11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

COUPLING OF LAMINATED COMPOSITE STRUCTURES IN THE FRAMEWORK OF ISOGEOMETRIC ANALYSIS

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Key words: *Strong/Weak Coupling, Isogeometric Analysis, Composite Laminates, Layerwise Theory.*

The concept of isogeometric analysis (IGA) aims to bridge the gap between computer aided design (CAD) and finite element analysis. IGA follows the isoparametric idea of representing the physical solution field with the same smooth, higher-order and higher-continuity NURBS basis functions that are used for the graphical representation of CAD geometries. The potential of this paradigm has been documented in a large number of proof-of-concept studies and benchmark solutions and shows superior properties compared to the finite element method (FEM) in many fields of applications. In the framework of laminated composite structures the IGA characteristic k-refinement facilitates a continuity controllable ply-model generation as required for analyses following a layerwise theory [1].

Layerwise theories (LW) consider separate stiffness contributions for each layer, thus avoiding a homogenization of the elasticity properties through the composite's thickness. They provide accurate stress fields equivalent to 3D models at reduced numerical costs but require the NURBS functions approximating the displacement field to be C^0-continuous at the interface between plies of different fiber angle orientation to ensure the balance of linear momentum and continuity of the traction field in multilayered composites. Equivalent-single-layer (ESL) methods are computationally even less demanding and may predict the global response of thin composite laminates accurately, but often fail to capture the three-dimensional stress field at the ply level in moderately thick and thick laminates. A patch-wise coupling of both theories, ESL and LW, allows to optimize industry relevant analysis models consisting of dozens of trimmed NURBS patches with regard to the structural needs for a reliable, highly accurate and computationally reasonable numerical prediction of the structure's mechanical properties. In this contribution we present strong and weak, Nitsche-based [2], coupling results for multi-patch composite structures including various laminate theory models.

We focus on in-plane and through-the-thickness modeling of laminate composite beams and shells and their patch-wise coupling (Figures 1,2). We demonstrate that the IGA weak coupling concept, enriched by a ficititious domain extension, is capable to combine conforming and non-conforming and even trimmed patches without compromising the accuracy of the analysis.

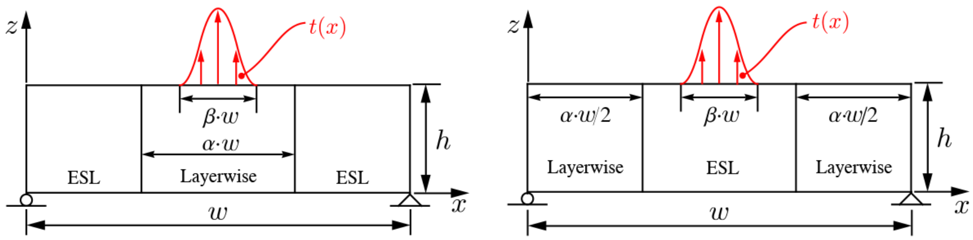

Figure 1: Hybrid multi-patch model of a laminate composite structure subjected to a bell-shape distributed surface load. The model couples patches based on an equivalent single layer theory (ESL) and a 3D equivalent layerwise theory.

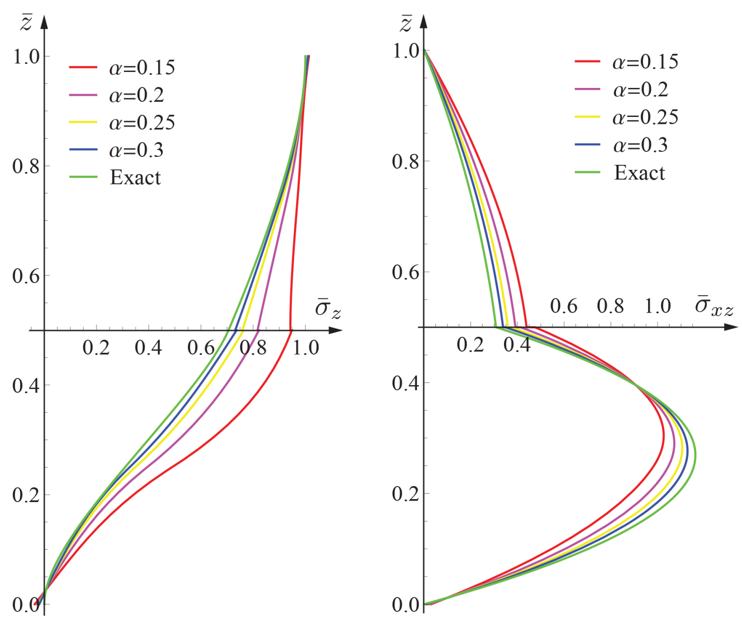

Figure 2: Through thickness stress distribution: transverse normal and shear stresses for different aspect ratios α of the layerwise model patch.

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