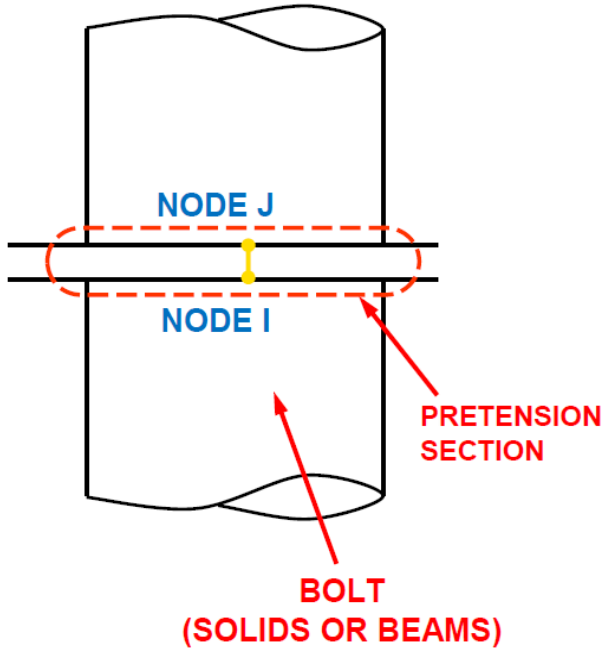
Bolt Pretension Object

Modeling the Bolt and Preload

Bolt Preload Definition

- Bolt Preload can be defined in both solid and line bodies.
- The bolt is split into two parts and they're connected by constraint equations to define a tension state.
- There are two methods of applying bolt preload:
  - Bolt pretension object
    - The bolt splitting and rejoining done by the Mechanical pre-processor.
    - No need to physically split the bolt
  - Translational joint
    - The bolt is split manually.
    - The two parts are connected manually using a translational joint.



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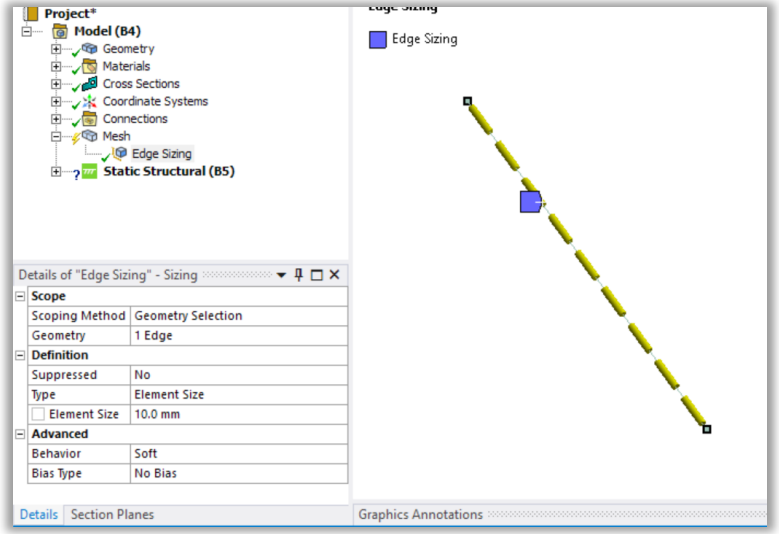
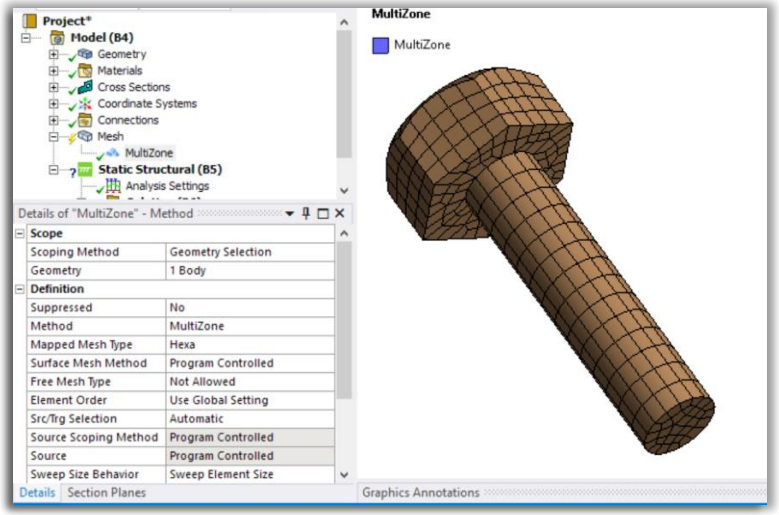
Mesh Considerations

- Since the bolt is sliced into two parts, it is necessary to have at least two elements along the bolt length.
- Meshing for Line bodies.
  - Add Edge Sizing for the lines
  - One can define No. of Divisions or Element Size for the selected edges
- Meshing for Solid Bodies
  - Add a Multizone Mesh Method
  - Can also define Body Sizing for uniform mesh size
  - Uniform, hex-dominated mesh is recommended for easy splitting of the cylinder into two halves





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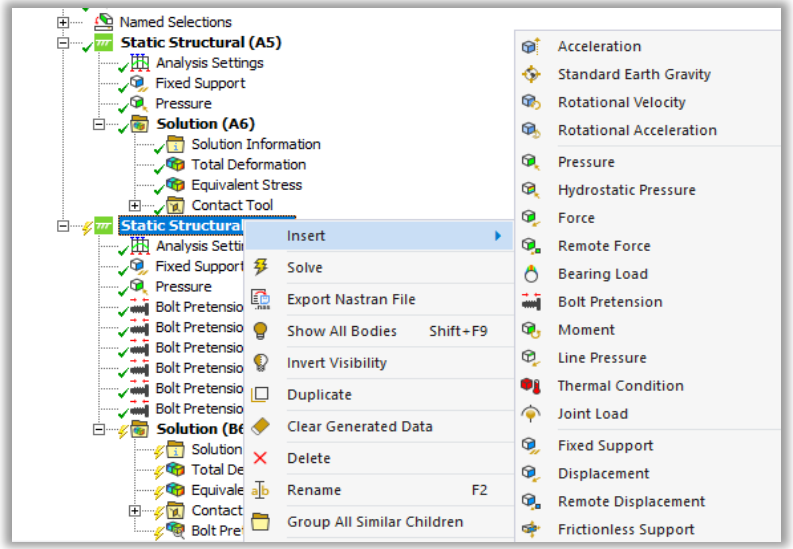
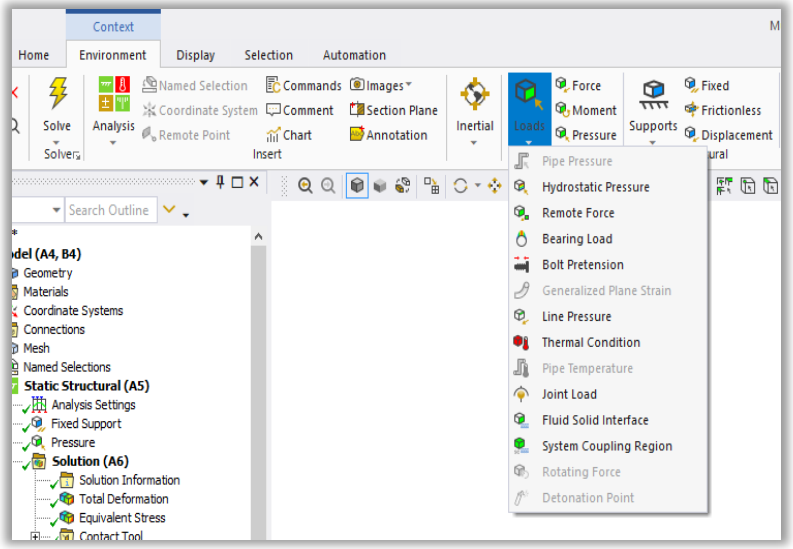
Bolt Pretension Object

- This is the most common way of defining bolt preload.
- The bolt pretension object can be scoped to both solid bodies and line bodies.
- In case of solid bodies, the bolt pretension object can be scoped to either a cylindrical surface or to a solid body of any geometry (for non-standard bolts).





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Bolt Pretension Object

- Caution: the cutting plane must NOT pass through a region where bonded contact is defined.
- By default the preprocessor slices the bolt close to the centroid of the bolt.
- If the centroid of the bolt lies in the threaded portion where bonded contact is defined, the default cutting plane is not acceptable.
- In such cases, the local coordinate system can be defined manually to control where the bolt is cut.

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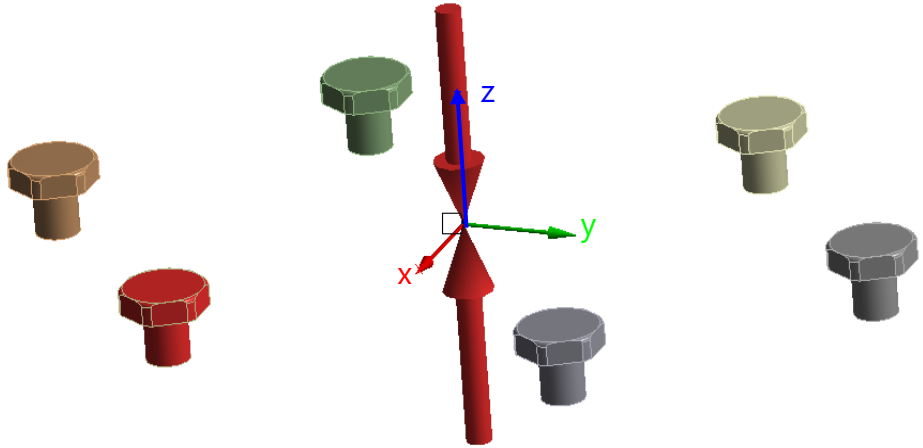
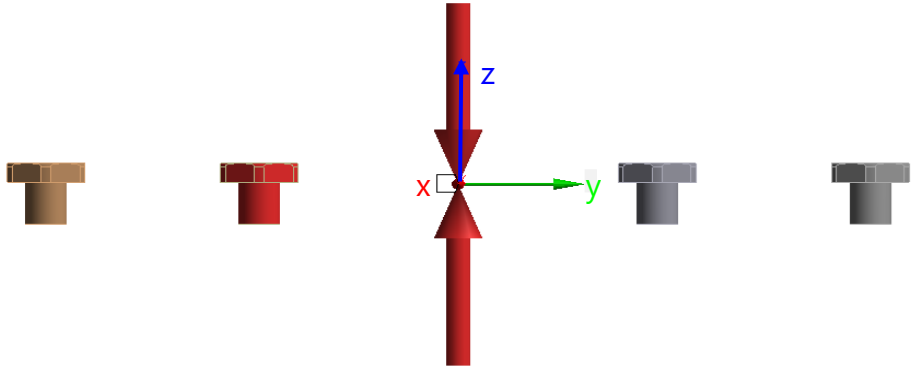
Bolt Pretension Object (cont.)

- The local coordinate system is defined such that,
  - A principal plane is used to define the location where the bolt is cut
  - A principal axis is used for defining the axis of the bolt.
- The bolt need not be cut exactly at the center, but it must be cut within the grip length of the bolt.
- The local principal axis must be parallel (need not be collinear) to the bolt axis.



Principal axis i.e. the z-axis is parallel (but not collinear) with the axes of all bolts



Principal plane i.e. the x-y plane, is within the grip-length of all bolts

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Defining Bolt Preload using Bolt Pretension Object

- Various options available to in the bolt pretension object – load, adjustment, lock, increment, open
- The two most important options to define bolt preload: load and lock.
  - Load: Specify the bolt preload in terms of tensile force developed in the bolt. Can be set in any step.
  - Lock: Simulates the physical scenario of bolt grip-length staying constant when the machine assembly is loaded. If the lock option is not used when operational loads are applied, the effective grip-length of the bolt will keep changing. Can be used in any step except first.

Tabular Data

	Steps	Define By	Preload [N]	Preadjustment [mm]	Increment [mm]
1	1.	Load	1500.	N/A	N/A
2	2.	Load	1500.	N/A	N/A
3	3.	Load	1500.	N/A	N/A
*					

Tabular Data

	Time [s]	Bolt Pretension (Adjustment Reaction) [mm]	Bolt Pretension (Working Load) [N]
1	1.	5.4398e-003	0.
2	2.	5.4399e-003	0.
3	3.	2.1324e-003	0.

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Other Options for Defining Bolt Preload

- Other options for specifying bolt preload:
  - Adjustment: The preload is defined in terms of the relative displacement between nodes I and J of the split bolt. Can be set in any step.
  - Open: This option is used to disengage the bolt, such that the bolt preload has no effect on the applied step. Can be used to simulate disassembly process. Can be set in any step.
  - Increment: This option applies an increment to the existing adjustment (thereby changing both the bolt adjustment and the tension in the bolt). Used to simulate additional tightening or loosening of the bolts. Can be set in any step except the first.

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Defining Bolt Pretension

- Bolt pretension object can used with all three bolt representations (solid body, line body, beam connection).
- When a bolt is modeled as a solid body, the bolt pretension object can be scoped in two ways
  - To cylindrical surface of the bolt: local coordinate system is defined behind-the-scenes by Ansys Mechanical preprocessor. The principal axis coincides with the cylinder axis, and the cutting plane divides the cylindrical surface into two cylindrical halves.
  - To solid body of the bolt: local coordinate system needs to be defined manually, such that the z-axis should be parallel to the bolt axis (the two need not be collinear), and the x-y plane should cut the bolt approximately midway (or at least within the grip-length).

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Defining Bolt Pretension (cont.)

- When a bolt is modeled as a line body, Ansys Mechanical preprocessor defines a local coordinate system automatically. The x-axis of the local coordinate system is the bolt axis, while the local y-z plane is the cutting plane.
- When a bolt is modeled as a beam connection, the local coordinate system is again defined by Ansys Mechanical preprocessor behind-the-scenes. The local coordinate system is similar to one defined for a line body representation of bolts.

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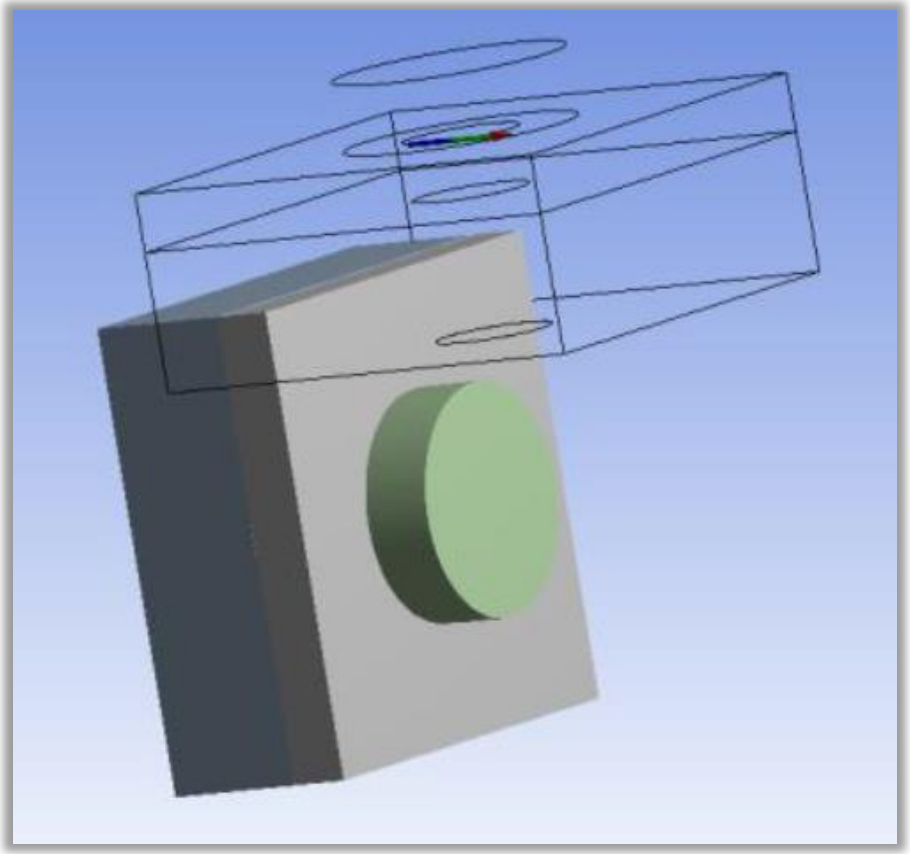
Limitations of Bolt Pretension

- Bolt pretension object has certain limitations:
  - Cannot handle large rotation: the direction of bolt preload remains constant throughout the simulation.
  - Cannot transfer shear loads
  - Cannot transfer moment when bolt is represented as a line body
- If none of the above three limitations are applicable, bolt pretension object should be used to save preprocessing time.
- If even one of the three limitations is relevant, then a translational joint should be used instead.



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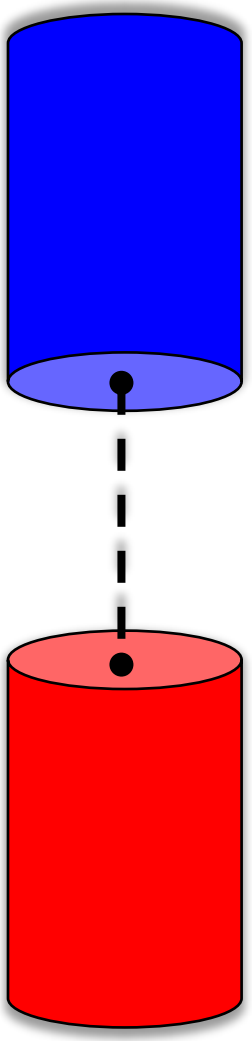
Translational Joint

- A “Joint Object” is used for defining the relative degrees of freedom (DOFs) between two parts or between a part and the ground.
- Constraint equations define the relative DOFs between a reference and a mobile structure.
- All DOFs are calculated on mobile side with respect to the reference side.
- There are 6 DOFs and depending on which DOFs are active there are several types of joints.
- The lock condition can be used to restrict the available relative DOFs for a given joint.



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Translational Joint (cont.)

- A translational joint is used for defining bolt preload. This is not the most preferred way, but it can used in place of bolt pretension object if any of the three limitations are relevant.
- In a translational joint only the X DOF is active and the other DOFs are inactive.
- The bolt is manually split into two parts in the CAD model.
- The two surfaces of the sectioned bolt are defined as mobile and reference. It is important to define the mobile and reference properly as this decides the direction of loading. The Configure tool may be used to ensure that the relative displacement between the two parts of the bolt is applied in the correct direction.
- Joint load or joint displacement may be used to define the bolt preload. The step at which the bolt is to be locked, can be specified.

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