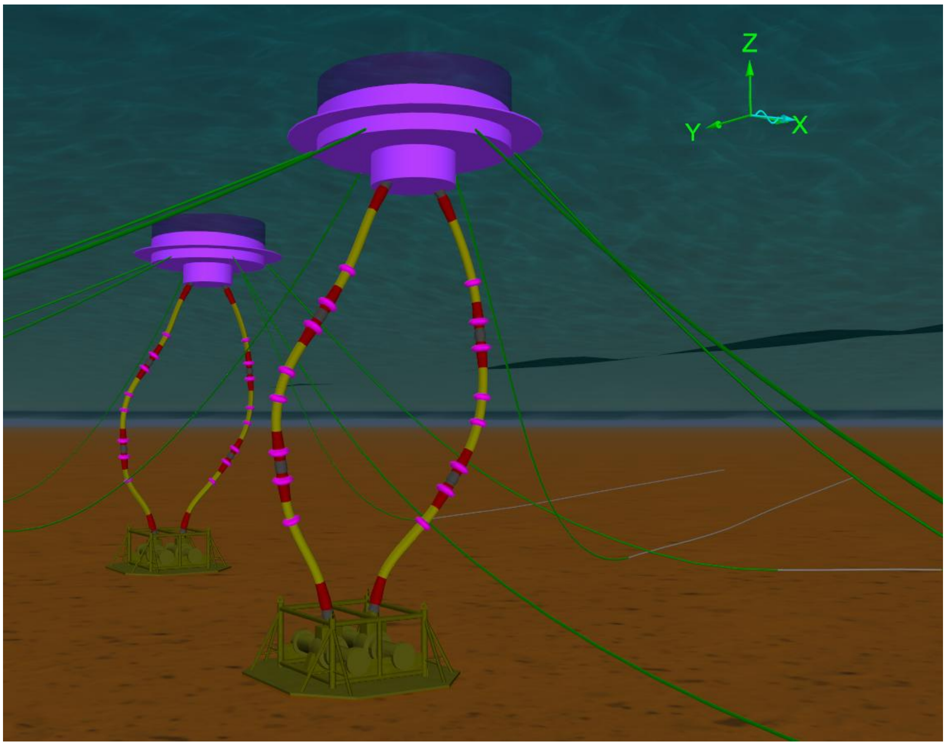
H01 Chinese lantern

Introduction

Risers descend from the underside of a moored CALM buoy to its base on the seabed in a Chinese lantern configuration.



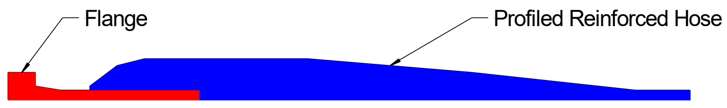
Building the model

The CALM buoy is modelled using the 6D buoy *spar* option – see example C06 CALM buoy for a discussion of some of the issues involved.

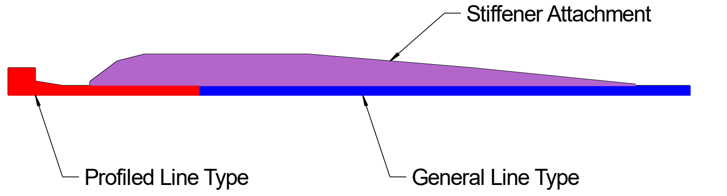
The risers are forced to bend outwards by angling the end fittings and adding buoyancy modules. Press *Ctrl+Y* to turn the local axes view on. You will need to switch to wireframe view to see this by pressing *Ctrl+G*, which toggles between the wireframe and shaded views. Note the direction of the Z-axis at each end of the risers.

Open the line data form for *Riser 1 without torsion*. Looking at the *structure* page, the hose structure is quite detailed, with typically 0.2m long segments. The hose is made up of sections of low-pressure bonded hose with reinforced ends, connected together with flanges. Each hose section comprises a steel flange and a reinforced profiled section that is bonded to the flange at each end, plus a central section of constant-diameter hose.

The sketch below shows the actual hose construction and the equivalent arrangement that is used in the model to represent it.



Hose End Structure



Model Equivalent

The main hose section is modelled in the usual way, using a *general* category line type named *Body*. The end flanges are modelled using a profiled line type; this is done by using the *homogeneous pipe* category of line type. Look at the *line type* data form; the *category* page shows which type is used for each line type. On the *geometry, mass & expansion* page, the line types that are of *homogeneous pipe* type can be given a variable inner and outer diameter. Right mouse click and select *edit variable data* to see the data that has been given to *Flange Profile End A* and *Flange Profile End B*. The data is the same except that end B has been reversed using the *reverse* button. In other words, the profile at end A goes from large diameter to small and the profile at end B goes from small to large. Clicking the *profile* button produces a graph showing the considered profile.

The reinforced section of hose, which has a profiled outer diameter, is modelled as a *stiffener type* attachment that is 'bonded' to the outer diameter of the flange and the *Body* hose. The stiffener's profile is created in the same way as for the end flanges: see the *Sheath Profile End A* and *Sheath Profile End B* variable datasets. The *homogeneous pipe* line type category calculates the stiffness properties for you, from the geometry and Young's modulus (E). In the case of the reinforced hose, it is a composite item and therefore using a single value of E to calculate both bending and axial stiffness is not correct, however in this instance it is the bending behaviour that is critical, therefore setting E for the bending stiffness is appropriate.

Because the profiled sections need to fit over the top of the basic hose and end fitting, we add them to the line as attachments. Back on the line data form, click on the *attachments* page to see how these are added. There are a number of floats attached to the hose, which are listed on this page too.

Click on the *attachment types...* button and look at the *stiffener types* page. This is where we define that the attachment is made up of the profiled line type that we have created, where its connection point is, and how the axial load and inertia are transferred. In this case, we are modelling something that is actually part of the hose, therefore we choose *over full length* to indicate that the stiffener is effectively bonded to the underlying line.

Close this window to go back to the line data form. Click on the *profile graph* button at the bottom of the form. This graph is useful to check that the stiffener attachments are positioned correctly and are the right way round. Note that the stiffener attachments are shown in blue. Here, the axis scales compress the view so that you can see the entire line's length on the one graph. Also note that the segmentation that you use for the profiled line sections affects the resulting profile. The section of line within the stiffener must have uniform segment length, and the stiffener length must be an exact multiple of the segment length, therefore some care is needed when selecting the segment lengths for the line sections that fall within the stiffener.

Modelling torsion in the risers can be important if the CALM buoy offset is large or if environmental loading is severe. It is worth checking critical cases with torsion included if you are going to do the bulk of your analysis without torsion. For this reason, there are two systems in the model, with and without torsion, which have been positioned so they see identical loading.

Results

Look at the animation through the latest wave (you can set the *period* covered by the replay on the *edit replay parameters* form). You can see that the upstream hoses 'kink' inwards for half of the wave cycle, i.e. they bend inwards rather than out in response to the wave loading. This is seen in cases both with and without torsion (the 'without torsion' set is in the foreground of the default view).

Note the results graphs shown have the arc length on the Y axis rather than the usual X axis. The numbers are also in descending order instead of increasing. This is achieved on the *select results* page by choosing *arc length axis: vertical* and *arc length axis inverted*. These options can be found below the *object* part of the form.

The range graph plots compare curvature results for *Riser 1*, with and without torsion. The upper graph is for the line that includes torsion. There is a slight difference in curvature distribution, but the extreme values are very similar. Assessing important engineering results, in this way, can help to establish whether it would be important to include torsion for certain lines in a model.