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Title of Dissertation/ Thesis: Investigative Application of the Intrinsic Extended Finite Element Method for the Computational Characterization of Composite Materials

Institution conferring degree: Virginia Tech

Degree awarded (abbreviate; e.g., Ph.D.): M.S.

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Committee Member: Dr. Alan Brown

Committee Member:

Committee Member: Dr. Rakesh Kapania

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Investigative Application of the Intrinsic Extended Finite Element Method for the Computational Characterization of Composite Materials

Sebastian P. Favè

Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Master of Science
in
Aerospace Engineering

Gary D. Seidel, Chair
Alan J. Brown
Rakesh K. Kapania

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Investigative Application of the Intrinsic Extended Finite Element Method for the Computational Characterization of Composite Materials

Sebastian P. Favè

(ABSTRACT)

Computational micromechanics analysis of carbon nanotube-epoxy nanocomposites, containing aligned nanotubes, is performed using the mesh independent intrinsic extended finite element method (IXFEM). The IXFEM employs a localized intrinsic enrichment strategy to treat arbitrary discontinuities defined through the level-set method separate from the problem domain discretization, i.e. the finite element (FE) mesh. A global domain decomposition identifies local subdomains for building distinct partition of unities that appropriately suit the approximation. Specialized inherently enriched shape functions, constructed using the moving least square method, enhance the approximation space in the vicinity of discontinuity interfaces, maintaining accuracy of the solution, while standard FE shape functions are used elsewhere. Comparison of the IXFEM in solving validation problems with strong and weak discontinuities against a standard finite element method (FEM) and analytic solutions validates the enriched intrinsic bases, and shows anticipated trends in the error convergence rates. Applying the IXFEM to model composite materials, through a representative volume element (RVE), the filler agents are defined as individual weak bimaterial interfaces. Though a series of RVE studies, calculating the effective elastic material properties of carbon nanotube-epoxy nanocomposite systems, the benefits in substituting the conventional mesh dependent FEM with the mesh independent IXFEM when completing micromechanics analysis, investigating effects of high filler count or an evolving microstructure, are demonstrated.

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