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PROBABILISTIC CHARACTERIZATION OF STIFFNESS AND STRENGTH PROPERTIES OF CARBON-NANOTUBE-REINFORCED-POLYMER-COMPOSITE MATERIAL

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ABSTRACT

The mechanical properties of polymeric materials can be enhanced by using carbon nanotubes as reinforcement. The resulting materials, known as nanocomposites, possess superior mechanical properties. However, studies still need to be carried out to fully characterize such materials, especially their variability due to the imperfections caused by practical manufacturing. Attributes to this variability include missing carbon atoms and imperfections in the nanotube and interface property variations. Experimental investigations for this purpose have limitations. Hence, computational modeling and simulation encompassing multiscale material behavior provides an alternate methodology to study the material behavior. Such a methodology combined with a probabilistic framework and analysis is developed in the present work. Therefore, the objective of the present work is to perform a probabilistic simulation and analysis of a Carbon-Nanotube-Reinforced-Polymer-Composite (CNTRPC) material to determine the probabilistic aspects of its stiffness and strength properties. The CNTRPC material is represented by developing a 3D multiscale finite element model of the Representative Volume Element (RVE) of the nanocomposite material. The nanocomposite model consists of a polymer matrix, an imperfect Single-Walled-Carbon-Nanotube (SWCNT) and an imperfect interface. The polymer matrix is modeled with the Mooney-Rivlin strain energy function and the imperfect interface region is modeled via van der Waals (vdW) links. The imperfect SWCNT is modeled as a space frame structure by using the Morse potential. In practical applications, the SWCNT and the vdW links are not perfect, and they possess structural defects. These defects are characterized using the Monte Carlo Simulation (MCS) technique. The probability distributions of stiffness and strength properties are determined based on relative frequency approach and an artificial neural network along with parametric Gaussian and two-parameter Weibull distributions. The most accurate distribution is determined. The probabilistic parameters of the Young's modulus and tensile strength of the CNTRPC material are determined.

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