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Modeling of moisture diffusion in permeable fiber-reinforced polymer composites using heterogeneous hybrid moisture element method

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Summary

A two-dimensional heterogeneous hybrid moisture element method (HHMEM) for modeling transient moisture diffusion in permeable fiber-reinforced polymer composites is proposed in this paper.

The HHMEM scheme is based on a heterogeneous hybrid moisture element (HHME), whose properties are determined by equivalent moisture capacitance and conductance matrixes calculated using the conventional finite element formulation with the similarity mass/stiffness property and matrix condensing operations. A coupled HHME-FE scheme is developed and implemented in computer codes MATLAB to analyze the transient moisture diffusion characteristics of polymeric composite materials containing multiple permeable fibers. The analysis commences by comparing the performance of the proposed scheme with that of the conventional FEM in modeling the moisture diffusion process. Both hexagonal and square fiber arrangements are studied. Having validated its performance, the scheme is then employed to investigate the relationship between the volume fraction of the permeable fibers in the resin composite and the rate of moisture diffusion. It is found that moisture diffusion is retarded significantly as the volume fraction of fibers increases.

The HHMEM approach proposed in this study provides a straightforward and efficient means of modeling transient moisture diffusion in polymeric composite materials containing multiple permeable fibers since only one HHME moisture characteristic matrixes of fibers needs to be calculated for all HHMEs sharing the same characteristics. Furthermore, different volume fractions can be modeled without modifying the original model simply by controlling the size of the inter-phase region within the HHME domain.