Table 13—Coefficients in Equations of Motion

Vertical Mode

$$A_{11} = \int a_{11}\,dx$$

$$A_{13} = \int a_{13}\,dx$$

$$A_{31} = A_{13}$$

$$B_{11} = \int b_{11}\,dx$$

$$B_{13} = \int b_{13}\,dx$$

$$B_{31} = B_{13}$$

$$A_{15} = -\int x\,a_{13}\,dx - \frac{U_0}{\omega_e^2} B_{13}$$

$$B_{15} = -\int x\,b_{13}\,dx + U_0 \cdot A_{13}$$

$$A_{51} = -\int x\,a_{13}\,dx + \frac{U_0}{\omega_e^2} B_{31}$$

$$B_{51} = -\int x\,b_{31}\,dx - U_0 \cdot A_{13}$$

$$A_{33} = \int a_{33}\,dx$$

$$B_{33} = \int b_{33}\,dx$$

$$A_{35} = -\int x\,a_{33}\,dx - \frac{U_0}{\omega_e^2} B_{33}$$

$$B_{35} = -\int x\,b_{33}\,dx + U_0\,A_{33}$$

$$A_{53} = -\int x\,a_{33}\,dx + \frac{U_0}{\omega_e^2} B_{33}$$

$$B_{53} = -\int x\,b_{33}\,dx - U_0\,A_{33}$$

$$A_{55} = \int x^2\,a_{33}\,dx + \frac{U_0^2}{\omega_e^2} A_{33}$$

$$B_{55} = \int x^2\,b_{33}\,dx + \frac{U_0^2}{\omega_e^2} B_{33}$$

$$C_{33} = \int c_{33}\,dx = \rho g \int B(x)\,dx$$

$$C_{35} = C_{53} = -\int x\,c_{33}\,dx = -\rho g \int x\,B(x)\,dx$$

$$C_{55} = \rho g\,\nabla\,\overline{GM}_L + LCF^2\,C_{33}$$

$$\approx \int x^2\,c_{33}\,dx = \rho g \int x^2\,B(x)\,dx$$

Horizontal Mode

$$A_{22} = \int a_{22}\,dx$$

$$A_{24} = A_{42} = \int a_{24}\,dx$$

$$A_{26} = \int x\,a_{22}\,dx + \frac{U_0}{\omega_e^2} B_{22}$$

$$A_{44} = \int a_{44}\,dx$$

$$A_{46} = \int x\,a_{24}\,dx + \frac{U_0}{\omega_e^2} B_{24}$$

$$B_{22} = \int b_{22}\,dx$$

$$B_{24} = B_{42} = \int b_{24}\,dx$$

$$B_{26} = \int x\,b_{22}\,dx - U_0\,A_{22}$$

$$B_{44} = \int b_{44}\,dx + B_e = B_{44}^*$$

$$B_{46} = \int x\,b_{24}\,dx - U_0\,A_{24}$$

$$A_{62} = \int x\,a_{22}\,dx - \frac{U_0}{\omega_e^2} B_{22}$$

$$B_{62} = \int x\,b_{22}\,dx + U_0\,A_{22}$$

$$A_{64} = \int x\,a_{24}\,dx - \frac{U_0}{\omega_e^2} B_{24}$$

$$B_{64} = \int x\,b_{24}\,dx + U_0\,A_{24}$$

$$A_{66} = \int x^2\,a_{22}\,dx + \frac{U_0^2}{\omega_e^2} A_{22}$$

$$B_{66} = \int x^2\,b_{22}\,dx + \frac{U_0^2}{\omega_e^2} B_{22}$$

$$C_{44} \approx \rho g\,\nabla\,\overline{GM}_T$$

All integrals are taken over the ship length.

The generalized normals for $k = 4, 5, 6$ can likewise be approximated by their two-dimensional equivalents,

$$n_4 = y n_3 - z n_2$$

$$\approx N_4$$

$$= \left(y \frac{\partial b}{\partial z} + z\right) \Big/ \sqrt{1 + \left(\frac{\partial b}{\partial z}\right)^2} \qquad (149a)$$

$$n_5 = z n_1 - x n_3$$

$$\approx -x N_3 \qquad (149b)$$

$$n_6 = x n_2 - y n_1$$

$$\approx +x N_2 \qquad (149c)$$

It was at this point in the analysis by Salvesen, et al (1970) that the surge degree of freedom was eliminated by arguing that $N_1 << N_k,\ k = 2,3...6$.