Special Issue on Multi-scale Computational Methods for Solids and Fluids ECCOMAS MSF 2025

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Abstract

This special issue contains six selected papers first presented in short format at the 7th International Conference ECCOMAS MSF 2025 Multi-scale Computational Methods for Solids and Fluids, organized in Dalmatian capital Split, Croatia, 25–27 June 2025.

Keywords: Fluid mechanics, solid mechanics, multi-scale computations.

1 Introduction

This special issue presents six selected papers from the 7th International Conference on Multi-scale Computational Methods for Solids and Fluids, a well-established series of international conferences held every two years in different European cities. The series has been organized under the umbrella of ECCOMAS, the European Community on Computational Methods in Applied Sciences, which supports the development and dissemination of advanced computational approaches in engineering and applied sciences.

The 7th conference in the series was held in Split, Croatia, at the Faculty of Civil Engineering, Architecture and Geodesy of the University of Split, the same as the 5th conference in the series in 2021. It was jointly organized by the Faculty of Civil Engineering, Architecture and Geodesy of the University of Split, Faculty of Civil Engineering of the University of Sarajevo and the Université de Technologie de Compiègne, a member of the Sorbonne University Alliance. The choice for the conference location was motivated by the city of Split's rich and layered history, as well as its vibrant academic life established at the University of Split, which was founded in 1974. The Faculty of Civil Engineering, Architecture and Geodesy offers bachelor, masters and doctoral studies, and has a long tradition in research activities, especially computational mechanics and modelling. It is also the publisher of the *International Journal for Engineering Modelling*.

The city of Split offers a unique experience of ancient and medieval settings, notably within Diocletian's Palace, a UNESCO World Heritage Site, that forms the historical core of the city. The palace is not a static relic but a living part of the city, inhabited for over seventeen centuries. This long tradition of transformation and reuse strongly corresponds to engineering themes such as resilience, durability and multi-scale behavior of materials and structures, which is also the foundation for ongoing scientific projects at the Faculty of Civil Engineering, Architecture and Geodesy aimed at the preservation of the Diocletian's palace. In addition to its historical significance, Split serves as a gate to the beautiful Adriatic islands and to the exploration of the Croatian Mediterranean.

This 7th conference in the series continued the tradition of providing a platform for presenting recent advances in numerical modeling, multi-scale and multiphysics methods, and their applications across a wide range of engineering problems. In this edition, a significant number of machine learning and AI applications was presented as well. By bringing together researchers at different stages of their careers and from diverse disciplinary backgrounds, the conference achieved in its main missions to promote open scientific dialogue, establish new research ideas and partnerships.

2 Selected Papers

The primary objective of this conference was to present and discuss recent advances in computational methods applied to solids and fluids, with a particular focus on multi-scale, multiphysics, and numerical modeling approaches relevant to engineering problems. Additionally, these research directions

were enhanced by the growing role of machine learning and artificial intelligence, as well as their integration with classical modeling and numerical methods.

The conference proceedings [1], containing 78 extended abstracts, provide a comprehensive overview of the scope and scientific content of the event (Figure 1). A selection of six papers resulting from the presented works was included in this special issue in the form of scientific paper, with the aim of a representative snapshot of current research directions and methodological innovations discussed at the conference.

The paper by Emina Hajdo, Emina Hadžalić and Adnan Ibrahimbegovic investigates the elastic web buckling behavior of steel plate girders with transverse stiffeners using a geometrically nonlinear finite element formulation. A systematic parametric study examines the effects of web and stiffener thickness, stiffener spacing, and flange-stiffener connectivity on the critical buckling load. The results provide detailed insight into the sensitivity of elastic stability to key design parameters and clarify the governing mechanisms of web buckling in stiffened plate girders.

In the contribution by Duje Pavić, Noemi Friedman, Hermann G. Matthies and Mijo Nikolić, the authors address limitations of discrete lattice models in reproducing continuum elastic behavior, particularly with respect to lateral deformations and Poisson's ratio effects. A set of correction coefficients is introduced at the lattice element model and calibrated using a Bayesian stochastic identification framework based on standard mechanical tests. The proposed methodology significantly improves the accuracy and robustness of lattice models and establishes a reliable basis for subsequent nonlinear analyses, including crack initiation and propagation.

The work by Jaka Dujc presents a constitutive framework for predicting the long-term degradation of polymer electrolyte membranes in fuel cells under cyclic hydration and thermal loading. The model combines temperature and hydration dependent elasticity, swelling, and plasticity with a chemically activated pinhole growth mechanism. Numerical simulations reproduce key experimental trends and provide a physically consistent explanation of the coupled effects governing membrane durability and lifetime.

The study by Nerma Lazović and Ajla Mulaomerović-Šeta focuses on flood extent and flood hazard mapping for the Sanica River using advanced hydraulic modeling techniques. A calibrated unsteady 2D HEC-RAS model, incorporating LiDAR-based topography and updated hydrological data, is used to assess flood behavior for multiple return periods. By comparing 1D and 2D modeling results, the authors demonstrate how model dimensionality

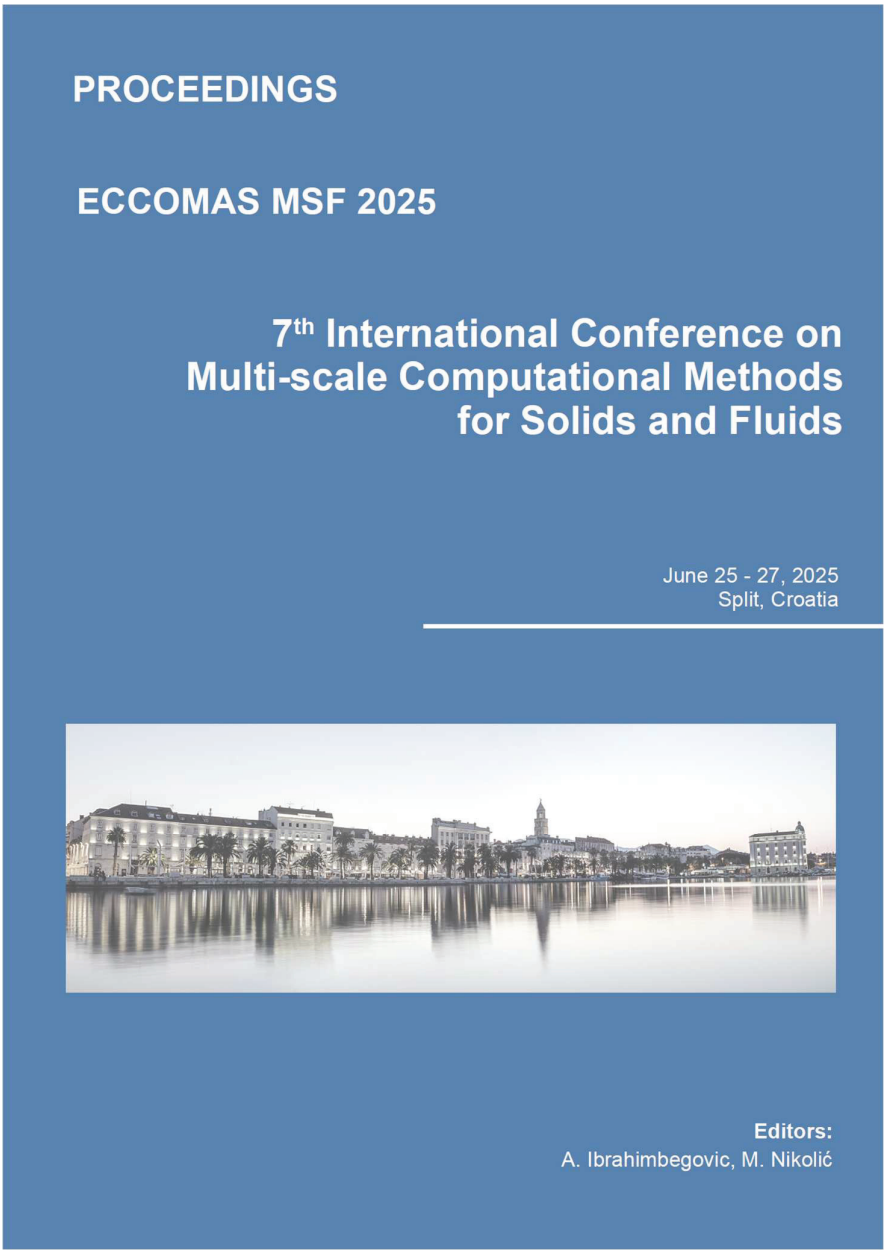

Figure 1 ECCOMAS MSF 2025 Proceedings.

can be efficiently selected based on reach-scale morphology, balancing accuracy and computational cost.

In the paper by Mohamed Taha Mhiri, Walid Larbi, Mnaouar Chouchane and Mohamed Guerich, honeycomb-based metamaterial substrates with positive and negative Poisson's ratios are investigated for piezoelectric energy-harvesting applications. The authors combine finite element simulations, neural-network-based surrogate modeling, and multiobjective evolutionary optimization to identify optimal geometric configurations. The results show notable improvements in power-to-mass ratio and a substantial extension of the operational lifetime of the piezoceramic layer, highlighting the potential of metamaterial-based harvesters for future applications.

Finally, Nives Brajčić Kurbaša, Blaž Gotovac and Vedrana Kozulić propose a mesh-free computational approach for small elastoplastic deformation analysis based on the Method of Variable Material Properties and atomic basis function collocation. By simultaneously updating elastic moduli and Poisson's ratio as smooth fields, the nonlinear problem is reduced to a sequence of linear elasticity problems. Validation against benchmark examples demonstrates high accuracy, numerical stability, and efficient convergence of the proposed formulation.

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References

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