T. Đukanović et al., focuses on GNSS observations from the SRJV station in Sarajevo, which indicate a northeastward motion of approximately 28 mm/year. Highlighting the sparse spatial distribution of geodetic instrumentation in Bosnia and Herzegovina, the authors call for a densified GNSS network and better integration with seismic and geological data to support hazard mapping and earthquake-resilient urban development.

Taken together, these six contributions establish a dynamic dialogue between civil engineering and geodesy on the topic of earthquake resilience. The geographic focus on the Western Balkans – particularly Bosnia and Herzegovina – adds both urgency and relevance, as this region lies within a high-risk seismic zone shaped by complex tectonic interactions. The collective scientific value of this issue lies in its ability to unify multiscale insights ranging from conservative yet practical equations for tunnel design, through nonlinear structural modeling and staged excavation simulations, to high-rate GNSS data for crustal motion monitoring and fault characterization.

Together, these studies forge a coherent toolbox for seismic hazard assessment: benchmarking simplified tunnel design methods against advanced soil–structure interaction models; validating deconfinement-based simulations for staged excavation; and clarifying how infill assumptions reshape seismic demand in reinforced concrete frames. Field-to-satellite analyses of the 2020 Petrinja earthquake, Kalman-filtered GNSS time series from Japan, and GNSS network evaluations for Bosnia and Herzegovina collectively demonstrate that high-resolution geodetic data are indispensable for quantifying ground deformation before, during, and after seismic events. By bridging the scale from tunnel lining stresses to plate-boundary dynamics, the papers underscore the importance of aligning simplified engineering rules with data-driven geophysical models to improve seismic hazard assessments and regulatory frameworks.

Ultimately, this issue advances the state of practice toward performance-based, geo-referenced earthquake engineering that is both computationally efficient and empirically grounded.

EDITORS’ BIOGRAPHIES

Gordana Broćeta

Gordana Broćeta, PhD, earned her master's and doctoral degrees in the field of Building Materials and Structures at the Faculty of Architecture, Civil Engineering, and Geodesy of the University of Banja Luka, where she currently works as a lecturer with the title of associate professor. She has gained extensive experience in designing concrete composites, as well as in examining and assessing the condition of concrete structures. Her scientific research focuses on influential factors that affect various aspects of the durability of concrete structures.

Anđelko Cumbo

Anđelko Cumbo, PhD, earned his doctoral degree at the Faculty of Civil Engineering and Architecture at the University of Niš and obtained his master's degree at the Faculty of Technical Sciences at the University of Novi Sad. He has gained several years of professional experience in the design, assessment, and examination of bridge and building structures. In his research work, he focuses on the development of computational modelling for the analysis of complex composite structures, as well as the analysis and modelling of structures under strong earthquakes. This includes the behaviour and strengthening of retrofitted and older structures. He has published scientific and professional papers in recognized journals and conferences in these fields.