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## APPENDIX

### Abaqus/Explicit Input file (only key areas are presented)

```
*Heading
** Job name: Quasi-static-deployment Model name: DMCBoom
** Generated by: Abaqus/CAE 6.14-1
**Preprint, echo=NO, model=NO, history=NO, contact=NO
**=====
** PARTS
**
*Part, name=Boom
*Node
.....
*Element, type=S4
.....
**-----
** Defining ABD stiffness matrices
**-----
** Section: Epoxy
*Shell General Section, elset=BoomEpoxy, density=6.28e-07
2569., 971.5, 2569., 0., 0., 1127.5, 0., 0.
0., 4.3, 0., 0., 0., 2.4, 4.3, 0.
0., 0., 0., 0., 2.7,
** Section: Silicone
*Shell General Section, elset=BoomHinge, density=5.81e-07
1809., 945., 1809., 0., 0., 945., 0., 0.
0., 0.62, 0., 0., 0., 0.58, 0.62, 0.
0., 0., 0., 0., 0.58,
*Transverse Shear
0.918, 0.918, 0.
*End Part
**-----
*Part, name=Dummy
*Node
    1,      0.,      0.,      0.
*Element, type=MASS, elset=Point_Inertia_MASS_
1, 1
*Mass, elset=Point_Inertia_MASS_
1e-09,
*Element, type=ROTARYI, elset=Point_Inertia_ROTI_
2, 1
*Rotary Inertia, elset=Point_Inertia_ROTI_
1e-06, 1e-06, 1e-06, 0., 0., 0.
*End Part
**-----
*Part, name=Rigid_Cylinder
*Node
*Element, type=C3D8R
** Section: RigidCylinder
**Solid Section, elset=Set-Body, material=Material-1
*End Part
```

```

**-----
**=====
** ASSEMBLY
**
**Assembly, name=Assembly
**
**Instance, name=Boom-1, part=Boom
**End Instance
**
**Instance, name=Rigid_Cylinder-1, part=Rigid_Cylinder
**End Instance
**
**Instance, name=Rigid_Cylinder-2, part=Rigid_Cylinder
**End Instance
**
**Instance, name=Dummy-1, part=Dummy
      0.,    0.,    100.
**End Instance
**-----
** Surface definitions
**-----
**Surface, type=NODE, name=Boom-1_LeftFold_CNS_, internal
Boom-1.LeftFold, 1.
**Surface, type=NODE, name=Boom-1_RightFold_CNS_, internal
Boom-1.RightFold, 1.
**-----
**
** Constraint: Couple_Left
**Coupling, constraint name=Couple_Left, ref node=Ref_Left, surface=Boom-
1_LeftFold_CNS_
**Kinematic
4, 4
** Constraint: Couple_Right
**Coupling, constraint name=Couple_Right, ref node=Ref_Right, surface=Boom-
1_RightFold_CNS_
**Kinematic
4, 4
** Constraint: Pure_Bending
**Equation
3
Ref_Left, 4, 1.
Ref_Right, 4, -1.
Dummy-1.Point, 4, -1.
** Constraint: RigidBody1
**Rigid Body, ref node=Rigid_Cylinder-1.Set-RP, elset=Rigid_Cylinder-1.Set-Body,
position=CENTER OF MASS
** Constraint: RigidBody2
**Rigid Body, ref node=Rigid_Cylinder-2.Set-RP, elset=Rigid_Cylinder-2.Set-Body,
position=CENTER OF MASS
**-----
**End Assembly

```

```

**=====

* Amplitude definitions
**-----
*Amplitude, name=ampDamping, time=TOTAL TIME, definition=SMOOTH STEP
    0.,      0.,      0.01,     10.,      0.3,      10.,      5.3,      10.
    5.35,    0.1,      5.4,      100.,     5.5,      0.1,      5.6,      0.1
    5.61,    10.,      9.6,      10.,      9.7,      0.1,      9.9,      100.
    10.1,    0.1,      10.6,     0.1,      22.6,     0.1
*Amplitude, name=ampFold, time=TOTAL TIME, definition=SMOOTH STEP
    0.,      0.,      0.3,      0.,      5.3,      1.,      5.5,      1.
    9.6,     1.85,    10.6,     1.85,    12.6,     1.,      14.6,     0.27
    18.6,    0.1,      22.6,     0.
*Amplitude, name=ampPinch, time=TOTAL TIME, definition=SMOOTH STEP
    0.,      0.,      0.3,      1.,      5.3,      1.,      5.4,      0.
**-----

** MATERIALS
**-----
*Material, name=Material-1
*Density
2.89e-11,
*Elastic
1e+06, 0.3
**-----

** INTERACTION PROPERTIES
**-----
*Surface Interaction, name=Frictionless
*Friction
0.,
**-----

** BOUNDARY CONDITIONS
**-----
** Name: BC-Centre_Horizontal Type: Displacement/Rotation
*Boundary
Boom-1.Set-Centre_Horizontal, 3, 3
** Name: BC-RigidBodyBot Type: Displacement/Rotation
*Boundary
Rigid_Cylinder-2.Set-RP, 1, 1
Rigid_Cylinder-2.Set-RP, 2, 2
Rigid_Cylinder-2.Set-RP, 3, 3
Rigid_Cylinder-2.Set-RP, 4, 4
Rigid_Cylinder-2.Set-RP, 5, 5
Rigid_Cylinder-2.Set-RP, 6, 6
** Name: BC-RigidBodyTop Type: Displacement/Rotation
*Boundary
Rigid_Cylinder-1.Set-RP, 1, 1
Rigid_Cylinder-1.Set-RP, 2, 2
Rigid_Cylinder-1.Set-RP, 3, 3
Rigid_Cylinder-1.Set-RP, 4, 4
Rigid_Cylinder-1.Set-RP, 5, 5
Rigid_Cylinder-1.Set-RP, 6, 6

```

```

** Name: BC-Rotate Type: Displacement/Rotation
*Boundary
Dummy-1.Point, 1, 1
Dummy-1.Point, 2, 2
Dummy-1.Point, 3, 3
Dummy-1.Point, 4, 4
Dummy-1.Point, 5, 5
Dummy-1.Point, 6, 6
** Name: BC-Rotate_Left Type: Displacement/Rotation
*Boundary
Ref_Left, 1, 1
Ref_Left, 2, 2
Ref_Left, 3, 3
Ref_Left, 5, 5
Ref_Left, 6, 6
** Name: BC-Rotate_Right Type: Displacement/Rotation
*Boundary
Ref_Right, 1, 1
Ref_Right, 2, 2
Ref_Right, 3, 3
Ref_Right, 5, 5
Ref_Right, 6, 6
**-----
** INTERACTIONS
**-----
** Interaction: General_Contact
*Contact, op=NEW
*Contact Inclusions, ALL EXTERIOR
*Contact Property Assignment
, , Frictionless
**-----
**=====
**Step
**=====
** STEP: Pinching
*Step, name=Pinching, nlgeom=YES
Pinching with rigid bodies
*Dynamic, Explicit, scale factor=0.98
, 0.3
*Bulk Viscosity
0.01, 0.
**
** BOUNDARY CONDITIONS
**
** Name: BC-RigidBodyBot Type: Displacement/Rotation
*Boundary, amplitude=ampPinch
Rigid_Cylinder-2.Set-RP, 1, 1
Rigid_Cylinder-2.Set-RP, 2, 2, 12.25
Rigid_Cylinder-2.Set-RP, 3, 3
Rigid_Cylinder-2.Set-RP, 4, 4
Rigid_Cylinder-2.Set-RP, 5, 5

```



```

Rigid_Cylinder-2.Set-RP, 6, 6
** Name: BC-RigidBodyTop Type: Displacement/Rotation
*Boundary, amplitude=ampPinch
Rigid_Cylinder-1.Set-RP, 1, 1
Rigid_Cylinder-1.Set-RP, 2, 2, -12.25
Rigid_Cylinder-1.Set-RP, 3, 3
Rigid_Cylinder-1.Set-RP, 4, 4
Rigid_Cylinder-1.Set-RP, 5, 5
Rigid_Cylinder-1.Set-RP, 6, 6
** Name: BC-Rotate Type: Displacement/Rotation
*Boundary, amplitude=ampFold
Dummy-1.Point, 1, 1
Dummy-1.Point, 2, 2
Dummy-1.Point, 3, 3
Dummy-1.Point, 4, 4, 1.57
Dummy-1.Point, 5, 5
Dummy-1.Point, 6, 6
**
** LOADS
**
** Name: viscousPressure Type: Pressure
*Dload, amplitude=ampDamping
Boom-1.Surf-visPressure, VP, 1.4528e-06
**
** OUTPUT REQUESTS
**
*Restart, write, number interval=1, time marks=NO
**
** FIELD OUTPUT: F-Output-1
**
*Output, field, time interval=0.01
*Node Output
U, UR
*Element Output, directions=YES
SE, SF
**
** HISTORY OUTPUT: H-Output-1
**
*Output, history, time interval=0.01
*Energy Output
ALLAE, ALLIE, ALLKE, ALLSE, ALLVD, ALLWK, ETOTAL
**
** HISTORY OUTPUT: H-Output_RM_UR
*Node Output, nset=Dummy-1.Point
RM, UR
**
*End Step
** -----
** STEP: Folding
**
*Step, name=Folding, nlgeom=YES

```

Folding  
\*Dynamic, Explicit, scale factor=0.98  
, 5.  
\*Bulk Viscosity  
0.05, 0.  
\*\*  
\*\* OUTPUT REQUESTS  
\*Restart, write, number interval=2, time marks=NO  
\*\*  
\*\* FIELD OUTPUT: F-Output-1  
\*Output, field, time interval=0.01  
\*Node Output  
U, UR  
\*Element Output, directions=YES  
SE, SF  
\*\*  
\*\* HISTORY OUTPUT: H-Output-1  
\*Output, history, time interval=0.01  
\*Energy Output  
ALLAE, ALLIE, ALLKE, ALLSE, ALLVD, ALLWK, ETOTAL  
\*\*  
\*\* HISTORY OUTPUT: H-Output\_RM\_UR  
\*Node Output, nset=Dummy-1.Point  
RM, UR  
\*\*  
\*End Step  
\*\* -----  
\*\*  
\*\* STEP: PinchRemove  
\*\*  
\*Step, name=PinchRemove, nlgeom=YES  
Remove pinching  
\*Dynamic, Explicit, scale factor=0.98  
, 0.1  
\*Bulk Viscosity  
0.06, 1.2  
\*\*  
\*\* INTERACTIONS  
\*\*  
\*\* Interaction: General\_Contact  
\*Contact, op=NEW  
\*Contact Inclusions, ALL EXTERIOR  
\*Contact Exclusions  
Boom-1.Surf-visPressure , Rigid\_Cylinder-1.Surf  
Boom-1.Surf-visPressure , Rigid\_Cylinder-2.Surf  
\*Contact Property Assignment  
, , Frictionless  
\*\*  
\*\* OUTPUT REQUESTS  
\*\*  
\*Restart, write, number interval=2, time marks=NO

```

**
** FIELD OUTPUT: F-Output-1
*Output, field, time interval=0.01
*Node Output
U, UR
*Element Output, directions=YES
SE, SF
**
** HISTORY OUTPUT: H-Output-1
*Output, history, time interval=0.01
*Energy Output
ALLAE, ALLIE, ALLKE, ALLSE, ALLVD, ALLWK, ETOTAL
**
** HISTORY OUTPUT: H-Output_RM_UR
*Node Output, nset=Dummy-1.Point
RM, UR
**
*End Step
** -----
**
** STEP: Balancing
**
*Step, name=Balancing, nlgeom=YES
*Dynamic, Explicit, scale factor=0.98
, 0.2
*Bulk Viscosity
0.06, 0.
**
** OUTPUT REQUESTS
**
*Restart, write, number interval=2, time marks=NO
**
** FIELD OUTPUT: F-Output-1
*Output, field, time interval=0.01
*Node Output
U, UR
*Element Output, directions=YES
SE, SF
**
** HISTORY OUTPUT: H-Output-1
*Output, history, time interval=0.01
*Energy Output
ALLAE, ALLIE, ALLKE, ALLSE, ALLVD, ALLWK, ETOTAL
**
** HISTORY OUTPUT: H-Output_RM_UR
*Node Output, nset=Dummy-1.Point
RM, UR
**
*End Step
** -----
**

```

```

** STEP: Folding_2
**
*Step, name=Folding_2, nlgeom=YES
*Dynamic, Explicit, scale factor=0.98
, 4.
*Bulk Viscosity
0.05, 0.
**
** OUTPUT REQUESTS
**
*Restart, write, number interval=1, time marks=NO
**
** FIELD OUTPUT: F-Output-1
**
*Output, field, time interval=0.01
*Node Output
U, UR
*Element Output, directions=YES
SE, SF
**
** HISTORY OUTPUT: H-Output-1
*Output, history, time interval=0.01
*Energy Output
ALLAE, ALLIE, ALLKE, ALLSE, ALLVD, ALLWK, ETOTAL
**
** HISTORY OUTPUT: H-Output_RM_UR
*Node Output, nset=Dummy-1.Point
RM, UR
**
*End Step
** -----
**
** STEP: Balancing_2
**
*Step, name=Balancing_2, nlgeom=YES
*Dynamic, Explicit, scale factor=0.98
, 1.
*Bulk Viscosity
0.06, 0.
**
** OUTPUT REQUESTS
**
*Restart, write, number interval=1, time marks=NO
**
** FIELD OUTPUT: F-Output-1
*Output, field, time interval=0.01
*Node Output
U, UR
*Element Output, directions=YES
SE, SF
**

```

```

** HISTORY OUTPUT: H-Output-1
*Output, history, time interval=0.01
*Energy Output
ALLAE, ALLIE, ALLKE, ALLSE, ALLVD, ALLWK, ETOTAL
**
** HISTORY OUTPUT: H-Output_RM_UR
*Node Output, nset=Dummy-1.Point
RM, UR
**
*End Step
** -----
**
** STEP: Deployment
**
*Step, name=Deployment, nlgeom=YES
Deployment
*Dynamic, Explicit, scale factor=0.98
, 12.
*Bulk Viscosity
0.1, 0.
**
** OUTPUT REQUESTS
**
*Restart, write, number interval=2, time marks=NO
**
** FIELD OUTPUT: F-Output-1
*Output, field, time interval=0.01
*Node Output
U, UR
*Element Output, directions=YES
SE, SF
**
** HISTORY OUTPUT: H-Output-1
*Output, history, time interval=0.001
*Energy Output
ALLAE, ALLIE, ALLKE, ALLSE, ALLVD, ALLWK, ETOTAL
**
** HISTORY OUTPUT: H-Output_RM_UR
*Node Output, nset=Dummy-1.Point
RM, UR
**
*End Step

```