S. MOTORA and M. FUJINO - University of Tokyo, Tokyo, Japan

It has been known that the strip method often gives good results when it is applied to a case where conditions are much different than the basic hypothesis of the strip method, for instance in case of fat and blunt ships or fast container ships.

High speed crafts are one of the cases where the strip method does not seem able to provide good prediction of motions in waves because they have relatively wide beam and moreover the geometrical form of transverse section varies remarkably along the longitudinal axis.

Bessho et al. /1/ applied the strip method to predicting the motion in waves of a high speed craft and indicated that the motions predicted thus agreed well with the observed motions in waves at a moderately high speed.

Encouraged by their success, the authors tried to predict the motions of a high speed craft by the strip method even when the craft emerged from the water surface for a fraction of period /3/4/. Some of the results will be briefly described below.

The prediction methods used in this project are as follows:

1) The ordinary strip method (A method)
2) Ordinary strip method with underwater form of the running attitude at a cruising speed (B method)
3) Hydrodynamic forces acting on the craft running at a speed are measured by the vertical PMM and used to solve the equations of motion (C method)
4) Taking account of variation-with-time of the immersed portion of the hull, two-dimensional hydrodynamic force for each transverse section is computed step by step by using Lewis form approximation. Furthermore the hydrodynamic force due to time-variation of the added mass is also taken into consideration as the impact hydrodynamic force. Hence, the equations of motion are solved step by step by numerical integration. This method was advocated by Yamamoto et al. /2/ to analyze the slamming of a displacement boat (D method).

The method to calculate the impact fluid force, which was used by Yamamoto et al., will be briefly described as follows:

1) Firstly, a ship is divided into a series of transverse strips. The impact force generated when a transverse strip immerses into the water is computed by Kármán's formula of impact force:

$$f_{imp} = \frac{\delta M_H}{\delta t} \cdot \bar{V} = \frac{/M_H/Zd=0 . \Delta X}{\Delta t . h} . \bar{V}$$

where M_H = sectional added mass for heave.
Zd = sectional draft.
Δ_x = longitudinal distance between two consecutive points indicated in Fig. 1.
h = length of a strip.
Δ_t = time interval at which the equations of motion are solved step by step.
V = vertical speed of a strip relative to the water surface.

2) It is assumed that the above-mentioned impact force is not generated when the hull emerges out of the water.

The amplitude of vertical motions computed by this method does not differ so much from those by the ordinary strip method. However, as shown in Fig. 2, the theoretical water pressure obtained by taking account of the above-mentioned impact fluid force agrees quite well with the measured pressure while the ordinary strip method fails to explain the measured pressure.

Deck wetness of a high speed craft with chines is computed theoretically and compared with the experimental results. In Fig. 3, calculated amplitudes of heave and pitch motions are shown by the solid lines, the broken lines, and the chain lines where experimental results are marked by plots. From Fig. 3, it will be observed that the prediction by C method agrees best with the observed motions.

In Fig. 4 are shown the theoretical lines which represent the critical values of wave-height/wave-length ratio to dominate whether or not the craft's bow scoops the surrounding water together with the experimental results. It will be observed that C method and M method agree well with experimental results. However, in higher Froude Number, theory fails to agree with experimental results due to jumping of the craft out of wave surface. (Fig. 5).

Japan Small Craft Inspection executed extensively full scale measurements of impact pressure on the craft's bottom as well as the model experiments. As a part of this project, the impact pressure on the bottom was computed by D method. The hull form of the high speed boat used in this calculation is the almost same as that described previously, that is to say, a chine boat. However, at the calculation, the hull form was substituted by a simplified form. Namely, a wall sided form with the form of load water plane exactly the same as that of real hull. The whole length of the craft was divided into 20 sections and the time interval Δt for numerical integration was 1/300 of the period of encounter.

- The critical speed at which the high speed craft jumps out of the water is shown in Fig. 6, where curves represent the results of model experiments and marks represent result of calculation. From this figure, it can be said that the theoretical values of critical speed for jumping agree well with the experimental results.

- An example of calculated amplitudes of heave and pitch is shown in Fig. 7 together with result of model experiment. Though amplitude of the theoretical value is smaller than experimental value, trend of variation with speed seems to be similar. Calculated time history of heave and pitch with and without impact force are shown in Fig. 8 together with model experiment data.

  Though the calculation without impact force gives fairly good agreement with experiment as far as the amplitude is concerned, it fails to show the rapid change of trim angle (bow up) when the craft lands on the water at the stern.

- Fig. 9 shows relation between craft's motion and timing of occurrence of the impact pressure on the craft's bottom. The impact pressure is calculated by substituting the predicted values of the craft's landing speed and landing attitude into Watanabe's formula /6/. The calculated longitudinal distribution of the impact pressure is also shown in Fig. 10. The predicted and the observed pressure are of almost the same order. Besides, the predicted impact pressure agrees well with the impact pressure obtained by full-scale measurements.

From the above investigation, it can be concluded that the strip method, modified appropriately by taking account of non-linear hydrodynamic force, seems able to be applied to fairly complex problems.

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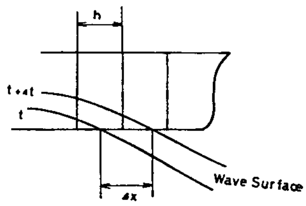

Fig. 1 Position of ship and wave (bottom emergence)

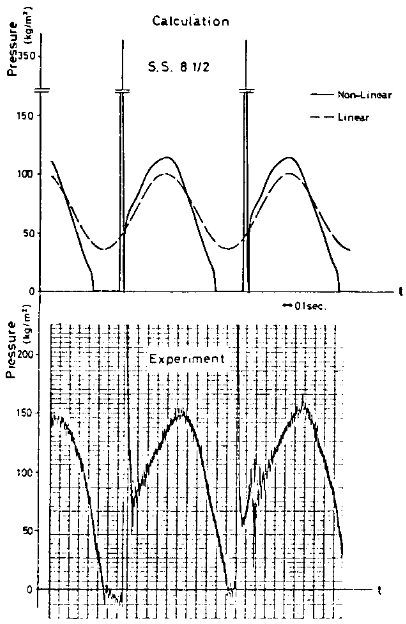

Fig. 2 Time history of pressure (F_n=0.13, λ/L=1.5, H_w/L=1/15)

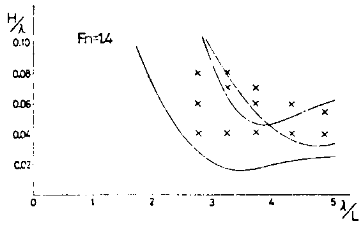

Fig. 5 Deck wetness vs. H/λ and λ/L

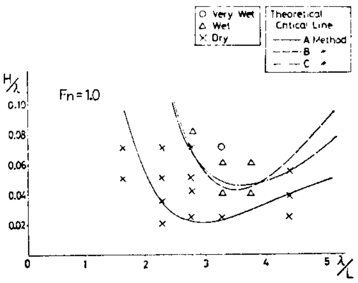

Fig. 4 Deck wetness vs. H/λ and λ/L

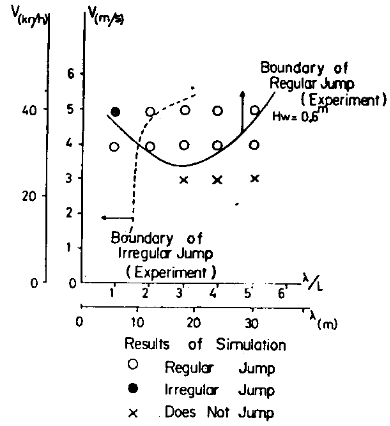

Fig. 6

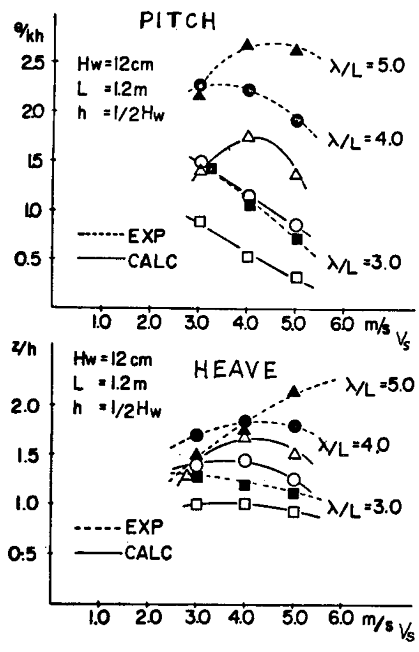

Fig. 7

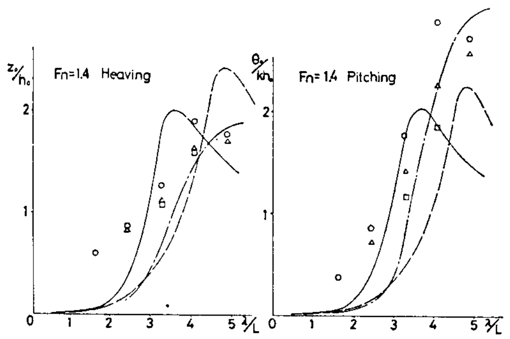

Fig. 3 Pitching, Heaving vs. λ/L

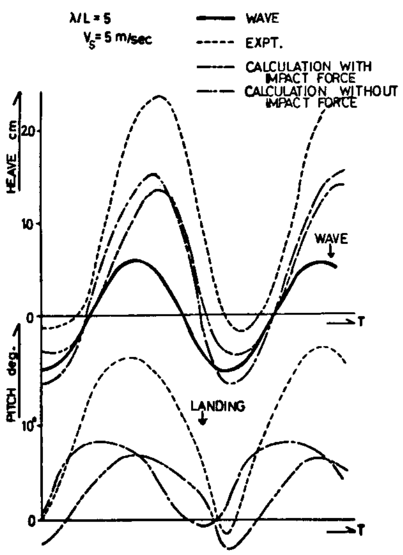

Fig. 8

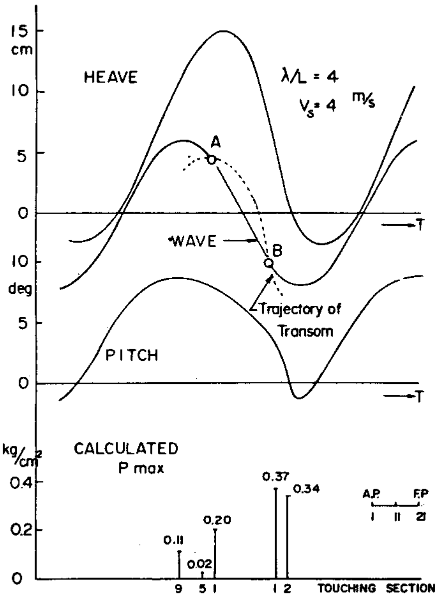

Fig. 9

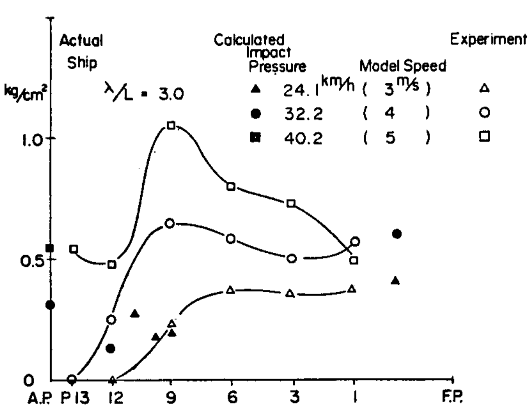

Fig. 10