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WATER WAVES GENERATED BY THREE DIMENSIONAL BED MOTION

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Abstract for the Paper to be Presented at The International Tsunami Symposium, May 25-29, 1981, Japan

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16. Abstract (Limit: 200 words)

An abstract is presented of a paper on theoretical three-dimensional results for the case of dipole dislocation of the sea floor with a finite aspect ratio (length/width of the bottom dislocation). The method developed by Lee and Chang (1980) for three-dimensional bed motion in the case of rectangular bed upthrust of finite aspect ratio is applied in this study. A potential flow is assumed; thus the velocity potential satisfies Laplace's equation and linearized boundary conditions. The solution is obtained using the Fourier transform for the spatial variables and the Laplace transform for the time variable. Results on water surface profiles for different lengths/widths of bottom dislocation were obtained and interesting features of generated wave patterns were found. Programs were developed for obtaining wave profiles along any arbitrarily chosen coordinates by a mathematical plantom.

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Water Waves Generated by Three Dimensional Bed Motion

by J.J. Chang[1] and J.J. Lee[2]

Waves generated by submarine earthquakes, commonly known as tsunamis, have been of interest to ocean and coastal engineers. In many instances, such waves have caused significant damage to the coastal regions. Estimation of the tsunami wave form is essential for the prediction of the wave profile in the propagation phase and the final wave form when the wave arrives in the coastal region.

Most of the theoretical models of tsunami generation have been based on linearized theory in either a two- or three-dimensional fluid domain of uniform depth. Solutions for two-dimensional bed motion have been tested both theoretically and experimentally (see Hammack (1973)). Solutions for three-dimensional bed motion in the case of rectangular bed upthrust of finite aspect ratio have recently been obtained by Lee and Chang (1980). The results are obtained by two-dimensional fast Fourier transform. Three-dimensional pictures showing generated wave patterns everywhere near the generation region have also been obtained by image processing technique. These results dramatized the importance of the three-dimensional effect even with the simple example of monopole upthrust of the sea floor.

This paper presents the theoretical three-dimensional results for the case of dipole dislocation of the sea floor with a finite aspect ratio (length/width of the bottom dislocation). The method developed in Lee and Chang (1980) is applied in this study. A potential flow is assumed; thus the velocity potential satisfies Laplace's equation and linearized boundary conditions as follows:

$$\begin{aligned} &\nabla^2\phi = 0 && 0<t<\infty,\ -\infty<x,y<\infty,\ -h<z<0 \\ &\phi_{tt} + g\phi_z = 0 && z=0 \\ &\phi_z = \xi_t(x,y;t) && z=-h \\ &\eta(x,y;t) = -\frac{1}{g}\phi_t(x,y,o;t) && \text{(water surface profile)} \end{aligned} \tag{1}$$

The solution is obtained by using the Fourier transform for the spatial variables x,y and the Laplace transform for time variable t. The bed deformation is assumed to be a rectangular block with a dipole type of deformation in x; this is specified as follows:

$$\xi(x,y;t) = \xi_o(1-e^{-\alpha t})(\sin\frac{\pi}{2}\frac{x}{B})[H(B^2-x^2)\ H(A^2-y^2)] \tag{2}$$

where ξ_o is the maximum amplitude of the vertical displacement and α is a time constant. The function $H(B^2-x^2)$ and $H(A^2-y^2)$ are heavy side step functions; 2A and 2B are the extent of the bottom deformation. From (2) it is seen that the maximum vertical displacement ξ_o occurs at $x = B$ while the minimum vertical displacement $-\xi_o$ occurs at $x = -B$ and that the net bottom deformation is equal to zero.

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Results on water surface profiles for different A/B have been obtained. Many interesting features of generated wave patterns have been found. Programs have also been developed which permit one to obtain wave profiles along any arbitrarily chosen coordinates by a mathematical plantom.

Figure 1 presents water surface profiles along the x-axis due to the bottom deformation specified in (2) with $B/h = 12.2$, $\xi_o/h = 0.2$ and $t_c\sqrt{gh}/B = 0.069$, $\alpha = 18.46$. Profiles are presented in the Lagrangian sense for different time parameters after the start of the bottom deformation. It is seen that at small t the wave profiles for A/B = 5 are identical to that of A/B = 2. However, as the end effect arrives at x-aix, the wave profiles, especially in the tail region, differ considerably. The profiles obtained show an asymmetric behavior due to the asymmetric bottom deformation. It should be noted that the present theoretical analyses do not treat the non-linear effect although the dispersive effect is allowed. Substantial modulation of the wave profiles can be observed in Figure 1.

Three-dimensional pictures (for A/B = 2) are shown in Figure 2 for different time parameters. The three dimensional pictures were constructed from 256 x 256 samples using the image processing technique. They show an overall pictorial view of the wave pattern for $t\sqrt{g/h} = 4.20$, 12.61, 21.02, and 29.43. By combining these types of pictures for different viewing angles (θ's and δ's) one is impressed with the complex nature of the generated wave pattern due to the three-dimensional bottom dislocation.

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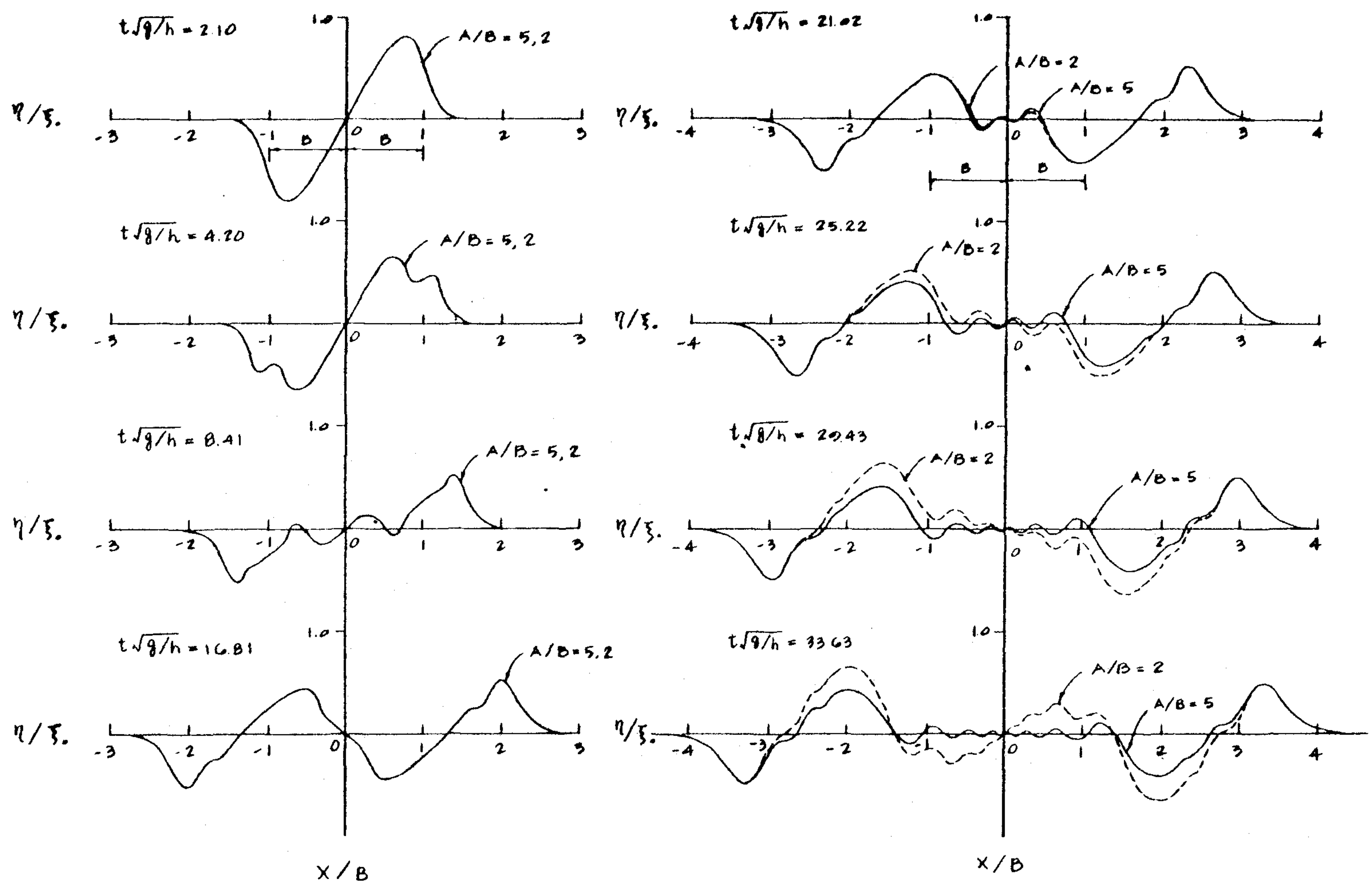

Figure 1. Water surface profile for two aspect ratios (A/B-5,2) along x axis (y=0) due to dislocation.

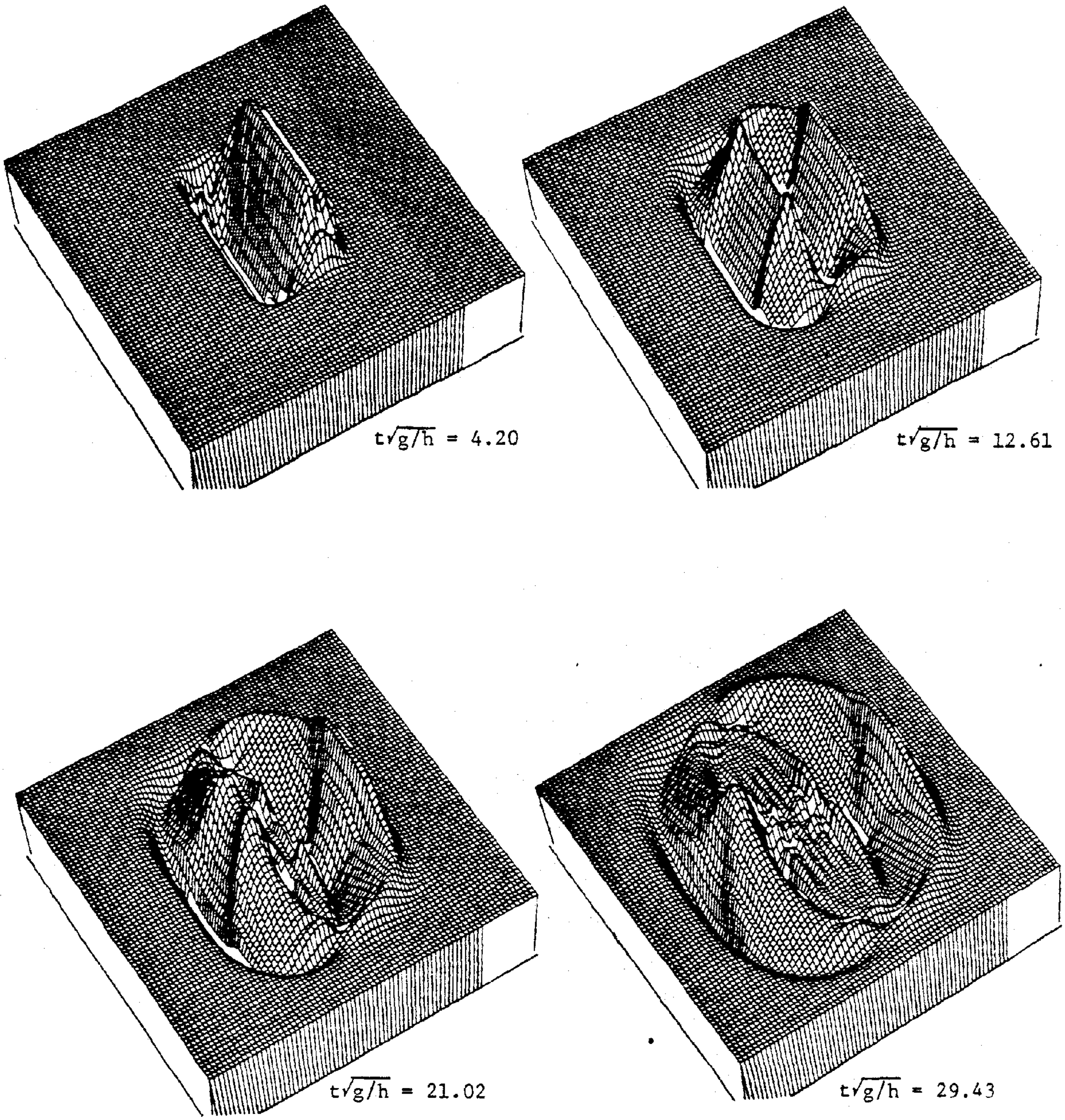

Figure 2. Three dimensional pictures showing the wave pattern near the generation region for specified time parameters (aspect ratio A/B=2, viewing angle θ=60°, δ=60°).