Bending of a beam in a sleeve

This example demonstrates the use of the edge-to-surface contact formulation that is applicable when a beam enclosing or enclosed by a surface of a shell or a solid comes in contact with that surface.

This page discusses:

- Application description
- Abaqus modeling approaches and simulation techniques
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Products: Abaqus/Standard

Application description

Four contact formulations are available for general contact in Abaqus/Standard: surface-to-surface, edge-to-surface, edge-to-edge, and vertex-to-surface. For the edge-to-surface contact formulation involving line elements, such as beams and trusses, the default secondary or main role assignment for the line element is that the line element acts as the secondary unless the line element radius exceeds twice the typical facet dimension of the other surface. More accurate contact resolution occurs with a relatively large diameter line element acting as the main surface to a more-refined faceted surface.

The edge-to-surface contact formulation with a main role assignment for beam elements is illustrated with this simple example of bending a beam in contact with a cylindrical sleeve.

Geometry

A beam of radius 10 mm and length 150 mm passes through a cylindrical sleeve of radius 15 mm, length 20 mm, and thickness 1 mm. The beam and cylinder are coaxial (Figure 1). Both are made of steel with a Young's modulus of 200 GPa and a Poisson's ratio of 0.3. The contact between the beam and cylindrical sleeve is considered frictionless with a "hard" pressure-overclosure relationship. The general contact formulation with self-contact of an all-encompassing surface is used.

Boundary conditions and loading

One end of the beam is held fixed while the other end is subjected to a bending load of 20 N along the global Y-axis. The sleeve is held fixed rigidly.

Abaqus modeling approaches and simulation techniques

The edge-to-surface contact formulation for beam elements in Abaqus/Standard general contact is invoked automatically. Since self-contact within the beam or the shell surface is not applicable in this example, an all-encompassing surface with frictionless contact and a "hard" pressure-overclosure relationship is used.

Mesh design

The shell mesh is offset to the interior surface of the sleeve.

Results and discussion

Since the beam edge is treated as the main while the sleeve is treated as the secondary, the contact between the beam and the sleeve surface is tracked well, leading to a good result and completion of the analysis (Figure 2). If the beam edge acts as a secondary to the main surface of the sleeve, the beam bends but penetrates the cylindrical sleeve significantly as contact is not enforced properly.

Input files

beam_bending_sleeve.inp

Bending of a beam in a sleeve.

Figures

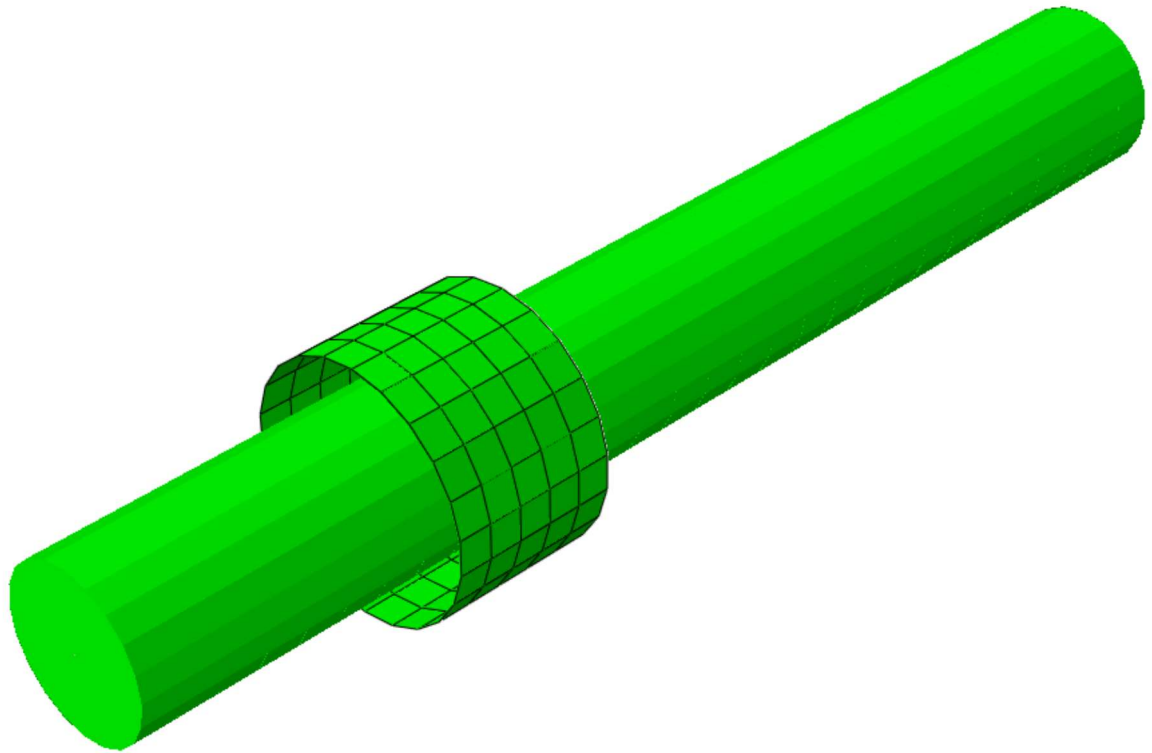**Figure 1. A beam passing through a cylindrical sleeve.**

Figure 2. Contact pressure (CPRESS) contour plot for the beam treated as the main.

CPRESS
+2.940e+04
+2.695e+04
+2.450e+04
+2.205e+04
+1.960e+04
+1.715e+04
+1.470e+04
+1.225e+04
+9.800e+03
+7.350e+03
+4.900e+03
+2.450e+03
+0.000e+00

Step: Step-1
Increment   6: Step Time =   1.000
Primary Var: CPRESS
Deformed Var: U   Deformation Scale Factor: +1.000e+00

CPRESS
+2.893e+03
+2.652e+03
+2.411e+03
+2.170e+03
+1.929e+03
+1.688e+03
+1.447e+03
+1.206e+03
+9.645e+02
+7.233e+02
+4.822e+02
+2.411e+02
+0.000e+00

Step: Step-1
Increment   5: Step Time =   0.5750
Primary Var: CPRESS
Deformed Var: U   Deformation Scale Factor: +1.000e+00