Introduction to Hydrodynamic Analysis with Ansys Aqwa

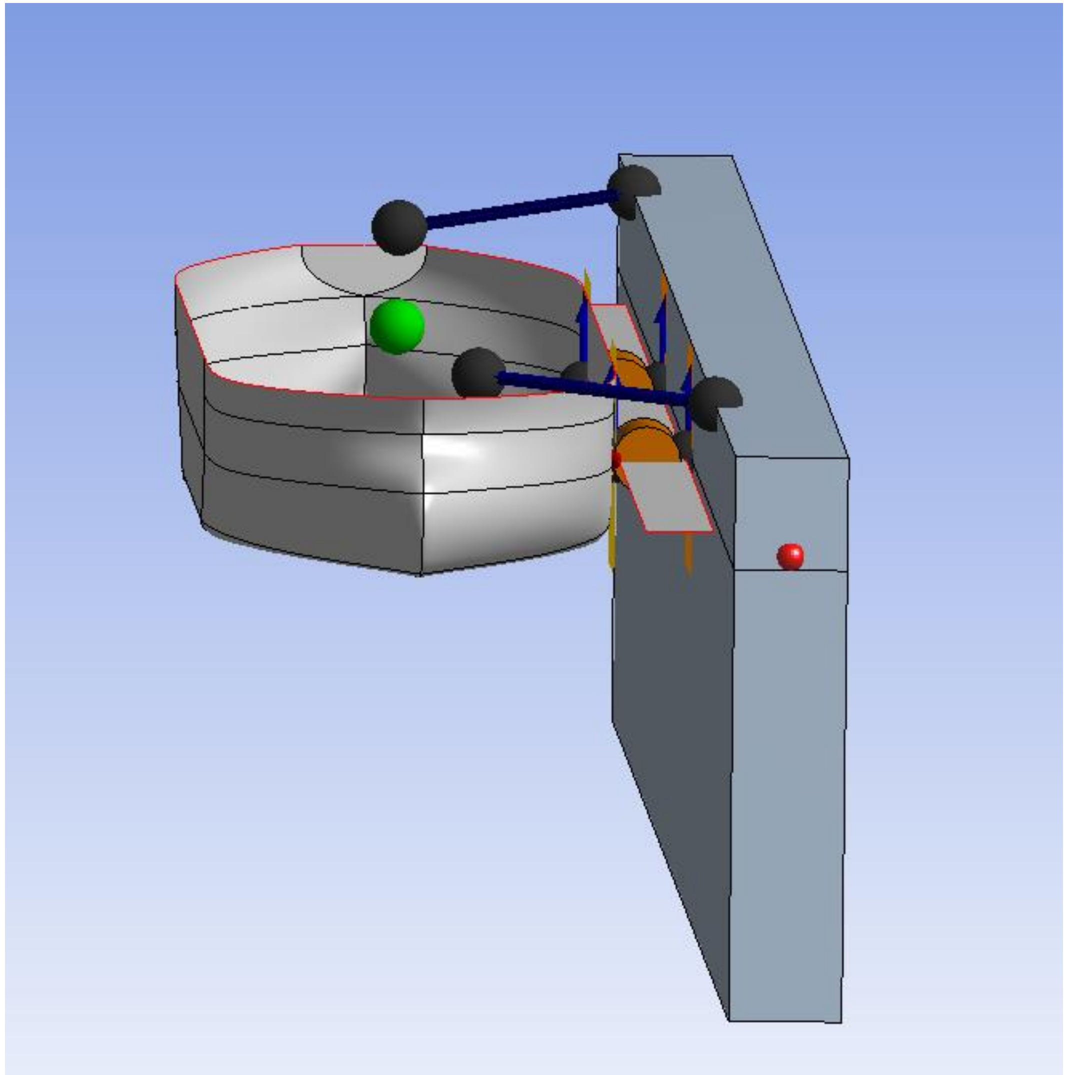
Workshop 07.1: Ship and Pier Hydrodynamic Interaction

Release 2021 R2

Ship and Pier Hydrodynamic Interaction

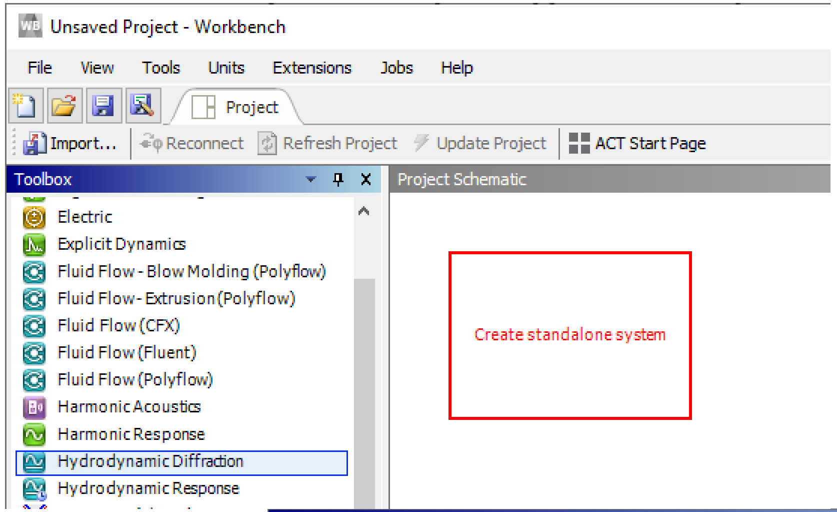
•The goal of this workshop is to

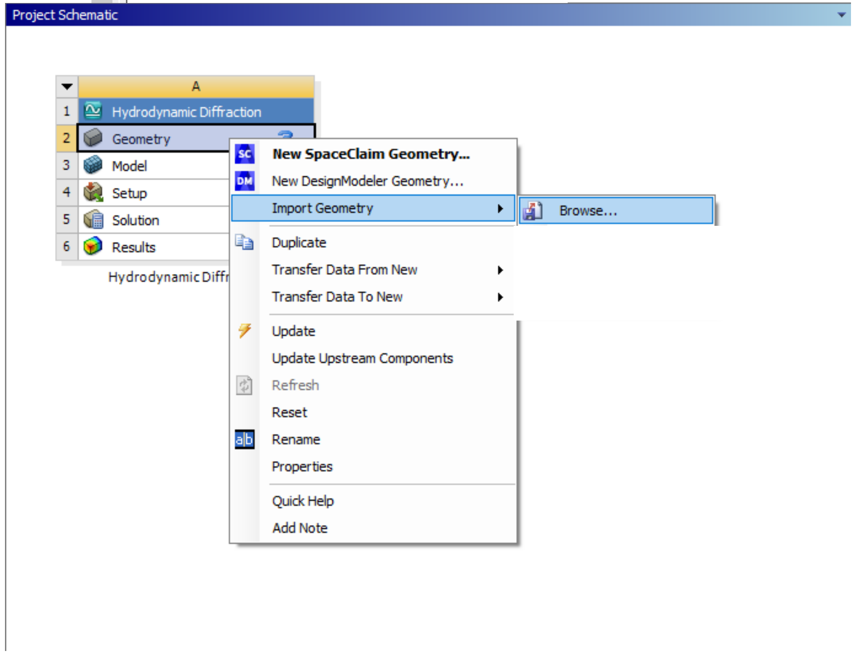
- Create a combined ship and pier hydrodynamic interaction model
- Introduce concepts of external lids and fixed structures
- Include fenders and linear elastic lines
- Undertake a time history dynamic solution with short crested waves



Create HD System

- Add HD system by drag and drop on to the WB Project Schematic page.
- Right-click on Geometry cell, Import Geometry > Browse, and browse to ShipPier.scdoc (this is the repaired geometry from Workshop 1)



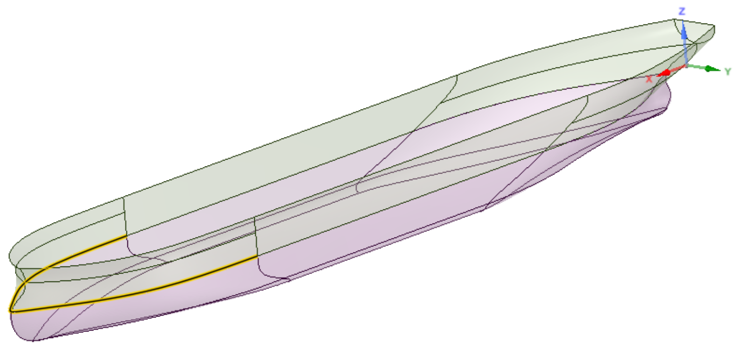


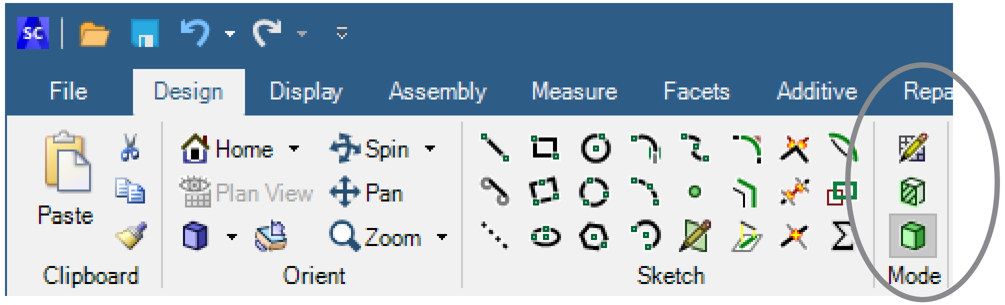
Import CAD Geometry

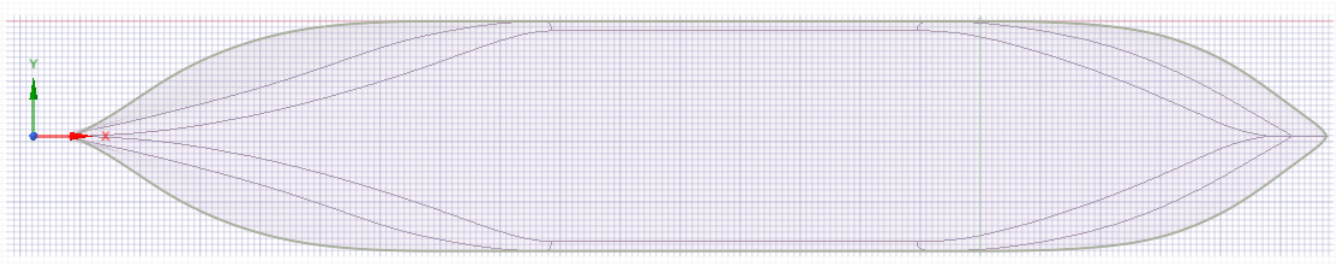
- Double click on Geometry cell to open SpaceClaim.
- We will now create a simple pier model and an area on the water surface to be used later as an external lid

Create Pier Geometry

- The pier is going to be a simple box. We are going to sketch a rectangle, then use the Pull and Move tools to create this.
- Select the global XY plane as the sketch plane. This can be achieved by first selecting two lines at the water line on the ship geometry, then select Sketch Mode from the Design tab.
- Select Plan View from the icons at the lower part of the graphics window.







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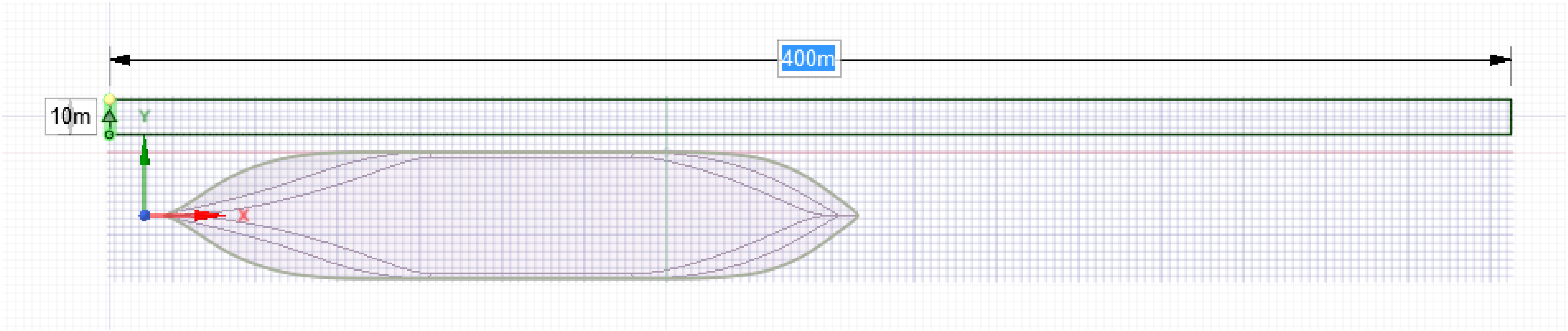
Create Pier Geometry

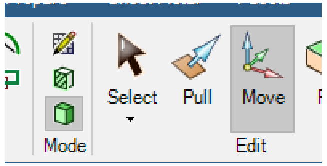
- Select the Rectangle sketch tool and create a rectangle adjacent to the ship. It should be on the positive Y side of the ship. Set the dimensions as shown (hint: you can use tab key to switch between the two variables to set them).

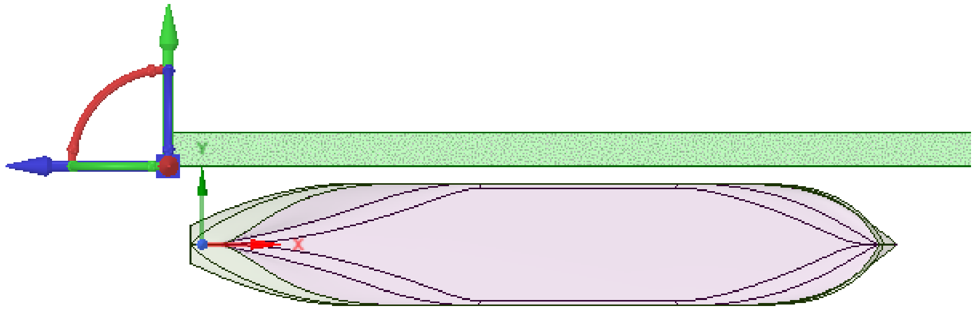


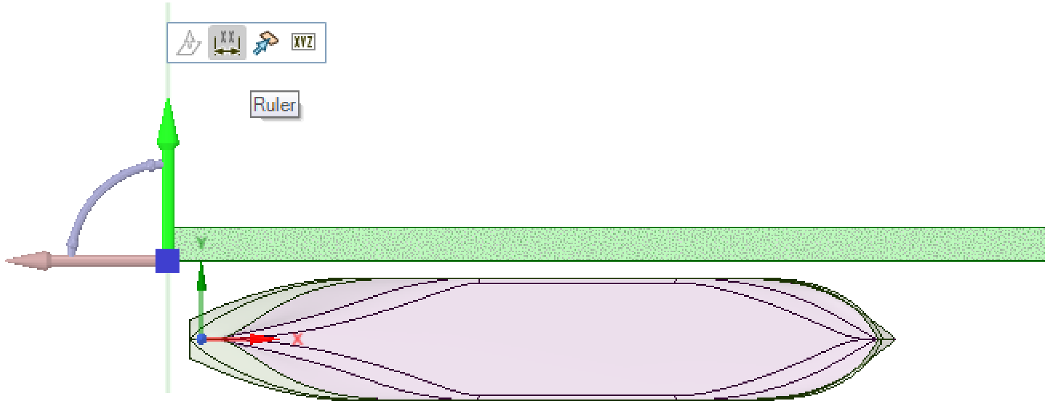
Ansys

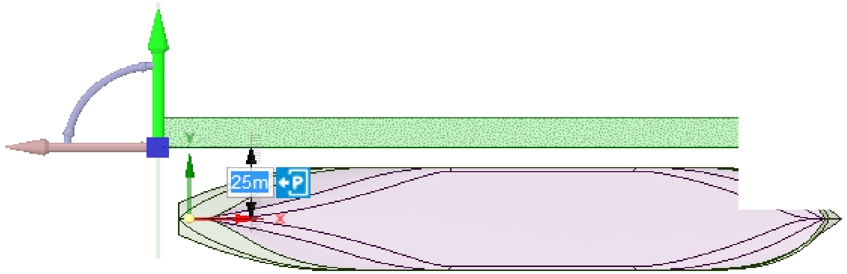
Create Pier Geometry

- To position the pier correctly relative to the ship we use the Move tool on the Design tab.
- Switch to 3D Mode and then select the Move tool
- Click on the surface we have just created and an axis set appears. Drag the origin of this to the lower left corner of the surface.
- Click on the green arrow of the Move tool axis, then select Ruler. Drag the yellow ball that appears so that it is coincident with the global origin. Then set the dimension to 25m.



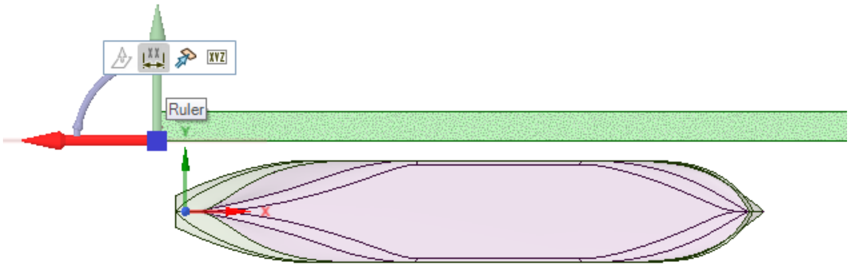


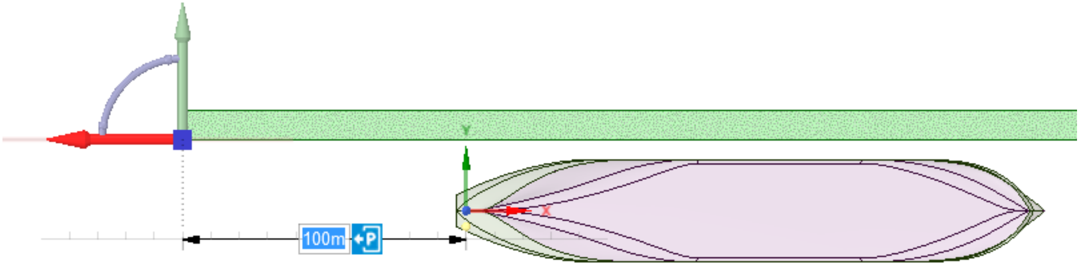




Create Pier Geometry

- Repeat this for the X direction by selecting the red arrow of the Move tool axis and drag the yellow ball so that it is coincident with the global origin. Then set the dimension to 100m.
- Hit Esc to exit the Move tool.





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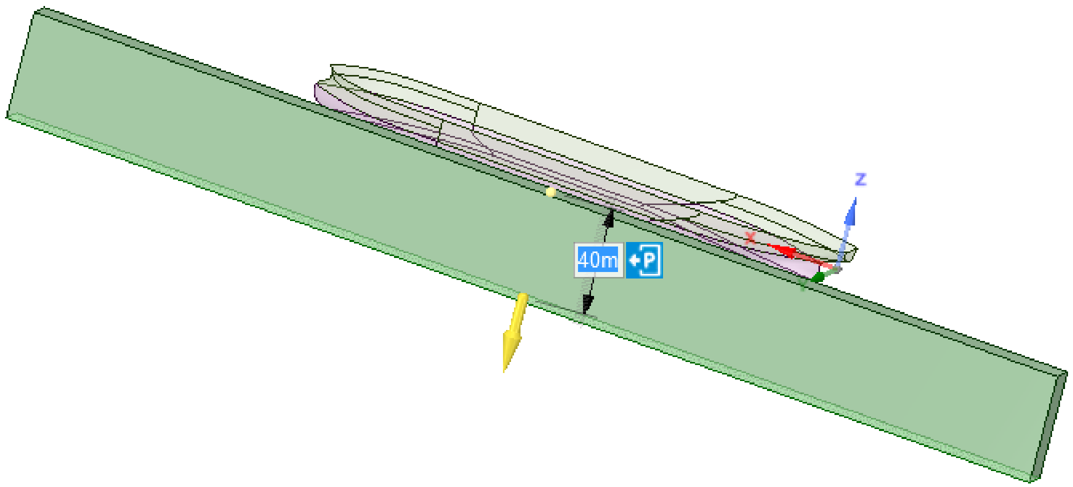
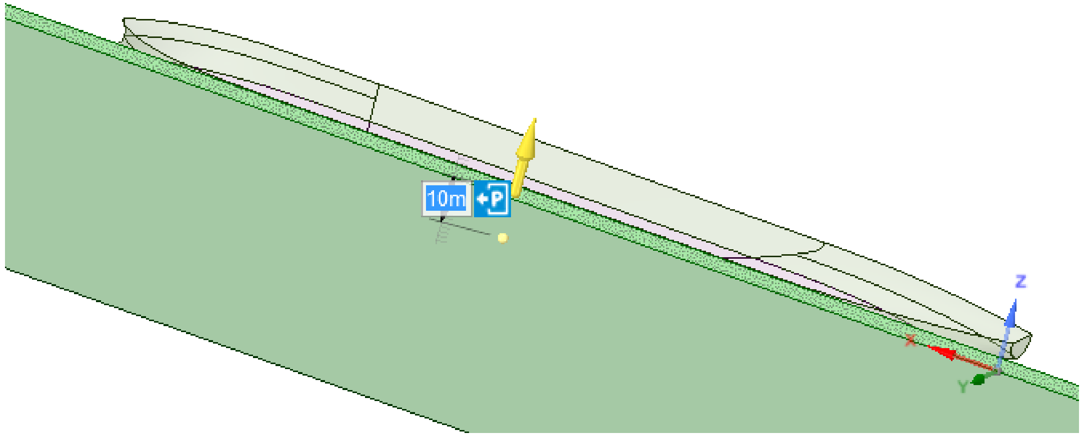
Create Pier Geometry

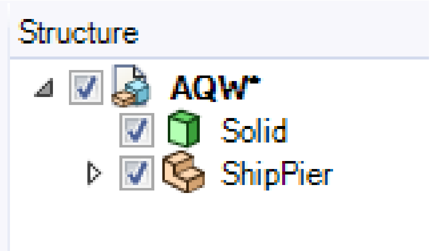
- To make the solid pier we choose the Pull tool.
- Click on the surface we have just created, a yellow arrow appears. Click on the arrow and drag the surface down. Set the dimension to 40m. Hit Esc to exit the tool.
- Reselect the top surface and using the Move tool drag the surface up and set the dimension to 10m

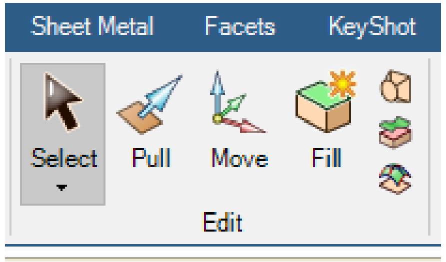


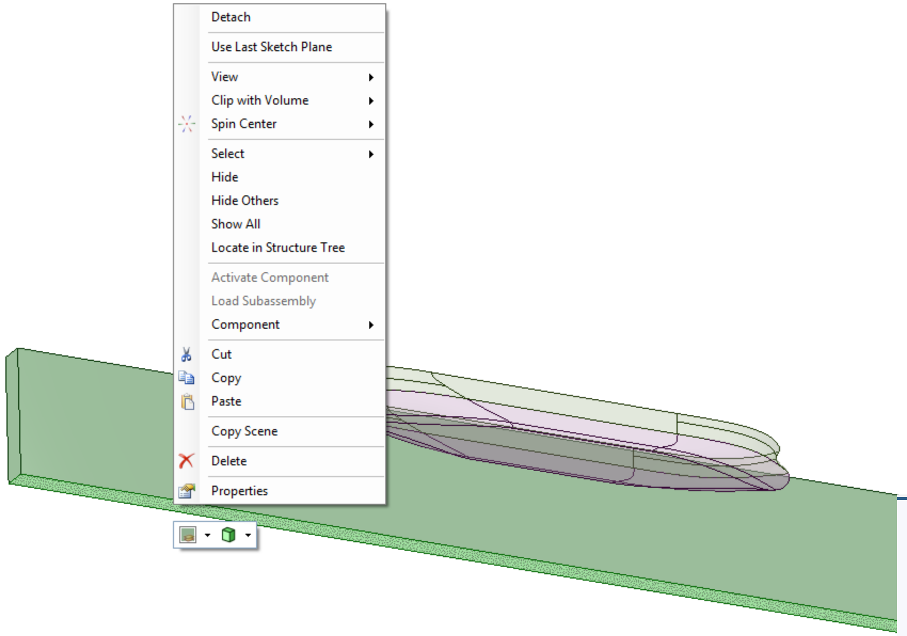


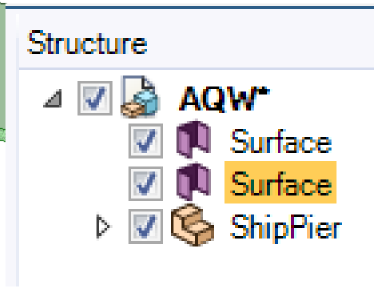
Create Pier Geometry

- At the moment the pier is a solid, but Aqwa requires a surface.
- Also, the base of the pier is going to be sitting on the seabed. We need to separate the pier base so that it can be assigned appropriate properties in Aqwa.
- Both these requirements can be achieved by detaching the bottom surface of the pier.
- Using the Select tool click on the surfac at the bottom of the pier, RMB > Detacl We now have two surfaces.



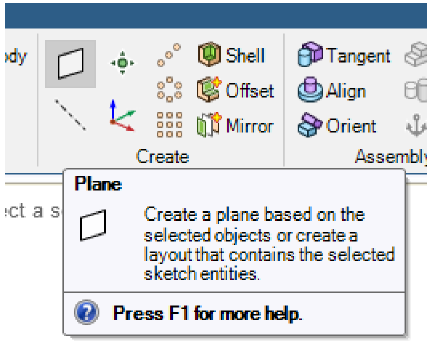


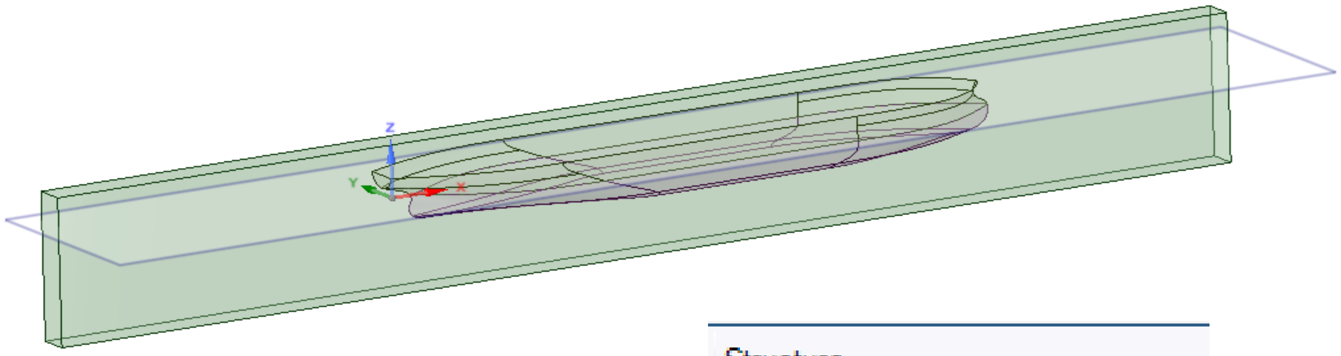


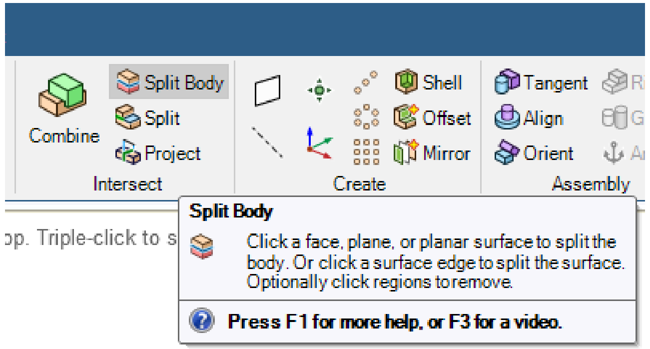


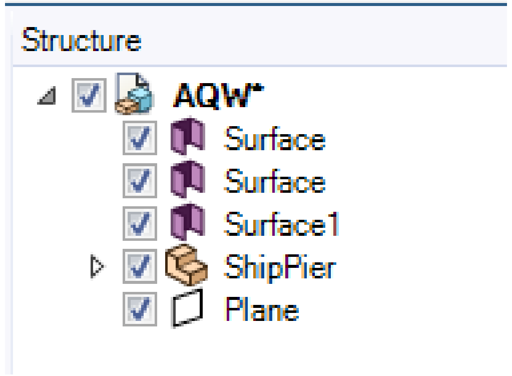
Define the Waterline

- We now need to cut the pier at the water line so that we can mesh without elements crossing this line.
- First create a Plane. Select two lines on the ship that are at the water line, then click on the Plane icon.
- Select the Split Body tool, select the pier in the graphics window, then click on the plane just created. Hit Esc to exit the Split Body tool.









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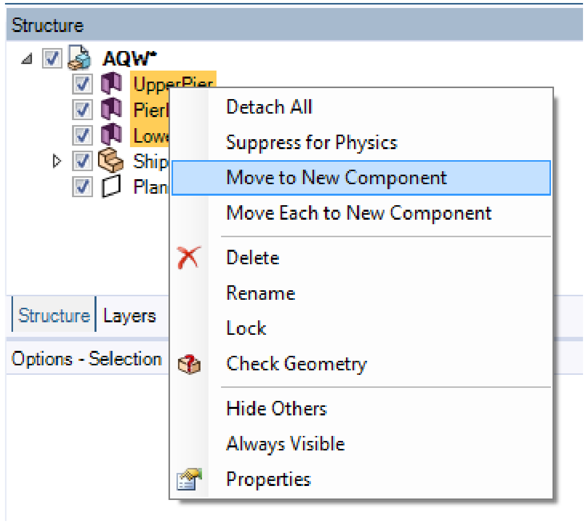
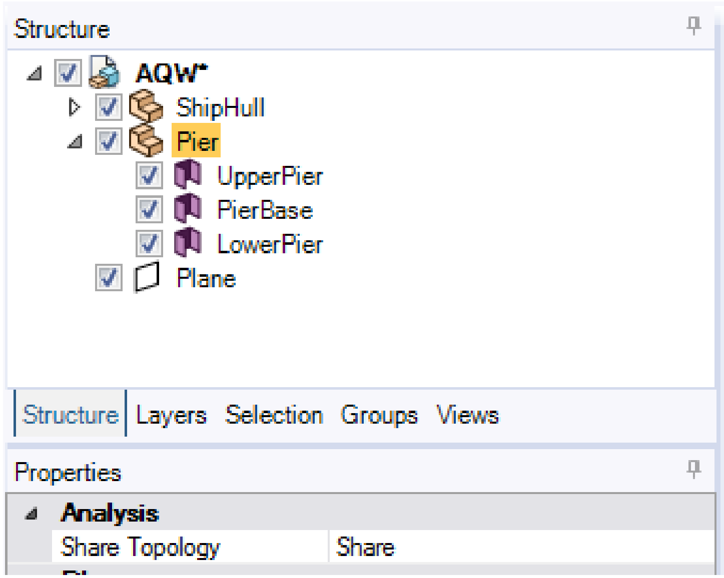
Define the Waterline

- We now have three parts for the pier, one above the water line, one below and a third representing the base (plus one part for the ship)
- By selecting each item in the tree the associated geometry will be highlighted in the graphics window.
- Identify the base and rename as PierBase. Similarly rename the UpperPier and LowerPier bodies
- Finally select the three parts of the pier and right-click > Move to New Component and rename as Pier. In the Properties panel, under Analysis, set the Share Topology to Share. This is already set for the Ship. Rename ShipPier component to ShipHull.





External Lid Geometry

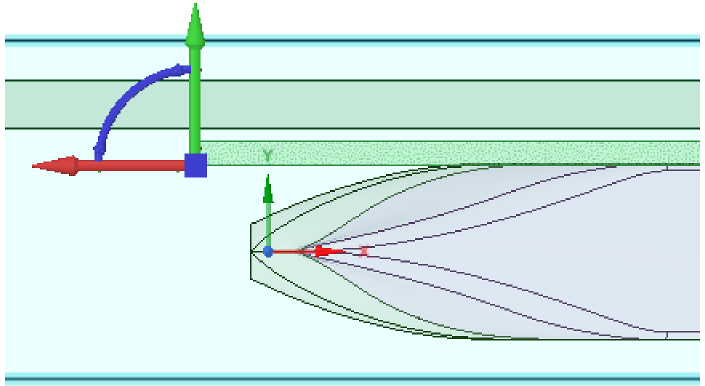
- For closely spaced multi-structure simulations it is recommended to include an external lid between the structures to limit standing wave formation between them
- The extent of the lid is not critical, but should cover an area that spans the extent of the adjacent structures
- We will use the same sketching tool to create a rectangular surface at the water line.

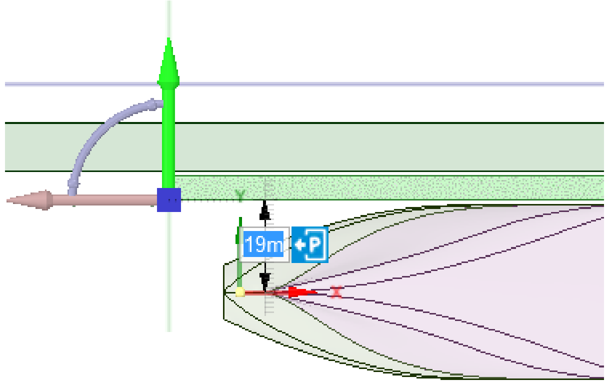
External Lid Geometry

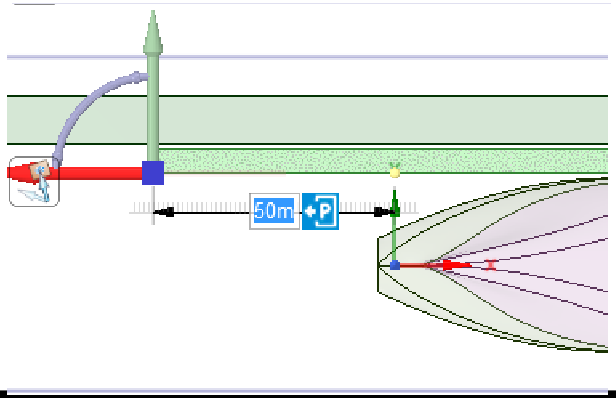
- Select the Plane that we created, then click on the Sketch Mode icon. As before choose the Plan View icon to look down on the sketch plane. Select the Rectangle sketch tool and create a rectangle between the ship and the pier. Set the dimensions as shown.

External Lid Geometry

- Go back to 3D Mode. Click on the Move tool.
- Select the surface we have just created. Drag the origin of the axis set that appears to the lower left corner of the surface.
- Click on the green arrow of the Move tool axis, then select Ruler. Drag the yellow ball that appears so that it is coincident with the global origin. Then set the dimension to 19m.
- Repeat with the red arrow and set dimension to 50m.
- Hit Esc to exit the Move tool.

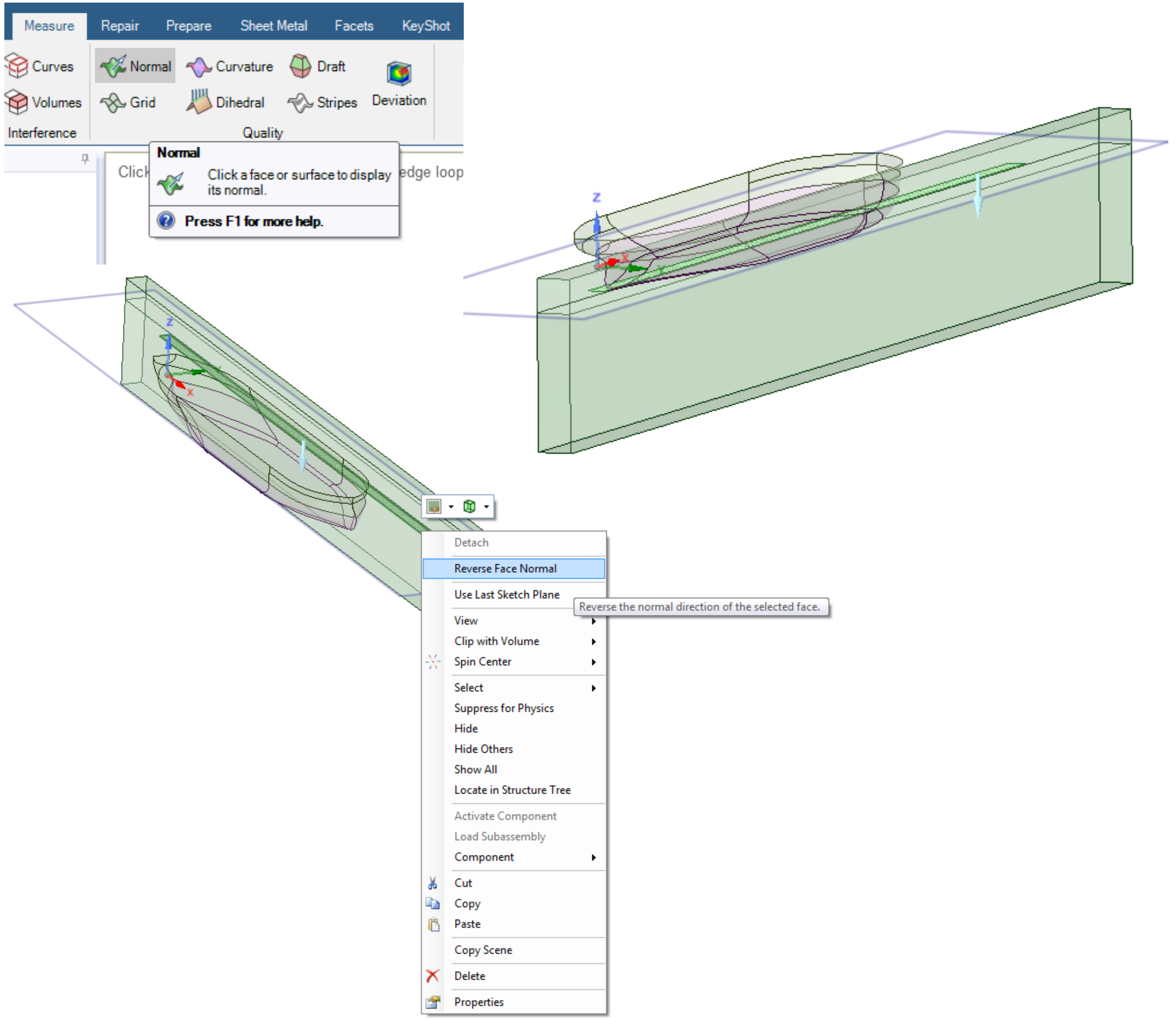






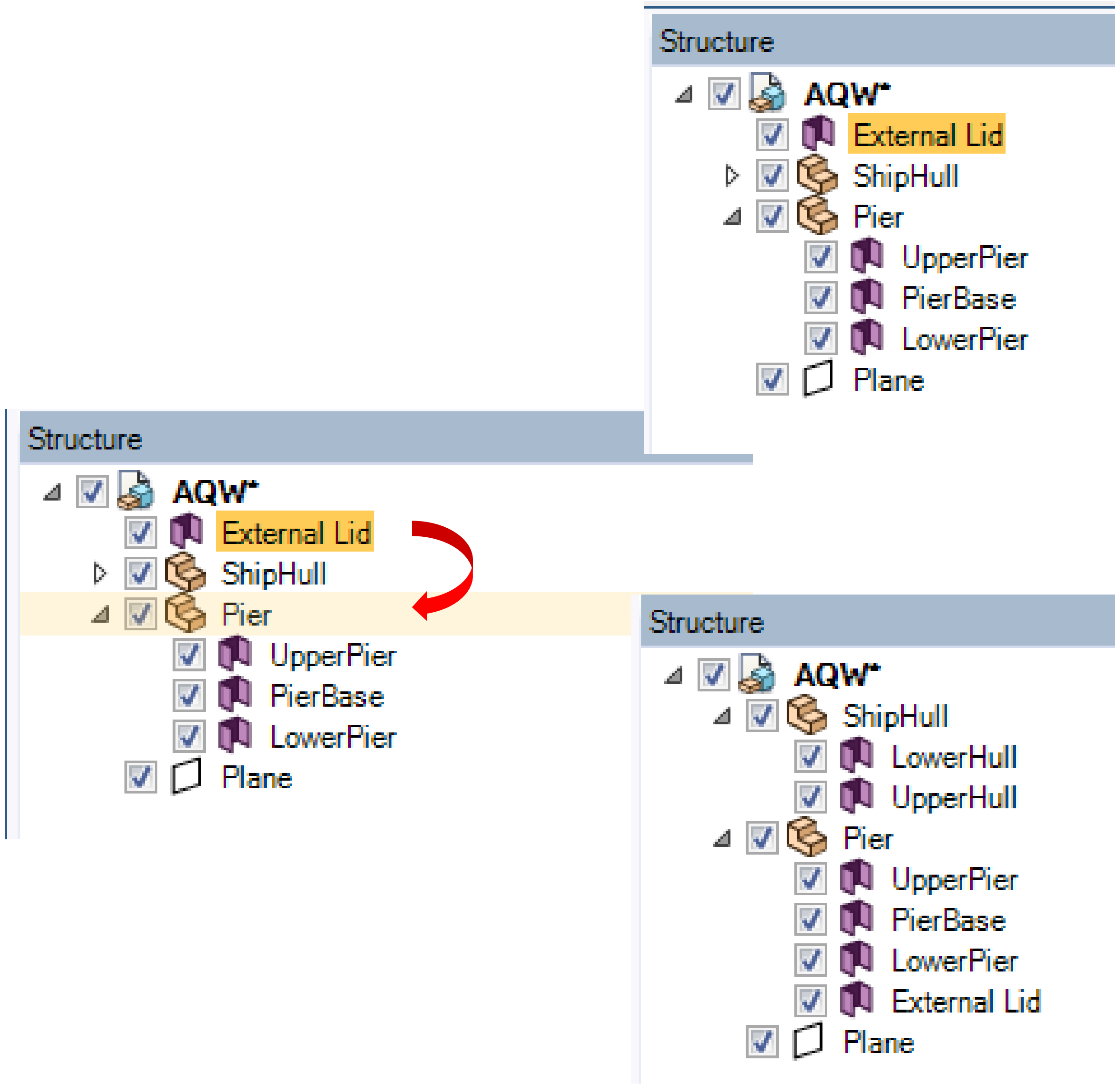
External Lid Geometry

- Aqwa requires that the normal for the external lid points upwards. To check this select the Measure tab, then choose the Normal icon. Click on the external lid surface we have just created.
- If necessary, reverse the surface normal by right-clicking on the surface and select Reverse Face Normal.



External Lid Geometry

- The external lid needs to be associated with one or other of the components in SpaceClaim, it should not be a separate structure in Aqwa
- Rename the created surface as External Lid
- With External Lid selected, drag onto the Pier component.
- Exit SpaceClaim



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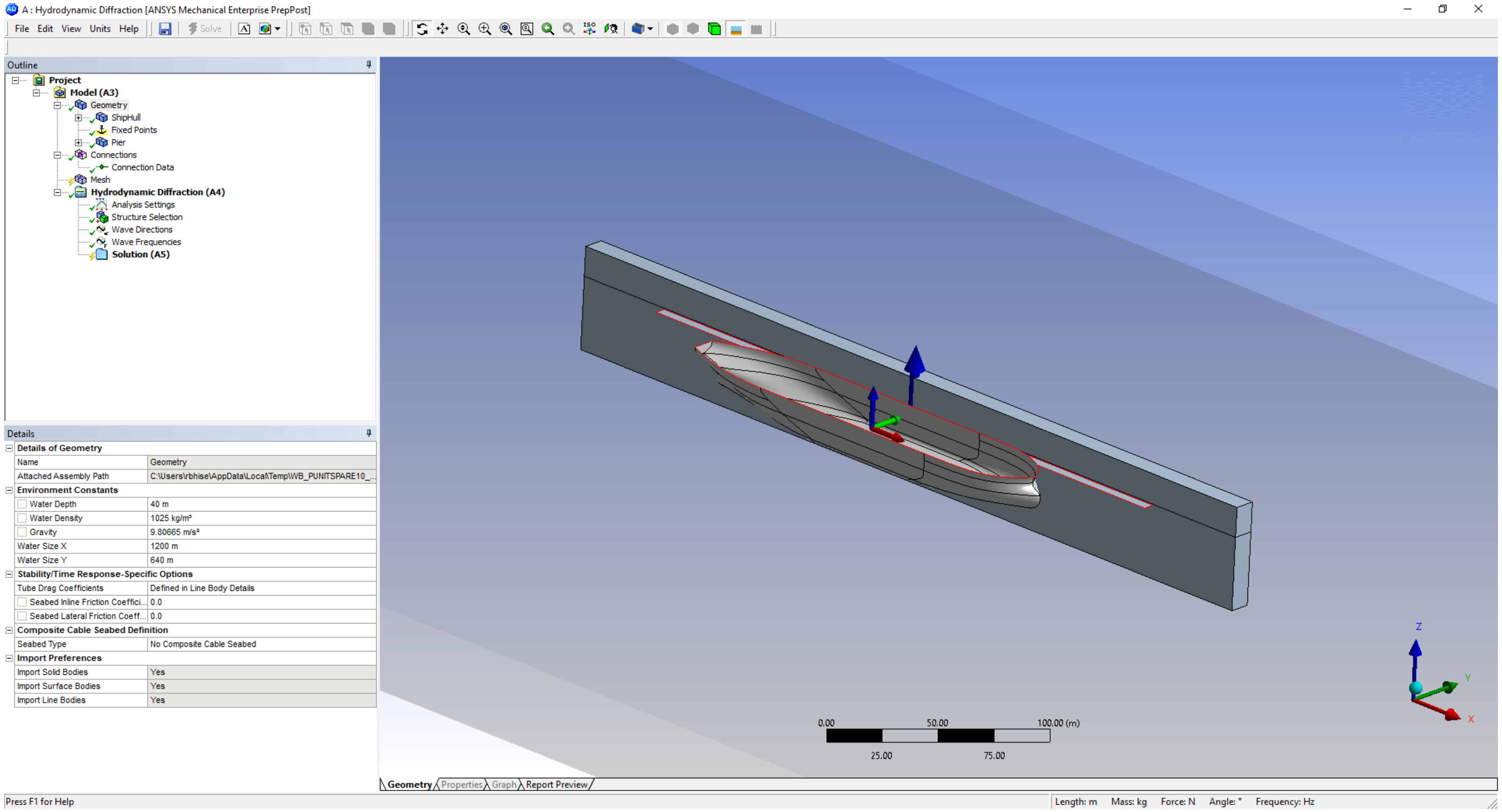
Adding Aqwa Specific Parameters

- Double-Click on Model Cell on Project Schematic.



Ansys

Global Parameters

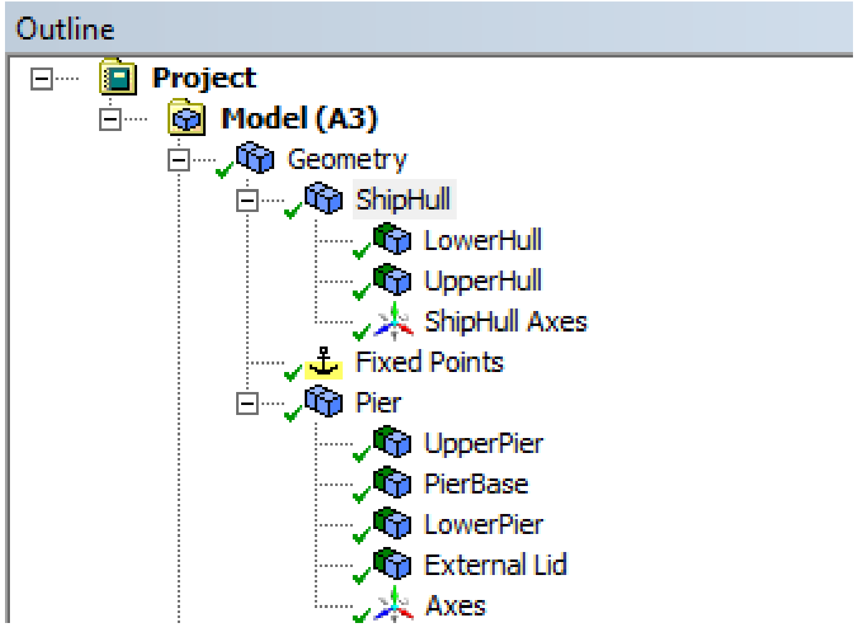
- Select the Geometry object in the tree. Set the Water Depth to 40m.

Details

Details of Geometry	
Name	Geometry
Attached Assembly Path	C:\Users\rbhise\AppData\Local\Temp\WB_PUNITSPARE10_...
Environment Constants	
Water Depth	40 m
Water Density	1025 kg/m³
Gravity	9.80665 m/s²
Water Size X	1200 m
Water Size Y	640 m
Stability/Time Response-Specific Options	
Tube Drag Coefficients	Defined in Line Body Details
Seabed Inline Friction Coeffici...	0.0
Seabed Lateral Friction Coeff...	0.0
Composite Cable Seabed Definition	
Seabed Type	No Composite Cable Seabed
Import Preferences	
Import Solid Bodies	Yes
Import Surface Bodies	Yes
Import Line Bodies	Yes

Vessel/Structure Parameters

- Select the ShipHull structure in the tree

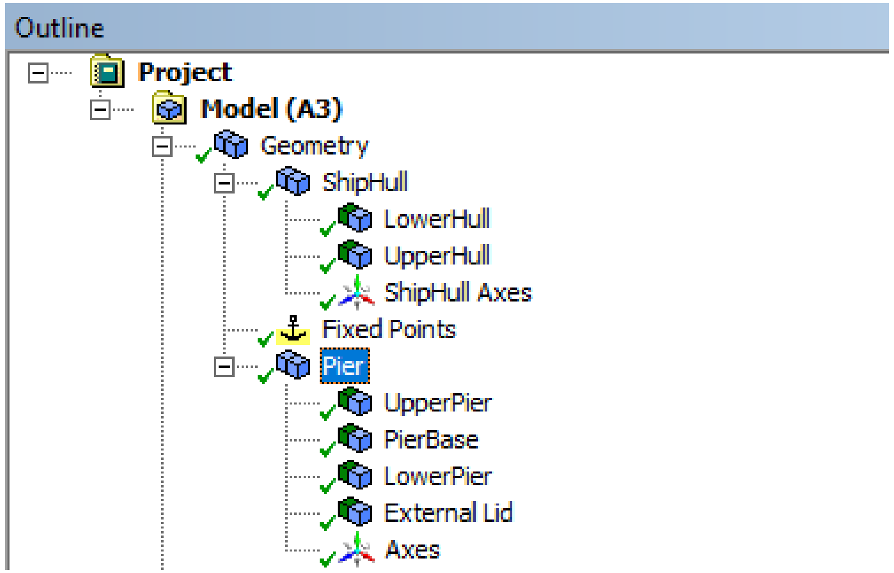


Details of ShipHull	
Name	ShipHull
Part Visibility	Visible
Part Activity	Not Suppressed
Part Color	
Mass Properties from Solver	
Total Mass	Solve Hydrostatics to Update
Advanced Options	
Generate Internal Lid	Yes
Lid Element Size Definition	Program Controlled
Current Calculation Position	At Fixed Depth
Current Calculation Depth	0.0 m

Set Generate Internal Lid Option in Details of ShipHull to “Yes”. This will remove any potential irregular frequencies.

Vessel/Structure Parameters

- Select the Pier structure in the tree



Details

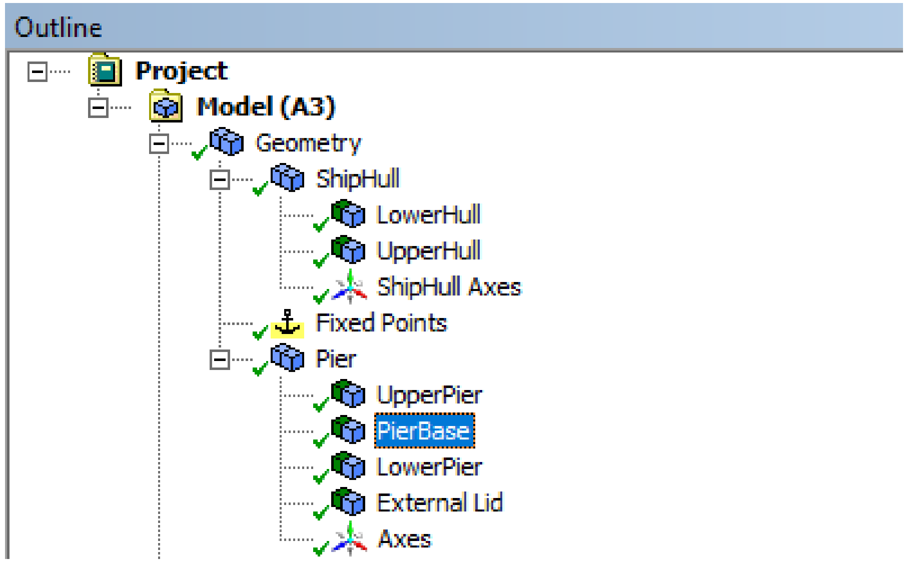
Details of Pier	
Name	Pier
Part Visibility	Visible
Part Activity	Not Suppressed
Part Color	
Mass Properties from Solver	
Total Mass	Solve Hydrostatics to Update
Advanced Options	
Generate Internal Lid	No
Current Calculation Position	At Fixed Depth
Current Calculation Depth	0.0 m
Submerged Structure Detection	Program Controlled
Override Calculated GMX	No
Override Calculated GMY	No
Fixity Options	
Structure Fixity	Structure is Fixed in Place
Force Multiplying Factors	
Drag Multiplying Factor	1
Mass Multiplying Factor	1
Slam Multiplying Factor	0.0
Shear Force/Bending Moment Options	
Calculate Shear Force/Bending ...	Not Permitted for Multiple Structures

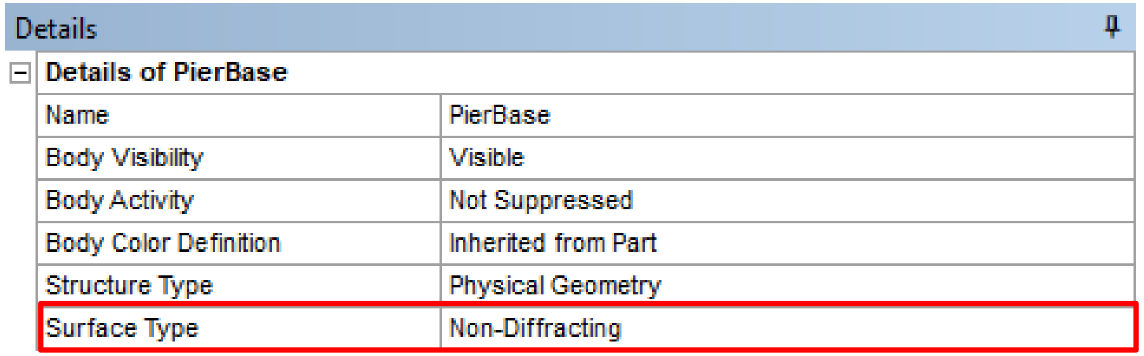
- Set Structure Fixity to Structure is Fixed in Place. Note that this is in effect only for the Hydrodynamic Diffraction analysis. The pier will have to be connected to ground by a rigid Joint for any subsequent Hydrodynamic Response analysis.

Ansys

Vessel/Structure Parameters

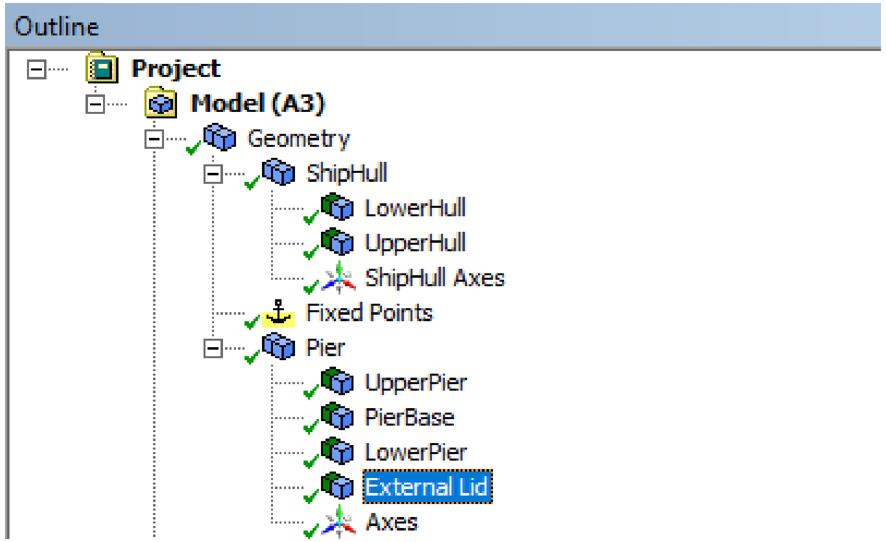
- The pier base must be set as non-diffracting, since the seabed acts as a boundary condition in the diffraction model, so errors would be generated if we left this as non-diffracting
- Select PierBase and set Surface Type as Non-Diffracting





Vessel/Structure Parameters

- The Pier body External Lid must be assigned the data to establish this as a lid, rather than a physical part of the pier.
- Select External Lid and set Structure Type as Abstract Geometry, and Abstract Type as External Lid. Leave the Lid Damping Factor at the default value of 0.02, and the Gap for Lid as 7m



Details

Details of External Lid	
Name	External Lid
Body Visibility	Visible
Body Activity	Not Suppressed
Body Color Definition	Inherited from Part
Structure Type	Abstract Geometry
Abstract Type	External Lid
Lid Damping Factor	0.02
Gap for External Lid	7 m

Analysis Settings

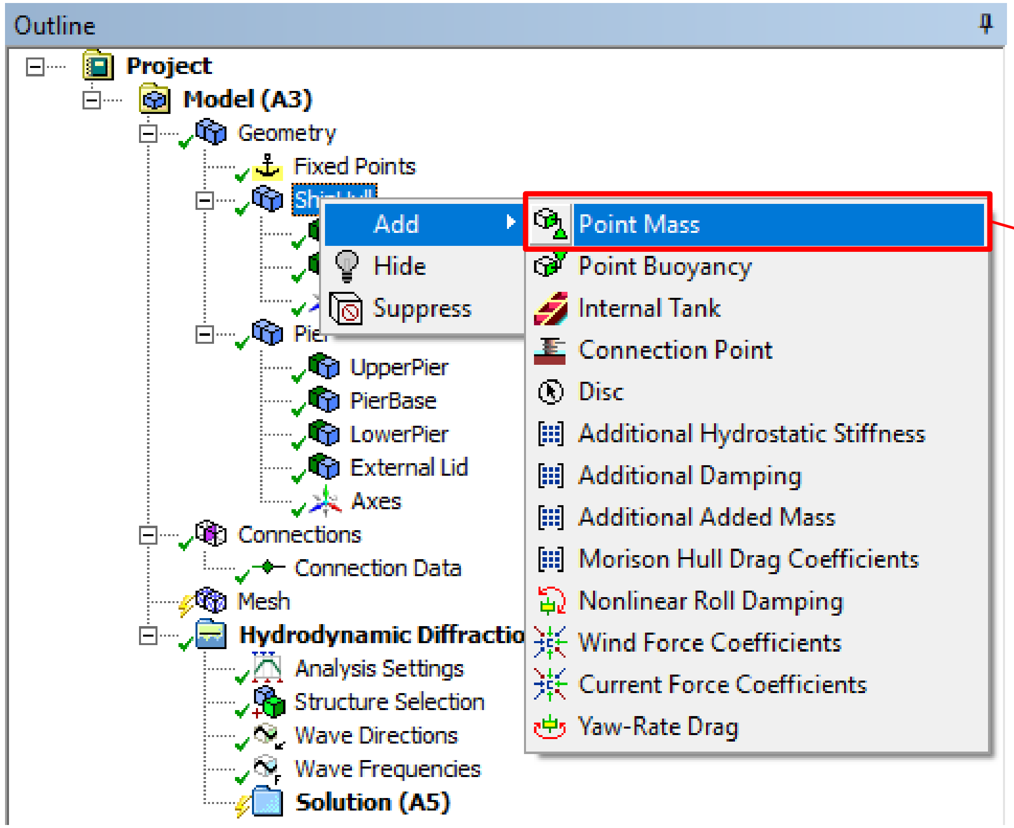
- Set Ignore Modelling Rule Violations to Yes
- Set Calculate Full QTF Matrix to No
- Set Include Multi-Directional Wave Interaction to No

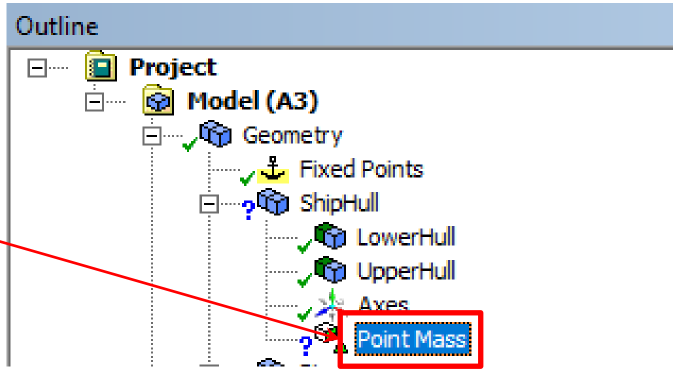
Details

Details of Analysis Settings	
Name	Analysis Settings
External Operation before Solving	None
External Operation after Solving	None
Parallel Processing	Program Controlled
Generate Wave Grid Pressures	Yes
Wave Grid Size Factor	2
Common Analysis Options	
Ignore Modelling Rule Violations	Yes
Calculate Extreme Low/High Fre...	Yes
Include Multi-Directional Wave Int...	No
Near Field Solution	Program Controlled
Linearized Morison Drag	No
QTF Options	
Calculate Full QTF Matrix	No
Output File Options	

Provide Additional Aqwa Elements

- For the pier and ship provide a point mass element
- This is inserted in the tree by selecting the required structure, and right clicking on Add > Point Mass





Point Mass Input

- Leave Mass Definition as Program Controlled
- For the ship set Radius of Gyration Values for the mass inertia as shown and VCG to 8.5 m
- For the pier, since this is a fixed body, we are not bothered about the inertia matrix, but it must be non-zero, so set the Radius of Gyration values to 1.0

Details

Details of Point Mass	
Name	Point Mass
Visibility	Visible
Activity	Not Suppressed
Point Mass Properties	
Mass Definition	Program Controlled
Z	8.5 m
Mass	Solve Hydrostatics to Update
Inertia Properties	
Define Inertia Values By	Radius of Gyration
Kxx	13.6 m
Kyy	50 m
Kzz	52 m
Ixy	0.0 kg.m²
Ixz	0.0 kg.m²
Iyz	0.0 kg.m²

Details

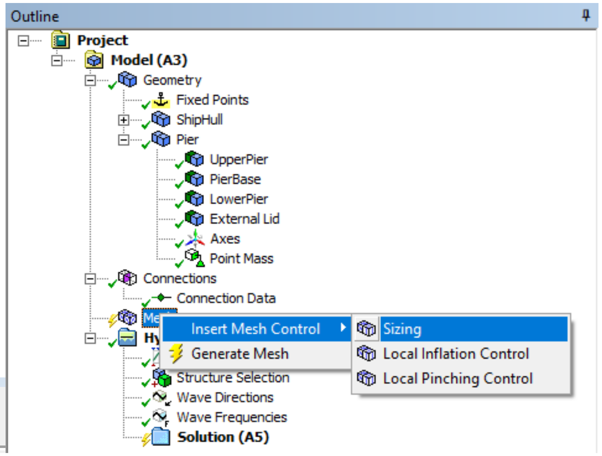
Details of Point Mass	
Name	Point Mass
Visibility	Visible
Activity	Not Suppressed
Point Mass Properties	
Mass Definition	Program Controlled
Z	0.0 m
Mass	Solve Hydrostatics to Update
Inertia Properties	
Define Inertia Values By	Radius of Gyration
Kxx	1 m
Kyy	1 m
Kzz	1 m
Ixy	0.0 kg.m²
Ixz	0.0 kg.m²
Iyz	0.0 kg.m²

Meshing

- Set the default meshing Max Element Size to 10 m and the Defeaturing Tolerance to 2 m

Details	
Details of Mesh	
Defaults	
Control Type	Basic Controls
Mesh Parameters	
Defeaturing Tolerance	2 m
Maximum Element Size	10 m
Maximum Allowed Frequency	0.161 Hz (Estimated from input)
Meshing Type	Program Controlled

- We will mesh the external lid and ship with smaller element sizes to improve the quality of the mesh. Note that the highest frequency allowed in the diffraction run is controlled by the largest element size.



- Select the External Lid body for the Select Geometry. Ensure that the selection tool is set to Bodies 
- Set Local Element Size to 5 m (this value must be smaller than the Max Element Size set on the main Mesh tool)

Details	
Details of Mesh Sizing	
Name	Mesh Sizing
Activity	Not Suppressed
Select Geometry	1 Bodies
Local Element Size	5 m

- Repeat for the Ship body and set Local Element Size to 5 m

Details	
Details of Mesh Sizing	
Name	Mesh Sizing
Activity	Not Suppressed
Select Geometry	2 Bodies
Local Element Size	5 m

- Generate Mesh

Generated Mesh Information	
Display Information For	All Structures
Total Nodes	3680
Total Elements	3520
Diffracting Nodes	2467
Diffracting Elements	2171
Line Body Nodes	0
Line Body Elements	0
Field Points	0

Structure Selection

- Under Structure Selection we now have the two structures, ShipHull and Pier, and we will use the default behavior that they are all in an Interacting Structure Group.

Details	
Details of Structure Selection	
Name	Structure Selection
Structures to Exclude	None
Group of Structures	
Interacting Structure Group 1	All
Interacting Structure Group 2	None
Motion Locks	
Apply Motion Lock to Group 1	No
Structure Ordering	
Structure 1	ShipHull
Structure 2	Pier

Wave Directions and Frequencies

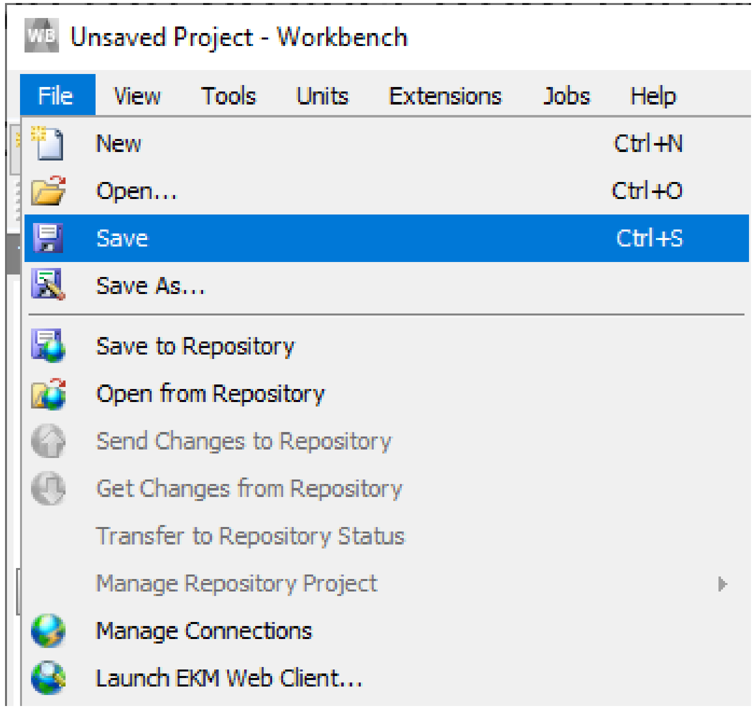
- These objects permit wave directions and frequencies to be defined either as a range or with individual values.
- Set Interval in the Details of Wave Directions to 30 degrees
- We can take manual control of the wave periods used in the analysis. Set Frequency/Period Definition in the Details of Wave Frequencies to Manual Definition. Set Lowest/Highest Frequency Definitions to Manual Definition. Set Longest Period to 60 seconds, and Shortest Period to 5.2 seconds. Set Number of Intermediate Values to 10. If required Additional Frequencies may be added around natural frequencies of the structures

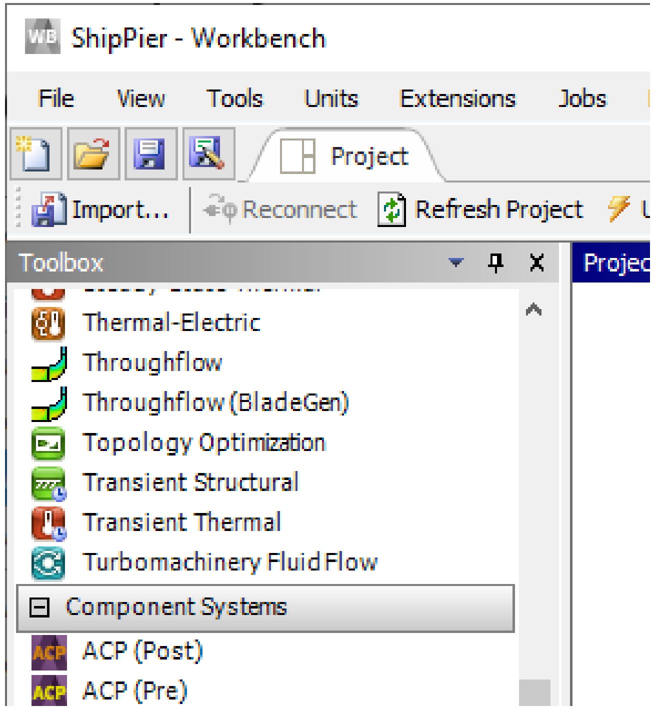
Details	
Details of Wave Directions	
Name	Wave Directions
Visibility	Visible
Type	Range of Directions, No Forward Speed
Required Wave Input	
Wave Range	-180° to 180°
Interval	30°
Number of Intermediate Directions	11
Optional Wave Directions A	
Additional Range	None
Optional Wave Directions B	
Additional Range	None
Optional Wave Directions C	
Additional Range	None
Optional Wave Directions D	
Additional Range	None

Details	
Details of Wave Frequencies	
Name	Wave Frequencies
Intervals Based Upon	Frequency
Incident Wave Frequency/Period Definition	
Range	Manual Definition
Definition Type	Range
Lowest Frequency Definition	Manual Definition
Lowest Frequency	0.01667 Hz
Longest Period	60 s
Highest Frequency Definition	Manual Definition
Highest Frequency	0.19231 Hz
Shortest Period	5.2 s
Number of Intermediate Values	10
Interval Frequency	0.01597 Hz

Save Project

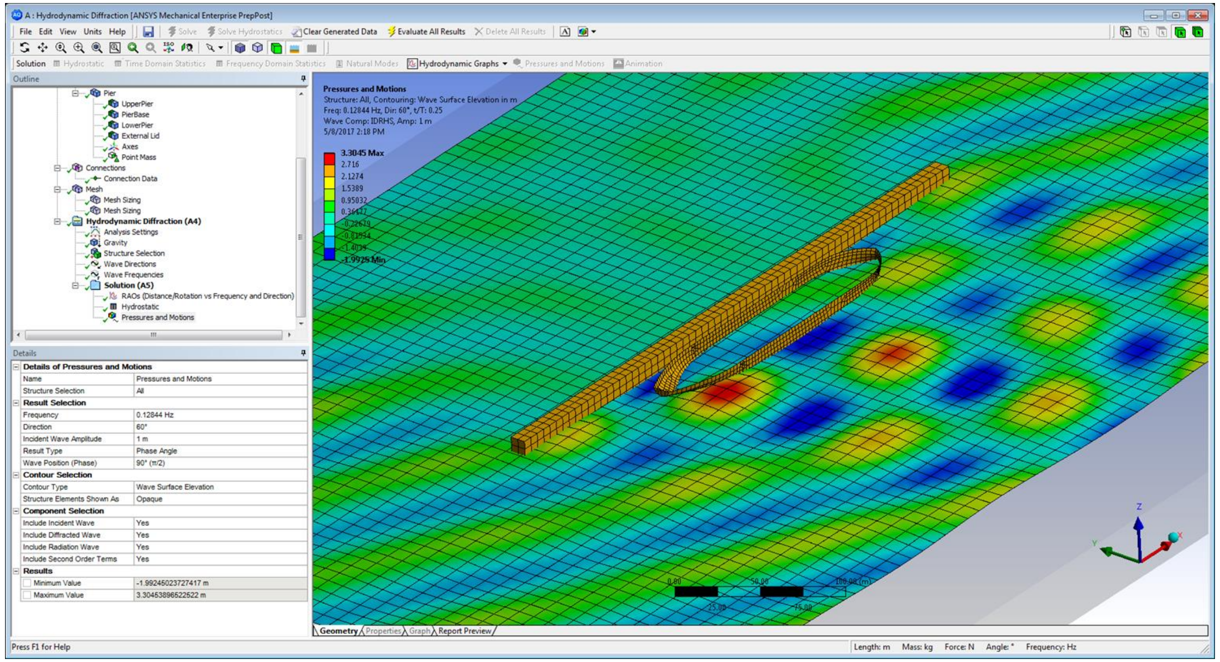
- Save the project from the Workbench Project Page, File > Save
- Browse to the training working directory and save the project as ShipPier.wbpj.

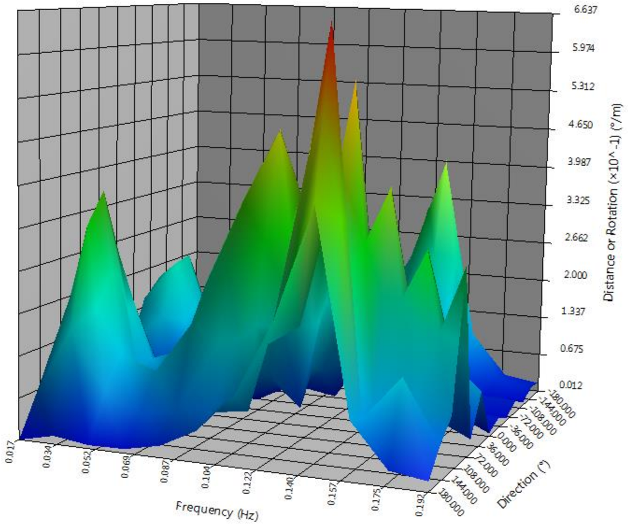




Solve

- Undertake a full hydrodynamic solve
- Add the following results
  - Pressures and Motions
  - RAOs (Global RX chosen here)
  - Hydrostatics



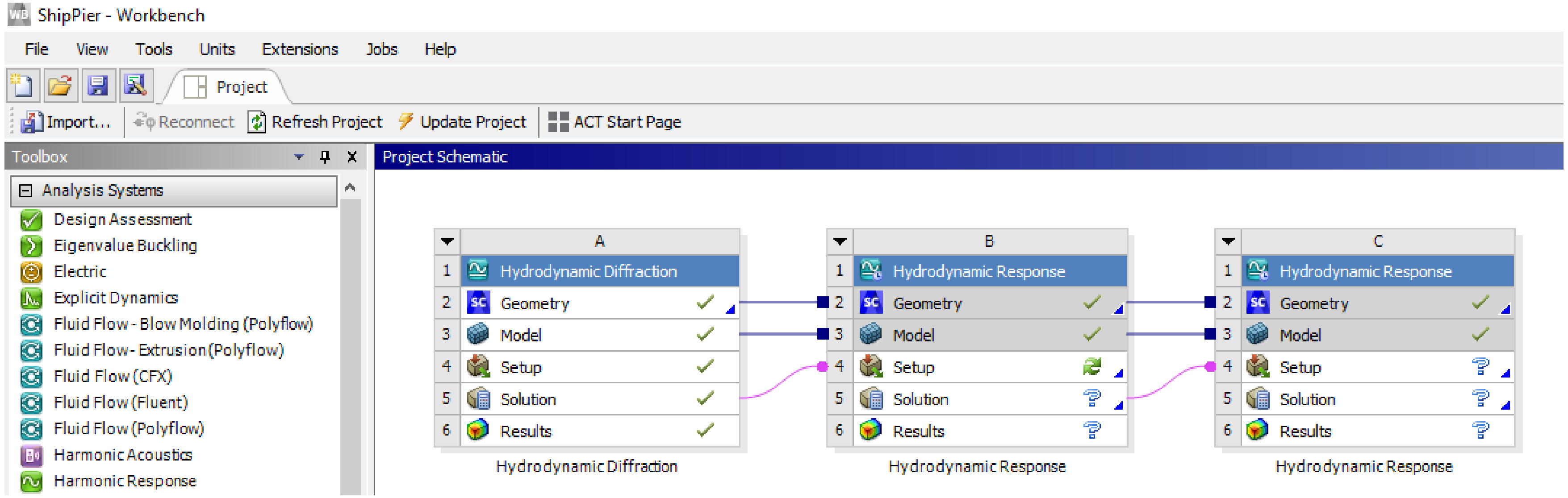


Hydrostatic Results

Structure		ShipHull				
Hydrostatic Stiffness						
Centre of Gravity (CoG) Position:	X:	109.02285 m	Y:	-4.4679e-3 m	Z:	8.5 m
		Z		RX		RY
Heave (Z):		60457832 N/m		4714.4873 N/°		2562713.3 N/°
Roll (RX):		270120.22 N.m/m		5992959.5 N.m/°		11467.083 N.m/°
Pitch (RY):		1.46833e8 N.m/m		11467.083 N.m/°		2.48188e9 N.m/°
Hydrostatic Displacement Properties						
Actual Volumetric Displacement:		43960.57 m³				
Equivalent Volumetric Displacement:		43960.57 m³				
Centre of Buoyancy (CoB) Position:	X:	109.02286 m	Y:	-4.4684e-3 m	Z:	-3.8269529 m
Out of Balance Forces/Weight:	FX:	-2.3426e-9	FY:	-2.6361e-8	FZ:	-2.1725e-7
Out of Balance Moments/Weight:	MX:	-8.4411e-7 m	MY:	-1.3648e-5 m	MZ:	1.5055e-6 m
Cut Water Plane Properties						
Cut Water Plane Area:		6014.6177 m²				
Centre of Floatation:	X:	106.59417 m	Y:	1.1176e-8 m		
Principal 2nd Moments of Area:	X:	576059.88 m⁴	Y:	14653264 m⁴		
Angle Principal Axis makes with X(FRA):		3.9688e-7°				
Small Angle Stability Parameters						
CoG to CoB (BG):		12.326953 m				
Metacentric Heights (GMX/GMY):		0.7770596 m		321.00046 m		
CoB to Metacentre (BMX/BMY):		13.104012 m		333.32742 m		
; Moments about Principal Axes (MX/MY):		5992934.5 N.m/°		2.47566e9 N.m/°		

Adding the HR Systems

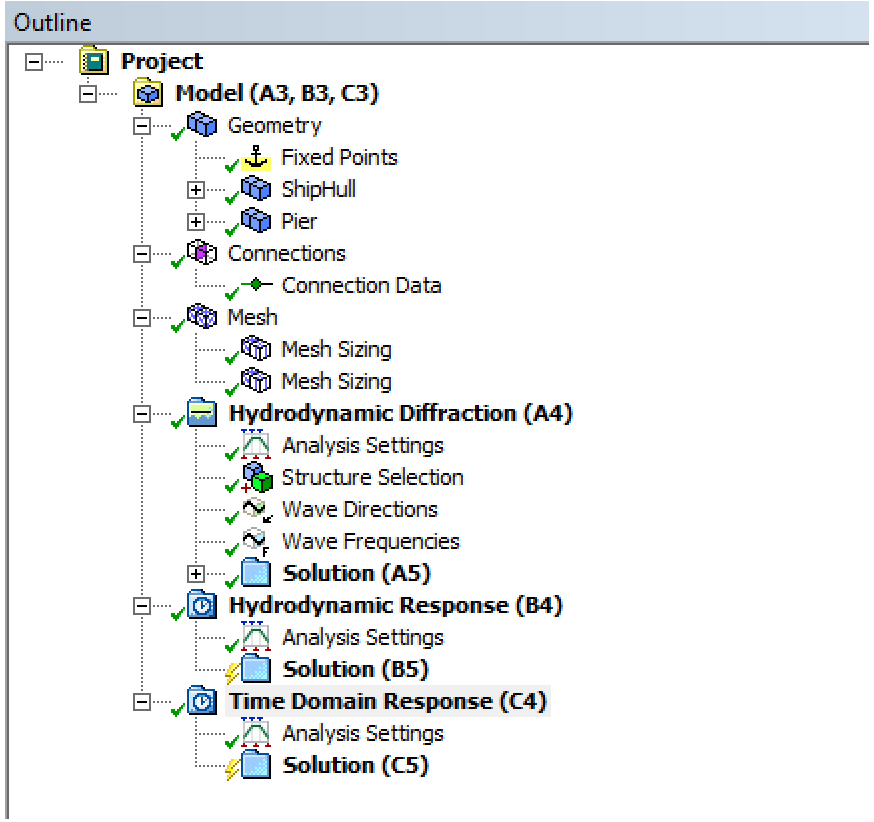
- Drag and drop a Hydrodynamic Response system to the WB Project Schematic while sharing the solution from Hydrodynamic Diffraction. Drag and drop a second HR system on to the solution of the first HR system.



Ansys

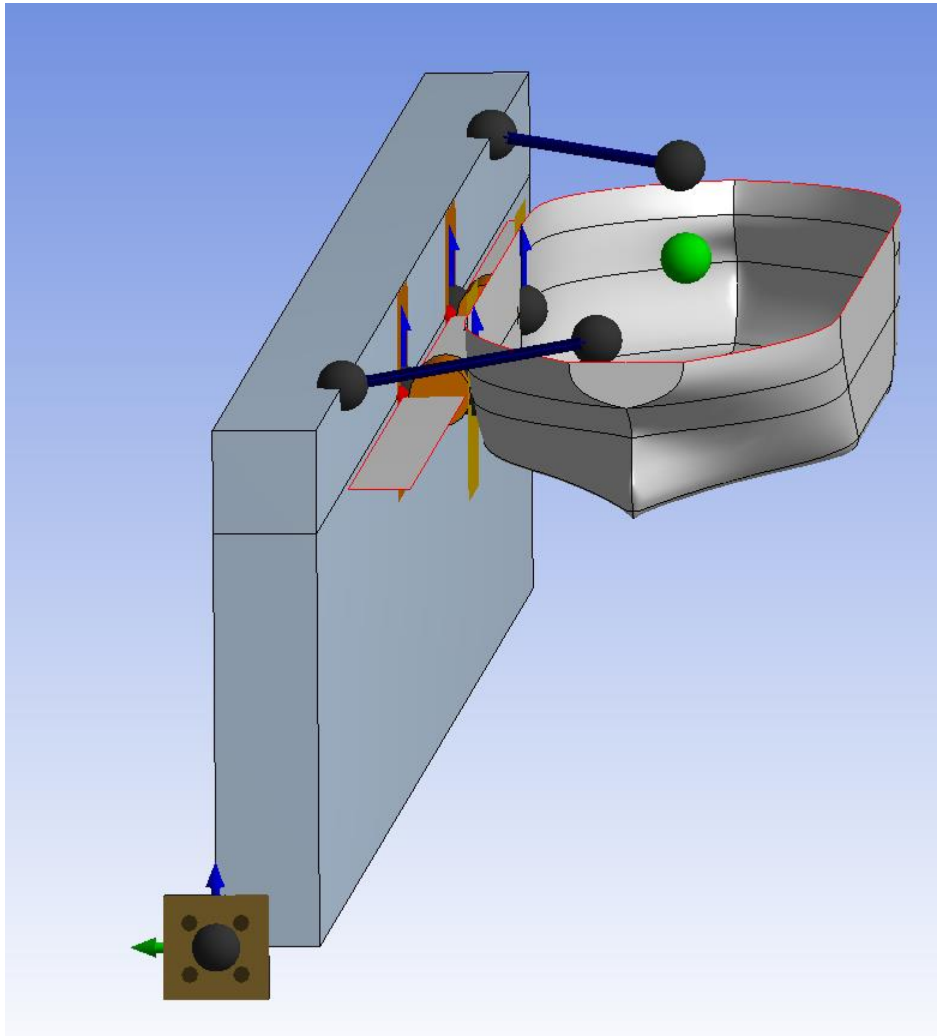
Set up Time Response System

- In the project tree, click on the second Hydrodynamic Response (C4), rename this Analysis system to Time Domain Response.



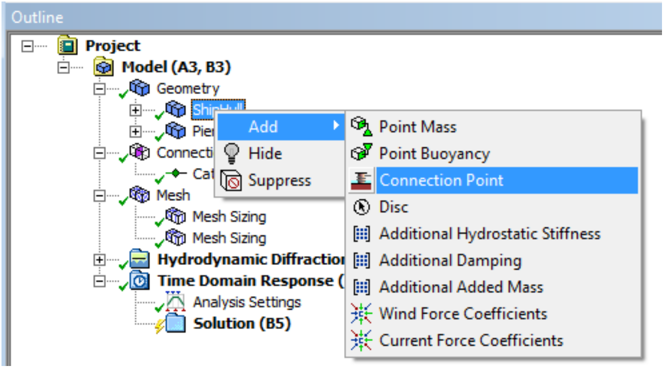
Set up Mooring Configuration

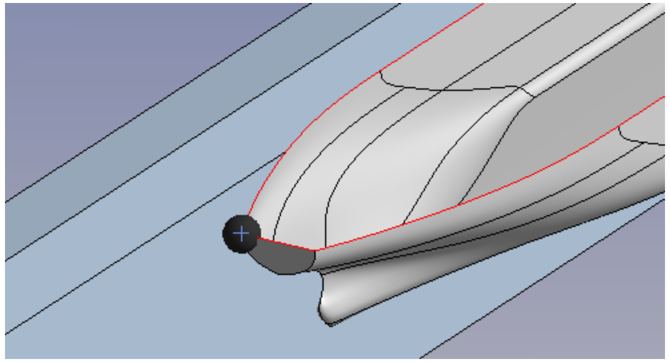
- The mooring configuration will consist of two tie lines and two floating fenders between the pier and the ship.
- In addition a rigid connection between the pier and the ground will need to be established (recall that the Structure is Fixed in Place option for the Pier structure is only valid for the Hydrodynamic Diffraction analysis)

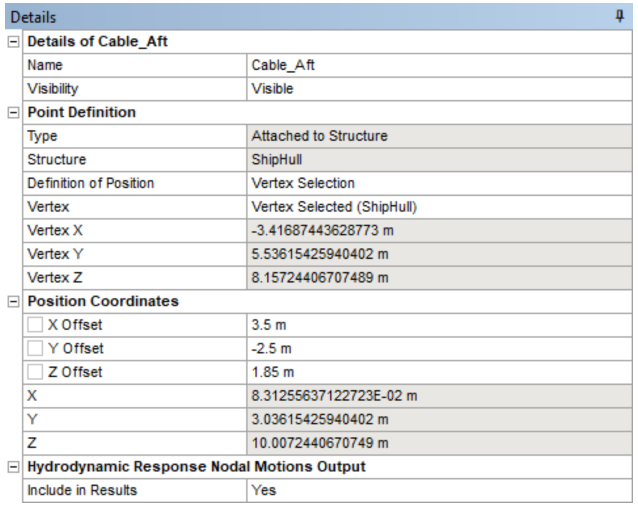


Create Connection Points on Ship

- Add two locations for the mooring system on the ship
- Select Geometry > ShipHull > Add > Connection Point
- Set Definition of Position to Vertex Selection and select the vertex nearest the pier at the aft of the vessel at the transom. Set the X/Y/Z Offsets as shown. Rename as Cable_Aft





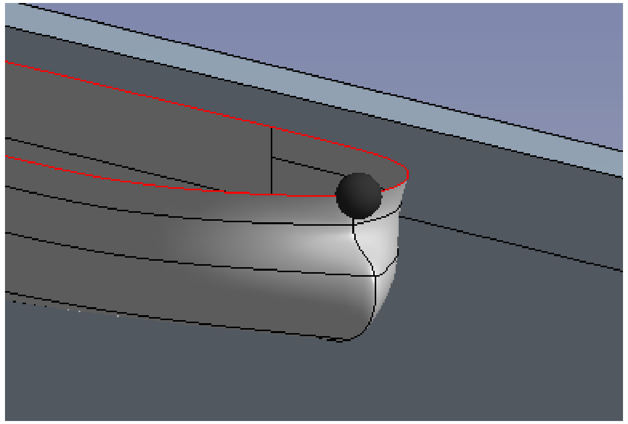


Details

Details of Cable_Aft	
Name	Cable_Aft
Visibility	Visible
Point Definition	
Type	Attached to Structure
Structure	ShipHull
Definition of Position	Vertex Selection
Vertex	Vertex Selected (ShipHull)
Vertex X	-3.41687443628773 m
Vertex Y	5.53615425940402 m
Vertex Z	8.15724406707489 m
Position Coordinates	
X Offset	3.5 m
Y Offset	-2.5 m
Z Offset	1.85 m
X	8.31255637122723E-02 m
Y	3.03615425940402 m
Z	10.0072440670749 m
Hydrodynamic Response Nodal Motions Output	
Include in Results	Yes

Create Connection Points on Ship

- Repeat for the connection at the bow of the ship
- Set Definition of Position to Vertex Selection and select the vertex top point of the bow of the vessel. Set the X/Y/Z Offsets as shown. Rename as Cable_Bow

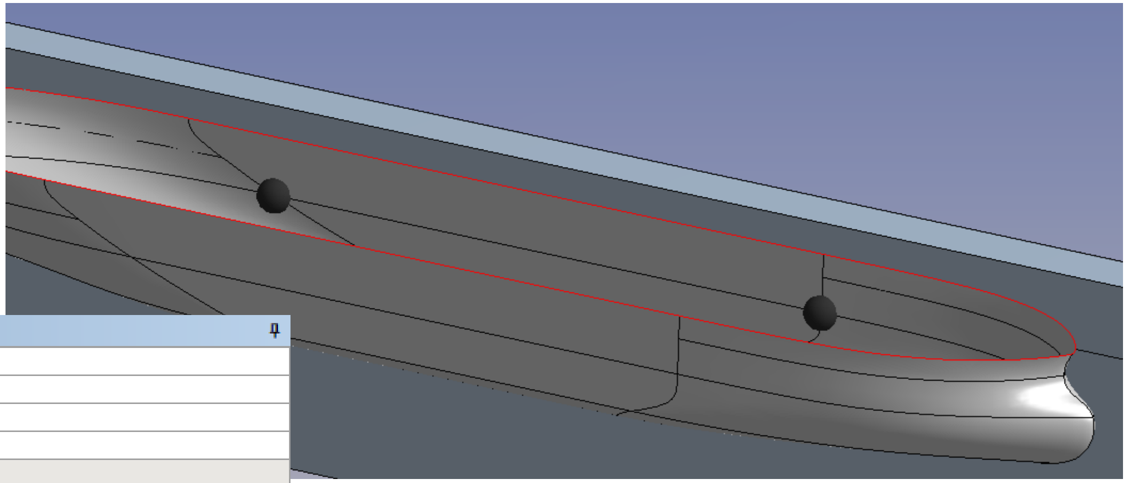


Details

Details of Cable_Bow	
Name	Cable_Bow
Visibility	Visible
Point Definition	
Type	Attached to Structure
Structure	ShipHull
Definition of Position	Vertex Selection
Vertex	Vertex Selected (ShipHull)
Vertex X	199.967959999772 m
Vertex Y	0.0 m
Vertex Z	8.15449199962286 m
Position Coordinates	
X Offset	-5 m
Y Offset	5 m
Z Offset	1.85 m
X	194.967959999772 m
Y	5 m
Z	10.0044919996229 m
Hydrodynamic Response Nodal Motions Output	
Include in Results	Yes

Create Connection Points on Ship

- Now add two connection points for the fenders
- Choose Vertex Selection for each, and select the two points at the water line as shown. No offsets are defined for these. Rename as Fender_Aft and Fender_Bow



Details	
Details of Fender_Aft	
Name	Fender_Aft
Visibility	Visible
Point Definition	
Type	Attached to Structure
Structure	ShipHull
Definition of Position	Vertex Selection
Vertex	Vertex Selected (ShipHull)
Vertex X	62.4810813164654 m
Vertex Y	18.0162519999991 m
Vertex Z	0.0 m
Position Coordinates	
X Offset	0.0 m
Y Offset	0.0 m
Z Offset	0.0 m
X	62.4810813164654 m
Y	18.0162519999991 m
Z	0.0 m
Hydrodynamic Response Nodal Motions Output	
Include in Results	Yes

Details	
Details of Fender_Bow	
Name	Fender_Bow
Visibility	Visible
Point Definition	
Type	Attached to Structure
Structure	ShipHull
Definition of Position	Vertex Selection
Vertex	Vertex Selected (ShipHull)
Vertex X	149.109866742321 m
Vertex Y	18.016252 m
Vertex Z	0.0 m
Position Coordinates	
X Offset	0.0 m
Y Offset	0.0 m
Z Offset	0.0 m
X	149.109866742321 m
Y	18.016252 m
Z	0.0 m
Hydrodynamic Response Nodal Motions Output	
Include in Results	Yes

Create Connection Points on Pier

- Add two locations for the mooring system on the pier
- Set Definition of Position to Coordinates and set X/Y/Z as shown. Rename as Cable_Aft
- Repeat for Cable_Bow

Details	
Details of Cable_Aft	
Name	Cable_Aft
Visibility	Visible
Point Definition	
Type	Attached to Structure
Structure	Pier
Definition of Position	X, Y and Z Coordinates
Position Coordinates	
X	-50 m
Y	25 m
Z	10 m
Hydrodynamic Response Nodal Motions Output	
Include in Results	Yes

Details	
Details of Cable_Bow	
Name	Cable_Bow
Visibility	Visible
Point Definition	
Type	Attached to Structure
Structure	Pier
Definition of Position	X, Y and Z Coordinates
Position Coordinates	
X	230 m
Y	25 m
Z	10 m
Hydrodynamic Response Nodal Motions Output	
Include in Results	Yes

Create Connection Points on Pier

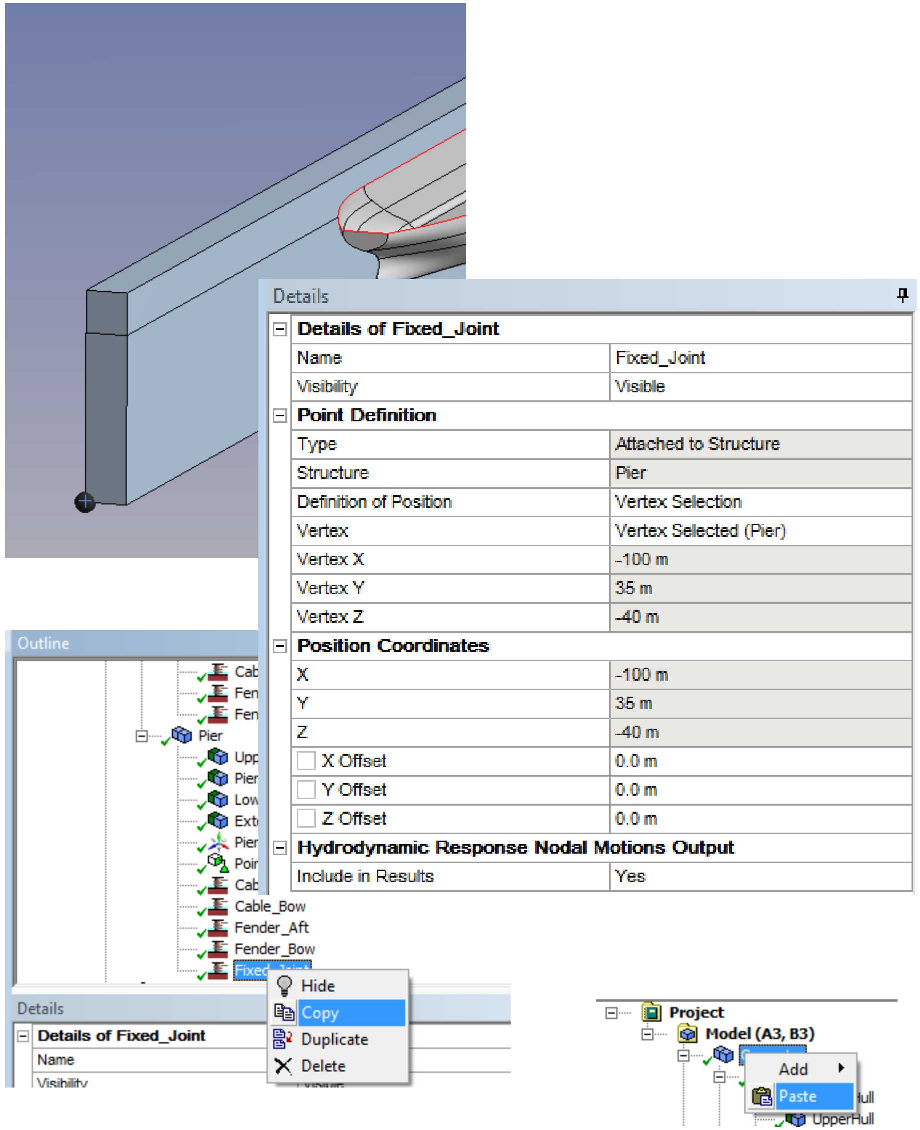
- Define the connection points for the fenders on the pier
- Set Definition of Position to Coordinates and set X/Y/Z as shown. Rename as Fender_Aft
- Repeat for Fender_Bow

Details	
Details of Fender_Aft	
Name	Fender_Aft
Visibility	Visible
Point Definition	
Type	Attached to Structure
Structure	Pier
Definition of Position	X, Y and Z Coordinates
Position Coordinates	
X	60 m
Y	25 m
Z	0.0 m
Hydrodynamic Response Nodal Motions Output	
Include in Results	Yes

Details	
Details of Fender_Bow	
Name	Fender_Bow
Visibility	Visible
Point Definition	
Type	Attached to Structure
Structure	Pier
Definition of Position	X, Y and Z Coordinates
Position Coordinates	
X	150 m
Y	25 m
Z	0.0 m
Hydrodynamic Response Nodal Motions Output	
Include in Results	Yes

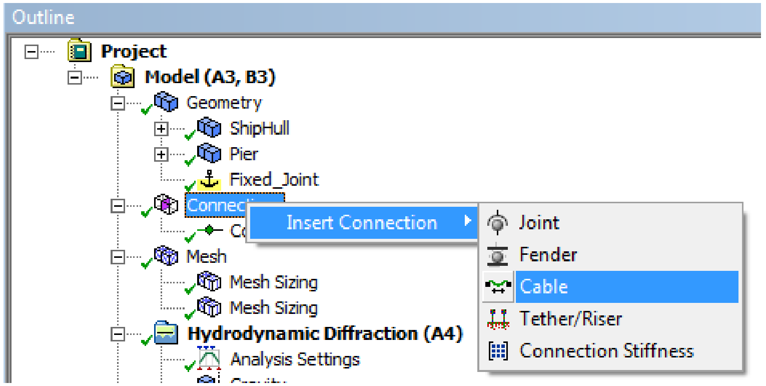
Create Connection Points on Pier

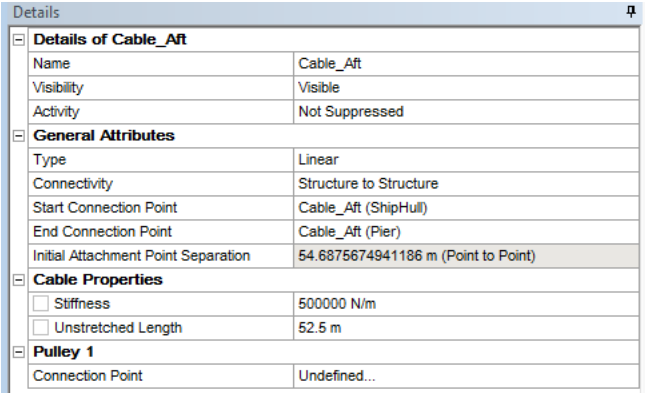
- For the rigid connection to ground the connection points are defined in two places. Firstly on the pier, and secondly as a Fixed Point. These two points should be coincident in space (otherwise the pier will be moved so that they are coincident)
- Add a new connection point to the pier, and set the Definition of Position to Vertex Selection. Choose one of the bottom corners of the pier. Rename as Fixed_Joint.
- To create the Fixed Point, select the just created Fixed_Joint connection, RMB and Copy. Select Fixed Points, RMB and Paste. This will ensure that the points are coincident. Select the new Fixed Point and rename Fixed_Joint

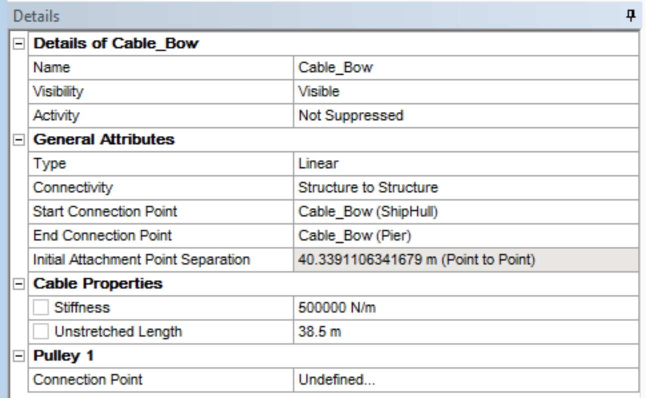


Mooring Line Connections

- To add a line select Connections > Insert Connection > Cable
- Rename mooring line as Cable_Aft
- Choose Structure & Structure for Connectivity and Linear for Type and add Stiffness and Unstretched Length as shown
- Duplicate this line to create a second line, Cable_Bow. Change Connection Points and Unstretched Length as shown.

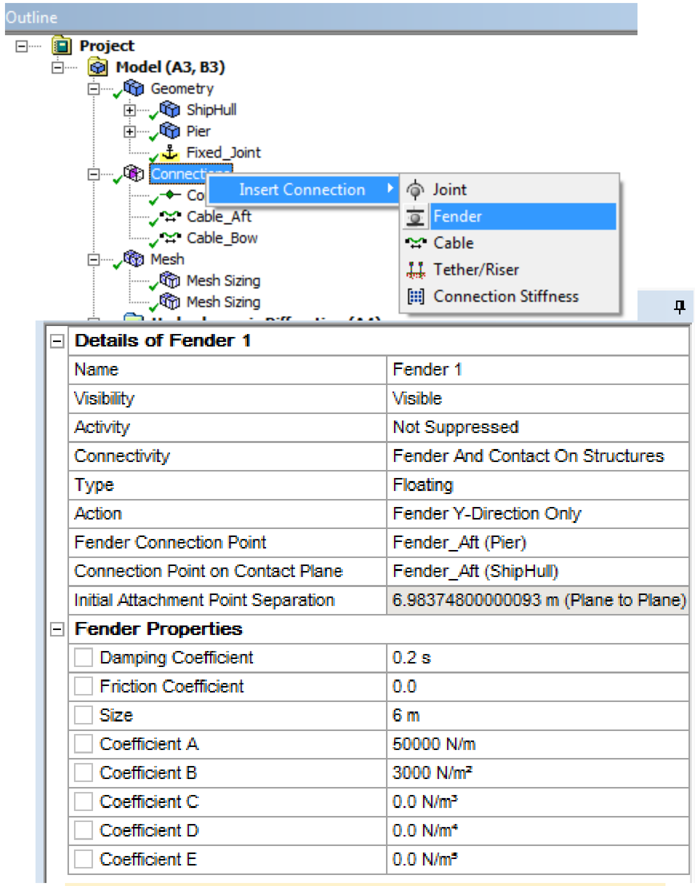


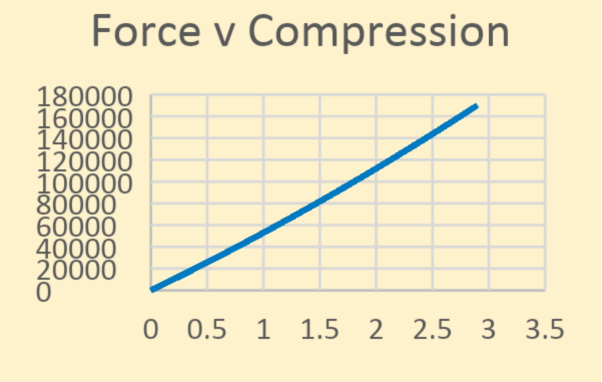




Fender Connections

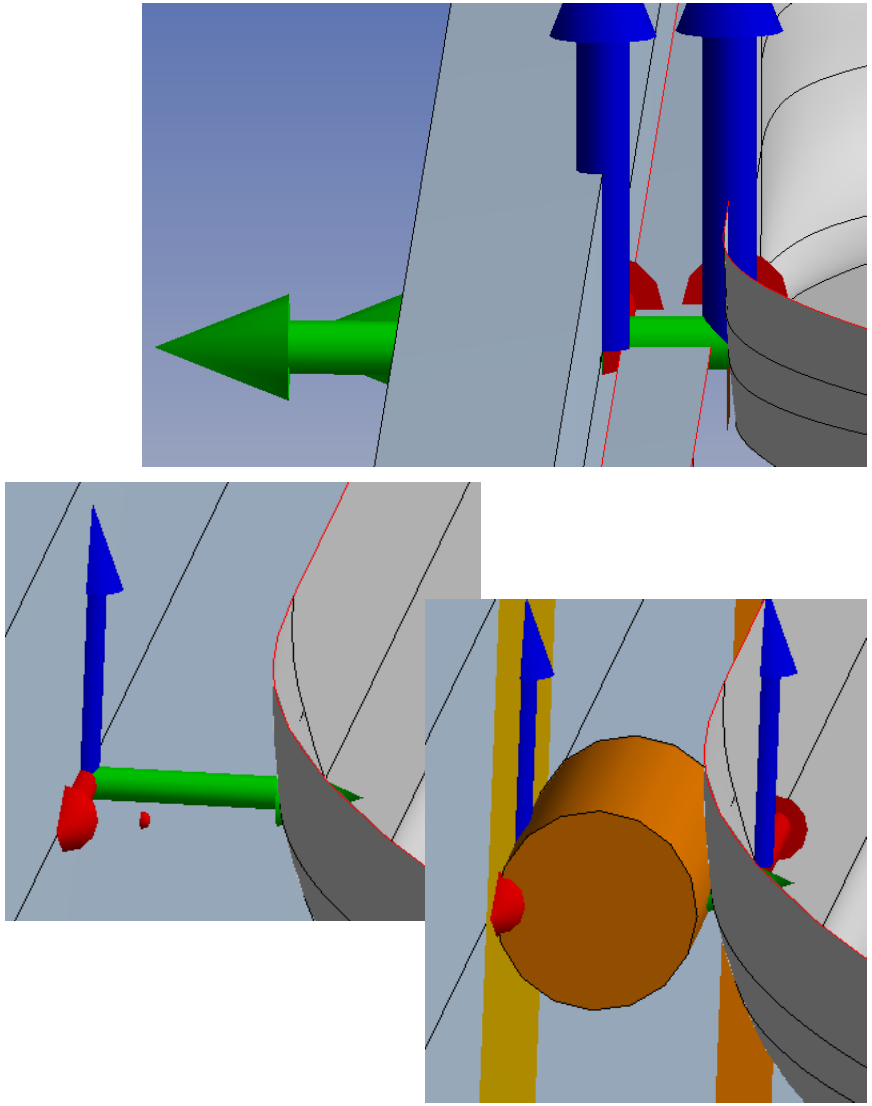
- Fenders are added in a similar way to mooring lines. The main difference is that fenders have axes associated with the attachment and contact surfaces
- Select Connections > Insert Connection > Fender
- Choose the Type to be Floating, and the Action to be Y Direction Only. This will be the direction of the normal to the contact plane on the fender connection. Choose the Connection Points and Fender Properties as shown. Note that this defines a non-linear compression characteristic





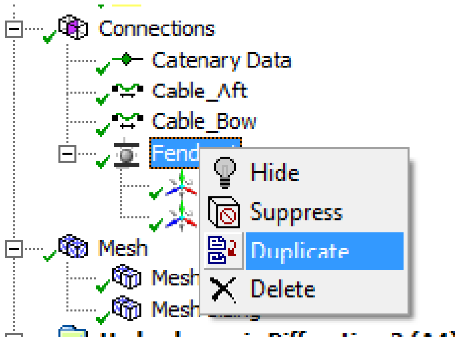
Fender Connections

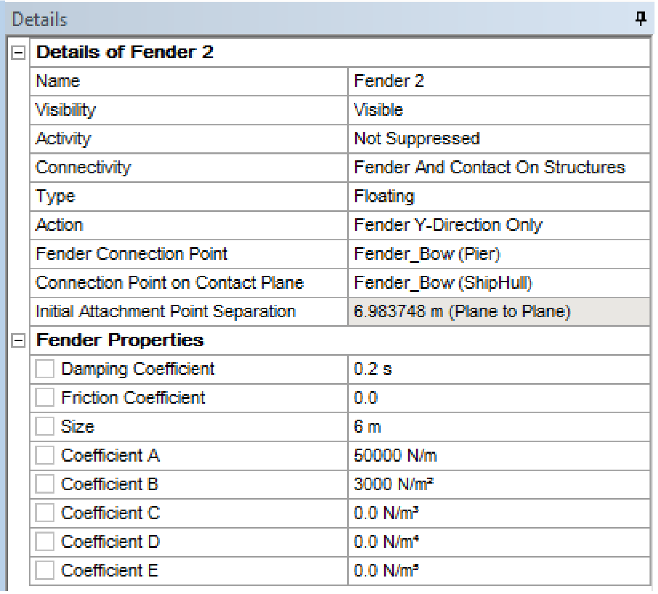
- The axes of the fenders need to be set up so that the direction of the compressive forces are correctly transferred to the adjacent structures
- We have chosen the fender Action to be Y Direction Only. This means that the Y axes for both the Fender Axes and the Contact Axes should be pointing towards each other. For the ship this is correct (the green arrow), but for the pier it is pointing into the pier itself
- Select the Fender Axes under Fender 1 and change the Alignment Method to Direction Entry. Set the Rotation About Global Z to 180 degrees. The Fender Axes are now correctly aligned. Selecting the Fender 1 will now show the fender.



Fender Connections

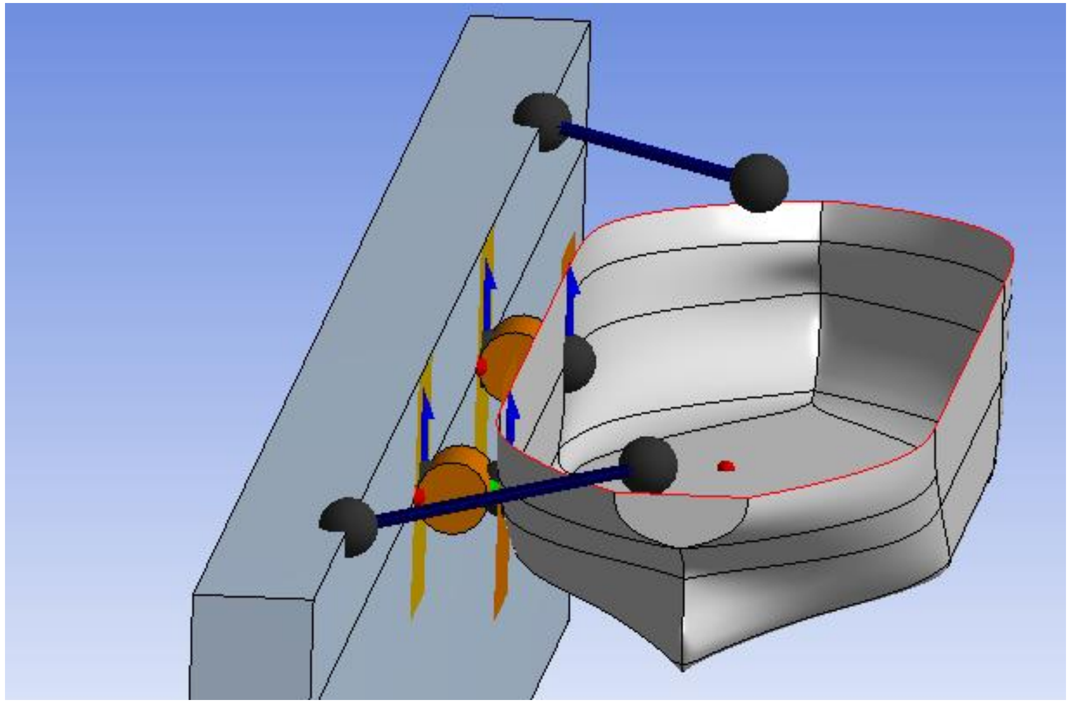
- For the second fender we can Duplicate the first fender and just change the Connection Points. Selecting Connections will show everything we have so far created





Details

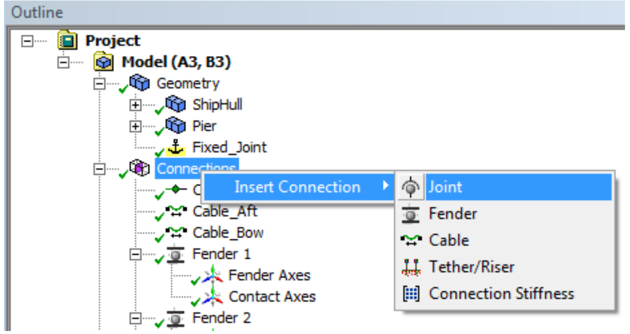
Details of Fender 2	
Name	Fender 2
Visibility	Visible
Activity	Not Suppressed
Connectivity	Fender And Contact On Structures
Type	Floating
Action	Fender Y-Direction Only
Fender Connection Point	Fender_Bow (Pier)
Connection Point on Contact Plane	Fender_Bow (ShipHull)
Initial Attachment Point Separation	6.983748 m (Plane to Plane)
Fender Properties	
Damping Coefficient	0.2 s
Friction Coefficient	0.0
Size	6 m
Coefficient A	50000 N/m
Coefficient B	3000 N/m²
Coefficient C	0.0 N/m³
Coefficient D	0.0 N/m⁴
Coefficient E	0.0 N/m⁵



Ansys

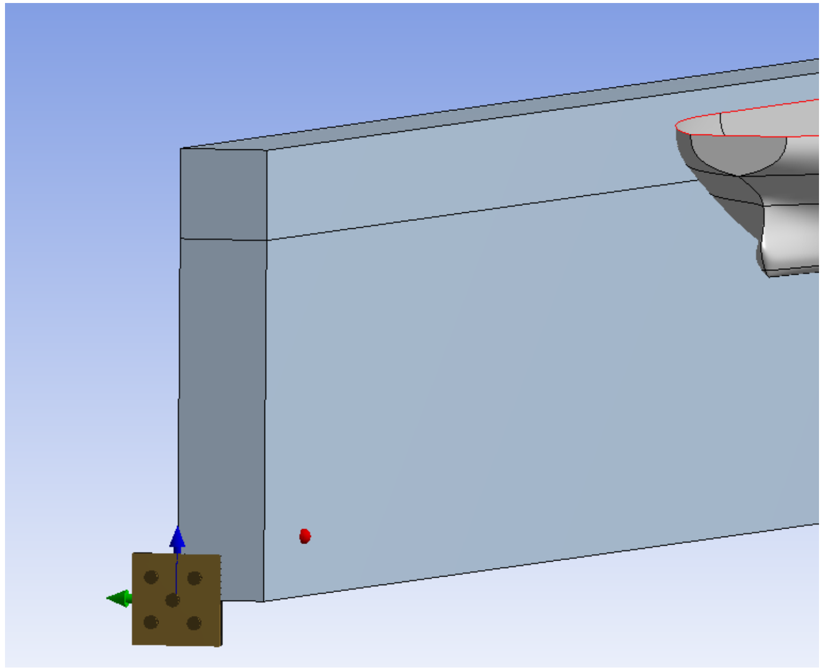
Pier Rigid Connection

- Insert Connection > Joint
- Set the Joint Type to Rigid
- Set Connectivity as Fixed Point to Structure and the connection points as shown



Details

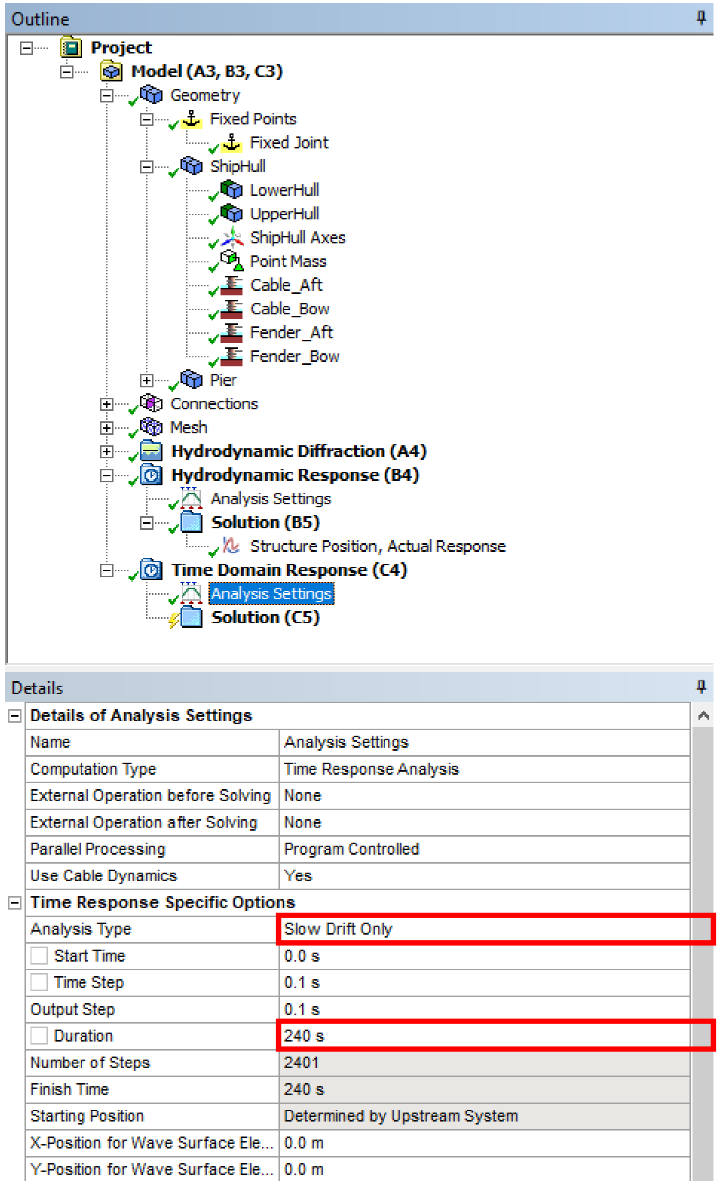
Details of Joint 1	
Name	Joint 1
Visibility	Visible
Activity	Not Suppressed
Type	Rigid
Connectivity	Fixed Point to Structure
Fixed Point	Fixed_Joint (Fixed)
Connection Point	Fixed_Joint (Pier)



Set up Time Response System Analysis Settings

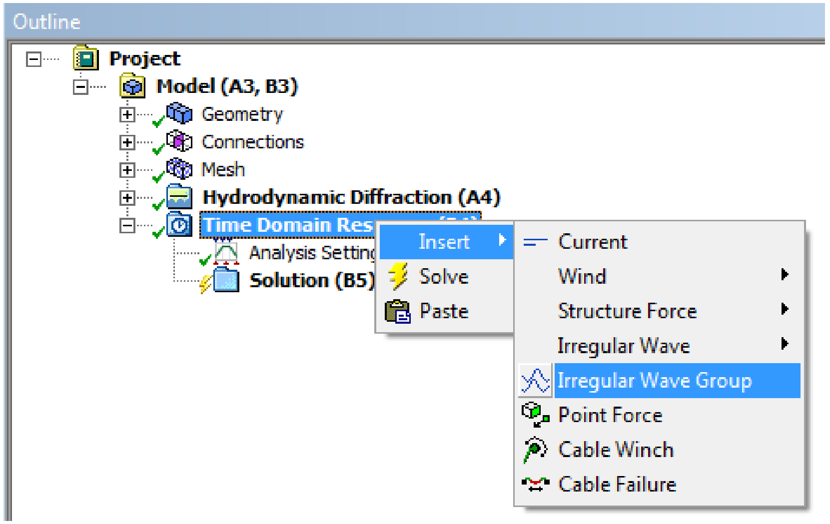
- Under Analysis Settings set Analysis Type as Slow Drift Only

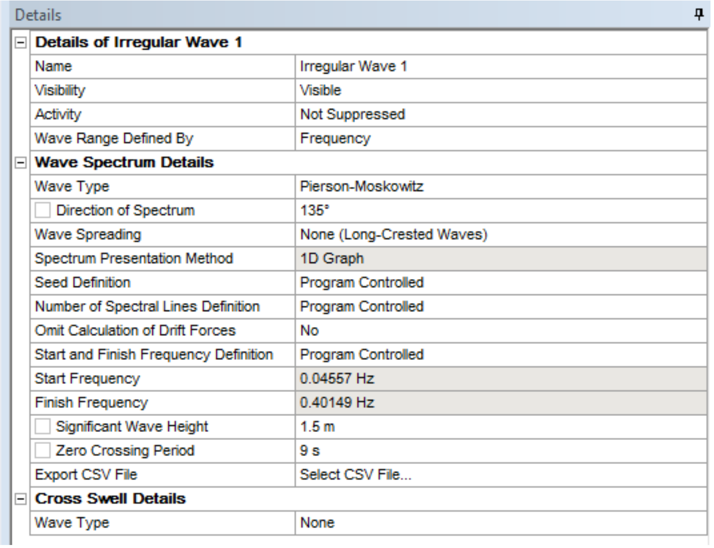
- Set Duration to be 240 seconds



Define Wave Environment

- To model short-crested waves we are going to define two spectra with different wave directions. To achieve this we may group together one or more irregular wave definitions.
- From Time Domain Response right-click > Insert > Irregular Wave Group
- From the Irregular Wave Group item right-click > Insert > Irregular Wave > Pierson-Moskowitz. Set Direction of Spectrum to 135°, Significant Wave Height as 1.5 m and Zero Crossing Period as 9 s





Define Wave Environment

- Create a second irregular wave as shown
- Add some results under Solution
  - Ship position X, Y and Z
  - Ship position RX, RY and RZ
  - Cable tensions for the two mooring lines
  - Fender forces for the two fenders
  - Reaction forces on the pier
- Solve

Details

Details of Irregular Wave 2	
Name	Irregular Wave 2
Visibility	Visible
Activity	Not Suppressed
Wave Range Defined By	Frequency
Wave Spectrum Details	
Wave Type	Pierson-Moskowitz
Direction of Spectrum	90°
Wave Spreading	None (Long-Crested Waves)
Spectrum Presentation Method	1D Graph
Seed Definition	Program Controlled
Number of Spectral Lines Definition	Program Controlled
Omit Calculation of Drift Forces	No
Start and Finish Frequency Definition	Program Controlled
Start Frequency	0.02734 Hz
Finish Frequency	0.24089 Hz
Significant Wave Height	1 m
Zero Crossing Period	15 s
Export CSV File	Select CSV File...
Cross Swell Details	
Wave Type	None

Typical Results