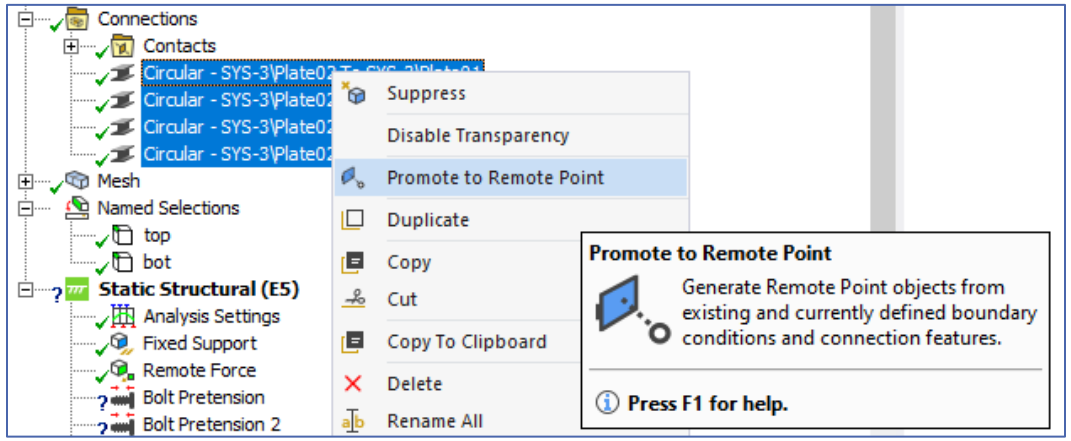
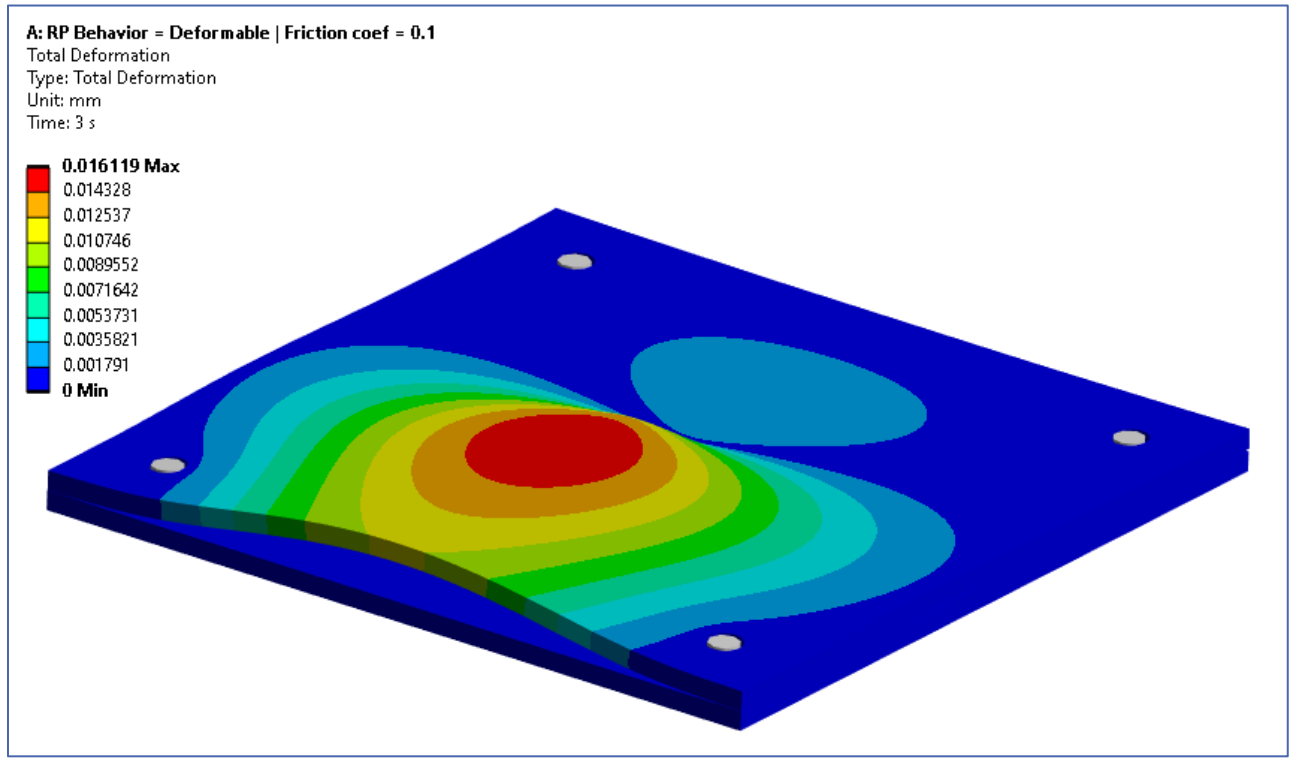
Automate Bolt Connection Generation and Release ROT DOFs at bolt ends





Background

Recently one of our customers reached out to us with the following challenge.
They needed to generate bolted connections such that:

a) the workflow is automated to generate large amount of bolted connections
b) preload must be applied
c) no moments are transferred to each bolt ends (meaning, end moments are released at each bolt end)
d) reaction forces can be extracted in all bolts

There are many ways to model bolted joints in Ansys:

1. both bolt and nut are modeled explicitly as solid bodies
2. simplified representation of a bolt as a line body
3. simplified representation of a bolt using a Beam Connection object
4. simplified representation of a bolt using a Translation Joint
5. simplified representation of a bolt using a Spring

Selection of a modeling strategy (solid vs line vs beam connection vs joint vs spring) depends on the goal of a particular analysis. For example, not every modeling strategy from above (1 – 5) can satisfy all the requirements that our customer needed in a) – d).

In this article, we will focus on a modeling strategy #3 (Beam Connection object) to highlight one workflow trick that this method has to offer.

Approach

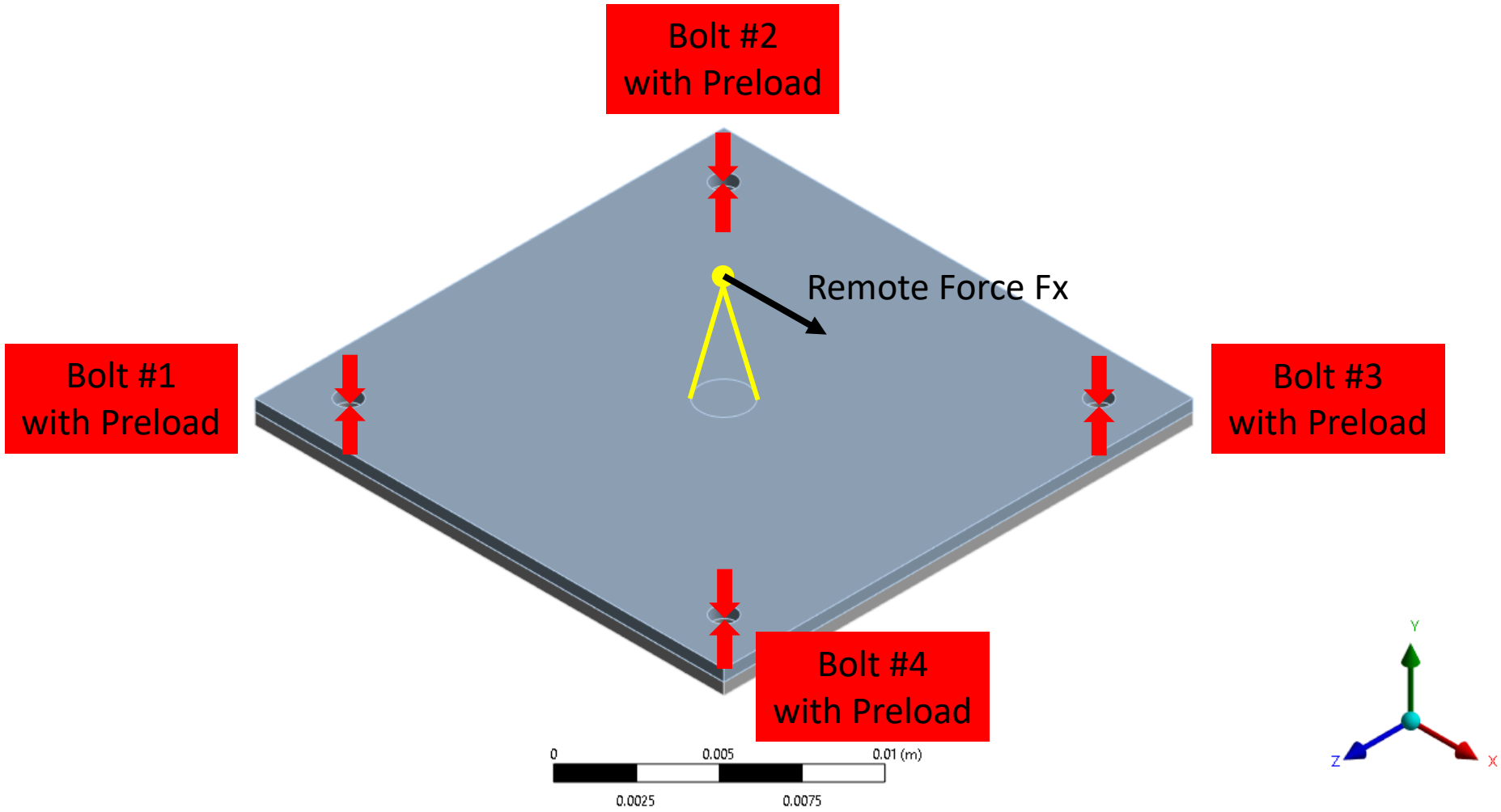
1	We will use [Object Generator] to create all required bolted connections at once	
2	We will then use [Promote to Remote Point] feature to create end points for each Beam Object created in 1)	
3	We will specify DOFs for all Remote Points deactivating Rotational DOFs	

Therefore, the workflow trick that we want to demonstrate is to use the [Promote to Remote Point] functionality.

The following slides will walk the reader through this workflow in more detail.

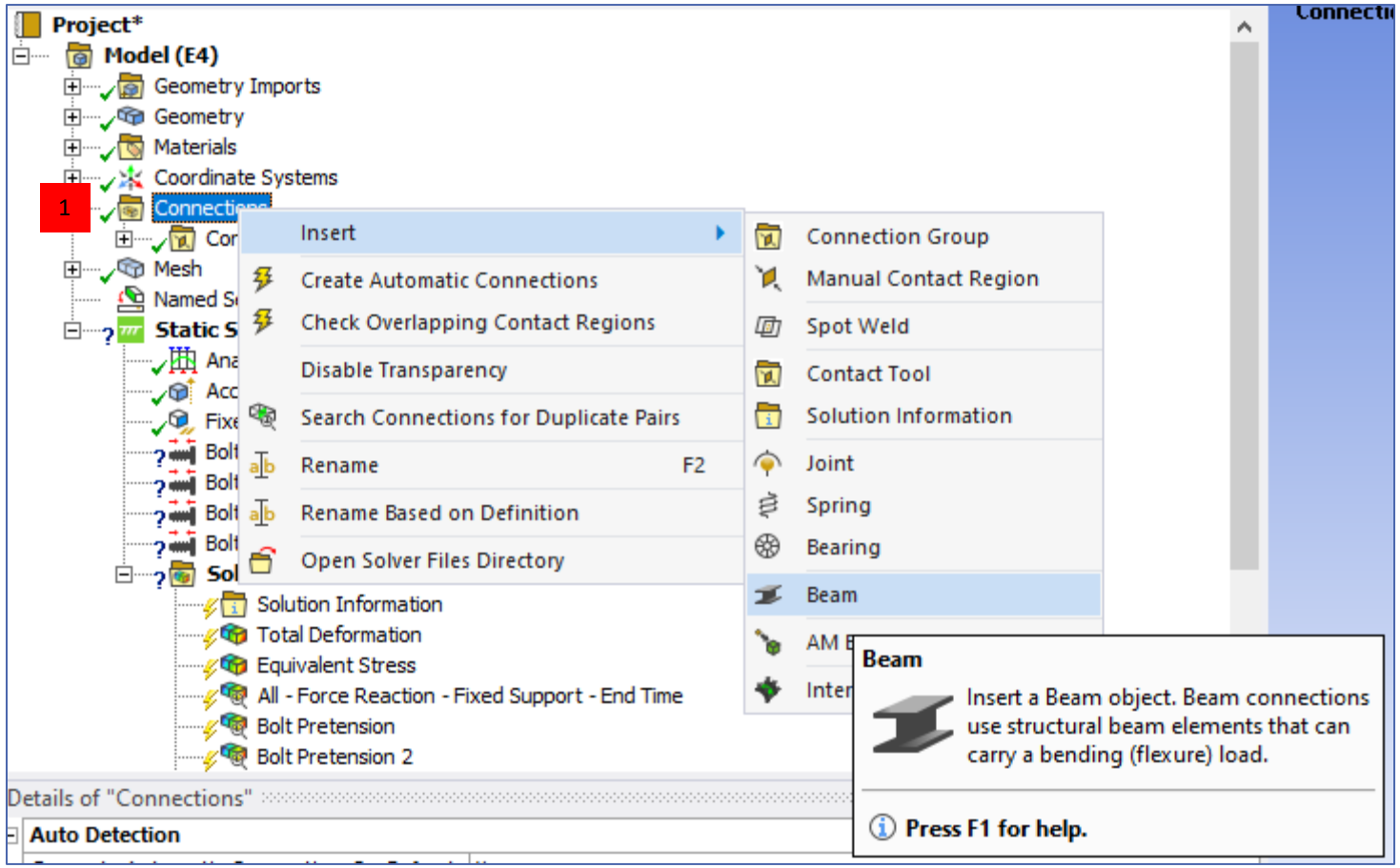
Ansys 2024 R1 will be used.

Geometry | Boundary Conditions | Loads



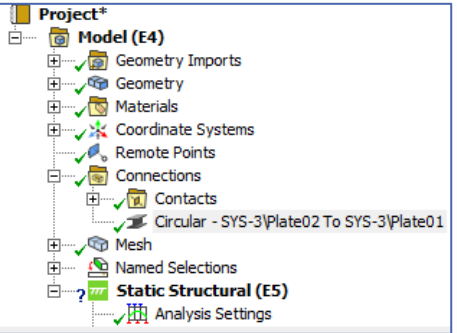
Insert 1 Beam object under Connections

1. RMB on Connections -> Insert -> Beam



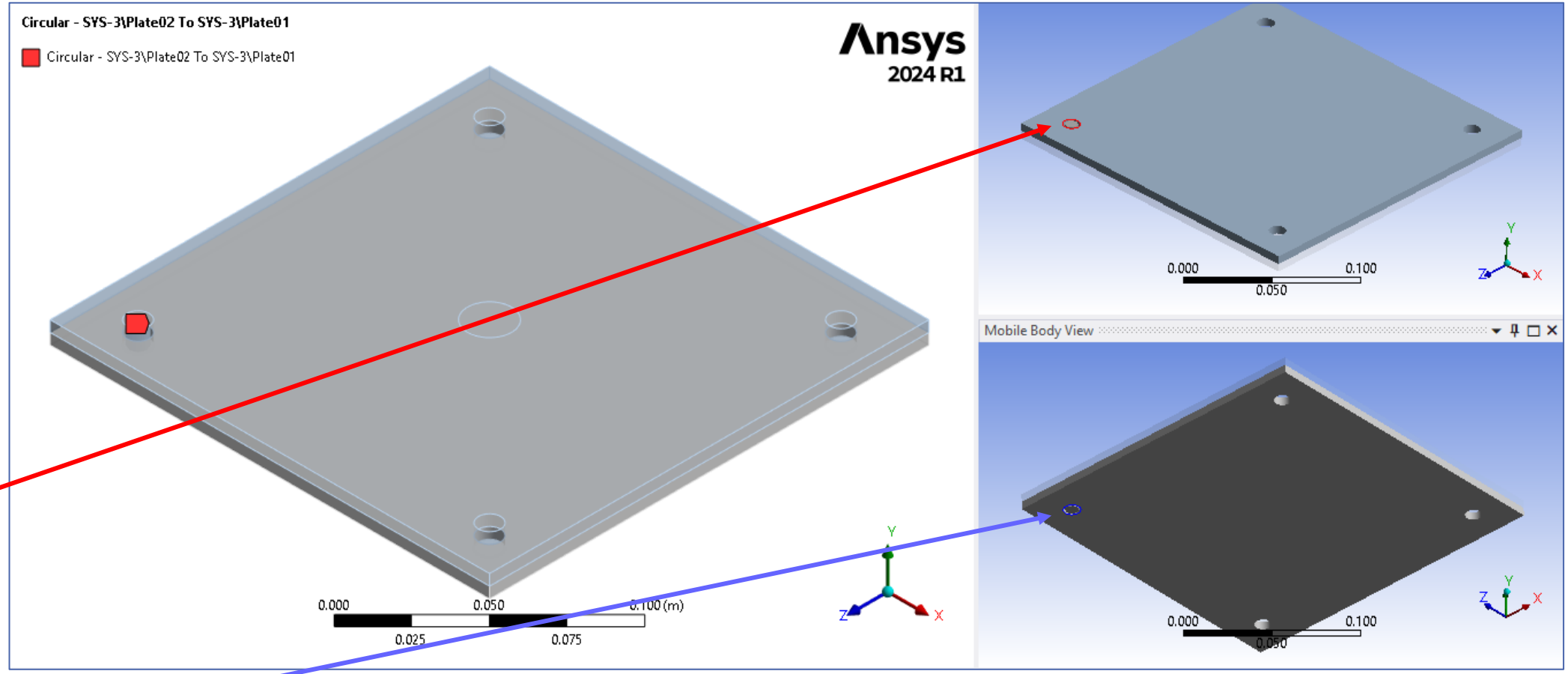
Insert 1 Beam object under Connections

Select 1 Edge for Reference side and 1 Edge for Mobile side



Details of "Circular - SYS-3\Plate02 To SYS-3\Plate01"

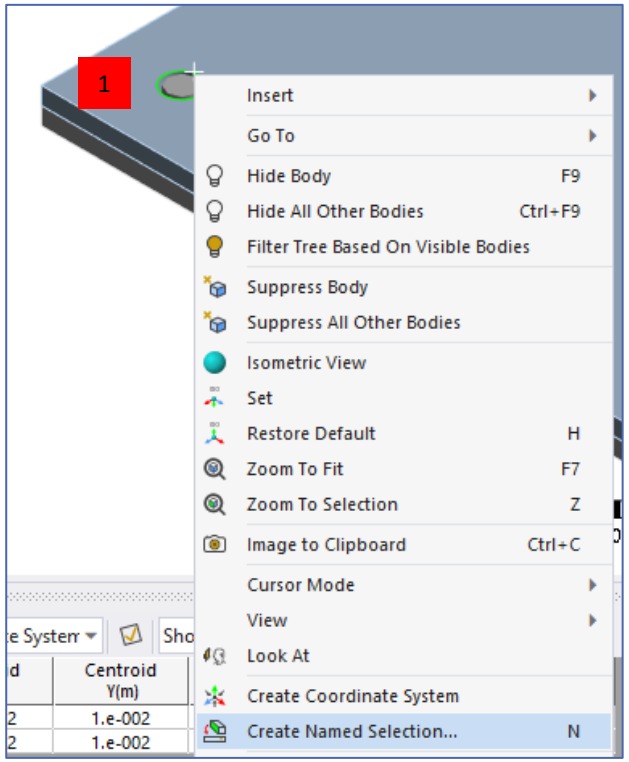
Graphics Properties	
Definition	
Material	Structural Steel
Cross Section	Circular
Radius	4.e-003 m
Suppressed	No
Beam Length	1.e-002 m
Element APDL Name	
Scope	
Scope	Body-Body
Reference	
Scoping Method	Geometry Selection
Applied By	Remote Attachment
Scope	1 Edge
Body	SYS-3\Plate02
Coordinate System	Global Coordinate System
Reference X Coordinate	-8.e-002 m
Reference Y Coordinate	1.e-002 m
Reference Z Coordinate	8.e-002 m
Reference Location	Click to Change
Behavior	Rigid
Pinball Region	All
Mobile	
Scoping Method	Geometry Selection
Applied By	Remote Attachment
Scope	1 Edge
Body	SYS-3\Plate01
Coordinate System	Global Coordinate System
Mobile X Coordinate	-8.e-002 m
Mobile Y Coordinate	0. m
Mobile Z Coordinate	8.e-002 m
Mobile Location	Click to Change
Behavior	Rigid

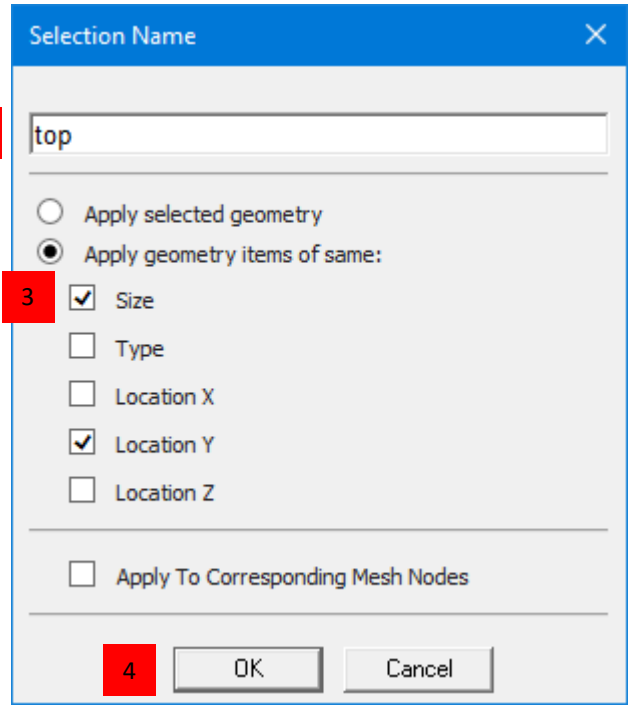


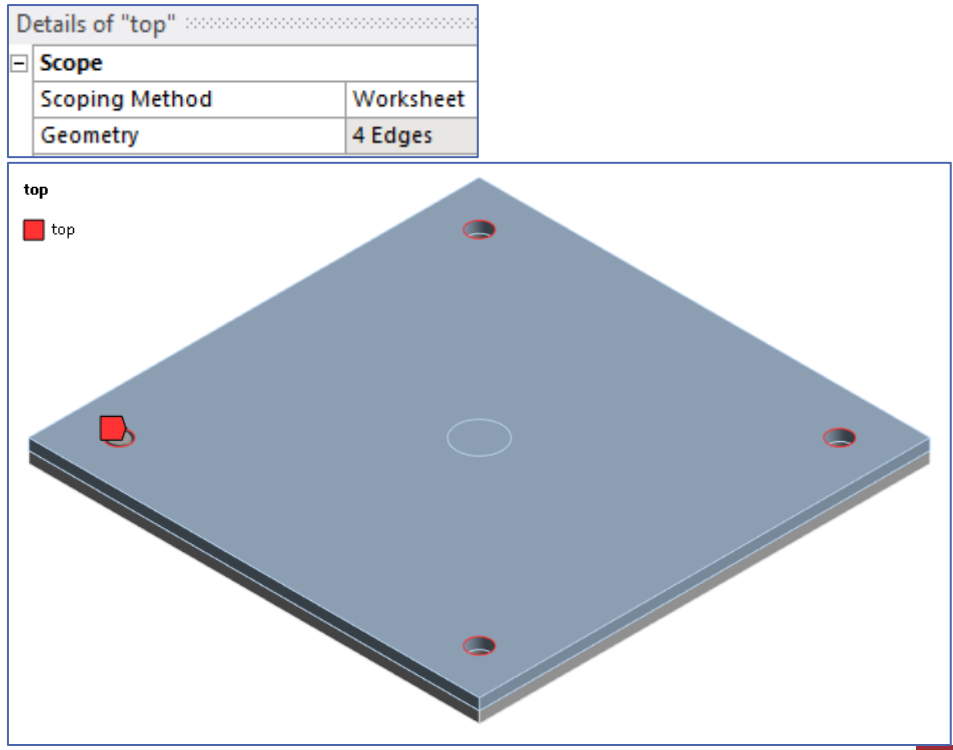
Create Named Selection for top and bottom holes

1. Select 1 bolt hole edge on the top plate -> RMB -> Create Named Selection
2. Give it a name, for example, [top]
3. Check box [Size] and [Location Y]
4. Click [OK]

As a result, Named Selection [top] will be created that contains 4 bolt hole edges of the top plate

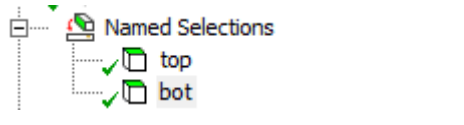






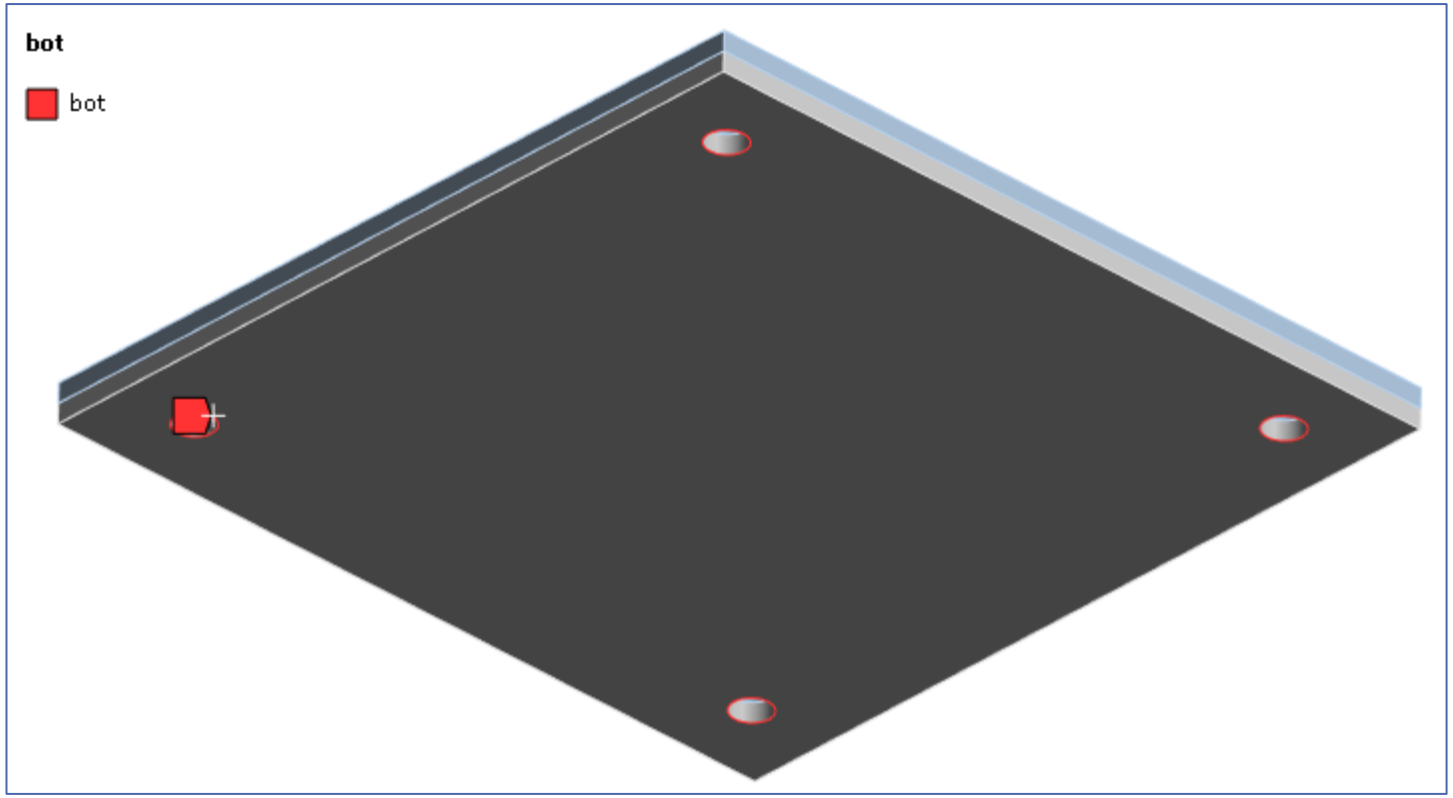
Create Named Selection for top and bottom holes

Repeat for bottom holes



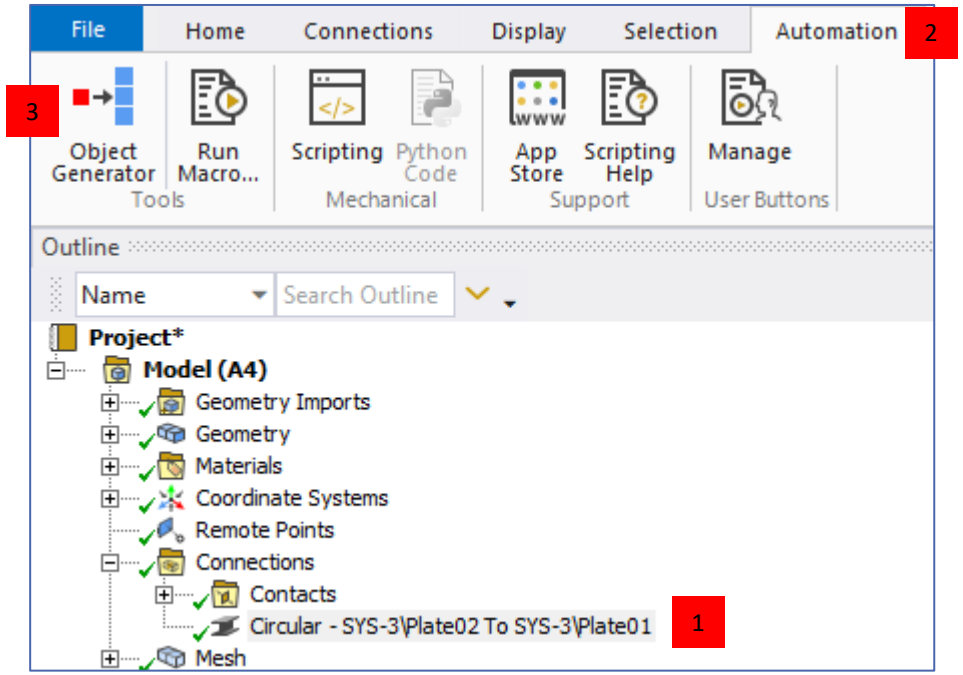
Details of "bot"

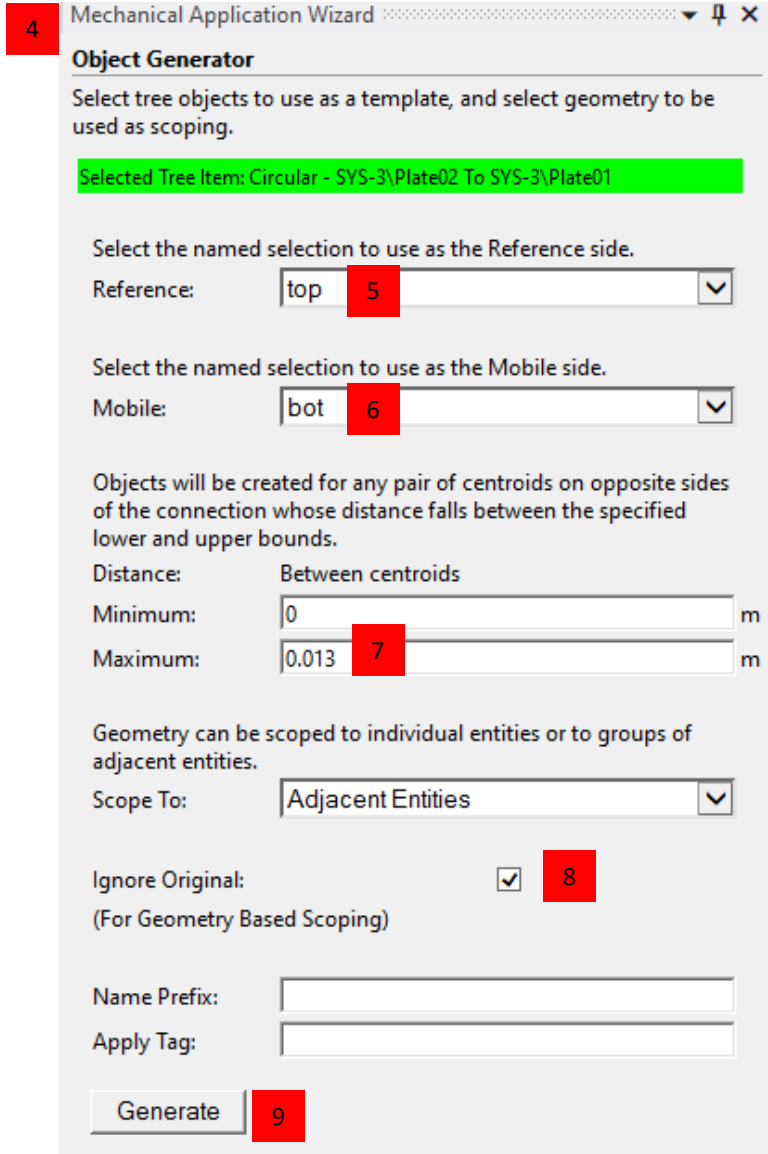
Scope	
Scoping Method	Worksheet
Geometry	4 Edges



Use Object Generator to create the rest of the bolts

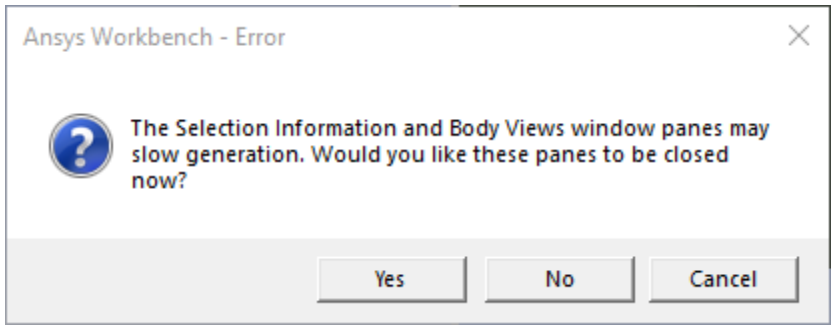
1. Select Beam object created before (Connections-> Circular – SYS-3\Plate02 To SYS-3\Plate01)
2. Switch to [Automation] tab
3. Click [Object Generator]
4. In [Mechanical Application Wizard]:
5. Select for [Reference]: [top]
6. Select for [Mobile]: [bot]
7. Specify [Distance: Between centroids]: Maximum = 0.013 m
   This will limit the search radius for given bolt object within 0.013 m
8. Make sure [Ignore Original] box is checked
9. Click [Generate]





Use Object Generator to create the rest of the bolts

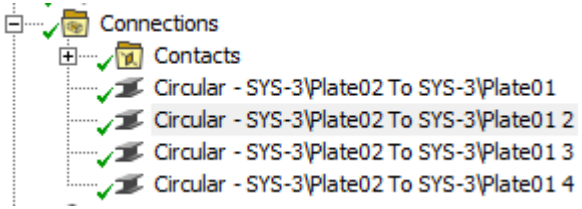
Click [No]

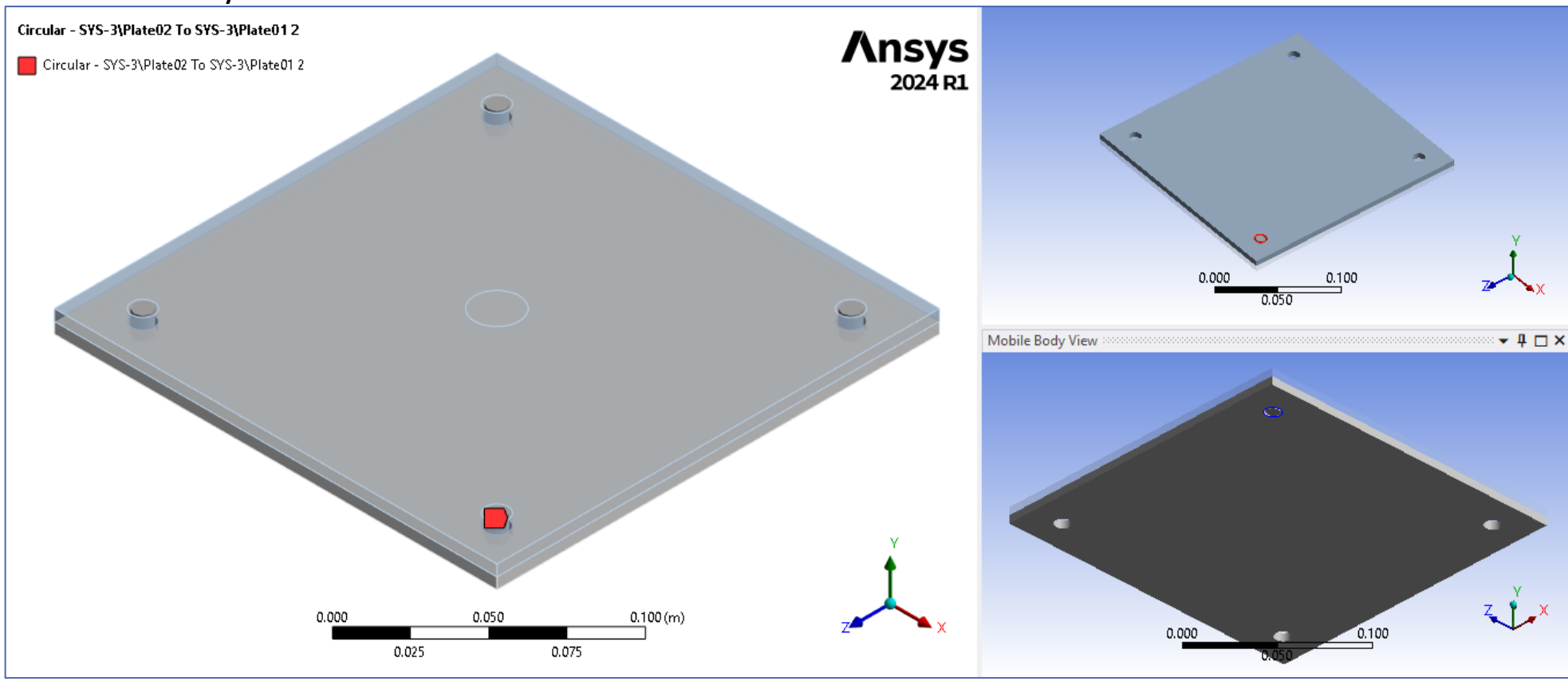


Use Object Generator to create the rest of the bolts

There are 4 Beam objects now.

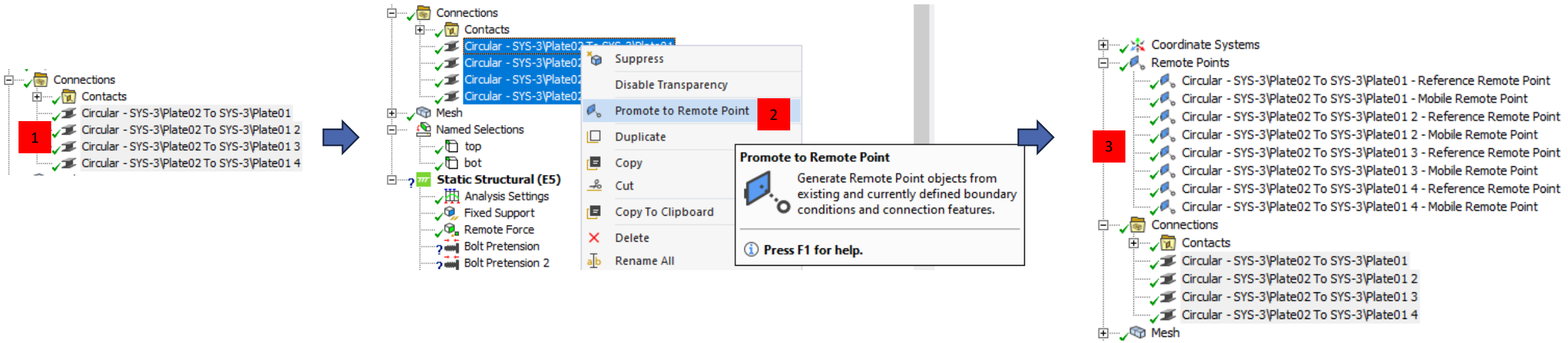
Make sure all of them were created correctly and have a correct orientation





Promote to Remote Points

1. Select all 4 Beam objects
2. RMB -> Promote to Remote Point
3. 8 Remote Points will be created



Change Remote Points behavior to Deformable and release end moments

1. Select all 8 Remote Points
2. Set [Behavior]: [Deformable]
3. Set [DOF Selection]: [Manual]
4. Set [Rotation X]: [Inactive]
   [Rotation Y]: [Inactive]
   [Rotation Z]: [Inactive]

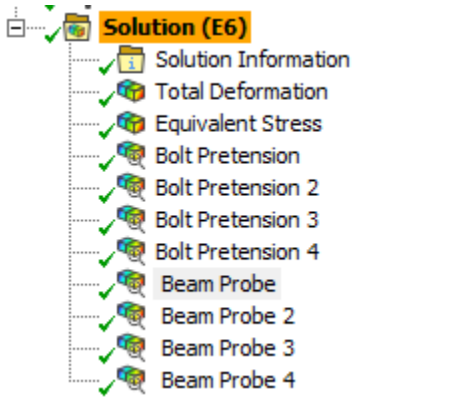
Details of "Multiple Selection"

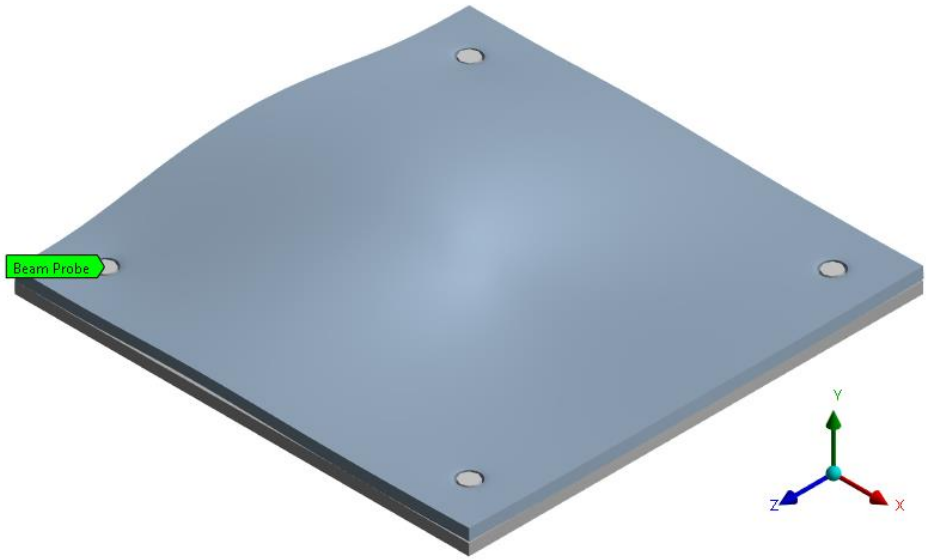
Scope	
Scoping Method	Geometry Selection
Geometry	1 Edge
Coordinate System	Global Coordinate System
X Coordinate	
Y Coordinate	
Z Coordinate	
Location	Click to Change
Definition	
Suppressed	No
Behavior	Deformable 2
Formulation	MPC
Relaxation Method	No
Pinball Region	All
DOF Selection	Manual 3
X Component	Active
Y Component	Active
Z Component	Active
Rotation X	Inactive
Rotation Y	Inactive 4
Rotation Z	Inactive
Pilot Node APDL Name	

Note:
It is important to set [Behavior] to [Deformable] instead of [Rigid].
For more information read:
https://ansyshelp.ansys.com/account/secured?returnurl=/Views/Secured/corp/v241/en/wb_sim/ds_remote_point_overview.html

Solve and check [Beam Probe]

1. Solve
2. Check [Beam Probe (Moment At I)] and [Beam Probe (Moment At J)]





Details of " Beam Probe"

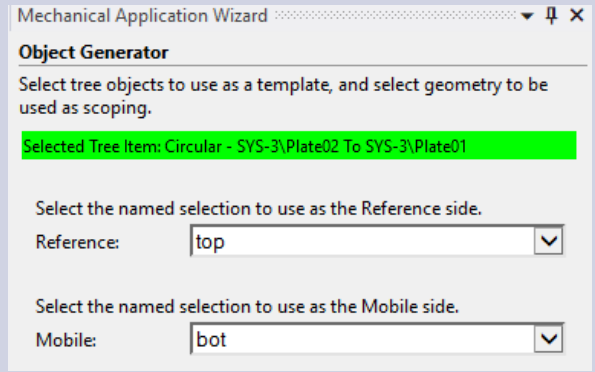
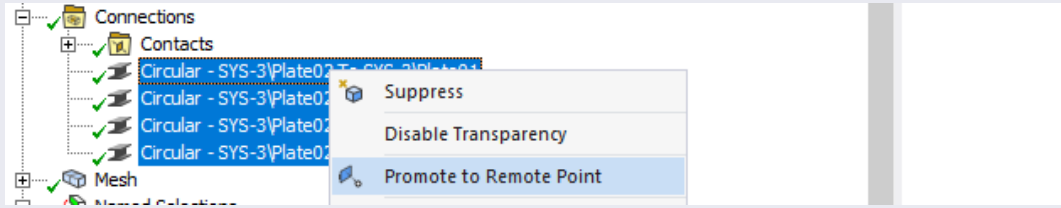
Definition	
Type	Beam Probe
Boundary Condition	Circular - SYS-3\Plate02 To SYS-3\Plate01
Suppressed	No
Options	
Result Selection	All
Display Time	End Time
Results	
Maximum Value Over Time	
Axial Force	400. N
Torque	7.9734e-015 N·mm
Shear Force At I	2.6027e-012 N
Shear Force At J	2.6016e-012 N
Moment At I	2.1675e-012 N·mm
Moment At J	2.1665e-012 N·mm
Minimum Value Over Time	
Axial Force	383.34 N
Torque	-1.0206e-014 N·mm
Shear Force At I	2.4509e-012 N
Shear Force At J	2.4526e-012 N
Moment At I	1.9886e-012 N·mm
Moment At J	1.8713e-012 N·mm

2

	Time [s]	Beam Probe (Moment At I) [N·mm]	Beam Probe (Moment At J) [N·mm]
1	1.	2.16e-012	2.1665e-012
2	2.	2.1675e-012	2.1547e-012
3	2.1	2.1584e-012	2.1533e-012
4	2.2	2.1509e-012	2.1439e-012
5	2.3	2.1233e-012	2.1399e-012
6	2.4	2.07e-012	2.0858e-012
7	2.55	2.1321e-012	2.0424e-012
8	2.775	1.9886e-012	2.0759e-012
9	3.	2.0649e-012	1.8713e-012

Conclusion

In conclusion, we demonstrated the use of [Promote to Remote Point] feature to automate/speed up creation of end points for Beam Objects representing bolts.
Traditional workflow would be to firstly create Remote Points for each bolt and create Beam Objects after that. This is a "bottom-up" approach.
We demonstrated an alternative "top-bottom" approach as follows:

1	We used [Object Generator] to create all required bolted connections at once	
2	We used [Promote to Remote Point] feature to create end points for each Beam Object created in 1)	
3	We specified DOFs for all Remote Points deactivating Rotational DOFs