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FE^2 MULTISCALE APPROACH OF GEOMETRICALLY NONLINEAR CARBON NANOTUBE REINFORCED COMPOSITES

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ABSTRACT

Main purpose of the present study is to investigate the behavior of carbon nanotube reinforced composites (CNT-RCs) subjected to geometrically nonlinear analysis using a multiscale simulation. At first, the atomic lattice of wavy CNTs is modeled according to the molecular structural mechanics approach (MSM) with geometrically nonlinear space frame elements between the bonds. Load-displacement curves are obtained under various loading conditions using non-linear finite element analysis. This nonlinear space frame structure is then projected to an equivalent nonlinear beam element (EBE). In both cases, the material properties are assumed to be linear. Subsequently, finite element models of representative volume elements (RVEs) are constructed comprised of two independent meshes: one with continuum four nodded quadrilateral elements for the matrix and a series of embedded EBEs for the full length CNTs inside the matrix. The multiscale simulation is performed in the context of a FE2 approach in which random RVEs are assigned to each Gauss point of the macrostructure using a nested nonlinear solution procedure. For this purpose, random wavy CNTs geometries are generated using the spectral representation method with evolutionary power spectrum. Numerical examples and their results examine the effectiveness of the CNTs' wavy geometry and the importance of geometric nonlinearities in the CNT-RCs behavior.