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Addendum: "Coupled Panel/Cavity Vibrations"

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In a recent article,[1] the author presented an assumed mode solution for the effect of an underlying cavity on the vibration characteristics of a thin, uniform, unstressed isotropic panel. For the sake of brevity, the structural stiffness matrix $K_{mn}{}^2$ in the final characteristic equation was written as a diagonal matrix of uncoupled nondimensional frequencies squared. However, for some of the boundary conditions considered in Ref. 1, use of a diagonal stiffness matrix is approximate and possibly inadequate. For example, if a panel has two parallel edges clamped and the other two edges simply supported or if it has all four edges clamped, the characteristic beam functions used for the assumed panel modes actually lead to an invacuo stiffness matrix $K_{mn,rs}$ containing static coupling terms.

Practically speaking, this static coupling has a small effect on the natural (coupled) frequency spectrum. However, for those problems where natural panel mode shapes are desired, the static coupling terms may be quite influential and should be included in the characteristic equation. Equation (24) in Ref. 1 is then written more completely as follows:

$$\sum_{r=1}^{\infty}\sum_{s=1}^{\infty}\left[(K_{mn,rs} - \bar{\delta}_{rs}K^2)W_{rs} - \kappa\bar{\mu}K^2\sum_{p=0}^{\infty}\sum_{q=0}^{\infty}G_{pq}P_{pr}P_{pm}P_{qs}P_{qn}W_{rs}\right] = 0 \qquad (24)$$

where $\bar{\delta}_{rs}$ is the Kroneker-delta and $m, n = 1, \ldots, \infty$. The eigenvalues K^2 may be obtained by established iterative procedures, whereas elements of the stiffness matrix are computed from the formula

$$K_{mn,rs} = K_{mr} + 2(L/w)^2H_{mr}H_{ns} + (L/w)^4K_{ns} \qquad (24a)$$

This expression is readily obtained via a Galerkin solution of Eq. (22),[1] for free vibrations. The terms in Eq. (24a) are:

$$\left.\begin{aligned} K_{mr} &= \begin{cases} F_m{}^4 & r = m \\ 0 & r \neq m \end{cases} \\ H_{mr} &= \begin{cases} F_m{}^2 & r = m \\ 0 & r \neq m \end{cases} \end{aligned}\right\} \begin{array}{c}\text{simply supported edges} \\ \text{at } \xi = 0 \text{ and } \xi = 1\end{array} \qquad (24b)$$

$$\left.\begin{aligned} K_{mr} &= \begin{cases} G_m{}^4 & r = m \\ 0 & r \neq m \end{cases} \\ H_{mr} &= \begin{cases} \dfrac{8G_m{}^2G_r{}^2(G_m\alpha_m - G_r\alpha_r)}{(G_r{}^4 - G_m{}^4)} & r + m \text{ even} \quad r \neq m \\ 0 \quad r + m \text{ odd} & r \neq m \\ (G_m{}^2\alpha_m{}^2 - 2\,G_m\alpha_m) & r = m \end{cases} \end{aligned}\right\}$$

$$\text{clamped edges at } \xi = 0 \text{ and } \xi = 1 \qquad (24c)$$

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Expressions similar to Eqs. (24b) and (24c) are obtained for terms having the subscripts ns by replacing m with n and r with s.

It also is to be noted that Eqs. (25) and (26) in Ref. 1 contain printing errors and should read as follows:

$$G_{pq} = \delta_q{}^p(\coth\nu_{pq}d)/\nu_{pq}L \qquad (25)$$

$$\frac{1}{\kappa} = \int_0^1 \Psi_m{}^2(\xi)d\xi\cdot\int_0^1 \Phi_n{}^2(\eta)d\eta \qquad (26)$$

Here, κ is independent of m and n and is constant for given boundary conditions. In the case of a panel simply supported on all four edges, $\kappa = \frac{1}{4}$; for a panel simply supported on two parallel edges and clamped on two parallel edges, $\kappa = \frac{1}{2}$; and when the panel is clamped on all four edges $\kappa = 1$.

Of additional interest to the subject matter is a recent British publication by Pretlove.[2] He has independently obtained Eq. (24) for a panel simply supported on all four edges and has included the results of calculations for two numerical examples. The convergence trends, which are presented for the fundamental coupled panel mode shape, suggest that a more detailed investigation of this acoustic coupling phenomenon may be warranted in connection with the panel flutter problem.

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Errata: "Aerodynamic Blast Simulation in Hypersonic Tunnels"

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The following equations contained typographical errors and are given here in their correct form:

$$\mathfrak{F}_3 = [(\gamma + 1)/(\gamma - 1)][(\gamma V/m) - 1] \qquad (17)$$

$$\left.\begin{aligned} \phi(\eta)/\phi(1) &= \mathfrak{F}_1{}^{1-m}\mathfrak{F}_3{}^{[m(\gamma-1)/(2\gamma-\alpha)]}\mathfrak{F}_4{}^{-\beta} \\ \psi(\eta)/\psi(1) &= \mathfrak{F}_1{}^{\sigma m}\mathfrak{F}_2{}^{-m\{[2+\sigma(1-\gamma)]/(2-\alpha)\}} \times \\ &\quad \mathfrak{F}_3{}^{m\{[1+\sigma(1-\gamma)]/(2\gamma-\alpha)\}} \times \\ &\quad \mathfrak{F}_4{}^{\beta[2+\sigma(2-\alpha)]/(2-\alpha)} \\ F(\eta)/F(1) &= \mathfrak{F}_1{}^{2+m(\sigma-2)} \times \\ &\quad \mathfrak{F}_2{}^{-1-[m(\gamma-1)(2+\sigma)]/(2-\alpha)} \times \\ &\quad \mathfrak{F}_4{}^{\beta[2(\alpha-1)+\sigma(2-\alpha)]/(2-\alpha)} \\ \eta &= \mathfrak{F}^{-m}\mathfrak{F}_2{}^{m(\gamma-1)/(2\gamma-\alpha)}\mathfrak{F}_4{}^{-\beta} \end{aligned}\right\} \qquad (18)$$

$$M_s = \dot{R}/a_1 \sim t^{(m-1)+\sigma m(\gamma-1)/2} \qquad (21)$$

Between Eqs. (15) and (16) in text

$$k = [2\gamma/(\gamma - 1)]^{1/2}[2/(\gamma + 1)]^{(\gamma+1)/2(\gamma-1)}$$

Between Eqs. (22) and (23) in text

$$M_s \sim t^{[\sigma(\gamma-1)-1]/3}$$

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