Technical Comment

Comment on "Divergence Study of a High-Aspect Ratio, Forward Swept Wing"

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IN an era of finite element methods and supercomputers, a modal method for static aeroelastic analysis[1] must be regarded as an anachronism. The method is now only of historical interest[2-5] and does not represent the current state of the art. The direct solution[6] is preferred because it avoids questions of convergence (other than a sufficient number of elements in the finite element model), and avoids the unnecessary intermediate step of a vibration analysis. Certainly a modal solution using vibration modes is valid since the modes satisfy all of the requirements of the Galerkin method. However, the general view has been that convergence in a static problem can only be achieved with a *large* number of vibration modes, and, as Sheena and Karpel[7] have shown, the series eventually does converge: somewhere between 25 to 35 modes were required to obtain a converged divergence speed in an example using a 190 degree-of-freedom model of a small aircraft. Reference 1 has not demonstrated that only four modes have achieved convergence at any of the five sweep angles analyzed.

Another series solution was utilized in the planar subsonic kernel function lifting-surface aerodynamic theory. The kernel function method assumes a series of pressure loading functions and satisfies the downwash condition of tangential flow at a number of points on the surface, usually at as many points as there are pressure loading functions, unless a least squares solution[8] is used. Neither the number of pressure functions/downwash control points nor the location of the points is discussed in Ref. 1. One would expect in an application to a very high aspect ratio wing that a large number of control points would be required in the spanwise direction, particularly in a vibration mode with many nodes along the span. Convergence of the generalized aerodynamic forces in, e.g., the third bending mode, has not been demonstrated.

It cannot be concluded that the EAL[9] and FAST[10] computer programs have been validated by the correlation study of Ref. 1. Since the aspect ratios studied are so high, the results of Fig. 4 of Diederich and Budiansky[11] might have correlated with the experimental data just as well, and those results would have made an interesting addition to Fig. 3, particularly to evaluate also the inaccuracies of the strip theory so popular in forward-swept wing stability analyses. Furthermore, one would not expect that the FAST code was in need of validation since it has been in use in one form or another since 1959.[12] However, what the FAST code does need for more validity is nonplanar surface and multiple body interference capability.[13,14] This is the subsonic wing/body capability of Ref. 6.

It should be remarked in closing that a forward-swept-wing aircraft will flutter in flight rather than diverge, but this matter has been addressed elsewhere,[15] and is not relevant to the present consideration of experimental correlation.

Received Oct. 17, 1988; revision received March 3, 1989.

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