

Introduction to Hydrodynamic Analysis with Ansys Aqwa

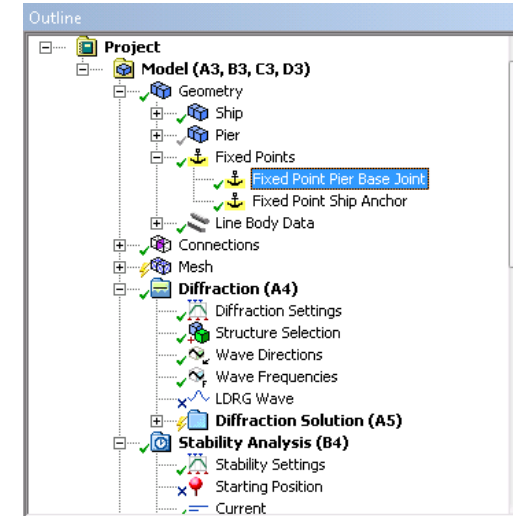
Module 06: Aqwa Cables, Joints, Fenders and Tethers

Release 2021 R2



/ Aqwa Attachment Points

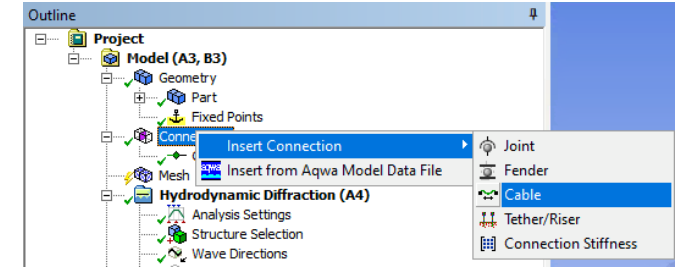
- Cables, Joints, Fenders and Tethers ('Connections') require Connection Points and/or Fixed Points to be created.
- Defined by X, Y, Z coordinates or by selecting a vertex from the geometry.
- Connection Points are attachment points on a structure; they move with the structure.
- Fixed Points are attachment points fixed in space (for example, on the seabed).
- Connections may be defined:
 - Between structures (Connection Point to Connection Point)
 - Between the ground and a structure (Fixed Point to Connection Point)
 - Between Fixed Points (special case for Linear cables with Pulleys)



Details	
Details of Fixed Point Pier Base Joint	
Name	Fixed Point Pier Base Joint
Visibility	Visible
Point Definition	
Type	Fixed
Definition of Position	Vertex Selection
Vertex	Vertex Selected (Pier)
Vertex X	100 m
Vertex Y	-30 m
Vertex Z	-100 m
Position Coordinates	
<input type="checkbox"/> X Offset	0.0 m
<input type="checkbox"/> Y Offset	0.0 m
<input type="checkbox"/> Z Offset	0.0 m
X	100 m
Y	-30 m
Z	-100 m

/ Aqwa Cables

- All connection types are added from Connections context menu
- Available cable types:
 - Linear
 - Nonlinear Polynomial
 - Nonlinear Steel Wire
 - Nonlinear Catenary
- Linear, Polynomial and Steel Wire cables are massless
- Nonlinear Catenary cables are composed of one or more Catenary Sections, with optional Catenary Buoys or Clump Weights between each section
- Linear cables may include Pulleys
- Linear and Polynomial cables may have a Cable Winch
- Any cable may be broken by a Cable Failure



Details	
Details of Cable 1	
Name	Cable 1
Visibility	Visible
Activity	Not Suppressed
General Attributes	
Type	Linear
Connectivity	Linear
Start Connection Point	Nonlinear Polynomial
End Connection Point	Nonlinear Steel Wire
Initial Attachment Point Separation	Not Available
Cable Properties	
Stiffness	0.0 N/m
<input type="checkbox"/> Unstretched Length	0.0 m
Pulley 1	
Connection Point	Undefined...

Details	
Details of Catenary Section 1	
Name	Catenary Section 1
Section Properties	
Mass/Unit Length	0.0 kg/m
Equivalent Cross-Sectional Area	0.0 m ²
Stiffness, EA	0.0 N
Maximum Tension	0.0 N
<input type="checkbox"/> Bending Stiffness, EI	0.0 N.m ²
<input type="checkbox"/> Axial Stiffness Coefficient k1	0.0 N
<input type="checkbox"/> Axial Stiffness Coefficient k2	0.0 N
<input type="checkbox"/> Axial Stiffness Coefficient k3	0.0 N
Section Hydrodynamic Properties	
<input type="checkbox"/> Added Mass Coefficient	1
<input type="checkbox"/> Transverse Drag Coefficient	1
Equivalent Diameter	0.0 m
<input type="checkbox"/> Longitudinal Drag Coefficient	0.025

Aqwa Joints

- Available joint types:
 - Ball and Socket (3 free rotational DoFs)
 - Universal (2 DoFs)
 - Hinged (1 DoF)
 - Rigid (locked)
- Stiffness, damping and friction may be associated with the joint freedoms
- Joint local axes can be defined to correctly orientate the connection

The screenshot displays the ANSYS Aqwa software interface. The top panel shows the 'Project' tree with 'Model (A3, B3)' expanded, containing 'Geometry', 'Ship', 'Fixed Points', 'Conn', 'Mesh', and 'Hydrodynamic Diffraction (A4)'. The 'Conn' node is selected, and the 'Insert Connection' menu is open, showing options: 'Joint', 'Fender', 'Cable', 'Tether/Riser', and 'Connection Stiffness'. The 'Joint' option is highlighted.

Below the tree, the 'Details' panel shows the 'Details of Joint 1' configuration:

Details of Joint 1	
Name	Joint 1
Visibility	Visible
Activity	Not Suppressed
Type	Hinged
Connectivity	Ball and Socket
Connection Point On Structure A	Universal
Connection Point On Structure B	Hinged
Joint Properties	Rigid

Below this, the 'Details of Joint Axes On Structure A' panel is shown:

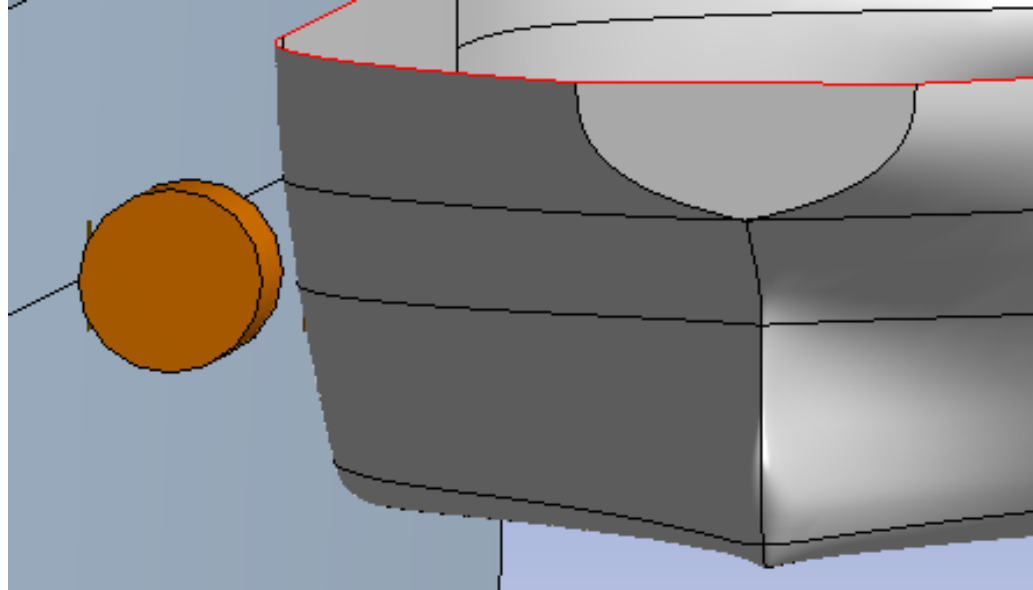
Details of Joint Axes On Structure A	
Name	Joint Axes On Structure A
Visibility	Visible
Axes Alignment	
Alignment Method	Direction Entry
Rotation About Global Z	0.0°
Rotation About Local Y	90°
Rotation About Local X	0.0°
Unit Vector X	[0.0, 0.0, -1]
Unit Vector Y	[0.0, 1, 0.0]
Unit Vector Z	[1, 0.0, 0.0]

Finally, the 'Joint Properties' panel is shown:

Joint Properties	
<input type="checkbox"/> Stiffness About X	1000 N.m/rad
<input type="checkbox"/> Damping About X	20000 N.m/(rad/s)
<input type="checkbox"/> Transverse Force Friction C...	0.0 m
<input type="checkbox"/> Overturning Moment Friction ...	0.0
<input type="checkbox"/> Axial Force Friction Coefficie...	0.0 m
<input type="checkbox"/> Constant Friction Moment (k4)	0.0 N.m

/ Aqwa Fenders

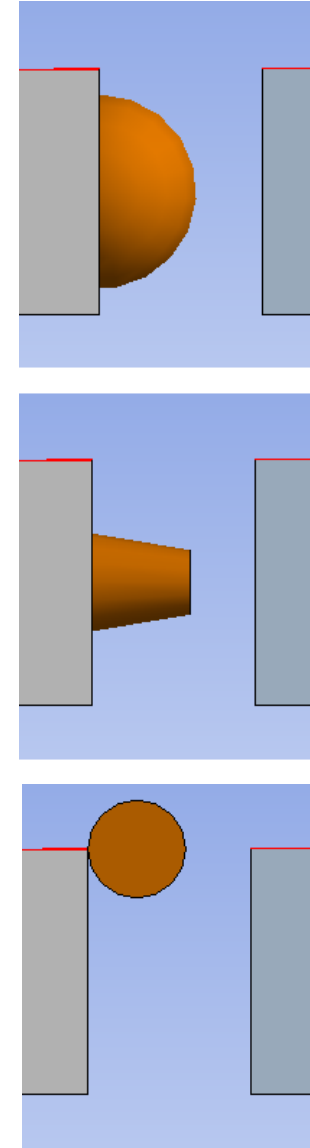
- Aqwa also offers the Fender (compression element) to model structure-to-structure or structure-to-ground interactions.
- Aqwa does not detect collisions between structures, or between a structure and the seabed, but fenders can be used to keep them separate.



/ Aqwa Fenders

There are three types of fender:

- Fixed, Omni-Directional – The fender is connected to one of the structures (or ground) and contact with the second structure may be anywhere on the surface of the fender (assumed spherical).
- Fixed, Directional – The fender is connected to one of the structures (or ground) and contact with the second structure is assumed to act in a given direction.
- Floating – The fender is not connected to either structure. Contact with either structure acts in a given direction. Note that the fender is vertically located at the still water level.



Aqwa Fenders

Fender data consists of:

- Connectivity
- Type
- Action
- Contact Points, using previously defined Connection or Fixed Points
- Fender Properties:
 - Damping Coefficient
 - Friction Coefficient
 - Size
 - Nonlinear stiffness coefficients
- Two sets of fender local axes, to define the fender direction and contact plane normal

Connectivity	Fender And Contact On Structures
Type	Fender And Contact On Structures
Action	Fender On Structure, Contact On Fixed Point
Fender Connection Point	Fender On Fixed Point, Contact On Structure

Type	Floating
Action	Floating
Fender Connection Point	Fixed

Action	Y Direction Only
Fender Connection Point	Omni-Directional
Contact Connection Point	X Direction Only
Fender Properties	Y Direction Only
<input type="checkbox"/> Damping Coefficient	Z Direction Only

Details	
Details of Fender 1	
Name	Fender 1
Visibility	Visible
Activity	Not Suppressed
Connectivity	Fender And Contact On Structures
Type	Floating
Action	Fender Y-Direction Only
Fender Connection Point	Fender_Aft (Pier)
Connection Point on Contact Pla...	Fender_Aft (ShipHull)
Initial Attachment Point Separation	6.98374800000093 m (Plane to Plane)
Fender Properties	
<input type="checkbox"/> Damping Coefficient	0.2 s
<input type="checkbox"/> Friction Coefficient	0.0
<input type="checkbox"/> Size	6 m
<input type="checkbox"/> Coefficient A	50000 N/m
<input type="checkbox"/> Coefficient B	3000 N/m²
<input type="checkbox"/> Coefficient C	0.0 N/m³
<input type="checkbox"/> Coefficient D	0.0 N/m⁴
<input type="checkbox"/> Coefficient E	0.0 N/m⁵

/ Aqwa Tethers

- Tethers are specifically intended for TLP analysis – calculations are most accurate when nearly vertical
- Finite Element calculations are performed for given material properties
- Defined by one or many Tether Sections
- Stiffness or Encastre conditions at each end
- Optional constraints between sections
- May also be used to model Risers with internal fluid

Details	
Details of Tether/Riser Section 1	
Name	Tether/Riser Section 1
Section Properties	
Density	0.0 kg/m ³
Young's Modulus	0.0 N/m ²
Outer Diameter	0.0 m
Thickness	0.0 m
<input type="checkbox"/> Added Mass Coefficient	1
<input type="checkbox"/> Transverse Drag Coefficient	0.75

Details	
Details of Tether/Riser 1	
Name	Tether/Riser 1
Visibility	Visible
Activity	Not Suppressed
General Attributes	
Connectivity	Fixed Point to Structure
Start Fixed Point	Undefined...
End Connection Point	Undefined...
Initial Attachment Point Separation	Not Available
Tether/Riser Section Selection	
Section 1: Type	None
Tether/Riser Boundary Conditions at Fixed Point	
Axial Stiffness	0.0 N/m
Rotational Constraint	Define Stiffnesses
<input type="checkbox"/> Stiffness about Tether/Riser Y Axis	0.0 N.m ²
<input type="checkbox"/> Stiffness about Tether/Riser Z Axis	0.0 N.m ²
Tether/Riser Boundary Conditions on Structure	
Axial Stiffness	0.0 N/m
Rotational Constraint	Define Stiffnesses
<input type="checkbox"/> Stiffness about Tether/Riser Y Axis	0.0 N.m ²
<input type="checkbox"/> Stiffness about Tether/Riser Z Axis	0.0 N.m ²
Tether/Riser Intermediate Constraints	
Additional Constraint 1	Define More Sections
Tether/Riser Specific Options	
<input type="checkbox"/> Number of Elements	50
<input type="checkbox"/> Tether Group Multiplier	1
<input type="checkbox"/> Anchor Cap Area	0.0 m ²
<input type="checkbox"/> Structure Cap Area	0.0 m ²
<input type="checkbox"/> Internal Fluid Pressure	0.0 N/m ²
<input type="checkbox"/> Internal Fluid Density	0.0 kg/m ³
<input type="checkbox"/> Axial Stress Impact Factor	0.0 kg/(m ² .s)
<input type="checkbox"/> Impact Half Life	0.0 s
<input checked="" type="checkbox"/> Lower Stop Position	0.0 m