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Component-Wise Method for Macro-Meso-Micro Modeling and Failure Analysis of Composite Structures

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This work assesses the advanced capabilities of the Component-Wise approach (CW) to model composite structures, with particular attention paid to the failure analyses. The CW has been recently proposed as an approach to model complex structures with far less degrees of freedom than classical shell and solid finite elements [1]. The CW exploits refined beam models based on the Carrera Unified Formulation (CUF) [2] to model each component of the structure. The classical finite element, 1D approach is used along one direction. On the other hand, the unknown variables are expanded over the remaining two local coordinates via Legendre polynomials, referred to as Hierarchical Legendre Expansions (HLE) [3]. Also, non-local expansion domains with curved boundaries are defined to capture the exact shape of the constituents independently of the refinement of the model. Figure 1 shows some examples of the modeling strategies allowed by the HLE models for a multi-layered plate. In particular, direct numerical simulation and homogenization cases are considered. The main strategies are the following:

- The classical Equivalent Single Layer (ESL) and Layer-Wise (LW) approaches. The macro- and mesoscales are considered.
- The CW approach in which the single fiber-matrix cells are considered. In other words, the structure is modeled up to the microscale.
- Global-local models in which ESL, LW and CW coexist.
- In a homogenization scenario, the CW may be used to model the unit cells or the representative volume elements and ESL and LW to model the macro, homogenized structure.

In all the cases described above, only HLE, 1D models are used. Also, any combination of the four strategies may be considered, and, for the macro- and mesoscale, CUF plates and shells can be exploited too.

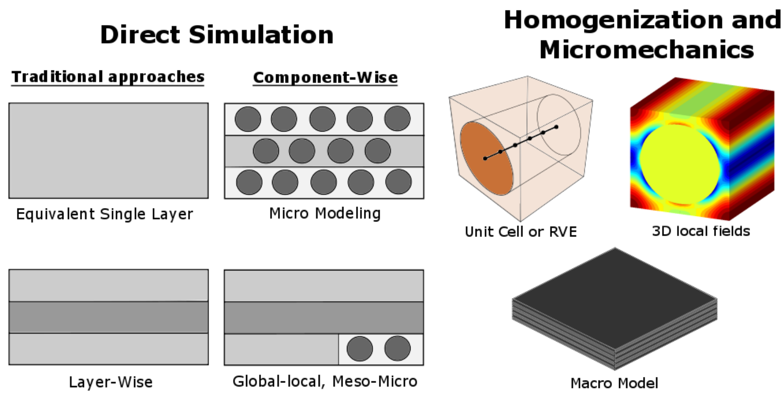

Figure 1. Modeling strategies for a multi-layer plate via HLE models.

Figures 2 and 3 show typical results obtained via the present formulation. The former presents the stress field distribution along a fiber-matric cell. The latter the micromechanical damage propagation in a randomly distributed fiber composite. In both cases, only 1D models were used. Further results will assess the accuracy and computational cost of the present formulation considering more complex structures and various modeling strategies.

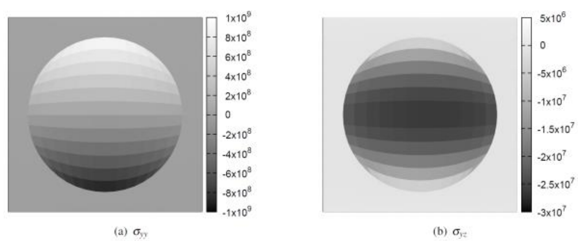

Figure 2. Longitudinal and transverse shear stress in a fiber-matrix cell, 9114 DOFs [4].

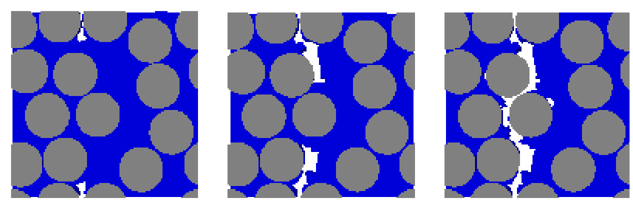

Figure 3. Micromechanical damage propagation, 34110 DOFs.

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