NINT	l	$\tilde{\xi}_l$
1	1	0
2	1	$\frac{-1}{\sqrt{3}}$
	2	$\frac{1}{\sqrt{3}}$
3	1	$\frac{-1}{\sqrt{3/5}}$
	2	$\frac{1}{\sqrt{3/5}}$
	3	0

3. The following element components may be specified:

NCOMP	Description	Output Label
1	Axial stress	STRS
2	Axial force	FORC
3	Axial strain	STRN

11.5.3 Examples

Example 1 (Planar Truss)

Here we consider a planar truss, shown schematically with node numbers in Fig. 11.5.14, subjected to multiple static loadings. Looking at the input file given in

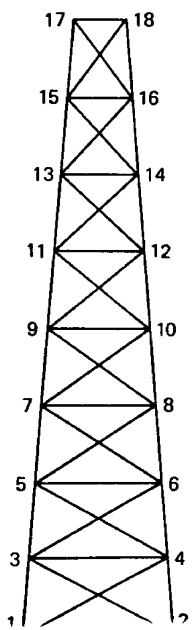

Table 11.5.1, note the use of generation capabilities, including the definition of the truss elements. In the time-sequence data we request three time steps and have set $\Delta t = 1.0$, although the code would default to this value. Two load vectors and load-time functions have been specified. The first load vector corresponds to a linearly varying lateral load, as might be used for preliminary seismic design. The second defines a uniform vertical load acting at every node. The load-time functions, shown schematically in Fig. 11.5.15, produce three different load cases combining varying proportions of the two load vectors. The output on pages 693 through 704 can be used to verify DLEARN upon installation on a new computer system.

TABLE 11.5.1 Input File for Planar Truss Problem

```
In 0.0      0
In 1.0      TRUSS TOWER WITH STATIC VERTICAL AND LATERAL LOADS
In 2.0      1     1     0     0     0     0     1     0     3    18     3     2     2     4     1
In 3.0      1     3     1     1     0     1          0.00        1.00        0.00        1.00
In 5.1      1     2          0.          0.
In 5.2     17     0         48.        768.
In 5.3      8     2
In 5.1      2     2        144.          0.
In 5.2     18     0         96.        768.
In 5.3      8     2

            1    18     1     0     0     1
In 6.0      1     0     0     1     1     1
            2     0     0     1     1     1

In 7.1      3     2        500.0       0.00       0.00
In 7.2     17     0       4000.0       0.00       0.00
In 7.3      7     2

In 7.1      3     2         0.00   -3000.0       0.00
In 7.2     18     0         0.00   -3000.0       0.00
In 7.3     15     1

            0.00          0.0
            1.00          1.0
            2.00          0.0
In 8.1      3.00          1.7
            0.00          0.0
            1.00          0.0
            2.00          1.0
            3.00          1.3
In 10.2.1   2    40       2     2     0     0     0     1     1     0
In 10.2.2   1          30000000.   7.30E-4       0.00        0.00       10.0
            2          30000000.   7.30E-4       0.00        0.00        6.0
In 10.2.3   0.00       -386.4        0.00
            1     1     1     3     1
            4     1     2
            5     1     2     4     1
            4     1     2
            9     1     3     4     1
            4     1     2
           13     2     1     4     1
            4     1     2
           17     2     2     3     1
            4     1     2
In 10.2.4.1 21    2     9    11     1
In 10.2.4.2  4    1     2
           25     2    10    12     1
            4     1     2
           29     2    11    12     1
            4     1     2
           33     2     9    12     1
            4     1     2
           37     2    10    11     1
            4     1     2
            *END
```

Coordinates

Boundary conditions

Load vector 1

Load vector 2

Load-time function 1

Load-time function 2

Element nodes

Element group

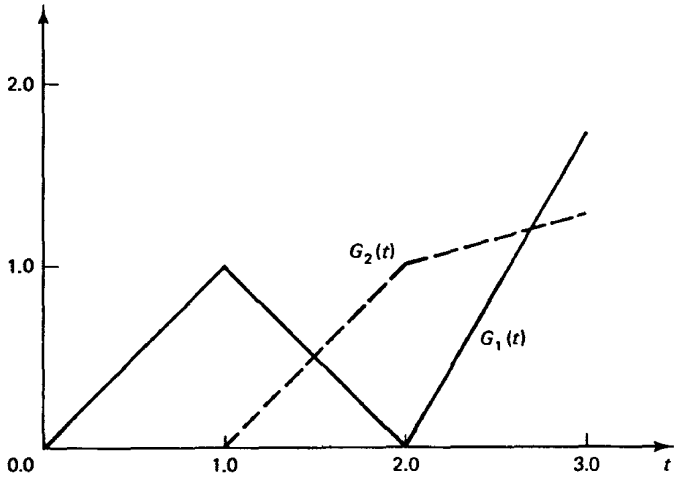

Figure 11.5.15 Load-time functions for planar truss problem.

```
TRUSS TOWER WITH STATIC VERTICAL AND LATERAL LOADS

E X E C U T I O N   C O N T R O L   I N F O R M A T I O N
     EXECUTION CODE . . . . . . . . . . . . . . . (IEXEC ) =

        EQ. 0, DATA CHECK
        EQ. 1, EXECUTION

     ANALYSIS CODE . . . . . . . . . . . . . . . . (IACODE) =

        EQ. 0, DYNAMIC ANALYSIS
        EQ. 1, STATIC ANALYSIS

     READ RESTART FILE CODE . . . . . . . . . . . (IREADR) =      1

        EQ. 0, DO NOT READ RESTART FILE
        EQ. 1, READ RESTART FILE

     WRITE RESTART FILE CODE . . . . . . . . . . . (IWRITR) =      1

        EQ. 0, DO NOT WRITE RESTART FILE
        EQ. 1, WRITE RESTART FILE

     INPUT DATA PRINT CODE . . . . . . . . . . . . (IPRTIN) =      1

        EQ. 0, PRINT NODAL AND ELEMENT INPUT DATA
        EQ. 1, DO NOT PRINT NODAL AND ELEMENT INPUT DATA

     RANK CHECK CODE . . . . . . . . . . . . . . . (IRANK ) =      1

        EQ. 0, DO NOT PERFORM RANK CHECK
        EQ. 1, PRINT NUMBERS OF ZERO AND NEGATIVE PIVOTS
        EQ. 2, PRINT ALL PIVOTS

     NUMBER OF TIME SEQUENCES . . . . . . . . . . (NUMSEQ) =      1

     NUMBER OF NODAL OUTPUT TIME-HISTORIES . . . (NDOUT ) =      0

     NUMBER OF SPACE DIMENSIONS . . . . . . . . . (NSD   ) =      3

     NUMBER OF NODAL POINTS . . . . . . . . . . . (NUMNP ) =     18

     NUMBER OF NODAL DEGREES-OF-FREEDOM . . . . (NDOF  ) =      3

     NUMBER OF LOAD VECTORS . . . . . . . . . . . (NLVECT) =      2

     NUMBER OF LOAD-TIME FUNCTIONS . . . . . . . (NLTFTN) =      2

     NUMBER OF POINTS ON LOAD-TIME FUNCTIONS . . (NPTSLF) =      4

     NUMBER OF ELEMENT GROUPS . . . . . . . . . . (NUMEG ) =      1
```

```
T I M E   S E Q U E N C E   D A T A
    NUMBER OF TIME SEQUENCES . . . . . . (NUMSEQ  ) =     1

    TIME SEQUENCE NUMBER . . . . . . . . (N       ) =     1
    NUMBER OF TIME STEPS . . . . . . . . (NSTEP(N)) =     3
    KINEMATIC PRINT INCREMENT  . . . . . (NDPRT(N)) =     1
    STRESS/STRAIN PRINT INCREMENT  . . . (NSPRT(N)) =     1
    TIME HISTORY PLOT INCREMENT  . . . . (NHPLT(N)) =     0
    NUMBER OF ITERATIONS . . . . . . . . (NITER(N)) =     1
    FIRST INTEGRATION PARAMETER  . . . . (ALPHA(N)) =  0.00000E+00
    SECOND INTEGRATION PARAMETER . . . . (BETA(N) ) =  1.00000E+00
    THIRD INTEGRATION PARAMETER  . . . . (GAMMA(N)) =  0.00000E+00
    TIME STEP  . . . . . . . . . . . . . (DT(N)   ) =  1.00000E+00

N O D A L   C O O R D I N A T E   D A T A

    NODE NO.          X1                X2                X3
       1        0.00000000E+00    0.00000000E+00    0.00000000E+00
       2        1.44000000E+02    0.00000000E+00    0.00000000E+00
       3        6.00000000E+00    9.60000000E+01    0.00000000E+00
       4        1.38000000E+02    9.60000000E+01    0.00000000E+00
       5        1.20000000E+01    1.92000000E+02    0.00000000E+00
       6        1.32000000E+02    1.92000000E+02    0.00000000E+00
       7        1.80000000E+01    2.88000000E+02    0.00000000E+00
       8        1.26000000E+02    2.88000000E+02    0.00000000E+00
       9        2.40000000E+01    3.84000000E+02    0.00000000E+00
      10        1.20000000E+02    3.84000000E+02    0.00000000E+00
      11        3.00000000E+01    4.80000000E+02    0.00000000E+00
      12        1.14000000E+02    4.80000000E+02    0.00000000E+00
      13        3.60000000E+01    5.76000000E+02    0.00000000E+00
      14        1.08000000E+02    5.76000000E+02    0.00000000E+00
      15        4.20000000E+01    6.72000000E+02    0.00000000E+00
      16        1.02000000E+02    6.72000000E+02    0.00000000E+00
      17        4.80000000E+01    7.68000000E+02    0.00000000E+00
      18        9.60000000E+01    7.68000000E+02    0.00000000E+00

N O D A L   B O U N D A R Y   C O N D I T I O N   C O D E S

    NODE NO.        DOF1       DOF2       DOF3
       1              1          1          1
       2              1          1          1
       3              0          0          1
       4              0          0          1
       5              0          0          1
       6              0          0          1
       7              0          0          1
       8              0          0          1
       9              0          0          1
      10              0          0          1
      11              0          0          1
      12              0          0          1
      13              0          0          1
      14              0          0          1
      15              0          0          1
      16              0          0          1
      17              0          0          1
      18              0          0          1

P R E S C R I B E D   F O R C E S   A N D   K I N E M A T I C
  B O U N D A R Y   C O N D I T I O N S
    LOAD VECTOR NUMBER =     1

    NODE NO.          DOF1              DOF2              DOF3
       3        5.00000000E+02    0.00000000E+00    0.00000000E+00
       5        1.00000000E+03    0.00000000E+00    0.00000000E+00
       7        1.50000000E+03    0.00000000E+00    0.00000000E+00
       9        2.00000000E+03    0.00000000E+00    0.00000000E+00
      11        2.50000000E+03    0.00000000E+00    0.00000000E+00
      13        3.00000000E+03    0.00000000E+00    0.00000000E+00
      15        3.50000000E+03    0.00000000E+00    0.00000000E+00
      17        4.00000000E+03    0.00000000E+00    0.00000000E+00
```

```
P R E S C R I B E D   F O R C E S   A N D   K I N E M A T I C
  B O U N D A R Y   C O N D I T I O N S

    LOAD VECTOR NUMBER =      2

    NODE NO.              DOF1              DOF2              DOF3
       3            0.00000000E+00   -3.00000000E+03   0.00000000E+00
       4            0.00000000E+00   -3.00000000E+03   0.00000000E+00
       5            0.00000000E+00   -3.00000000E+03   0.00000000E+00
       6            0.00000000E+00   -3.00000000E+03   0.00000000E+00
       7            0.00000000E+00   -3.00000000E+03   0.00000000E+00
       8            0.00000000E+00   -3.00000000E+03   0.00000000E+00
       9            0.00000000E+00   -3.00000000E+03   0.00000000E+00
      10            0.00000000E+00   -3.00000000E+03   0.00000000E+00
      11            0.00000000E+00   -3.00000000E+03   0.00000000E+00
      12            0.00000000E+00   -3.00000000E+03   0.00000000E+00
      13            0.00000000E+00   -3.00000000E+03   0.00000000E+00
      14            0.00000000E+00   -3.00000000E+03   0.00000000E+00
      15            0.00000000E+00   -3.00000000E+03   0.00000000E+00
      16            0.00000000E+00   -3.00000000E+03   0.00000000E+00
      17            0.00000000E+00   -3.00000000E+03   0.00000000E+00
      18            0.00000000E+00   -3.00000000E+03   0.00000000E+00

L O A D - T I M E   F U N C T I O N   D A T A

    NUMBER OF LOAD-TIME FUNTIONS . . . . . (NLTFTN  ) =      2

    FUNCTION NUMBER      1

              TIME                LOAD FACTOR

         0.00000000E+00        0.00000000E+00
         1.00000000E+00        1.00000000E+00
         2.00000000E+00        0.00000000E+00
         3.00000000E+00        1.70000000E+00

    FUNCTION NUMBER      2

              TIME                LOAD FACTOR

         0.00000000E+00        0.00000000E+00
         1.00000000E+00        0.00000000E+00
         2.00000000E+00        1.00000000E+00
         3.00000000E+00        1.30000000E+00


  E L E M E N T   G R O U P   D A T A

      ELEMENT GROUP NUMBER . . . . . . . . . . . . (NEG   ) =      1


  T W O / T H R E E - N O D E   T R U S S   E L E M E N T S

      ELEMENT TYPE NUMBER . . . . . . . . . . . . (NTYPE ) =      2

      NUMBER OF ELEMENTS . . . . . . . . . . . . (NUMEL ) =     40

      NUMBER OF ELEMENT MATERIAL SETS . . . . . . (NUMAT ) =      2

      NUMBER OF ELEMENT NODES . . . . . . . . . . (NEN   ) =      2

      NUMBER OF STRESS/STRAIN TIME HISTORIES . . (NSOUT ) =      0

      STRESS OUTPUT PRINT CODE . . . . . . . . . (ISTPRT) =      0

         EQ.0, STRESS OUTPUT PRINTED
         EQ.1, STRESS OUTPUT NOT PRINTED

      BODY FORCE LOAD-TIME FUNCTION NUMBER . . . (LFBODY) =      0

      INTEGRATION CODE . . . . . . . . . . . . . (NINT  ) =      1

         EQ.1, 1-POINT GAUSSIAN QUADRATURE
         EQ.2, 2-POINT GAUSSIAN QUADRATURE
         EQ.3, 3-POINT GAUSSIAN QUADRATURE
```

M A T E R I A L S E T D A T A

NUMBER OF MATERIAL SETS . . . . . (NUMAT) = 2

SET NUMBER	YOUNG'S MODULUS	MASS DENSITY	MASS DAMPING	STIFFNESS DAMPING	AREA
1	3.0000E+07	7.3000E-04	0.0000E+00	0.0000E+00	1.0000E+01
2	3.0000E+07	7.3000E-04	0.0000E+00	0.0000E+00	6.0000E+00

G R A V I T Y V E C T O R C O M P O N E N T S

X-1 DIRECTION . . . . . = 0.00000000E+00

X-2 DIRECTION . . . . . = -3.86400000E+02

X-3 DIRECTION . . . . . = 0.00000000E+00

E L E M E N T D A T A

ELEMENT	MATERIAL	NODE 1	NODE 2
1	1	1	3
2	1	3	5
3	1	5	7
4	1	7	9
5	1	2	4
6	1	4	6
7	1	6	8
8	1	8	10
9	1	3	4
10	1	5	6
11	1	7	8
12	1	9	10
13	2	1	4
14	2	3	6
15	2	5	8
16	2	7	10
17	2	2	3
18	2	4	5
19	2	6	7
20	2	8	9
21	2	9	11
22	2	11	13
23	2	13	15
24	2	15	17
25	2	10	12
26	2	12	14
27	2	14	16
28	2	16	18
29	2	11	12
30	2	13	14
31	2	15	16
32	2	17	18
33	2	9	12
34	2	11	14
35	2	13	16
36	2	15	18
37	2	10	11
38	2	12	13
39	2	14	15
40	2	16	17

```
TRUSS TOWER WITH STATIC VERTICAL AND LATERAL LOADS

E Q U A T I O N   S Y S T E M   D A T A
     NUMBER OF EQUATIONS . . . . . . . . . . . . . (NEQ    ) =       32
     NUMBER OF TERMS IN LEFT-HAND-SIDE MATRIX  . (NALHS ) =      192
     MEAN HALF BANDWIDTH . . . . . . . . . . . . . (MEANBW) =        6
     TOTAL LENGTH OF BLANK COMMON REQUIRED . . . (NWORDS) =     2012

 D I S P L A C E M E N T S
     STEP NUMBER =          1
     TIME        =  1.000E+00

     NODE NO.            DOF1            DOF2            DOF3
        3          -3.55458742E-02  -3.80776188E-02   0.00000000E+00
        4          -3.39701332E-02   2.82149641E-02   0.00000000E+00
        5          -1.18072704E-01  -6.85865605E-02   0.00000000E+00
        6          -1.16727240E-01   4.99146888E-02   0.00000000E+00
        7          -2.46087075E-01  -9.10080677E-02   0.00000000E+00
        8          -2.44821303E-01   6.49165276E-02   0.00000000E+00
        9          -4.15844342E-01  -1.05185369E-01   0.00000000E+00
       10          -4.14547637E-01   7.29927551E-02   0.00000000E+00
       11          -6.33329338E-01  -1.22704195E-01   0.00000000E+00
       12          -6.31285639E-01   8.31843360E-02   0.00000000E+00
       13          -9.00366267E-01  -1.27236953E-01   0.00000000E+00
       14          -8.98780674E-01   8.21569828E-02   0.00000000E+00
       15          -1.20224430E+00  -1.20066166E-01   0.00000000E+00
       16          -1.20101352E+00   7.13913000E-02   0.00000000E+00
       17          -1.52011008E+00  -1.04034181E-01   0.00000000E+00
       18          -1.51917308E+00   5.35084016E-02   0.00000000E+00
```

ENT STRESSES AND STRAINS

ENT GROUP NUMBER . . . . . (NEG) = 1

INT. PT. NUMBER	X1 COORD.	X2 COORD.	X3 COORD.	STRESS	FORCE	STRAIN
1	3.00E+00	4.80E+01	0.00E+00	-1.25E+04	-1.25E+05	-4.18E-04
1	9.00E+00	1.44E+02	0.00E+00	-1.11E+04	-1.11E+05	-3.70E-04
1	1.50E+01	2.40E+02	0.00E+00	-9.47E+03	-9.47E+04	-3.16E-04
1	2.10E+01	3.36E+02	0.00E+00	-7.72E+03	-7.72E+04	-2.57E-04
1	1.41E+02	4.80E+01	0.00E+00	9.44E+03	9.44E+04	3.15E-04
1	1.35E+02	1.44E+02	0.00E+00	8.36E+03	8.36E+04	2.79E-04
1	1.29E+02	2.40E+02	0.00E+00	7.16E+03	7.16E+04	2.39E-04
1	1.23E+02	3.36E+02	0.00E+00	5.82E+03	5.82E+04	1.94E-04
1	7.20E+01	9.60E+01	0.00E+00	3.58E+02	3.58E+03	1.19E-05
1	7.20E+01	1.92E+02	0.00E+00	3.36E+02	3.36E+03	1.12E-05
1	7.20E+01	2.88E+02	0.00E+00	3.52E+02	3.52E+03	1.17E-05
1	7.20E+01	3.84E+02	0.00E+00	4.05E+02	4.05E+03	1.35E-05
1	6.90E+01	4.80E+01	0.00E+00	-2.10E+03	-1.26E+04	-7.00E-05
1	6.90E+01	1.44E+02	0.00E+00	-2.13E+03	-1.28E+04	-7.10E-05
1	6.90E+01	2.40E+02	0.00E+00	-2.21E+03	-1.32E+04	-7.35E-05
1	6.90E+01	3.36E+02	0.00E+00	-2.20E+03	-1.32E+04	-7.33E-05
1	7.50E+01	4.80E+01	0.00E+00	1.33E+03	7.96E+03	4.42E-05
1	7.50E+01	1.44E+02	0.00E+00	1.56E+03	9.35E+03	5.20E-05
1	7.50E+01	2.40E+02	0.00E+00	1.65E+03	9.87E+03	5.49E-05
1	7.50E+01	3.36E+02	0.00E+00	1.70E+03	1.02E+04	5.68E-05
1	2.70E+01	4.32E+02	0.00E+00	-9.68E+03	-5.81E+04	-3.23E-04
1	3.30E+01	5.28E+02	0.00E+00	-6.61E+03	-3.96E+04	-2.20E-04
1	3.90E+01	6.24E+02	0.00E+00	-3.64E+03	-2.18E+04	-1.21E-04
1	4.50E+01	7.20E+02	0.00E+00	-1.19E+03	-7.16E+03	-3.98E-05

E L E M E N T S T R E S S E S A N D S T R A I N S

ELEMENT GROUP NUMBER . . . . . (NEG) = 1

ELEMENT NUMBER	INT. PT. NUMBER	X1 COORD.	X2 COORD.	X3 COORD.	STRESS	FORCE	STRA
25	1	1.17E+02	4.32E+02	0.00E+00	7.39E+03	4.43E+04	2.46E
26	1	1.11E+02	5.28E+02	0.00E+00	4.88E+03	2.93E+04	1.63E
27	1	1.05E+02	6.24E+02	0.00E+00	2.53E+03	1.52E+04	8.43E
28	1	9.90E+01	7.20E+02	0.00E+00	6.23E+02	3.74E+03	2.08E
29	1	7.20E+01	4.80E+02	0.00E+00	7.30E+02	4.38E+03	2.43E
30	1	7.20E+01	5.76E+02	0.00E+00	6.61E+02	3.96E+03	2.20E
31	1	7.20E+01	6.72E+02	0.00E+00	6.15E+02	3.69E+03	2.05E
32	1	7.20E+01	7.68E+02	0.00E+00	5.86E+02	3.51E+03	1.95E
33	1	6.90E+01	4.32E+02	0.00E+00	-2.26E+03	-1.36E+04	-7.54E
34	1	6.90E+01	5.28E+02	0.00E+00	-2.04E+03	-1.22E+04	-6.79E
35	1	6.90E+01	6.24E+02	0.00E+00	-1.71E+03	-1.03E+04	-5.71E
36	1	6.90E+01	7.20E+02	0.00E+00	-1.12E+03	-6.69E+03	-3.72E
37	1	7.50E+01	4.32E+02	0.00E+00	1.57E+03	9.39E+03	5.22E
38	1	7.50E+01	5.28E+02	0.00E+00	1.54E+03	9.27E+03	5.15E
39	1	7.50E+01	6.24E+02	0.00E+00	1.36E+03	8.16E+03	4.53E
40	1	7.50E+01	7.20E+02	0.00E+00	9.65E+02	5.79E+03	3.22E

D I S P L A C E M E N T S

STEP NUMBER = 2

TIME = 2.000E+00

NODE NO.	DOF1	DOF2	DOF3
3	-1.03904457E-03	-7.03705120E-03	0.00000000E+00
4	1.03904457E-03	-7.03705120E-03	0.00000000E+00
5	-7.97810718E-04	-1.32947618E-02	0.00000000E+00
6	7.97810718E-04	-1.32947618E-02	0.00000000E+00
7	-6.72223927E-04	-1.85330487E-02	0.00000000E+00
8	6.72223927E-04	-1.85330487E-02	0.00000000E+00
9	-6.43972712E-04	-2.28047225E-02	0.00000000E+00
10	6.43972712E-04	-2.28047225E-02	0.00000000E+00
11	-9.38067044E-04	-2.78375422E-02	0.00000000E+00
12	9.38067044E-04	-2.78375422E-02	0.00000000E+00
13	-5.64200278E-04	-3.15277555E-02	0.00000000E+00
14	5.64200278E-04	-3.15277555E-02	0.00000000E+00
15	-2.80376309E-04	-3.38077792E-02	0.00000000E+00
16	2.80376309E-04	-3.38077792E-02	0.00000000E+00
17	-6.37576302E-05	-3.48593216E-02	0.00000000E+00
18	6.37576302E-05	-3.48593216E-02	0.00000000E+00

INT STRESSES AND STRAINS

INT GROUP NUMBER . . . . . (NEG) = 1

INT. PT. NUMBER	X1 COORD.	X2 COORD.	X3 COORD.	STRESS	FORCE	STRAIN
1	3.00E+00	4.80E+01	0.00E+00	-2.21E+03	-2.21E+04	-7.37E-05
1	9.00E+00	1.44E+02	0.00E+00	-1.94E+03	-1.94E+04	-6.48E-05
1	1.50E+01	2.40E+02	0.00E+00	-1.63E+03	-1.63E+04	-5.43E-05
1	2.10E+01	3.36E+02	0.00E+00	-1.33E+03	-1.33E+04	-4.43E-05
1	1.41E+02	4.80E+01	0.00E+00	-2.21E+03	-2.21E+04	-7.37E-05
1	1.35E+02	1.44E+02	0.00E+00	-1.94E+03	-1.94E+04	-6.48E-05
1	1.29E+02	2.40E+02	0.00E+00	-1.63E+03	-1.63E+04	-5.43E-05
1	1.23E+02	3.36E+02	0.00E+00	-1.33E+03	-1.33E+04	-4.43E-05
1	7.20E+01	9.60E+01	0.00E+00	4.72E+02	4.72E+03	1.57E-05
1	7.20E+01	1.92E+02	0.00E+00	3.99E+02	3.99E+03	1.33E-05
1	7.20E+01	2.88E+02	0.00E+00	3.73E+02	3.73E+03	1.24E-05
1	7.20E+01	3.84E+02	0.00E+00	4.02E+02	4.02E+03	1.34E-05
1	6.90E+01	4.80E+01	0.00E+00	-5.65E+02	-3.39E+03	-1.88E-05
1	6.90E+01	1.44E+02	0.00E+00	-4.42E+02	-2.65E+03	-1.47E-05
1	6.90E+01	2.40E+02	0.00E+00	-4.53E+02	-2.72E+03	-1.51E-05
1	6.90E+01	3.36E+02	0.00E+00	-4.22E+02	-2.53E+03	-1.41E-05
1	7.50E+01	4.80E+01	0.00E+00	-5.65E+02	-3.39E+03	-1.88E-05
1	7.50E+01	1.44E+02	0.00E+00	-4.42E+02	-2.65E+03	-1.47E-05
1	7.50E+01	2.40E+02	0.00E+00	-4.53E+02	-2.72E+03	-1.51E-05
1	7.50E+01	3.36E+02	0.00E+00	-4.22E+02	-2.53E+03	-1.41E-05
1	2.70E+01	4.32E+02	0.00E+00	-1.57E+03	-9.43E+03	-5.24E-05
1	3.30E+01	5.28E+02	0.00E+00	-1.14E+03	-6.85E+03	-3.80E-05
1	3.90E+01	6.24E+02	0.00E+00	-7.04E+02	-4.23E+03	-2.35E-05
1	4.50E+01	7.20E+02	0.00E+00	-3.23E+02	-1.94E+03	-1.08E-05

E L E M E N T S T R E S S E S A N D S T R A I N S

ELEMENT GROUP NUMBER . . . . . (NEG) = 1

ELEMENT NUMBER	INT. PT. NUMBER	X1 COORD.	X2 COORD.	X3 COORD.	STRESS	FORCE	STRAI
25	1	1.17E+02	4.32E+02	0.00E+00	-1.57E+03	-9.43E+03	-5.24E-
26	1	1.11E+02	5.28E+02	0.00E+00	-1.14E+03	-6.85E+03	-3.80E-
27	1	1.05E+02	6.24E+02	0.00E+00	-7.04E+02	-4.23E+03	-2.35E-
28	1	9.90E+01	7.20E+02	0.00E+00	-3.23E+02	-1.94E+03	-1.08E-
29	1	7.20E+01	4.80E+02	0.00E+00	6.70E+02	4.02E+03	2.23E-
30	1	7.20E+01	5.76E+02	0.00E+00	4.70E+02	2.82E+03	1.57E-
31	1	7.20E+01	6.72E+02	0.00E+00	2.80E+02	1.68E+03	9.35E-
32	1	7.20E+01	7.68E+02	0.00E+00	7.97E+01	4.78E+02	2.66E-
33	1	6.90E+01	4.32E+02	0.00E+00	-5.90E+02	-3.54E+03	-1.97E-
34	1	6.90E+01	5.28E+02	0.00E+00	-4.65E+02	-2.79E+03	-1.55E-
35	1	6.90E+01	6.24E+02	0.00E+00	-3.61E+02	-2.16E+03	-1.20E-
36	1	6.90E+01	7.20E+02	0.00E+00	-2.04E+02	-1.22E+03	-6.79E-
37	1	7.50E+01	4.32E+02	0.00E+00	-5.90E+02	-3.54E+03	-1.97E-
38	1	7.50E+01	5.28E+02	0.00E+00	-4.65E+02	-2.79E+03	-1.55E-
39	1	7.50E+01	6.24E+02	0.00E+00	-3.61E+02	-2.16E+03	-1.20E-
40	1	7.50E+01	7.20E+02	0.00E+00	-2.04E+02	-1.22E+03	-6.79E-

D I S P L A C E M E N T S

STEP NUMBER = 3

TIME = 3.000E+00

NODE NO.	DOF1	DOF2	DOF3
3	3.34677851E-02	2.40035164E-02	0.00000000E+00
4	3.60482223E-02	-4.22890665E-02	0.00000000E+00
5	1.16477083E-01	4.19970369E-02	0.00000000E+00
6	1.18322861E-01	-7.65042123E-02	0.00000000E+00
7	2.44742627E-01	5.39419704E-02	0.00000000E+00
8	2.46165751E-01	-1.01982625E-01	0.00000000E+00
9	4.14556396E-01	5.95759242E-02	0.00000000E+00
10	4.15835582E-01	-1.18602200E-01	0.00000000E+00
11	6.31453204E-01	6.70291111E-02	0.00000000E+00
12	6.33161773E-01	-1.38859420E-01	0.00000000E+00
13	8.99237866E-01	6.41814424E-02	0.00000000E+00
14	8.99909074E-01	-1.45212494E-01	0.00000000E+00
15	1.20168354E+00	5.24506079E-02	0.00000000E+00
16	1.20157427E+00	-1.39006859E-01	0.00000000E+00
17	1.51998256E+00	3.43155377E-02	0.00000000E+00
18	1.51930059E+00	-1.23227045E-01	0.00000000E+00

E M E N T S T R E S S E S A N D S T R A I N S

ELEMENT GROUP NUMBER . . . . . (NEG) = 1

ENT BER	INT. PT. NUMBER	X1 COORD.	X2 COORD.	X3 COORD.	STRESS	FORCE	STRAIN
1	1	3.00E+00	4.80E+01	0.00E+00	8.12E+03	8.12E+04	2.71E-04
2	1	9.00E+00	1.44E+02	0.00E+00	7.22E+03	7.22E+04	2.41E-04
3	1	1.50E+01	2.40E+02	0.00E+00	6.21E+03	6.21E+04	2.07E-04
4	1	2.10E+01	3.36E+02	0.00E+00	5.06E+03	5.06E+04	1.69E-04
5	1	1.41E+02	4.80E+01	0.00E+00	-1.39E+04	-1.39E+05	-4.62E-04
6	1	1.35E+02	1.44E+02	0.00E+00	-1.23E+04	-1.23E+05	-4.08E-04
7	1	1.29E+02	2.40E+02	0.00E+00	-1.04E+04	-1.04E+05	-3.47E-04
8	1	1.23E+02	3.36E+02	0.00E+00	-8.47E+03	-8.47E+04	-2.82E-04
9	1	7.20E+01	9.60E+01	0.00E+00	5.86E+02	5.86E+03	1.95E-05
10	1	7.20E+01	1.92E+02	0.00E+00	4.61E+02	4.61E+03	1.54E-05
11	1	7.20E+01	2.88E+02	0.00E+00	3.95E+02	3.95E+03	1.32E-05
12	1	7.20E+01	3.84E+02	0.00E+00	4.00E+02	4.00E+03	1.33E-05
13	1	6.90E+01	4.80E+01	0.00E+00	9.71E+02	5.83E+03	3.24E-05
14	1	6.90E+01	1.44E+02	0.00E+00	1.25E+03	7.48E+03	4.16E-05
15	1	6.90E+01	2.40E+02	0.00E+00	1.30E+03	7.80E+03	4.33E-05
16	1	6.90E+01	3.36E+02	0.00E+00	1.36E+03	8.14E+03	4.52E-05
17	1	7.50E+01	4.80E+01	0.00E+00	-2.46E+03	-1.47E+04	-8.19E-05
18	1	7.50E+01	1.44E+02	0.00E+00	-2.44E+03	-1.47E+04	-8.14E-05
19	1	7.50E+01	2.40E+02	0.00E+00	-2.55E+03	-1.53E+04	-8.50E-05
20	1	7.50E+01	3.36E+02	0.00E+00	-2.55E+03	-1.53E+04	-8.49E-05
21	1	2.70E+01	4.32E+02	0.00E+00	6.54E+03	3.92E+04	2.18E-04
22	1	3.30E+01	5.28E+02	0.00E+00	4.32E+03	2.59E+04	1.44E-04
23	1	3.90E+01	6.24E+02	0.00E+00	2.23E+03	1.34E+04	7.44E-05
24	1	4.50E+01	7.20E+02	0.00E+00	5.47E+02	3.28E+03	1.82E-05

E L E M E N T S T R E S S E S A N D S T R A I N S

ELEMENT GROUP NUMBER . . . . . (NEG) = 1

ELEMENT NUMBER	INT. PT. NUMBER	X1 COORD.	X2 COORD.	X3 COORD.	STRESS	FORCE	STRAI
25	1	1.17E+02	4.32E+02	0.00E+00	-1.05E+04	-6.32E+04	-3.51E-
26	1	1.11E+02	5.28E+02	0.00E+00	-7.17E+03	-4.30E+04	-2.39E-
27	1	1.05E+02	6.24E+02	0.00E+00	-3.94E+03	-2.36E+04	-1.31E-
28	1	9.90E+01	7.20E+02	0.00E+00	-1.27E+03	-7.62E+03	-4.23E-
29	1	7.20E+01	4.80E+02	0.00E+00	6.10E+02	3.66E+03	2.03E-
30	1	7.20E+01	5.76E+02	0.00E+00	2.80E+02	1.68E+03	9.32E-
31	1	7.20E+01	6.72E+02	0.00E+00	-5.46E+01	-3.28E+02	-1.82E-
32	1	7.20E+01	7.68E+02	0.00E+00	-4.26E+02	-2.56E+03	-1.42E-
33	1	6.90E+01	4.32E+02	0.00E+00	1.08E+03	6.49E+03	3.61E-
34	1	6.90E+01	5.28E+02	0.00E+00	1.11E+03	6.64E+03	3.69E-
35	1	6.90E+01	6.24E+02	0.00E+00	9.91E+02	5.94E+03	3.30E-
36	1	6.90E+01	7.20E+02	0.00E+00	7.08E+02	4.25E+03	2.36E-
37	1	7.50E+01	4.32E+02	0.00E+00	-2.75E+03	-1.65E+04	-9.15E-
38	1	7.50E+01	5.28E+02	0.00E+00	-2.47E+03	-1.48E+04	-8.25E-
39	1	7.50E+01	6.24E+02	0.00E+00	-2.08E+03	-1.25E+04	-6.94E-
40	1	7.50E+01	7.20E+02	0.00E+00	-1.37E+03	-8.24E+03	-4.58E-

A M I C S T O R A G E A L L O C A T I O N I N F O R M A T I O N

ARRAY NO.	ARRAY	ADDRESS	DIM1	DIM2	DIM3	PREC.
1	NSTEP	1	1	0	0	1
2	NDPRT	3	1	0	0	1
3	NSPRT	5	1	0	0	1
4	NHPLT	7	1	0	0	1
5	NITER	9	1	0	0	1
6	ALPHA	11	1	0	0	2
7	BETA	13	1	0	0	2
8	GAMMA	15	1	0	0	2
9	DT	17	1	0	0	2
10	D	19	3	18	0	2
11	X	127	3	18	0	2
12	ID	235	3	18	0	1
13	F	289	3	18	2	2
14	G	505	4	2	2	2
15	G1	537	2	0	0	2
16	IDIAG	541	32	0	0	1
17	NGRP	573	1	0	0	1
*****	BEGIN ELEMENT GROUP NUMBER 1					
18	NPAR	575	16	0	0	1
19	MP	591	29	0	0	1
20	W	621	1	0	0	2
21	DET	623	1	0	0	2
22	SHL	625	2	2	1	2
23	SHG	633	2	2	1	2
24	XS	641	3	1	0	2
25	RHO	647	2	0	0	2
26	RDAMPM	651	2	0	0	2
27	RDAMPK	655	2	0	0	2
28	AREA	659	2	0	0	2
29	C	663	1	1	2	2
30	GRAV	667	3	0	0	2
31	IEN	673	2	40	0	1
32	MAT	753	40	0	0	1
33	LM	793	3	2	40	1
34	ELEFFM	1033	6	6	0	2
35	XL	1105	3	2	0	2
36	WORK	1117	16	0	0	2
37	B	1149	1	6	0	2
38	DMAT	1161	1	1	0	2
39	DB	1163	1	6	0	2
40	VL	1175	3	2	0	2
41	AL	1187	3	2	0	2
42	ELRESF	1199	6	0	0	2
43	DL	1211	3	2	0	2
44	STRAIN	1223	1	0	0	2
45	STRESS	1225	1	0	0	2
46	FORCE	1227	1	0	0	2
*****	END ELEMENT GROUP DATA					
47	ALHS	1229	192	0	0	2
48	BRHS	1613	32	0	0	2

TRUSS TOWER WITH STATIC VERTICAL AND LATERAL LOADS

E X E C U T I O N T I M I N G I N F O R M A T I O N

I N I T I A L I Z A T I O N P H A S E	=	1.578E+00
S O L U T I O N P H A S E	=	2.461E+00
FORMATION OF LEFT-HAND-SIDE MATRICES	=	1.797E-01
FACTORIZATIONS	=	1.953E-02
FORMATION OF RIGHT-HAND-SIDE VECTORS	=	5.859E-02
FORWARD REDUCTIONS/BACK SUBSTITUTIONS	=	1.953E-02
CALCULATION OF ELEMENT OUTPUT	=	1.781E+00

SUBTOTAL	=	2.059E+00

Example 2 (Static Analysis of a Plane Strain Cantilever Beam)

This problem illustrates the use of the four-node quadrilateral, elastic continuum element. The mathematical model and corresponding mesh are shown in Figs. 4.4.1 and 4.4.2. In Table 11.5.2 we present the input file needed for one of the static analyses discussed in Chapter 4. Notice that the nodes have been numbered in a manner that minimizes the bandwidth of the effective mass matrix M^* (i.e., the stiffness matrix K). Observe that the boundary condition codes are set to allow warping of the root section of the cantilever, which is consistent with the analytic solution. The single load vector specified represents the consistent nodal loads $f_a^\varepsilon = \int N_a f \, d\Omega$ computed from the surface tractions defined in Chapter 4. In this example, the nodal loads were computed by hand. An alternative procedure is to use the element surface loads described in Sec. In.10.1.5. However, note that the element surface loads are restricted to piecewise linear variation. The parabolic variation of end shear cannot be exactly represented by *continuous* piecewise linear variation, but it can be exactly represented by *discontinuous* piecewise linear interpolation (see Sec. 1.15, Exercise 1).

TABLE 11.5.2 Input File for Static Analysis of Cantilever Beam

```
ln 0.0      0
ln 1.0      PLANE STRAIN CANTILEVER BEAM: STATIC ANALYSIS WITH CONSISTENT NODAL FORCES
ln 2.0      1     1     0     0     0     0     1     0     2    45     2     1     1     1     1
ln 3.0      1     1     1     1     0     1           0.0         0.0         0.0         1.0
ln 5.1      1     4           0.0         0.0
ln 5.2                       16.0         0.0
                             16.0         2.0
                              0.0         2.0
ln 5.3      8     5     4     1                                   Coordinates
            1                 1     1
ln 6.0      5                 1     0
            6    41     5     1     0                            Boundary conditions
            2        -7.500E-01   0.17383
            3        -1.500E+00   0.13867
            4        -2.250E+00   0.08008
            5         0.000E+00   0.01465
ln 7.1     41         0.000E+00  -0.09280                        Load vector
           42         0.000E+00  -0.17383
           43         0.000E+00  -0.13867
           44         0.000E+00  -0.08008
           45         0.000E+00  -0.01465
ln 8.1        0.0         1.0
ln 10.1.1   1    32     1     0     0     1     0     0     0     0     0     0     0
ln 10.1.2   1                1.00       0.300           0.0         0.0         0.0
ln 10.1.3                                                                                  Element
ln 10.1.4.1 1     1     1     6     7     2     1                                          group
ln 10.1.4.2 8     4     5     4     1     1                 Element nodes
            *END
```

Example 3 (Dynamic Analysis of a Plane Strain Cantilever Beam)

This problem, like the previous one, employs the configuration illustrated in Figs. 4.4.1 and 4.4.2. However, here the beam is forced dynamically. The beam is assumed initially at rest and all loads, namely, those of the static linear elasticity solution, are applied instantaneously at $t = 0^+$. The following data were employed in this calculation:

$$P(t) = 1000H(t) \qquad \text{(load factor, see Sec. 4.4)}$$

$$\left.\begin{aligned} \lambda &= 1.2 \times 10^6 \\ \mu &= 0.8 \times 10^6 \end{aligned}\right\} \qquad \text{(Lamé parameters)}$$

$$\rho = 2.0 \times 10^{-3} \qquad \text{(density)}$$