CHAPTER 2

PLANE TRUSS

CONTENTS

2.1 Introduction

The material presented in Chapter 1 of this manual is a prerequisite for a reasonable understanding of the materials presented in this Chapter.

A plane truss structure is a system of members interconnected by hinged joints, lying in a plane. The plane chosen is at the user's option and is specified in the TYPE command. All loads act in the plane of the structure and must be applied at the joints. STRUDL does not handle member loads on a truss structure, the user must resolve member loads into equivalent joint loads. Loads applied at the joints must be resolved into loads in the direction of the two global axes of the chosen plane. The axial deformations considered in the analysis result from tension and compression forces in the members. Axial forces act through the centroids of the member cross-sections, thereby eliminating bending moments in the members.

STRUDL provides the engineer with two basic analysis capabilities. The DETERMINATE ANALYSIS for determinate structures and the STIFFNESS ANALYSIS for both determinate and indeterminate structures. The DETERMINATE ANALYSIS has the advantage that it does not require the specification of member properties and the disadvantage that only member and joint forces are obtained in the results. The member properties required to perform a STIFFNESS ANALYSIS are:

a. Cross-Sectional Area
b. Member Length
c. Modules of Elasticity

The example problems presented in this chapter illustrate how STRUDL may be used to analyze a simple truss. The first problem shown in Figure 2.2a is solved using the DETERMINATE ANALYSIS capability. This same problem when modified by the addition of a second diagonal member, (for the second problem) makes the problem indeterminate and thus requires a STIFFNESS ANALYSIS. The second problem is shown in Figure 2.3a.

2.2 Determinate Truss Problem

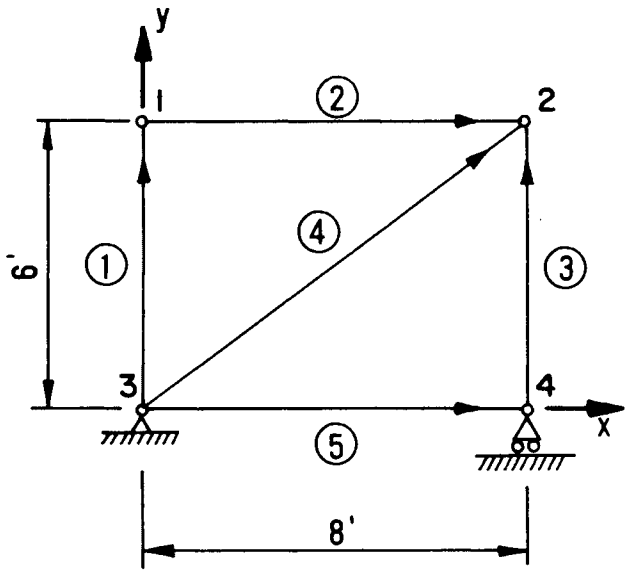
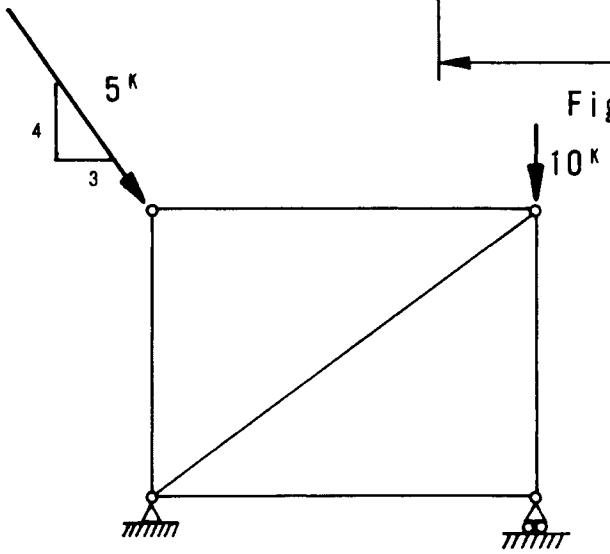
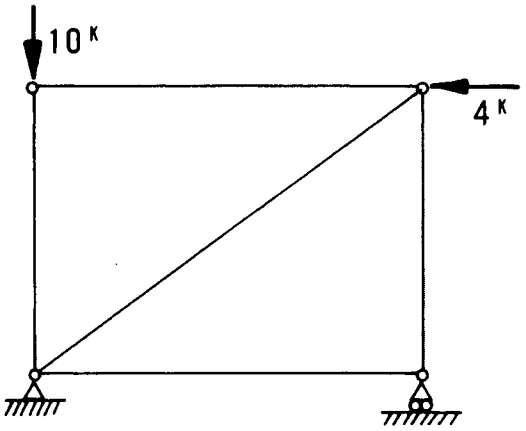


Fig- 2.2a



LOADING 1

Fig. 2.2b



LOADING 2

Fig. 2.2c

The ICES coding form shown below contains the STRUDL input commands used to describe the geometry and topology of the truss shown in Figure 2.2a subjected to the loading conditions shown in Figures 2.2b and 2.2c. The user identification

and sequence number follow the "$" to the right of the input command. Instructions on the procedures for filling out input forms and submitting problems are covered in Appendix E.

The first command calls the STRUDL subsystem and initializes the system for a new problem. The second command TYPE PLANE TRUSS identifies the structural type and also specifies the plane to be used for two-dimensional structures. No plane is given here so the assumed XY plane will be used.

The origin of the global axes system is taken at the left support joint with positive directions as indicated by the coordinate axes. The units given for this problem are in feet and kips. STRUDL assumes that the units are inches, pounds, radians, etc., unless specified otherwise by the user. The UNITS FEET KIPS command informs STRUDL of the units of length and force to be used in the input and output commands that follow.

Using the joint numbering shown, the joint coordinates are listed below the JOINT COORDINATES command on line 0040. This command specifies the structural geometry and the support joints. The support joints are assumed fully fixed in accordance with the structural TYPE specified. Joint 4 is free to move in the X-Global direction; therefore, it must be released as shown by the JOINT RELEASE COMMAND on line 0090.

The MEMBER INCIDENCES command is used to define the structural connectivity and to establish the directions of the local member X-axes (the positive direction being from the starting joint number to the ending joint number). Using the assigned member numbers and the directions as indicated by the arrows, the member number followed by the starting joint number and the ending joint number are listed for each member below the MEMBER INCIDENCE command.

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COMPUTER SYSTEMS

ICES

ADDRESS DIST. GROUP BATCH: $ 14 705

SUBSYSTEM NAME | SOURCE DIST. UNIT | CHARGE DIST. UNIT | EXPENDITURE AUTHORIZATION | SPECIAL DESIGNATION WHEN APPLICABLE | SEQUENCE

```
STRUDL 'PROB. 2.2'                                        0001
TYPE PLANE TRUSS                                            20
UNITS FEET KIPS                                             30
JOINT COORDINATES                                           40
     1 X 0 Y 6                                              50
     2 X 8 Y 6                                              60
     3 X 0 Y 0   SUPPORT                                    70
     4 X 8 Y 0   SUPPORT                                    80
JOINT 4 RELEASE FORCE X                                     90
MEMBER INCIDENCES                                          100
     1 3 1   $ MEMBER 1 GOES FROM JOINT 3 TO JOINT 1       110
     2 1 2                                                 120
     3 4 2                                                 130
     4 3 2                                                 140
     5 3 4                                                 150
```

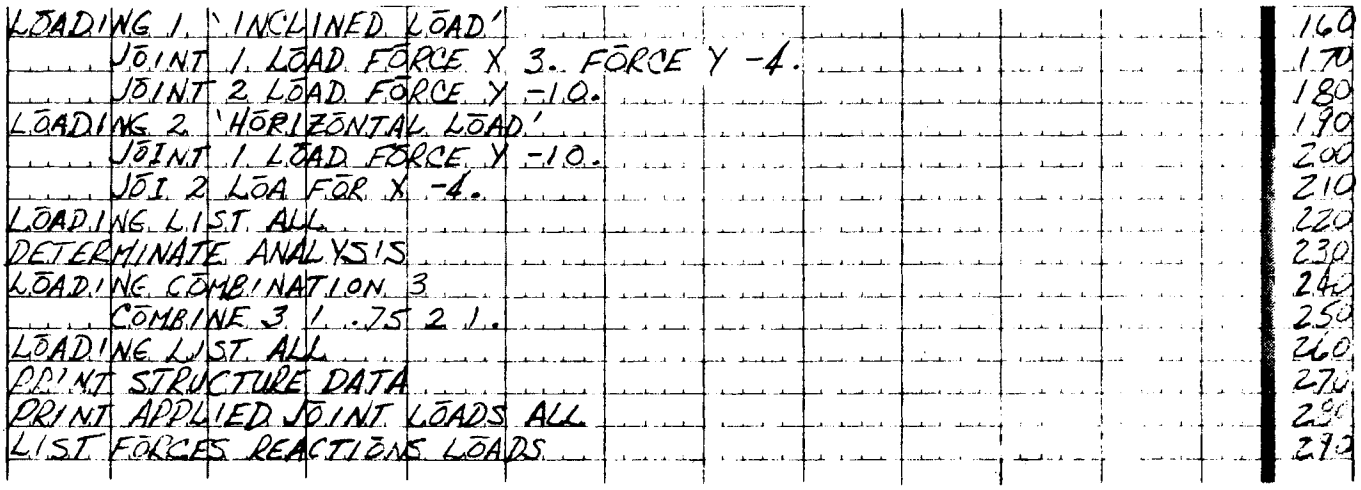
The two loading conditions are identified by the loading condition identification commands on lines 0160 and 0190. The inclined load at Joint 1 must be resolved into the directions of the global X and Y axes. The two components of this load in the global coordinate system are given in the command JOINT 1 LOAD FORCE X 3. FORCE Y -4 (-4 denotes a negative 4). The loads for loading Condition 2 follow the second loading condition identifier LOADING 2 'HORIZONTAL LOAD' command.

Having completely described the loading conditions, it is now necessary to inform STRUDL which loads are to be considered active in the analysis. This is accomplished by the LOAD LIST ALL command which informs STRUDL that all previously defined loading conditions are active. Now the analysis is performed by the DETERMINATE ANALYSIS command which computes the results. Results are now available internally for these two loading conditions.

To further illustrate the flexibility of STRUDL, we can now combine the results of these two loading conditions. Assume a third loading condition which combines 75 percent of LOADING 1 and 100 Percent of LOADING 2. This may be accomplished by using the dependent loading application commands LOADING COMBINATION 3 and COMBINE 3 1 .75 2 1. command which actually creates results in the linear combinations specified.

Now results are available internally for all three loadings, but before requesting the results it is a good idea to verify the STRUDL interpretation of the input language. STRUDL provides the user with the ability to have all of the input data printed or only selected portions of the input data printed.

Here we have elected to use the two commands on lines 0270 and 0280. Note that the same input information could be obtained using the single PRINT DATA command. Results are now obtained using the LIST FORCES REACTIONS LOADS command. The output includes the member forces and support reactions for each loading condition.



The following STRUDL output includes:

(a) The user's input commands
(b) The interpretation of the user's commands
(c) The computed results

```
STRUDL 'PROB 2.2'

        ************************************************
        *                                              *
        *     ICES STRUDL II      VERSION 1 MOD 1      *
        *       THE STRUCTURAL DESIGN LANGUAGE         *
        *    MASSACHUSETTS INSTITUTE OF TECHNOLOGY     *
        *             STATE OF CALIFORNIA              *
        *     BRIDGE DEPARTMENT DIVISION OF HWYS.      *
        *    SPECIAL STUDIES SECTION  PH. 445-6519     *
        *     NOVEMBER 1969  INSTALLED APRIL 1970      *
        *           18:59:06       6/12/70            *
        *                                              *
        ************************************************

TYPE PLANE TRUSS                                        $ 14T 05    0020
UNITS FEET KIPS                                         $ 14T 05    0030
JOINT COORDINATES                                       $ 14T 05    0040
     1 X 0. Y 6.                                        $ 14T 05    0050
     2 X 8. Y 6.                                        $ 14T 05    0060
     3 X 0. Y 0. SUPPORT                                $ 14T 05    0070
     4 X 8. Y 0. SUPPORT                                $ 14T 05    0080
JOINT 4 RELEASE FORCE X                                 $ 14T 05    0090
MEMBER INCIDENCES                                       $ 14T 05    0100
     1 3 1    $ MEMBER 1 GOES FROM JOINT 3 TO JOINT 1   $ 14T 05    0110
     2 1 2                                              $ 14T 05    0120
     3 4 2                                              $ 14T 05    0130
     4 3 2                                              $ 14T 05    0140
     5 3 4                                              $ 14T 05    0150
LOADING 1 'INCLINED LOAD'                               $ 14T 05    0160
     JOINT 1 LOAD FORCE X 3. FORCE Y -4.                $ 14T 05    0170
     JOINT 2 LOAD FORCE Y -10.                          $ 14T 05    0180
LOADING 2 'HORIZONTAL LOAD'                             $ 14T 05    0190
     JOINT 1 LOAD FORCE Y -10.                          $ 14T 05    0200
     JOI 2 LOA FOR X -4.                                $ 14T 05    0210
LOADING LIST ALL                                        $ 14T 05    0220
DETERMINANT ANALYSIS                                    $ 14T 05    0230
LOADING COMBINATION 3                                   $ 14T 05    0240
     COMBINE 3 1 .75 2 1.                               $ 14T 05    0250
LOADING LIST ALL                                        $ 14T 05    0260
PRINT STRUCTURE DATA                                    $ 14T 05    0270
```

```
*****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE   *
*****************************************

JOB ID -  PROB 2.2     JOB TITLE - NONE GIVEN

ACTIVE UNITS -  LENGTH        WEIGHT        ANGLE        TEMPERATURE       TIME
                 FEET          KIP           RAD           DEGF            SEC

          ********** STRUCTURAL DATA **********


ACTIVE STRUCTURE TYPE - PLANE   TRUSS

ACTIVE COORDINATE AXES  X Y

JOINT COORDINATES-----------------------------------------/  STATUS---/
JOINT            X             Y             Z      CONDITION

1              0.C           6.CCC         0.C                 ACTIVE
2              8.COC         6.000         0.0                 ACTIVE
3              0.C           0.C           0.C      SUPPORT    ACTIVE
4              8.CCC         C.0           0.0      SUPPORT    ACTIVE


JOINT RELEASES--------------------------------/ELASTIC SUPPORT RELEASES-----------------------------------------------/
JOINT   FORCE  MOMENT   THETA 1  THETA 2  THETA 3      KFX           KFY           KFZ           KMX           KMY           KMZ
4       X                C.C      C.C      0.0          0.0           0.0           0.0           0.0           0.0           0.0


MEMBER INCIDENCES----------/ LENGTH------/   RELEASES---------------------/ STATUS--/
MEMBER   START      END        LOCAL COORD.      START            END
                                              FORCE  MOMENT   FORCE  MOMENT

1        3          1              6.000                                    ACTIVE
2        1          2              8.000                                    ACTIVE
3        4          2              6.000                                    ACTIVE
4        3          2             10.000                                    ACTIVE
5        3          4              8.000                                    ACTIVE


MEMBER PROPERTIES-----------------------------------------------------------------------------------------------------/
MEMBER/SEG TYPE       SEG.L   COMP  AX/YD      AY/ZD      AZ/YC       IX/ZC       IY/EY       IZ/EZ       SY          SZ


MEMBER CONSTANTS------------------------------------------------------------------------------------------------------/
CONSTANT   STANDARD VALUE   DOMAIN,          VALUE       MEMBER LIST

   E            0.144CCC    ALL

   G            C.C         ALL

DENSITY         1.727999    ALL

  CTE           1.CCCCCC    ALL

  BETA          C.C         ALL

POISSON         C.C         ALL


*****************************************
*  END OF DATA FROM  INTERNAL STORAGE   *
*****************************************
```

PRINT APPLIED JOINT LOADS ALL $ 14T 05 0280

```
*****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE   *
*****************************************

JOB ID -  PROB 2.2     JOB TITLE - NONE GIVEN

ACTIVE UNITS -  LENGTH        WEIGHT        ANGLE       TEMPERATURE      TIME
                 FEET          KIP           RAD           DEGF           SEC


          ********** LOADING DATA **********


LOADING - 1             INCLINED LOAD                                   STATUS - ACTIVE

JOINT LOADS----------------------------------------/ ----------------------------------/
JOINT     STEP   FORCE X          Y          Z      MOMENT X          Y          Z
1                      3.000      -4.000     0.0          0.0        0.0        0.0
2                      0.0       -10.000     0.0          0.0        0.0        0.0


LOADING - 2             HORIZONTAL LOAD                                 STATUS - ACTIVE

JOINT LOADS----------------------------------------/ ----------------------------------/
JOINT     STEP   FORCE X          Y          Z      MOMENT X          Y          Z
1                      0.0       -10.000     0.0          0.0        0.0        0.0
2                     -4.000       0.0       0.0          0.0        0.0        0.0


LOADING - 3                                                             STATUS - ACTIVE

          COMBINATION GIVEN -    1          0.750      2          1.000


*****************************************
*  END OF DATA FROM  INTERNAL STORAGE   *
*****************************************
```

****
RESULTS OF LATEST ANALYSES
****

PROBLEM - PROB 2.2 TITLE - NONE GIVEN

ACTIVE UNITS FEET KIP RAD DEGF SEC

ACTIVE STRUCTURE TYPE PLANE TRUSS

ACTIVE COORDINATE AXES X Y

LOADING - 1 INCLINED LOAD

MEMBER FORCES

MEMBER	JOINT	AXIAL FORCE
1	1	-3.9999990
2	2	-2.9999990
3	2	-12.2499990
4	2	3.7499990
5	4	0.0

RESULTANT JOINT LOADS - SUPPORTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
3	-2.9999990	1.7500000	
4	0.0	12.2499990	

RESULTANT JOINT LOADS - FREE JOINTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
1	2.9999990	-3.9999990	
2	-0.0000002	-9.9999990	

LOADING - 2 HORIZONTAL LOAD

MEMBER FORCES

MEMBER	JOINT	AXIAL FORCE
1	1	-9.9999990
2	2	0.0
3	2	2.9999990
4	2	-4.9999990
5	4	0.0

RESULTANT JOINT LOADS - SUPPORTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
3	3.9999990	12.9999943	
4	0.0	-2.9999990	

RESULTANT JOINT LOADS - FREE JOINTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
1	0.0	-9.9999990	
2	-3.9999990	0.0000002	

LOADING - 2

MEMBER FORCES

MEMBER	JOINT	AXIAL FORCE
1	1	-12.9999990
2	2	-2.2499990
3	2	-6.1874990
4	2	-2.1874990
5	4	0.0

RESULTANT JOINT LOADS - SUPPORTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
3	1.7499990	14.3124943	
4	0.0	6.1874990	

RESULTANT JOINT LOADS - FREE JOINTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
1	2.2499990	-12.9999990	
2	-3.9999990	-7.4999952	

2.3 Indeterminate Truss Problem

To illustrate the versatility of STRUDL we continue with PROBLEM 2.3 utilizing all the data input in PROBLEM 2.2. The addition of member 6 makes the truss indeterminate to the first degree. STRUDL provides us with two alternatives in the solution of this problem. The first alternative would be to assume a force in one of the members, thus making the structure determinate and request a PRELIMINARY ANALYSIS. The second alternate, which would yield the exact results, requires the member properties of the members and a STIFFNESS ANALYSIS.

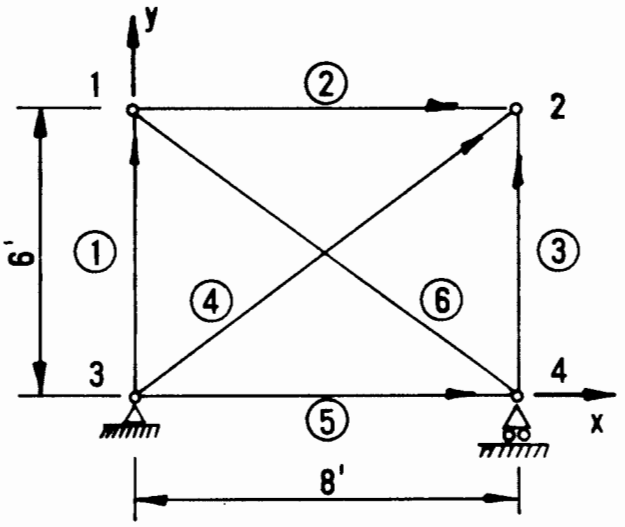


Fig. 2.3a

LOADING 1 & LOADING 2 of PROB. 2.2

Cross Sectional Areas

Member 1,3 $2.0in^2$ E=30,000 ksi

Member 2,5 $1.0in^2$

Member 4,6 $1.5in^2$

We will take the second alternative and begin the problem by changing the problem identifier and the problem description that is entered in STRUDL language by the command CHANGE ID 'PROB 2.3' 'INDETERMINATE TRUSS' on line 0300. We can now add the information needed to describe the revised truss.

```
CHANGE ID 'PROB 2.3'  'INDETERMINATE TRUSS'                    300
MEMBER 6 GOES FROM 4 TO 1                                      310
UNITS INCHES                                                   320
MEMBER PROPERTIES PRISMATIC                                    330
    1 3 AX 2.                                                  340
    2 5 AX 1.                                                  350
    4 6 AX 1.5                                                 360
CONSTANTS E 30000. ALL                                         370
```

Member 6 is added using the MEMBER INCIDENCES command. The member cross-sectional areas from Figure 2.3a are entered using the MEMBER PROPERTIES PRISMATIC command followed by a listing of the member numbers and their corresponding cross-sectional areas. Note the UNITS INCHES command given just prior to the MEMBER PROPERTIES PRISMATIC command, changing the units to inches to facilitate inputting the cross-sectional areas directly. Inserting the UNITS command between the MEMBER PROPERTIES and the first entry in the list will result in a program error.

If the modulus of elasticity of the members is not given, STRUDL will assume a modulus of elasticity E of 1.0 PSI. Output displacements computed using the assumed value should be divided by E to obtain the true values. We shall use the modulus of elasticity for steel for this problem. The current units are inches and kips, thus the modulus is specified CONSTANTS E 30000. ALL.

We have now completely described the second problem and a verification of the additions is in order. Since we can select the input data to be printed out, we will request data in the areas affected by our change. The commands on lines 0380 thru 0400 will provide the printout necessary to verify the additional input. The loading conditions originally described remain the same and no additional loading conditions have been given since the last LOADING LIST command; thus, all loads are still active including LOADING COMBINATION 3.

```
PRINT MEMBER INCIDENCES ALL                                    380
PRINT MEMBER PROPERTIES ALL                                    390
PRINT MEMBER CONSTANTS ALL                                     400
STIFFNESS ANALYSIS                                             410
LIST FORCES REACTIONS DISPLACEMENTS LOADS                      420
```

The analysis can now be performed using the STIFFNESS ANALYSIS command. Results available are requested by the LIST command on line 0420. In addition to the forces and reactions obtained in PROB 2.2, we now have the joint displacements and the joint loads. The joint displacements are given in the global coordinate system and may be used to sketch the deformed structure. The joint loads are calculated using the computed free joint displacements. They may be compared to the applied joint loads to measure the accuracy of the stiffness analysis.

The following computer listing shows the user's input, the STRUDL interpretation of his input and the computed results.

```
CHANGE ID 'PROB 2.3' 'INDETERMINATE TRUSS'                    $ 14T 05    0300
MEMBER 6 GOES FROM 4 TO 1                                     $ 14T 05    0310
UNITS INCHES                                                  $ 14T 05    0320
MEMBER PROPERTIES PRISMATIC                                   $ 14T 05    0330
     1 3 AX 2.                                                $ 14T 05    0340
     2 5 AX 1.                                                $ 14T 05    0350
     4 6 AX 1.5                                               $ 14T 05    0360
CONSTANTS E 30000. ALL                                        $ 14T 05    0370
PRINT MEMBER INCIDENCES ALL                                   $ 14T 05    0380
```

```
****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE  *
****************************************

JOB ID -  PROB 2.3     JOB TITLE - INDETERMINATE TRUSS

ACTIVE UNITS -  LENGTH        WEIGHT        ANGLE        TEMPERATURE       TIME
MEMBER INCIDENCES-INCH------/   KIP           RAD           DEGF            SEC
MEMBER    START     END

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

****************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
****************************************
```

```
PRINT MEMBER PROPERTIES ALL                                   $ 14T 05    0390
```

```
****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE  *
****************************************

JOB ID -  PROB 2.3     JOB TITLE - INDETERMINATE TRUSS

ACTIVE UNITS -  LENGTH        WEIGHT        ANGLE        TEMPERATURE       TIME
                  INCH          KIP           RAD           DEGF            SEC

MEMBER PROPERTIES----------------------------------------------------------------------------------------/
MEMBER/SEG TYPE        SEG.L   COMP  AX/YD     AY/ZD     AZ/YC     IX/ZC     IY/EY     IZ/EZ     SY        SZ
1         PRISMATIC                  2.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0
                                     0.0       0.0       0.0       0.0       0.0       0.0
2         PRISMATIC                  1.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0
                                     0.0       0.0       0.0       0.0       0.0       0.0
3         PRISMATIC                  2.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0
                                     0.0       0.0       0.0       0.0       0.0       0.0
4         PRISMATIC                  1.500     0.0       0.0       0.0       0.0       0.0       0.0       0.0
                                     0.0       0.0       0.0       0.0       0.0       0.0
5         PRISMATIC                  1.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0
                                     0.0       0.0       0.0       0.0       0.0       0.0
6         PRISMATIC                  1.500     0.0       0.0       0.0       0.0       0.0       0.0       0.0
                                     0.0       0.0       0.0       0.0       0.0       0.0

****************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
****************************************
```

```
PRINT MEMBER CONSTANTS ALL                                    $ 14T 05     0400


****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE  *
****************************************

JOB ID -  FROM 2.3      JOB TITLE - INDETERMINATE TRUSS

ACTIVE UNITS -  LENGTH        WEIGHT        ANGLE        TEMPERATURE      TIME
                 INCH          KIP           RAD           DEGF           SEC

MEMBER CONSTANTS----------------------------------------------------------------------------------------------------/
CONSTANT   STANDARD VALUE   DOMAIN,          VALUE        MEMBER LIST


    E          29355.950094     ALL

    G              0.0          ALL

DENSITY            0.001000     ALL

  CTE              1.000000     ALL

 BETA              0.0          ALL

POISSON            0.0          ALL


****************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
****************************************

STIFFNESS ANALYSIS                                            $ 14T 05     0410

LIST FORCES REACTIONS DISPLACEMENTS LOADS                     $ 14T 05     0420


****************************
*RESULTS OF LATEST ANALYSES*
****************************

 PROBLEM - FROM 2.3  TITLE - INDETERMINATE TRUSS

 ACTIVE UNITS  INCH KIP  RAD  DEGF SEC

 ACTIVE STRUCTURE TYPE  PLANE   TRUSS

 ACTIVE COORDINATE AXES  X Y

 LOADING - 1            INCLINED LOAD


 MEMBER  FORCES

MEMBER   JOINT         AXIAL FORCE

1          1            -2.2874346
2          2            -0.7165603
3          2           -10.5374327
4          2             0.8557259
5          4             2.2034187
6          1            -2.8542733
```

RESULTANT JOINT LOADS - SUPPORTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
3	-2.9999990	1.7499990	
4	0.0000000	12.2499952	

RESULTANT JOINT LOADS - FREE JOINTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
1	2.9999990	-3.9999990	
2	0.0000000	-9.9999952	

RESULTANT JOINT DISPLACEMENTS - SUPPORTS

JOINT	DISPLACEMENT		
	X DISP.	Y DISP.	Z DISP.
3	0.0	0.0	
4	0.0073069	0.0	

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT	DISPLACEMENT		
	X DISP.	Y DISP.	Z DISP.
1	0.0147625	-0.0027449	
2	0.0124694	-0.0126449	

LOADING - 2 HORIZONTAL LOAD

MEMBER FORCES

MEMBER	JOINT	AXIAL FORCE
1	1	-10.4834166
2	2	-0.6445595
3	2	2.5165756
4	2	-4.1942959
5	4	-0.6445595
6	1	0.8056993

RESULTANT JOINT LOADS - SUPPORTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
3	3.9999990	12.9999943	
4	-0.0000000	-2.9999990	

RESULTANT JOINT LOADS - FREE JOINTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
1	0.0000000	-9.9999952	
2	-3.9999990	0.0000000	

RESULTANT JOINT DISPLACEMENTS - SUPPORTS

JOINT	DISPLACEMENT		
	X DISP.	Y DISP.	Z DISP.
3	0.0	0.0	
4	-0.0020626	0.0	

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT	DISPLACEMENT		
	X DISP.	Y DISP.	Z DISP.
1	-0.0141833	-0.0125801	
2	-0.0162459	0.0030199	

LOADING - 3

MEMBER FORCES

MEMBER	JOINT	AXIAL FORCE
1	1	-12.1989908
2	2	-1.1819944
3	2	-5.3864918
4	2	-3.5225C19
5	4	1.0680046
6	1	-1.3350C5E

RESULTANT JOINT LOADS - SUPPORTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
3	1.7499990	14.3124905	
4	-C.0000000	6.1874952	

RESULTANT JOINT LOADS - FREE JOINTS

JOINT	FORCE		
	X FORCE	Y FORCE	Z FORCE
1	2.2499990	-12.9999905	
2	-3.9999990	-7.4999952	

RESULTANT JOINT DISPLACEMENTS - SUPPORTS

JOINT	DISPLACEMENT		
	X DISP.	Y DISP.	Z DISP.
3	0.0	0.0	
4	0.0034176	C.0	

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT	DISPLACEMENT		
	X DISP.	Y DISP.	Z DISP.
1	-0.0031115	-0.0146388	
2	-C.0068938	-0.0064638	

2.4 Example Truss Problem

Part 1

Use STRUDL to determine the bar forces, joint displacements, and reactions in the planar truss shown below for the indicated loading conditions. Assume a value of 30,000 ksi for the modulus of elasticity. List the results in units of kips and inches.

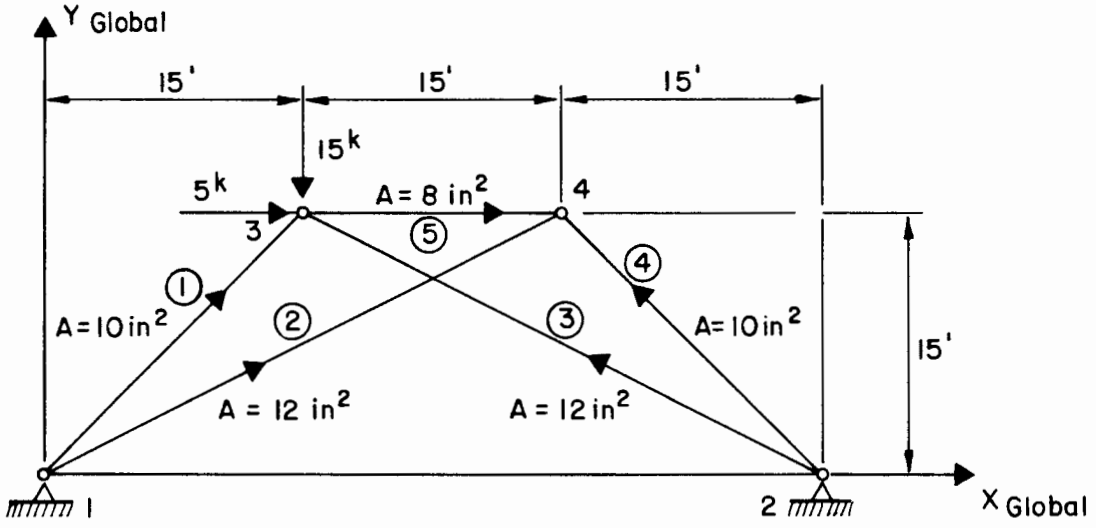


Figure 2.4

The ICES/STRUDL coding for this problem is as follows:

```
STRUDL 'PROB2.4A' 'EXAMPLE TRUSS PROBLEM'                    $ 14T 60    0010
TYPE PLANE TRUSS                                             $ 14T 60    0020
UNITS FEET KIPS                                              $ 14T 60    0030
JOINT COORDINATES                                            $ 14T 60    0040
     1     0.    0.  SUPPORT                                 $ 14T 60    0050
     2    45.    0.  SUPPORT                                 $ 14T 60    0060
     3    15.   15.                                         $ 14T 60    0070
     4    30.   15.                                         $ 14T 60    0080
```

```
MEMBER INCIDENCES                                          $ 14T 60    0090
     1    1    3                                          $ 14T 60    0100
     2    1    4                                          $ 14T 60    0110
     3    2    3                                          $ 14T 60    0120
     4    2    4                                          $ 14T 60    0130
     5    3    4                                          $ 14T 60    0140
UNITS INCHES                                               $ 14T 60    0150
MEMBER PROPERTIES PRISMATIC                                $ 14T 60    0160
     1 4  AX   10.                                         $ 14T 60    0170
     2 3  AX   12.                                         $ 14T 60    0180
     5    AX    8.                                         $ 14T 60    0190
CONSTANTS E 3.E4 ALL                                       $ 14T 60    0200
LOADING 1                                                  $ 14T 60    0210
     JOINT 3 LOADING FORCE X 5. FORCE Y -15.               $ 14T 60    0220
LOAD LIST ALL                                              $ 14T 60    0225
PRINT DATA                                                 $ 14T 60    0230
STIFFNESS ANALYSIS                                         $ 14T 60    0240
LIST FORCES REACTIONS DISPLACEMENTS                        $ 14T 60    0250
```

Part 2

This portion demonstrates the users capability for altering the input and re-solving the problem. In this particular instance, a stiffness matrix will replace the member properties for member 5.

The following ICES/STRUDL coding is a continuation of the coding from Part 1.

```
CHANGE ID 'PROB2.4B' 'TRUSS PROBLEM ENTER STIFFNESS MATRIX'  $ 14T 60    0300
DELETIONS                                                  $ 14T 60    0310
MEMBER 5 PROPERTIES                                        $ 14T 60    0320
ADDITIONS                                                  $ 14T 60    0330
MEMBER 5 PROPERTIES STIFFNESS MATRIX COLUMNS 1             $ 14T 60    0340
     ROW 1 1333.33                                         $ 14T 60    0350
PRINT MEMBER PROPERTIES                                    $ 14T 60    0360
STIFFNESS ANALYSIS                                         $ 14T 60    0370
LIST FORCES REACTIONS DISPLACEMENTS LOADS                  $ 14T 60    0380
```

2.5 Example Truss Problem

Use STRUDL to determine the bar forces, joint displacements, and reactions in the planar truss shown below for the indicated loading condition. Assume a value of 36,000 ksi for the modulus of elasticity. List the results in units of kips and inches.

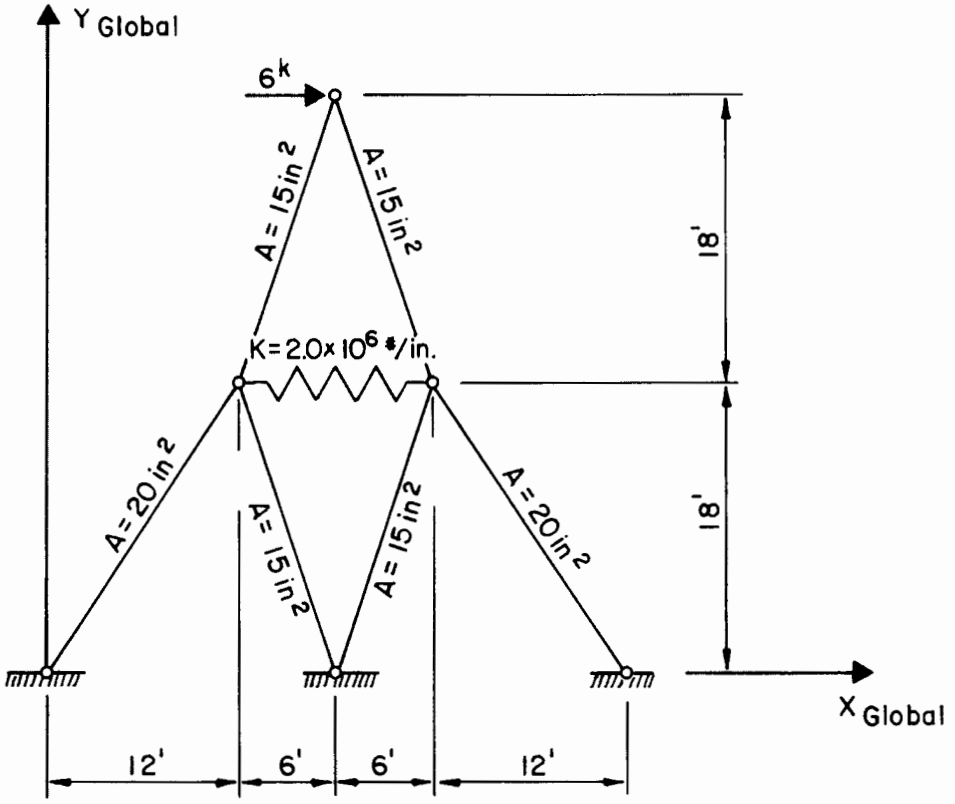


Figure 2.5

The ICES/STRUDL coding for this problem is as follows:

```
STRUDL 'PROB 2.5' 'EXAMPLE TRUSS PROBLEM'                    $ 14T 61   0010
TYPE PLANE TRUSS                                             $ 14T 61   0020
UNITS FEET KIPS                                              $ 14T 61   0030
JOINT COORDINATES                                            $ 14T 61   0040
     1    18.0      36.0                                     $ 14T 61   0050
     2    12.0      18.0                                     $ 14T 61   0060
     3    24.0      18.0                                     $ 14T 61   0070
     4     0.0       0.0 SUPPORT                             $ 14T 61   0080
     5    18.0       0.0 SUPPORT                             $ 14T 61   0090
     6    36.0       0.0 SUPPORT                             $ 14T 61   0100
MEMBER INCIDENCES                                            $ 14T 61   0110
     1    2    1                                            $ 14T 61   0120
     2    3    1                                            $ 14T 61   0130
     3    2    3                                            $ 14T 61   0140
     4    4    2                                            $ 14T 61   0150
     5    5    2                                            $ 14T 61   0160
     6    5    3                                            $ 14T 61   0170
     7    6    3                                            $ 14T 61   0180


UNITS INCHES                                                 $ 14T 61   0190
MEMBER PROPERTIES                                            $ 14T 61   0200
     1 2 5 6 PRISMATIC AX 15.0                               $ 14T 61   0210
     4 7 PRISMATIC AX 20.0                                   $ 14T 61   0220
     3 STIFFNESS MATRIX COLUMNS 1                            $ 14T 61   0230
          ROW 1  2000.                                       $ 14T 61   0240
CONSTANTS E 36000. ALL                                       $ 14T 61   0250
LOADING 1                                                    $ 14T 61   0260
     JOINT 1 LOAD FORCE X 6.                                 $ 14T 61   0270
LOAD LIST ALL                                                $ 14T 61   0280
STIFFNESS ANALYSIS                                           $ 14T 61   0290
PRINT DATA                                                   $ 14T 61   0300
LIST FORCES REACTIONS DISPLACEMENTS                          $ 14T 61   0310
```