# E03 Detailed hinged stinger

This model represents a stinger hinged off the back of a lay vessel, as per the example E02 Rigid hinged stinger. Here, the stinger is modelled using an arrangement of lines connected together, providing a more accurate representation of the true structural and hydrodynamic properties of the welded steel framework.

As the interaction between the pipeline and the stinger can tolerate axial movement of the pipe, this model allows the pipe to move in and out of the tensioner. The model therefore represents the situation where welding operations have been suspended and the pipe is moving relative to the vessel to limit stresses.
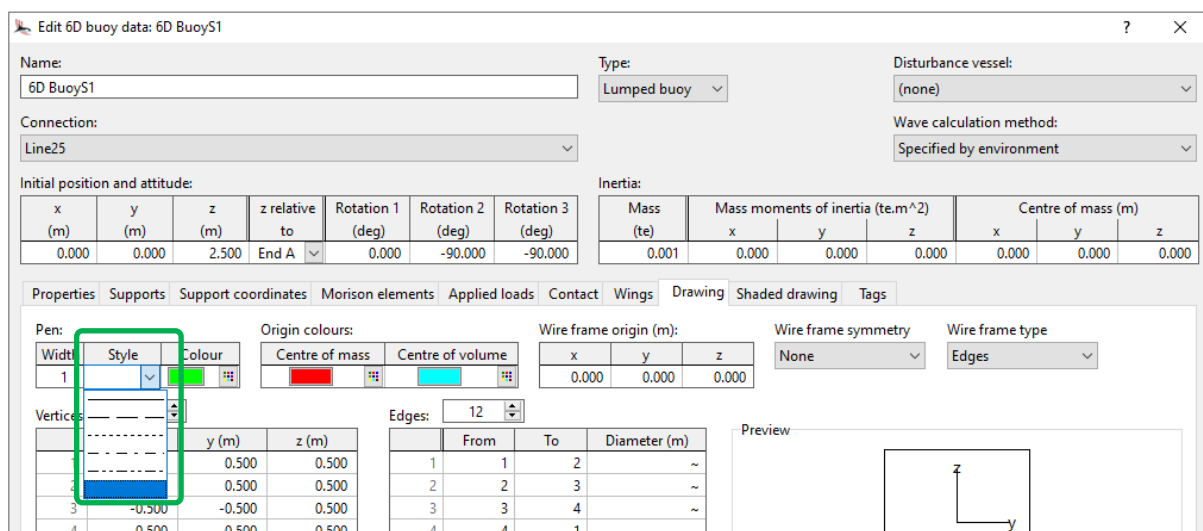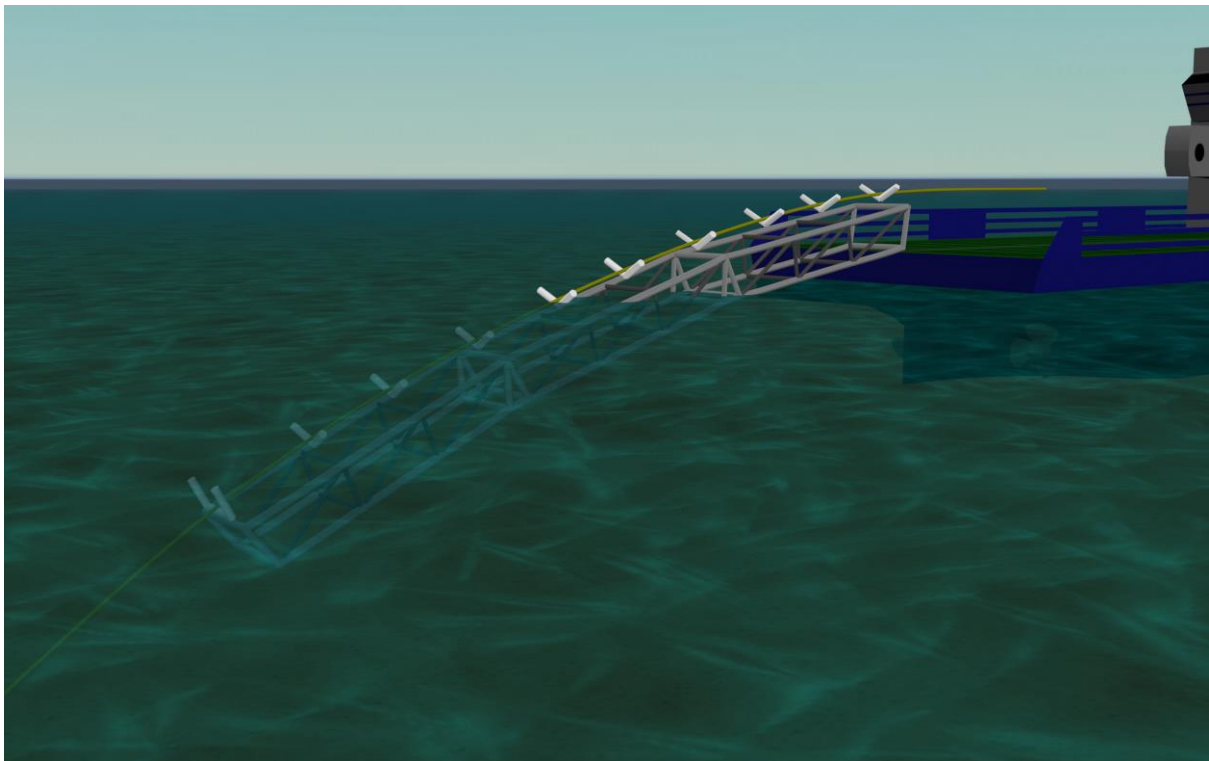
Building the model

The active parts of the model consist of a lay vessel, the pipeline being laid, a tensioner and a stinger. The stinger is connected to the vessel using two constraint objects, to represent a hinged system. The welded framework of the stinger has been modelled using homogeneous pipe line types; the use of multi-segment lines allows us to accurately model the flexing of the steel stinger framework.

To view the construction of the stinger frame, make sure the *model browser* is in *view by groups* mode; this is set by right-mouse clicking in the *model browser* and checking that the *view by groups* option is ticked.

One of the groups is called *Stinger*. Within this group, in addition to hinges and spacers, are three sub-groups, *Section1*, *Section2* and *Section3*, and in each of these sub-groups are groups called *Stb Side…*, *Port Side…* and *Cross Braces…*, which contain the groups of lines building up the frame. The *Cross Braces…* group contains some 6D buoys, which are used to carry the supports (rollers).

In this case, we want to show the support, but not the buoy drawing itself. Here, the buoy is shown in the model view (*Ctrl + H* toggles between shown and hidden for any object) but is removed from the model view by selecting the bottom pen style option on the *drawing* tab, as shown below.

Setting up groups of lines and buoys, for a stinger like this, is made straightforward by a combination of the *all objects data* form and the duplication facilities available in the *model browser*. By placing sets 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 object names at the start can make this process run much more smoothly.

The individual rollers are built using the supports feature, available for vessels and 6D buoys. Multiple supports can be assigned to one vessel or 6D buoy, but in this case, each buoy carries a single support.

Open the data form for the buoy named *6D BuoyS1* (located in the *Cross Braces* sub group of *Section1*). The data form 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. In this case, there is a single V-shaped support positioned at a z-offset of 0.6m.

Note that the final support is defined as a U rather than a V profile to limit the lateral motion of the lay pipe at the end of the stinger. 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.

Friction is applied to the contact between the pipe and the supports. This is specified on the *friction coefficients* data form, accessible from the *model browser*. In this case a friction factor of 0.2 is applied to all the supports contacting the pipe. The '~' symbol in this instance denotes that the same coefficient is applied in both the normal (resists sliding motion that would drag a line over or around a support) and axial (resists sliding along the support cylinder's axis) directions.

The vessel is the OrcaFlex default vessel. The pipeline and stinger are placed on the vessel's axis of symmetry but can easily be repositioned by using the move selected objects wizard available from the *model browser*. A tensioner is included in the model, which maintains a tension of 150kN throughout the simulation (see the example E02 Rigid hinged stinger for details on how to model tensioners).

The stinger is connected to the vessel via two hinge constraints *Hinge Stb* and *Hinge Port*. These constraints each have a single rotational degree of freedom, allowing the stinger to rotate relative to the vessel.

For the environmental data, a spreading stern sea – modelled using the JONSWAP spectrum – has been applied. The spectrum has been split into 5 wave directions with an arbitrary spreading exponent of 24. This is combined with a 0.5 m/s slab current onto the port bow (quartering seas).

The simulation was run for 50s, post build-up, with a *simulation time origin* of 8810s which imposes a particularly steep rising wave on the system.

Results

Loading the simulation file *E03 Detailed hinged stinger.sim* also loads the default workspace. The bottom right-hand plot shows a range graph for *max von Mises stress* for the first 200m of pipe, and time histories for *support reaction force* and *support lift out* for the last support on the stinger.

The range graph of von Mises stress for the first 200m shows the variation over the upper part of the line where the stresses are highest (i.e. the stinger region); the stresses are low elsewhere.

Support reaction force and *support lift out* time histories are two of the results available with the pipelay supports feature. These are reported for a specific support, and in this case the results are shown for the last support on the stinger. You will see that a low *support reaction force* corresponds with a high *support lift out* value, and vice versa. For this support, the pipe remains in contact at all times over the specified simulation period. If there was a clearance, the reaction force would become zero.

The example E01 Simple rigid stinger, and its supporting description document, provide further details about the definition of support contact clearance and lift out results.

In this model the positions of the supports have not been optimised, and therefore the stresses are highest at the first and last rollers. The positions of the rollers can easily be adjusted in order to even out the stress over the stinger region.

Open the Workspace file *E03 Detailed hinged stinger static state results.wrk*, to see a list of the static state *reaction force* results for all of the supports. This provides a convenient way to monitor the results of changes made to the support positions. The static state results table will remain visible

even if you reset the model, change something and then run statics again. Note that, in order to get multiple static state results listed in the same results window, you need to hold the *Ctrl* key down while you click *show*.

Finally, note that the analysis uses a constant normal drag coefficient of 1.2 for the lay pipe. This simple approach is likely to be conservative and the use of a variable drag coefficient based on the local instantaneous Reynolds' number would probably reduce stress levels.

For further details about modelling variation of line drag with Reynolds number, see the example [A01 Catenary and wave systems](#).