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Calculated vessel motion: comparison with NMIWAVE

1. Introduction

Vessel motion in OrcaFlex may be determined in a number of ways. Here, we are concerned with the calculation, in the time domain, of the motion governed by frequency-dependent wave load RAOs, added mass and damping. In order to validate this calculation, BMT Fluid Mechanics Limited set up equivalent models of a tethered vessel in NMIWAVE and OrcaFlex and demonstrated that both programs predicted the same vessel motions.

NMIWAVE is a frequency-domain program for estimating wave forces and motions of offshore structures and vessels in waves. It is published by BMT, and has been in general use by industry since 1977.

The uses of NMIWAVE results in this validation are twofold. Firstly, NMIWAVE provides the added mass and damping matrices and wave load RAOs, for each wave period, required as input data by OrcaFlex. And secondly, it calculates, in the *frequency* domain, displacement RAOs which may be compared to those derived from the OrcaFlex vessel motion in the *time* domain.

2. Input data

The vessel was a simple cuboid with sides of 90 m, height of 80 m, and a draught of 40 m, in water of depth 400 m. The vessel was given a mass of 30 kte; moments of inertia about (x,y,z) were calculated as (36.25, 36.25, 40.49) kte.m^2. It was tethered at each lower corner to the seabed, the tethers providing a total vertical stiffness of 111 kN/m.

3. NMIWAVE simulations

A series of NMIWAVE simulations were performed with regular waves of period from 5 to 36 seconds. These simulations provided (i) added mass and damping matrices and wave load RAOs, for each wave period, to be entered into OrcaFlex, and (ii) vessel displacement results, in the form of response amplitude operators (RAOs), again for each wave period, against which the vessel motion calculated by OrcaFlex may be compared.

4. OrcaFlex simulations

OrcaFlex simulations were run for each wave period. To avoid the effects of any transient behaviour, each simulation was run for 200 seconds and only the motion over the last wave period of each simulation was analyzed. The vessel motion in these models was calculated from the frequency-dependent wave load RAO and added mass and damping data obtained from NMIWAVE, using the convolution integral method of Cummins (1962), based upon the added mass and damping data for *all* wave periods (5–36 seconds).

To confirm that the frequency-dependence was in fact a significant factor, another set of simulations were run with constant (*ie* frequency-*in*dependent) added mass and damping. The data used were the same as those for those of the 15 second period frequency-dependent case.

5. Results comparison

The RAO amplitude and phase was determined from the vessel motion in the last wave period of the OrcaFlex simulations, and may be compared directly with the displacement RAO calculated independently by NMIWAVE. The graphs below show the results of this comparison. The RAOs predicted by OrcaFlex and NMIWAVE show excellent agreement, confirming that the OrcaFlex implementation of vessel frequency-dependent added mass and damping is correct.

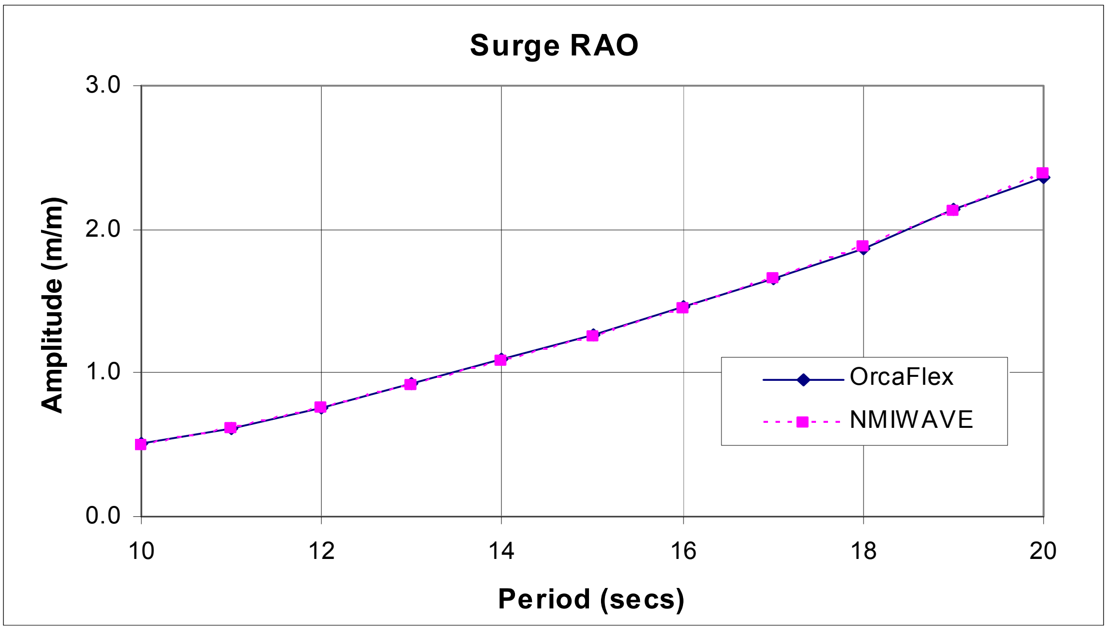

Figure 1: Comparison of Surge RAO amplitude

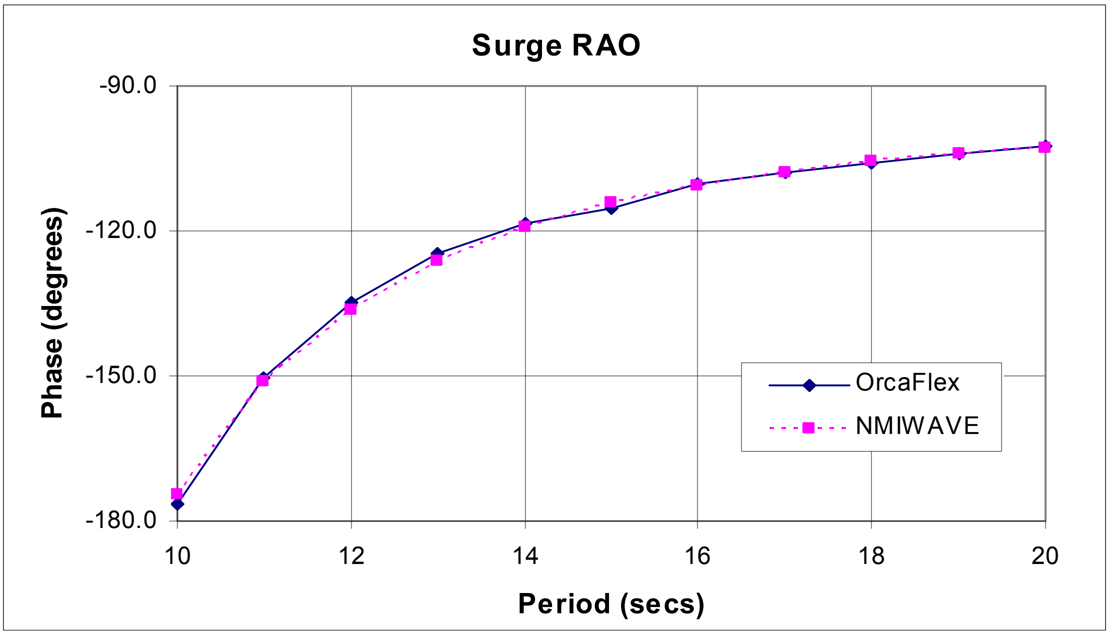

Figure 2: Comparison of Surge RAO phase

6. Frequency-dependent *v* Constant

The difference between frequency-dependent and constant-frequency calculations is shown in the two graphs below. Quite clearly, there is a significant frequency dependence. Note also that the two calculation methods give the same results for period 15 seconds, where they have the same data, giving further confirmation of the frequency-dependent calculation.

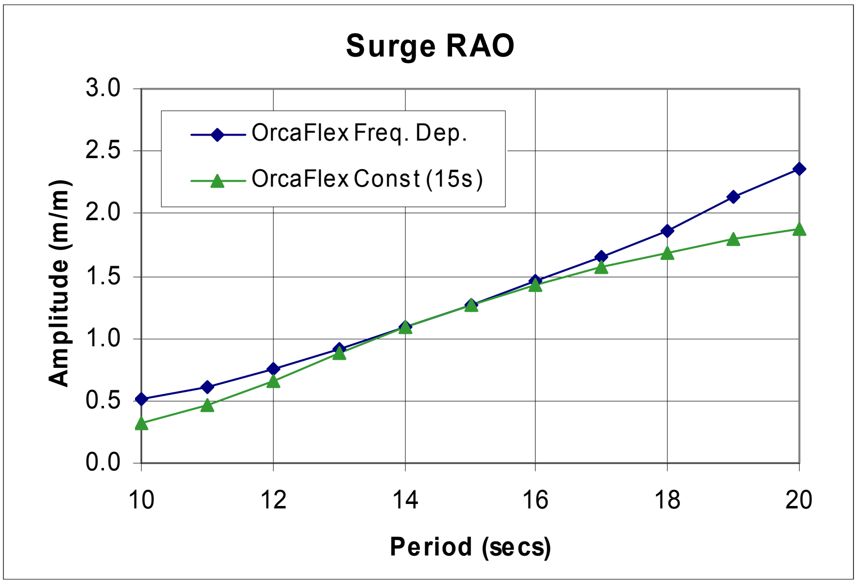

Figure 3: Surge RAO amplitude, frequency-dependent *v* constant

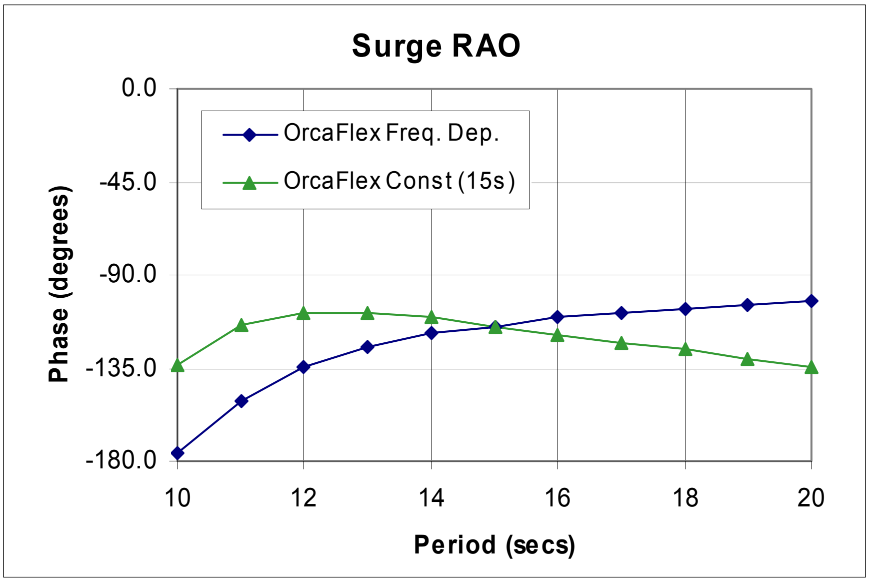

Figure 4: Surge RAO phase, frequency-dependent *v* constant

7. References

Cummins W E, 1962. The impulse response function and ship motions. Schiffstechnik, **9**, 101-109.