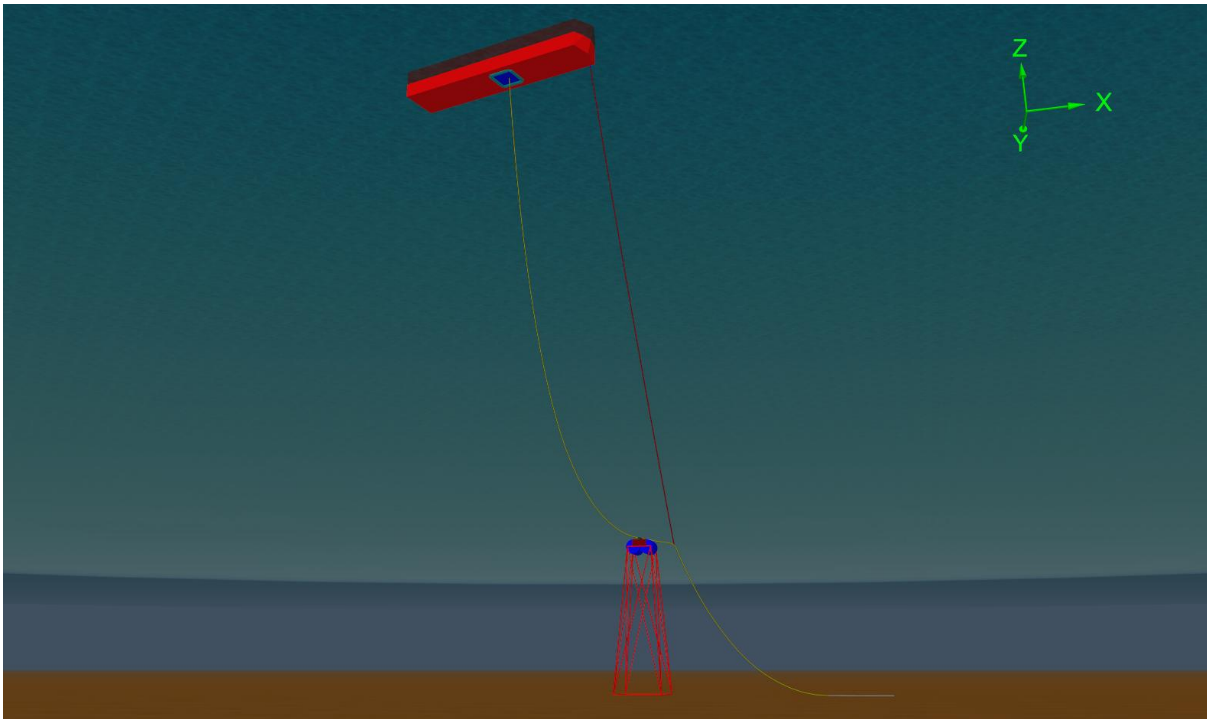
D03 Lay on tower

Introduction



This is an example of installing a riser over a subsea tower in 300m water depth. The riser is being paid out from the moonpool of an installation vessel and is supported from an auxiliary winch at the bow of the ship. Positioned approximately 14m along from the winch-to-riser connection point is a clamp, which has to be placed in the centre of the support tower.

This example demonstrates how:

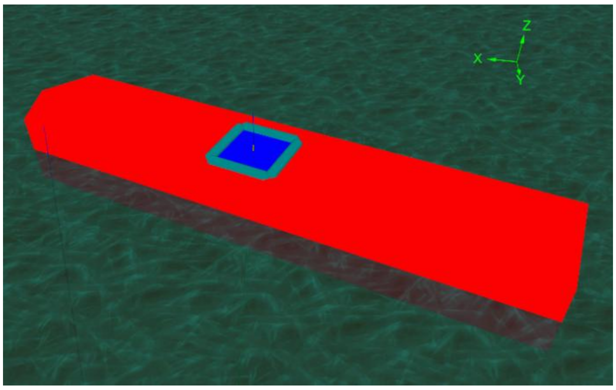
- A line can be guided into position using shapes.
- Friction between lines and shapes can be modelled.
- Clearance checks with moonpool edges can be performed.
- Physical and hydrodynamic properties for a winch wire can be obtained.
- Hydrodynamic shielding within a vessel moonpool can be captured.

The installation will take place very slowly and only in calm weather, so a series of static snapshots would usually be sufficient. However, it is simple and convenient to run the analysis dynamically and the replay gives a valuable view of the overall operation.

Building the model

Ensure that *view by groups* is selected from the model browser (right-mouse click in the *model browser* to find this option) and take a look at the *Vessel Structure* group.

Moonpool modelling



The vessel has a blue-coloured shape connected to it (*Moonpool Shielding*) which represents the inside of the moonpool.

The shape type is *trapped water* so any line nodes within the shape's volume will have the wave and current load algorithms turned off. This represents shielding from direct wave and current loading. When the nodes leave the confines of the shape these forces are turned back on again.

Note this is not the same as setting drag and added mass to zero. The line will be moving in the moonpool water and so relative flow will not be zero. This means drag and added mass on the line will not be zero.

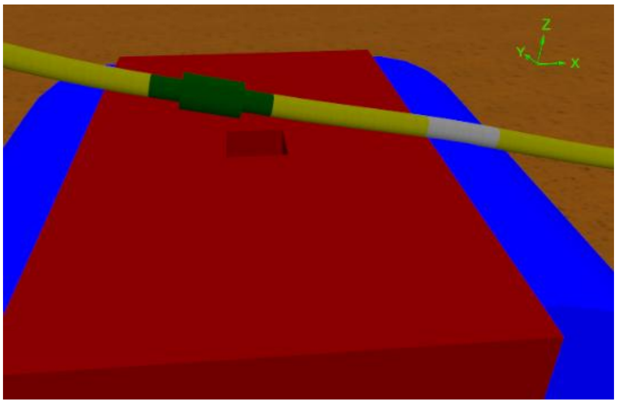
The boundaries of the moonpool edge are marked by a series of single segment lines in the *Moonpool Top* and *Moonpool Bottom* groups of the model browser. These lines have negligible physical and hydrodynamic properties but have a contact radius of 1m (*contact diameter* = 2m). Each is positioned with centreline 1m from the moonpool edge so the line outer edge is at the boundary. Clearance information can then be obtained between the flowline and the moonpool edges. The boundaries are pale blue in the view above.

Note that *line clashing* does not need to be switched on to get clearance results. The clashing algorithm significantly slows the simulation run-time, meaning it should only be considered if it's really necessary e.g. for re-runs of selected cases where clearance was found to be zero or negative (which indicates that one line is inside the other). For most analyses, contact is undesirable and so clearance results are sufficient to indicate if system change is required. Clash checking is used if information about the energy involved in the contact is required, of if behaviour post-contact needs to be assessed.

Tower modelling

The tower arrangement is listed in the *Tower Structure* group of the model browser. It uses a dummy vessel, *Tower*, as a common axis system and all its *calculation* properties are set to *None*. The *Dummy Tower* vessel type provides the *drawing* data for the tower legs. The arch and hole for the clamp are produced by elastic solid type shapes with contact stiffness so they generate a reaction force.

Flowline, clamp and winch modelling



Next, take a look at the *Winches and Flowline* group. The flowline is split into two lines connected either side of the clamp: see the *Flowline* sub-group. They have encastré connections to the clamp (*end connection stiffness* = Infinity).

The lines representing the flowlines are able to interact with the *elastic solid* type shapes of the tower. So, more line segments have been introduced – in the regions of flowline near the tower – to allow the lines to better follow the curve of the arch.

The clamp is modelled as a 6D *spar buoy* (named *clamp buoy*) with small diameters at the ends and a larger one in the middle. Rotation about the local x and y axis are restrained by the flowline connections and reaction from the arch.

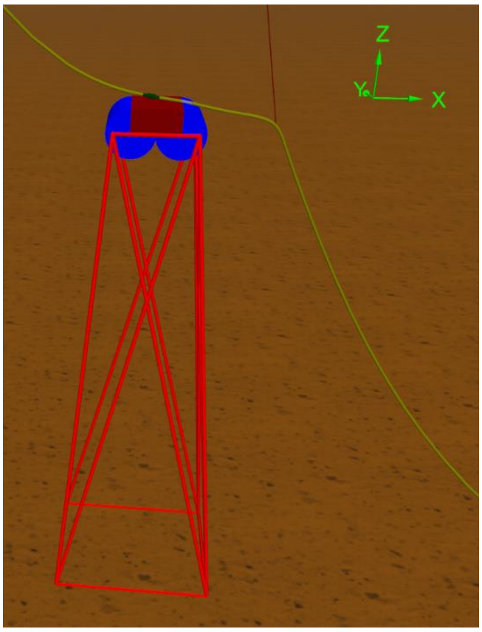
The buoy is prevented from spinning about its local z-axis by the fact that torsion is included on the flowlines. In this case, modelling torsion is necessary because we are connecting the auxiliary winch wire to the flowline at a point that is offset from the line's axis. However, if we didn't include torsion on the flowlines then there would be nothing to prevent the clamp buoy from spinning, which could prevent the static calculation from converging. In this situation, offsetting the *centre of mass* of the buoy slightly will help to prevent the buoy from rotating, by providing a unique static solution.

The buoy's *total contact area* is 3.6m^2. Generally, contact occurs between buoy vertices and shape surfaces. To visualise this, you need to change the buoy *draw stack using* setting to *draw square cylinders* (on its *drawing* page) and the view to wire frame. There are 24 vertices in total, so each represents an area of 3.6 / 24 = 0.15m^2.

When the clamp is being slid into place, only four vertices will be in contact i.e. those for the larger diameter part of the clamp. This means a contact area of 0.6m^2. When dropped in place there will be eight vertices in contact for the smaller diameter cylinders, so a contact area of 1.2m^2. The exact values are not critical in this application, but it shows the principle.

Both flowline lengths, and the clamp buoy, interact with the arch shapes. This reaction includes friction. Opening the *friction coefficients* data form from the model browser to see the relevant settings on the *line types* and *6D buoys* pages. For further details about setting this data, refer to the Modelling, data and results | Friction coefficients data page of the help.

The installation operation is performed using two winches: a main winch and an auxiliary one. The *MainWinch* object represents the main riser handling winch in the moonpool of the lay vessel. It is connected to the *Upper Flowline* at end A (the top end) and paid out to lower the flowline slightly. As the winch wire is short and remains in air, the length and stiffness of the winch object are sufficient to model its response.



The *Aux Winch* object, in the *Clamp Control Winch* sub-group, is positioned at the stern of the vessel and its purpose is to lift the riser into position. For this operation, the length of the auxiliary winch wire will be much longer than the length of the main winch, and most of its length is submerged.

This means that the mass, displacement and hydrodynamic loading on the wire could be significant in the context of the overall system behaviour. So, most of the winch wire length is modelled as a line (*Aux Winch Wire*). End B of the wire is connected directly to the *Lower Flowline*.

The winch object itself (*Aux Winch*) is connected between the vessel and end A of the *Aux Winch Wire*. The winch has only sufficient length to allow pay in without ending up with zero length.

Note, an alternative to this approach is to use *line feeding* for the *Aux Winch Wire*. Further details about modelling line feeding can be found in the example D04 J-tube pull in.

In the static analysis, the *MainWinch* and *Aux Winch* have a *specified length* of 5m and 20m respectively. The winches are active in different stages to enable the desired installation sequence. The stages are listed below and finish with 8 seconds of settle time during stage 4. Note that stage 0, the wave build-up stage, can be used as a normal stage here as no waves are applied (the wave *height* is set to zero on the *waves* page of the *environment* data form).

Stage	Time	Main Winch		Auxiliary Winch	
		Payout (m)	Payout rate (m/s)	Payout (m)	Payout rate (m/s)
Statics	–	–	–	–	–
0	-8s to 0s	0	~	-5	-0.625
1	0s to 16s	5	0.3125	0	–
2	16s to 32s	5	0.3125	0	–
3	32s to 48s	0	–	-4	-0.25
4	48s to 64s	0	–	0	–

Table 1: Winch payout settings

Results

Open the workspace *D03 Curvature and contact.wrk*. Watch the animation for the whole simulation and note how the clamp drops into its slot.

The left-hand plots show curvature about the local y axis (curving in the vertical plane) for the *Upper*… and *Lower Flowline* lengths. The right-hand graph shows the *line clearance* between the *Upper Flowline* and the moonpool edges.

Run the replay and note how the curvature changes close to the arch. Also note how the minimum clearance varies along the length of the flowline as it is paid out using the main winch.