MULTISCALE ANALYSIS OF MATERIAL DAMPING PROPERTIES FOR TEXTILE COMPOSITES

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INTRODUCTION

Material damping represents the cumulative contributions of the viscoelastic response of the constituents, cyclic heat flow and the friction at the fiber/matrix interface. Recent work on the material damping of FRP has shown that the composite damping depends on an array of micromechanics and laminate parameters, including constituent material properties, fiber volume fraction, stacking sequence and so on. These studies, however, are mostly limited to unidirectional composites. On the other hand, textile composites are applied to many fields such as the space structures, sports items. Though many researchers have reported the static characteristics of textile composites, the material damping of those materials have not been investigated.

In this paper, material damping analysis for textile composites based on mesh superposition method has been proposed.

MULTISCALE ANALYSIS OF MATERIAL DAMPING

In the present work, the general vibration equations of motion can then be written in the form of relation Eq.1.

\[
\begin{bmatrix}
M^G & M^{GL} \\
M^{LG} & M^L
\end{bmatrix}
\begin{bmatrix}
\ddot{d}^G \\
\ddot{d}^L
\end{bmatrix}
+
\begin{bmatrix}
K^G & K^{GL} \\
K^{LG} & K^L
\end{bmatrix}
\begin{bmatrix}
d^G \\
d^L
\end{bmatrix}
=
\begin{bmatrix}
P^G \\
P^L
\end{bmatrix}
\]

(1)

A modal damping ratio, the ratio of the dissipated energy during one complete cycle to the maximum stored energy from the beginning of the loading to the maximum, is expressed as

\[
\zeta_n = \frac{1}{4\pi} \frac{\Delta U_n}{U_n}
\]

(2)

where \(\Delta U_n\) is the total damping energy per cycle of vibration, \(U_n\) is the maximum strain energy and \(n\) is the modal number. In terms of the present method, each energy are given by following equations

\[
U = \frac{1}{2} \begin{bmatrix}
u^G \\
u^L
\end{bmatrix}^T
\begin{bmatrix}
K^G & K^{GL} \\
K^{LG} & K^L
\end{bmatrix}
\begin{bmatrix}
u^G \\
u^L
\end{bmatrix}
\]

(3)
\[
\Delta U = \frac{1}{2} \left\{ \begin{bmatrix} u^G \\ u^L \end{bmatrix} \right\}^T \begin{bmatrix} \Psi^G_{LL} & \Psi^G_{GL} \\ \Psi^{GL}_{LG} & \Psi^L_L \end{bmatrix} \begin{bmatrix} u^G \\ u^L \end{bmatrix}
\]

(4)

SIMULATION OF MATERIAL DAMPING FOR TEXTILE COMPOSITES

The proposed method has been applied for the analytical study of material damping. Test specimens have been fabricated by the hand-lay up method, using vinylester resin (supplied from Showa polymer Co. LTD.: R-806) reinforced by E-glass woven cloth fabric with 3 bundles (supplied from Asahi fiber glass Co. LTD.: WR570B). The dimensions of analytical model are 51.5mm in length, 11.7mm in width, 0.50mm in thickness. Fig.1 shows the local model of simulation.

Fig.2 shows the comparison between computational and experimental result. Vibration tests have been carried out in the low-pressure condition (40Pa) in order to consider effect of aerodynamic force. The computational results both natural frequency and damping ratio have a good agreement with the experimental ones as shown in Fig.2. From this results, it can be recognized that the material damping of plain woven composites can be estimated with the proposed method.