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三维机织复合材料细观黏弹性梁模型

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Visco-elastic Meso Beam Model of 3D Woven Composites

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摘要 建立了两种组合梁模型，分别模拟3D机织复合材料内部和表面纤维束的细观结构，模型反映了纤维束细观结构和变形的周期性，考虑了纤维束的局部弯/剪耦合效应和局部偏轴效应。实验确定了一种树脂基体各向同性蠕变本构的参数，在此基础上建立了纤维束横观各向同性的蠕变本构模型，将基体和纤维束的蠕变本构应用于上述细观组合梁模型，用于分析3D机织复合材料宏观平均的黏弹性应力 应变响应。用上述模型分析了一种环氧树脂/玻纤体系3D机织复合材料的细观应力分布和平均宏观模量，模拟了其蠕变、弹性回复曲线，模型预测与实验结果吻合。

关键词： 3D机织复合材料 细观力学 局部弯/剪耦合效应 局部偏轴效应 组合梁单元 黏弹性

Abstract： Two combined beam models are developed to represent respectively the meso structures of inner and surface fiber bundles in 3D woven composites. The periodicities of meso structures and meso deformation are contained in the models. The effects of local bending/shearing coupling and local off axial tension of fiber bundles are taken into account. An isotropic visco-elastic constitution, used to describe resin matrix, is calibrated by a resin creep experiment. Based on it, a transverse isotropic visco-elastic constitution is suggested for characterizing the creep behaviors of fiber bundles. These two visco-elastic constitutions are employed in the combined beam models to predict the overall visco-elastic responses of 3D woven composites. This visco-elastic combined beam model is applied to a 3D woven epoxy resin/glass fiber composite. The local stresses and average elastic constants are predicted and creep elastic recovering curves are simulated. Model predictions are in good agreement with experiment data.

Keywords： 3D woven composites meso mechanics local bending/shearing coupling effect local off axial tension effect combined beam element visco-elasticity

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