Appendix C

The Finite Element Analysis of the Optimal Structures in Chapter 5

Six-bar truss with weight of 4962.1 lb (optimal result from the proposed ACO algorithm, Rajan, 1995 and Nanakorn and Meesomklin, 2001)

```
FINITE ELEMENT ANALYSIS PROGRAM
C++ VERSION BY PRUETTHA NANAKORN
1994.

VERSION : 960331

INPUT: 6bar4962.1NoWeight.txt
NOTE:

Number of nodal points                     = 5
Number of elements                         = 6
Number of material sets                    = 6
Number of Dimensions                       = 2
Number of Dof's / node      (default)      = 2
Number of nodes / element  (Maximum)       = 2
Number of load cases                       = 1

NODAL COORDINATES ::
NOTE:

 NODE          1 COOR          2 COOR         dof

    1        0.000000        0.000000
    2      360.000000        0.000000
    3      720.000000        0.000000
    4        0.000000      360.000000
    5      360.000000      360.000000

ELEMENTS ::
NOTE:

 ELEM   MAT     1 NODE     2 NODE

    1     1          4          5
    2     2          1          2
    3     3          2          3
    4     4          4          2
    5     5          1          5
    6     6          5          3

BOUNDARIES ::
NOTE:

 NODE      1 NDF      2 NDF

    1          1          1
    4          1          1

NODAL FORCED BOUNDARY VALUE ::
NOTE:

 LOAD CASE: 1
 NODE            1 NDF            2 NDF

    2        0.000000     -100.000000
    3        0.000000     -100.000000

PROPORTIONAL LOADING ::
NOTE:

 LOADING CONTROL

 LOAD CASE: 1
                Tmin           Tmax              A1              A2
                  A3             A4              A5               L

    1       0.000000     100.000000        0.000000        1.000000
            0.000000       0.000000        0.000000        0.000000

MATERIAL PROPERTIES ::
NOTE:

 SET 1  Element Type 2
```

```
Young's Modulus =10000.000000
Area =30.000000


 SET 2  Element Type 2
Young's Modulus =10000.000000
Area =19.900000


 SET 3  Element Type 2
Young's Modulus =10000.000000
Area =15.500000


 SET 4  Element Type 2
Young's Modulus =10000.000000
Area =7.220000


 SET 5  Element Type 2
Young's Modulus =10000.000000
Area =22.000000


 SET 6  Element Type 2
Young's Modulus =10000.000000
Area =22.000000


----------------------------------------------------------------

MACRO COMMANDS ::
NOTE:

Dt                 1.000000
Loop               1.000000
Time
TangForm
SolvAddU
Disp               1.000000        1         1         5         1
Stre
Next
END
----------------------------------------------------------------

----------------------------------------------------------------

     TIME= 1.000000
     STEP= 1/1

DISPLACEMENT ::
USER FACTOR =    1.000000e+000
LOAD CASE  1 'S FACTOR =    1.000000e+000


 NODE          1 COOR          2 COOR           1 NDF          2 NDF

    1       0.000000        0.000000  0.000000e+000  0.000000e+000
    2     360.000000        0.000000 -3.618090e-001 -1.772105e+000
    3     720.000000        0.000000 -5.940671e-001 -1.999734e+000
    4       0.000000      360.000000  0.000000e+000  0.000000e+000
    5     360.000000      360.000000  2.400000e-001 -7.028335e-001


Stress 1 = 6.666667e+000

Stress 2 = -1.005025e+001

Stress 3 = -6.451613e+000

Stress 4 = 1.958745e+001

Stress 5 = -6.428243e+000

Stress 6 = 6.428243e+000
1  Max 0.000000e+000  6.666667e+000 3.000000e+001
```

```
   Min 0.000000e+000
2  Max 0.000000e+000  -1.005025e+001 1.990000e+001
   Min 2.000000e+000
3  Max 0.000000e+000  -6.451613e+000 1.550000e+001
   Min 0.000000e+000
4  Max 1.000000e+000  1.958745e+001 7.220000e+000
   Min 0.000000e+000
5  Max 0.000000e+000  -6.428243e+000 2.200000e+001
   Min 0.000000e+000
6  Max 0.000000e+000  6.428243e+000 2.200000e+001
   Min 0.000000e+000

Stressmax= 1.958745e+001

Stressmin= -1.005025e+001

AbsStressmax= 1.958745e+001

AbsStressmin= 1.005025e+001
 NO CONVERGENCE TEST 1/1
-----------------------------------------------------------------

-----------------------------------------------------------------

Terminated normally by STOP.

-----------------------------------------------------------------
```

Ten-bar truss with weight of 5490.7 lb (optimal result from the proposed ACO algorithm)

```
FINITE ELEMENT ANALYSIS PROGRAM
C++ VERSION BY PRUETTHA NANAKORN
1994.

VERSION : 960331

INPUT: 10bar5490.71NoWeight.txt
NOTE:

Number of nodal points                  = 6
Number of elements                      = 10
Number of material sets                 = 10
Number of Dimensions                    = 2
Number of Dof's / node     (default)    = 2
Number of nodes / element (Maximum)     = 2
Number of load cases                    = 1

NODAL COORDINATES ::
NOTE:

 NODE         1 COOR         2 COOR         dof

    1       0.000000       0.000000
    2     360.000000       0.000000
    3     720.000000       0.000000
    4       0.000000     360.000000
    5     360.000000     360.000000
    6     720.000000     360.000000

ELEMENTS ::
NOTE:

 ELEM  MAT    1 NODE    2 NODE

    1    1       4         5
    2    2       5         6
    3    3       1         2
    4    4       2         3
    5    5       2         5
    6    6       3         6
    7    7       2         4
    8    8       1         5
    9    9       3         5
   10   10       2         6

BOUNDARIES ::
NOTE:

 NODE      1 NDF      2 NDF

    1          1          1
    4          1          1

NODAL FORCED BOUNDARY VALUE ::
NOTE:

 LOAD CASE: 1
 NODE           1 NDF          2 NDF

    2       0.000000    -100.000000
    3       0.000000    -100.000000

PROPORTIONAL LOADING ::
NOTE:

 LOADING CONTROL

 LOAD CASE: 1
                 Tmin           Tmax             A1             A2
                   A3             A4             A5              L

    1        0.000000     100.000000       0.000000       1.000000
             0.000000       0.000000       0.000000       0.000000
```

```
MATERIAL PROPERTIES ::
NOTE:

 SET 1  Element Type 2
Young's Modulus =10000.000000
Area =33.500000


 SET 2  Element Type 2
Young's Modulus =10000.000000
Area =1.620000


 SET 3  Element Type 2
Young's Modulus =10000.000000
Area =22.900000


 SET 4  Element Type 2
Young's Modulus =10000.000000
Area =14.200000


 SET 5  Element Type 2
Young's Modulus =10000.000000
Area =1.620000


 SET 6  Element Type 2
Young's Modulus =10000.000000
Area =1.620000


 SET 7  Element Type 2
Young's Modulus =10000.000000
Area =7.970000


 SET 8  Element Type 2
Young's Modulus =10000.000000
Area =22.900000


 SET 9  Element Type 2
Young's Modulus =10000.000000
Area =22.000000


 SET 10  Element Type 2
Young's Modulus =10000.000000
Area =1.620000

-----------------------------------------------------------------

MACRO COMMANDS ::
NOTE:

Dt                1.000000
Loop              1.000000
Time
TangForm
SolvAddU
Disp              1.000000         1         1         6         1
Stre
Next
END

-----------------------------------------------------------------

-----------------------------------------------------------------

     TIME= 1.000000
     STEP= 1/1

DISPLACEMENT ::
```

```
USER FACTOR =    1.000000e+000
LOAD CASE  1 'S FACTOR =    1.000000e+000

 NODE          1 COOR          2 COOR            1 NDF            2 NDF

    1        0.000000         0.000000  0.000000e+000  0.000000e+000
    2      360.000000         0.000000 -2.810740e-001 -1.287736e+000
    3      720.000000         0.000000 -5.300487e-001 -1.998943e+000
    4        0.000000       360.000000  0.000000e+000  0.000000e+000
    5      360.000000       360.000000  2.377136e-001 -7.766470e-001
    6      720.000000       360.000000  2.775648e-001 -1.959092e+000

Stress 1 = 6.603156e+000

Stress 2 = 1.106979e+000

Stress 3 = -7.807611e+000

Stress 4 = -6.915964e+000

Stress 5 = 1.419693e+001

Stress 6 = 1.106979e+000

Stress 7 = 1.398142e+001

Stress 8 = -7.485186e+000

Stress 9 = 6.312965e+000

Stress 10 = -1.565505e+000
1  Max 0.000000e+000  6.603156e+000 3.350000e+001
   Min 0.000000e+000
2  Max 0.000000e+000  1.106979e+000 1.620000e+000
   Min 0.000000e+000
3  Max 0.000000e+000  -7.807611e+000 2.290000e+001
   Min 2.000000e+000
4  Max 0.000000e+000  -6.915964e+000 1.420000e+001
   Min 0.000000e+000
5  Max 1.000000e+000  1.419693e+001 1.620000e+000
   Min 0.000000e+000
6  Max 0.000000e+000  1.106979e+000 1.620000e+000
   Min 0.000000e+000
7  Max 0.000000e+000  1.398142e+001 7.970000e+000
   Min 0.000000e+000
8  Max 0.000000e+000  -7.485186e+000 2.290000e+001
   Min 0.000000e+000
9  Max 0.000000e+000  6.312965e+000 2.200000e+001
   Min 0.000000e+000
10  Max 0.000000e+000  -1.565505e+000 1.620000e+000
   Min 0.000000e+000

Stressmax= 1.419693e+001

Stressmin= -7.807611e+000

AbsStressmax= 1.419693e+001

AbsStressmin= 7.807611e+000
 NO CONVERGENCE TEST 1/1
-------------------------------------------------------------

-------------------------------------------------------------

Terminated normally by STOP.

-------------------------------------------------------------
```

Ten-bar truss with weight of 5458.3 lb (optimal result from Galante, 1996)

```
FINITE ELEMENT ANALYSIS PROGRAM
C++ VERSION BY PRUETTHA NANAKORN
1994.

VERSION : 960331

INPUT: 10barGalante5458.30NoWeight.txt
NOTE:

Number of nodal points                     = 6
Number of elements                         = 10
Number of material sets                    = 10
Number of Dimensions                       = 2
Number of Dof's / node      (default)      = 2
Number of nodes / element  (Maximum)       = 2
Number of load cases                       = 1

NODAL COORDINATES ::
NOTE:

 NODE          1 COOR          2 COOR          dof

    1        0.000000        0.000000
    2      360.000000        0.000000
    3      720.000000        0.000000
    4        0.000000      360.000000
    5      360.000000      360.000000
    6      720.000000      360.000000

ELEMENTS ::
NOTE:

 ELEM   MAT     1 NODE     2 NODE

    1     1          4          5
    2     2          5          6
    3     3          1          2
    4     4          2          3
    5     5          2          5
    6     6          3          6
    7     7          2          4
    8     8          1          5
    9     9          3          5
   10    10          2          6

BOUNDARIES ::
NOTE:

 NODE      1 NDF      2 NDF

    1          1          1
    4          1          1

NODAL FORCED BOUNDARY VALUE ::
NOTE:

 LOAD CASE: 1
 NODE            1 NDF            2 NDF

    2        0.000000      -100.000000
    3        0.000000      -100.000000

PROPORTIONAL LOADING ::
NOTE:

 LOADING CONTROL

 LOAD CASE: 1
                  Tmin             Tmax               A1               A2
                    A3               A4               A5                L

    1         0.000000       100.000000         0.000000         1.000000
              0.000000         0.000000         0.000000         0.000000

MATERIAL PROPERTIES ::
```

```
NOTE:

 SET 1  Element Type 2
Young's Modulus =10000.000000
Area =33.500000

 SET 2  Element Type 2
Young's Modulus =10000.000000
Area =1.620000

 SET 3  Element Type 2
Young's Modulus =10000.000000
Area =22.000000

 SET 4  Element Type 2
Young's Modulus =10000.000000
Area =14.200000

 SET 5  Element Type 2
Young's Modulus =10000.000000
Area =1.620000

 SET 6  Element Type 2
Young's Modulus =10000.000000
Area =1.620000

 SET 7  Element Type 2
Young's Modulus =10000.000000
Area =7.970000

 SET 8  Element Type 2
Young's Modulus =10000.000000
Area =22.900000

 SET 9  Element Type 2
Young's Modulus =10000.000000
Area =22.000000

 SET 10  Element Type 2
Young's Modulus =10000.000000
Area =1.620000

-----------------------------------------------------------------

MACRO COMMANDS ::
NOTE:

Dt                 1.000000
Loop               1.000000
Time
TangForm
SolvAddU
Disp               1.000000        1        1        6        1
Stre
Next
END
-----------------------------------------------------------------
-----------------------------------------------------------------

     TIME= 1.000000
     STEP= 1/1

DISPLACEMENT ::
USER FACTOR =    1.000000e+000
LOAD CASE  1 'S FACTOR =    1.000000e+000
```

```
NODE          1 COOR          2 COOR          1 NDF          2 NDF

   1       0.000000        0.000000   0.000000e+000  0.000000e+000
   2     360.000000        0.000000  -2.920843e-001 -1.294935e+000
   3     720.000000        0.000000  -5.411820e-001 -2.012268e+000
   4       0.000000      360.000000   0.000000e+000  0.000000e+000
   5     360.000000      360.000000   2.380342e-001 -7.782941e-001
   6     720.000000      360.000000   2.768076e-001 -1.973495e+000

Stress 1 = 6.612061e+000

Stress 2 = 1.077039e+000

Stress 3 = -8.113452e+000

Stress 4 = -6.919380e+000

Stress 5 = 1.435114e+001

Stress 6 = 1.077039e+000

Stress 7 = 1.392849e+001

Stress 8 = -7.503610e+000

Stress 9 = 6.316083e+000

Stress 10 = -1.523163e+000
1  Max 0.000000e+000  6.612061e+000 3.350000e+001
   Min 0.000000e+000
2  Max 0.000000e+000  1.077039e+000 1.620000e+000
   Min 0.000000e+000
3  Max 0.000000e+000  -8.113452e+000 2.200000e+001
   Min 2.000000e+000
4  Max 0.000000e+000  -6.919380e+000 1.420000e+001
   Min 0.000000e+000
5  Max 1.000000e+000  1.435114e+001 1.620000e+000
   Min 0.000000e+000
6  Max 0.000000e+000  1.077039e+000 1.620000e+000
   Min 0.000000e+000
7  Max 0.000000e+000  1.392849e+001 7.970000e+000
   Min 0.000000e+000
8  Max 0.000000e+000  -7.503610e+000 2.290000e+001
   Min 0.000000e+000
9  Max 0.000000e+000  6.316083e+000 2.200000e+001
   Min 0.000000e+000
10  Max 0.000000e+000  -1.523163e+000 1.620000e+000
   Min 0.000000e+000

Stressmax= 1.435114e+001

Stressmin= -8.113452e+000

AbsStressmax= 1.435114e+001

AbsStressmin= 8.113452e+000
 NO CONVERGENCE TEST 1/1
---------------------------------------------------------------

---------------------------------------------------------------

Terminated normally by STOP.

---------------------------------------------------------------
```

Ten-bar truss with weight of 5499.4 lb (optimal result from Nanakorn and Meesomklin, 2001)

```
FINITE ELEMENT ANALYSIS PROGRAM
C++ VERSION BY PRUETTHA NANAKORN
1994.

VERSION : 960331

INPUT: 10barKonlakarn5499.4NoWeight.txt
NOTE:

Number of nodal points                    = 6
Number of elements                        = 10
Number of material sets                   = 10
Number of Dimensions                      = 2
Number of Dof's / node     (default)      = 2
Number of nodes / element  (Maximum)      = 2
Number of load cases                      = 1

NODAL COORDINATES ::
NOTE:

 NODE          1 COOR          2 COOR          dof

    1        0.000000        0.000000
    2      360.000000        0.000000
    3      720.000000        0.000000
    4        0.000000      360.000000
    5      360.000000      360.000000
    6      720.000000      360.000000

ELEMENTS ::
NOTE:

 ELEM   MAT    1 NODE    2 NODE

    1     1         4         5
    2     2         5         6
    3     3         1         2
    4     4         2         3
    5     5         2         5
    6     6         3         6
    7     7         2         4
    8     8         1         5
    9     9         3         5
   10    10         2         6

BOUNDARIES ::
NOTE:

 NODE      1 NDF     2 NDF

    1          1         1
    4          1         1

NODAL FORCED BOUNDARY VALUE ::
NOTE:

 LOAD CASE: 1
 NODE            1 NDF            2 NDF

    2         0.000000      -100.000000
    3         0.000000      -100.000000

PROPORTIONAL LOADING ::
NOTE:

 LOADING CONTROL

 LOAD CASE: 1
                  Tmin             Tmax               A1               A2
                    A3               A4               A5                L

    1         0.000000       100.000000         0.000000         1.000000
              0.000000         0.000000         0.000000         0.000000
```

```
MATERIAL PROPERTIES ::
NOTE:

 SET 1  Element Type 2
Young's Modulus =10000.000000
Area =33.500000


 SET 2  Element Type 2
Young's Modulus =10000.000000
Area =1.620000


 SET 3  Element Type 2
Young's Modulus =10000.000000
Area =22.900000


 SET 4  Element Type 2
Young's Modulus =10000.000000
Area =15.500000


 SET 5  Element Type 2
Young's Modulus =10000.000000
Area =1.620000


 SET 6  Element Type 2
Young's Modulus =10000.000000
Area =1.620000


 SET 7  Element Type 2
Young's Modulus =10000.000000
Area =7.220000


 SET 8  Element Type 2
Young's Modulus =10000.000000
Area =22.900000


 SET 9  Element Type 2
Young's Modulus =10000.000000
Area =22.000000


 SET 10  Element Type 2
Young's Modulus =10000.000000
Area =1.620000

-----------------------------------------------------------------

MACRO COMMANDS ::
NOTE:

Dt                 1.000000
Loop               1.000000
Time
TangForm
SolvAddU
Disp               1.000000         1         1         6         1
Stre
Next
END
-----------------------------------------------------------------
-----------------------------------------------------------------

     TIME= 1.000000
     STEP= 1/1

DISPLACEMENT ::
```

```
USER FACTOR =    1.000000e+000
LOAD CASE  1 'S FACTOR =    1.000000e+000

NODE         1 COOR         2 COOR           1 NDF            2 NDF

   1       0.000000       0.000000  0.000000e+000  0.000000e+000
   2     360.000000       0.000000 -2.768093e-001 -1.349783e+000
   3     720.000000       0.000000 -5.062836e-001 -1.995824e+000
   4       0.000000     360.000000  0.000000e+000  0.000000e+000
   5     360.000000     360.000000  2.406289e-001 -7.916248e-001
   6     720.000000     360.000000  2.672634e-001 -1.969189e+000

Stress 1 = 6.684136e+000

Stress 2 = 7.398462e-001

Stress 3 = -7.689146e+000

Stress 4 = -6.374287e+000

Stress 5 = 1.550439e+001

Stress 6 = 7.398462e-001

Stress 7 = 1.490241e+001

Stress 8 = -7.652721e+000

Stress 9 = 6.351198e+000

Stress 10 = -1.046300e+000
1  Max 0.000000e+000  6.684136e+000 3.350000e+001
   Min 0.000000e+000
2  Max 0.000000e+000  7.398462e-001 1.620000e+000
   Min 0.000000e+000
3  Max 0.000000e+000  -7.689146e+000 2.290000e+001
   Min 2.000000e+000
4  Max 0.000000e+000  -6.374287e+000 1.550000e+001
   Min 0.000000e+000
5  Max 1.000000e+000  1.550439e+001 1.620000e+000
   Min 0.000000e+000
6  Max 0.000000e+000  7.398462e-001 1.620000e+000
   Min 0.000000e+000
7  Max 0.000000e+000  1.490241e+001 7.220000e+000
   Min 0.000000e+000
8  Max 0.000000e+000  -7.652721e+000 2.290000e+001
   Min 0.000000e+000
9  Max 0.000000e+000  6.351198e+000 2.200000e+001
   Min 0.000000e+000
10  Max 0.000000e+000  -1.046300e+000 1.620000e+000
   Min 0.000000e+000

Stressmax= 1.550439e+001

Stressmin= -7.689146e+000

AbsStressmax= 1.550439e+001

AbsStressmin= 7.689146e+000
 NO CONVERGENCE TEST 1/1
------------------------------------------------------------

------------------------------------------------------------

Terminated normally by STOP.

------------------------------------------------------------
```

Ten-bar truss with weight of 5613.6 lb (optimal result from Rajeev and Krishnamoorthy, 1992)

```
FINITE ELEMENT ANALYSIS PROGRAM
C++ VERSION BY PRUETTHA NANAKORN
1994.

VERSION : 960331

INPUT: 10barRajeev5613.6NoWeight.txt
NOTE:

Number of nodal points                 = 6
Number of elements                     = 10
Number of material sets                = 10
Number of Dimensions                   = 2
Number of Dof's / node      (default)  = 2
Number of nodes / element  (Maximum)   = 2
Number of load cases                   = 1

NODAL COORDINATES ::
NOTE:

 NODE          1 COOR         2 COOR         dof

    1        0.000000       0.000000
    2      360.000000       0.000000
    3      720.000000       0.000000
    4        0.000000     360.000000
    5      360.000000     360.000000
    6      720.000000     360.000000

ELEMENTS ::
NOTE:

 ELEM   MAT    1 NODE    2 NODE

    1    1         4         5
    2    2         5         6
    3    3         1         2
    4    4         2         3
    5    5         2         5
    6    6         3         6
    7    7         2         4
    8    8         1         5
    9    9         3         5
   10   10         2         6

BOUNDARIES ::
NOTE:

 NODE      1 NDF      2 NDF

    1         1          1
    4         1          1

NODAL FORCED BOUNDARY VALUE ::
NOTE:

 LOAD CASE: 1
 NODE           1 NDF          2 NDF

    2        0.000000    -100.000000
    3        0.000000    -100.000000

PROPORTIONAL LOADING ::
NOTE:

 LOADING CONTROL

 LOAD CASE: 1
                 Tmin           Tmax            A1             A2
                   A3             A4            A5              L

    1        0.000000     100.000000      0.000000       1.000000
             0.000000       0.000000      0.000000       0.000000
```

```
MATERIAL PROPERTIES ::
NOTE:

 SET 1  Element Type 2
Young's Modulus =10000.000000
Area =33.500000


 SET 2  Element Type 2
Young's Modulus =10000.000000
Area =1.620000


 SET 3  Element Type 2
Young's Modulus =10000.000000
Area =22.000000


 SET 4  Element Type 2
Young's Modulus =10000.000000
Area =15.500000


 SET 5  Element Type 2
Young's Modulus =10000.000000
Area =1.620000


 SET 6  Element Type 2
Young's Modulus =10000.000000
Area =1.620000


 SET 7  Element Type 2
Young's Modulus =10000.000000
Area =14.200000


 SET 8  Element Type 2
Young's Modulus =10000.000000
Area =19.900000


 SET 9  Element Type 2
Young's Modulus =10000.000000
Area =19.900000


 SET 10  Element Type 2
Young's Modulus =10000.000000
Area =2.620000


-----------------------------------------------------------------

MACRO COMMANDS ::
NOTE:

Dt                 1.000000
Loop               1.000000
Time
TangForm
SolvAddU
Disp               1.000000        1        1        6        1
Stre
Next
END
-----------------------------------------------------------------

-----------------------------------------------------------------

     TIME= 1.000000
     STEP= 1/1

DISPLACEMENT ::
```

```
USER FACTOR =    1.000000e+000
LOAD CASE  1 'S FACTOR =    1.000000e+000

 NODE          1 COOR          2 COOR            1 NDF            2 NDF

    1        0.000000        0.000000  0.000000e+000  0.000000e+000
    2      360.000000        0.000000 -3.187346e-001 -9.983859e-001
    3      720.000000        0.000000 -5.380818e-001 -2.000752e+000
    4        0.000000      360.000000  0.000000e+000  0.000000e+000
    5      360.000000      360.000000  2.205325e-001 -7.589057e-001
    6      720.000000      360.000000  3.440626e-001 -1.877222e+000

Stress 1 = 6.125903e+000

Stress 2 = 3.431392e+000

Stress 3 = -8.853739e+000

Stress 4 = -6.092977e+000

Stress 5 = 6.652227e+000

Stress 6 = 3.431392e+000

Stress 7 = 9.439601e+000

Stress 8 = -7.477406e+000

Stress 9 = 6.711555e+000

Stress 10 = -3.000538e+000
1   Max 0.000000e+000   6.125903e+000 3.350000e+001
    Min 0.000000e+000
2   Max 0.000000e+000   3.431392e+000 1.620000e+000
    Min 0.000000e+000
3   Max 0.000000e+000   -8.853739e+000 2.200000e+001
    Min 2.000000e+000
4   Max 0.000000e+000   -6.092977e+000 1.550000e+001
    Min 0.000000e+000
5   Max 0.000000e+000   6.652227e+000 1.620000e+000
    Min 0.000000e+000
6   Max 0.000000e+000   3.431392e+000 1.620000e+000
    Min 0.000000e+000
7   Max 1.000000e+000   9.439601e+000 1.420000e+001
    Min 0.000000e+000
8   Max 0.000000e+000   -7.477406e+000 1.990000e+001
    Min 0.000000e+000
9   Max 0.000000e+000   6.711555e+000 1.990000e+001
    Min 0.000000e+000
10   Max 0.000000e+000   -3.000538e+000 2.620000e+000
    Min 0.000000e+000

Stressmax= 9.439601e+000

Stressmin= -8.853739e+000

AbsStressmax= 9.439601e+000

AbsStressmin= 8.853739e+000
 NO CONVERGENCE TEST 1/1
-----------------------------------------------------------------

-----------------------------------------------------------------

Terminated normally by STOP.

-----------------------------------------------------------------
```

Fifty-two-bar truss with weight of 1902.6 kgf (optimal result from the proposed ACO algorithm)

```
FINITE ELEMENT ANALYSIS PROGRAM
C++ VERSION BY PRUETTHA NANAKORN
1994.

VERSION : 960331

INPUT: 52bar1902.61NoWeight.txt
NOTE:

Number of nodal points              = 20
Number of elements                  = 52
Number of material sets             = 12
Number of Dimensions                = 2
Number of Dof's / node    (default) = 2
Number of nodes / element (Maximum) = 2
Number of load cases                = 1

NODAL COORDINATES ::
NOTE:

 NODE          1 COOR          2 COOR        dof

    1        0.000000        0.000000
    2     2000.000000        0.000000
    3     4000.000000        0.000000
    4     6000.000000        0.000000
    5        0.000000     3000.000000
    6     2000.000000     3000.000000
    7     4000.000000     3000.000000
    8     6000.000000     3000.000000
    9        0.000000     6000.000000
   10     2000.000000     6000.000000
   11     4000.000000     6000.000000
   12     6000.000000     6000.000000
   13        0.000000     9000.000000
   14     2000.000000     9000.000000
   15     4000.000000     9000.000000
   16     6000.000000     9000.000000
   17        0.000000    12000.000000
   18     2000.000000    12000.000000
   19     4000.000000    12000.000000
   20     6000.000000    12000.000000

ELEMENTS ::
NOTE:

 ELEM  MAT    1 NODE    2 NODE

    1   1         1         5
    2   1         2         6
    3   1         3         7
    4   1         4         8
    5   2         2         5
    6   2         1         6
    7   2         3         6
    8   2         2         7
    9   2         4         7
   10   2         3         8
   11   3         5         6
   12   3         6         7
   13   3         7         8
   14   4         5         9
   15   4         6        10
   16   4         7        11
   17   4         8        12
   18   5         6         9
   19   5         5        10
   20   5         7        10
   21   5         6        11
   22   5         8        11
   23   5         7        12
   24   6         9        10
   25   6        10        11
```

26	6	11	12
27	7	9	13
28	7	10	14
29	7	11	15
30	7	12	16
31	8	10	13
32	8	9	14
33	8	11	14
34	8	10	15
35	8	12	15
36	8	11	16
37	9	13	14
38	9	14	15
39	9	15	16
40	10	13	17
41	10	14	18
42	10	15	19
43	10	16	20
44	11	14	17
45	11	13	18
46	11	15	18
47	11	14	19
48	11	16	19
49	11	15	20
50	12	17	18
51	12	18	19
52	12	19	20

BOUNDARIES ::
NOTE:

NODE	1 NDF	2 NDF
1	1	1
2	1	1
3	1	1
4	1	1

NODAL FORCED BOUNDARY VALUE ::
NOTE:

LOAD CASE: 1

NODE	1 NDF	2 NDF
17	100000.000000	200000.000000
18	100000.000000	200000.000000
19	100000.000000	200000.000000
20	100000.000000	200000.000000

PROPORTIONAL LOADING ::
NOTE:

LOADING CONTROL

LOAD CASE: 1

	Tmin A3	Tmax A4	A1 A5	A2 L
1	0.000000 0.000000	100.000000 0.000000	0.000000 0.000000	1.000000 0.000000

MATERIAL PROPERTIES ::
NOTE:

SET 1 Element Type 2
Young's Modulus =207000.000000
Area =4658.055000

SET 2 Element Type 2
Young's Modulus =207000.000000
Area =1161.288000

SET 3 Element Type 2
Young's Modulus =207000.000000
Area =494.193000

```
 SET 4  Element Type 2
Young's Modulus =207000.000000
Area =3303.219000


 SET 5  Element Type 2
Young's Modulus =207000.000000
Area =940.000000


 SET 6  Element Type 2
Young's Modulus =207000.000000
Area =494.193000


 SET 7  Element Type 2
Young's Modulus =207000.000000
Area =2238.705000


 SET 8  Element Type 2
Young's Modulus =207000.000000
Area =1008.385000


 SET 9  Element Type 2
Young's Modulus =207000.000000
Area =494.193000


 SET 10  Element Type 2
Young's Modulus =207000.000000
Area =1283.868000


 SET 11  Element Type 2
Young's Modulus =207000.000000
Area =1161.288000


 SET 12  Element Type 2
Young's Modulus =207000.000000
Area =494.193000


------------------------------------------------------------

MACRO COMMANDS ::
NOTE:

Dt               1.000000
Loop             1.000000
Time
TangForm
SolvAddU
Disp             1.000000        1        1        20        1
Stre
Next
END
------------------------------------------------------------

------------------------------------------------------------

     TIME= 1.000000
     STEP= 1/1

DISPLACEMENT ::
USER FACTOR =    1.000000e+000
LOAD CASE  1 'S FACTOR =    1.000000e+000


 NODE        1 COOR        2 COOR         1 NDF          2 NDF

    1      0.000000      0.000000  0.000000e+000  0.000000e+000
```

2	2000.000000	0.000000	0.000000e+000	0.000000e+000
3	4000.000000	0.000000	0.000000e+000	0.000000e+000
4	6000.000000	0.000000	0.000000e+000	0.000000e+000
5	0.000000	3000.000000	5.240107e+000	2.431419e+000
6	2000.000000	3000.000000	4.071861e+000	9.389795e-001
7	4000.000000	3000.000000	3.766583e+000	6.209381e-002
8	6000.000000	3000.000000	4.166531e+000	-1.291827e+000
9	0.000000	6000.000000	1.223166e+001	5.036712e+000
10	2000.000000	6000.000000	1.104212e+001	2.274434e+000
11	4000.000000	6000.000000	1.047975e+001	2.600235e-001
12	6000.000000	6000.000000	1.060255e+001	-2.377064e+000
13	0.000000	9000.000000	2.060267e+001	7.640765e+000
14	2000.000000	9000.000000	1.937449e+001	3.803048e+000
15	4000.000000	9000.000000	1.875106e+001	8.456983e-001
16	6000.000000	9000.000000	1.840034e+001	-2.892713e+000
17	0.000000	12000.000000	2.986551e+001	1.020626e+001
18	2000.000000	12000.000000	2.826587e+001	5.448211e+000
19	4000.000000	12000.000000	2.751277e+001	1.917690e+000
20	6000.000000	12000.000000	2.769513e+001	-2.170358e+000

Stressmax= 1.797652e+002

Stressmin= -1.655633e+002

AbsStressmax= 1.797652e+002

AbsStressmin= 1.655633e+002
NO CONVERGENCE TEST 1/1

Terminated normally by STOP.

Fifty-two-bar truss with weight of 1972.7 kgf (optimal result from Wu and Chow, 1995)

```
FINITE ELEMENT ANALYSIS PROGRAM
C++ VERSION BY PRUETTHA NANAKORN
1994.

VERSION : 960331

INPUT: 52bar1972.7ShyueJianWuNoWeight.txt
NOTE:

Number of nodal points                  = 20
Number of elements                      = 52
Number of material sets                 = 12
Number of Dimensions                    = 2
Number of Dof's / node      (default)   = 2
Number of nodes / element   (Maximum)   = 2
Number of load cases                    = 1

NODAL COORDINATES ::
NOTE:
```

NODE	1 COOR	2 COOR	dof
1	0.000000	0.000000	
2	2000.000000	0.000000	
3	4000.000000	0.000000	
4	6000.000000	0.000000	
5	0.000000	3000.000000	
6	2000.000000	3000.000000	
7	4000.000000	3000.000000	
8	6000.000000	3000.000000	
9	0.000000	6000.000000	
10	2000.000000	6000.000000	
11	4000.000000	6000.000000	
12	6000.000000	6000.000000	
13	0.000000	9000.000000	
14	2000.000000	9000.000000	
15	4000.000000	9000.000000	
16	6000.000000	9000.000000	
17	0.000000	12000.000000	
18	2000.000000	12000.000000	
19	4000.000000	12000.000000	
20	6000.000000	12000.000000	

```
ELEMENTS ::
NOTE:
```

ELEM	MAT	1 NODE	2 NODE
1	1	1	5
2	1	2	6
3	1	3	7
4	1	4	8
5	2	2	5
6	2	1	6
7	2	3	6
8	2	2	7
9	2	4	7
10	2	3	8
11	3	5	6
12	3	6	7
13	3	7	8
14	4	5	9
15	4	6	10
16	4	7	11
17	4	8	12
18	5	6	9
19	5	5	10
20	5	7	10
21	5	6	11
22	5	8	11
23	5	7	12
24	6	9	10
25	6	10	11

26	6	11	12
27	7	9	13
28	7	10	14
29	7	11	15
30	7	12	16
31	8	10	13
32	8	9	14
33	8	11	14
34	8	10	15
35	8	12	15
36	8	11	16
37	9	13	14
38	9	14	15
39	9	15	16
40	10	13	17
41	10	14	18
42	10	15	19
43	10	16	20
44	11	14	17
45	11	13	18
46	11	15	18
47	11	14	19
48	11	16	19
49	11	15	20
50	12	17	18
51	12	18	19
52	12	19	20

BOUNDARIES ::
NOTE:

NODE	1 NDF	2 NDF
1	1	1
2	1	1
3	1	1
4	1	1

NODAL FORCED BOUNDARY VALUE ::
NOTE:

LOAD CASE: 1

NODE	1 NDF	2 NDF
17	100000.000000	200000.000000
18	100000.000000	200000.000000
19	100000.000000	200000.000000
20	100000.000000	200000.000000

PROPORTIONAL LOADING ::
NOTE:

LOADING CONTROL

LOAD CASE: 1

	Tmin A3	Tmax A4	A1 A5	A2 L
1	0.000000 0.000000	100.000000 0.000000	0.000000 0.000000	1.000000 0.000000

MATERIAL PROPERTIES ::
NOTE:

SET 1 Element Type 2
Young's Modulus =207000.000000
Area =4658.055000

SET 2 Element Type 2
Young's Modulus =207000.000000
Area =1161.288000

SET 3 Element Type 2
Young's Modulus =207000.000000
Area =645.160000

```
 SET 4  Element Type 2
Young's Modulus =207000.000000
Area =3303.219000


 SET 5  Element Type 2
Young's Modulus =207000.000000
Area =1045.159000


 SET 6  Element Type 2
Young's Modulus =207000.000000
Area =494.193000


 SET 7  Element Type 2
Young's Modulus =207000.000000
Area =2477.414000


 SET 8  Element Type 2
Young's Modulus =207000.000000
Area =1045.159000


 SET 9  Element Type 2
Young's Modulus =207000.000000
Area =285.161000


 SET 10  Element Type 2
Young's Modulus =207000.000000
Area =1696.771000


 SET 11  Element Type 2
Young's Modulus =207000.000000
Area =1045.159000


 SET 12  Element Type 2
Young's Modulus =207000.000000
Area =641.289000


----------------------------------------------------------------

MACRO COMMANDS ::
NOTE:

Dt                1.000000
Loop              1.000000
Time
TangForm
SolvAddU
Disp              1.000000        1        1        20        1
Stre
Next
END

----------------------------------------------------------------

----------------------------------------------------------------

     TIME= 1.000000
     STEP= 1/1

DISPLACEMENT ::
USER FACTOR =    1.000000e+000
LOAD CASE  1 'S FACTOR =    1.000000e+000


 NODE         1 COOR        2 COOR          1 NDF          2 NDF

    1       0.000000      0.000000  0.000000e+000  0.000000e+000
```

```
   2    2000.000000        0.000000  0.000000e+000  0.000000e+000
   3    4000.000000        0.000000  0.000000e+000  0.000000e+000
   4    6000.000000        0.000000  0.000000e+000  0.000000e+000
   5       0.000000     3000.000000  5.101229e+000  2.422932e+000
   6    2000.000000     3000.000000  4.100765e+000  9.375873e-001
   7    4000.000000     3000.000000  3.812780e+000  5.650918e-002
   8    6000.000000     3000.000000  4.130940e+000 -1.284134e+000
   9       0.000000     6000.000000  1.181564e+001  5.003919e+000
  10    2000.000000     6000.000000  1.062700e+001  2.237866e+000
  11    4000.000000     6000.000000  1.004265e+001  2.567451e-001
  12    6000.000000     6000.000000  1.017573e+001 -2.359833e+000
  13       0.000000     9000.000000  2.017897e+001  7.388327e+000
  14    2000.000000     9000.000000  1.869967e+001  3.686808e+000
  15    4000.000000     9000.000000  1.804816e+001  8.170591e-001
  16    6000.000000     9000.000000  1.771993e+001 -2.847064e+000
  17       0.000000    12000.000000  2.881764e+001  9.446366e+000
  18    2000.000000    12000.000000  2.772231e+001  5.153455e+000
  19    4000.000000    12000.000000  2.716783e+001  1.786952e+000
  20    6000.000000    12000.000000  2.736410e+001 -2.253092e+000

Stressmax= 1.789236e+002

Stressmin= -1.531071e+002

AbsStressmax= 1.789236e+002

AbsStressmin= 1.531071e+002
 NO CONVERGENCE TEST 1/1
----------------------------------------------------------------

----------------------------------------------------------------

Terminated normally by STOP.

----------------------------------------------------------------
```

One-bay eight-story frame with weight of 7032.4 lb (optimal result from the proposed ACO algorithm)

```
FINITE ELEMENT ANALYSIS PROGRAM
C++ VERSION BY PRUETTHA NANAKORN
1994.

VERSION : 20021101


Number of nodal points                  = 18
Number of elements                      = 24
Number of material sets                 = 8
Number of Dimensions                    = 2
Number of Dof's / node       (default)  = 3
Number of nodes / element    (Maximum)  = 2
Number of load cases                    = 1

NODAL COORDINATES ::
NOTE:

 NODE        1 COOR        2 COOR        dof

   1       0.000000      0.000000
   2     120.000000      0.000000
   3       0.000000    120.000000
   4     120.000000    120.000000
   5       0.000000    240.000000
   6     120.000000    240.000000
   7       0.000000    360.000000
   8     120.000000    360.000000
   9       0.000000    480.000000
  10     120.000000    480.000000
  11       0.000000    600.000000
  12     120.000000    600.000000
  13       0.000000    720.000000
  14     120.000000    720.000000
  15       0.000000    840.000000
  16     120.000000    840.000000
  17       0.000000    960.000000
  18     120.000000    960.000000

ELEMENTS ::
NOTE:

 ELEM  MAT    1 NODE    2 NODE

   1    1        1         3
   2    1        2         4
   3    1        3         5
   4    1        4         6
   5    2        5         7
   6    2        6         8
   7    2        7         9
   8    2        8        10
   9    3        9        11
  10    3       10        12
  11    3       11        13
  12    3       12        14
  13    4       13        15
  14    4       14        16
  15    4       15        17
  16    4       16        18
  17    5        3         4
  18    5        5         6
  19    6        7         8
  20    6        9        10
  21    7       11        12
  22    7       13        14
  23    8       15        16
  24    8       17        18

BOUNDARIES ::
NOTE:
```

NODE	1 NDF	2 NDF	3 NDF
1	1	1	1
2	1	1	1

NODAL FORCED BOUNDARY VALUE ::
NOTE:

LOAD CASE: 1

NODE	1 NDF	2 NDF	3 NDF
1	0.000000	-100.000000	0.000000
2	0.000000	-100.000000	0.000000
3	0.272000	-100.000000	0.000000
4	0.000000	-100.000000	0.000000
5	0.544000	-100.000000	0.000000
6	0.000000	-100.000000	0.000000
7	0.816000	-100.000000	0.000000
8	0.000000	-100.000000	0.000000
9	1.088000	-100.000000	0.000000
10	0.000000	-100.000000	0.000000
11	1.361000	-100.000000	0.000000
12	0.000000	-100.000000	0.000000
13	1.633000	-100.000000	0.000000
14	0.000000	-100.000000	0.000000
15	1.905000	-100.000000	0.000000
16	0.000000	-100.000000	0.000000
17	2.831000	-100.000000	0.000000
18	0.000000	-100.000000	0.000000

PROPORTIONAL LOADING ::
NOTE:

LOADING CONTROL

LOAD CASE: 1

	Tmin A3	Tmax A4	A1 A5	A2 L
1	0.000000 0.000000	100.000000 0.000000	1.000000 0.000000	0.000000 0.000000

MATERIAL PROPERTIES ::
NOTE:

```
 SET 1  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus      =       29000.000000
Area                         =      10.300000
Izz                          =      510.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0   =        0.000000
QbA0   =        0.000000
QbA1   =        0.000000

 SET 2  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus      =       29000.000000
Area                         =      10.300000
Izz                          =      510.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0   =        0.000000
QbA0   =        0.000000
QbA1   =        0.000000

 SET 3  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus      =       29000.000000
Area                         =      7.680000
Izz                          =      301.000000
Hinge Data:
```

```
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 4  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus      =     29000.000000
Area                       =         4.160000
Izz                        =         88.600000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 5  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus      =     29000.000000
Area                       =         10.300000
Izz                        =         510.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 6  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus      =     29000.000000
Area                       =         13.000000
Izz                        =         843.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 7  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus      =     29000.000000
Area                       =         7.680000
Izz                        =         301.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 8  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus      =     29000.000000
Area                       =         7.680000
Izz                        =         301.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000
-----------------------------------------------------------------------

MACRO COMMANDS ::
NOTE:
```

```
Dt              1.000000
Loop            1.000000
Time
Tang
Form
Solv
Stre
FacU
AddU
SumUserFac
Disp            1.000000      1      1      18      1
Next
END
```

TIME= 1.000000
STEP= 1/1

DISPLACEMENT ::
USER FACTOR =   1.000000e+000
LOAD CASE 1 'S FACTOR =   1.000000e+000

NODE	1 COOR	2 COOR	1 NDF	2 NDF	3 NDF
1	0.000000	0.000000	0.000000e+000	-1.000000e+002	0.000000e+000
2	120.000000	0.000000	0.000000e+000	-1.000000e+002	0.000000e+000
3	0.000000	120.000000	1.151100e-001	-1.003000e+002	-1.070424e-003
4	120.000000	120.000000	1.150557e-001	-1.003428e+002	-1.069930e-003
5	0.000000	240.000000	3.127886e-001	-1.005633e+002	-1.398336e-003
6	120.000000	240.000000	3.126796e-001	-1.006419e+002	-1.398083e-003
7	0.000000	360.000000	5.253018e-001	-1.007901e+002	-1.361904e-003
8	120.000000	360.000000	5.251720e-001	-1.008972e+002	-1.361776e-003
9	0.000000	480.000000	7.395457e-001	-1.009806e+002	-1.493389e-003
10	120.000000	480.000000	7.393717e-001	-1.011084e+002	-1.492743e-003
11	0.000000	600.000000	1.018161e+000	-1.011869e+002	-2.086835e-003
12	120.000000	600.000000	1.017796e+000	-1.013331e+002	-2.085689e-003
13	0.000000	720.000000	1.320277e+000	-1.013428e+002	-2.072958e-003
14	120.000000	720.000000	1.319837e+000	-1.015006e+002	-2.072679e-003
15	0.000000	840.000000	1.692363e+000	-1.015365e+002	-1.916575e-003
16	120.000000	840.000000	1.691849e+000	-1.017047e+002	-1.915658e-003
17	0.000000	960.000000	1.984917e+000	-1.016345e+002	-1.636038e-003
18	120.000000	960.000000	1.984155e+000	-1.018057e+002	-1.635059e-003

NO CONVERGENCE TEST 1/1

Terminated normally by STOP.

One-bay eight-story frame with weight of 7376.1 lb (optimal result from Camp et al., 1998)

```
FINITE ELEMENT ANALYSIS PROGRAM
C++ VERSION BY PRUETTHA NANAKORN
1994.

VERSION : 20021101


Number of nodal points                    = 18
Number of elements                        = 24
Number of material sets                   = 8
Number of Dimensions                      = 2
Number of Dof's / node      (default)     = 3
Number of nodes / element (Maximum)       = 2
Number of load cases                      = 1

NODAL COORDINATES ::
NOTE:

 NODE          1 COOR          2 COOR          dof

   1         0.000000        0.000000
   2       120.000000        0.000000
   3         0.000000      120.000000
   4       120.000000      120.000000
   5         0.000000      240.000000
   6       120.000000      240.000000
   7         0.000000      360.000000
   8       120.000000      360.000000
   9         0.000000      480.000000
  10       120.000000      480.000000
  11         0.000000      600.000000
  12       120.000000      600.000000
  13         0.000000      720.000000
  14       120.000000      720.000000
  15         0.000000      840.000000
  16       120.000000      840.000000
  17         0.000000      960.000000
  18       120.000000      960.000000

ELEMENTS ::
NOTE:

 ELEM  MAT    1 NODE    2 NODE

   1    1        1         3
   2    1        2         4
   3    1        3         5
   4    1        4         6
   5    2        5         7
   6    2        6         8
   7    2        7         9
   8    2        8        10
   9    3        9        11
  10    3       10        12
  11    3       11        13
  12    3       12        14
  13    4       13        15
  14    4       14        16
  15    4       15        17
  16    4       16        18
  17    5        3         4
  18    5        5         6
  19    6        7         8
  20    6        9        10
  21    7       11        12
  22    7       13        14
  23    8       15        16
  24    8       17        18

BOUNDARIES ::
NOTE:
```

NODE	1 NDF	2 NDF	3 NDF
1	1	1	1
2	1	1	1

NODAL FORCED BOUNDARY VALUE ::
NOTE:

LOAD CASE: 1

NODE	1 NDF	2 NDF	3 NDF
1	0.000000	-100.000000	0.000000
2	0.000000	-100.000000	0.000000
3	0.272000	-100.000000	0.000000
4	0.000000	-100.000000	0.000000
5	0.544000	-100.000000	0.000000
6	0.000000	-100.000000	0.000000
7	0.816000	-100.000000	0.000000
8	0.000000	-100.000000	0.000000
9	1.088000	-100.000000	0.000000
10	0.000000	-100.000000	0.000000
11	1.361000	-100.000000	0.000000
12	0.000000	-100.000000	0.000000
13	1.633000	-100.000000	0.000000
14	0.000000	-100.000000	0.000000
15	1.905000	-100.000000	0.000000
16	0.000000	-100.000000	0.000000
17	2.831000	-100.000000	0.000000
18	0.000000	-100.000000	0.000000

PROPORTIONAL LOADING ::
NOTE:

LOADING CONTROL

LOAD CASE: 1

	Tmin A3	Tmax A4	A1 A5	A2 L
1	0.000000 0.000000	100.000000 0.000000	1.000000 0.000000	0.000000 0.000000

MATERIAL PROPERTIES ::
NOTE:

SET 1 Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus = 29000.000000
Area = 13.500000
Izz = 712.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0 = 0.000000
QbA0 = 0.000000
QbA1 = 0.000000

SET 2 Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus = 29000.000000
Area = 9.120000
Izz = 375.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0 = 0.000000
QbA0 = 0.000000
QbA1 = 0.000000

SET 3 Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus = 29000.000000
Area = 7.680000
Izz = 301.000000
Hinge Data:

```
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 4  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus       =      29000.000000
Area                         =        4.710000
Izz                          =        103.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 5  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus       =      29000.000000
Area                         =        10.300000
Izz                          =        510.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 6  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus       =      29000.000000
Area                         =        10.300000
Izz                          =        510.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 7  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus       =      29000.000000
Area                         =        10.300000
Izz                          =        510.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

 SET 8  Element Type 4
Two-Noded Two-Dimensional Beam-Column Element with Semi-Rigid Ends.
Young's Modulus       =      29000.000000
Area                         =        7.680000
Izz                          =        301.000000
Hinge Data:
Number of hinges = 0

Distribute loads
QaA0    =         0.000000
QbA0    =         0.000000
QbA1    =         0.000000

----------------------------------------------------------------

MACRO COMMANDS ::
NOTE:
```

```
Dt                 1.000000
Loop               1.000000
Time
Tang
Form
Solv
Stre
FacU
AddU
SumUserFac
Disp               1.000000      1       1      18      1
Next
END
```

TIME= 1.000000
STEP= 1/1

DISPLACEMENT ::
USER FACTOR =   1.000000e+000
LOAD CASE 1 'S FACTOR =   1.000000e+000

NODE	1 COOR	2 COOR	1 NDF	2 NDF	3 NDF
1	0.000000	0.000000	0.000000e+000	-1.000000e+002	0.000000e+000
2	120.000000	0.000000	0.000000e+000	-1.000000e+002	0.000000e+000
3	0.000000	120.000000	9.375979e-002	-1.002290e+002	-9.551405e-004
4	120.000000	120.000000	9.370577e-002	-1.002614e+002	-9.546400e-004
5	0.000000	240.000000	2.620693e-001	-1.004300e+002	-1.258478e-003
6	120.000000	240.000000	2.619599e-001	-1.004895e+002	-1.258105e-003
7	0.000000	360.000000	4.910806e-001	-1.006864e+002	-1.495233e-003
8	120.000000	360.000000	4.909167e-001	-1.007776e+002	-1.494861e-003
9	0.000000	480.000000	7.362968e-001	-1.009015e+002	-1.618598e-003
10	120.000000	480.000000	7.360782e-001	-1.010162e+002	-1.618230e-003
11	0.000000	600.000000	9.979905e-001	-1.011075e+002	-1.680193e-003
12	120.000000	600.000000	9.977172e-001	-1.012413e+002	-1.679863e-003
13	0.000000	720.000000	1.251416e+000	-1.012633e+002	-1.667951e-003
14	120.000000	720.000000	1.251088e+000	-1.014087e+002	-1.667457e-003
15	0.000000	840.000000	1.572868e+000	-1.014345e+002	-1.786325e-003
16	120.000000	840.000000	1.572355e+000	-1.015890e+002	-1.784972e-003
17	0.000000	960.000000	1.839543e+000	-1.015210e+002	-1.520030e-003
18	120.000000	960.000000	1.838781e+000	-1.016782e+002	-1.519042e-003

NO CONVERGENCE TEST 1/1

Terminated normally by STOP.
