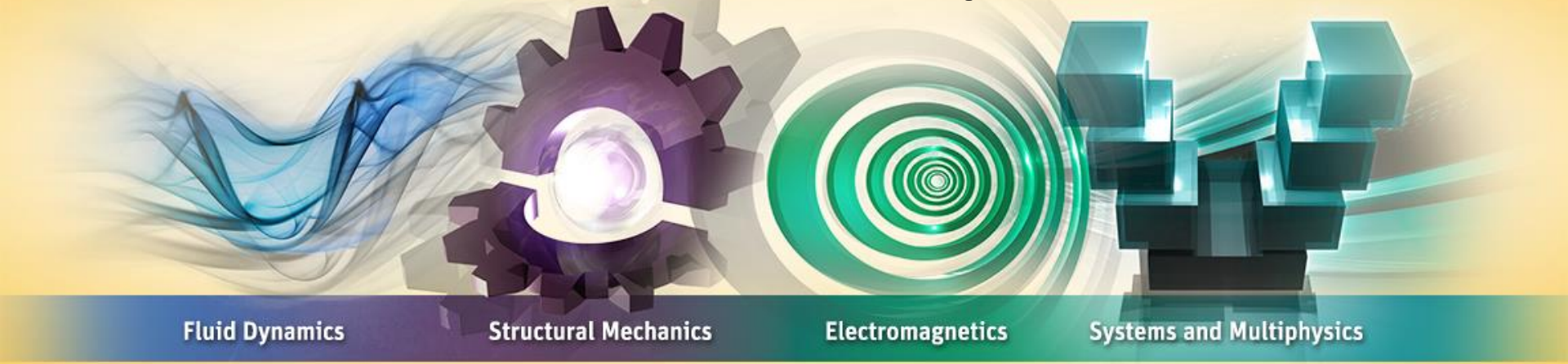
Lecture 6
Remote Boundary Conditions and Constraint Equations

16.0 Release



Introduction to ANSYS Mechanical

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Chapter Overview

In this chapter we introduce the concepts and uses for Remote Boundary Conditions:

A. Definitions
B. Remote Points
C. Behavior Control
D. Pinball Control
E. Remote Point Sharing
F. Display Options
G. Workshop 6.1, Remote Boundary Conditions
H. Appendix

A. Definitions

Remote boundary conditions provide a means to apply a condition whose center of action is not located where the condition is scoped (i.e, “remotely”).

Remote Boundary Conditions include: Point masses, thermal point masses, springs, joints, remote displacement, remote force and moment loads.

As the list above implies, not all the items constitute a “boundary condition”.

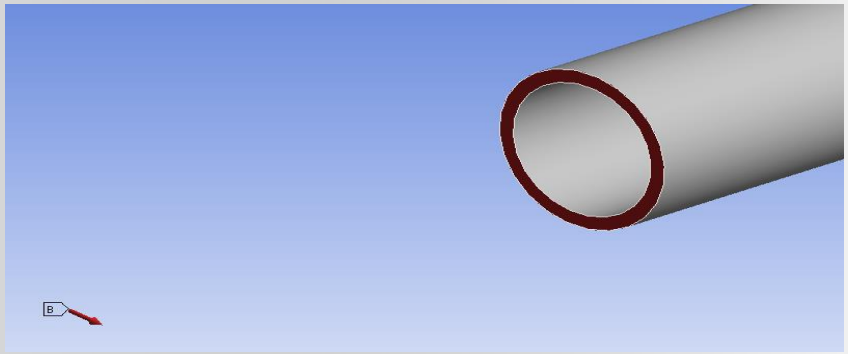
Common features of all remote conditions:

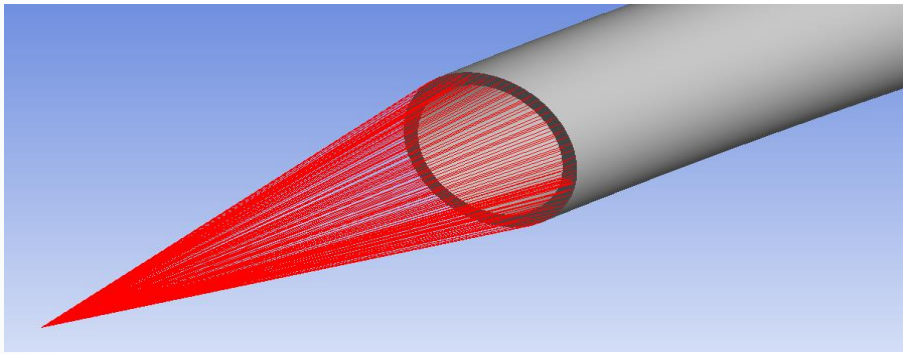
- All use MPC contact constraint equations in the application of the condition.
- Geometry behavior can be set to rigid, deformable or coupled.
- Large numbers of remote conditions can be costly in terms of solution times.

B. Remote Points

- A remote point can be defined at an arbitrary location and is then scoped to the existing geometry where desired. A specific “condition” (described earlier) is then applied to the remote point.

Remote Force Example





. . . Remote Points

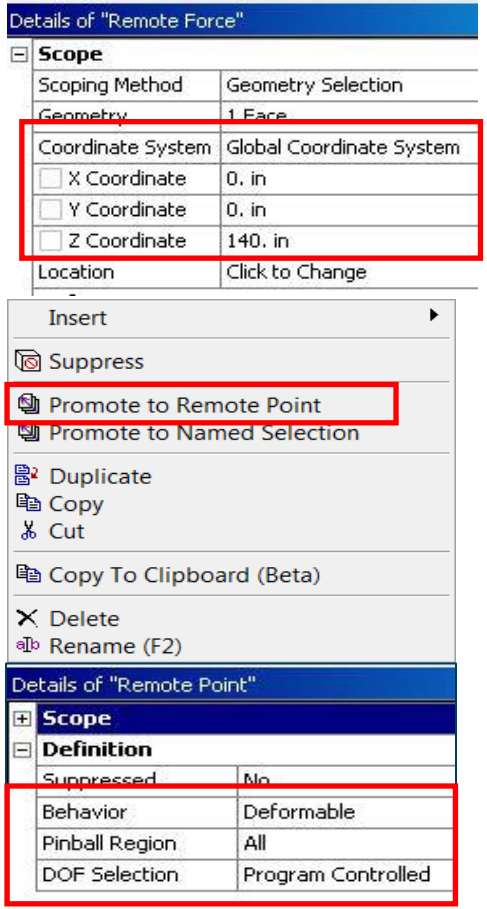
Remote points occur automatically when a remote BC is defined.

- **The coordinates shown in the details indicate the location of the remote point.**
- **Locations can be in terms of global or local coordinates.**
- **A point associated with a remote boundary condition can be "promoted" to an independent remote point via RMB.**

Additional Controls:

- **Remote boundary conditions contain a "behavior" control that allow rigid, deformable or coupled settings.**
- **Pinball Region allows a reduction in the amount of constraint equations used.**
- **DOF Selection allows independent selection of the degrees of freedom associated with the remote condition.**

Each is discussed next . . .

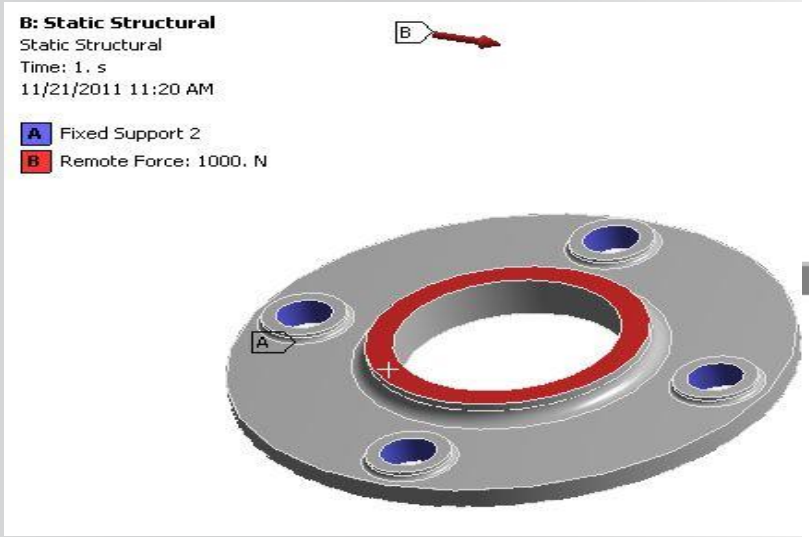


C. Behavior Control

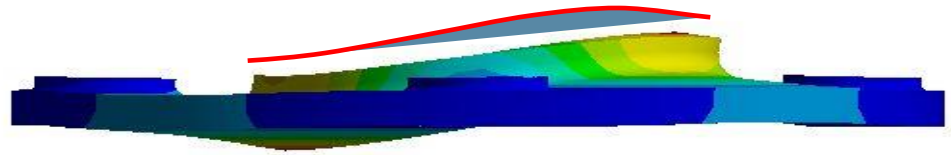
Several examples are included to illustrate the rigid/deformable option:

- **Example of a remote force scoped to the face shown in red:**

Behavior	Deformable
Advanced	Rigid
Pinball Region	Deformable



Deformable

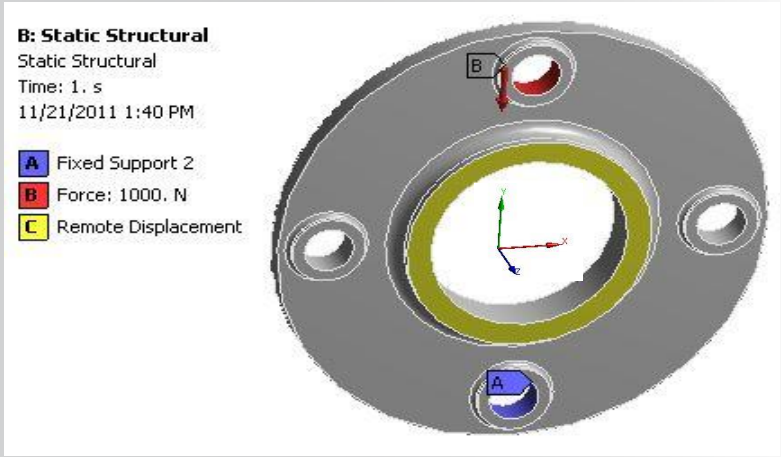


Rigid

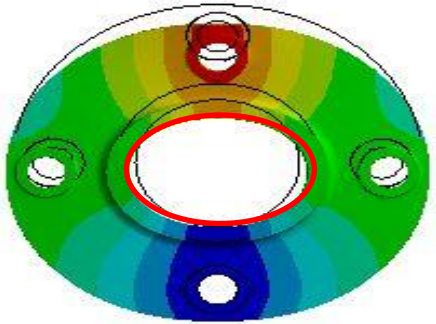
. . . Behavior Control

A remote displacement scoped to the yellow face with all directions free except the out of plane, Z direction:

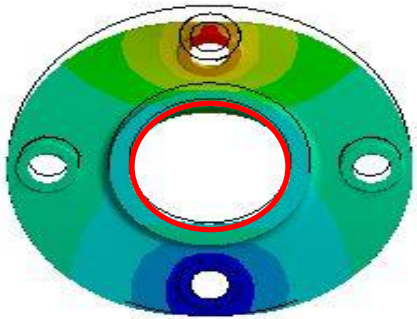
- **Notice in the deformable case the circular section has become “egg shaped” whereas the rigid section maintains its circular shape.**



Deformable



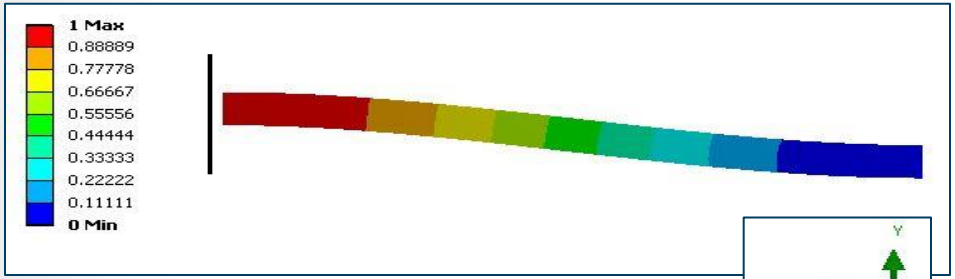
Rigid



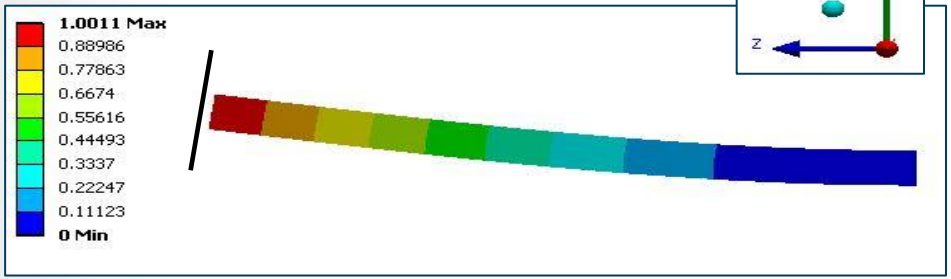
. . . Behavior Control

A remote displacement scoped to the end of the beam. The "coupled" option is chosen.

With all DOF active notice the beam end remains in plane (the scoped face contains no Z deformation because the remote point contains none).



In this case the Z DOF is set inactive. Thus the scoped face is free to deform in the Z direction.

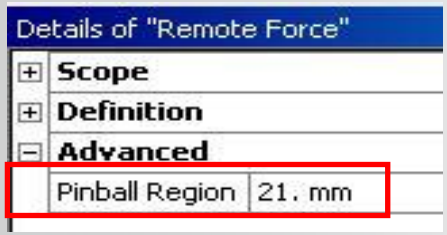


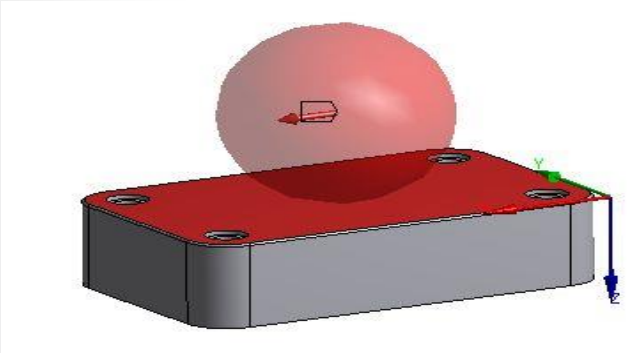
D. Pinball Control

Large numbers of constraint equations can slow down compute times or cause over-constraint conditions. The "Pinball Region" settings allows the number of constraint equations to be limited as well as controlling their location:

- **Default setting = All (note, to return to the default enter zero "0").**
- **If the default ("All") is active, no pinball is displayed graphically.**
- **If a value is entered for the pinball region, a sphere representing the pinball is displayed.**

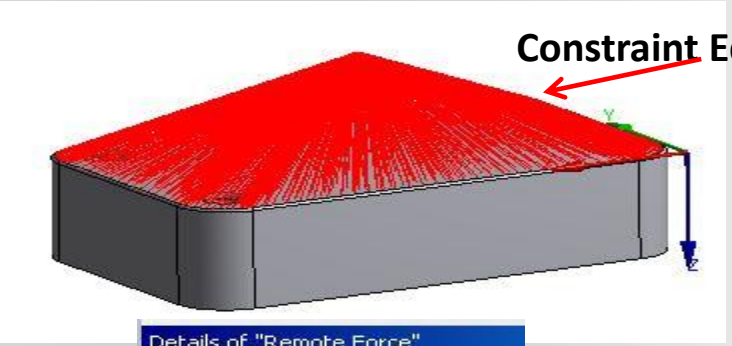
- **Note: if a pinball region is defined such that no part penetrates the scoped region, no constraint equations are written and an error message will be displayed.**



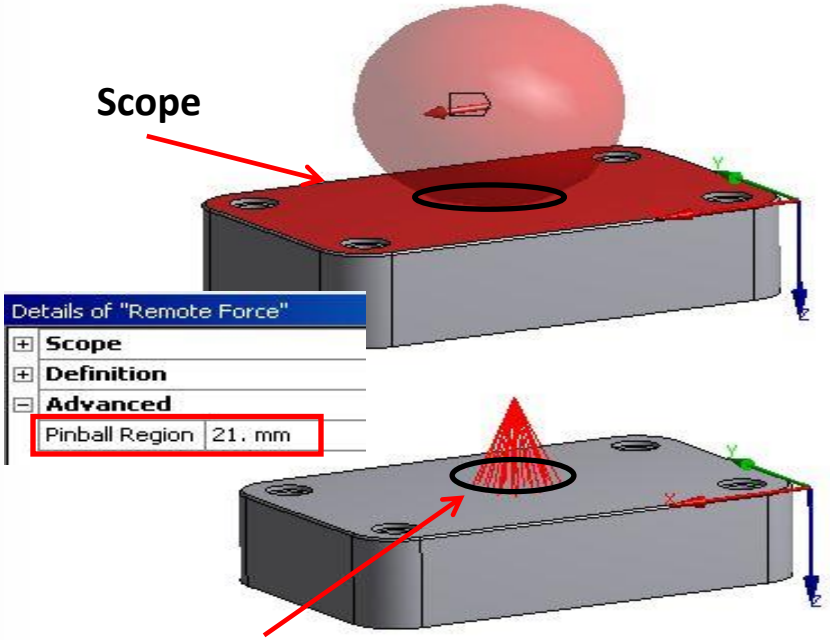


. . . Pinball Control

Notice when the pinball region is defined, only parts of the scoped region that are penetrated by the pinball have constraint equations defined.



Details of "Remote Force"	
Scope	
Definition	
Advanced	
Pinball Region	All



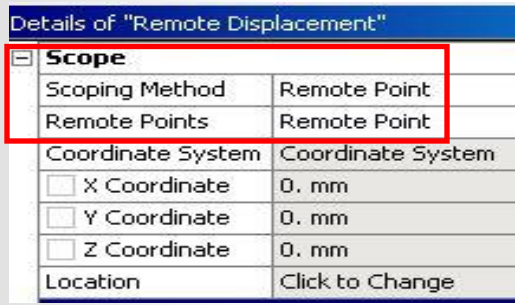
Details of "Remote Force"	
Scope	
Definition	
Advanced	
Pinball Region	21. mm

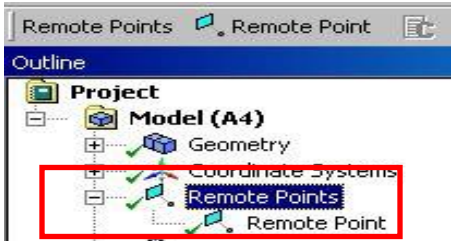
E. Remote Point Sharing

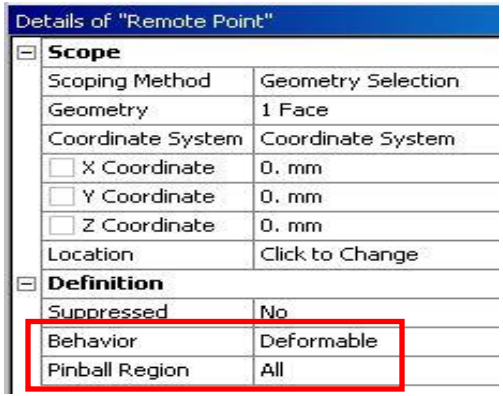
Since each remote condition defines its own remote point and constraint equations, multiple conditions can adversely affect solution times. In cases where multiple remote conditions share a remote location, a single remote point can be used for all conditions:

- Remote points are created in advance of the remote boundary conditions.
- Notice the details for each remote point contain all the same settings discussed earlier.

If remote points exist in the model, remote boundary conditions can be scoped to them.



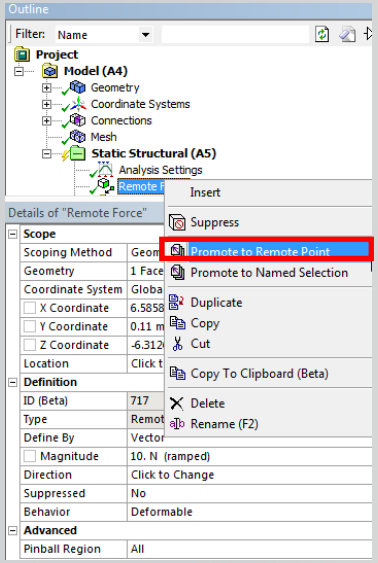




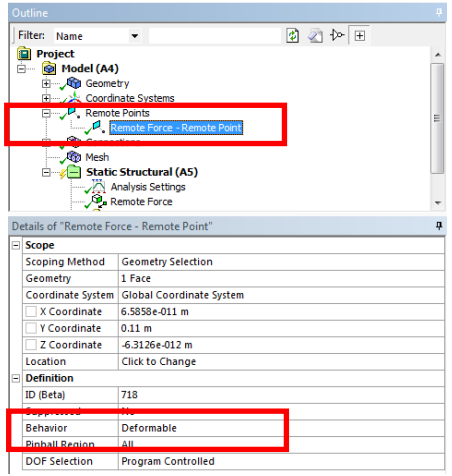
… Remote Point Sharing

Once a remote boundary condition is set on the analysis branch, remote point can be promoted to be reused on other conditions:

- **RMB on remote Boundary condition > Promote to remote point**

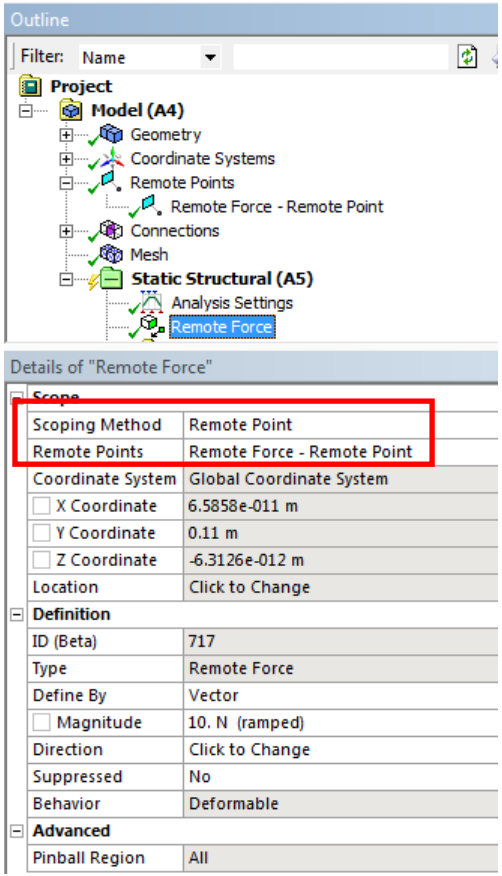


- **Remote point becomes accessible in the tree outline:**
- **Details of remote point remain unchanged**
- **Remote point can be renamed**



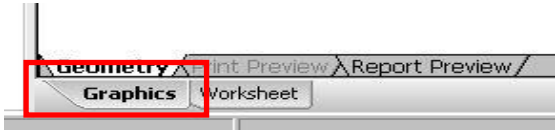
… Remote Point Sharing

- Details of remote boundary condition have changed:
  - Scoping method is now “remote point”
  - Remote point coordinates and behavior cannot be changed from this details window. Any change has to be done on remote point details window.
  - New Boundary condition can be scoped on this remote point.



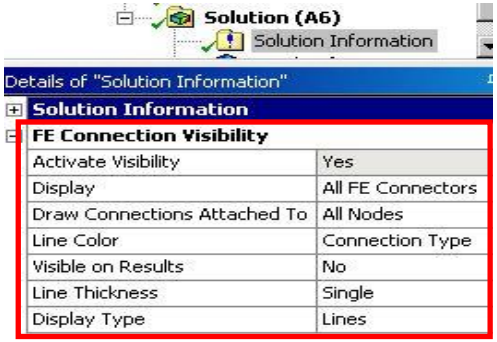
F. Display Options

Constraint equations generated by remote boundary conditions can be displayed graphically by configuring the “FE Connection Visibility” settings and clicking the “Graphics” tab.



Display Options:

- “Activate Visibility” by default is set to “Yes”. For maximum performance on large models, or if you know you will never view FE connections you can set this to “No” prior to solving.
- Can display all connections or filter by type.
- Option to display connections on results plots.
- Control cosmetics (e.g. color, line versus point, etc.).



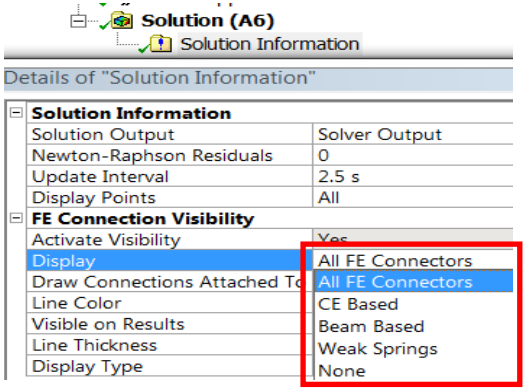
“RMB > Export FE Connections” from the solution information branch allows details for FE connections to be exported. The current visibility settings control the content of the export.

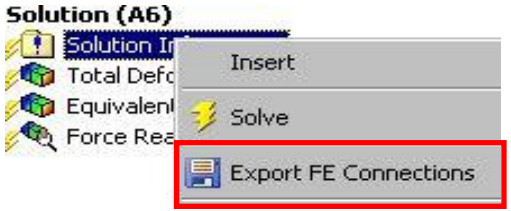
ANSYS . . . Display Options

As stated earlier, remote boundary conditions are defined using constraint equations (CE).

Several other FE connections exist which can also be displayed and exported.

- Beam based connections are used to define spot welds.
- Weak springs are applied to a model when a structural under-constraint condition is possible.

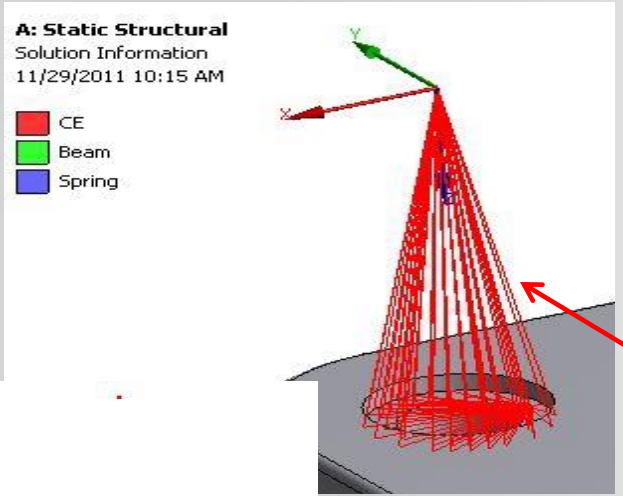


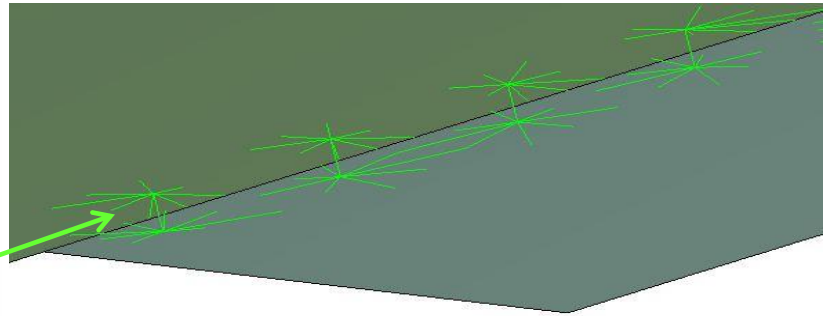


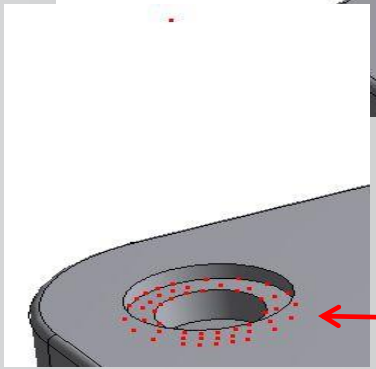
- Export FE Connections will create a text file containing all constraint equations written in ANSYS MAPDL command language.

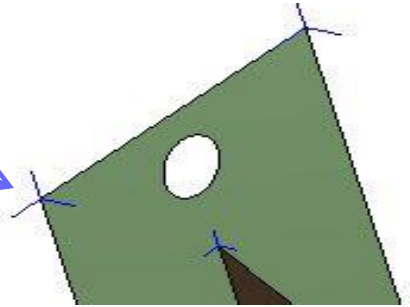
. . . Display Options

Examples of FE Connection display options:



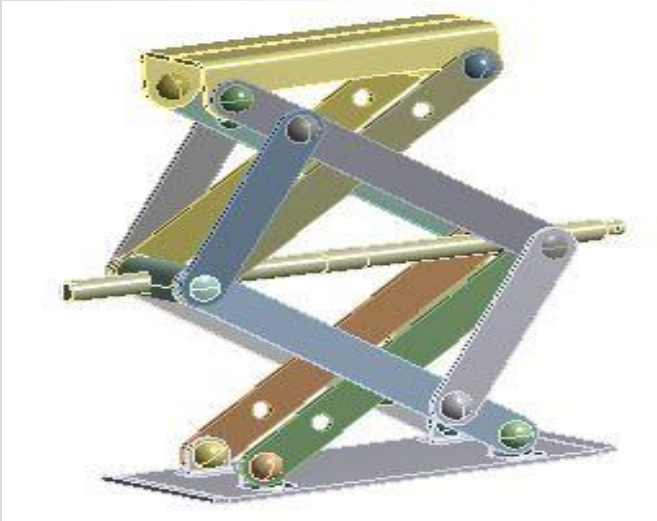






G. Workshop 6.1

- **Workshop 6.1 – Remote Boundary Conditions**



H. APPENDIX

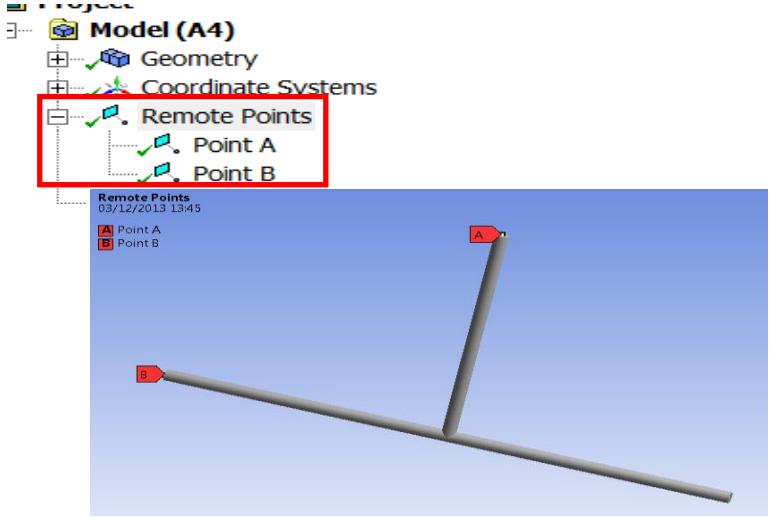
- Constraint Equations
- CE Exemple

Constraint Equations

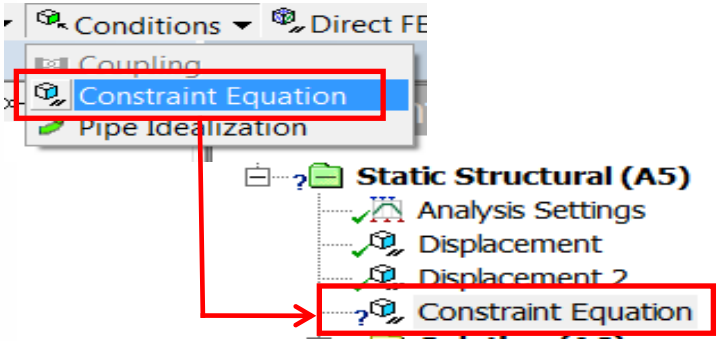
- Constraint equations allow you to relate the motion of different portions of a model through the use of an equation.
- The equation relates the degrees of freedom (DOF) of one or more remote points for Static and Transient Structural, Harmonic and Modal analysis systems.
- Constraint equations are linear combinations.
- Can be applied to joints when using the ANSYS Rigid Dynamics solver (not covered here).

. . . Constraint Equations

Constraint equations require the use of remote points as defined here in the desired locations.

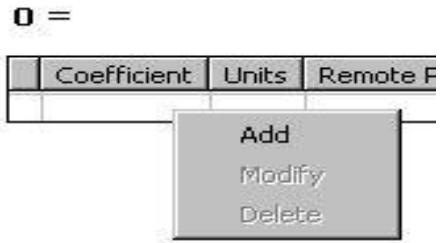


A constraint equation is added to the environment from the "Conditions" menu.

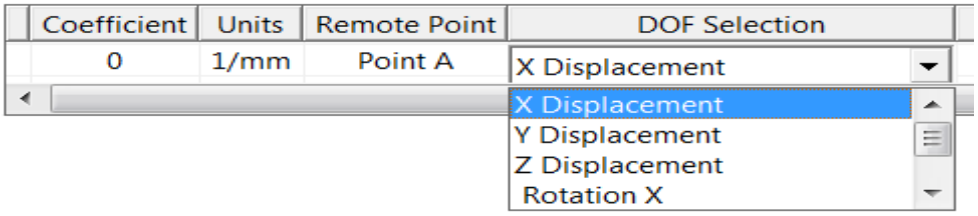


. . . Constraint Equations

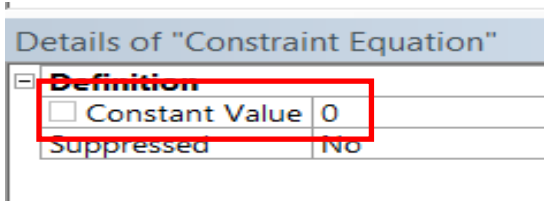
The constraint equation is then constructed using the worksheet. New rows are added for each term in the expression by right clicking to "Add".



Fields for remote point and DOF selection are drop down choices in the worksheet. Coefficient values are entered as needed.



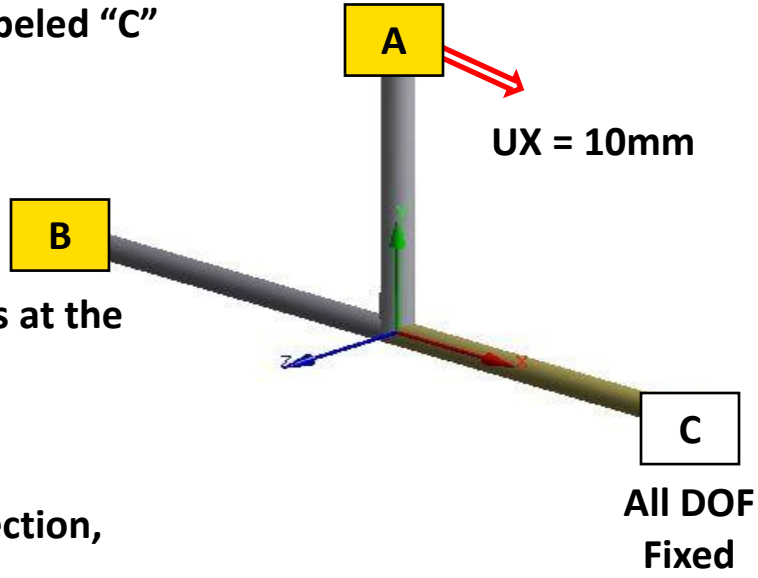
Finally a constant value can be added in the details for the constraint equation.



Examples follow . . .

CE Example

In this example a beam model is constrained at the end labeled “C” and loaded at point “A” as shown here.



A constraint equation is defined to control the movements at the point labeled “B” relative to point “A”:

$$UAx = UBz$$

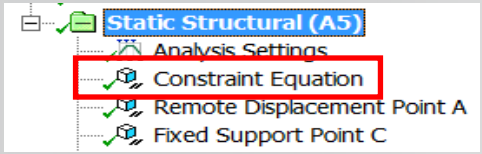
What this relation says is, what point A does in the +X direction, point B must do in the +Z direction.

The equation can be re-written as:

$$0 = UBz - UAx$$

. . . CE Example

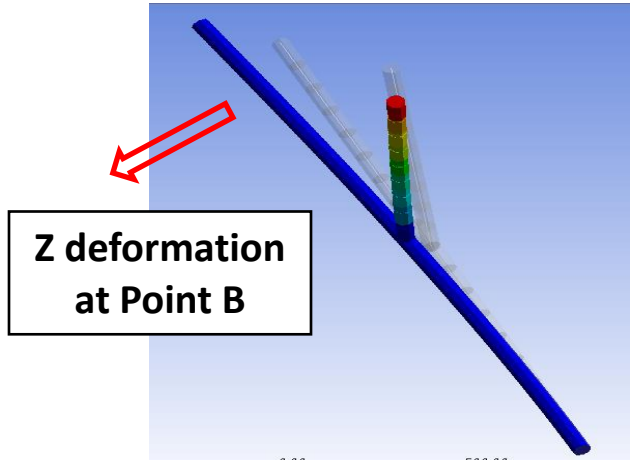
After inserting a constraint equation in the environment, the Worksheet is configured as shown here.



Constraint Equation

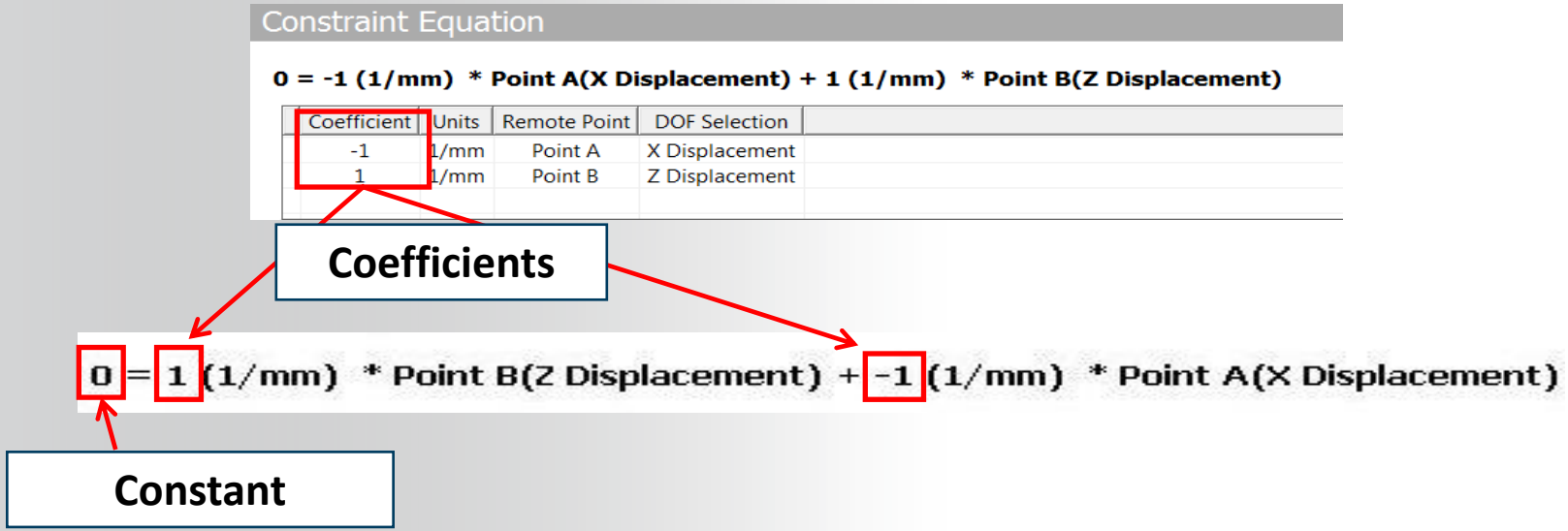
0 = -1 (1/mm) * Point A(X Displacement) + 1 (1/mm) * Point B(Z Displacement)

Coefficient	Units	Remote Point	DOF Selection
-1	1/mm	Point A	X Displacement
1	1/mm	Point B	Z Displacement



. . . CE Example

Notice the expression is written above the worksheet columns.



In this example both constants were set to unity (1) and the constant value to zero. Other values may be provided in different expressions.

Workshop 6.2

- **Workshop 6.2 – Constraint Equations**