Non-Intrusive Coupling of Abaqus and a 3-D Scale-Bridging Generalized Finite Element Method

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ABSTRACT

In many engineering applications, it is necessary to account for interactions among multiple spatial scales through numerical simulations. Resolving fine-scale features such as cracks and localized nonlinearities with high fidelity is critical for the accurate prediction of service life or failure of structures. Three-dimensional models with detailed meshes and advanced modelling techniques are usually required to capture accurate fine-scale responses. However, adopting such models on the structural/global-scale is computationally inefficient and sometimes unfeasible for problems involving a large number of local features. A coarse mesh is often sufficient for predicting the global behaviour of a structure.

In this talk, we present a multi-scale computational framework that couples Abaqus models and 3-D Generalized FEM discretizations based on numerically-defined enrichment functions – the GFEM^{gl}. The structural-scale problem is modelled in Abaqus using a coarse mesh of 3D or shell elements suitable for capturing the macro-scale response of the structure. Fine-scale problems solved in parallel provide enrichment functions for the GFEM^{gl}. These functions enable the GFEM^{gl} to accurately approximate localized phenomena such as crack propagation using coarse meshes. The interactions between structural (Abaqus) and GFEM^{gl} models are captured using the Iterative Global-Local method (IGL). In this method, global-scale displacements are passed to GFEM^{gl} models as boundary conditions while residual forces along the interface between the two models are applied to the structural model.

The proposed multiscale framework is non-intrusive in the sense that only standard output quantities from the finite element simulations are exchanged during the coupling process. The interaction between Abaqus and the GFEM^{gl} solver requires no knowledge of the discretization technique adopted in the other solver. Numerical examples of a T-joint structure subjected to fatigue crack propagation are presented to demonstrate the accuracy and applicability of the proposed framework.