THE ROLE OF HIGHER-ORDER FINITE ELEMENTS IN THE ANALYSIS OF MULTILAYERED AND MULTIFUNCTIONAL STRUCTURES

Enrico Zappino

Mul2 Team, Politecnico di Torino

The use of composite materials has brought evident advantages in the fields of aerospace engineering. At the same time, numerical models built on the foundation of classical theories are no longer effective due to the complexity introduced by multilayer materials. Orthotropic properties, interlaminar interfaces, and matrix/fiber interaction originate complex stress fields than cannot be predicted using simple kinematic models. Complexities are even more evident when multifunctional materials are considered that is, additional fields interact with the mechanical domain leading to even more complex strain and stress fields.

Among the advanced approaches proposed in recent years to increase predictive capabilities in the analysis of composite materials, the Carrera unified formulation has proven to be very effective in the multi-field analysis of multilayer structures.

This seminar aims to illustrate the latest innovations in the context of Carrera unified formulation and how they can play a key role in the study of next-generation composite structures. The talk will introduce, at first, the main features of the mathematical formulation by highlighting its compactness and the generality of the formalism. The advantages of utilizing advanced models, whether one- or two-dimensional, will be illustrated through a discussion of classical benchmarks and results obtained for more complex configurations. The impact of using this formulation in the multifield analysis will then be discussed with a focus on thermo-elastic and piezo-mechanical applications. Particular attention will be paid to the computational advantages introduced by the formulation and the capabilities of developing global-local models without the need for dedicated strategies. In conclusion, more recent extensions of this approach will be discussed, particularly with the application to virtual manufacturing of composite materials, an area in which the development of accurate predictive tools could lead to significant performance and economic advantages.