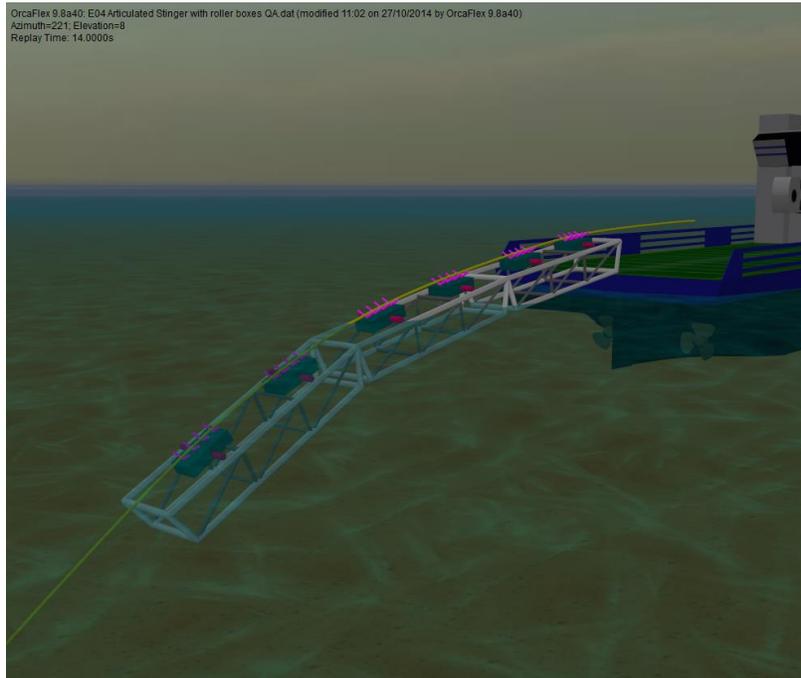


E04 Articulated stinger with roller boxes



This model represents a three-section articulated stinger with roller boxes, hinged off the back of a lay vessel. The stinger is detailed using an arrangement of single segment lines connected to 6D buoys (the buoys being assigned negligible properties), providing an accurate representation of the true hydrodynamic properties of the welded steel framework.

Previous examples in this set have treated each roller box on the stinger as a single support. This approach will be quite satisfactory for many applications, but it is not a precise representation of reality because each roller box actually consists of a set of rollers attached to a frame that is able to pivot slightly relative to the stinger. In this example, we model the roller boxes in detail.

The model

The active parts of the model consist of a lay vessel, the pipe being laid, and a stinger. The stinger is connected to the vessel using a constraint object, with one rotational degree of freedom (as described in previous pipelay examples) and the same arrangement is used to hinge adjacent sections of stinger. The welded framework of the stinger has been modelled with homogeneous pipes connected to 6D buoys (one 6D buoy per stinger section). The buoys have been set with negligible properties so that they don't influence the hydrodynamic behaviour of the stinger, which is defined only by the lines in this example. In each stinger section both ends of each line are connected to the buoy, and each line has been given only one segment, which means that each of

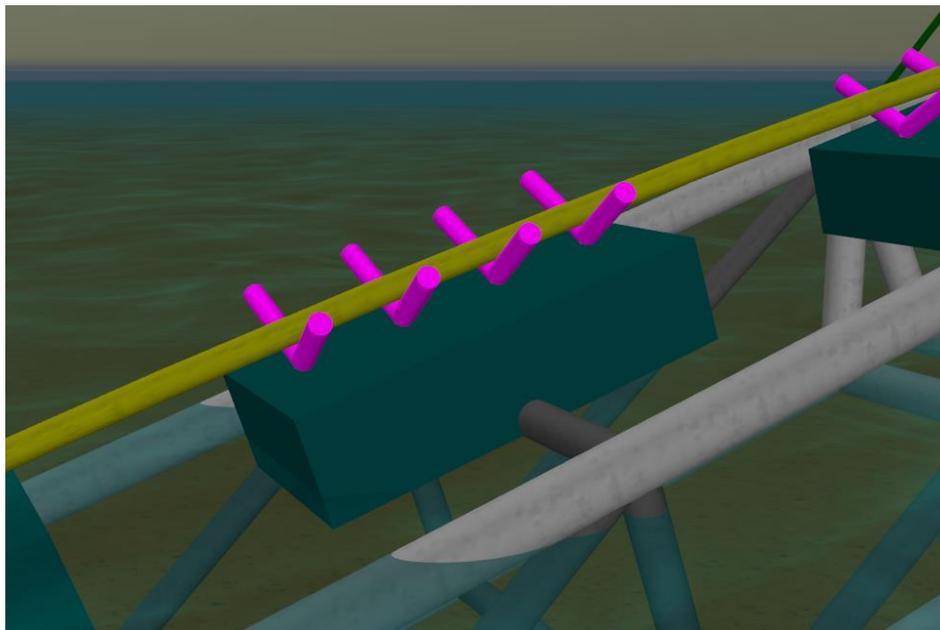
the three sections of the stinger acts as a rigid body (see [example E03](#) for guidance on how to model the stinger structure in detail).

To best view the build-up of the stinger frame, set the model browser to [view by groups](#). There are two main groups set up, called [Stinger](#), and [Roller Boxes](#).

The [Stinger](#) group contains four sub-groups: one group for each of the sections, and then one group containing the connecting elements (hinges). Grouping the connecting elements together makes it easy to hide them, as has been done in this model: as with individual items, select the group in the model browser and either toggle [Ctrl-H](#) or right click and select [hide](#). The stinger section sub-groups are called [Section1](#), [Section2](#) and [Section3](#). Each of these contain a 6D buoy, and sub-groups called [Stb Side](#), [Port Side](#) and [Cross Braces](#), which contain the groups of lines building up the frame.

Setting up sets of lines and buoys in groups like the stinger above is made straightforward by a combination of the duplication facilities in the model browser and the [all objects data](#) form. By placing the set of lines and buoys in a group, the user has the option of duplicating and moving groups using standard model browser facilities. Careful choice of names at the start can make this process run much more smoothly.

The individual rollers are built by assigning supports to 6D buoys. Multiple supports can be assigned to a vessel or 6D buoy, and in this case, four have been grouped into sections representing roller boxes (each roller box being a 6D buoy that can pivot relative to the stinger).



Pivoting roller box modelled using a 6D buoy with 4 'Vee' supports

As part of each roller box sub-group there is a further constraint, which controls the motion of the 6D buoy. The constraints allow the roller box to pivot as they would in practice, they also have a non-linear rotational stiffness, which allows them to rotate, but only between a limited angle range, to represent physical stops. Open the variable data item [roller box rotation stops](#). The variable data

has been set up so that the constraints are free to rotate up to $\pm 5^\circ$ about the mean position. Beyond that, the moment increases significantly, which prevents further rotation. A second non-linear rotational stiffness profile exists to limit the main stinger hinges to $\pm 10^\circ$ rotation. Close the variable data form and re-set the model (F12). Put the model into the default view (Ctrl + T) and then open the data form for the constraint *Roller box Hinge6*.

This is the hinge on the left-most roller box in this view. On the *degrees of freedom* page the *Ry* degree of freedom is ticked meaning that this constraint can rotate about its y-axis, but cannot move about any other degree of freedom. Note that the *initial value* is set to zero. This is the orientation at which the constraint starts the static solution. The *declination* of the constraint is also zero – this is the position about which the rotational stiffness is applied, so the roller box in the view will be able to rotate + or $- 5^\circ$ about the rotation that you currently see (i.e. with the roller box in line with the section of stinger). With the data form moved slightly to one side, try different values in the Initial Value box to see the roller box rotating to new initial positions. Note that this only changes the position that the constraint starts the static calculation in, it does not change the position about which the $\pm 5^\circ$ limits apply, so the end result in this case will be the same. To change the position about which the limits apply you would have to alter the *declination* of the constraint.

Open the data form for the 6D buoy named *Roller Box1*, which is located in the group *Roller Boxes*. It contains two tabs, *supports* and *support coordinates*, which are used to define the geometry of the supports, where they are positioned, and what line or lines they are supporting. For each roller box there are 4 vee supports, positioned at various X intervals and a Z offset of 0.6m. Multiple coordinate systems can be defined if necessary (for example if some supports are mounted on the vessel and some on the stinger), but in this case all the supports relate to the same coordinate system, at the centre of the 6D buoy. Hence, the Z offset places the supports 0.6m above the centre of the buoy, and at X positions fore and aft of the centre of the buoy. The information on this data form is repeated for each roller box buoy (6 in total).

Note that the supports are all individually specified, even if they are all on a single buoy, so it is possible to specify different types if required, including customised profiles.

For the environmental data a 1.5m Hs, 8s Tz head sea based on the Jonswap spectrum has been applied combined with a 0.5 m/s surface current onto the port beam.

Results

Re-open the sim file and then load the workspace *E04 Articulated stinger results.wrk* to view a set of plots that summarise the behaviour of the system.

The range graph of *max von Mises stress* for Stage 1 of the simulation (top left-hand graph) shows the variation over the upper part of the line; the stresses are low elsewhere. Dynamic variations are large and the highest stresses occur in the stinger region, as expected.

The upper right-hand graph shows the rotation of the last roller box from its initial rotation, and the lower right-hand graph shows the same result but for the hinge between stinger sections 2 & 3. In this graph the effect of a non-linear rotational stiffness modelling limit stops at $\pm 10^\circ$ rotation can clearly be seen.

See *example E01* for a full description of the results available for the supports. Examination of the dynamic replay, where contact with the supports is shown by colouring the support white, shows that the pipe is lifting off some of the rollers along the stinger length. This is indicating that this particular set of environmental conditions is too severe for the current stinger arrangement, and further adjustments to the roller positions would be necessary.