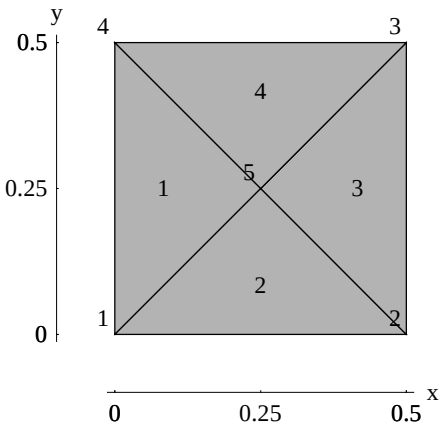
CHAPTER SIX

Plates and Shells

Example 6.3 (p. 302): Using Triangles from SHELL63



1×1 plate $h = 0.1 \quad E = 10920 \quad \nu = 0.3 \quad q = 1$

Essential boundary conditions:

$$w_1 = \theta_{x1} = \theta_{y1} = 0.$$

$$w_2 = \theta_{y2} = 0.$$

$$\theta_{x3} = \theta_{y3} = 0.$$

$$w_4 = \theta_{x4} = \theta_{y4} = 0.$$

AnsysFiles\\Chap06\\PlateEx63.txt

```
!* Example 6.3 Square plate subjected to a distributed load
!* 4 triangular plate element model
/PREP7
!*
ET,1,SHELL63
!*
KEYOPT,1,1,0
KEYOPT,1,2,0
KEYOPT,1,3,1
KEYOPT,1,5,0
KEYOPT,1,6,0
KEYOPT,1,7,0
KEYOPT,1,8,0
KEYOPT,1,9,0
KEYOPT,1,11,0
!*
R,1,0.1, , , , , ,
RMORE, , , ,
RMORE
RMORE, ,
!*
!*
MPTEMP,,,,,,,,
MPTEMP,1,0
MPDATA,EX,1,,10920
MPDATA,PRXY,1,,0.3
```

```
MP,DENS,1,1,0.3
N,1,,,,,,,
N,2,.5,,,,,,
N,3,0.5,.5,,,,,
N,4,0,0.5,,,,,
N,5,0.25,0.25,,,,,
e,4,1,5,5
e,1,2,5,5
e,2,3,5,5
e,3,4,5,5
D,1, , , , , ,UZ,ROTX,ROTY, , ,
D,2, , , , , ,UZ,ROTY, , , ,
D,3, , , , , ,ROTX,ROTY, , , ,
D,4, , , , , ,UZ,ROTX,ROTY, , ,
SFE,1,1,PRES, ,1, , ,
SFE,2,1,PRES, ,1, , ,
SFE,3,1,PRES, ,1, , ,
SFE,4,1,PRES, ,1, , ,
FINISH
/SOL
/STATUS,SOLU
SOLVE
FINISH
/POST1
!*
PRNSOL,U,Z
```

```
 PRINT U    NODAL SOLUTION PER NODE

  ***** POST1 NODAL DEGREE OF FREEDOM LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0

  THE FOLLOWING DEGREE OF FREEDOM RESULTS ARE IN GLOBAL COORDINATES

    NODE      UZ
       1   0.0000
       2   0.0000
       3  0.19973E-02
       4   0.0000
       5  0.95695E-03

 MAXIMUM ABSOLUTE VALUES
```

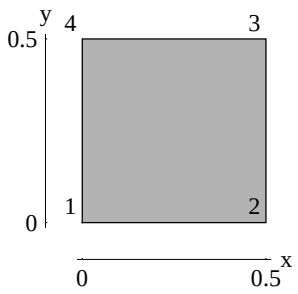
```
 NODE          3
 VALUE   0.19973E-02


 PRINT S    ELEMENT SOLUTION PER ELEMENT

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


  ELEMENT=       1        SHELL63
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       4  -31.411     -9.4233      0.0000      6.2911      0.0000
0.0000
       1  -15.558     -4.6673      0.0000     -4.4416      0.0000
0.0000
       5   11.780      17.486      0.0000     -7.3982      0.0000
0.0000
       5   11.780      17.486      0.0000     -7.3982      0.0000
0.0000
       4   31.411      9.4233     -1.0000     -6.2911      0.0000
0.0000
       1   15.558      4.6673     -1.0000      4.4416      0.0000
0.0000
       5  -11.780     -17.486     -1.0000      7.3982      0.0000
0.0000
       5  -11.780     -17.486     -1.0000      7.3982      0.0000
0.0000

  ELEMENT=       2        SHELL63
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       1  -1.5201     -5.0671      0.0000     -8.1132      0.0000
0.0000
       2  -1.9962     -6.6540      0.0000     -2.3738      0.0000
0.0000
       5   11.360      12.997      0.0000     -6.0766      0.0000
0.0000
       5   11.360      12.997      0.0000     -6.0766      0.0000
0.0000
       1   1.5201      5.0671     -1.0000      8.1132      0.0000
0.0000
       2   1.9962      6.6540     -1.0000      2.3738      0.0000
0.0000
       5  -11.360     -12.997     -1.0000      6.0766      0.0000
```

```
0.0000
       5  -11.360     -12.997     -1.0000      6.0766      0.0000
0.0000

  ELEMENT=       3        SHELL63
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       2 -0.32122      1.4791      0.0000     0.26681      0.0000
0.0000
       3   22.013      18.902      0.0000     0.55170      0.0000
0.0000
       5   9.9098      9.5395      0.0000     -7.3982      0.0000
0.0000
       5   9.9098      9.5395      0.0000     -7.3982      0.0000
0.0000
       2  0.32122     -1.4791     -1.0000    -0.26681      0.0000
0.0000
       3  -22.013     -18.902     -1.0000    -0.55170      0.0000
0.0000
       5  -9.9098     -9.5395     -1.0000      7.3982      0.0000
0.0000
       5  -9.9098     -9.5395     -1.0000      7.3982      0.0000
0.0000

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


  ELEMENT=       4        SHELL63
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       3   33.288      23.719      0.0000     -3.7808      0.0000
0.0000
       4  -34.153     -26.603      0.0000     0.92759      0.0000
0.0000
       5   10.329      14.029      0.0000     -8.7198      0.0000
0.0000
       5   10.329      14.029      0.0000     -8.7198      0.0000
0.0000
       3  -33.288     -23.719     -1.0000      3.7808      0.0000
0.0000
       4   34.153      26.603     -1.0000    -0.92759      0.0000
0.0000
       5  -10.329     -14.029     -1.0000      8.7198      0.0000
0.0000
```

```
        5  -10.329     -14.029     -1.0000      8.7198      0.0000
0.0000
```

Example 6.4 (p. 321): Square plate subjected to distributed load using quadrilateral element — SHELL43

■ One element solution



1×1 plate $h = 0.1 \quad E = 10920 \quad \nu = 0.3 \quad q = 1$

Essential boundary conditions $w_1 = \theta_{x1} = \theta_{y1} = w_2 = \theta_{y2} = \theta_{x3} = \theta_{y3} = w_4 = \theta_{x4} = \theta_{y4} = 0$.

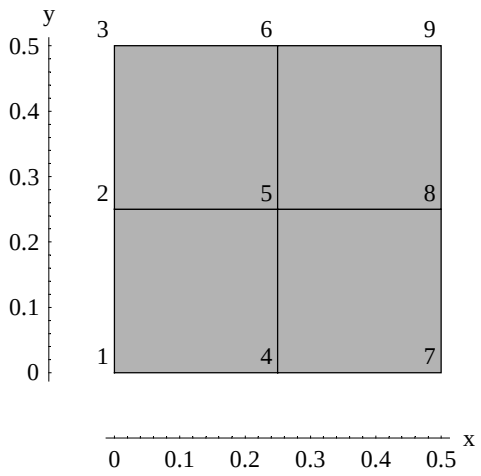
AnsysFiles\\Chap06\\PlateEx64.txt

```
!* Example 6.4 Square plate subjected to a distributed load
!* One plate element model
/PREP7
!*
ET,1,SHELL43
!*
KEYOPT,1,1,0
KEYOPT,1,2,0
KEYOPT,1,3,1
KEYOPT,1,5,0
KEYOPT,1,6,0
```

```
KEYOPT,1,7,0
KEYOPT,1,8,0
KEYOPT,1,9,0
KEYOPT,1,11,0
!*
R,1,0.1, , , , , ,
RMORE, , , ,
RMORE
RMORE, ,
!*
!*
MPTEMP,,,,,,,,
MPTEMP,1,0
MPDATA,EX,1,,10920
MPDATA,PRXY,1,,0.3
k,1,,,,,,,
k,2,.5,,,,,,
k,3,0.5,.5,,,,,
k,4,0,0.5,,,,,
a,1,2,3,4
esize,.5
amesh,1
DL,1, ,UZ,
DL,1, ,ROTY,
DL,2, ,ROTY,
DL,3, ,ROTX,
DL,4, ,UZ,
DL,4, ,ROTY,
DL,4, ,ROTX,
SFA,1,1,PRES,1
FINISH
/SOL
/STATUS,SOLU
SOLVE
FINISH
/POST1
!*
PRNSOL,U,Z
```

```
 PRINT U    NODAL SOLUTION PER NODE

  ***** POST1 NODAL DEGREE OF FREEDOM LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0

  THE FOLLOWING DEGREE OF FREEDOM RESULTS ARE IN GLOBAL COORDINATES

    NODE      UZ
       1   0.0000
       2   0.0000
       3  0.50629E-03
       4   0.0000

 MAXIMUM ABSOLUTE VALUES
 NODE          3
 VALUE   0.50629E-03

 PRINT S    ELEMENT SOLUTION PER ELEMENT

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


  ELEMENT=       1        SHELL43
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       1  0.15266E-13 0.50626E-13  0.0000    -0.80112
-0.83267E-16-0.11102E-14
       2  0.68667      2.2889      0.0000    -0.80112     0.20600
-0.11102E-14
       3  0.68667      2.2889      0.0000    -0.17708E-13 0.20600
3.5440
       4  0.15266E-13 0.50626E-13  0.0000    -0.17708E-13-0.27756E-15
3.5440
       1 -0.15266E-13-0.50626E-13 -1.0000     0.80112
-0.16653E-15-0.11102E-14
       2 -0.68667     -2.2889     -1.0000     0.80112     0.20600
-0.11102E-14
       3 -0.68667     -2.2889     -1.0000     0.17708E-13 0.20600
3.5440
       4 -0.15266E-13-0.50626E-13 -1.0000     0.17708E-13 0.27756E-16
3.5440
```

■ Four element solution (p. 323)



1×1 plate $h = 0.1 \quad E = 10920 \quad \nu = 0.3 \quad q = 1$

AnsysFiles\\Chap06\\PlateEx64FourElem.txt

```
!* Example 6.4 Square plate subjected to a distributed load
!* Four plate element model
/PREP7
!*
ET,1,SHELL43
!*
KEYOPT,1,1,0
KEYOPT,1,2,0
KEYOPT,1,3,1
KEYOPT,1,5,0
KEYOPT,1,6,0
KEYOPT,1,7,0
KEYOPT,1,8,0
KEYOPT,1,9,0
KEYOPT,1,11,0
!*
```

```
R,1,0.1, , , , , ,
RMORE, , , ,
RMORE
RMORE, ,
!*
!*
MPTEMP,,,,,,,,
MPTEMP,1,0
MPDATA,EX,1,,10920
MPDATA,PRXY,1,,0.3
k,1,,,,,,,
k,2,.5,,,,,,
k,3,0.5,.5,,,,,
k,4,0,0.5,,,,,
a,1,2,3,4
esize,.25
amesh,1
DL,1, ,UZ,
DL,1, ,ROTY,
DL,2, ,ROTY,
DL,3, ,ROTX,
DL,4, ,UZ,
DL,4, ,ROTY,
DL,4, ,ROTX,
SFA,1,1,PRES,1
FINISH
/SOL
/STATUS,SOLU
SOLVE
FINISH
/POST1
!*
PRNSOL,U,Z
 PRINT U    NODAL SOLUTION PER NODE

  ***** POST1 NODAL DEGREE OF FREEDOM LISTING *****

 LOAD STEP=     1  SUBSTEP=     1
  TIME=    1.0000      LOAD CASE=   0
```

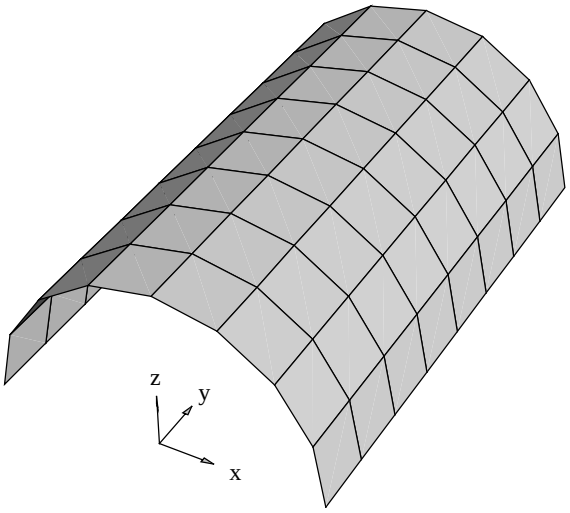
```
 THE FOLLOWING DEGREE OF FREEDOM RESULTS ARE IN GLOBAL COORDINATES

   NODE      UZ
      1   0.0000
      2   0.0000
      3   0.0000
      4  0.20405E-02
      5  0.14762E-02
      6   0.0000
      7  0.11192E-02
      8   0.0000
      9  0.81890E-03

 MAXIMUM ABSOLUTE VALUES
 NODE          4
 VALUE   0.20405E-02

 PRINT S    ELEMENT SOLUTION PER ELEMENT

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


  ELEMENT=       1        SHELL43
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       1 -0.23448E-12-0.24147E-14  0.0000     -3.2821
-0.33307E-15-0.88818E-15
       3   1.0061      3.3536      0.0000     -7.3449     0.23464
-0.88818E-15
       9  -10.602    -0.12877      0.0000     -6.1711     0.23464
3.0004
       8  -11.608     -3.4824      0.0000     -2.1083    -0.49960E-15
3.0004
       1  0.23448E-12 0.24147E-14 -1.0000      3.2821
-0.19429E-15-0.15543E-14
       3  -1.0061     -3.3536     -1.0000      7.3449     0.23464
-0.11102E-14
       9   10.602     0.12877     -1.0000      6.1711     0.23464
3.0004
       8   11.608      3.4824     -1.0000      2.1083     0.47184E-15
3.0004

  ELEMENT=       2        SHELL43
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
```

```
       3   1.0061      3.3536      0.0000     -6.1937     0.23464
0.11102E-15
       2   1.5759      5.2529      0.0000     -2.1309      1.9430
-0.44409E-15
       5   13.184      8.7353      0.0000     -1.4661      1.9430
0.73810
       9   12.614      6.8360      0.0000     -5.5289     0.23464
0.73810
       3  -1.0061     -3.3536     -1.0000      6.1937     0.23464
-0.99920E-15
       2  -1.5759     -5.2529     -1.0000      2.1309      1.9430
-0.33307E-15
       5  -13.184     -8.7353     -1.0000      1.4661      1.9430
0.73810
       9  -12.614     -6.8360     -1.0000      5.5289     0.23464
0.73810

  ELEMENT=       3        SHELL43
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       8  -11.608     -3.4824      0.0000     -2.1083     0.10825E-14
3.0004
       9  -9.8009      2.5413      0.0000     -3.6869    -0.18856
3.0004
       7  -14.311      1.1882      0.0000     -1.5786    -0.18856
3.9153
       6  -16.118     -4.8355      0.0000    -0.81268E-13-0.11657E-14
3.9153
       8   11.608      3.4824     -1.0000      2.1083    -0.24980E-15
3.0004
       9   9.8009     -2.5413     -1.0000      3.6869    -0.18856
3.0004
       7   14.311     -1.1882     -1.0000      1.5786    -0.18856
3.9153
       6   16.118      4.8355     -1.0000     0.81268E-13 0.24980E-15
3.9153

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


  ELEMENT=       4        SHELL43
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       9   13.415      9.5061      0.0000     -3.0448    -0.18856
```

```
0.73810
       5   14.672      13.695      0.0000     -1.4661     0.45397
0.73810
       4   19.182      15.048      0.0000    -0.67502E-13 0.45397
1.1463
       7   17.926      10.859      0.0000     -1.5786    -0.18856
1.1463
       9  -13.415     -9.5061     -1.0000      3.0448    -0.18856
0.73810
       5  -14.672     -13.695     -1.0000      1.4661     0.45397
0.73810
       4  -19.182     -15.048     -1.0000     0.67502E-13 0.45397
1.1463
       7  -17.926     -10.859     -1.0000      1.5786    -0.18856
1.1463
```

Shell analysis example

This example is not included in the printed book.



Cylinderical barrel shell. Arc angle = 80°, symmetric about y-z plane. Radius = 25 m. Length = 50 m. Thickness = 0.25m. $E = 4.32 \times 10^8\ N/m^2$ and $\nu = 0$. Load due to gravity. Mass density = $36.7347\,\mathrm{kg}/m^3$. Acceleration due to gravity = $9.8\ m/s^2$.

The shell is supported (u, w, θ_z = 0) along the two curved sides only. The sides along the y-direction are free.

Taking advantage of symmetry we can model a 1/4 of the shell.

The following analytical solution of the problem is available.

Maximum deflection (at the center of longitudinal edge) = 0.3024 m (Cook et al, Concepts and Applications of finite element analysis, 4th Edition p. 584, Wiley 2002)

■ 2×2 Mesh

AnsysFiles\\Chap06\\ShellEx4Elem.txt

```
!* Shell analysis example. p. 331
!* 2x2 Mesh
/PREP7
ET,1,SHELL143
KEYOPT,1,2,0
KEYOPT,1,3,1
KEYOPT,1,4,0
KEYOPT,1,5,0
KEYOPT,1,6,0
R,1,0.25
MP,EX,1,4.32e8        ! MATERIAL PROPERTIES
MP,NUXY,1,0.0
MP,DENS,1,36.7347
CSYS,1
K,1,25,50
K,2,25,50,25          ! DEFINE KEYPOINTS AND AREA
K,3,25,90
K,4,25,90,25
A,1,3,4,2
ESIZE,,2
AMESH,1
CSYS,0                ! SWITCH BACK TO GLOBAL CARTESIAN C.S.
DL,3, ,UX,
DL,3, ,UY,
DL,3, ,ROTZ,
DL,      2, ,SYMM
DL,      1, ,SYMM
ACEL,,9.8
FINISH
/SOLU
SOLVE
FINISH
/POST1
```

```
 PRINT U    NODAL SOLUTION PER NODE

  ***** POST1 NODAL DEGREE OF FREEDOM LISTING *****
```

```
 LOAD STEP=     1  SUBSTEP=     1
  TIME=    1.0000      LOAD CASE=   0

 THE FOLLOWING DEGREE OF FREEDOM RESULTS ARE IN GLOBAL COORDINATES

   NODE      UY
      1 -0.35763
      2  0.52439E-01
      3 -0.74481E-01
      4   0.0000
      5  0.36954E-01
      6   0.0000
      7   0.0000
      8 -0.26099
      9 -0.53222E-01

MAXIMUM ABSOLUTE VALUES
NODE          1
VALUE  -0.35763


PRINT S    ELEMENT SOLUTION PER ELEMENT

***** POST1 ELEMENT NODAL STRESS LISTING *****

 LOAD STEP=     1  SUBSTEP=     1
  TIME=    1.0000      LOAD CASE=   0
 SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

 THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


 ELEMENT=       1        SHELL143
   NODE    SX          SY          SZ          SXY         SYZ
SXZ
       1   68611.      24285.      56143.     -40837.      56824.
-97058.
       3   68611.      24285.     -99878.     -40837.      52360.
-91950.
       9   54346.      19386.     -99878.     -32477.     -3795.5
5315.2
       8   54346.      19386.      56143.     -32477.      667.90
207.00
       1  -79282.     -25013.     0.20592E+06  44549.      32064.
-54173.
       3  -79282.     -25013.     -69575.      44549.      33837.
-59867.
       9  -66611.     -20933.     -69575.      37358.     -65321.
0.11188E+06
       8  -66611.     -20933.     0.20592E+06  37358.     -67094.
0.11757E+06
```

```
  ELEMENT=       2        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       3  0.16916E+06  5271.2     -99948.     -29861.     -4669.2
26896.
       2  0.16916E+06  5271.2      48850.     -29861.     -8408.5
45698.
       5  0.11572E+06  3525.8      48850.     -20200.      10191.
-59787.
       9  0.11572E+06  3525.8     -99948.     -20200.      13931.
-78589.
       3 -0.18905E+06 -5866.1     -69505.      33302.     -11102.
63379.
       2 -0.18905E+06 -5866.1      27989.      33302.     -8408.5
45698.
       5 -0.13904E+06 -4394.9      27989.      24721.      3778.3
-23417.
       9 -0.13904E+06 -4394.9     -69505.      24721.      1084.6
-5735.4

  ELEMENT=       3        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       8   54346.      19386.      3359.7     -32477.      91296.
-0.15179E+06
       9   54346.      19386.     -43932.     -32477.      74008.
-0.13221E+06
       7 -0.23128E-04-0.77520E-05 -43932.     0.13390E-04  56987.
-0.10272E+06
       6 -0.23133E-04-0.77548E-05  3359.7     0.13394E-04  74275.
-0.12231E+06
       8  -66611.     -20933.     0.10842E+06  37358.     -25325.
50201.
       9  -66611.     -20933.     -28383.      37358.     -14608.
21281.
       7 -0.20293E-04-0.68078E-05 -28383.     0.11754E-04 -63847.
0.10657E+06
       6 -0.20300E-04-0.68090E-05 0.10842E+06 0.11757E-04 -74565.
0.13549E+06

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES
```

```
  ELEMENT=       4        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       9  0.11572E+06  3525.8     -43872.     -20200.      6563.9
-37063.
       5  0.11572E+06  3525.8      20477.     -20200.     -1403.0
3584.4
       4 -0.22700E-04-0.66795E-06  20477.     0.38954E-05  6640.7
-42033.
       7 -0.22728E-04-0.66903E-06 -43872.     0.39009E-05  14608.
-82681.
       9 -0.13904E+06 -4394.9     -28443.      24721.     -15691.
89148.
       5 -0.13904E+06 -4394.9      12373.      24721.     -7815.9
39954.
       4 -0.28402E-04-0.84558E-06  12373.     0.49018E-05 -2714.0
11020.
       7 -0.28435E-04-0.84643E-06 -28443.     0.49072E-05 -10589.
60213.
```

■ 4×4 Mesh

AnsysFiles\\Chap06\\ShellEx16Elem.txt

```
!* Shell analysis example. p. 331
!* 4x4 Mesh
/PREP7
ET,1,SHELL143
KEYOPT,1,2,0
KEYOPT,1,3,1
KEYOPT,1,4,0
KEYOPT,1,5,0
KEYOPT,1,6,0
R,1,0.25
MP,EX,1,4.32e8        ! MATERIAL PROPERTIES
MP,NUXY,1,0.0
MP,DENS,1,36.7347
CSYS,1
K,1,25,50
K,2,25,50,25          ! DEFINE KEYPOINTS AND AREA
K,3,25,90
K,4,25,90,25
A,1,3,4,2
ESIZE,,4
AMESH,1
CSYS,0                ! SWITCH BACK TO GLOBAL CARTESIAN C.S.
DL,3, ,UX,
DL,3, ,UY,
DL,3, ,ROTZ,
DL,      2, ,SYMM
DL,      1, ,SYMM
ACEL,,9.8
FINISH
/SOLU
SOLVE
FINISH
/POST1
```

```
 PRINT U    NODAL SOLUTION PER NODE

  ***** POST1 NODAL DEGREE OF FREEDOM LISTING *****
```

```
 LOAD STEP=     1  SUBSTEP=     1
  TIME=    1.0000      LOAD CASE=   0

 THE FOLLOWING DEGREE OF FREEDOM RESULTS ARE IN GLOBAL COORDINATES

   NODE      UY
      1 -0.28483
      2  0.42346E-01
      3 -0.17722
      4 -0.69604E-01
      5  0.11965E-01
      6   0.0000
      7  0.39168E-01
      8  0.29880E-01
      9  0.15866E-01
     10   0.0000
     11   0.0000
     12   0.0000
     13   0.0000
     14 -0.11710
     15 -0.20878
     16 -0.26549
     17 -0.16472
     18 -0.12832
     19 -0.71072E-01
     20 -0.64348E-01
     21 -0.49446E-01
     22 -0.27056E-01
     23  0.11195E-01
     24  0.86716E-02
     25  0.45164E-02

 MAXIMUM ABSOLUTE VALUES
 NODE          1
 VALUE  -0.28483


 PRINT S    ELEMENT SOLUTION PER ELEMENT

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

 LOAD STEP=     1  SUBSTEP=     1
  TIME=    1.0000      LOAD CASE=   0
 SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

 THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


 ELEMENT=       1        SHELL143
   NODE    SX          SY          SZ          SXY         SYZ
SXZ
```

```
       1   4980.6      3033.6     0.17891E+06 -3909.9      62502.
-87973.
       3   4980.6      3033.6     -65395.     -3909.9      61516.
-88741.
      17   5117.6      3077.6     -65395.     -3989.3     -38970.
54768.
      16   5117.6      3077.6     0.17891E+06 -3989.3     -37984.
55536.
       1  -8897.9     -3770.9     0.29797E+06  5807.9      52993.
-74392.
       3  -8897.9     -3770.9      8021.3      5807.9      52027.
-75190.
      17  -8690.5     -3692.3      8021.3      5679.2     -67233.
95132.
      16  -8690.5     -3692.3     0.29797E+06  5679.2     -66268.
95930.

  ELEMENT=       2        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       3   43651.      10421.     -66075.     -21351.      11576.
-24421.
       4   43651.      10421.     -84280.     -21351.      11086.
-24071.
      20   42445.      10122.     -84280.     -20749.      5569.1
-12239.
      17   42445.      10122.     -66075.     -20749.      6058.6
-12589.
       3  -57583.     -11592.      8701.4      25855.      4584.6
-9428.3
       4  -57583.     -11592.     -53571.      25855.      4686.9
-10347.
      20  -55489.     -11174.     -53571.      24918.     -14185.
30125.
      17  -55489.     -11174.      8701.4      24918.     -14288.
31044.

  ELEMENT=       3        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       4  0.11323E+06  8536.1     -84288.     -31098.     -1848.9
6809.5
       5  0.11323E+06  8536.1     -21796.     -31098.     -2637.9
9175.5
      23  0.10661E+06  8014.6     -21796.     -29238.      8960.6
-34111.
      20  0.10661E+06  8014.6     -84288.     -29238.      9749.6
-36477.
       4 -0.13558E+06 -9327.4     -53563.      35569.     -5768.0
21436.
```

```
       5 -0.13558E+06 -9327.4     -25510.      35569.     -5117.8
18431.
      23 -0.12732E+06 -8780.5     -25510.      33442.      88.815
-1000.5
      20 -0.12732E+06 -8780.5     -53563.      33442.     -561.36
2004.5

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


  ELEMENT=       4        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
       5  0.15932E+06  1262.5     -21591.     -14184.     -467.19
5193.7
       2  0.15932E+06  1262.5      12806.     -14184.     -1004.2
9520.3
       7  0.14692E+06  1160.6      12806.     -13060.      1145.6
-15052.
      23  0.14692E+06  1160.6     -21591.     -13060.      1682.6
-19378.
       5 -0.18490E+06 -1372.3     -25716.      15931.     -1302.3
14739.
       2 -0.18490E+06 -1372.3     -4623.8      15931.     -1004.2
9520.3
       7 -0.17002E+06 -1265.4     -4623.8      14669.      314.02
-5547.2
      23 -0.17002E+06 -1265.4     -25716.      14669.      15.936
-328.41

  ELEMENT=       5        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
      16   5117.6      3077.6     0.15616E+06 -3989.3      81400.
-0.11246E+06
      17   5117.6      3077.6     -62101.     -3989.3      78425.
-0.11448E+06
      18   4990.9      3068.8     -62101.     -3938.7     -11350.
13729.
      15   4990.9      3068.8     0.15616E+06 -3938.7     -8375.6
15754.
      16  -8690.5     -3692.3     0.26747E+06  5679.2      34582.
-45596.
      17  -8690.5     -3692.3      4998.7      5679.2      31304.
```

```
-47187.
      18  -9836.6     -4201.0      4998.7      6443.6     -76657.
0.10700E+06
      15  -9836.6     -4201.0     0.26747E+06  6443.6     -73379.
0.10859E+06

  ELEMENT=       6        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
      17   42445.      10122.     -62699.     -20749.      27999.
-58664.
      20   42445.      10122.     -72690.     -20749.      25983.
-56396.
      21   35722.      8504.3     -72690.     -17447.      22955.
-49903.
      18   35722.      8504.3     -62699.     -17447.      24971.
-52171.
      17  -55489.     -11174.      5596.2      24918.     -6242.0
14766.
      20  -55489.     -11174.     -47006.      24918.     -6210.5
12642.
      21  -50795.     -10308.     -47006.      22896.     -22152.
46829.
      18  -50795.     -10308.      5596.2      22896.     -22184.
48953.

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


  ELEMENT=       7        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
      20  0.10661E+06  8014.6     -72684.     -29238.      6413.9
-23917.
      23  0.10661E+06  8014.6     -16961.     -29238.      3704.5
-15367.
      24   82738.      6181.6     -16961.     -22620.      14047.
-53965.
      21   82738.      6181.6     -72684.     -22620.      16756.
-62515.
      20 -0.12732E+06 -8780.5     -47011.      33442.     -11515.
42994.
      23 -0.12732E+06 -8780.5     -21985.      33442.     -9651.9
34480.
```

```
      24 -0.10391E+06 -7219.1     -21985.      27392.     -5007.0
17145.
      21 -0.10391E+06 -7219.1     -47011.      27392.     -6869.8
25659.

  ELEMENT=       8        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
      23  0.14692E+06  1160.6     -16782.     -13060.      911.45
-9962.5
       7  0.14692E+06  1160.6      11995.     -13060.     -666.85
3265.4
       8  0.10904E+06  856.14      11995.     -9662.5      1131.7
-17292.
      24  0.10904E+06  856.14     -16782.     -9662.5      2710.0
-30520.
      23 -0.17002E+06 -1265.4     -22164.      14669.     -2265.4
26349.
       7 -0.17002E+06 -1265.4     -4143.6      14669.     -1498.4
12770.
       8 -0.13131E+06 -983.56     -4143.6      11365.     -372.11
-103.50
      24 -0.13131E+06 -983.56     -22164.      11365.     -1139.1
13475.

  ELEMENT=       9        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
      15   4990.9      3068.8     0.10099E+06 -3938.7      94868.
-0.12916E+06
      18   4990.9      3068.8     -52874.     -3938.7      89236.
-0.13182E+06
      19   3003.6      2036.0     -52874.     -2505.4      25949.
-41433.
      14   3003.6      2036.0     0.10099E+06 -2505.4      31582.
-38775.
      15  -9836.6     -4201.0     0.20716E+06  6443.6      9752.3
-7599.2
      18  -9836.6     -4201.0      3270.5      6443.6      4832.3
-11276.
      19  -9432.6     -4061.4      3270.5      6202.5     -79030.
0.10849E+06
      14  -9432.6     -4061.4     0.20716E+06  6202.5     -74110.
0.11217E+06

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE
```

THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES

ELEMENT= 10 SHELL143

NODE	SX	SY	SZ	SXY	SYZ	SXZ
18	35722.	8504.3	-53270.	-17447.	42656.	-89431.
21	35722.	8504.3	-50363.	-17447.	38384.	-83625.
22	19334.	4619.3	-50363.	-9460.9	39265.	-85514.
19	19334.	4619.3	-53270.	-9460.9	43537.	-91320.
18	-50795.	-10308.	3666.9	22896.	-18570.	41868.
21	-50795.	-10308.	-32075.	22896.	-17336.	35866.
22	-36485.	-7518.2	-32075.	16568.	-28168.	59095.
19	-36485.	-7518.2	3666.9	16568.	-29401.	65097.

ELEMENT= 11 SHELL143

NODE	SX	SY	SZ	SXY	SYZ	SXZ
21	82738.	6181.6	-50360.	-22620.	13754.	-52050.
24	82738.	6181.6	-10890.	-22620.	9304.6	-37332.
25	41734.	3104.8	-10890.	-11385.	16630.	-64672.
22	41734.	3104.8	-50360.	-11385.	21080.	-79389.
21	-0.10391E+06	-7219.1	-32078.	27392.	-16371.	60379.
24	-0.10391E+06	-7219.1	-14079.	27392.	-12938.	45677.
25	-63399.	-4443.5	-14079.	16785.	-9596.8	33209.
22	-63399.	-4443.5	-32078.	16785.	-13030.	47912.

ELEMENT= 12 SHELL143

NODE	SX	SY	SZ	SXY	SYZ	SXZ
24	0.10904E+06	856.14	-10763.	-9662.5	1944.6	-22665.
8	0.10904E+06	856.14	7828.1	-9662.5	-363.14	

```
-3132.2
       9   53084.      414.87      7828.1     -4693.1      798.82
-16413.
      25   53084.      414.87     -10763.     -4693.1      3106.6
-35946.
      24 -0.13131E+06 -983.56     -14206.      11365.     -2978.2
33602.
       8 -0.13131E+06 -983.56     -1956.7      11365.     -1866.9
14056.
       9  -75596.     -570.08     -1956.7      6564.9     -1101.4
5306.1
      25  -75596.     -570.08     -14206.      6564.9     -2212.6
24852.

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


  ELEMENT=      13        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
      14   3003.6      2036.0      31395.     -2505.4      98547.
-0.13141E+06
      19   3003.6      2036.0     -23723.     -2505.4      90402.
-0.13497E+06
      13 -0.45854E-04-0.23015E-04 -23723.     0.32488E-04  67731.
-0.10259E+06
      10 -0.45846E-04-0.23028E-04  31395.     0.32495E-04  75876.
-99036.
      14  -9432.6     -4061.4      84907.      6202.5     -24743.
44664.
      19  -9432.6     -4061.4      2534.5      6202.5     -29183.
35812.
      13 -0.44746E-04-0.22484E-04  2534.5     0.31721E-04 -63064.
84200.
      10 -0.44767E-04-0.22477E-04  84907.     0.31723E-04 -58624.
93051.

  ELEMENT=      14        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
      19   19334.      4619.3     -23852.     -9460.9      53543.
-0.11207E+06
      22   19334.      4619.3     -19329.     -9460.9      48390.
-0.10526E+06
```

```
      12 -0.46934E-05-0.96997E-06 -19329.     0.21343E-05  49760.
-0.10820E+06
      13 -0.46930E-05-0.97244E-06 -23852.     0.21369E-05  54914.
-0.11501E+06
      19  -36485.     -7518.2      2662.9      16568.     -30157.
67425.
      22  -36485.     -7518.2     -10183.      16568.     -25298.
52764.
      12 -0.63352E-05-0.13277E-05 -10183.     0.29008E-05 -29191.
61113.
      13 -0.63402E-05-0.13271E-05  2662.9     0.29012E-05 -34050.
75774.

  ELEMENT=      15        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
      22   41734.      3104.8     -19337.     -11385.      18823.
-71499.
      25   41734.      3104.8     -5078.1     -11385.      14399.
-56501.
      11  0.21419E-05 0.16946E-06 -5078.1    -0.60317E-06  17046.
-66378.
      12  0.21417E-05 0.16964E-06 -19337.    -0.60349E-06  21470.
-81376.
      22  -63399.     -4443.5     -10174.      16785.     -19118.
70099.
      25  -63399.     -4443.5     -3448.4      16785.     -13374.
47152.
      11 -0.34382E-05-0.23133E-06 -3448.4     0.89231E-06 -12126.
42493.
      12 -0.34383E-05-0.23160E-06 -10174.     0.89281E-06 -17869.
65440.

 ***** POST1 ELEMENT NODAL STRESS LISTING *****

  LOAD STEP=     1  SUBSTEP=     1
   TIME=    1.0000      LOAD CASE=   0
  SHELL RESULTS FOR TOP/BOTTOM ALSO MID WHERE APPROPRIATE

  THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES


  ELEMENT=      16        SHELL143
    NODE    SX          SY          SZ          SXY         SYZ
SXZ
      25   53084.      414.87     -5030.8     -4693.1      2614.9
-29380.
       9   53084.      414.87      1272.2     -4693.1      270.21
-10863.
       6 -0.67609E-05-0.39629E-07  1272.2     0.52223E-06  664.15
```

```
-15366.
      11 -0.67851E-05-0.39928E-07 -5030.8     0.52500E-06  3008.9
-33883.
      25  -75596.     -570.08     -3495.7      6564.9     -3225.1
37372.
       9  -75596.     -570.08      879.20      6564.9     -1630.0
10857.
       6 -0.54305E-05-0.29656E-07  879.20     0.40704E-06 -1356.6
7731.3
      11 -0.54659E-05-0.29823E-07 -3495.7     0.40954E-06 -2951.7
34246.
```

Von Mises Stresses