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Towards exact and scalable computational multiscale strategies for delamination analysis

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ABSTRACT

Despite many studies since the beginning of the eighties, the prediction of delamination remains a scientific challenge. Moreover one industrial objective is to replace some of the numerous experimental tests by numerical simulations, in other words to perform Virtual Delamination Testing (VDT). The novelty is that now industrials trust such a numerical prediction is possible. Indeed, in the last twenty years, there have been many advances toward a better understanding of damage mechanisms and the mechanics of laminated composites, both on the microscale and on the mesoscale [1-3] coupled with the development of advanced anisotropic material models.

It seems that today one of the main breakthrough that could be done concerns the robust multiscale computation of delamination. Unfortunately the use of micro or meso models leads, even for simple specimens, to enormous difficulties such as the huge required number of d.o.f.. Hence the simulation of industrial structures is not affordable with traditional computational approaches. Therefore delamination computation appears to be a fantastic playground for all the emerging computational techniques and in particular multiscale strategies and X-FEM [4-8].

Our aim is to be able to compute the delamination response of large and possibly thick composite structures. The delamination is here taken into account by means of damageable interfaces [2]. We have chosen to adopt the multi-scale framework proposed in [4] because of the mixed (normal stress, displacement) character of this Domain Decomposition Method which allows an easy implementation of non-linear interfacial constitutive laws. Three scales are involved the macro-scale of the plate the meso-scale of the ply and the micro-scale associated with a fine discretization of each ply especially needed to properly describe the solution in the vicinity of edges and delaminating fronts. Due to the localization of delamination its computation for large structures implies the use of many meso-sub-domains and therefore the extensible character of the method is a mandatory requirement. In this case this led us to modify

the iterative strategy in order incorporate the macro-effect of the delamination crack in the macro-part of the solution. Contrary to what has been possible in [9] this effect is introduced here implicitly by means of sub-iterations. The meso problem which involves many sub-domains needs also to be solved iteratively. At present we use an iterative solver of BDD type as described in [10]. First examples show the feasibility and efficiency of the method. Current works concerns the introduction in the iterative process of a 3D like plate solution as a third scale.

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