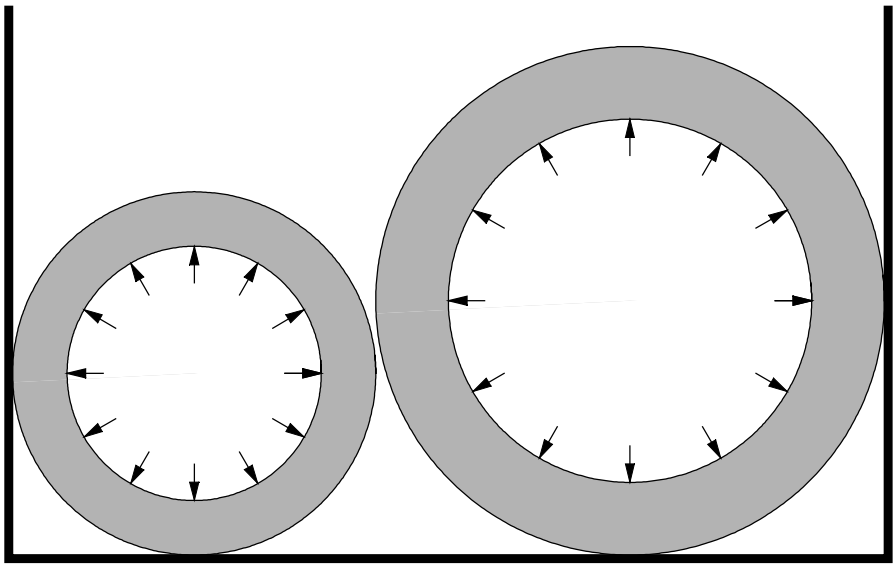
CHAPTER TEN

Contact Problems

Tension Plate Example: Hyperelastic material (p. 513)

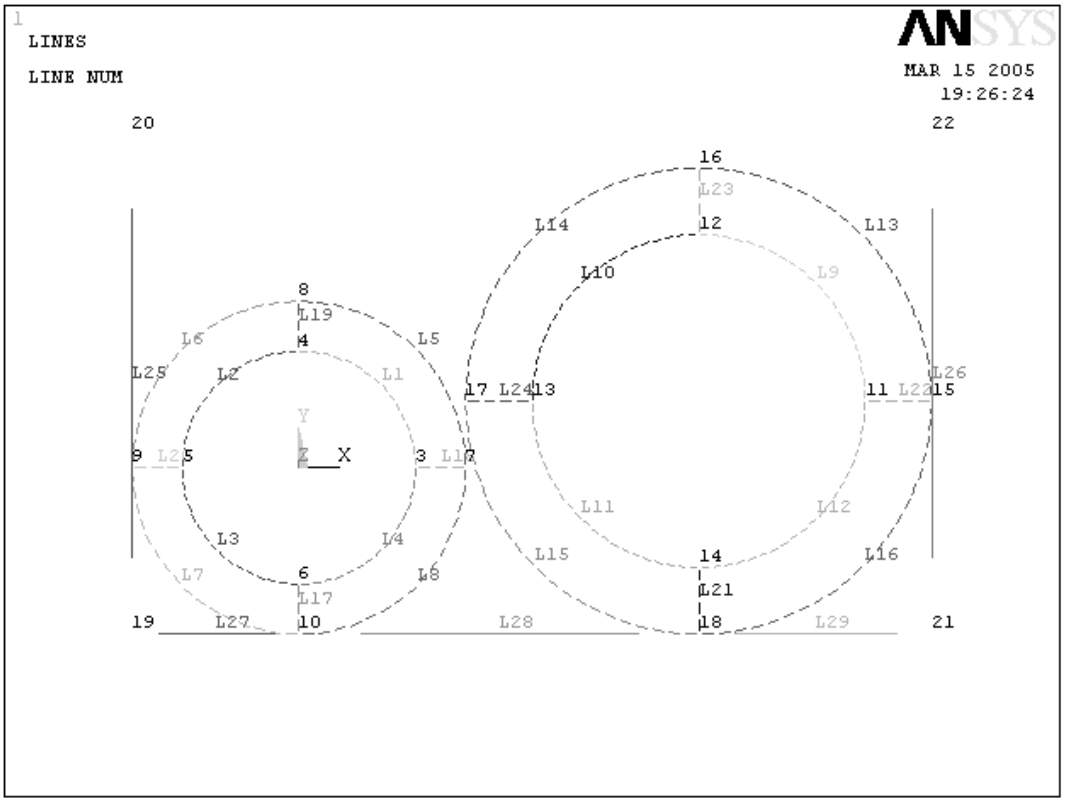
Consider the two cylinders problem shown in Figure. The smaller cylinder has inner and outer radii of 35 mm and 50 mm respectively. The larger cylinder has inner and outer radii of 50 mm and 70 mm respectively. Assume $E = 2000\,N/\text{mm}^2$ and $\nu = 0.2$. The coefficient of friction between all contact surfaces is assumed to be 0.2. The walls and the base of box in which the cylinders are placed are considered rigid. Both cylinders are subjected to inside pressure of $100\,N/\text{mm}^2$.



The global coordinate system is defined with the origin at the center of the left cylinder. The center of the right cylinder is located at (120,20). The model is created by defining several key points and lines as shown in the following Figure. To prevent rigid body motion both horizontal and vertical displacements at key points 9, 10, 15, and 18 are set to zero. The following contactor-target pairs are defined.

Contactor	Target
L13 and L16	L26 (Right rigid wall)
L15 and L16	L28 and L29 (Bottom rigid wall)
L7 and L8	L27 (Bottom rigid wall)
L5 and L7	L25 (Left rigid wall)
L5	L15

Key points and lines used to create model



AnsysFiles\\Chap10\\cylidersContact.txt

```
/PREP7
!*
ET,1,PLANE42
!*
KEYOPT,1,1,0
KEYOPT,1,2,0
KEYOPT,1,3,2
KEYOPT,1,5,0
KEYOPT,1,6,0
!*
```

```
!*
MPTEMP,,,,,,,,
MPTEMP,1,0
MPDATA,EX,1,,2000
MPDATA,PRXY,1,,.2
!* Define key points, lines and areas
K,1,,,,
K,2,120,20,,
CIRCLE,1, 35, , ,360, ,
CIRCLE,1, 50, , ,360, ,
CIRCLE,2,50, , ,360, ,
CIRCLE,2,70, , ,360, ,
LSTR,      10,       6
LSTR,       3,       7
LSTR,       4,       8
LSTR,       5,       9
LSTR,      18,      14
LSTR,      11,      15
LSTR,      12,      16
LSTR,      13,      17
AL,17,8,18,4
AL,18,5,19,1
AL,19,6,20,2
AL,20,7,17,3
AL,21,16,22,12
AL,22,13,23,9
AL,23,14,24,10
AL,24,15,21,11
!* Create mesh
ESIZE,5
MSHKEY,1
AMESH,ALL
!* Create key points and lines for defining
!* rigid walls and base
K,19,-50,-50,,
K,20,-50,100,,
K,21,190,-50,,
K,22,190,100,,
LSTR,19,20
```

```
LSTR,21,22
LSTR,19,10
LSTR,10,18
LSTR,18,21
!* Fix initial contact points between
!* rigid walls and cylinders
DK,10, , , ,0,UX, , , , , ,
DK,10, , , ,0,UY, , , , , ,
DK,18, , , ,0,UX, , , , , ,
DK,18, , , ,0,UY, , , , , ,
DK,9, , , ,0,UX, , , , , ,
DK,9, , , ,0,UY, , , , , ,
DK,15, , , ,0,UX, , , , , ,
DK,15, , , ,0,UY, , , , , ,
!* Apply pressure
SFL,1,PRES,100,
SFL,2,PRES,100,
SFL,3,PRES,100,
SFL,4,PRES,100,
SFL,9,PRES,100,
SFL,10,PRES,100,
SFL,11,PRES,100,
SFL,12,PRES,100,
/COM, CONTACT PAIR CREATION - START
!* Contact between two cylinders
MP,MU,1,0.2
MAT,1
R,3
REAL,3
ET,2,169
ET,3,175
R,3,,,1.0,0.1,0,
RMORE,,,1.0E20,0.0,1.0,
RMORE,0.0,0,1.0,,1.0,0.5
RMORE,0,1.0,1.0,0.0,,1.0
RMORE,10.0
KEYOPT,3,3,0
KEYOPT,3,4,0
KEYOPT,3,5,0
```

```
KEYOPT,3,7,0
KEYOPT,3,8,0
KEYOPT,3,9,1
KEYOPT,3,10,1
KEYOPT,3,11,0
KEYOPT,3,12,0
KEYOPT,3,2,0
! Generate the target surface
LSEL,S,,,14
LSEL,A,,,15
CM,_TARGET,LINE
TYPE,2
NSLL,S,1
ESLN,S,0
ESURF
! Generate the contact surface
LSEL,S,,,5
LSEL,A,,,8
CM,_CONTACT,LINE
TYPE,3
NSLL,S,1
ESLN,S,0
ESURF
ALLSEL
ESEL,ALL
ESEL,S,TYPE,,2
ESEL,A,TYPE,,3
ESEL,R,REAL,,3
/PSYMB,ESYS,1
/PNUM,TYPE,1
/NUM,1
EPLOT
ESEL,ALL
/COM, CONTACT PAIR CREATION - START
!* Contact between large cylinder and right wall
CM,_NODECM,NODE
CM,_ELEMCM,ELEM
CM,_KPCM,KP
CM,_LINECM,LINE
```

```
CM,_AREACM,AREA
CM,_VOLUCM,VOLU
/GSAV,cwz,gsav,,temp
MP,MU,1,0.2
MAT,1
R,4
REAL,4
ET,4,169
ET,5,175
KEYOPT,5,9,0
KEYOPT,5,10,1
R,4,
RMORE,
RMORE,,0
RMORE,0
! Generate the target surface
LSEL,S,,,26
CM,_TARGET,LINE
TYPE,4
LATT,-1,4,4,-1
TYPE,4
LMESH,ALL
! Generate the contact surface
LSEL,S,,,13
LSEL,A,,,16
CM,_CONTACT,LINE
TYPE,5
NSLL,S,1
ESLN,S,0
ESURF
*SET,_REALID,4
ALLSEL
ESEL,ALL
ESEL,S,TYPE,,4
ESEL,A,TYPE,,5
ESEL,R,REAL,,4
LSEL,S,REAL,,4
/PSYMB,ESYS,1
/PNUM,TYPE,1
```

```
/NUM,1
EPLOT
! Reverse target normals
CM,_Y,LINE
LSEL, , , ,      26
CM,_YEL,ELEM
CM,_YND,NODE
NSLL,S,1
ESLN,S,1
ESEL,R,REAL,,_REALID
ESURF,,REVERSE
CMSEL,S,_Y
CMSEL,S,_YEL
CMSEL,S,_YND
CMDELE,_Y
CMDELE,_YEL
CMDELE,_YND
/REPLOT
!*
ESEL,ALL
ESEL,S,TYPE,,4
ESEL,A,TYPE,,5
ESEL,R,REAL,,4
LSEL,S,REAL,,4
/PSYMB,ESYS,1
/PNUM,TYPE,1
/NUM,1
EPLOT
ESEL,ALL
ESEL,S,TYPE,,4
ESEL,A,TYPE,,5
ESEL,R,REAL,,4
LSEL,S,REAL,,4
CMSEL,A,_NODECM
CMDEL,_NODECM
CMSEL,A,_ELEMCM
CMDEL,_ELEMCM
CMSEL,S,_KPCM
CMDEL,_KPCM
```

```
CMSEL,S,_LINECM
CMDEL,_LINECM
CMSEL,S,_AREACM
CMDEL,_AREACM
CMSEL,S,_VOLUCM
CMDEL,_VOLUCM
/GRES,cwz,gsav
CMDEL,_TARGET
CMDEL,_CONTACT
/COM, CONTACT PAIR CREATION - END
!*
!*
/COM, CONTACT PAIR CREATION - START
!* Contact between large cylinder and base
CM,_NODECM,NODE
CM,_ELEMCM,ELEM
CM,_KPCM,KP
CM,_LINECM,LINE
CM,_AREACM,AREA
CM,_VOLUCM,VOLU
/GSAV,cwz,gsav,,temp
MP,MU,1,0.2
MAT,1
R,5
REAL,5
ET,6,169
ET,7,175
KEYOPT,7,9,0
KEYOPT,7,10,1
R,5,
RMORE,
RMORE,,0
RMORE,0
! Generate the target surface
LSEL,S,,,28
LSEL,A,,,29
CM,_TARGET,LINE
TYPE,6
LATT,-1,5,6,-1
```

```
TYPE,6
LMESH,ALL
! Generate the contact surface
LSEL,S,,,15
LSEL,A,,,16
CM,_CONTACT,LINE
TYPE,7
NSLL,S,1
ESLN,S,0
ESURF
*SET,_REALID,5
ALLSEL
ESEL,ALL
ESEL,S,TYPE,,6
ESEL,A,TYPE,,7
ESEL,R,REAL,,5
LSEL,S,REAL,,5
/PSYMB,ESYS,1
/PNUM,TYPE,1
/NUM,1
EPLOT
! Reverse target normals
FLST,5,2,4,ORDE,2
FITEM,5,28
FITEM,5,-29
CM,_Y,LINE
LSEL, , , ,P51X
CM,_YEL,ELEM
CM,_YND,NODE
NSLL,S,1
ESLN,S,1
ESEL,R,REAL,,_REALID
ESURF,,REVERSE
CMSEL,S,_Y
CMSEL,S,_YEL
CMSEL,S,_YND
CMDELE,_Y
CMDELE,_YEL
CMDELE,_YND
```

```
/REPLOT
!*
ESEL,ALL
ESEL,S,TYPE,,6
ESEL,A,TYPE,,7
ESEL,R,REAL,,5
LSEL,S,REAL,,5
/PSYMB,ESYS,1
/PNUM,TYPE,1
/NUM,1
EPLOT
ESEL,ALL
ESEL,S,TYPE,,6
ESEL,A,TYPE,,7
ESEL,R,REAL,,5
LSEL,S,REAL,,5
CMSEL,A,_NODECM
CMDEL,_NODECM
CMSEL,A,_ELEMCM
CMDEL,_ELEMCM
CMSEL,S,_KPCM
CMDEL,_KPCM
CMSEL,S,_LINECM
CMDEL,_LINECM
CMSEL,S,_AREACM
CMDEL,_AREACM
CMSEL,S,_VOLUCM
CMDEL,_VOLUCM
/GRES,cwz,gsav
CMDEL,_TARGET
CMDEL,_CONTACT
/COM, CONTACT PAIR CREATION - END
!*
!*
/COM, CONTACT PAIR CREATION - START
!* Contact between small cylinder and left wall
CM,_NODECM,NODE
CM,_ELEMCM,ELEM
CM,_KPCM,KP
```

```
CM,_LINECM,LINE
CM,_AREACM,AREA
CM,_VOLUCM,VOLU
/GSAV,cwz,gsav,,temp
MP,MU,1,0.2
MAT,1
R,6
REAL,6
ET,8,169
ET,9,175
KEYOPT,9,9,0
KEYOPT,9,10,1
R,6,
RMORE,
RMORE,,0
RMORE,0
! Generate the target surface
LSEL,S,,,25
CM,_TARGET,LINE
TYPE,8
LATT,-1,6,8,-1
TYPE,8
LMESH,ALL
! Generate the contact surface
LSEL,S,,,6
LSEL,A,,,7
CM,_CONTACT,LINE
TYPE,9
NSLL,S,1
ESLN,S,0
ESURF
*SET,_REALID,6
ALLSEL
ESEL,ALL
ESEL,S,TYPE,,8
ESEL,A,TYPE,,9
ESEL,R,REAL,,6
LSEL,S,REAL,,6
/PSYMB,ESYS,1
```

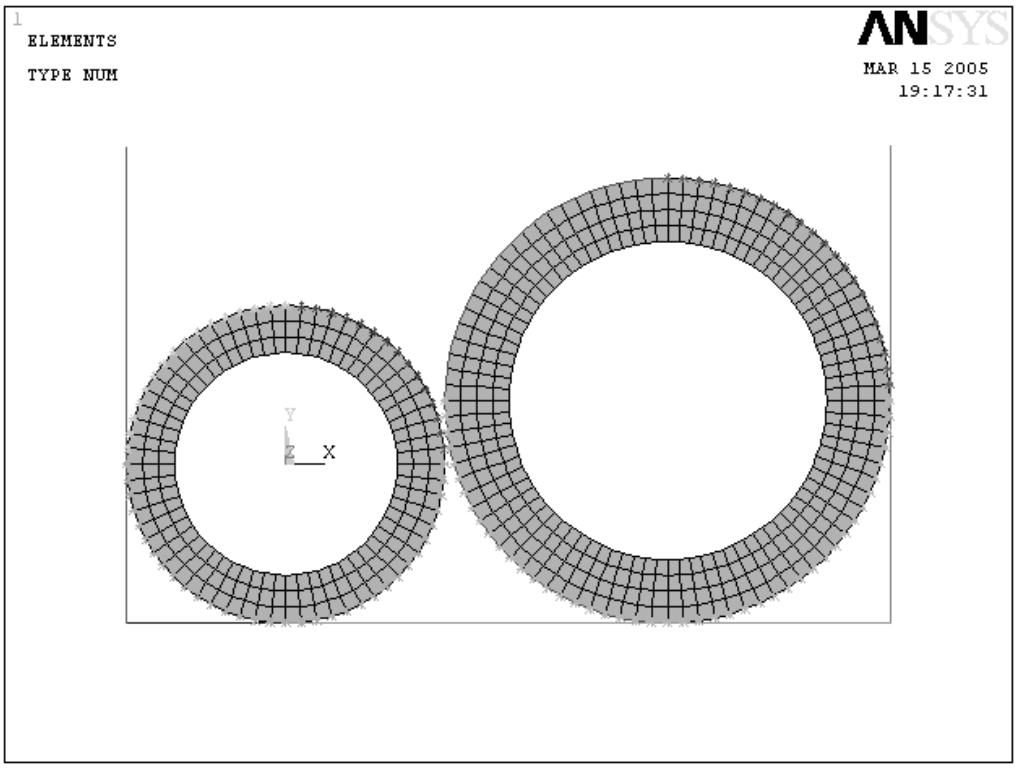
```
/PNUM,TYPE,1
/NUM,1
EPLOT
ESEL,ALL
ESEL,S,TYPE,,8
ESEL,A,TYPE,,9
ESEL,R,REAL,,6
LSEL,S,REAL,,6
CMSEL,A,_NODECM
CMDEL,_NODECM
CMSEL,A,_ELEMCM
CMDEL,_ELEMCM
CMSEL,S,_KPCM
CMDEL,_KPCM
CMSEL,S,_LINECM
CMDEL,_LINECM
CMSEL,S,_AREACM
CMDEL,_AREACM
CMSEL,S,_VOLUCM
CMDEL,_VOLUCM
/GRES,cwz,gsav
CMDEL,_TARGET
CMDEL,_CONTACT
/COM, CONTACT PAIR CREATION - END
!*
!*
/COM, CONTACT PAIR CREATION - START
!* Contact between small cylinder and base
CM,_NODECM,NODE
CM,_ELEMCM,ELEM
CM,_KPCM,KP
CM,_LINECM,LINE
CM,_AREACM,AREA
CM,_VOLUCM,VOLU
/GSAV,cwz,gsav,,temp
MP,MU,1,0.2
MAT,1
R,7
REAL,7
```

```
ET,10,169
ET,11,175
KEYOPT,11,9,0
KEYOPT,11,10,1
R,7,
RMORE,
RMORE,,0
RMORE,0
! Generate the target surface
LSEL,S,,,27
CM,_TARGET,LINE
TYPE,10
LATT,-1,7,10,-1
TYPE,10
LMESH,ALL
! Generate the contact surface
LSEL,S,,,7
LSEL,A,,,8
CM,_CONTACT,LINE
TYPE,11
NSLL,S,1
ESLN,S,0
ESURF
*SET,_REALID,7
ALLSEL
ESEL,ALL
ESEL,S,TYPE,,10
ESEL,A,TYPE,,11
ESEL,R,REAL,,7
LSEL,S,REAL,,7
/PSYMB,ESYS,1
/PNUM,TYPE,1
/NUM,1
EPLOT
! Reverse target normals
CM,_Y,LINE
LSEL, , , ,      27
CM,_YEL,ELEM
CM,_YND,NODE
```

```
NSLL,S,1
ESLN,S,1
ESEL,R,REAL,,_REALID
ESURF,,REVERSE
CMSEL,S,_Y
CMSEL,S,_YEL
CMSEL,S,_YND
CMDELE,_Y
CMDELE,_YEL
CMDELE,_YND
/REPLOT
!*
ESEL,ALL
ESEL,S,TYPE,,10
ESEL,A,TYPE,,11
ESEL,R,REAL,,7
LSEL,S,REAL,,7
/PSYMB,ESYS,1
/PNUM,TYPE,1
/NUM,1
EPLOT
ESEL,ALL
ESEL,S,TYPE,,10
ESEL,A,TYPE,,11
ESEL,R,REAL,,7
LSEL,S,REAL,,7
CMSEL,A,_NODECM
CMDEL,_NODECM
CMSEL,A,_ELEMCM
CMDEL,_ELEMCM
CMSEL,S,_KPCM
CMDEL,_KPCM
CMSEL,S,_LINECM
CMDEL,_LINECM
CMSEL,S,_AREACM
CMDEL,_AREACM
CMSEL,S,_VOLUCM
CMDEL,_VOLUCM
/GRES,cwz,gsav
```

```
CMDEL,_TARGET
CMDEL,_CONTACT
/COM, CONTACT PAIR CREATION - END
FINISH
!* Solution and post processing
/SOL
/STATUS,SOLU
NSUBST,100,0,0
SOLVE
FINISH
/POST1
/DSCALE,1,1.0
PLDISP,1
```

Finite element model



vonMises stresses shown on deformed shape