Higher order theories for the static and dynamic analysis of anisotropic shell structures

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Abstract. In this contribution we present a generalized approach for the static and dynamic analysis of doubly curved shell structures laminated with generally anisotropic materials. Based on Higher Order Shear Deformation Theories (HSDTs), the three-dimensional static and the dynamic response of structures of very complex shapes is detected using a two-dimensional approach. The fundamental equations are obtained from the Hamiltonian Principle, and they are numerically solved by the Generalized Differential Quadrature (GDQ) method. The accuracy of the methodology is pointed out in some validating examples. Then, parametric investigations are performed on many laminated shells of different materials and shapes.

Theoretical aspects and numerical strategies

New advances in several engineering fields require alternative approaches for the numerical modelling of innovative materials and structures of very complex shapes. In this context, the geometric description is a key factor for an efficient prediction of the structural response. Referring to the evaluation of the unknown field variable, Higher Order Shear Deformation Theories (HSDTs) [1] are used with a generalized formulation so that the three-dimensional response of doubly-curved structures laminated with generally anisotropic materials is predicted with a reduced computational effort (Figure 1). The present continuum-based model is based on an efficient homogenization of the constitutive material, taking into account all the possible coupling and stretching effects that occur in very complicated lamination schemes. Furthermore, an effective strategy for the assessment of surface and point loads is presented [2]. As far as the solution of the problem is concerned, the GDQ method is adopted to solve the fundamental equations directly in the strong form using a very little number of degrees of freedom [3]. Once the two-dimensional solution is derived, an efficient post-processing technique leads to an accurate prediction of the three-dimensional response of the structure even though the proposed formulation provides a two-dimensional solution of the problem under investigation.

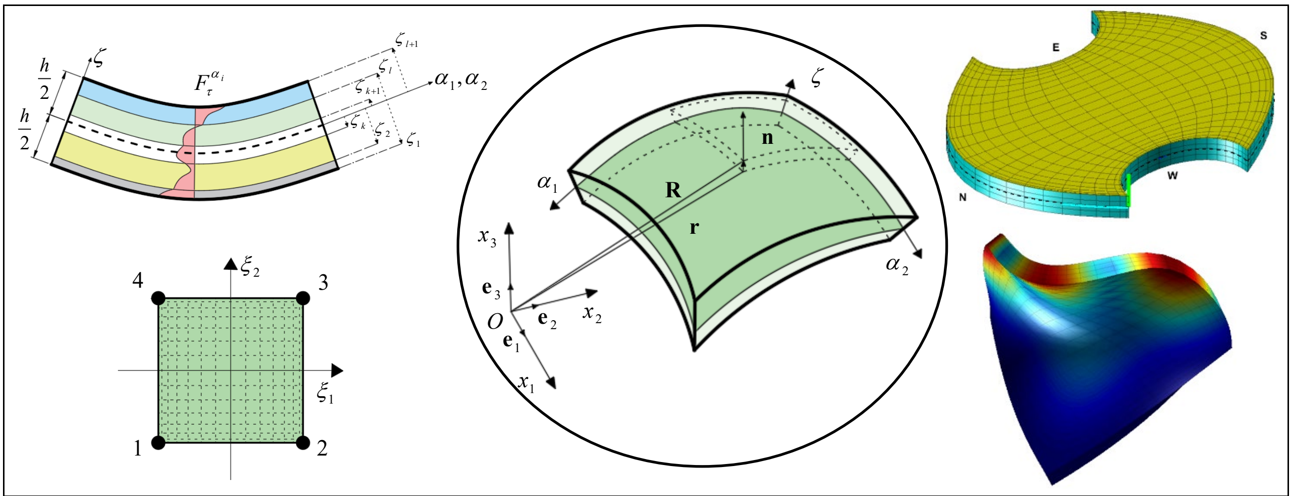

Figure 1: Two-dimensional GDQ modeling of laminated anisotropic doubly-curved shell structures.

Numerical examples and parametric investigations

The accuracy of the present higher order model is verified in a series of validating examples performed on structures of different shapes and materials, where the numerical results are compared to those coming from refined three-dimensional Finite Element models. Structures of different shapes and materials are studied, taking into account in the lamination scheme, among others, honeycomb cells, Functionally Graded Materials (FGMs) and Carbon Nanotubes (CNTs) [3]. Furthermore, the effect of a general variation of the constituent material is considered, as well as the presence of porosity. Finally, systematic parametric investigations are carried out in order to show the sensitivity of the geometry and the materials used.

References

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