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A NON-INTRUSIVE GLOBAL-LOCAL APPROACH FOR THE COUPLING OF LAMINATED PLATES AND 3D MODELS

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The simulation of composite structures requires to take into account critical phenomena (like delamination) happening at small scales. This leads to very large nonlinear problems. Our purpose is to reduce the complexity of the problem by a non-intrusive coupling a plate model with a 3D modeling near critical areas, in order to create an efficient and accurate hybrid model (figure 1,2).

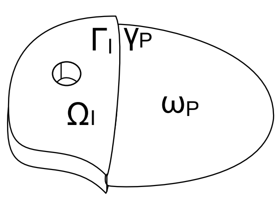

Figure 1: Hybrid modeling of a thin structure

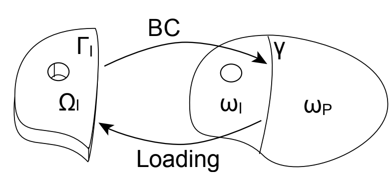

Figure 2: Iterative process

Classically, industrial computations deal with these problems through sub-modeling techniques: boundary conditions are deduced from a global plate computation and local 3D computations are conducted in critical areas. Unfortunately, these techniques neglect the effects of local evolutions on the global problem, which can lead to important errors on the engineering quantities of interest.

We propose a strategy based on a non-intrusive coupling technique [1]. The hybrid 3D-plate model is defined as the limit of an iterative process, which alternates global-plate and local-3D computations. The method makes use of two overlapping models, a 2D one (plate or shell, which remains unchanged during the whole analysis) and a 3D refined one, where structural details or complex non-linearity, such as contact or delamination, can be introduced. In the overlapping region the plate model can therefore be seen as a fictitious domain/model, and it is virtually substituted by the 3D model. Nevertheless the effectiveness of the method is better when the plate model is somehow the homogenized counterpart of the 3D one. One interest of the method is that the 3D domain of interest can be treated with dedicated research software with most advanced models and solvers.

The zooming step requires the definition of recovered 3D quantities from the plate computation. The calculation of analytic corrected kinematic or static fields is possible but would require complex reconstruction of higher derivatives, which would be quite intrusive. So, in the spirit of homogenization, we propose to pre-compute localization operators which relate 2D quantities to 3D ones by means of appropriate "cell problems". The associated stress and warping distributions can the be used in order to define various boundary conditions on the 3D problems (Neumann, weak [2] and strong Dirichlet). The global correction step is a plate resolution with updated loading inside the zone of interest. As the local computations can be slightly contaminated by edge effects, we add a small 3D buffer layer, to absorb the local effect. Using this coupling along two interfaces open new opportunities related to Optimized-Schwarz methods, like using a preconditioned conjugate gradient to solve the resultant problem always in a non-intrusive way. This method was implemented in a *Python* script which drives two instances of *Code_Aster* (for both the global and local resolutions) in [3].

A typical example of application is the bolted assembly of two plates. Here the basic connector between two plates is virtually substituted by a full 3D model with contact. The global model is solved with *Code_Aster* and the local model can be solved with *COFAST3D*, which is a software developed in LMT-Cachan and dedicated to contact problems. (figure 3).

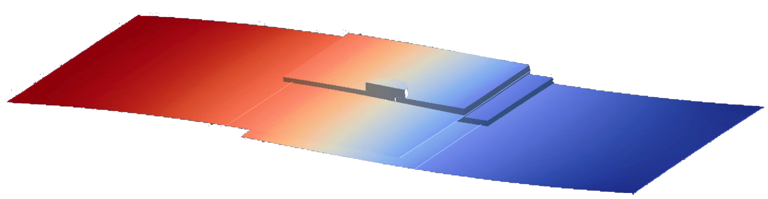

Figure 3: Example on a two plate assembly, the connector is replaced by a full 3D model with contact.

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