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A Micromechanical Model for Wave Propagation in Plain-Weave Textile Composites

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[Abstract] In this paper we adapt and extend the results of a recently developed continuum mixture model to study wave propagation interaction with plain weave textile composites. The original model, which was first used to study wave propagation in bi-laminated composites, is based on approximate distributions for some of the transverse stress and displacement components. This results in two coupled partial differential equations describing the micromechanical behavior of the layered composite. Next, we idealize the complex weave unit cell into segments of bi-laminated composite, which geometrically model the undulation. Formal solutions for the two coupled equations are then obtained in each of the segments. Finally, the transfer matrix method is used to relate the solutions at one end of the idealized unit cell to the other, to obtain the unit cell global transfer matrix and to derive the dispersion equation of the system. The procedure is applied to a graphite-epoxy plain-weave composite and several characteristics are observed. Very good convergence is achieved using only a small number of segments.

Nomenclature

A	=	transfer matrix of a composite segment
a	=	length of the straight part of the idealized unit cell
b	=	length of the tapered part of the idealized unit cell
C	=	stiffness matrix of the weave tow
c	=	wave speed
d	=	half minimum height of the idealized unit cell
h	=	half thickness of the yarn
L	=	length of the idealized unit cell
n	=	number of segments in tapered part
n_1	=	volume fraction of weft
n_2	=	volume fraction of warp
t	=	time
U	=	displacement amplitude
u	=	displacement vector
V	=	displacement amplitude ratio
α	=	characteristic value
ρ	=	density of the weave material
σ	=	stress tensor
ω	=	angular frequency of the propagating wave
ξ	=	wave number

I. Introduction

Textile Composites in general, and plain-weave fabrics in particular, proved to be complex, structural materials with the potential of enhancing many of the shortcomings of conventional layered or fiber-reinforced composites. Plain-weave composites consist of two sets of interlaced fibers, known as the warp and the weft tows.

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