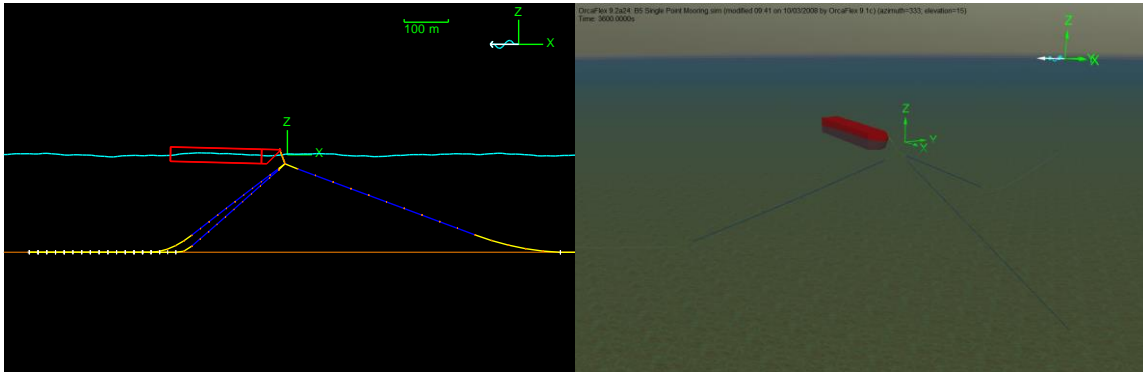*Orcina*

C05 Single Point Mooring

1. Introduction

An OrcaFlex default vessel is moored using three legs and a short chafe chain from the connecting node. This system is often used as a temporary mooring. In OrcaFlex, we aim to inspect the load on the moorings and quantify the mooring offset for this vessel in this sea state. The simulation uses irregular waves acting for a duration of 1 hour.

2. Building the Model

The main mooring lines are composed of chain sections, which are drawn yellow, with a polyester rope mid-section, drawn blue. The top end connection point is known as a node, and has been modelled in OrcaFlex using a 3D buoy. The buoy is net heavy in the water, and has no hydrodynamic properties. We are assuming that the mooring system motion will be dominated by the hydrodynamics of the lines – this demonstrates that it is not always necessary to enter data for every object attribute.

As the chains have no bending stiffness, there is no need for the node to be able to rotate or transmit bend moments – so a 3D buoy is appropriate for the node.

The vessel motion is calculated in all six degrees of freedom, so that the mooring offset in these environmental conditions can be evaluated taking into account the restraint from the moorings. The chains have a high axial stiffness, but quite a coarse segmentation, as we are not concerned about their curvature. If the simulation is repeated with refined segmentation in the moorings, especially over the touchdown region, the vessel offset and mooring tensions are only slightly affected, but the curvatures will change. Therefore in this instance we can use coarse segmentation, which will allow the simulation to run more quickly.

The vessel is deliberately not included in statics, in order to demonstrate that the drift motion is calculated.

The effects on the vessel that we want to include in the dynamic calculation are ticked in the Included Effects box on the Vessel Data form, Calculation tab. Some of these effects depend only on the low frequency primary motion, some depend on only the wave frequency primary motion, and some depend on all of the primary motion (for more details, see OrcaFlex Help *System*
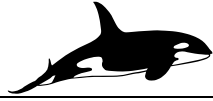
Modelling: Data and Results | Vessels | Vessel Modelling Overview). Because of this, we also need to specify whether the primary motion is treated as low frequency, wave frequency or a mixture of both. In this example the Included Effects include both low and wave frequency contributions, so we have set the 'Primary Motion is treated as' option to 'Both low and wave frequency'. We then also need to set an appropriate dividing period to filter the primary motion into its low frequency and wave frequency components, so that the calculation can use the appropriate part for each load. Ideally, the dividing period should be set to a value that is much longer than the wave periods, but much shorter than the second order periods, which are usually given by the vessel's surge, sway and / or yaw natural periods.

To find the vessel's natural periods, we can perform a modal analysis on the whole system. To do this, reset the model (press F12) and then open the vessel data form. Change the 'Included in Static Analysis' option to 6DOF. Then close the data form and run statics (F9), OK the warning box that appears regarding vessel scaling (this is discussed in more detail in Example 'A03 Jumper to High Tower').

Open the Modal Analysis form from the Results menu. Make sure that 'whole system' is selected in the Object box and 'Calculate mode shapes' is selected lower down so you can see the modes. Then press the Calculate button. The first three modes reported on the Modes Table tab refer to vessel natural periods; this can be clearly seen by moving to the View tab of the Modal Analysis form, and clicking through the different modes (make sure that you have the animation period set to Fixed, 5s rather than Mode period). Note that the view can be rotated and zoomed in the same way as the usual OrcaFlex view window. Mode 1 is a natural sway period of the vessel, Mode 2 is a surge and Mode 3 is a yaw. The shortest of these periods is 157s, and the storm applied has Tp 16.7s, so for this example we have selected 50 s as being a suitable value to use as the dividing period.

3.   Results

Re-open the simulation file and then open the Workspace 'C05 Single Point Mooring results.wrk'. Tensions for the chafe chain and also for the most loaded mooring line are plotted for the period of simulation when the largest loads occur (see the middle and lower right-hand graphs). We have taken statistics for the top line tension to find the time of greatest tension before the time histories were plotted (top right-hand graph).

The vessel excursion envelope is plotted on an X-Y graph. X-Y graphs can be used to plot any two values from a simulation. They are often used for envelopes of position, or for other coupled data, such as tension-angle plots for bend stiffener design. The initial slow drift (due to the vessel's exclusion from statics) can be clearly seen on the x-y graph.