Development of accurate and efficient structural models for analysis of multilayered and sandwich structures of industrial interest

Abstract

The purpose of this thesis is the development of accurate and efficient structural models for the analysis of multilayered and sandwich structures. Starting from the 3-D zig-zag adaptive (ZZA) theory by Icardi and Sola, a number of variants are created, in order to understand when transverse displacement representation is essential, or, vice versa, a simpler kinematics can be assumed. Higher-order theories are developed both in mixed and displacement-based forms and their coefficients are redefined for each layer across the thickness and calculated by imposing the full set of physical constraints of the parent theory (ZZA). Using this approach, zig-zag functions can be changed or omitted, those describing the variation of displacements across the thickness can be assumed differently for each displacement component and from point to point across the thickness. On the contrary, the accuracy of lower-order theories that do not have these features become strongly case dependent. Such findings are confirmed by means of numerous challenging benchmarks. Different loading (both localized and distributed) and boundary conditions are examined for elastostatic cases, where laminations with strongly asymmetries are also studied. Also damaged lay-ups are analysed, because this conditions could occur during service life and structural models should be able to accurately capture this. Moreover, the capability of theories to precisely calculate natural frequencies, to describe response to impulsive blast pulse loading and to catch effects on pumping vibrations of soft-core sandwiches are tested. Impact damage analysis and two-material wedge problems are also approached. A generalization of the adaptive zig-zag theory by Icardi and Sola is also presented, whose particularizations have the same accuracy of the parent theory but lower processing time, thus a higher efficiency. Such theory is able to match the results of most used formulations in the literature and, thanks to its simple displacement field, is the most suitable to apply the Strain Energy Update Technique. Such technique allows to get accurate C0 finite elements and to improve the results of the analyses obtained by means of commercial finite elements software.