공력탄성학 과제물 4번

제출기한: 11월 26일 (금)

Consider the typical section airfoil with two degrees of freedom as discussed in class. Assuming the 2-D incompressible strip aerodynamics, equations for the lift and pitch moment at the elastic axis are given by Eqs. 5-311 and 5-312 (B.A.H., p. 272), respectively.

1) Derive the equations of motion.

2) Assuming a solution of the form $\alpha = \bar{\alpha} e^{pt}$ and $h = \bar{h} e^{pt}$, where $p = \sigma + i\omega$, set up the flutter determinant.

3) Considering the following numerical parameters:

$$e = 0.4b,\ \frac{\omega_h}{\omega_\alpha} = 0.5,\ x_\alpha \equiv \frac{S_\alpha}{Mb} = 0.05,\ r_\alpha \equiv \sqrt{\frac{I_\alpha}{Mb^2}} = 0.5,\ \frac{2M}{\pi\rho bS} = 10$$

plot the roots (real and imaginary parts) of the characteristic equation as function of the reduced velocity ($\frac{U}{b\omega_\alpha}$) and identify the flutter point (including flutter mode) for the following cases:

3.1) Quasi-steady aerodynamics (with and without aero damping)

3.2) Quasi-unsteady aerodynamics

3.3) Unsteady aerodynamics

4) Repeat (3) for $\frac{\omega_h}{\omega_\alpha} = 0.1$ and $\frac{\omega_h}{\omega_\alpha} = 0.8$

5) Compare your solutions and discuss the importance of the different terms of the aerodynamic operator (i.e., aerodynamic mass, damping, and stiffness).

6) Use Equation 6-136 (B.A.) to determine the reduced flutter velocity for the above cases, and compare with the results obtained from (3) and (4). Comment on the eventual discrepancies.