FLUTTER ANALYSIS OF COMPOSITE WINGS BY 1D CUF MODELS

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ABSTRACT

Flutter analyses of composite wings are presented in this paper. Wing structures are modeled by means of the 1D Carrera Unified Formulation (CUF) for refined finite elements. CUF 1D models have recently been developed for isotropic [1, 2] and composite structures [3]. CUF models exploit arbitrary order expansions of the generalized variables above the cross-section of the structure. Different expansion functions can be adopted such as polynomial or sinusoidal. In this paper, the TE 1D CUF class is exploited where Taylor-like polynomial expansions are adopted. The order \( N \) of the expansion is a free-parameter of the formulation; in other words, \( N \) is one of the inputs of the analysis. Any-order models can be obtained with no need of ad hoc formulations by exploiting the so-called fundamental nuclei formulation which allows one to obtain finite element matrices in a form that is independent of the order of the model. 1D CUF models allow us to detect highly accurate shell-like static deformations and modal shapes of thin-walled structures with a significant reduction of computational costs.

1D CUF structural models were herein coupled to a refined version of the Doublet-Lattice Method, DLM, based on a quartic approximation of the oscillatory kernel [4]. Flutter analyses were performed by means of the g-method [5]. Table 1 shows a typical result from the present formulation. A straight composite wing made of an eight-layer laminate was considered. Natural frequencies and flutter velocities were obtained and compared with those by Kameyama and Fukunaga [6]. A fourth-order TE model was used, \( N = 4 \). Results from 1D CUF models accurately match those from 2D CLT models with small computational costs.
Table 1: Vibration frequencies [Hz] and flutter velocities [m/s] of an eight-layer straight laminated wing

<table>
<thead>
<tr>
<th>Model</th>
<th>$f_1$</th>
<th>$f_2$</th>
<th>$f_3$</th>
<th>$f_4$</th>
<th>$f_5$</th>
<th>$V_F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N = 4$</td>
<td>7.2</td>
<td>45.1</td>
<td>58.9*</td>
<td>126.5</td>
<td>181.9*</td>
<td>38.2</td>
</tr>
<tr>
<td>Kameyama and Fukunaga (2007) (CLT)</td>
<td>7.3</td>
<td>45.4</td>
<td>59.1*</td>
<td>127.7</td>
<td>182.3*</td>
<td>38.8</td>
</tr>
</tbody>
</table>

(*torsional mode)

REFERENCES


