Dynamic Behavior of a Moored Floating Fish Farm in Ocean Waves

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1. Introduction

The most of nearshore areas along the coastline of the Sea of Japan are not blessed with the gulfs or natural reefs. So in those areas so many kinds of man-made Fish Aggregation Devices (FADs) and artificial aquatic habitats have been submerged to cultivate and proliferate the aquatic resources. However, to utilize the ocean space furthermore effectively, the technology of offshore aqua-culture must be developed by coastal engineers and oceanographers.

This paper is concerned with the dynamic response of a floating fish farm to the periodic waves. The objectives of this study are

1) to derive a numerical model which can evaluate the dynamic response of the moored fish farm to the waves, and
2) to combine laboratory tests and the dynamic calculation to obtain optimum design criteria for first farm facilities.

2. Wave forces acting on the plain nets

As shown in Figure 1, the predominant governing parameters of the fluid forces on nets are diameter of the net and the mesh of it. The mesh of the net relates to the projected rate; S as

$$S = \frac{\text{Projected area of the net}}{\text{Whole area of the net}}$$

A series of laboratory tests were carried out to measure the drag and lift forces on the plain knotless nets and to estimate the hydrodynamic co-efficients of the nets.

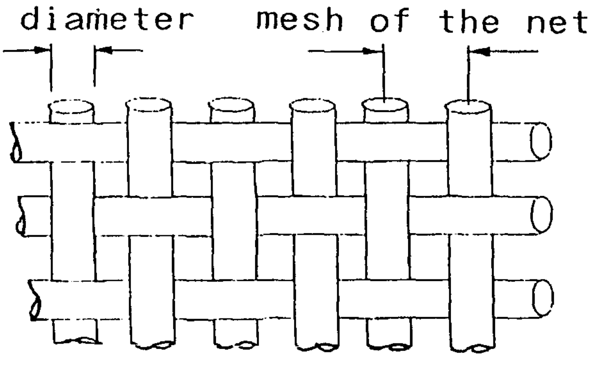

Figure 1 Parameters of plain net

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Figure 2 shows the measuring apparatus. The fluid forces on the plain net were measured by the 3 axial load cell which was attached to the truck on a water tank.

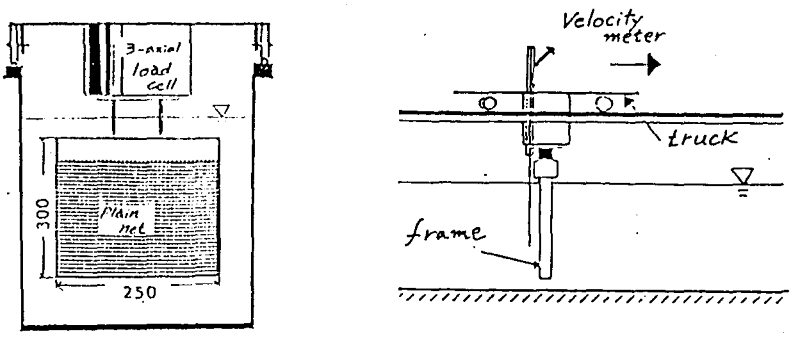

Figure 2 Measuring apparatus

Figure 3 exhibits the relationship between the drag coefficients and the Reynolds number. Reynolds number is defined by

$$Re=\frac{Ud}{\nu} \qquad ......(1)$$

where U is the velocity of the water particle, d is the diameter of the plain net, is the kinematic viscosity of the water. The drag coefficient of the net were found to be clearly related to the Reynolds number, and the empirical relationship was obtained as

$$Cd=9.84Re^{-0.36} \qquad ......(2)$$

The computed results of the wave force on the plain nets were in good agreement with the measured results when the value of Cd given by the Eq.(2) were used.

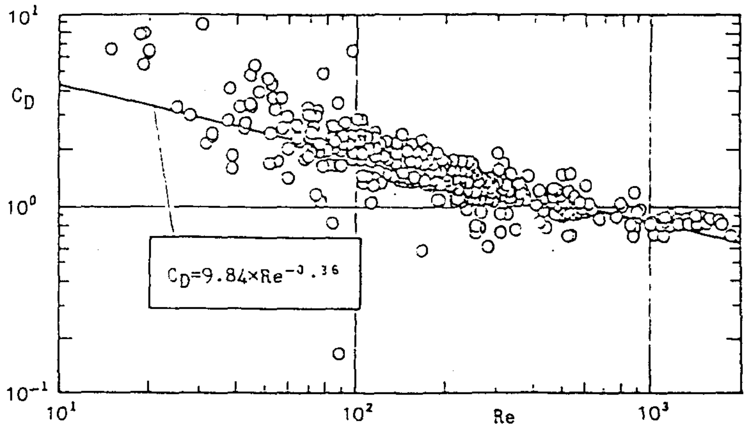

Figure 3 Relationship between Cd and Reynolds number

3. Dynamic response model of the moored floating fish farm to the waves

A numerical model of the structure's dynamic movement under the wave action was developed using the lumped mass method. Figure 3 represents the coordinate system and forces acting on the cage schematically. Equations of the two-dimensional motion of the fish farm are introduced as follows

$$M\ddot{x}=Fh+Ha-Hao \qquad \ldots\ldots(3)$$

$$M\ddot{z}=Fv+Fb-Va-Vao-Mg \qquad \ldots\ldots.(4)$$

$$I\ddot{\theta}=(Ha-Hao)m+(Va-Vao)n+FhP \qquad \ldots\ldots(5)$$

where M is the mass of the cage, Fh and Fv are horizontal and vertical component of the wave forces respectively, H and V are horizontal and vertical component of the mooring line forces, subscript a and ao indicate inshore and offshore component respectively, is the rotation angle of the cage, and I are the inertia moment of the cage about the center of the gravity.
Wave forces were estimated by the Morison equation.
The time histories of swaying and heaving at each phase within wave periods are shown in Figure 5 and that of pitching is in Figure 6.

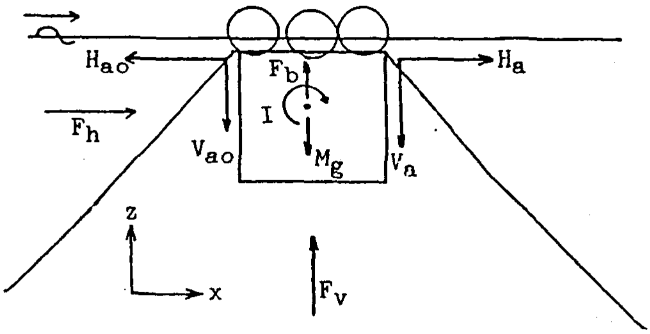

Figure 4 Coordinate system and outer forces

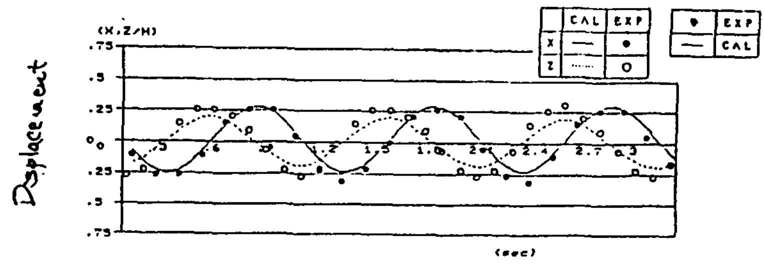

Figure 5 Time histories of the heaving and swaying of the floating cage

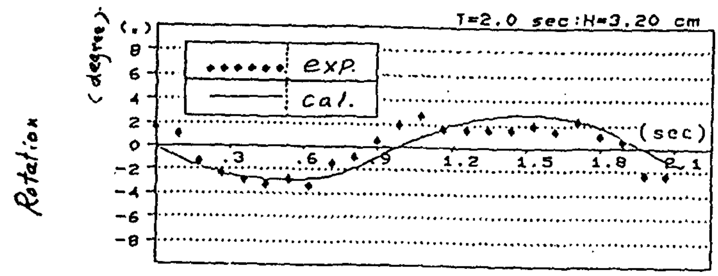

Figure 6 Time history of the pitching motion of the cage

The numerical results (solid and dotted lines) indicate similar tendency to the measured results.

4. *Conclusions*

In designing the aquatic structures, the most important point is to estimate the hydraulic forces acting on it correctly. The drag coefficient of the plain nets is one of significant parameter in calculation of fluid forces. The empirical relationship of the drag coefficients of the plain nets gives satisfying estimation of wave forces acting on nets. The numerical two dimensional models presented in this paper has been found to provide a proper estimation of the dynamic response of the floating fish farm to the waves. It will be efficient in designing other fishery structures surrounded by plain nets.

5. References

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