*Mathematical and Computational Applications*

*Editorial*

# Mathematical and Computational Modelling in Mechanics of Materials and Structures

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The intersection of mathematics and computational modeling with the mechanics of materials and structural engineering continues to yield substantial advancements in both theoretical and applied domains. This Special Issue, titled **"Mathematical and Computational Modelling in Mechanics of Materials and Structures",** brings together contributions from researchers worldwide, each advancing methodologies and insights that are crucial for addressing the complex challenges in structural resilience, material behaviour, and dynamic system stability. The issue presents a diverse collection of research that pushes the boundaries of how we understand and model intricate material and structural interactions across various scales and applications.

Structural reliability and robustness are central themes, as exemplified by Jin, Liu, and He [1], who developed a mathematical model that integrates structural reliability and robustness through a strain energy evaluation index. Their findings provide a robust framework for understanding how structures withstand damage, enabling more informed maintenance and lifecycle management strategies. In a similar vein, the study by Moumen et al. [2] examines porous–elastic systems, focusing on nonlinear damping, infinite memory, and distributed delay. They demonstrate the well-posedness and stability of these systems, which are critical for applications involving complex wave propagation.

Dynamic behaviour and stability analyses are also prominent topics in this Issue. Usman, Abdallah, and Imran [3] apply an asymptotic perturbation method to investigate nonlinear stability in a ship rolling model, revealing how bifurcation parameters impact stability and making a vital contribution to the understanding of dynamic maritime environments. Extending this focus to dynamic systems, Grau Turuelo and Breitkopf [4] introduce an algebraic model to predict high-temperature annealed structures in silicon, which has practical applications for industries that rely on materials exposed to extreme conditions.

A meshless computational strategy has been developed to overcome challenges in analyzing higher-order strain gradient plate models, particularly for complex geometries and microscale effects. This approach eliminates the need for traditional meshing, offering both computational efficiency and improved accuracy in capturing refined material behaviors. The study demonstrates significant potential for applications in micro- and nano-engineering, particularly in the design of high-performance structures. The method and its findings are presented by Fabbrocino et al. [5], providing an advanced framework for modeling strain gradient continua.

The phenomenon of self-synchronization between non-ideal sources mounted on rectangular plates is explored with a focus on how time delay influences synchronization dynamics. The study highlights conditions leading to fast or late synchronization, offering new insights into vibration control and energy efficiency in mechanical systems. By combining theoretical analysis with computational modeling, this work provides a deeper understanding of synchronization in non-ideal systems. These findings, as discussed by Djanan et al. [6], have practical applications in optimizing systems sensitive to vibratory responses.

The behavior of porous-elastic materials under time-dependent swelling is analyzed through a theoretical framework that incorporates memory-type constitutive models. This approach captures the intricate interplay between swelling and deformation, offering predictive tools for applications in fields like geomechanics and bioengineering. Computational simulations validate the theoretical model, showcasing the material's complex responses to various loading conditions. The work, conducted by Al-Mahdi et al. [7], provides valuable insights into optimizing porous-elastic systems for diverse engineering and biomedical applications.

Material properties, particularly those of composites and auxetic structures, are explored from multiple perspectives. Sotiropoulos and Tserpes [8] apply an interval-based method to assess uncertainty in unidirectional composite materials, quantifying the effects of material variability on structural performance. This complements the work by Yin et al. [9], who introduce a novel orthogonal polynomial method for auxetic structures. Their method accounts for epistemic uncertainties, significantly enhancing the predictability of auxetic materials, which are valued for their unusual deformation characteristics. Another standout pieces of composite research, by Pittella et al. [10], provides a microwave characterization of PA6/GNP composites. Their findings have implications for electromagnetic interference shielding, showcasing how composite properties can be optimized for advanced electronic applications.

Several contributions advance computational methodologies to improve the accuracy and efficiency of modeling. Al-Gharabli et al. [11] analyze viscoelastic plates with nonlinear frictional damping, deriving decay rate estimates that are critical for stability assessments in viscoelastic systems. Additionally, Naderian et al. [12] introduce an integrated finite strip method for simulating hybrid fiber-reinforced polymer bridge systems. Their model enhances the efficiency of analyzing these structures, which is particularly relevant in ultra-long span bridges. Furthermore, the research by Mirzaee Kakhki et al. [13] on high-order shape functions using the semi-analytical finite element (SAFE) method highlights how wave propagation problems can be effectively addressed using advanced computational techniques.

The issue also delves into the use of innovative modeling approaches for specific applications. In biomedical engineering, Gupta and Chanda [14] utilize hierarchical metamaterial-based patterns for skin-grafting applications. Their findings demonstrate the potential for greater expansion in skin grafts, presenting a breakthrough for burn treatment and tissue engineering. Similarly, Garg et al. [15] investigate the use of adhesive materials for crown and crown–root fractures in dental applications, utilizing computational modeling to assess the effectiveness of different adhesives in mitigating traumatic injury stress. This biomedical focus is complemented by Mechkour [16], who models perforated piezoelectric plates, analyzing how specific structural dimensions influence effective properties, thus broadening the scope of piezoelectric applications.

Thermoelastic stress analysis (TSA) is also highlighted by Duarte et al. [17], who created a finite element model to simulate TSA's effectiveness across different materials and loading conditions. Their study provides a comprehensive tool for analyzing structural integrity through thermal imaging, which is increasingly relevant for non-destructive testing. Finally, Mubaraki [18] offers an in-depth examination of Rayleigh waves in coated orthorhombic half-spaces, presenting a pseudo-differential model that captures the essential characteristics of elastic surface waves—a model with broad implications for seismic and material sciences.

In summary, this Special Issue presents a compelling array of studies that leverage mathematical and computational approaches to deepen our understanding of materials and structural behaviour. From dynamic stability in engineered systems to the nuanced performance of composites, the research showcased here demonstrates the power of interdisciplinary collaboration and innovation. These contributions not only enhance the predictive capabilities of computational models but also provide practical insights for engineers, material scientists, and biomedical researchers alike.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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