WATER-SURFACE DYNAMICS AMONG A PERIODIC ARRAY OF FLOATING BODIES SUBJECT TO REGULAR INCIDENT WAVES

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Summary Theoretical and experimental study on the water-surface dynamics among a periodic array of floating bodies placed in an incident regular wave train are conducted. The focus is placed on the possible wave trapping among the array and non-linear double-frequency oscillations of the water-surface.

WAVE TRAPPING

When a body is placed at the very center of a narrow wave tank of width B in a regular wave train, which is hydrodynamically equivalent to a regular-wave incidence to an array of an infinite number of identical bodies placed with center-to-center distance B apart along the line perpendicular to the direction of the incident waves, it is indicated theoretically that waves could be trapped between the body and the tank walls and thus the energy of the incident waves are accumulated in the trapped waves as time goes by, which eventually may result in an extremely large water-surface movement. Recently it has been shown that, even when a long periodic array of identical bodies is placed in head waves, wave trapping could occur (Maniar & Newman).

Since, if this is really the case, it is obvious that it has very serious implications for the design of such structures as a column-supported semi-submersible oil rig or a very large floating airport supported on a periodic array of a large number of legs (possibly several thousands) now projected in Japan, experiments were conducted to see if wave trapping really occurs. In the experiment, an array of 50 identical truncated vertical cylinders intersecting the free surface was fixed in regular head waves with equal distance in one line and the water-surface movements among the array were measured at 14 locations. Figure 1 shows the typical results on the spatial distributions of the water-surface elevations along the array obtained in the experiment. In the figure, the corresponding calculation results based on the linear potential theory are also shown for comparison. As the wave period was changed by as small as 1/100 second from 0.68sec. to 0.69sec., the theoretical calculation results suddenly blew up while the experimental results remained as if nothing happened.

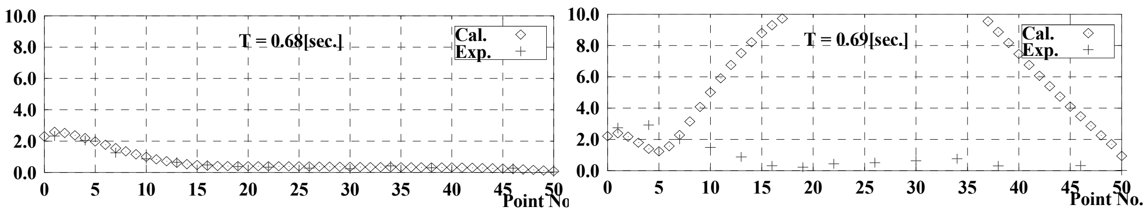

Figure 1 The spatial distributions of the water-surface elevation amplitude along the array of 50 vertical truncated cylinders in head waves (The vertical axis represents the ratio of the water-surface elevation amplitude and the incident-wave amplitude.)

As it turned out that the wave period 0.69sec. coincides with the onset of the wave trapping, it is apparent that the theoretically predicted extreme water-surface movement due to trapped waves does not take place in reality. It will be shown that if damping forces due to viscosity are properly accounted for in the theory, the experimental results obtained in trapped waves can be well reproduced in the calculation.

NON-LINEAR DOUBLE FREQUENCY OSCILLATIONS OF THE WATER SURFACE

Besides the experiment using a 1x50 array of truncated cylinders shown above, another experiment was carried out in which an array of 2x9 cylinders was placed in regular head waves. An interesting fact observed in this experiment is that noticeable movements of the water surface oscillating with the frequency 2ω were induced in incident waves of frequency ω between the two rows as shown in Figure 2.

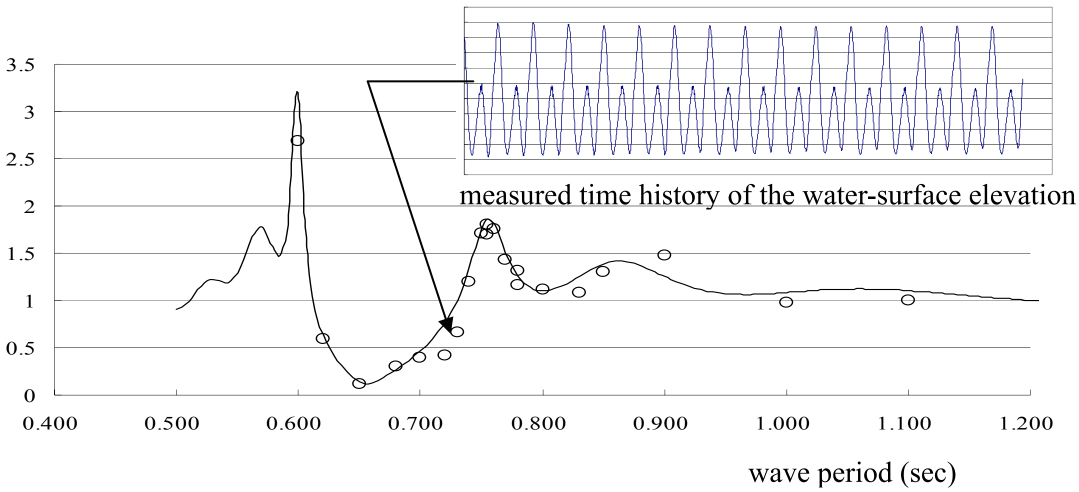

Figure 2 The frequency response characteristics of the water-surface elevations between the two rows of the array of 2x9 cylinders in head waves (solid line: linear-theory calculation, circles: experimental results)

APPLICATION OF A PERIODIC ARRAY OF BODIES TO A BREAK-WATER

Since, when incident waves are trapped in a periodic array of bodies, little energy is transmitted to the other side of the array, an attempt was made to apply the array to a break-water. The unique feature of this type of break-water is that, at least theoretically, the wave transmission can be controlled by tuning the center-to-center distance of the bodies to the incident-wave length and thus the transmission of long waves could be suppressed without geometrically enlarging the bodies themselves.

References

[1] H.D. Maniar and J.N. Newman: Wave diffraction by a long array of cylinders, *J. Fluid Mech.* **339**; 309-330, 1997.