Some Simplified Considerations on the Low-Frequency Motion of a Deep Draft Floating Platform

by

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During the last years several floating platform concepts have been proposed which all should fullfill the requirements of minimizing the motions in waves. One such concept is the deep draft concrete floating platform illustrated in Figure 1. The draft is approx. 130 m. The platform have indeed very small 1.order motions. However, experiments demonstrate that in all 6 degree of freedom, the low-frequency motions are of comparable magnitude to the first order motions.

In this situations we wanted to check if some simplified considerations could be used to estimate the low-frequency motions and to improve the physical insight in how the different parts of the platform contribute to the motions. The approach has been more intuitively than formally correct.

We consider head sea, and thus surge, pitch and heave only. Due to symmetry, heave can be handled seperately, while surge and pitch are coupled. The coupled low-frequency motion is computed by a proceedure given by Langley /1/. Assuming linear response, it is based on Newman's hypothesis /2/. I.e. we need the drift force from regular waves only to estimate the slowly oscillatory motions. The slowly oscillatory excitation spectrum is found following Pinkster /3/. Both a "white noise" approximation and a "full integration" are used to estimate the standard deviation of the response.

The major approximations are related to computation of the drift forces. In surge. the following proceedure is applied: The platform is considered fixed. Only the vertical columns are considered. The diffracted waves from each cylinder are computed as if the cylinder was alone. The far field diffracted waves are thus approximated by the sum of the diffracted waves from each column, taking into account the phase shift only. The ratio (Drift force on N cylinders / N times the drift force on one cylinder) is denoted the interaction coefficient, λ. As the wave length tends to infinity, λ tends to N.

The approach has shown up to work very well for the relevant deep draft platforms, see Figure 2, where this simplified approach is compared with results from a panel program. The effect of platform motions is negligible in this case.

The steady pitch moment on one single, fixed cylinder can be found by using the Mac Camy & Fuchs solution on the cylinder surface. The pitch moment on an array of cylinders has been estimated by assuming the same interaction coefficient to be valid for pitch as was found for surge.

For heave, we use the results from Lee & Newman /4/ and Mc Iver /5/. I.e. as a first approximation the vertical drift force can be estimated by considering each structural part of the platform independently. The results from Lee & Newman for a submerged, slender and fixed body is used to estimate the force on the pontoon. The contribution from the column is splitted in two: At the bottom surface the horizontal, undisturbed water velocity is used only. At the cone, a long wave length approach is used to estimate the circumferential velocity, and the undisturbed water velocity is used in the vertical direction. Further, the vertical drift force resulting from the coupling between the first order surge acceleration and the first order pitch is included (Pinkster). The different contributions to the vertical drift force obtained in this manner is shown in Figure 3.

Solving for the coupled low-frequency surge - pitch motion, it was found that the coupling term was of no significance in our case. A white noise approximation is sufficient accurate.

The computed low frequency motion responses are shown in Figure 4, 5 and 6. Different damping ratios are used. Model test results are also presented. For surge and pitch the trends in the computed results and the model tests are very similar. However, the accuracy of the estimates depends on which damping ratio should be applied. For heave the comparison is not that satisfactory. In particular for the shorter wave periods, the motion response is underestimated.

So far we have concluded that the simplified approach has contributed to insight which parts of the platform contributes to the drift forces and to establish some simple "order of magnitude" expressions for the drift forces and the low-frequency motions. The need for improved computational tools is obvious.

REFERENCES

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5. Mc Iver, P.: Discussion of "Wave drift enhancement effect in multicolumn structure" by R.E. Taylor and S.M: Hung" Applied Ocean Research, 1985, Vol 7, No. 3.

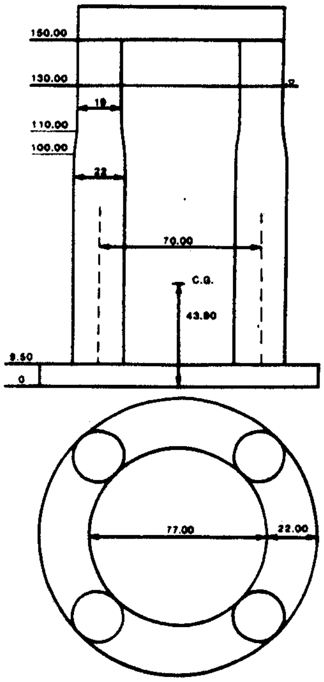

Fig. 1 Platform geometry

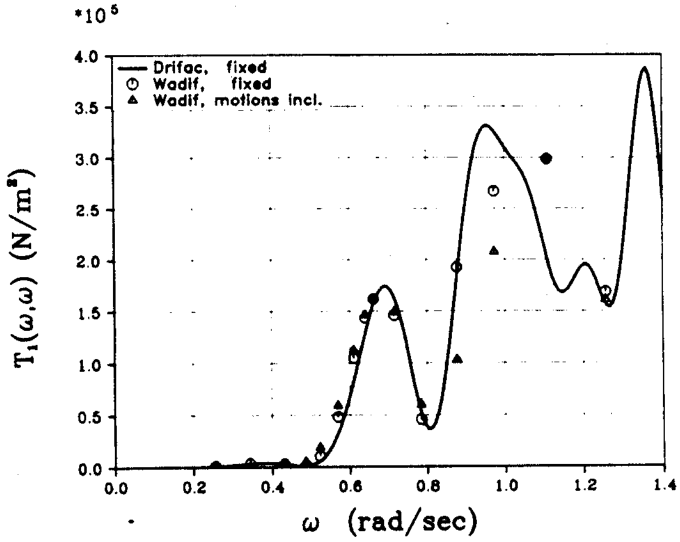

Fig. 2 Drift force in surge. Present approach (Drifac). Panel method (Wadif).

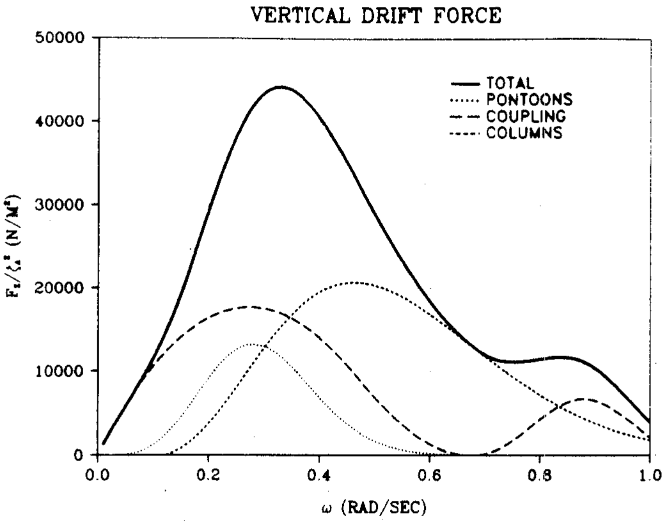

Fig. 3 Contributions to the vertical drift force, Platform fixed, simplified approach.

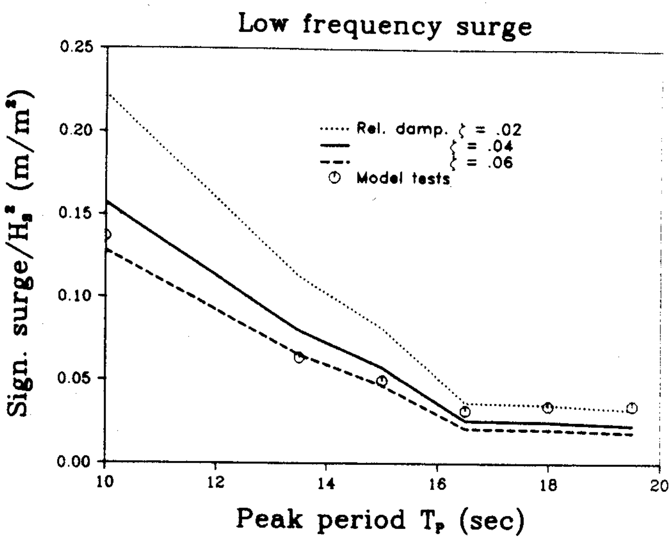

Fig. 4 Significant low-frequency surge motion. Computed and measured response in Jonswap spectra of different peak periods.

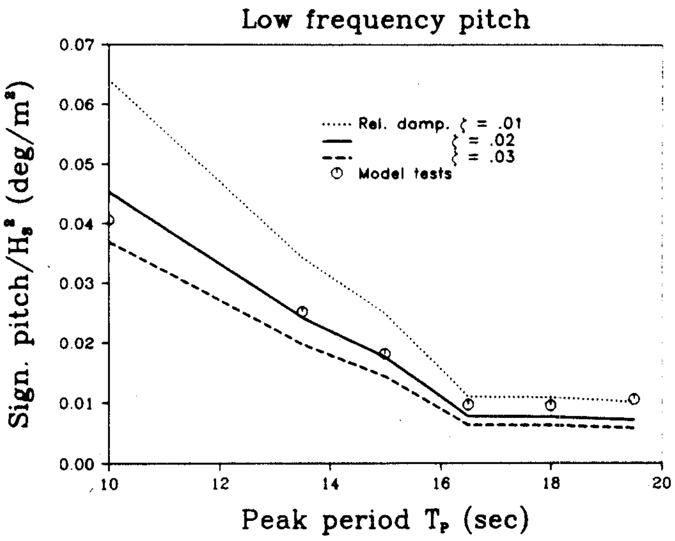

Fig. 5 As Fig. 4 - pitch motion

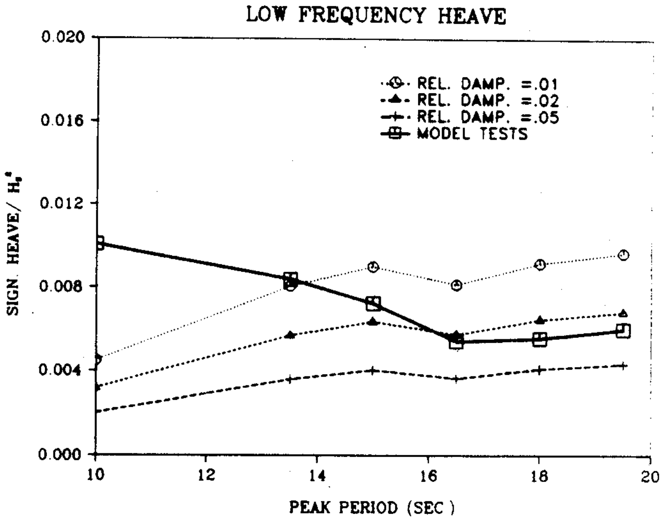

Fig. 6 As Fig. 4 - heave motion

Grue: Did you also estimate slow-drift damping for the TLP? If not, you may obtain this damping coefficient by the method of Zhao & Faltinsen presented in the Workshop!

Nielsen: No, I did not. However a rough estimate indicates that wave-drift-force damping may contribute 0.5% ——2% damping in surge. This is based on the shortest wave lengths. The uncertainty in the estimate is related to how the interactions between the 4 columns influence the damping. For the largest wavelength the wave-drift-force damping in surge is negligible. How wave-drift-force damping influences pitch and heave we do not know.

Yue: If you compare the second- *vs.* first-order motion *velocities* rather than *amplitudes,*the actual ratio may not be unreasonable. It appears that a direct perturbation approach may not be in peril yet.

Nielsen: As illustrated, the ratio between the r.m.s. low-frequency motion response and the r.m.s. first-order motion response was in the range of 1 ——6. In heave (and pitch) the natural frequency $\omega \approx 0.15$. Typical wave frequencies are $\omega \approx 0.65$. Therefore, the ratios between low-frequency and first-order velocities will be in the range 0.2 ——1.4. This should indicate that the perturbation approach is reasonable.