Advanced FEs for the analysis of composite structure with global/local and node-dependent kinematics approaches

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In the modern engineering, composite structures are widely adopted, especially in the aerospace industry. The outstanding mechanical propoerties which they ensure are due to their heterogeneous nature. However, this gives rise to significant challenges to numerical modeling. For this purpose, a great variety of structural models has been proposed in history. Models based on classical theories are capable to detect the structural behavior of slender structures, whereas when the transverse stresses of cross-section (for beams) or thickness (for plates/shells) need to be accurately described, refined models have to be included. Generally, the accuracy of the model can be achieved by increasing the order of the mathematical function used for the description of the cross-secion or thickness. This automatically leads to an increased number of degrees of freedom in FE models and makes the solution computationally expensive. However, a local refinement of the model, where higher-order phenomena are expected to occur, can help to reach a compromise between the desired accuracy and solution expenses. The local refinement can be achieved adopting the global/local (see [1]) or the Node-Dependent Kinematics (NDK) (see [2]) approaches. The former distinguishes the kinematic theories at the FE level, whereas the latter at the structural node level. The present work wants to apply these two mathematical techniques for the static analysis of composite structures in the framework of the Carrera Unified Formulation ([3]). In fact, this formulation allows to build FEs with low-order Equivalent Single Layer (ESL) theories and refined Layer-Wise (LW) theories with ease and to mix them within the global/local and NDK scenarios. Several analyses are carried out employing 1D beams and 2D plates/shells models, showing the applicability of the two approaches and the advantages in terms of accuracy and computational saving that they guarantee.

References

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