**PRINCIPLES OF NAVAL ARCHITECTURE**

**Table 13—Coefficients in Equations of Motion**

**Vertical Mode**

\[ A_{11} = \int a_{11} \, dx \]
\[ A_{12} = \int a_{12} \, dx \]
\[ A_{22} = A_{33} \]
\[ B_{11} = \int b_{11} \, dx \]
\[ B_{12} = \int b_{12} \, dx \]
\[ B_{22} = B_{32} \]
\[ A_{15} = -\int x \, a_{13} \, dx - \frac{U_0}{\omega_x} B_{13} \]
\[ A_{15} = -\int x \, b_{13} \, dx + U_0 A_{13} \]
\[ A_{25} = -\int x \, a_{23} \, dx + \frac{U_0}{\omega_x} B_{23} \]
\[ A_{25} = -\int x \, b_{23} \, dx - U_0 A_{23} \]
\[ A_{35} = -\int x \, a_{33} \, dx + \frac{U_0}{\omega_x} B_{33} \]
\[ A_{35} = -\int x \, b_{33} \, dx - U_0 A_{33} \]
\[ A_{44} = \int a_{44} \, dx \]
\[ A_{44} = \int x \, a_{24} \, dx + \frac{U_0}{\omega_x} B_{24} \]
\[ B_{22} = \int b_{22} \, dx \]
\[ B_{24} = B_{42} = \int b_{24} \, dx \]
\[ B_{30} = \int x \, b_{22} \, dx - U_0 A_{22} \]
\[ B_{30} = \int b_{30} \, dx + B_e = B_{34} \]
\[ B_{40} = \int x \, b_{24} \, dx - U_0 A_{24} \]
\[ A_{42} = \int x \, a_{22} \, dx - \frac{U_0}{\omega_x} B_{22} \]
\[ B_{42} = \int x \, b_{22} \, dx + U_0 A_{22} \]
\[ A_{44} = \int x \, a_{24} \, dx - \frac{U_0}{\omega_x} B_{24} \]
\[ B_{44} = \int x \, b_{24} \, dx + U_0 A_{24} \]
\[ A_{54} = \int x^2 \, a_{22} \, dx + \frac{U_0^2}{2\omega_x^2} A_{22} \]
\[ B_{54} = \int x^2 \, b_{22} \, dx + \frac{U_0^2}{2\omega_x^2} B_{22} \]
\[ C_{44} \approx \rho g \nabla \overline{GM_L} \]

All integrals are taken over the ship length.

The general normalized normals for \( k = 4, 5, 6 \) can likewise be approximated by their two-dimensional equivalents,

\[ n_4 = y n_3 - z n_2 \]
\[ \approx N_4 \]
\[ = \left( y \frac{\partial b}{\partial z} + z \right) \sqrt{1 + \left( \frac{\partial b}{\partial z} \right)^2} \] (149a)
\[ n_5 = z n_1 - x n_3 \]
\[ \approx -x N_3 \] (149b)
\[ n_6 = x n_2 - y n_1 \]
\[ \approx +x N_2 \] (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 \( N_1 << N_k, k = 2,3...6 \).