Correction in SPM: Change to "absolute value"

$$u = \frac{H}{2}\frac{gT}{L}\frac{\cosh\left[2\pi\,(z + d)/L\right]}{\cosh\left[2\pi d/L\right]}\cos\left(\frac{2\pi t}{T}\right) \qquad (7\text{-}23)$$

$$\frac{du}{dt} \approx \frac{\partial u}{\partial t} = \frac{g\pi H}{L}\frac{\cosh\left[2\pi\,(z + d)/L\right]}{\cosh\left[2\pi d/L\right]}\sin\left(-\frac{2\pi t}{T}\right) \qquad (7\text{-}24)$$

Introducing these expressions into equation (7-20) gives

$$f_i = C_M\,\rho g\,\frac{\pi D^2}{4}\,H\left\{\frac{\pi}{L}\frac{\cosh\left[2\pi\,(z + d)/L\right]}{\cosh\left[2\pi d/L\right]}\right\}\sin\left(-\frac{2\pi t}{T}\right) \qquad (7\text{-}25)$$

$$f_D = C_D\,\frac{1}{2}\,\rho g\,D\,H^2\left\{\frac{gT^2}{4L^2}\left\{\frac{\cosh\left[2\pi\,(z + d)/L\right]}{\cosh\left[2\pi d/L\right]}\right\}^2\right\}\cos\left(\frac{2\pi t}{T}\right)\left|\cos\left(\frac{2\pi t}{T}\right)\right| \qquad (7\text{-}26)$$

Equations (7-25) and (7-26) show that the two force components vary with elevation on the pile z and with time t. The inertia force f_i is maximum for $\sin(-2\pi t/T) = 1$, or for $t = -T/4$ for Airy wave theory. Since $t = 0$ corresponds to the wave crest passing the pile, the inertia force attains its maximum value $T/4$ sec *before* passage of the wave crest. The maximum value of the drag force component f_D coincides with passage of the wave crest when $t = 0$.

Variation in magnitude of the maximum inertia force per unit length of pile with elevation along the pile is, from equation (7-25), identical to the variation of particle acceleration with depth. The maximum value is largest at the surface $z = 0$ and decreases with depth. The same is true for the drag force component f_D; however, the decrease with depth is more rapid since the attenuation factor, $\cosh[2\pi(z + d)/L]/\cosh[2\pi d/L]$, is squared. For a quick estimate of the variation of the two force components relative to their respective maxima, the curve labeled $K = 1/\cosh[2\pi d/L]$ in Figure 7-68 can be used. The ratio of the force at the bottom to the force at the surface is equal to K for the inertia forces, and to K^2 for the drag forces.

The design wave will usually be too high for Airy theory to provide an accurate description of the flow field. Nonlinear theories in Chapter 2 showed that wavelength and elevation of wave crest above stillwater level depend on wave steepness and the *wave height-water depth* ratio. The influence of steepness on crest elevation η_c and wavelength is presented graphically in Figures 7-69 and 7-70. The use of these figures is illustrated by the following examples.

* * * * * * * * * * * * * * * EXAMPLE PROBLEM 17 * * * * * * * * * * * * * * *

GIVEN: Depth $d = 4.5$ m (14.8 ft), wave height $H = 3.0$ m (9.8 ft), and wave period $T = 10$ s.

FIND: Crest elevation above stillwater level, wavelength, and relative variation of force components along the pile.