$$u = a_1\cos\alpha + a_2\cos 2\alpha + \ldots \tag{7.18}$$

in which α is the phase angle and the a_n are velocity amplitude coefficients. Even though the time averaged bottom velocity is zero ($\overline{u} \equiv 0$), the net onshore shear stress, $\overline{\tau}$, is positive (i.e. shoreward) since

$$\tau = \frac{\rho f}{8} |u|u \tag{7.19}$$

where ρ is the mass density of water and f is the Darcy-Weisbach fraction factor. Fig. 7.11 is based on stream function (nonlinear) wave theory and presents the average non-dimensional shoreward shear stress, $\overline{\tau'}$,

$$\overline{\tau'} = \frac{\overline{|u|u}}{(H/T^2)} \tag{7.20}$$

as a function of relative water depth, h/L_o and wave steepness, H/L_o.

7.4 RESEARCH NEEDS

It is clear that the development of an adequate capability to predict shoreline response to future sea level rise rates will require a consideration of cross-shore sediment transport fundamentals and applications, and a quantitative understanding of the transport components. The Bruun Rule, while a good first model, is deficient in not allowing for the onshore transport of sand that is clearly occurring at some locations and undoubtedly occurring at many less evident locations. The three types of research needs identified fall in the categories of analysis of existing data, new data, and new technology.

7.4.1 Analysis of Existing Data

Isolation of Anthropogenic Effects - The substantial effects that navigational structures and sand management practices at entrances can have on shoreline stability have been noted and illustrated by the examples in Figs. 7.8 and 7.9. Similar effects are known to occur and be substantial at many other locations, i.e. Folly Beach, SC, Tybee Island, GA, Santa Barbara, CA, and Assateague Island, MD. In addition to the effects at entrances, the effects of groins, seawalls, etc. should be considered. A straightforward methodology could be applied; however, it is believed that development of new, more effective methodology would be worthwhile.