# A novel refined 1D model for the accurate stress analysis of composite structures with arbitrary curved sections

E. Carrera*, A.G. de Miguel, A. Pagani

Department of Mechanical and Aerospace Engineering, Politecnico di Torino,
Corso Duca degli Abruzzi 24, 10129 Torino, Italy.

**Abstract** This paper presents a novel one-dimensional refined model to deal with the analysis of composite structures with any-complex geometry of the cross-section. During the last decades, multilayered structures have been progressively introduced by the industry and nowadays they are used not only in second level components, but also for main structural parts, such as wings and automotive chassis. Commercial codes based on solid elements are widely used by structural engineers, but they are not always suitable to capture the complex stress fields of composite structures, and the generation of detailed macro-scale models require prohibiting computational efforts. In this context, the Carrera Unified Formulation provides a efficient tool to devise structural models for layered structures that are able to obtain highly accurate solutions at a global-local level with great benefits in terms of computational costs. In its 1D version, the CUF enables to generate refined beam models which are independent of the order and class of theory of structure. A component-wise approach based on the use Legendre-type polynomials has been developed to expand the mechanical variables over the cross-section of laminated structures from the macro scale up to the fibre-matrix scale. In this manner, the kinematic field is enriched with an arbitrary number of higher-order terms that are introduced in the model as an user input. Moreover, the blending function method is proposed in this work as a mapping technique to obtain geometrically-exact models that are able to represent any curved shape of the section. Shear locking phenomena is overcome by the use of mixed interpolated beam elements along the axis. The MITC method allows also to represent correctly the complete state of stress of the structure, which is of major importance to understand composite-related phenomena, such as delamination and matrix debonding. Several numerical examples are included and the results are compared with those of the literature, if possible, as well as solid solutions obtained from commercial softwares.

*Corresponding author: erasmo.carrera@polito.it