STAAD.*Pro* 2007

AMERICAN EXAMPLES MANUAL

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About STAAD.*Pro*

STAAD.Pro is a general purpose structural analysis and design program with applications primarily in the building industry - commercial buildings, bridges and highway structures, industrial structures, chemical plant structures, dams, retaining walls, turbine foundations, culverts and other embedded structures, etc. The program hence consists of the following facilities to enable this task.

1. Graphical model generation utilities as well as text editor based commands for creating the mathematical model. Beam and column members are represented using lines. Walls, slabs and panel type entities are represented using triangular and quadrilateral finite elements. Solid blocks are represented using brick elements. These utilities allow the user to create the geometry, assign properties, orient cross sections as desired, assign materials like steel, concrete, timber, aluminum, specify supports, apply loads explicitly as well as have the program generate loads, design parameters etc.
2. Analysis engines for performing linear elastic and pdelta analysis, finite element analysis, frequency extraction, and dynamic response (spectrum, time history, steady state, etc.).
3. Design engines for code checking and optimization of steel, aluminum and timber members. Reinforcement calculations for concrete beams, columns, slabs and shear walls. Design of shear and moment connections for steel members.
4. Result viewing, result verification and report generation tools for examining displacement diagrams, bending moment and shear force diagrams, beam, plate and solid stress contours, etc.
5. Peripheral tools for activities like import and export of data from and to other widely accepted formats, links with other popular softwares for niche areas like reinforced and prestressed concrete slab design, footing design, steel connection design, etc.
6. A library of exposed functions called OpenSTAAD which allows users to access STAAD.Pro's internal functions and routines as well as its graphical commands to tap into STAAD's database and link input and output data to third-party software written using languages like C, C++, VB, VBA, FORTRAN, Java, Delphi, etc. Thus, OpenSTAAD allows users to link in-house or third-party applications with STAAD.Pro.

About the STAAD.*Pro* Documentation

The documentation for STAAD.Pro consists of a set of manuals as described below. These manuals are normally provided only in the electronic format, with perhaps some exceptions such as the Getting Started Manual which may be supplied as a printed book to first time and new-version buyers.

All the manuals can be accessed from the Help facilities of STAAD.Pro. Users who wish to obtain a printed copy of the books may contact Research Engineers. REI also supplies the manuals in the PDF format at no cost for those who wish to print them on their own. See the back cover of this book for addresses and phone numbers.

Getting Started and Tutorials : This manual contains information on the contents of the STAAD.Pro package, computer system requirements, installation process, copy protection issues and a description on how to run the programs in the package. Tutorials that provide detailed and step-by-step explanation on using the programs are also provided.

Examples Manual
This book offers examples of various problems that can be solved using the STAAD engine. The examples represent various structural analyses and design problems commonly encountered by structural engineers.

Graphical Environment
This document contains a detailed description of the Graphical User Interface (GUI) of STAAD.Pro. The topics covered include model generation, structural analysis and design, result verification, and report generation.

Technical Reference Manual
This manual deals with the theory behind the engineering calculations made by the STAAD engine. It also includes an explanation of the commands available in the STAAD command file.

International Design Codes
This document contains information on the various Concrete, Steel, and Aluminum design codes, of several countries, that are implemented in STAAD.

The documentation for the STAAD.Pro Extension component(s) is available separately.

Introduction

The tutorials in the Getting Started Manual mention 2 methods of creating the STAAD input data.

a. Using the facilities of the Graphical User Interface (GUI) modelling mode
b. Using the editor which comes built into the STAAD program

Method (a) is explained in great detail in the various tutorials of that manual.

The emphasis in this Examples manual is on creating the data using method (b). A number of examples, representing a wide variety of structural engineering problems, are presented. All the input needed is explained line by line to facilitate the understanding of the STAAD command language. These examples also illustrate how the various commands in the program are to be used together.

Although a user can prepare the input through the STAAD GUI, it is quite useful to understand the language of the input for the following reasons:

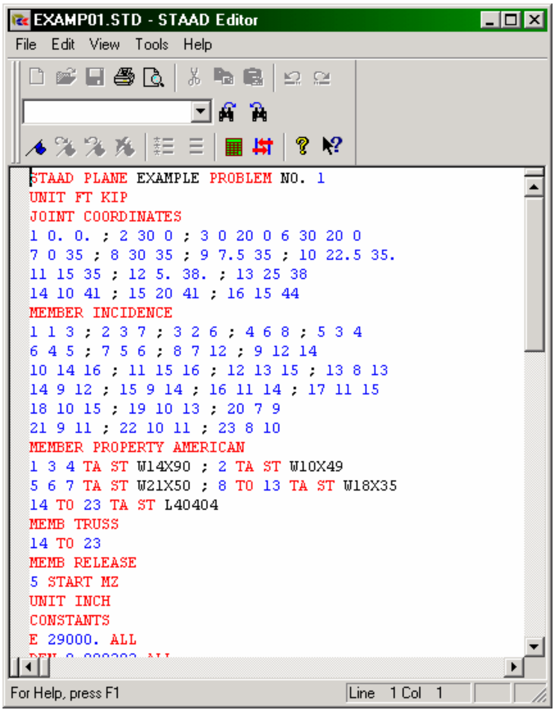
1) STAAD is a large and comprehensive structural engineering software. Knowledge of the STAAD language can be very useful in utilizing the large number of facilities available in the program.

   The Graphical User Interface can be used to generate the input file for even the most complex of structures. However, the user can easily make changes to the input data if he/she has a good understanding of the command language and syntax of the input.

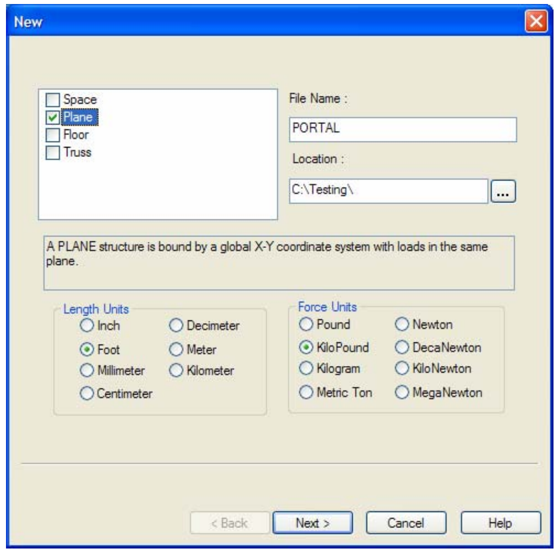
2) The input file represents the user's thought about what he/she wants to analyze or design. With the knowledge of the STAAD command language, the user or any other person can verify the accuracy of the work.

The commands used in the input file are explained in Section 5 of the STAAD Technical Reference Manual. Users are urged to refer to that manual for a better understanding of the language.

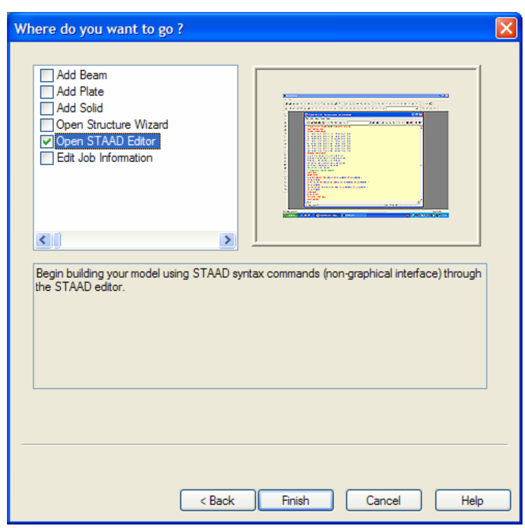
The procedure for creating the file using the built-in editor is explained further below in this section. Alternatively, any standard text editor such as Notepad or WordPad may also be used to create the command file. However, the STAAD.Pro command file editor offers the advantage of syntax checking as we type the commands. The STAAD.Pro keywords, numeric data, comments, etc. are displayed in distinct colors in the STAAD.Pro editor. A typical editor screen is shown below to illustrate its general appearance.



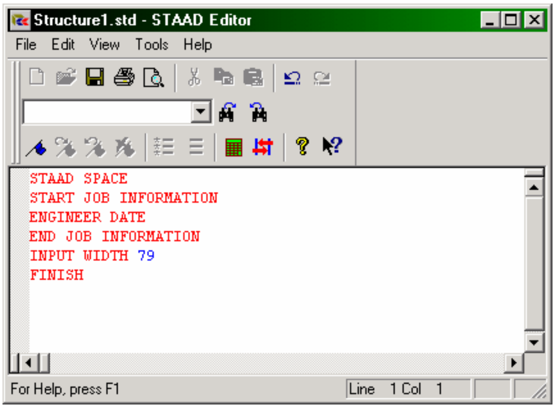
To access the built-in editor, first start the program and follow the steps explained in Sections 1.3 and 1.4 of the Getting Started manual.



You will then encounter the dialog box shown in the following figure. In this dialog box, choose *Open STAAD Editor*.



At this point, the editor screen will open as shown below.



Delete all the command lines displayed in the editor window and type the lines shown in bold in the various examples in this book (You don't have to delete the lines if you know which to keep and where to fill in the rest of the commands). The commands may be typed in upper or lower case letters.

For your convenience, the data for all the examples presented in this manual are supplied to you along with the program CD. You will find them in the folder location

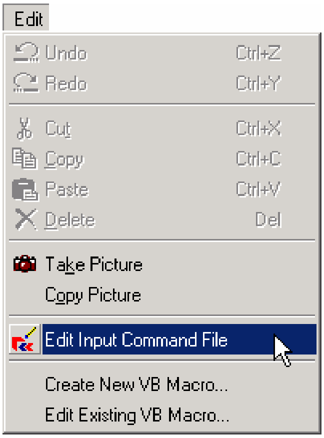
X:\spro2007\staad\examp\us

where

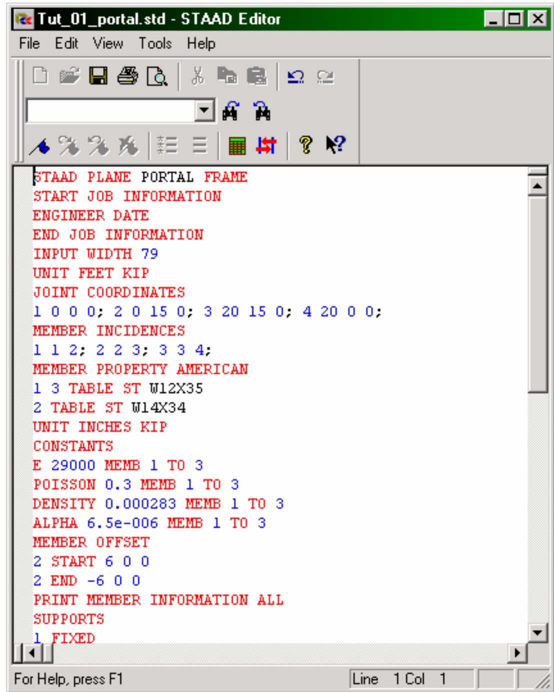
"X:" is the drive, and "spro2007" is the name of the installation folder if you happened to go with the default during installation. The example files are named in accordance with the order they appear in this manual, namely, examp01.std for example 1, examp08.std for example 8, and so on.

The second part of this book contains a set of verification problems which compares the analytical results from the program with standard publications on the subject. They too are installed along with the examples.

To view their contents in the editor, open the file you are interested in. Then, click on the STAAD editor icon, or, go to the *Edit* menu, and choose *Edit Input Command File*, as shown below.



A new window will open up with the data listed as shown here:



To exit the *Editor*, select the *File* | *Exit* menu option of the editor window (not the File | Exit menu of the main window behind the editor window).

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PART – I

APPLICATION EXAMPLES

Description of Example Problems

1) **Example problem No. 1** - Plane frame with steel design. After one analysis, member selection is requested. Since member sizes change during the member selection, another analysis is done followed by final code checking to verify that the final sizes meet the requirements of the code based on the latest analysis results.

2) **Example problem No. 2 -** A floor structure (bound by global X-Z axis) made up of steel beams is subjected to area load (i.e. load/area of floor). Load generation based on one-way distribution is illustrated in this example.

3) **Example problem No. 3** - A portal frame type steel structure is sitting on a concrete footing. The soil is to be considered as an elastic foundation.

4) **Example problem No. 4** - This example is a typical case of a load-dependent structure where the structural condition changes for different load cases. In this example, different bracing members are made inactive for different load cases. This is done to prevent these members from carrying any compressive forces.

5) **Example problem No. 5** - This example demonstrates the application of support displacement load (commonly known as sinking support) on a space frame structure.

6) **Example problem No. 6** - This is an example of prestress loading in a plane frame structure. It covers two situations: 1) The prestressing effect is transmitted from the member on which it is applied to the rest of the structure through the connecting members (known in the program as PRESTRESS load). 2) The prestressing effect is experienced by the member(s) alone and not transmitted to the rest of the structure (known in the program as POSTSTRESS load).

7) **Example problem No. 7** - This example illustrates modelling of structures with OFFSET connections. Offset connections arise when the center lines of the connected members do not intersect at the connection point. The connection eccentricity is modeled through specification of MEMBER OFFSETS.

8) **Example problem No. 8** - In this example, concrete design is performed on some members of a space frame structure. Design calculations consist of computation of reinforcement for beams and columns. Secondary moments on the columns are obtained through the means of a P-Delta analysis.

9) **Example problem No. 9** - A space frame structure in this example consists of frame members and finite elements. The finite element part is used to model floor flat plates and a shear wall. Design of an element is performed.

10) **Example problem No. 10** - A tank structure is modeled with four-noded plate elements. Water pressure from inside is used as loading for the tank. Reinforcement calculations have been done for some elements.

11) **Example problem No. 11** - Dynamic analysis (Response Spectrum) is performed for a steel structure. Results of a static and dynamic analysis are combined. The combined results are then used for steel design.

12) **Example problem No. 12** - This example demonstrates generation of load cases for the type of loading known as a moving load. This type of loading occurs classically when the load-causing units move on the structure, as in the case of trucks on a bridge deck. The mobile loads are discretized into several individual immobile load cases at discrete positions. During this process, enormous number of load cases may be created resulting in plenty of output to be sorted. To avoid looking into a lot of output, the maximum force envelope is requested for a few specific members.

13) **Example problem No. 13** - Calculation of displacements at intermediate points of members of a plane frame is demonstrated in this example.

14) **Example problem No. 14** - A space frame is analyzed for seismic loads. The seismic loads are generated using the procedures of the 1994 UBC Code. A P-Delta analysis is peformed to obtain the secondary effects of the lateral and vertical loads acting simultaneously.

15) **Example problem No. 15** - A space frame is analyzed for loads generated using the built-in wind and floor load generation facilities.

16) **Example problem No. 16** - Dynamic Analysis (Time History) is performed for a 3 span beam with concentrated and distributed masses. The structure is subjected to "forcing function" and "ground motion" loading. The maxima of the joint displacements, member end forces and support reactions are determined.

17) **Example problem No. 17** - The usage of User Provided Steel Tables is illustrated in this example for the analysis and design of a plane frame.

18) **Example problem No. 18** - This is an example which demonstrates the calculation of principal stresses on a finite element.

19) **Example problem No. 19** - This example demonstrates the usage of inclined supports. The word INCLINED refers to the fact that the restraints at a joint where such a support is specified are along a user-specified axis system instead of along the default directions of the global axis system. STAAD offers a few different methods for assigning inclined supports, and we examine those in this example.

20) **Example problem No. 20** - This example generates the geometry of a cylindrical tank structure using the cylindrical coordinate system.

21) **Example problem No. 21** - This example illustrates the modeling of tension-only members using the MEMBER TENSION command.

22) **Example problem No. 22** - A space frame structure is subjected to a sinusoidal loading. The commands necessary to describe the sine function are demonstrated in this example. Time History analysis is performed on this model.

23) **Example problem No. 23** - This example illustrates the usage of commands necessary to automatically generate spring supports for a slab on grade. The slab is subjected to various types of loading and analysis of the structure is performed.

24) **Example problem No. 24** - This is an example of the analysis of a structure modelled using “SOLID” finite elements. This example also illustrates the method for applying an “enforced” displacement on the structure.

25) **Example problem No. 25** - This example demonstrates the usage of compression-only members. Since the structural condition is load dependent, the PERFORM ANALYSIS command is specified, once for each primary load case.

26) **Example problem No. 26** - The structure in this example is a building consisting of member columns as well as floors made up of beam members and plate elements. Using the master-slave command, the floors are specified to be rigid diaphragms for inplane actions but flexible for bending actions.

27) **Example problem No. 27** - This example illustrates the usage of commands necessary to apply the compression only attribute to automatically generated spring supports for a slab on grade. The slab is subjected to pressure and overturning loading. A tension/compression only analysis of the structure is performed.

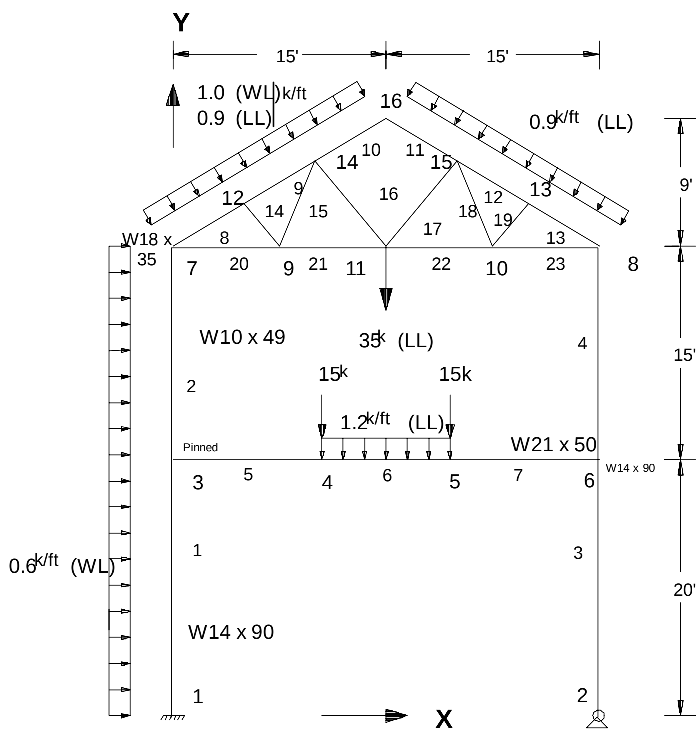
28) **Example problem No. 28** - This example demonstrates the input required for obtaining the modes and frequencies of the skewed bridge. The structure consists of piers, pier-cap girders and a deck slab.

29) **Example problem No. 29** - Analysis and design of a structure for seismic loads is demonstrated in this example. The elaborate dynamic analysis procedure called time history analysis is used.

NOTES

Example Problem No. 1

Plane frame with steel design. After one analysis, member selection is requested. Since member sizes change during the member selection, another analysis is done followed by final code checking to verify that the final sizes meet the requirements of the code based on the latest analysis results.



Actual input is shown in bold lettering followed by explanation.

STAAD PLANE EXAMPLE PROBLEM NO. 1

Every input has to start with the word STAAD. The word PLANE signifies that the structure is a plane frame structure and the geometry is defined through X and Y axes.

UNIT FT KIP

Specifies the unit to be used.

JOINT COORDINATES
1 0. 0. ; 2 30 0 ; 3 0 20 0 6 30 20 0
7 0 35 ; 8 30 35 ; 9 7.5 35 ; 10 22.5 35.
11 15 35 ; 12 5. 38. ; 13 25 38
14 10 41 ; 15 20 41 ; 16 15 44

Joint number followed by X and Y coordinates are provided above. Since this is a plane structure, the Z coordinates need not be provided. Semicolon signs (;) are used as line separators to allow for input of multiple sets of data on one line.

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

Defines the members by the joints they are connected to.

MEMBER PROPERTY AMERICAN
1 3 4 TABLE ST W14X90 ; 2 TA ST W10X49
5 6 7 TA ST W21X50 ; 8 TO 13 TA ST W18X35
14 TO 23 TA ST L40404

Member properties are from the AISC steel table. The word ST stands for standard single section.

MEMB TRUSS

```
14 TO 23
```

The above command defines that members 14 through 23 are of type truss. This means that these members can carry only axial tension/compression and no moments.

```
MEMB RELEASE
5 START MZ
```

Member 5 has local moment-z (MZ) released at the start joint. This means that the member cannot carry any moment-z (i.e. strong axis moment) at node 3.

```
UNIT INCH
CONSTANTS
E 29000. ALL
DEN 0.000283 ALL
POISSON STEEL ALL
BETA 90.0 MEMB 3 4
UNIT FT
```

The CONSTANT command initiates input for material constants like E (modulus of elasticity), POISSON, etc. Length unit is changed from FEET to INCH to facilitate the input. The BETA command specifies that members 3 and 4 are rotated by 90 degrees around their own longitudinal axis. See section 1 of the Technical Reference Manual for the definition of the BETA angle.

```
SUPPORT
1 FIXED ; 2 PINNED
```

A fixed support is located at joint 1 and a pinned support at joint 2.

```
PRINT MEMBER INFORMATION LIST  1  5  14
PRINT MEMBER PROPERTY LIST  1  2  5  8  14
```

The above PRINT commands are self-explanatory. The LIST option restricts the print output to the members listed.

```
LOADING 1 DEAD AND LIVE LOAD
```

Load case 1 is initiated long with an accompanying title.

```
SELFWEIGHT Y -1.0
```

One of the components of load case 1 is the selfweight of the structure acting in the global Y direction with a factor of -1.0. Since global Y is vertically upward, the factor of -1.0 indicates that this load will act downwards.

```
JOINT LOAD
4  5  FY  -15. ; 11  FY  -35.
```

Load 1 contains joint loads also. Loads are applied at nodes 4, 5 and 11. FY indicates that the load is a force in the global Y direction.

```
MEMB LOAD
8  TO  13 UNI Y  -0.9 ; 6  UNI GY  -1.2
```

Load 1 contains member loads also. GY indicates that the load is in the global Y direction while Y indicates local Y direction. The word UNI stands for uniformly distributed load. Loads are applied on members 6, and, 8 to 13.

```
CALCULATE RAYLEIGH FREQUENCY
```

The above command at the end of load case 1, is an instruction to perform a natural frequency calculation based on the Rayleigh method using the data in the above load case.

```
LOADING  2 WIND FROM LEFT
MEMBER LOAD
1  2  UNI  GX  0.6 ; 8  TO  10  UNI Y  -1.
```

Load case 2 is initiated and contains several member loads.

```
* 1/3 RD INCREASE IS ACCOMPLISHED BY 75% LOAD
LOAD COMB 3  75 PERCENT DL LL WL
1  0.75  2  0.75
```

The above command identifies a combination load (case no. 3) with a title. The subsequent line provides the load cases and their respective factors used for the load combination. Any line beginning with the * mark is treated as a comment line.

PERFORM ANALYSIS

This command instructs the program to proceed with the analysis.

LOAD LIST 1 3

The above command activates load cases 1 and 3 only for the commands to follow. This also means that load case 2 will be made inactive.

PRINT MEMBER FORCES
PRINT SUPPORT REACTION

The above PRINT commands are self-explanatory. Also note that all the forces and reactions will be printed for load cases 1 and 3 only.

PARAMETER
CODE AISC
NSF 0.85 ALL
BEAM 1.0 ALL
KY 1.2 MEMB 3 4
RATIO 0.9 ALL
PROFILE W14 MEMB 1 3 4

The PARAMETER command is used to specify steel design parameters such as NSF, KY, etc. Information on these parameters can be obtained from the manual where the implementation of the code is explained. The BEAM parameter is specified to perform design at every 1/12th point along the member length which by the way is the default too. The RATIO parameter specifies that the ratio of actual loading over section capacity should not exceed 0.9.

SELECT ALL

The above command instructs the program to select the most economic section for ALL the members based on the results of the analysis.

GROUP MEMB 1 3 4
GROUP MEMB 5 6 7
GROUP MEMB 8 TO 13
GROUP MEMB 14 TO 23

Although the program selects the most economical section for all members, it is not always practical to use many different sizes in one structure. GROUPing is a procedure by which the cross section which has the largest value for the specified attribute, which in this case is the default and hence the AREA, from among the associated member list, is assigned to all members in the list. Hence, the cross sections for members 1, 3 and 4 are replaced with the one with the largest area from among the three.

PERFORM ANALYSIS

As a result of the selection and grouping, the member sizes are no longer the same as the ones used in the original analysis. Hence, it is necessary to reanalyze the structure using the new properties to get new values of forces in the members.

PARAMETER
BEAM 1.0 ALL
RATIO 1.0 ALL
TRACK 1.0 ALL

A new set of values are now provided for the above parameters. The actual load to member capacity RATIO has been redefined as 1.0. The TRACK parameter tells the program to print out the design results to the intermediate level of descriptivity.

```
CHECK CODE ALL
```

With the above command, the latest member sizes with the latest analysis results are checked to verify that they satisfy the CODE specifications.

```
STEEL TAKE OFF
```

The above command instructs the program to list the length and weight of all the different member sizes.

```
FINISH
```

This command terminates the STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

  1. STAAD PLANE EXAMPLE PROBLEM NO. 1
  2. UNIT FT KIP
  3. JOINT COORDINATES
  4. 1 0. 0. ; 2 30 0 ; 3 0 20 0 6 30 20 0
  5. 7 0 35 ; 8 30 35 ; 9 7.5 35 ; 10 22.5 35.
  6. 11 15 35 ; 12 5. 38. ; 13 25 38
  7. 14 10 41 ; 15 20 41 ; 16 15 44
  8. MEMBER INCIDENCE
  9. 1 1 3 ; 2 3 7 ; 3 2 6 ; 4 6 8 ; 5 3 4
 10. 6 4 5 ; 7 5 6 ; 8 7 12 ; 9 12 14
 11. 10 14 16 ; 11 15 16 ; 12 13 15 ; 13 8 13
 12. 14 9 12 ; 15 9 14 ; 16 11 14 ; 17 11 15
 13. 18 10 15 ; 19 10 13 ; 20 7 9
 14. 21 9 11 ; 22 10 11 ; 23 8 10
 15. MEMBER PROPERTY AMERICAN
 16. 1 3 4 TA ST W14X90 ; 2 TA ST W10X49
 17. 5 6 7 TA ST W21X50 ; 8 TO 13 TA ST W18X35
 18. 14 TO 23 TA ST L40404
 19. MEMB TRUSS
 20. 14 TO 23
 21. MEMB RELEASE
 22. 5 START MZ
 23. UNIT INCH
 24. CONSTANTS
 25. E 29000. ALL
 26. DEN 0.000283 ALL
 27. POISSON STEEL ALL
 28. BETA 90.0 MEMB 3 4
 29. UNIT FT
 30. SUPPORT
 31. 1 FIXED ; 2 PINNED
 32. PRINT MEMBER INFORMATION LIST 1 5 14

MEMBER INFORMATION
------------------
MEMBER    START    END         LENGTH     BETA
          JOINT   JOINT        (FEET)     (DEG)     RELEASES

   1        1       3         20.000      0.00
   5        3       4         10.000      0.00    000001000000
  14        9      12          3.905                 TRUSS

************ END OF DATA FROM INTERNAL STORAGE ************
 33. PRINT MEMBER PROPERTY LIST 1 2 5 8 14

MEMBER PROPERTIES. UNIT - INCH
-----------------
MEMB   PROFILE              AX/          IZ/          IY/        IX/
                            AY           AZ           SZ         SY

  1  ST  W14X90           26.50       999.00       362.00       4.06
                           6.17        13.75       142.51      49.86
  2  ST  W10X49           14.40       272.00        93.40       1.39
                           3.39         7.47        54.51      18.68
  5  ST  W21X50           14.70       984.00        24.90       1.14
                           7.92         4.66        94.48       7.63
  8  ST  W18X35           10.30       510.00        15.30       0.51
                           5.31         3.40        57.63       5.10
 14  ST  L40404            1.94         1.22         4.85       0.04
                           0.67         0.67         0.79       1.72

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

```
 34. LOADING 1 DEAD AND LIVE LOAD
 35. SELFWEIGHT Y -1.0
 36. JOINT LOAD
 37. 4 5 FY -15. ; 11 FY -35.
 38. MEMB LOAD
 39. 8 TO 13 UNI Y -0.9 ; 6 UNI GY -1.2
 40. CALCULATE RAYLEIGH FREQUENCY
 41. LOADING 2  WIND FROM LEFT
 42. MEMBER LOAD
 43. 1 2 UNI GX 0.6 ; 8 TO 10 UNI Y -1.
 44. * 1/3 RD INCREASE IS ACCOMPLISHED BY 75% LOAD
 45. LOAD COMB 3 75 PERCENT DL LL WL
 46. 1 0.75 2 0.75
 47. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    16/    23/     2
  ORIGINAL/FINAL BAND-WIDTH=     5/     4/     15 DOF
  TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =     43
  SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.0/   4239.9 MB

 ZERO STIFFNESS IN DIRECTION 6 AT JOINT      9 EQN.NO.      21

       LOADS APPLIED OR DISTRIBUTED HERE FROM ELEMENTS WILL BE IGNORED.
       THIS MAY BE DUE TO ALL MEMBERS AT THIS JOINT BEING RELEASED OR
       EFFECTIVELY RELEASED IN THIS DIRECTION.
 ZERO STIFFNESS IN DIRECTION 6 AT JOINT     11 EQN.NO.      31
 ZERO STIFFNESS IN DIRECTION 6 AT JOINT     10 EQN.NO.      37
**********************************************************
*                                                        *
* RAYLEIGH FREQUENCY FOR LOADING     1 =    3.13870 CPS  *
* MAX DEFLECTION =  1.21727 INCH GLO X,  AT JOINT     7  *
*                                                        *
**********************************************************

 48. LOAD LIST 1 3
 49. PRINT MEMBER FORCES


MEMBER END FORCES    STRUCTURE TYPE = PLANE
-----------------
ALL UNITS ARE -- KIP  FEET     (LOCAL )

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z


    1    1     1     54.05     -2.00     0.00      0.00      0.00     -61.73
               3    -52.26      2.00     0.00      0.00      0.00      21.71
         3     1     40.71     18.99     0.00      0.00      0.00     247.88
               3    -39.36     -9.99     0.00      0.00      0.00      41.96

    2    1     3     33.81     -5.48     0.00      0.00      0.00     -21.71
               7    -33.07      5.48     0.00      0.00      0.00     -60.43
         3     3     28.90     -0.16     0.00      0.00      0.00     -41.96
               7    -28.35      6.91     0.00      0.00      0.00     -11.07

    3    1     2     58.79      0.00    -2.00      0.00      0.00       0.00
               6    -56.99      0.00     2.00      0.00     40.02       0.00
         3     2     55.17      0.00    -3.51      0.00      0.00       0.00
               6    -53.82      0.00     3.51      0.00     70.15       0.00

    4    1     6     31.94      0.00    -5.48      0.00     59.00       0.00
               8    -30.59      0.00     5.48      0.00     23.14       0.00
         3     6     31.66      0.00   -13.66      0.00    105.27       0.00
               8    -30.65      0.00    13.66      0.00     99.64       0.00

    5    1     3     -3.48     18.45     0.00      0.00      0.00       0.00
               4      3.48    -17.95     0.00      0.00      0.00     181.99
         3     3    -10.15     10.46     0.00      0.00      0.00       0.00
               4     10.15    -10.09     0.00      0.00      0.00     102.77
```

```
MEMBER END FORCES    STRUCTURE TYPE = PLANE
-----------------
ALL UNITS ARE -- KIP  FEET     (LOCAL )
```

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
6	1	4	-3.48	2.95	0.00	0.00	0.00	-181.99
		5	3.48	9.55	0.00	0.00	0.00	148.98
	3	4	-10.15	-1.16	0.00	0.00	0.00	-102.77
		5	10.15	10.53	0.00	0.00	0.00	44.30
7	1	5	-3.48	-24.55	0.00	0.00	0.00	-148.98
		6	3.48	25.05	0.00	0.00	0.00	-99.02
	3	5	-10.15	-21.78	0.00	0.00	0.00	-44.30
		6	10.15	22.16	0.00	0.00	0.00	-175.42
8	1	7	36.55	16.61	0.00	0.00	0.00	60.43
		12	-36.45	-11.19	0.00	0.00	0.00	20.62
	3	7	37.63	10.46	0.00	0.00	0.00	11.07
		12	-37.55	-2.02	0.00	0.00	0.00	25.31
9	1	12	36.79	8.94	0.00	0.00	0.00	-20.62
		14	-36.68	-3.52	0.00	0.00	0.00	56.94
	3	12	36.68	7.58	0.00	0.00	0.00	-25.31
		14	-36.60	0.86	0.00	0.00	0.00	44.91
10	1	14	41.86	-19.60	0.00	0.00	0.00	-56.94
		16	-41.75	25.03	0.00	0.00	0.00	-73.18
	3	14	34.33	-13.87	0.00	0.00	0.00	-44.91
		16	-34.25	22.31	0.00	0.00	0.00	-60.56
11	1	15	41.84	-19.64	0.00	0.00	0.00	-57.15
		16	-41.73	25.06	0.00	0.00	0.00	-73.18
	3	15	35.88	-15.65	0.00	0.00	0.00	-42.58
		16	-35.80	19.72	0.00	0.00	0.00	-60.56
12	1	13	40.10	7.86	0.00	0.00	0.00	-27.12
		15	-40.00	-2.44	0.00	0.00	0.00	57.15
	3	13	27.72	8.78	0.00	0.00	0.00	-3.26
		15	-27.64	-4.71	0.00	0.00	0.00	42.58
13	1	8	40.52	11.33	0.00	0.00	0.00	23.14
		13	-40.41	-5.91	0.00	0.00	0.00	27.12
	3	8	26.74	19.68	0.00	0.00	0.00	99.64
		13	-26.66	-15.61	0.00	0.00	0.00	3.26
14	1	9	-2.25	0.01	0.00	0.00	0.00	0.00
		12	2.27	0.01	0.00	0.00	0.00	0.00
	3	9	5.65	0.01	0.00	0.00	0.00	0.00
		12	-5.63	0.01	0.00	0.00	0.00	0.00
15	1	9	1.81	0.01	0.00	0.00	0.00	0.00
		14	-1.77	0.01	0.00	0.00	0.00	0.00
	3	9	-4.75	0.01	0.00	0.00	0.00	0.00
		14	4.78	0.01	0.00	0.00	0.00	0.00
16	1	11	-24.42	0.02	0.00	0.00	0.00	0.00
		14	24.46	0.02	0.00	0.00	0.00	0.00
	3	11	-10.26	0.01	0.00	0.00	0.00	0.00
		14	10.29	0.01	0.00	0.00	0.00	0.00
17	1	11	-21.23	0.02	0.00	0.00	0.00	0.00
		15	21.27	0.02	0.00	0.00	0.00	0.00
	3	11	-23.98	0.01	0.00	0.00	0.00	0.00
		15	24.01	0.01	0.00	0.00	0.00	0.00
18	1	10	-1.73	0.01	0.00	0.00	0.00	0.00
		15	1.76	0.01	0.00	0.00	0.00	0.00
	3	10	5.70	0.01	0.00	0.00	0.00	0.00
		15	-5.67	0.01	0.00	0.00	0.00	0.00

```
 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET     (LOCAL )

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

   19    1    10      2.00      0.01     0.00      0.00      0.00       0.00
              13     -1.98      0.01     0.00      0.00      0.00       0.00
         3    10     -6.90      0.01     0.00      0.00      0.00       0.00
              13      6.92      0.01     0.00      0.00      0.00       0.00

   20    1     7    -17.32      0.02     0.00      0.00      0.00       0.00
               9     17.32      0.02     0.00      0.00      0.00       0.00
         3     7    -19.97      0.02     0.00      0.00      0.00       0.00
               9     19.97      0.02     0.00      0.00      0.00       0.00

   21    1     9    -19.46      0.02     0.00      0.00      0.00       0.00
              11     19.46      0.02     0.00      0.00      0.00       0.00
         3     9    -14.53      0.02     0.00      0.00      0.00       0.00
              11     14.53      0.02     0.00      0.00      0.00       0.00

   22    1    10    -21.50      0.02     0.00      0.00      0.00       0.00
              11     21.50      0.02     0.00      0.00      0.00       0.00
         3    10     -5.75      0.02     0.00      0.00      0.00       0.00
              11      5.75      0.02     0.00      0.00      0.00       0.00

   23    1     8    -23.44      0.02     0.00      0.00      0.00       0.00
              10     23.44      0.02     0.00      0.00      0.00       0.00
         3     8      0.86      0.02     0.00      0.00      0.00       0.00
              10     -0.86      0.02     0.00      0.00      0.00       0.00

 ************** END OF LATEST ANALYSIS RESULT **************


  50. PRINT SUPPORT REACTION


 SUPPORT REACTIONS -UNIT KIP  FEET    STRUCTURE TYPE = PLANE
 -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1      2.00     54.05      0.00      0.00      0.00    -61.73
         3    -18.99     40.71      0.00      0.00      0.00    247.88
    2    1     -2.00     58.79      0.00      0.00      0.00      0.00
         3     -3.51     55.17      0.00      0.00      0.00      0.00

 ************** END OF LATEST ANALYSIS RESULT **************


  51. PARAMETER
  52. CODE AISC
  53. NSF 0.85 ALL
  54. BEAM 1.0 ALL
  55. KY 1.2 MEMB 3 4
  56. RATIO 0.9 ALL
  57. PROFILE W14 MEMB 1 3 4
  58. SELECT ALL
```

```
                      STAAD/Pro MEMBER SELECTION - (AISC 9TH EDITION)
                      **************************

ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)

MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                         FX            MY             MZ       LOCATION
=======================================================================

    1  ST   W14X109                   (AISC SECTIONS)
                           PASS     AISC- H1-3         0.870        3
                       40.71 C         0.00         247.88        0.00
    2  ST   W12X40                    (AISC SECTIONS)
                           PASS     AISC- H1-2         0.776        1
                       33.07 C         0.00          60.43       15.00
    3  ST   W14X90                    (AISC SECTIONS)
                           PASS     AISC- H1-3         0.756        3
                       53.82 C       -70.15           0.00       20.00
    4  ST   W14X109                   (AISC SECTIONS)
                           PASS     AISC- H1-3         0.820        3
                       31.66 C       105.27           0.00        0.00
    5  ST   W24X62                    (AISC SECTIONS)
                           PASS     AISC- H2-1         0.843        1
                        3.48 T         0.00        -181.99       10.00
    6  ST   W24X62                    (AISC SECTIONS)
                           PASS     AISC- H2-1         0.859        1
                        3.48 T         0.00        -185.45        2.50
    7  ST   W24X62                    (AISC SECTIONS)
                           PASS     AISC- H2-1         0.812        3
                       10.15 T         0.00         175.42       10.00
    8  ST   W16X31                    (AISC SECTIONS)
                           PASS     AISC- H1-2         0.832        1
                       36.55 C         0.00          60.43        0.00
    9  ST   W14X30                    (AISC SECTIONS)
                           PASS     AISC- H1-2         0.876        1
                       36.68 C         0.00         -56.94        5.83
   10  ST   W18X35                    (AISC SECTIONS)
                           PASS     AISC- H1-2         0.829        1
                       41.75 C         0.00          73.18        5.83
   11  ST   W18X35                    (AISC SECTIONS)
                           PASS     AISC- H1-2         0.829        1
                       41.73 C         0.00          73.18        5.83
   12  ST   W14X30                    (AISC SECTIONS)
                           PASS     AISC- H1-2         0.896        1
                       40.00 C         0.00         -57.15        5.83
   13  ST   W18X40                    (AISC SECTIONS)
                           PASS     AISC- H1-3         0.869        3
                       26.74 C         0.00          99.64        0.00
   14  ST   L20203                    (AISC SECTIONS)
                           PASS     AISC- H1-1         0.755        3
                        5.65 C         0.00           0.00        0.00
   15  ST   L25253                    (AISC SECTIONS)
                           PASS     AISC- H1-1         0.333        1
                        1.81 C         0.00           0.00        0.00
   16  ST   L25205                    (AISC SECTIONS)
                           PASS     TENSION            0.864        1
                       24.46 T         0.00           0.00        7.81
   17  ST   L25205                    (AISC SECTIONS)
                           PASS     TENSION            0.848        3
                       24.01 T         0.00           0.00        7.81
   18  ST   L30253                    (AISC SECTIONS)
                           PASS     AISC- H1-1         0.831        3
                        5.70 C         0.00           0.00        0.00
   19  ST   L20202                    (AISC SECTIONS)
                           PASS     TENSION            0.662        3
                        6.92 T         0.00           0.00        3.91
   20  ST   L25204                    (AISC SECTIONS)
                           PASS     TENSION            0.870        3
                       19.97 T         0.00           0.00        0.00
   21  ST   L25204                    (AISC SECTIONS)
                           PASS     TENSION            0.847        1
                       19.46 T         0.00           0.00        0.00
```

```
ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)

 MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                          FX            MY             MZ       LOCATION
 =======================================================================

     22  ST   L20205                 (AISC SECTIONS)
                           PASS     TENSION            0.862         1
                       21.50 T         0.00            0.00        0.00
     23  ST   L30254                 (AISC SECTIONS)
                           PASS     TENSION            0.826         1
                       23.44 T         0.00            0.00        0.00

    59. GROUP MEMB 1 3 4

   GROUPING BASED ON MEMBER      4  (ST  W14X109         ) LIST=      1....
    60. GROUP MEMB 5 6 7

   GROUPING BASED ON MEMBER      7  (ST  W24X62          ) LIST=      5....
    61. GROUP MEMB 8 TO 13

   GROUPING BASED ON MEMBER     13  (ST  W18X40          ) LIST=      8....
    62. GROUP MEMB 14 TO 23

   GROUPING BASED ON MEMBER     23  (ST  L30254          ) LIST=     14....
    63. PERFORM ANALYSIS

    ** ALL CASES BEING MADE ACTIVE BEFORE RE-ANALYSIS. **
    ZERO STIFFNESS IN DIRECTION 6 AT JOINT      9 EQN.NO.      21
          LOADS APPLIED OR DISTRIBUTED HERE FROM ELEMENTS WILL BE IGNORED.
          THIS MAY BE DUE TO ALL MEMBERS AT THIS JOINT BEING RELEASED OR
          EFFECTIVELY RELEASED IN THIS DIRECTION.
    ZERO STIFFNESS IN DIRECTION 6 AT JOINT     11 EQN.NO.      31
    ZERO STIFFNESS IN DIRECTION 6 AT JOINT     10 EQN.NO.      37

   **********************************************************
   *                                                        *
   * RAYLEIGH FREQUENCY FOR LOADING     1 =    3.70474 CPS  *
   * MAX DEFLECTION =  0.97912 INCH GLO X,  AT JOINT     7  *
   *                                                        *
   **********************************************************

    64. PARAMETER
    65. BEAM 1.0 ALL
    66. RATIO 1.0 ALL
    67. TRACK 1.0 ALL
    68. CHECK CODE ALL

                STAADPro CODE CHECKING - (AISC 9TH EDITION)
                         ***********************

 ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)
 MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                          FX            MY             MZ       LOCATION
 =======================================================================
      1  ST   W14X109                (AISC SECTIONS)
                           PASS     AISC- H1-3         0.872         3
                       41.05 C         0.00          248.38        0.00

  -----------------------------------------------------------------------
 | MEM=     1, UNIT KIP-INCH, L= 240.0 AX=  32.00 SZ=   173.2 SY=    61.2|
 | KL/R-Y=  64.2  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 21.60 |
 | FTZ= 21.60  FCY= 27.00  FTY= 27.00  FC= 17.02  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
      2  ST   W12X40                 (AISC SECTIONS)
                           PASS     AISC- H1-2         0.807         1
                       32.88 C         0.00           63.34       15.00

  -----------------------------------------------------------------------
 | MEM=     2, UNIT KIP-INCH, L= 180.0 AX=  11.80 SZ=    51.9 SY=    11.0|
 | KL/R-Y=  93.1  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 21.60 |
 | FTZ= 21.60  FCY= 27.00  FTY= 27.00  FC= 13.83  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
```

```
ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)
 MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                          FX            MY             MZ       LOCATION
 =======================================================================
      3  ST   W14X109                (AISC SECTIONS)
                            PASS     AISC- H1-3         0.618         3
                        54.16 C       -70.30            0.00       20.00

  -----------------------------------------------------------------------
 | MEM=     3, UNIT KIP-INCH, L= 240.0 AX=  32.00 SZ=   173.2 SY=    61.2|
 | KL/R-Y=  77.1  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 21.60 |
 | FTZ= 21.60  FCY= 27.00  FTY= 27.00  FC= 15.68  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
      4  ST   W14X109                (AISC SECTIONS)
                            PASS     AISC- H1-3         0.844         3
                        31.76 C       108.43            0.00        0.00

  -----------------------------------------------------------------------
 | MEM=     4, UNIT KIP-INCH, L= 180.0 AX=  32.00 SZ=   173.2 SY=    61.2|
 | KL/R-Y=  57.8  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
 | FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 17.64  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
      5  ST   W24X62                 (AISC SECTIONS)
                            PASS     AISC- H2-1         0.865         1
                         4.29 T         0.00         -186.81       10.00

  -----------------------------------------------------------------------
 | MEM=     5, UNIT KIP-INCH, L= 120.0 AX=  18.20 SZ=   130.6 SY=     9.8|
 | KL/R-Y=  87.2  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 19.84 |
 | FTZ= 21.60  FCY= 27.00  FTY= 27.00  FC= 14.38  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
      6  ST   W24X62                 (AISC SECTIONS)
                            PASS     AISC- H2-1         0.886         1
                         4.29 T         0.00         -191.30        2.50

  -----------------------------------------------------------------------
 | MEM=     6, UNIT KIP-INCH, L= 120.0 AX=  18.20 SZ=   130.6 SY=     9.8|
 | KL/R-Y=  87.2  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 19.84 |
 | FTZ= 21.60  FCY= 27.00  FTY= 27.00  FC= 14.38  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
      7  ST   W24X62                 (AISC SECTIONS)
                            PASS     AISC- H2-1         0.828         3
                        10.48 T         0.00          178.73       10.00

  -----------------------------------------------------------------------
 | MEM=     7, UNIT KIP-INCH, L= 120.0 AX=  18.20 SZ=   130.6 SY=     9.8|
 | KL/R-Y=  87.2  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 19.84 |
 | FTZ= 21.60  FCY= 27.00  FTY= 27.00  FC= 14.38  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
      8  ST   W18X40                 (AISC SECTIONS)
                            PASS     AISC- H1-2         0.603         1
                        34.39 C         0.00           63.34        0.00

  -----------------------------------------------------------------------
 | MEM=     8, UNIT KIP-INCH, L=  70.0 AX=  11.80 SZ=    68.4 SY=     6.4|
 | KL/R-Y=  55.0  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
 | FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 17.08  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
      9  ST   W18X40                 (AISC SECTIONS)
                            PASS     AISC- H1-2         0.570         1
                        34.70 C         0.00          -58.69        5.83

  -----------------------------------------------------------------------
 | MEM=     9, UNIT KIP-INCH, L=  70.0 AX=  11.80 SZ=    68.4 SY=     6.4|
 | KL/R-Y=  55.0  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
 | FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 17.08  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
     10  ST   W18X40                 (AISC SECTIONS)
                            PASS     AISC- H1-2         0.653         1
                        40.60 C         0.00           66.79        5.83

  -----------------------------------------------------------------------
 | MEM=    10, UNIT KIP-INCH, L=  70.0 AX=  11.80 SZ=    68.4 SY=     6.4|
 | KL/R-Y=  55.0  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
 | FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 17.08  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
      11  ST   W18X40                 (AISC SECTIONS)
                            PASS     AISC- H1-2         0.652         1
                        40.50 C         0.00           66.79        5.83

  -----------------------------------------------------------------------
 | MEM=    11, UNIT KIP-INCH, L=  70.0 AX=  11.80 SZ=    68.4 SY=     6.4|
 | KL/R-Y=  55.0  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
 | FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 17.08  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
```

```
ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)
 MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                          FX            MY             MZ       LOCATION
 =======================================================================
     12  ST   W18X40                   (AISC SECTIONS)
                            PASS     AISC- H1-2         0.585        1
                        36.69 C          0.00         -59.71        5.83

  -----------------------------------------------------------------------
 | MEM=    12, UNIT KIP-INCH, L=  70.0 AX=  11.80 SZ=    68.4 SY=     6.4|
 | KL/R-Y=  55.0  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
 | FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 17.08  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
     13  ST   W18X40                   (AISC SECTIONS)
                            PASS     AISC- H1-3         0.885        3
                        27.20 C          0.00         101.49        0.00

  -----------------------------------------------------------------------
 | MEM=    13, UNIT KIP-INCH, L=  70.0 AX=  11.80 SZ=    68.4 SY=     6.4|
 | KL/R-Y=  55.0  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
 | FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 17.08  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
     14  ST   L30254                   (AISC SECTIONS)
                            PASS     AISC- H1-1         0.155        3
                         2.89 C          0.00           0.00        0.00

  -----------------------------------------------------------------------
 | MEM=    14, UNIT KIP-INCH, L=  46.9 AX=   1.31 SZ=     0.3 SY=     0.7|
 | KL/R- =  90.1  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
 | FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC= 14.20  FT= 21.60  FV=  0.00   |
  -----------------------------------------------------------------------
     15  ST   L30254                   (AISC SECTIONS)
                            PASS     AISC- H1-1         0.329        1
                         2.93 C          0.00           0.00        0.00

  -----------------------------------------------------------------------
 | MEM=    15, UNIT KIP-INCH, L=  78.0 AX=   1.31 SZ=     0.3 SY=     0.7|
 | KL/R- = 148.3  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
 | FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC=  6.79  FT= 21.60  FV=  0.00   |
  -----------------------------------------------------------------------
     16  ST   L30254                   (AISC SECTIONS)
                            PASS     TENSION            0.848        1
                        24.04 T          0.00           0.00        7.81

  -----------------------------------------------------------------------
 | MEM=    16, UNIT KIP-INCH, L=  93.7 AX=   1.31 SZ=     0.3 SY=     0.7|
 | KL/R- = 178.0  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
 | FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC=  4.72  FT= 21.60  FV=  0.00   |
  -----------------------------------------------------------------------
     17  ST   L30254                   (AISC SECTIONS)
                            PASS     TENSION            0.816        3
                        23.14 T          0.00           0.00        7.81

  -----------------------------------------------------------------------
 | MEM=    17, UNIT KIP-INCH, L=  93.7 AX=   1.31 SZ=     0.3 SY=     0.7|
 | KL/R- = 178.0  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
 | FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC=  4.72  FT= 21.60  FV=  0.00   |
  -----------------------------------------------------------------------
     18  ST   L30254                   (AISC SECTIONS)
                            PASS     AISC- H1-1         0.558        3
                         4.98 C          0.00           0.00        0.00

  -----------------------------------------------------------------------
 | MEM=    18, UNIT KIP-INCH, L=  78.0 AX=   1.31 SZ=     0.3 SY=     0.7|
 | KL/R- = 148.3  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
 | FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC=  6.79  FT= 21.60  FV=  0.00   |
  -----------------------------------------------------------------------
     19  ST   L30254                   (AISC SECTIONS)
                            PASS     TENSION            0.213        3
                         6.03 T          0.00           0.00        3.91

  -----------------------------------------------------------------------
 | MEM=    19, UNIT KIP-INCH, L=  46.9 AX=   1.31 SZ=     0.3 SY=     0.7|
 | KL/R- =  90.1  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
 | FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC= 14.20  FT= 21.60  FV=  0.00   |
  -----------------------------------------------------------------------
    20  ST   L30254                   (AISC SECTIONS)
                            PASS     TENSION            0.552        3
                        15.66 T          0.00           0.00        0.00

  -----------------------------------------------------------------------
 | MEM=    20, UNIT KIP-INCH, L=  90.0 AX=   1.31 SZ=     0.3 SY=     0.7|
 | KL/R- = 170.9  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
 | FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC=  5.11  FT= 21.60  FV=  0.00   |
  -----------------------------------------------------------------------
```

```
ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)

MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                         FX            MY             MZ       LOCATION
=======================================================================
    21  ST   L30254                    (AISC SECTIONS)
                          PASS     TENSION            0.631         1
                      17.91 T         0.00            0.00        0.00
 -----------------------------------------------------------------------
| MEM=    21, UNIT KIP-INCH, L=  90.0 AX=   1.31 SZ=     0.3 SY=     0.7|
| KL/R- = 170.9  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
| FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC=  5.11  FT= 21.60  FV=  0.00   |
 -----------------------------------------------------------------------
    22  ST   L30254                    (AISC SECTIONS)
                          PASS     TENSION            0.686         1
                      19.45 T         0.00            0.00        0.00
 -----------------------------------------------------------------------
| MEM=    22, UNIT KIP-INCH, L=  90.0 AX=   1.31 SZ=     0.3 SY=     0.7|
| KL/R- = 170.9  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
| FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC=  5.11  FT= 21.60  FV=  0.00   |
 -----------------------------------------------------------------------
    23  ST   L30254                    (AISC SECTIONS)
                          PASS     TENSION            0.653         1
                      18.51 T         0.00            0.00        0.00
 -----------------------------------------------------------------------
| MEM=    23, UNIT KIP-INCH, L=  90.0 AX=   1.31 SZ=     0.3 SY=     0.7|
| KL/R- = 170.9  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
| FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC=  5.11  FT= 21.60  FV=  0.00   |
 -----------------------------------------------------------------------

     69. STEEL TAKE OFF

  STEEL TAKE-OFF
  --------------

     PROFILE                 LENGTH(FEET)      WEIGHT(KIP )

  ST  W14X109                     55.00             5.977
  ST  W12X40                      15.00             0.601
  ST  W24X62                      30.00             1.854
  ST  W18X40                      34.99             1.402
  ST  L30254                      66.43             0.296
                                             ----------------
                                   TOTAL =         10.130

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

   70. FINISH

            *********** END OF THE STAAD.Pro RUN ***********

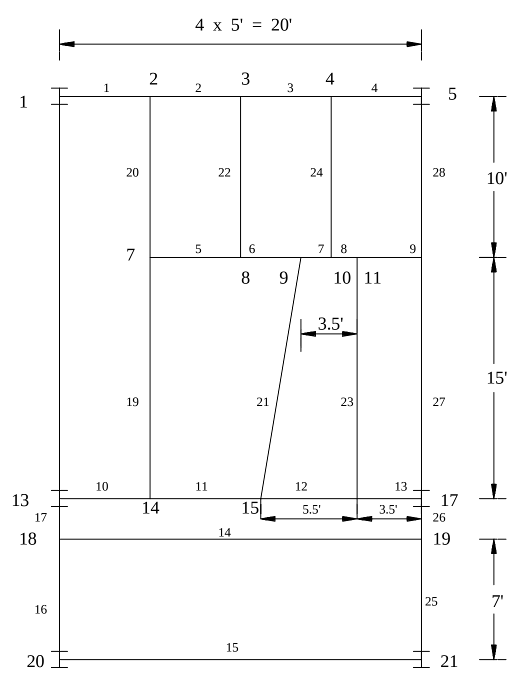
              **** DATE=             TIME=       ****

        ************************************************************
        *         For questions on STAAD.Pro, please contact       *
        *   Research Engineers Offices at the following locations  *
        *                                                          *
        *              Telephone                 Email             *
        *  USA:      +1 (714)974-2500       support@bentley.com    *
        *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
        *  UK        +44(1454)207-000       support@reel.co.uk     *
        *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
        *  GERMANY   +49/931/40468-71       info@reig.de           *
        *  NORWAY    +47 67 57 21 30        staad@edr.no           *
        *  SINGAPORE +65 6225-6158          support@bentley.com    *
        *  INDIA     +91(033)4006-2021      support@bentley.com    *
        *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
        *  CHINA     +86(411)363-1983       support@bentley.com    *
        *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
        *                                                          *
        *  North America                   support@bentley.com     *
        *  Europe                          support@bentley.com     *
        *  Asia                            support@bentley.com     *
        ************************************************************
```

Example Problem No. 2

A floor structure (bound by global X-Z axis) made up of steel beams is subjected to area load (i.e. load/area of floor). Load generation based on one-way distribution is illustrated in this example.

In the case of loads such as joint loads and member loads, the magnitude and direction of the load at the applicable joints and members is directly known from the input. However, the area load is a different sort of load where a load intensity on the given area has to be converted to joint and member loads. The calculations required to perform this conversion are done only during the analysis. Consequently, the loads generated from the AREA LOAD command can be viewed only after the analysis is completed.



Actual input is shown in bold lettering followed by explanation.

STAAD FLOOR A FLOOR FRAME DESIGN WITH AREA LOAD

Every input has to start with the word STAAD. The word FLOOR signifies that the structure is a floor structure and the structure is in the x – z plane.

UNIT FT KIP

Defines the UNITs for data to follow.

JOINT COORDINATES
1 0. 0. 0. 5 20. 0. 0. ; 7 5. 0. 10.
8 10. 0. 10. ; 9 13. 0. 10. ; 10 15. 0. 10. ; 11 16.5 0. 10.
12 20. 0. 10. ; 13 0. 0. 25. ; 14 5. 0. 25. ; 15 11. 0. 25.
16 16.5 0. 25 ; 17 20. 0. 25. 18 0. 0. 28.
19 20. 0. 28. ; 20 0. 0. 35. ; 21 20. 0. 35.

Joint number followed by X, Y and Z coordinates are provided above. Since this is a floor structure, the Y coordinates are all the same, in this case zero. Semicolon signs (;) are used as line separators to allow for input of multiple sets of data on one line. Joints between 1 and 5 (i.e. 2, 3, 4) are generated in the first line of input taking advantage of the equal spacing between the joints (see section 5 of the Technical Reference Manual for more information).

MEMBER INCIDENCES
1 1 2 4 ; 5 7 8 9 ; 10 13 14 13 ; 14 18 19
15 20 21 ; 16 18 20 ; 17 13 18 ; 18 1 13
19 7 14 ; 20 2 7 ; 21 9 15
22 3 8 ; 23 11 16 ; 24 4 10 ; 25 19 21
26 17 19 ; 27 12 17 ; 28 5 12

Defines the members by the joints they are connected to.

```
MEMB PROP AMERICAN
1 TO 28 TABLE ST W12X26
```

Member properties are specified from the AISC steel table. In this case, the W12X26 section is chosen. The word ST stands for standard single section.

```
* MEMBERS WITH PINNED ENDS ARE RELEASED FOR MZ
  MEMB RELEASE
  1  5  10  14  15  18  17  28  26  20  TO  24  START MZ
  4  9  13  14  15  18  16  27  25  19  21  TO  24  END MZ
```

The first set of members (1 5 10 etc) have local moment-z (MZ) released at the start joint. This means that these members cannot carry any moment-z (i.e. strong axis moment) at the start joint. The second set of members have MZ released at the end joints. Any line beginning with the * mark is treated as a comment line.

```
CONSTANT
E 4176E3 ALL
POISSON STEEL ALL
```

The CONSTANT command initiates input for material constants like E (modulus of elasticity), POISSON, etc. E has been assigned as 4176E3 (4176000.0 Kips/sq.ft) which is the equivalent of 29000 ksi. The built-in default for Poisson’s value for steel is used during the analysis.

```
SUPPORT
1  5  13  17  20  21  FIXED
```

The above joints are declared as being restrained for all 6 global degrees of freedom.

```
LOADING  1  300  POUNDS PER SFT DL+LL
```

Load case 1 is initiated followed by a title.

```
AREA LOAD
1  TO  28  ALOAD  -0.30
```

All the 28 members are subjected to an Area load of 0.3 kips/sq.ft. The program converts area loads into individual member loads.

PERFORM ANALYSIS PRINT LOAD DATA

This command instructs the program to proceed with the analysis. The PRINT LOAD DATA command is specified to obtain a listing of the member loads which were generated from the AREA LOAD.

PARAMETERS
CODE AISC
BEAM 1 ALL
DMAX 2.0 ALL
DMIN 1.0 ALL
UNT 1.0 ALL
UNB 1.0 ALL

The PARAMETER command is used to specify steel design parameters (Table 2.1 of Technical Reference Manual). Design is to be performed per the specifications of the AISC ASD Code. The BEAM parameter is specified to perform design at every 1/12th point along the member length. DMAX and DMIN specify maximum and minimum depth limitations to be used during member selection. UNT and UNB stand for unsupported length for top and bottom flange to be used for calculation of allowable bending stress.

SELECT MEMB 2 6 11 14 15 16 18 19 21 23 24 27

The above command instructs the program to select the most economical section from the AISC steel table for the members listed.

FINISH

The FINISH command terminates the STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

  1. STAAD FLOOR  A FLOOR FRAME DESIGN WITH AREA LOAD
  2. UNIT FT KIP
  3. JOINT COORDINATES
  4. 1 0. 0. 0.  5 20. 0. 0. ; 7 5. 0. 10.
  5. 8 10. 0. 10. ; 9 13. 0. 10. ; 10 15. 0. 10. ; 11 16.5 0. 10.
  6. 12 20. 0. 10. ; 13 0. 0. 25. ; 14 5. 0. 25. ; 15 11. 0. 25.
  7. 16 16.5 0. 25 ; 17 20. 0. 25. 18 0. 0. 28.
  8. 19 20. 0. 28. ; 20 0. 0. 35. ; 21 20. 0. 35.
  9. MEMBER INCIDENCES
 10. 1 1 2 4 ; 5 7 8 9 ; 10 13 14 13 ; 14 18 19
 11. 15 20 21 ; 16 18 20 ; 17 13 18 ; 18 1 13
 12. 19 7 14 ; 20 2 7 ; 21 9 15
 13. 22 3 8 ; 23 11 16 ; 24 4 10 ; 25 19 21
 14. 26 17 19 ; 27 12 17 ; 28 5 12
 15. MEMB PROP AMERICAN
 16. 1 TO 28 TABLE ST W12X26
 17. * MEMBERS WITH PINNED ENDS ARE RELEASED FOR MZ
 18. MEMB RELEASE
 19. 1 5 10 14 15 18 17 28 26 20 TO 24 START MZ
 20. 4 9 13 14 15 18 16 27 25 19 21 TO 24 END MZ
 21. CONSTANT
 22. E 4176E3 ALL
 23. POISSON STEEL ALL
 24. SUPPORT
 25. 1 5 13 17 20 21 FIXED
 26. LOADING 1 300 POUNDS PER SFT DL+LL
 27. AREA LOAD
 28. 1 TO 28 ALOAD -0.30
 29. PERFORM ANALYSIS PRINT LOAD DATA

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    20/    28/     6
  ORIGINAL/FINAL BAND-WIDTH=    11/     5/     15 DOF
  TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     42
  SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.0/  40264.0 MB

LOADING     1  300 POUNDS PER SFT DL+LL
-----------
MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

  10    -0.450 GY   0.00    5.00
  11    -0.450 GY   0.00    6.00
  12    -0.450 GY   0.00    5.50
  13    -0.450 GY   0.00    3.50
  14    -1.500 GY   0.00   20.00
  15    -1.050 GY   0.00   20.00
  18    -0.750 GY   0.00   25.00
  19                                                -1.950    -1.650 GY
  20    -1.500 GY   0.00   10.00
  21    -1.725 GY   0.00   15.13
  22    -1.500 GY   0.00   10.00
  23                                                -1.050    -1.350 GY
  24    -1.500 GY   0.00   10.00
  27    -0.525 GY   0.00   15.00
  28    -0.750 GY   0.00   10.00


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

```
30. PARAMETERS
31. CODE AISC
32. BEAM 1.0 ALL
33. DMAX 2.0 ALL
34. DMIN 1.0 ALL
35. UNT 1.0 ALL
36. UNB 1.0 ALL
37. SELECT MEMB 2 6 11 14 15 16 18 19 21 23 24 27

                 STAAD.PRO MEMBER SELECTION - (AISC 9TH EDITION)
                 ***********************************************

ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)

MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                         FX            MY             MZ       LOCATION
=======================================================================

     2 ST   W21X44                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.863         1
                       0.00 T         0.00       -139.46         0.00
     6 ST   W18X35                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.897         1
                       0.00 T         0.00       -102.32         3.00
    11 ST   W21X48                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.911         1
                       0.00 T         0.00       -167.74         6.00
    14 ST   W16X26                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.987         1
                       0.00 T         0.00        -75.00        10.00
    15 ST   W14X22                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.915         1
                       0.00 T         0.00        -52.50        10.00
    16 ST   W12X19                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.744         1
                       0.00 T         0.00        -31.50         0.00
    18 ST   W12X26                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.886         1
                       0.00 T         0.00        -58.59        12.50
    19 ST   W24X55                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.978         1
                       0.00 T         0.00       -221.85         0.00
    21 ST   W12X22                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.984         1
                       0.00 T         0.00        -49.38         7.57
    23 ST   W12X19                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.797         1
                       0.00 T         0.00        -33.75         7.50
    24 ST   W12X19                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.443         1
                       0.00 T         0.00        -18.75         5.00
    27 ST   W21X48                 (AISC SECTIONS)
                          PASS     AISC- H1-3         0.937         1
                       0.00 T         0.00       -172.59         0.00
```

```
 38. FINISH

****************************************************************************
**WARNING** SOME MEMBER SIZES HAVE CHANGED SINCE LAST ANALYSIS.
            IN THE POST PROCESSOR, MEMBER QUERIES WILL USE THE LAST
            ANALYSIS FORCES WITH THE UPDATED MEMBER SIZES.
            TO CORRECT THIS INCONSISTENCY, PLEASE DO ONE MORE ANALYSIS.
            FROM THE UPPER MENU, PRESS RESULTS, UPDATE PROPERTIES, THEN
            FILE SAVE; THEN ANALYZE AGAIN WITHOUT THE GROUP OR SELECT
            COMMANDS.
****************************************************************************


          *********** END OF THE STAAD.Pro RUN ***********

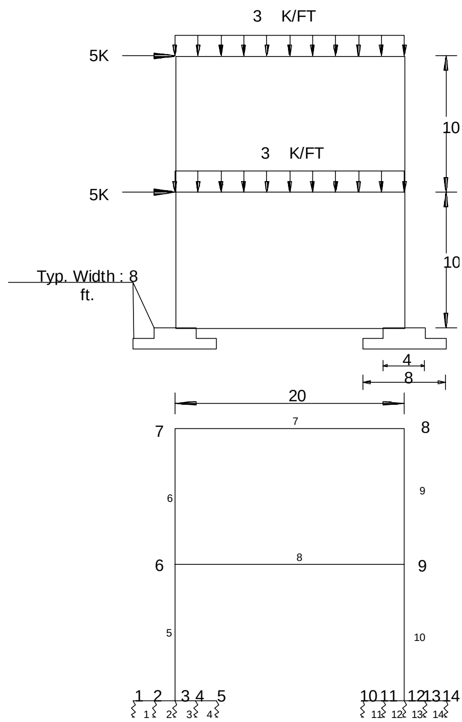
            **** DATE=            TIME=            ****

      ************************************************************
      *         For questions on STAAD.Pro, please contact       *
      *   Research Engineers Offices at the following locations  *
      *                                                          *
      *             Telephone                 Email              *
      *  USA:      +1 (714)974-2500      support@bentley.com     *
      *  CANADA    +1 (905)632-4771      detech@odandetech.com   *
      *  UK        +44(1454)207-000      support@reel.co.uk      *
      *  FRANCE    +33(0)1 64551084      support@reel.co.uk      *
      *  GERMANY   +49/931/40468-71      info@reig.de            *
      *  NORWAY    +47 67 57 21 30       staad@edr.no            *
      *  SINGAPORE +65 6225-6158         support@bentley.com     *
      *  INDIA     +91(033)4006-2021     support@bentley.com     *
      *  JAPAN     +81(03)5952-6500      eng-eye@crc.co.jp       *
      *  CHINA     +86(411)363-1983      support@bentley.com     *
      *  THAILAND  +66(0)2645-1018/19    support@bentley.com     *
      *                                                          *
      *  North America                  support@bentley.com      *
      *  Europe                         support@bentley.com      *
      *  Asia                           support@bentley.com      *
      ************************************************************
```

NOTES

Example Problem No. 3

A portal frame type steel structure is sitting on concrete footing. The soil is to be considered as an elastic foundation. Value of soil subgrade reaction is known from which spring constants are calculated by multiplying the subgrade reaction by the tributary area of each modeled spring.



NOTE:

1) All dimensions are in feet.
2) Soil Subgrade Reaction - 250 Kips/cft

Spring constant calculation

Spring of joints 1, 5, 10 & 14 = 8 x 1 x 250
= 2000Kips/ft

Spring of joints 2, 3, 4, 11, 12 & 13 = 8 x 2 x 250
= 4000Kips/ft

Actual input is shown in bold lettering followed by explanation.

STAAD PLANE PORTAL ON FOOTING FOUNDATION

Every input has to start with the word STAAD. The word PLANE signifies that the structure is a plane frame structure and the geometry is defined through X and Y axes.

UNIT FT KIPS

Specifies the unit to be used for data to follow.

JOINT COORDINATES
1 0.0 0.0 0.0 5 8.0 0.0 0.0
6 4.0 10.0 0.0 ; 7 4.0 20.0 0.0
8 24.0 20.0 0.0 ; 9 24.0 10.0 0.0
10 20.0 0.0 0.0 14 28.0 0.0 0.0

Joint number followed by X, Y and Z coordinates are provided above. Since this is a plane structure, the Z coordinates are given as all zeros. Semicolon signs (;) are used as line separators to facilitate specification of multiple sets of data on one line.

MEMBER INCIDENCES
1 1 2 4
5 3 6 ; 6 6 7
7 7 8 ; 8 6 9
9 8 9 ;10 9 12
11 10 11 14

Defines the members by the joints they are connected to.

MEMBER PROPERTIES AMERICAN
1 4 11 14 PRIS YD 1.0 ZD 8.0
2 3 12 13 PRIS YD 2.0 ZD 8.0
5 6 9 10 TABLE ST W10X33
7 8 TA ST W12X26

The first two lines define member properties as PRIS (prismatic) followed by YD (depth) and ZD (width) values. The program will calculate the properties necessary to do the analysis. Additional information is available in sections 1 and 5 of the Technical

Reference Manual. Member properties for the remaining members are chosen from the American (AISC) steel table. The word ST stands for standard single section.

```
* E FOR STEEL IS 29,000 AND FOR CONCRETE 3000
UNIT INCHES
CONSTANTS
E 29000. MEMB 5 TO 10
E 3000. MEMB 1  TO  4  11  TO  14
DEN 0.283E-3  MEMB  5  TO  10
DEN  8.68E-5  MEMB  1  TO  4  11  TO  14
POISSON STEEL MEMB 5 TO 10
POISSON CONCRETE MEMB 1 TO 4 11 TO 14
```

The CONSTANT command initiates input for material constants like E (modulus of elasticity), Density and Poisson’s ratio. Length unit is changed from FT to INCH to facilitate the input. Any line beginning with an * mark is treated as a comment line.

```
UNIT FT
SUPPORTS
2 TO 4  11  TO  13  FIXED BUT MZ KFY 4000.
1  5  10  14  FIXED BUT MZ KFY 2000.
```

The supports for the structure are specified above. The first set of joints are restrained in all directions except MZ (which is global moment-z). Also, a spring having a spring constant of 4000 kip/ft is provided in the global Y direction at these nodes. The second set is similar to the former except for a different value of the spring constant.

```
LOADING 1 DEAD AND WIND LOAD COMBINED
```

Load case 1 is initiated followed by a title.

```
SELF Y -1.0
```

The selfweight of the structure is specified as acting in the global Y direction with a -1.0 factor. Since global Y is vertically upwards, the -1.0 factor indicates that this load will act downwards.

JOINT LOAD
6 7 FX 5.0

Load 1 contains joint loads also. FX indicates that the load is a force in the global X direction. The load is applied at nodes 6 and 7.

MEMBER LOAD
7 8 UNI GY -3.0

Load 1 contains member loads also. GY indicates that the load acts in the global Y direction. The word UNI stands for uniformly distributed load, and is applied on members 7 and 8, acting downwards.

PERFORM ANALYSIS

This command instructs the program to proceed with the analysis.

PRINT ANALYSIS RESULTS

The above PRINT command instructs the program to print analysis results which include joint displacements, member forces and support reactions.

FINISH

This command terminates the STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************


  1. STAAD PLANE PORTAL ON FOOTING FOUNDATION
  2. UNIT FT KIPS
  3. JOINT COORDINATES
  4. 1   0.0  0.0  0.0  5  8.0  0.0 0.0
  5. 6   4.0 10.0 0.0 ; 7  4.0 20.0 0.0
  6. 8  24.0 20.0 0.0 ; 9  24.0 10.0 0.0
  7. 10 20.0 0.0 0.0 14 28.0 0.0 0.0
  8. MEMBER INCIDENCES
  9. 1 1 2 4
 10. 5 3 6 ; 6 6 7
 11. 7 7 8 ; 8 6 9
 12. 9 8 9 ;10 9 12
 13. 11 10 11 14
 14. MEMBER PROPERTIES AMERICAN
 15. 1 4 11 14 PRIS YD 1.0 ZD 8.0
 16. 2 3 12 13 PRIS YD 2.0 ZD 8.0
 17. 5 6 9 10 TA ST W10X33
 18. 7 8 TA ST W12X26
 19. * E FOR STEEL IS 29,000 AND FOR CONCRETE 3000
 20. UNIT INCHES
 21. CONSTANTS
 22. E 29000. MEMB 5 TO 10
 23. E  3000. MEMB 1 TO 4 11 TO 14
 24. DEN 0.283E-3 MEMB 5 TO 10
 25. DEN 8.68E-5  MEMB 1 TO 4 11 TO 14
 26. POISSON STEEL MEMB 5 TO 10
 27. POISSON CONCRETE MEMB 1 TO 4 11 TO 14
 28. UNIT FT
 29. SUPPORTS
 30. 2 TO 4  11 TO 13 FIXED BUT MZ KFY 4000.
 31. 1 5 10 14 FIXED BUT MZ KFY 2000.
 32. LOADING 1 DEAD AND WIND LOAD COMBINED
 33. SELF Y -1.0
 34. JOINT LOAD
 35. 6 7 FX 5.0
 36. MEMBER LOAD
 37. 7 8 UNI GY -3.0
 38. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------


  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    14/    14/    10
  ORIGINAL/FINAL BAND-WIDTH=     3/     3/     12 DOF
  TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     32
  SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =    12.0/  3144.2 MB,  EXMEM =  568.2 MB
```

```
 39. PRINT ANALYSIS RESULTS

 JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = PLANE
 ------------------
JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    1    1    0.00000  -0.04257   0.00000   0.00000   0.00000  -0.00028
    2    1    0.00000  -0.04893   0.00000   0.00000   0.00000  -0.00023
    3    1    0.00000  -0.05440   0.00000   0.00000   0.00000  -0.00020
    4    1    0.00000  -0.05852   0.00000   0.00000   0.00000  -0.00017
    5    1    0.00000  -0.06131   0.00000   0.00000   0.00000  -0.00010
    6    1    0.32290  -0.07856   0.00000   0.00000   0.00000  -0.00485
    7    1    0.64181  -0.09085   0.00000   0.00000   0.00000  -0.00671
    8    1    0.62413  -0.10248   0.00000   0.00000   0.00000   0.00395
    9    1    0.33042  -0.08885   0.00000   0.00000   0.00000   0.00015
   10    1    0.00000  -0.03597   0.00000   0.00000   0.00000  -0.00055
   11    1    0.00000  -0.04885   0.00000   0.00000   0.00000  -0.00051
   12    1    0.00000  -0.06101   0.00000   0.00000   0.00000  -0.00048
   13    1    0.00000  -0.07162   0.00000   0.00000   0.00000  -0.00043
   14    1    0.00000  -0.08043   0.00000   0.00000   0.00000  -0.00035

 SUPPORT REACTIONS -UNIT KIPS FEET    STRUCTURE TYPE = PLANE
 -----------------
JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    2    1      0.00     16.31      0.00      0.00      0.00      0.00
    3    1     -0.60     18.13      0.00      0.00      0.00      0.00
    4    1      0.00     19.51      0.00      0.00      0.00      0.00
   11    1      0.00     16.28      0.00      0.00      0.00      0.00
   12    1     -9.40     20.34      0.00      0.00      0.00      0.00
   13    1      0.00     23.87      0.00      0.00      0.00      0.00
    1    1      0.00      7.10      0.00      0.00      0.00      0.00
    5    1      0.00     10.22      0.00      0.00      0.00      0.00
   10    1      0.00      6.00      0.00      0.00      0.00      0.00
   14    1      0.00     13.41      0.00      0.00      0.00      0.00

 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIPS FEET

 MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

     1     1    1      0.00      7.10     0.00      0.00      0.00       0.00
                2      0.00     -4.70     0.00      0.00      0.00      11.79

     2     1    2      0.00     21.00     0.00      0.00      0.00     -11.79
                3      0.00    -16.20     0.00      0.00      0.00      49.00

     3     1    3      0.00    -22.53     0.00      0.00      0.00     -67.89
                4      0.00     27.33     0.00      0.00      0.00      18.04

     4     1    4      0.00     -7.82     0.00      0.00      0.00     -18.04
                5      0.00     10.22     0.00      0.00      0.00       0.00

     5     1    3     56.86      0.60     0.00      0.00      0.00      18.89
                6    -56.54     -0.60     0.00      0.00      0.00     -12.90

     6     1    6     29.01    -11.35     0.00      0.00      0.00     -50.36
                7    -28.68     11.35     0.00      0.00      0.00     -63.15

     7     1    7     16.35     28.68     0.00      0.00      0.00      63.15
                8    -16.35     31.84     0.00      0.00      0.00     -94.76

     8     1    6     -6.95     27.53     0.00      0.00      0.00      63.26
                9      6.95     32.99     0.00      0.00      0.00    -117.93

     9     1    8     31.84     16.35     0.00      0.00      0.00      94.76
                9    -32.17    -16.35     0.00      0.00      0.00      68.74

    10     1    9     65.16      9.40     0.00      0.00      0.00      49.19
               12    -65.49     -9.40     0.00      0.00      0.00      44.82

    11     1   10      0.00      6.00     0.00      0.00      0.00       0.00
               11      0.00     -3.60     0.00      0.00      0.00       9.59
```

```
MEMBER END FORCES    STRUCTURE TYPE = PLANE
-----------------
ALL UNITS ARE -- KIPS FEET

MEMBER  LOAD  JT     AXIAL    SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z


   12    1    11      0.00     19.88     0.00      0.00      0.00      -9.59
              12      0.00    -15.08     0.00      0.00      0.00      44.55

   13    1    12      0.00    -30.08     0.00      0.00      0.00     -89.37
              13      0.00     34.88     0.00      0.00      0.00      24.41

   14    1    13      0.00    -11.01     0.00      0.00      0.00     -24.41
              14      0.00     13.41     0.00      0.00      0.00       0.00

************** END OF LATEST ANALYSIS RESULT **************


 40. FINISH

          *********** END OF THE STAAD.Pro RUN ***********

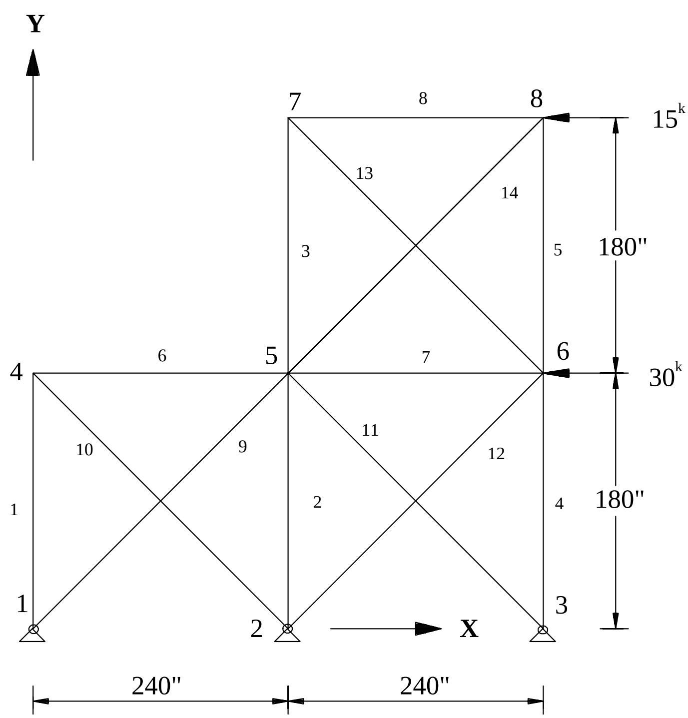
            **** DATE=               TIME=          ****

      ************************************************************
      *         For questions on STAAD.Pro, please contact       *
      *   Research Engineers Offices at the following locations  *
      *                                                          *
      *              Telephone                Email              *
      *  USA:      +1 (714)974-2500       support@bentley.com    *
      *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
      *  UK        +44(1454)207-000       support@reel.co.uk     *
      *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
      *  GERMANY   +49/931/40468-71       info@reig.de           *
      *  NORWAY    +47 67 57 21 30        staad@edr.no           *
      *  SINGAPORE +65 6225-6158          support@bentley.com    *
      *  INDIA     +91(033)4006-2021      support@bentley.com    *
      *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
      *  CHINA     +86(411)363-1983       support@bentley.com    *
      *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
      *                                                          *
      *  North America                   support@bentley.com     *
      *  Europe                          support@bentley.com     *
      *  Asia                            support@bentley.com     *
      ************************************************************
```

NOTES

Example Problem No. 4

This example is a typical case of a load-dependent structure where the structural condition changes for different load cases. In this example, different bracing members are made inactive for different load cases. This is done to prevent these members from carrying any compressive forces.



Actual input is shown in bold lettering followed by explanation.

STAAD PLANE
*** A PLANE FRAME STRUCTURE WITH TENSION BRACING**

Every input has to start with the word STAAD. The word PLANE signifies that the structure is a plane frame structure and the geometry is defined through X and Y axes.

UNIT INCH KIP

Specifies the unit to be used.

SET NL 3

This structure has to be analysed for 3 primary load cases. Consequently, the modeling of our problem requires us to define 3 sets of data, with each set containing a load case and an associated analysis command. Also, the members which get switched off in the analysis for any load case have to be restored for the analysis for the subsequent load case. To accommodate these requirements, it is necessary to have 2 commands, one called “SET NL” and the other called “CHANGE”. The SET NL command is used above to indicate the total number of primary load cases that the file contains. The CHANGE command will come in later (after the PERFORM ANALYSIS command).

JOINT COORDINATES
1 0 0 0 3 480. 0 0
4 0 180. 0 6 480. 180. 0
7 240. 360. 0 ; 8 480. 360. 0

Joint number followed by X, Y and Z coordinates are provided above. Since this is a plane structure, the Z coordinates are given as all zeros. Semicolon signs (;) are used as line separators, to facilitate specification of multiple sets of data on one line.

MEMBER INCIDENCE
1 1 4 2 ; 3 5 7 ; 4 3 6 ; 5 6 8 ; 6 4 5 7
8 7 8 ; 9 1 5 ; 10 2 4 ; 11 3 5 ; 12 2 6
13 6 7 ; 14 5 8

Defines the members by the joints they are connected to.

```
MEMBER TRUSS
9 TO 14
```

The above command defines that members 9 through 14 are of type truss. This means these members can only carry axial tension/compression and no moments.

```
MEMBER PROP AMERICAN
1 TO 5 TABLE ST W12X26
6  7  8  TA ST W18X35
9 TO 14 TA LD L50505
```

Properties for all members are assigned from the American (AISC) steel table. The word ST stands for standard single section. The word LD stands for long leg back-to-back double angle. Since the spacing between the two angles of the double angle is not provided, it is assumed to be 0.0.

```
CONSTANTS
E 29000. ALL
POISSON STEEL ALL
```

The CONSTANT command initiates input for material constants like E (modulus of elasticity), Poisson’s ratio, etc. Built-in default value of steel is used for the latter.

```
SUPPORT
1  2  3  PINNED
```

PINNED supports are specified at Joints 1, 2 and 3. The word PINNED signifies that no moments will be carried by these supports.

```
INACTIVE MEMBERS 9 TO 14
```

The above command makes the listed members inactive. The stiffness contribution of these members will not be considered in the analysis till they are made active again.

UNIT FT
LOADING 1 DEAD AND LIVE LOAD

Load case 1 is initiated along with an accompanying title. The length UNIT is changed from INCH to FT for input values which follow.

MEMBER LOAD
6 8 UNI GY -1.0
7 UNI GY -1.5

Load 1 contains member loads. GY indicates that the load acts in the global Y direction. The word UNI stands for uniformly distributed load. The loads are applied on members 6, 8 and 7.

PERFORM ANALYSIS

This command instructs the program to proceed with the analysis. It is worth noting that members 9 TO 14 will not be used in this analysis since they were declared inactive earlier. In other words, for dead and live load, the bracings are not used to carry any load.

CHANGES

The members inactivated earlier are restored using the CHANGE command.

INACTIVE MEMBERS 10 11 13

A new set of members are made inactive. The stiffness contribution from these members will not be used in the analysis till they are made active again. They have been inactivated to prevent them from being subject to any forces for the next load case.

LOADING 2 WIND FROM LEFT

Load case 2 is initiated along with an accompanying title.

JOINT LOAD
4 FX 30 ; 7 FX 15

Load 2 contains joint loads. FX indicates that the load is a force in the global X direction. Nodes 4 and 7 are subjected to the loads.

```
PERFORM ANALYSIS
```

This command instructs the program to proceed with the analysis. The analysis will be performed for load case 2 only.

```
CHANGE
```

The above CHANGE command is an instruction to re-activate all inactive members.

```
INACTIVE MEMBERS  9  12  14
```

Members 9, 12 and 14 are made inactive. The stiffness contribution of these members will not be used in the analysis till they are made active again. They have been inactivated to prevent them from being subject to compressive forces for the next load case.

```
LOADING 3 WIND FROM RIGHT
```

Load case 3 is initiated followed by a title.

```
JOINT LOAD
6 FX -30 ; 8 FX -15
```

Load 3 contains joint loads at nodes 6 and 8. FX indicates that the load is a force in the global X direction. The negative numbers (-30 and -15) indicate that the load is acting along the negative global X direction.

```
LOAD COMBINATION  4
1  0.75  2  0.75
LOAD COMBINATION  5
1  0.75  3  0.75
```

Load combination case 4 involves the algebraic summation of the results of load cases 1 and 2 after multiplying each by a factor of 0.75. For load combinations, the program simply gathers the results of the component primary cases, factors them appropriately, and combines them algebraically. Thus, an analysis in the real sense of the term (multiplying the inverted stiffness matrix by the load vector) is not carried out for load combination cases. Load combination case 5 combines the results of load cases 1 and 3.

PERFORM ANALYSIS

This command instructs the program to proceed with the analysis. Only primary load case 3 will be considered for this analysis. (As explained earlier, a combination case is not truly analysed for, but handled using other means.)

CHANGE

The above CHANGE command will re-activate all inactive members.

LOAD LIST ALL

At the end of any analysis, only those load cases for which the analysis was done most recently, are recognized as the "active" load cases. The LOAD LIST ALL command enables all the load cases in the structure to be made active for further processing.

PRINT MEMBER FORCES

The above PRINT command is an instruction to produce a report, in the output file, of the member end forces.

LOAD LIST 1 4 5

A LOAD LIST command is a means of instructing the program to use only the listed load cases for further processing.

PARAMETER
CODE AISC
BEAM 1.0 ALL
UNT 6.0 ALL
UNB 6.0 ALL
KY 0.5 ALL

The PARAMETER command is used to specify the steel design parameters (information on these parameters can be obtained from the manual where the implementation of the code is explained). Design will be done according to the specifications of the AISC ASD Code. The BEAM parameter is specified to perform design at every 1/12th point along the member length. UNT and UNB represent the unsupported length of the flanges to be used for calculation of allowable bending stress. KY 0.5 ALL sets the effective length factor for column buckling about the local Y-axis to be 0.5 for ALL members.

CHECK CODE ALL

The above command instructs the program to perform a check to determine how the user defined member sizes along with the latest analysis results meet the code requirements.

FINISH

This command terminates a STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

 1. STAAD PLANE A PLANE FRAME STRUCTURE WITH TENSION BRACING
 2. UNIT INCH KIP
 3. SET NL 3
 4. JOINT COORDINATES
 5. 1 0 0 0 3 480. 0 0
 6. 4 0 180. 0 6 480. 180. 0
 7. 7 240. 360. 0 ; 8 480. 360. 0
 8. MEMBER INCIDENCE
 9. 1 1 4 2 ; 3 5 7 ; 4 3 6 ; 5 6 8 ; 6 4 5 7
10. 8 7 8 ; 9 1 5 ; 10 2 4 ; 11 3 5 ; 12 2 6
11. 13 6 7 ;14 5 8
12. MEMBER TRUSS
13. 9 TO 14
14. MEMBER PROP AMERICAN
15. 1 TO 5 TABLE ST W12X26
16. 6 7 8 TA ST W18X35
17. 9 TO 14 TA LD L50505
18. CONSTANTS
19. E 29000. ALL
20. POISSON STEEL ALL
21. SUPPORT
22. 1 2 3 PINNED
23. INACTIVE MEMBERS 9 TO 14
24. UNIT FT
25. LOADING 1 DEAD AND LIVE LOAD
26. MEMBER LOAD
27. 6 8 UNI GY -1.0
28. 7 UNI GY -1.5
29. PERFORM ANALYSIS

        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     8/    14/     3
 ORIGINAL/FINAL BAND-WIDTH=     4/     4/     12 DOF
 TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     18
 SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.0/  40263.3 MB

30. CHANGES
31. INACTIVE MEMBERS 10 11 13
32. LOADING 2 WIND FROM LEFT
33. JOINT LOAD
34. 4 FX 30 ; 7 FX 15
35. PERFORM ANALYSIS
36. CHANGE
37. INACTIVE MEMBERS 9 12 14
38. LOADING 3 WIND FROM RIGHT
39. JOINT LOAD
40. 6 FX -30 ; 8 FX -15
41. LOAD COMBINATION 4
42. 1 0.75 2 0.75
43. LOAD COMBINATION 5
44. 1 0.75 3 0.75
45. PERFORM ANALYSIS
46. CHANGE
47. LOAD LIST ALL
```

```
 48. PRINT MEMBER FORCES

MEMBER END FORCES    STRUCTURE TYPE = PLANE
-----------------
ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1     1    1      8.26     -0.67     0.00      0.00      0.00       0.00
               4     -8.26      0.67     0.00      0.00      0.00     -10.06
          2    1     -0.31      0.22     0.00      0.00      0.00       0.00
               4      0.31     -0.22     0.00      0.00      0.00       3.27
          3    1     15.83     -0.19     0.00      0.00      0.00       0.00
               4    -15.83      0.19     0.00      0.00      0.00      -2.91
          4    1      5.97     -0.34     0.00      0.00      0.00       0.00
               4     -5.97      0.34     0.00      0.00      0.00      -5.09
          5    1     18.07     -0.65     0.00      0.00      0.00       0.00
               4    -18.07      0.65     0.00      0.00      0.00      -9.73

    2     1    2     38.47     -0.05     0.00      0.00      0.00       0.00
               5    -38.47      0.05     0.00      0.00      0.00      -0.77
          2    2      9.06      0.16     0.00      0.00      0.00       0.00
               5     -9.06     -0.16     0.00      0.00      0.00       2.45
          3    2     28.79     -0.15     0.00      0.00      0.00       0.00
               5    -28.79      0.15     0.00      0.00      0.00      -2.24
          4    2     35.64      0.08     0.00      0.00      0.00       0.00
               5    -35.64     -0.08     0.00      0.00      0.00       1.26
          5    2     50.45     -0.15     0.00      0.00      0.00       0.00
               5    -50.45      0.15     0.00      0.00      0.00      -2.26

    3     1    5     10.14     -2.20     0.00      0.00      0.00     -13.11
               7    -10.14      2.20     0.00      0.00      0.00     -19.84
          2    5     -0.29      0.42     0.00      0.00      0.00       3.37
               7      0.29     -0.42     0.00      0.00      0.00       2.97
          3    5     10.88     -0.63     0.00      0.00      0.00      -5.26
               7    -10.88      0.63     0.00      0.00      0.00      -4.23
          4    5      7.38     -1.33     0.00      0.00      0.00      -7.30
               7     -7.38      1.33     0.00      0.00      0.00     -12.66
          5    5     15.76     -2.12     0.00      0.00      0.00     -13.78
               7    -15.76      2.12     0.00      0.00      0.00     -18.05

    4     1    3     23.26      0.72     0.00      0.00      0.00       0.00
               6    -23.26     -0.72     0.00      0.00      0.00      10.83
          2    3     24.66      0.07     0.00      0.00      0.00       0.00
               6    -24.66     -0.07     0.00      0.00      0.00       1.10
          3    3    -11.25     -0.16     0.00      0.00      0.00       0.00
               6     11.25      0.16     0.00      0.00      0.00      -2.44
          4    3     35.95      0.60     0.00      0.00      0.00       0.00
               6    -35.95     -0.60     0.00      0.00      0.00       8.95
          5    3      9.01      0.42     0.00      0.00      0.00       0.00
               6     -9.01     -0.42     0.00      0.00      0.00       6.30

    5     1    6      9.86      2.20     0.00      0.00      0.00      15.84
               8     -9.86     -2.20     0.00      0.00      0.00      17.11
          2    6     10.95      0.37     0.00      0.00      0.00       2.70
               8    -10.95     -0.37     0.00      0.00      0.00       2.85
          3    6     -0.35     -0.33     0.00      0.00      0.00      -2.12
               8      0.35      0.33     0.00      0.00      0.00      -2.80
          4    6     15.61      1.92     0.00      0.00      0.00      13.90
               8    -15.61     -1.92     0.00      0.00      0.00      14.97
          5    6      7.13      1.40     0.00      0.00      0.00      10.29
               8     -7.13     -1.40     0.00      0.00      0.00      10.74

    6     1    4      0.67      8.26     0.00      0.00      0.00      10.06
               5     -0.67     11.74     0.00      0.00      0.00     -44.76
          2    4     29.78     -0.31     0.00      0.00      0.00      -3.27
               5    -29.78      0.31     0.00      0.00      0.00      -2.95
          3    4     20.79      0.38     0.00      0.00      0.00       2.91
               5    -20.79     -0.38     0.00      0.00      0.00       4.71
          4    4     22.84      5.97     0.00      0.00      0.00       5.09
               5    -22.84      9.03     0.00      0.00      0.00     -35.78
          5    4     16.09      6.48     0.00      0.00      0.00       9.73
               5    -16.09      8.52     0.00      0.00      0.00     -30.04
```

```
MEMBER END FORCES    STRUCTURE TYPE = PLANE
-----------------
ALL UNITS ARE -- KIP  FEET
```

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
7	1	5	-1.47	16.60	0.00	0.00	0.00	58.64
		6	1.47	13.40	0.00	0.00	0.00	-26.67
	2	5	17.55	-0.33	0.00	0.00	0.00	-2.88
		6	-17.55	0.33	0.00	0.00	0.00	-3.80
	3	5	44.21	0.37	0.00	0.00	0.00	2.78
		6	-44.21	-0.37	0.00	0.00	0.00	4.56
	4	5	12.06	12.20	0.00	0.00	0.00	41.82
		6	-12.06	10.30	0.00	0.00	0.00	-22.85
	5	5	32.05	12.72	0.00	0.00	0.00	46.07
		6	-32.05	9.78	0.00	0.00	0.00	-16.58
8	1	7	2.20	10.14	0.00	0.00	0.00	19.84
		8	-2.20	9.86	0.00	0.00	0.00	-17.11
	2	7	14.58	-0.29	0.00	0.00	0.00	-2.97
		8	-14.58	0.29	0.00	0.00	0.00	-2.85
	3	7	14.67	0.35	0.00	0.00	0.00	4.23
		8	-14.67	-0.35	0.00	0.00	0.00	2.80
	4	7	12.58	7.38	0.00	0.00	0.00	12.66
		8	-12.58	7.62	0.00	0.00	0.00	-14.97
	5	7	12.65	7.87	0.00	0.00	0.00	18.05
		8	-12.65	7.13	0.00	0.00	0.00	-10.74
9	1	1	0.00	0.00	0.00	0.00	0.00	0.00
		5	0.00	0.00	0.00	0.00	0.00	0.00
	2	1	-33.37	0.00	0.00	0.00	0.00	0.00
		5	33.37	0.00	0.00	0.00	0.00	0.00
	3	1	0.00	0.00	0.00	0.00	0.00	0.00
		5	0.00	0.00	0.00	0.00	0.00	0.00
	4	1	-25.03	0.00	0.00	0.00	0.00	0.00
		5	25.03	0.00	0.00	0.00	0.00	0.00
	5	1	0.00	0.00	0.00	0.00	0.00	0.00
		5	0.00	0.00	0.00	0.00	0.00	0.00
10	1	2	0.00	0.00	0.00	0.00	0.00	0.00
		4	0.00	0.00	0.00	0.00	0.00	0.00
	2	2	0.00	0.00	0.00	0.00	0.00	0.00
		4	0.00	0.00	0.00	0.00	0.00	0.00
	3	2	-25.74	0.00	0.00	0.00	0.00	0.00
		4	25.74	0.00	0.00	0.00	0.00	0.00
	4	2	0.00	0.00	0.00	0.00	0.00	0.00
		4	0.00	0.00	0.00	0.00	0.00	0.00
	5	2	-19.31	0.00	0.00	0.00	0.00	0.00
		4	19.31	0.00	0.00	0.00	0.00	0.00
11	1	3	0.00	0.00	0.00	0.00	0.00	0.00
		5	0.00	0.00	0.00	0.00	0.00	0.00
	2	3	0.00	0.00	0.00	0.00	0.00	0.00
		5	0.00	0.00	0.00	0.00	0.00	0.00
	3	3	-29.88	0.00	0.00	0.00	0.00	0.00
		5	29.88	0.00	0.00	0.00	0.00	0.00
	4	3	0.00	0.00	0.00	0.00	0.00	0.00
		5	0.00	0.00	0.00	0.00	0.00	0.00
	5	3	-22.41	0.00	0.00	0.00	0.00	0.00
		5	22.41	0.00	0.00	0.00	0.00	0.00
12	1	2	0.00	0.00	0.00	0.00	0.00	0.00
		6	0.00	0.00	0.00	0.00	0.00	0.00
	2	2	-22.31	0.00	0.00	0.00	0.00	0.00
		6	22.31	0.00	0.00	0.00	0.00	0.00
	3	2	0.00	0.00	0.00	0.00	0.00	0.00
		6	0.00	0.00	0.00	0.00	0.00	0.00
	4	2	-16.73	0.00	0.00	0.00	0.00	0.00
		6	16.73	0.00	0.00	0.00	0.00	0.00
	5	2	0.00	0.00	0.00	0.00	0.00	0.00
		6	0.00	0.00	0.00	0.00	0.00	0.00

```
 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

   13    1     6      0.00      0.00     0.00      0.00      0.00       0.00
               7      0.00      0.00     0.00      0.00      0.00       0.00
         2     6      0.00      0.00     0.00      0.00      0.00       0.00
               7      0.00      0.00     0.00      0.00      0.00       0.00
         3     6    -17.55      0.00     0.00      0.00      0.00       0.00
               7     17.55      0.00     0.00      0.00      0.00       0.00
         4     6      0.00      0.00     0.00      0.00      0.00       0.00
               7      0.00      0.00     0.00      0.00      0.00       0.00
         5     6    -13.16      0.00     0.00      0.00      0.00       0.00
               7     13.16      0.00     0.00      0.00      0.00       0.00

   14    1     5      0.00      0.00     0.00      0.00      0.00       0.00
               8      0.00      0.00     0.00      0.00      0.00       0.00
         2     5    -17.76      0.00     0.00      0.00      0.00       0.00
               8     17.76      0.00     0.00      0.00      0.00       0.00
         3     5      0.00      0.00     0.00      0.00      0.00       0.00
               8      0.00      0.00     0.00      0.00      0.00       0.00
         4     5    -13.32      0.00     0.00      0.00      0.00       0.00
               8     13.32      0.00     0.00      0.00      0.00       0.00
         5     5      0.00      0.00     0.00      0.00      0.00       0.00
               8      0.00      0.00     0.00      0.00      0.00       0.00


 ************** END OF LATEST ANALYSIS RESULT **************
  49. LOAD LIST 1 4 5
  50. PARAMETER
  51. CODE AISC
  52. BEAM 1.0 ALL
  53. UNT 6.0 ALL
  54. UNB 6.0 ALL
  55. KY 0.5 ALL
  56. CHECK CODE ALL

                    STAAD.PRO CODE CHECKING - (AISC 9TH EDITION)
                    ********************************************

ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)

MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                         FX            MY             MZ       LOCATION
=======================================================================

    1  ST   W12X26                   (AISC SECTIONS)
                           PASS     AISC- H1-3        0.285         5
                       18.07 C         0.00           9.73      15.00
    2  ST   W12X26                   (AISC SECTIONS)
                           PASS     AISC- H1-1        0.416         5
                       50.45 C         0.00           2.26      15.00
    3  ST   W12X26                   (AISC SECTIONS)
                           PASS     AISC- H1-3        0.394         5
                       15.76 C         0.00          18.05      15.00
    4  ST   W12X26                   (AISC SECTIONS)
                           PASS     AISC- H1-1        0.394         4
                       35.95 C         0.00          -8.95      15.00
    5  ST   W12X26                   (AISC SECTIONS)
                           PASS     AISC- H1-3        0.346         4
                       15.61 C         0.00         -14.97      15.00
    6  ST   W18X35                   (AISC SECTIONS)
                           PASS     AISC- H1-1        0.442         4
                       22.84 C         0.00          35.78      20.00
    7  ST   W18X35                   (AISC SECTIONS)
                           PASS     AISC- H1-1        0.591         5
                       32.05 C         0.00          46.07       0.00
    8  ST   W18X35                   (AISC SECTIONS)
                           PASS     AISC- H1-3        0.302         4
                       12.58 C         0.00         -23.69      10.00
    9  LD   L50505                   (AISC SECTIONS)
                           PASS     TENSION           0.191         4
                       25.03 T         0.00           0.00       0.00
```

```
ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)

MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                         FX            MY             MZ       LOCATION
=======================================================================

    10  LD   L50505                   (AISC SECTIONS)
                           PASS     TENSION            0.147         5
                       19.31 T        0.00             0.00        0.00
    11  LD   L50505                   (AISC SECTIONS)
                           PASS     TENSION            0.171         5
                       22.41 T        0.00             0.00        0.00
    12  LD   L50505                   (AISC SECTIONS)
                           PASS     TENSION            0.128         4
                       16.73 T        0.00             0.00        0.00
    13  LD   L50505                   (AISC SECTIONS)
                           PASS     TENSION            0.100         5
                       13.16 T        0.00             0.00        0.00
    14  LD   L50505                   (AISC SECTIONS)
                           PASS     TENSION            0.102         4
                       13.32 T        0.00             0.00        0.00

   57. FINISH


            *********** END OF THE STAAD.Pro RUN ***********

              **** DATE=             TIME=           ****

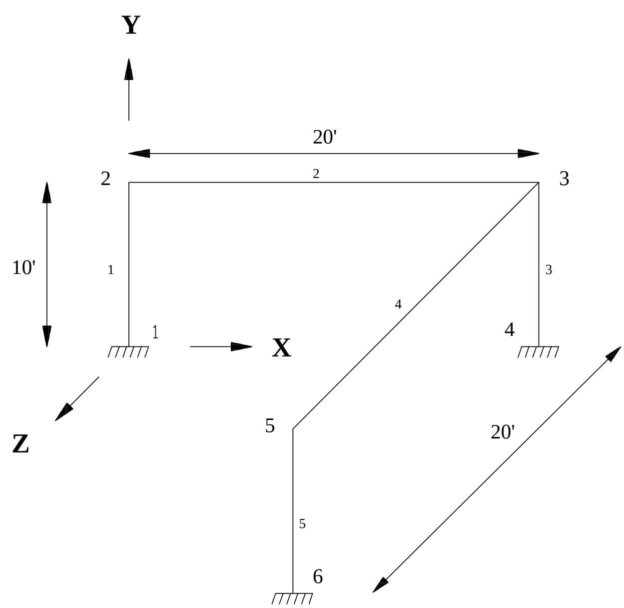
        ************************************************************
        *         For questions on STAAD.Pro, please contact       *
        *   Research Engineers Offices at the following locations  *
        *                                                          *
        *              Telephone                 Email             *
        *  USA:      +1 (714)974-2500       support@bentley.com    *
        *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
        *  UK        +44(1454)207-000       support@reel.co.uk     *
        *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
        *  GERMANY   +49/931/40468-71       info@reig.de           *
        *  NORWAY    +47 67 57 21 30        staad@edr.no           *
        *  SINGAPORE +65 6225-6158          support@bentley.com    *
        *  INDIA     +91(033)4006-2021      support@bentley.com    *
        *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
        *  CHINA     +86(411)363-1983       support@bentley.com    *
        *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
        *                                                          *
        *  North America                   support@bentley.com     *
        *  Europe                          support@bentley.com     *
        *  Asia                            support@bentley.com     *
        ************************************************************
```

NOTES

NOTES

Example Problem No. 5

This example demonstrates the application of support displacement load (commonly known as sinking support) on a space frame structure.



Actual input is shown in bold lettering followed by explanation.

STAAD SPACE TEST FOR SUPPORT DISPLACEMENT

Every input has to start with the word STAAD. The word SPACE signifies that the structure is a space frame structure (3-D) and the geometry is defined through X, Y and Z coordinates.

UNITS KIP FEET

Specifies the unit to be used for data to follow.

JOINT COORDINATES
1 0.0 0.0 0.0 ; 2 0.0 10.0 0.0
3 20.0 10.0 0.0 ; 4 20.0 0.0 0.0
5 20. 10. 20. ; 6 20. 0. 20.

Joint number followed by X, Y and Z coordinates are provided above. Semicolon signs (;) are used as line separators. That enables us to provide multiple sets of data on one line.

MEMBER INCIDENCE
1 1 2 3
4 3 5 ; 5 5 6

Defines the members by the joints they are connected to.

UNIT INCH
MEMB PROP
1 TO 5 PRIS AX 10. IZ 300. IY 300. IX 10.

Member properties have been defined above using the PRISMATIC attribute. Values of AX (area), IZ (moment of inertia about major axis), IY (moment of inertia about minor axis) and IX (torsional constant) are provided in INCH unit.

CONSTANT
E 29000. ALL
POISSON STEEL ALL

Material constants like E (modulus of elasticity) and Poisson’s ratio are specified following the command CONSTANTS.

SUPPORT
1 4 6 FIXED

Joints 1, 4 and 6 are fixed supports.

LOADING 1 SINKING SUPPORT

Load case 1 is initiated along with an accompanying title.

SUPPORT DISPLACEMENT LOAD
4 FY -0.50

Load 1 is a support displacement load which is also commonly known as a sinking support. FY signifies that the support settlement is in the global Y direction and the value of this settlement is 0.5 inch downward.

PERFORM ANALYSIS

This command instructs the program to proceed with the analysis.

PRINT ANALYSIS RESULTS

The above PRINT command instructs the program to print joint displacements, support reactions and member forces.

FINISH

This command terminates the STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************


  1. STAAD SPACE TEST FOR SUPPORT DISPLACEMENT
  2. UNITS KIP FEET
  3. JOINT COORDINATES
  4. 1 0.0 0.0 0.0 ; 2 0.0 10.0 0.0
  5. 3 20.0 10.0 0.0 ; 4 20.0 0.0 0.0
  6. 5 20. 10. 20. ; 6 20. 0. 20.
  7. MEMBER INCIDENCE
  8. 1 1 2 3
  9. 4 3 5 ; 5 5 6
 10. UNIT INCH
 11. MEMB PROP
 12. 1 TO 5 PRIS AX 10. IZ 300. IY 300. IX 10.
 13. CONSTANT
 14. E 29000. ALL
 15. POISSON STEEL ALL
 16. SUPPORT
 17. 1 4 6 FIXED
 18. LOADING 1 SINKING SUPPORT
 19. SUPPORT DISPLACEMENT LOAD
 20. 4 FY -0.50
 21. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     6/     5/     3
  ORIGINAL/FINAL BAND-WIDTH=     2/     2/     12 DOF
  TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     18
  SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =    12.0/  3144.1 MB,  EXMEM =  568.2 MB


 22. PRINT ANALYSIS RESULTS


JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = SPACE
------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    1    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
    2    1    0.09125  -0.00040  -0.01078  -0.00014   0.00050  -0.00154
    3    1    0.09118  -0.49919  -0.09118  -0.00154   0.00000  -0.00154
    4    1    0.00000  -0.50000   0.00000   0.00000   0.00000   0.00000
    5    1    0.01078  -0.00040  -0.09125  -0.00154  -0.00050  -0.00014
    6    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
```

```
  SUPPORT REACTIONS -UNIT KIP  INCH    STRUCTURE TYPE = SPACE
  -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1      0.08      0.97      0.15     19.22     -0.46    107.07
    4    1      0.07     -1.95     -0.07    107.18      0.00    107.18
    6    1     -0.15      0.97     -0.08    107.07      0.46     19.22


  MEMBER END FORCES    STRUCTURE TYPE = SPACE
  -----------------
  ALL UNITS ARE -- KIP  INCH

 MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z


    1    1     1      0.97     -0.08     0.15     -0.46    -19.22     107.07
               2     -0.97      0.08    -0.15      0.46      0.65    -116.64

    2    1     2      0.08      0.97     0.15      0.65     -0.46     116.64
               3     -0.08     -0.97    -0.15     -0.65    -36.66     116.82

    3    1     3     -1.95     -0.07     0.07      0.00   -116.17    -116.17
               4      1.95      0.07    -0.07      0.00    107.18     107.18

    4    1     3      0.08     -0.97    -0.15     -0.65     36.66    -116.82
               5     -0.08      0.97     0.15      0.65      0.46    -116.64

    5    1     5      0.97      0.15     0.08      0.46   -116.64      -0.65
               6     -0.97     -0.15    -0.08     -0.46    107.07      19.22


  ************** END OF LATEST ANALYSIS RESULT **************

   23. FINISH


           *********** END OF THE STAAD.Pro RUN ***********

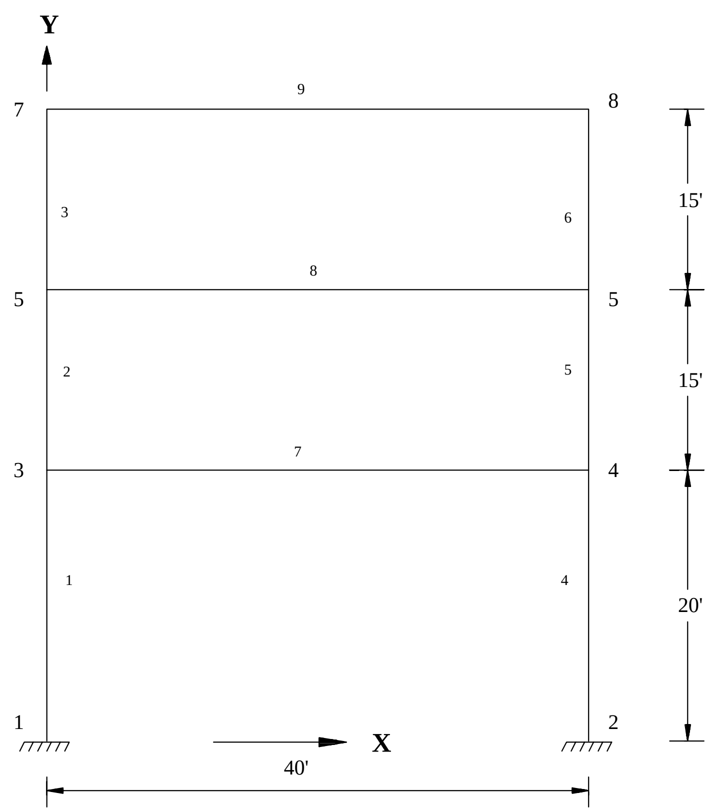
             **** DATE=                TIME=          ****

        ************************************************************
        *         For questions on STAAD.Pro, please contact       *
        *   Research Engineers Offices at the following locations  *
        *                                                          *
        *              Telephone                Email              *
        *  USA:      +1 (714)974-2500       support@bentley.com    *
        *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
        *  UK        +44(1454)207-000       support@reel.co.uk     *
        *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
        *  GERMANY   +49/931/40468-71       info@reig.de           *
        *  NORWAY    +47 67 57 21 30        staad@edr.no           *
        *  SINGAPORE +65 6225-6158          support@bentley.com    *
        *  INDIA     +91(033)4006-2021      support@bentley.com    *
        *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
        *  CHINA     +86(411)363-1983       support@bentley.com    *
        *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
        *                                                          *
        *  North America                   support@bentley.com     *
        *  Europe                          support@bentley.com     *
        *  Asia                            support@bentley.com     *
        ************************************************************
```

NOTES

Example Problem No. 6

This is an example of prestress loading in a plane frame structure. It covers two situations: 1) From the member on which it is applied, the prestressing effect is transmitted to the rest of the structure through the connecting members (known in the program as PRESTRESS load). 2) The prestressing effect is experienced by the member(s) alone and not transmitted to the rest of the structure (known in the program as POSTSTRESS load).



Actual input is shown in bold lettering followed by explanation.

STAAD PLANE FRAME WITH PRESTRESSING LOAD

Every input has to start with the word STAAD. The word PLANE signifies that the structure is a plane frame structure and the geometry is defined through X and Y axes.

UNIT KIP FT

Specifies the unit to be used for input to follow.

JOINT COORD
1 0. 0. ; 2 40. 0. ; 3 0. 20. ; 4 40. 20.
5 0. 35. ; 6 40. 35. ; 7 0. 50. ; 8 40. 50.

Joint number followed by X and Y coordinates are provided above. Since this is a plane structure, the Z coordinates need not be provided. Semicolon signs (;) are used as line separators, and that allows us to provide multiple sets of data on one line.

MEMBER INCIDENCE
1 1 3 ; 2 3 5 ; 3 5 7 ; 4 2 4 ; 5 4 6
6 6 8 ; 7 3 4 ; 8 5 6 ; 9 7 8

Defines the members by the joints they are connected to.

SUPPORT
1 2 FIXED

The supports at joints 1 and 2 are defined to be fixed supports.

MEMB PROP
1 TO 9 PRI AX 2.2 IZ 1.0

Member properties are provided using the PRI (prismatic) attribute. Values of area (AX) and moment of inertia about the major axis (IZ) are provided.

UNIT INCH
CONSTANT
E 3000. ALL ; POISSON CONCRETE ALL

The CONSTANT command initiates input for material constants like E (modulus of elasticity), Poisson's ratio, etc. Length unit is changed from FT to INCH to facilitate the input.

```
LOADING 1 PRESTRESSING LOAD
MEMBER PRESTRESS
7  8  FORCE 300. ES 3. EM -12. EE 3.
```

Load case 1 is initiated along with an accompanying title. Load 1 contains PRESTRESS load. Members 7 and 8 have a cable force of 300 kips. The location of the cable at the start (ES) and end (EE) is 3 inches above the center of gravity while at the middle (EM) it is 12 inches below the c.g. The assumptions and facts associated with this type of loading are explained in section 1 of the Technical Reference Manual.

```
LOADING 2 POSTSTRESSING LOAD
MEMBER POSTSTRESS
7  8 FORCE 300. ES 3. EM -12. EE 3.
```

Load case 2 is initiated along with an accompanying title. Load 2 is a POSTSTRESS load. Members 7 and 8 have cable force of 300 kips. The location of the cable is the same as in load case 1. For a difference between PRESTRESS loading and POSTSTRESS loading, as well as additional information about both types of loads, please refer to section 1 of the Technical Reference Manual.

```
PERFORM ANALYSIS
```

This command instructs the program to perform the analysis.

```
UNIT FT
PRINT ANALYSIS RESULT
```

The above command is an instruction to write joint displacements, support reactions and member forces in the output file. The preceding line causes the results to be written in the length unit of feet.

```
FINISH
```

This command terminates the STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

  1. STAAD PLANE  FRAME WITH PRESTRESSING LOAD
  2. UNIT KIP FT
  3. JOINT COORD
  4. 1 0. 0. ; 2 40. 0. ; 3 0. 20. ; 4 40. 20.
  5. 5 0. 35. ; 6 40. 35. ; 7 0. 50. ; 8 40. 50.
  6. MEMBER INCIDENCE
  7. 1 1 3 ; 2 3 5 ; 3 5 7 ; 4 2 4 ; 5 4 6
  8. 6 6 8 ; 7 3 4 ; 8 5 6 ; 9 7 8
  9. SUPPORT
 10. 1 2 FIXED
 11. MEMB PROP
 12. 1 TO 9 PRI AX 2.2 IZ 1.0
 13. UNIT INCH
 14. CONSTANT
 15. E 3000. ALL
 16. POISSON CONCRETE ALL
 17. LOADING 1 PRESTRESSING LOAD
 18. MEMBER PRESTRESS
 19. 7 8 FORCE 300. ES 3. EM -12. EE 3.
 20. LOADING 2 POSTSTRESSING LOAD
 21. MEMBER POSTSTRESS
 22. 7 8 FORCE 300. ES 3. EM -12. EE 3.
 23. PERFORM ANALYSIS

        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     8/     9/     2
  ORIGINAL/FINAL BAND-WIDTH=     2/     2/      9 DOF
  TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =     18
  SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =    12.0/  3144.1 MB,  EXMEM =  568.2 MB

 24. UNIT FT
 25. PRINT ANALYSIS RESULT

 JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = PLANE
 ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN


    1    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
    2    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
    3    1    0.07698   0.00000   0.00000   0.00000   0.00000   0.00039
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
    4    1   -0.07698   0.00000   0.00000   0.00000   0.00000  -0.00039
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
    5    1    0.07224   0.00000   0.00000   0.00000   0.00000   0.00087
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
    6    1   -0.07224   0.00000   0.00000   0.00000   0.00000  -0.00087
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
    7    1   -0.00059   0.00000   0.00000   0.00000   0.00000   0.00015
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
    8    1    0.00059   0.00000   0.00000   0.00000   0.00000  -0.00015
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
```

```
 SUPPORT REACTIONS -UNIT KIP  FEET    STRUCTURE TYPE = PLANE
 -----------------
JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1     -6.71      0.00      0.00      0.00      0.00     58.62
         2      0.00      0.00      0.00      0.00      0.00      0.00
    2    1      6.71      0.00      0.00      0.00      0.00    -58.62
         2      0.00      0.00      0.00      0.00      0.00      0.00

 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET

 MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1      0.00      6.71     0.00      0.00      0.00      58.62
               3      0.00     -6.71     0.00      0.00      0.00      75.67
         2     1      0.00      0.00     0.00      0.00      0.00       0.00
               3      0.00      0.00     0.00      0.00      0.00       0.00

    2    1     3      0.00     13.92     0.00      0.00      0.00      90.81
               5      0.00    -13.92     0.00      0.00      0.00     117.98
         2     3      0.00      0.00     0.00      0.00      0.00       0.00
               5      0.00      0.00     0.00      0.00      0.00       0.00

    3    1     5      0.00      2.34     0.00      0.00      0.00      38.31
               7      0.00     -2.34     0.00      0.00      0.00      -3.16
         2     5      0.00      0.00     0.00      0.00      0.00       0.00
               7      0.00      0.00     0.00      0.00      0.00       0.00

    4    1     2      0.00     -6.71     0.00      0.00      0.00     -58.62
               4      0.00      6.71     0.00      0.00      0.00     -75.67
         2     2      0.00      0.00     0.00      0.00      0.00       0.00
               4      0.00      0.00     0.00      0.00      0.00       0.00

    5    1     4      0.00    -13.92     0.00      0.00      0.00     -90.81
               6      0.00     13.92     0.00      0.00      0.00    -117.98
         2     4      0.00      0.00     0.00      0.00      0.00       0.00
               6      0.00      0.00     0.00      0.00      0.00       0.00

    6    1     6      0.00     -2.34     0.00      0.00      0.00     -38.31
               8      0.00      2.34     0.00      0.00      0.00       3.16
         2     6      0.00      0.00     0.00      0.00      0.00       0.00
               8      0.00      0.00     0.00      0.00      0.00       0.00

    7    1     3    304.85    -37.50     0.00      0.00      0.00    -241.48
               4   -304.85    -37.50     0.00      0.00      0.00     241.48
         2     3    297.65    -37.50     0.00      0.00      0.00     -75.00
               4   -297.65    -37.50     0.00      0.00      0.00      75.00

    8    1     5    286.07    -37.50     0.00      0.00      0.00    -231.29
               6   -286.07    -37.50     0.00      0.00      0.00     231.29
         2     5    297.65    -37.50     0.00      0.00      0.00     -75.00
               6   -297.65    -37.50     0.00      0.00      0.00      75.00

    9    1     7     -2.34      0.00     0.00      0.00      0.00       3.16
               8      2.34      0.00     0.00      0.00      0.00      -3.16
         2     7      0.00      0.00     0.00      0.00      0.00       0.00
               8      0.00      0.00     0.00      0.00      0.00       0.00

 ************** END OF LATEST ANALYSIS RESULT **************
```

```
26. FINISH

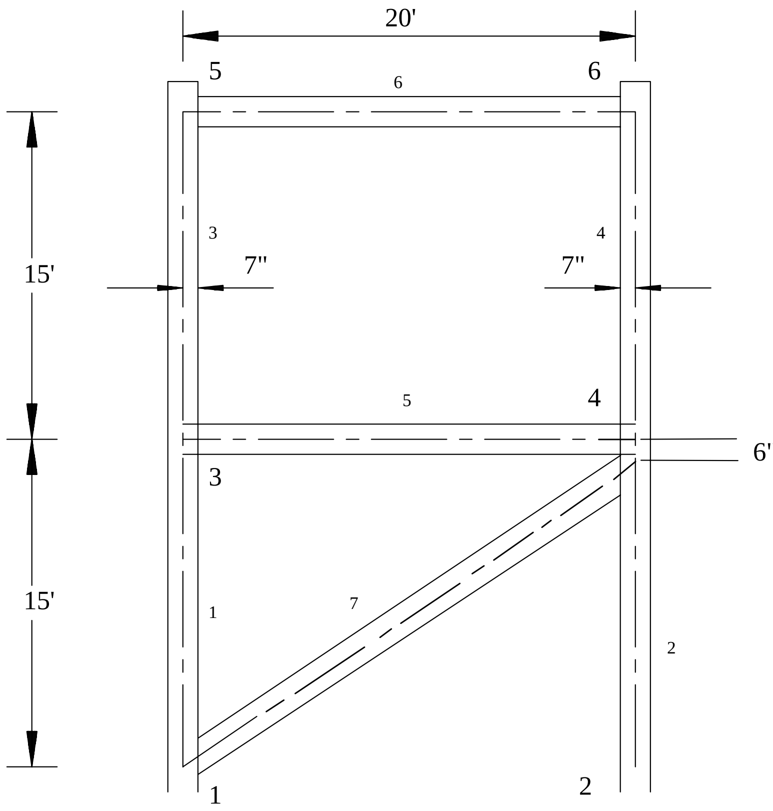
             *********** END OF THE STAADPro RUN ***********

                 **** DATE=              TIME=          ****

         ************************************************************
         *         For questions on STAAD.Pro, please contact       *
         *   Research Engineers Offices at the following locations  *
         *                                                           *
         *              Telephone                 Email              *
         *  USA:      +1 (714)974-2500       support@bentley.com     *
         *  CANADA    +1 (905)632-4771       detech@odandetech.com   *
         *  UK        +44(1454)207-000       support@reel.co.uk      *
         *  FRANCE    +33(0)1 64551084       support@reel.co.uk      *
         *  GERMANY   +49/931/40468-71       info@reig.de            *
         *  NORWAY    +47 67 57 21 30        staad@edr.no            *
         *  SINGAPORE +65 6225-6158          support@bentley.com     *
         *  INDIA     +91(033)4006-2021      support@bentley.com     *
         *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp       *
         *  CHINA     +86(411)363-1983       support@bentley.com     *
         *  THAILAND  +66(0)2645-1018/19     support@bentley.com     *
         *                                                           *
         *  North America                   support@bentley.com      *
         *  Europe                          support@bentley.com      *
         *  Asia                            support@bentley.com      *
         ************************************************************
```

Example Problem No. 7

This example illustrates modelling of structures with OFFSET connections. OFFSET connections arise when the center lines of the connected members do not intersect at the connection point. The connection eccentricity behaves as a rigid link and is modeled through specification of MEMBER OFFSETS.



Actual input is shown in bold lettering followed by explanation.

STAAD PLANE TEST FOR MEMBER OFFSETS

Every input has to start with the word STAAD. The word PLANE signifies that the structure is a plane frame structure and the geometry is defined through X and Y axes.

UNIT FT KIP

Specifies the unit to be used for data to follow.

JOINT COORD
1 0. 0. ; 2 20. 0. ; 3 0. 15.
4 20. 15. ; 5 0. 30. ; 6 20. 30.

Joint number followed by X and Y coordinates are provided above. Since this is a plane structure, the Z coordinates need not be provided. Semicolon signs (;) are used as line separators. This allows us to provide multiple sets of data in one line.

MEMB INCI
1 1 3 2 ; 3 3 5 4
5 3 4 ; 6 5 6 ; 7 1 4

Defines the members by the joints they are connected to.

MEMB PROP AMERICAN
1 TO 4 TABLE ST W14X90
5 6 TA ST W12X26
7 TA LD L90408

Member properties are assigned from the American (AISC) steel table for all members. The word ST stands for standard single section. LD stands for long leg back-to-back double angle.

UNIT INCH
MEMB OFFSET
5 6 START 7.0 0.0 0.0
5 6 END -7.0 0.0 0.0
7 END -7.0 -6.0 0.0

The above specification states that an OFFSET is located at the START/END joint of the members. The X, Y and Z global coordinates of the offset distance from the corresponding incident joint are also provided. These attributes are applied to members 5, 6 and 7.

```
CONSTANT
E 29000. ALL
POISSON STEEL ALL
```

Material constants like E (modulus of elasticity) and Poisson’s ratio are provided following the keyword CONSTANT.

```
SUPPORT
1  2  PINNED
```

Pinned supports are specified at joints 1 and 2. The word PINNED signifies that no moments will be carried by these supports.

```
LOADING 1 WIND LOAD
```

Load case 1 is initiated along with an accompanying title.

```
JOINT LOAD
3 FX 50. ; 5 FX 25.0
```

Load 1 contains joint loads at nodes 3 and 5. FX indicates that the load is a force in the global X direction.

```
PERFORM ANALYSIS
```

The above command is an instruction to perform the analysis.

```
UNIT FT
PRINT FORCES
PRINT REACTIONS
```

The above PRINT commands are self-explanatory. The preceding line causes the results to be written in the length unit of feet.

FINISH

This command terminates a STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

  1. STAAD PLANE TEST FOR MEMBER OFFSETS
  2. UNIT FT KIP
  3. JOINT COORD
  4. 1 0. 0. ; 2 20. 0. ; 3 0. 15.
  5. 4 20. 15. ; 5 0. 30. ; 6 20. 30.
  6. MEMB INCI
  7. 1 1 3 2; 3 3 5 4
  8. 5 3 4 ; 6 5 6 ; 7 1 4
  9. MEMB PROP AMERICAN
 10. 1 TO 4 TABLE ST W14X90
 11. 5 6 TA ST W12X26
 12. 7 TA LD L90408
 13. UNIT INCH
 14. MEMB OFFSET
 15. 5 6 START 7.0 0.0 0.0
 16. 5 6 END  -7.0 0.0 0.0
 17. 7 END -7.0 -6.0 0.0
 18. CONSTANT
 19. E 29000. ALL
 20. POISSON STEEL ALL
 21. SUPPORT
 22. 1 2 PINNED
 23. LOADING 1 WIND LOAD
 24. JOINT LOAD
 25. 3 FX 50. ; 5 FX 25.0
 26. PERFORM ANALYSIS

        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     6/     7/     2
  ORIGINAL/FINAL BAND-WIDTH=     3/     3/      9 DOF
  TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     14
  SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =    12.0/  3144.0 MB,  EXMEM =  568.2 MB

 27. UNIT FT
 28. PRINT FORCES

 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1    -10.74     -4.50     0.00      0.00      0.00       4.32
               3     10.74      4.50     0.00      0.00      0.00     -71.76

    2    1     2     75.00     -5.63     0.00      0.00      0.00       0.00
               4    -75.00      5.63     0.00      0.00      0.00     -84.43

    3    1     3     -6.74     11.89     0.00      0.00      0.00     111.89
               5      6.74    -11.89     0.00      0.00      0.00      66.49

    4    1     4      6.74     13.11     0.00      0.00      0.00     128.22
               6     -6.74    -13.11     0.00      0.00      0.00      68.40
```

```
 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    5    1     3     66.39     -3.99     0.00      0.00      0.00     -37.80
               4    -66.39      3.99     0.00      0.00      0.00     -37.37

    6    1     5     13.11     -6.74     0.00      0.00      0.00     -62.55
               6    -13.11      6.74     0.00      0.00      0.00     -64.47

    7    1     1   -106.66     -0.56     0.00      0.00      0.00      -4.32
               4    106.66      0.56     0.00      0.00      0.00      -9.16


 ************** END OF LATEST ANALYSIS RESULT **************

  29. PRINT REACTIONS

 SUPPORT REACTIONS -UNIT KIP  FEET    STRUCTURE TYPE = PLANE
 -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1    -80.63    -75.00      0.00      0.00      0.00      0.00
    2    1      5.63     75.00      0.00      0.00      0.00      0.00


 ************** END OF LATEST ANALYSIS RESULT **************

  30. FINISH

           *********** END OF THE STAAD.Pro RUN ***********

             **** DATE=                TIME=          ****

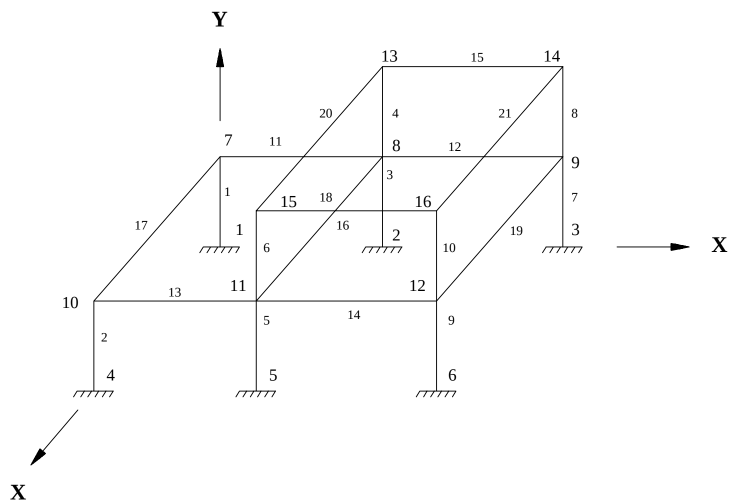
       ************************************************************
       *         For questions on STAAD.Pro, please contact       *
       *   Research Engineers Offices at the following locations  *
       *                                                          *
       *             Telephone               Email                *
       *  USA:      +1 (714)974-2500      support@bentley.com     *
       *  CANADA    +1 (905)632-4771      detech@odandetech.com   *
       *  UK        +44(1454)207-000      support@reel.co.uk      *
       *  FRANCE    +33(0)1 64551084      support@reel.co.uk      *
       *  GERMANY   +49/931/40468-71      info@reig.de            *
       *  NORWAY    +47 67 57 21 30       staad@edr.no            *
       *  SINGAPORE +65 6225-6158         support@bentley.com     *
       *  INDIA     +91(033)4006-2021     support@bentley.com     *
       *  JAPAN     +81(03)5952-6500      eng-eye@crc.co.jp       *
       *  CHINA     +86(411)363-1983      support@bentley.com     *
       *  THAILAND  +66(0)2645-1018/19    support@bentley.com     *
       *                                                          *
       *  North America                  support@bentley.com      *
       *  Europe                         support@bentley.com      *
       *  Asia                           support@bentley.com      *
       ************************************************************
```

NOTES

NOTES

Example Problem No. 8

In this example, concrete design is performed on some members of a space frame structure. Design calculations consist of computation of reinforcement for beams and columns. Secondary moments on the columns are obtained through the means of a P-Delta analysis.



The above example represents a space frame, and the members are made of concrete. The input in the next page will show the dimensions of the members.

Two load cases, namely one for dead plus live load and another with dead, live and wind load, are considered in the design.

Actual input is shown in bold lettering followed by explanation.

STAAD SPACE FRAME WITH CONCRETE DESIGN

Every input has to start with the word STAAD. The word SPACE signifies that the structure is a space frame structure (3-D) and the geometry is defined through X, Y and Z coordinates.

UNIT KIP FT

Specifies the unit to be used.

JOINT COORDINATE
1 0 0 0 ; 2 18 0 0 ; 3 38 0. 0
4 0 0 24 ; 5 18 0 24 ; 6 38 0 24
7 0 12 0 ; 8 18. 12 0 ; 9 38 12 0
10 0 12 24 ; 11 18 12 24 ; 12 38 12 24
13 18 24 0 ; 14 38 24 0 ; 15 18 24 24
16 38 24 24

Joint number followed by X, Y and Z coordinates are provided above. Semicolon signs (;) are used as line separators to facilitate input of multiple sets of data on one line.

MEMBER INCIDENCE
1 1 7 ; 2 4 10 ; 3 2 8 ; 4 8 13
5 5 11 ; 6 11 15 ; 7 3 9 ; 8 9 14
9 6 12 ; 10 12 16 ; 11 7 8 12
13 10 11 14 ; 15 13 14 ; 16 15 16
17 7 10 ; 18 8 11 ; 19 9 12
20 13 15 ; 21 14 16

Defines the members by the joints they are connected to.

UNIT INCH
MEMB PROP
1 2 PRISMATIC YD 12.0 IZ 509. IY 509. IX 1018.
3 TO 10 PR YD 12.0 ZD 12.0 IZ 864. IY 864. IX 1279.
11 TO 21 PR YD 21.0 ZD 16.0 IZ 5788. IY 2953. IX 6497.

All member properties are provided using the PRISMATIC option. YD and ZD stand for depth and width. If ZD is not provided, a circular shape with diameter = YD is assumed for that cross section. All properties required for the analysis, such as, Area, Moments of Inertia, etc. are calculated automatically from these dimensions unless these are explicitly defined. For this particular example, moments of inertia (IZ, IY) and torsional constant (IX) are provided, so these will not be re-calculated. The IX, IY, and IZ values provided in this example are only half the values of a full section to account for the fact that the full moments of inertia will not be effective due to cracking of concrete. Clause 10.11.1 of ACI 318-99 offers some guidelines on the amount of reduction to be applied on the gross section moment of inertia for beams, columns, walls and slabs to account for cracking.

```
CONSTANT
E 3150.0 ALL
POISSON CONCRETE ALL
UNIT FT
CONSTANT
DEN .15 ALL
```

The CONSTANT command initiates input for material constants like E (modulus of elasticity), Poisson’s ratio, Density, etc. Length unit is changed from INCH to FT to facilitate input for DENsity. The built-in value for Poisson’s ratio for concrete will be used in the analysis.

```
SUPPORT
1 TO 6 FIXED
```

Joints 1 to 6 are fixed supports.

```
LOAD 1 (1.4DL + 1.7LL)
```

Load case 1 is initiated followed by a title.

```
SELF Y -1.4
```

The selfweight of the structure is applied in the global Y direction with a -1.4 factor. Since global Y is vertically upward, the negative factor indicates that this load will act downwards.

MEMB LOAD
11 TO 16 UNI Y -2.8
11 TO 16 UNI Y -5.1

Load 1 contains member loads also. Y indicates that the load is in the local Y direction. The word UNI stands for uniformly distributed load.

LOAD 2 .75 (1.4DL + 1.7LL + 1.7WL)

Load case 2 is initiated along with an accompanying title.

REPEAT LOAD
1 0.75

The above command will gather the load data values from load case 1, multiply them with a factor of 0.75 and utilize the resulting values in load 2.

JOINT LOAD
15 16 FZ 8.5
11 FZ 20.0
12 FZ 16.0
10 FZ 8.5

Load 2 contains some additional joint loads also. FZ indicates that the load is a force in the global Z direction.

PDELTA ANALYSIS

This command instructs the program to proceed with the analysis. The analysis type is P-DELTA indicating that second-order effects are to be calculated.

PRINT FORCES LIST 2 5 9 14 16

Member end forces are printed using the above PRINT command. The LIST option restricts the print output to the members listed.

START CONCRETE DESIGN

The above command initiates a concrete design.

CODE ACI
TRACK 1.0 MEMB 14
TRACK 2.0 MEMB 16
MAXMAIN 11 ALL

The values for the concrete design parameters are defined in the above commands. Design is performed per the ACI 318 Code. The TRACK value dictates the extent of design related information that should appear in the output. MAXMAIN indicates that the maximum size of main reinforcement is the #11 bar. These parameters are described in the manual where American concrete design related information is available.

DESIGN BEAM 14 16

The above command instructs the program to design beams 14 and 16 for flexure, shear and torsion.

DESIGN COLUMN 2 5

The above command instructs the program to design columns 2 and 5 for axial load and biaxial bending.

END CONCRETE DESIGN

This will end the concrete design.

FINISH

This command terminates the STAAD run.

```
          ****************************************************
          *                                                  *
          *           STAAD.Pro                              *
          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
          *           Date=                                  *
          *           Time=                                  *
          *                                                  *
          *      USER ID:                                    *
          ****************************************************

  1. STAAD SPACE FRAME WITH CONCRETE DESIGN
  2. UNIT KIP FT
  3. JOINT COORDINATE
  4. 1 0 0 0 ; 2 18 0 0 ; 3 38 0. 0
  5. 4 0 0 24 ; 5 18 0 24 ; 6 38 0 24
  6. 7 0 12 0 ; 8 18 12 0 ; 9 38 12 0
  7. 10 0 12 24 ; 11 18 12 24 ; 12 38 12 24
  8. 13 18 24 0 ; 14 38 24 0 ; 15 18 24 24
  9. 16 38 24 24
 10. MEMBER INCIDENCE
 11. 1 1 7 ; 2 4 10 ; 3 2 8 ; 4 8 13
 12. 5 5 11 ; 6 11 15 ; 7 3 9 ; 8 9 14
 13. 9 6 12 ; 10 12 16 ; 11 7 8 12
 14. 13 10 11 14 ; 15 13 14 ; 16 15 16
 15. 17 7 10 ; 18 8 11 ; 19 9 12
 16. 20 13 15 ; 21 14 16
 17. UNIT INCH
 18. MEMB PROP
 19. 1 2 PRISMATIC YD 12.0 IZ 509. IY 509. IX 1018.
 20. 3 TO 10 PR YD 12.0 ZD 12.0 IZ 864. IY 864. IX 1279.
 21. 11 TO 21 PR YD 21.0 ZD 16.0 IZ 5788. IY 2953. IX 6497.
 22. CONSTANT
 23. E 3150. ALL
 24. POISSON CONCRETE ALL
 25. UNIT FT
 26. CONSTANT
 27. DEN .15 ALL
 28. SUPPORT
 29. 1 TO 6 FIXED
 30. LOAD 1 (1.4DL + 1.7LL)
 31. SELF Y -1.4
 32. MEMB LOAD
 33. 11 TO 16 UNI Y -2.8
 34. 11 TO 16 UNI Y -5.1
 35. LOAD 2 .75(1.4DL + 1.7LL + 1.7WL)
 36. REPEAT LOAD
 37. 1 0.75
 38. JOINT LOAD
 39. 15 16 FZ 8.5
 40. 11 FZ 20.0
 41. 12 FZ 16.0
 42. 10 FZ 8.5
 43. PDELTA ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    16/    21/     6
  ORIGINAL/FINAL BAND-WIDTH=     6/     5/     30 DOF
  TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =     60
  SIZE OF STIFFNESS MATRIX =        2 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.1/   4238.7 MB

 44. PRINT FORCES LIST 2 5 9 14 16
```

```
MEMBER END FORCES    STRUCTURE TYPE = SPACE
-----------------
ALL UNITS ARE -- KIP  FEET     (LOCAL )

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

   2     1     4     68.03     -4.09    -0.70      0.00      2.78     -17.47
              10    -66.05      4.09     0.70      0.00      5.59     -31.66
         2     4     54.78     -3.41    -6.92      1.01     41.72     -15.20
              10    -53.30      3.41     6.92     -1.01     41.27     -25.77

   5     1     5    289.32     -0.63    -0.73      0.00      2.90      -4.49
              11   -286.80      0.63     0.73      0.00      5.83      -3.12
         2     5    227.51     -1.07   -14.33      0.89     89.77      -6.98
              11   -225.62      1.07    14.33     -0.89     82.23      -5.88

   9     1     6    170.72      4.45    -0.67      0.00      2.69      15.79
              12   -168.20     -4.45     0.67      0.00      5.40      37.59
         2     6    139.11      2.78   -14.67      0.17     92.23       8.40
              12   -137.22     -2.78    14.67     -0.17     83.84      24.98

  14     1    11     -9.09     97.14     0.00     -0.21     -0.01     371.01
              12      9.09     70.66     0.00      0.21      0.00    -106.19
         2    11     -7.71     73.04     0.61     -0.83     -8.45     279.75
              12      7.71     52.81    -0.61      0.83     -3.80     -77.50

  16     1    15     13.63     84.54     0.00      0.03      0.00     105.46
              16    -13.63     83.26     0.00     -0.03      0.00     -92.76
         2    15     10.22     63.37     0.06     -0.08     -0.74      78.82
              16    -10.22     62.48    -0.06      0.08     -0.54     -69.92


************** END OF LATEST ANALYSIS RESULT **************


 45. START CONCRETE DESIGN
 46. CODE ACI
 47. TRACK 1.0 MEMB 14
 48. TRACK 2.0 MEMB 16
 49. MAXMAIN 11 ALL
 50. DESIGN BEAM 14 16

=====================================================================

       BEAM  NO.    14 DESIGN RESULTS - FLEXURE PER CODE ACI 318-05

LEN -  20.00FT.  FY - 60000.  FC - 4000.  SIZE - 16.00 X 21.00 INCHES

LEVEL    HEIGHT     BAR INFO       FROM           TO          ANCHOR
       FT.    IN.              FT.     IN.     FT.     IN.   STA  END
_____________________________________________________________________

  1    0 + 2-3/4    2-NUM.10     0 + 2-5/8     20 + 0-0/0    NO   YES
|----------------------------------------------------------------|
|   CRITICAL POS MOMENT=    191.31 KIP-FT  AT 11.67 FT, LOAD    1|
|   REQD STEEL=  2.50 IN2, ROW=0.0085, ROWMX=0.0214 ROWMN=0.0033 |
|   MAX/MIN/ACTUAL BAR SPACING= 10.00/ 2.54/10.73 INCH           |
|   REQD. DEVELOPMENT LENGTH = 43.55 INCH                        |
|----------------------------------------------------------------|

  Cracked Moment of Inertia Iz at above location =    4265.14 inch^4

  2    1 + 6-1/8    4-NUM.11     0 + 0-0/0     16 + 2-0/0    YES  NO
|----------------------------------------------------------------|
|   CRITICAL NEG MOMENT=    371.01 KIP-FT  AT  0.00 FT, LOAD    1|
|   REQD STEEL=  5.38 IN2, ROW=0.0184, ROWMX=0.0214 ROWMN=0.0033 |
|   MAX/MIN/ACTUAL BAR SPACING= 10.00/ 2.82/ 3.53 INCH           |
|   REQD. DEVELOPMENT LENGTH = 80.14 INCH                        |
|----------------------------------------------------------------|

  Cracked Moment of Inertia Iz at above location =    8050.77 inch^4
```

```
  3    1 + 6-3/8    3-NUM.6     15 + 2-1/4     20 + 0-0/0    NO   YES
 |----------------------------------------------------------------|
 |   CRITICAL NEG MOMENT=    106.19 KIP-FT  AT 20.00 FT, LOAD    1|
 |   REQD STEEL=  1.31 IN2, ROW=0.0044, ROWMX=0.0214 ROWMN=0.0033 |
 |   MAX/MIN/ACTUAL BAR SPACING= 10.00/ 1.75/ 5.62 INCH           |
 |   REQD. DEVELOPMENT LENGTH = 21.35 INCH                        |
 |----------------------------------------------------------------|

  Cracked Moment of Inertia Iz at above location =    2640.84 inch^4

       B E A M  N O.    14 D E S I G N  R E S U L T S - SHEAR

 AT START SUPPORT - Vu=   84.21 KIP  Vc=   35.16 KIP  Vs=   77.12 KIP
 Tu=    0.21 KIP-FT  Tc=    5.70 KIP-FT  Ts=   0.00 KIP-FT  LOAD     1
 NO STIRRUPS ARE REQUIRED FOR TORSION.
 REINFORCEMENT IS REQUIRED FOR SHEAR.
 PROVIDE NUM. 5 2-LEGGED STIRRUPS AT  4.6 IN. C/C FOR  102. IN.

 AT END   SUPPORT - Vu=   57.72 KIP  Vc=   35.16 KIP  Vs=   41.81 KIP
 Tu=    0.21 KIP-FT  Tc=    5.70 KIP-FT  Ts=   0.00 KIP-FT  LOAD     1
 NO STIRRUPS ARE REQUIRED FOR TORSION.
 REINFORCEMENT IS REQUIRED FOR SHEAR.
 PROVIDE NUM. 4 2-LEGGED STIRRUPS AT  9.2 IN. C/C FOR  102. IN.

 ___  11J____________________  240.X  16.X  21_____________________  12J____
|                                                                          |
||========================================================================||
| 4#11H |18.| |0.TO |194. | | | | | | | | | | | | 3#6 H  18.|182.TO  240. |
| 24#5 C/C  5 | | | | | | | | | | | | | | | |  |  |  | 13#4 C/C  9  | |
| 2#10H | 3.| |3.TO |240. | | | | | | | | | | | |  |  |  |  |  |  |  |  | |
|========================================================================||
|                                                                          |
|__________________________________________________________________________|
 ___________      ___________      ___________      ___________      ___________
|           |    |           |    |           |    |           |    |           |
|   OOOO    |    |   OOOO    |    |   OOOO    |    |   OOOO    |    |    ooo    |
| 4#11      |    | 4#11      |    | 4#11      |    | 4#11      |    | 3#6       |
|           |    |           |    |           |    |           |    |           |
|           |    | 2#10      |    | 2#10      |    | 2#10      |    | 2#10      |
|           |    |    OO     |    |    OO     |    |    OO     |    |    OO     |
|           |    |           |    |           |    |           |    |           |
|___________|    |___________|    |___________|    |___________|    |___________|


 =====================================================================

       BEAM  NO.    16 DESIGN RESULTS - FLEXURE PER CODE ACI 318-05

 LEN -  20.00FT.  FY - 60000.  FC - 4000.  SIZE - 16.00 X 21.00 INCHES

 LEVEL    HEIGHT     BAR INFO       FROM           TO         ANCHOR
        FT.    IN.              FT.     IN.     FT.     IN.   STA  END
 _____________________________________________________________________

  1    0 + 2-3/4    3-NUM.11     0 + 0-0/0     20 + 0-0/0    YES  YES
 |----------------------------------------------------------------|
 |   CRITICAL POS MOMENT=    320.39 KIP-FT  AT 10.00 FT, LOAD    1|
 |   REQD STEEL=  4.50 IN2, ROW=0.0154, ROWMX=0.0214 ROWMN=0.0033 |
 |   MAX/MIN/ACTUAL BAR SPACING= 10.00/ 2.82/ 5.30 INCH           |
 |   REQD. DEVELOPMENT LENGTH = 53.43 INCH                        |
 |----------------------------------------------------------------|

  Cracked Moment of Inertia Iz at above location =    6625.00 inch^4

  2    1 + 6-3/8    3-NUM.6      0 + 0-0/0      2 + 3-3/4    YES  NO
 |----------------------------------------------------------------|
 |   CRITICAL NEG MOMENT=    105.46 KIP-FT  AT  0.00 FT, LOAD    1|
 |   REQD STEEL=  1.30 IN2, ROW=0.0043, ROWMX=0.0214 ROWMN=0.0033 |
 |   MAX/MIN/ACTUAL BAR SPACING= 10.00/ 1.75/ 5.62 INCH           |
 |   REQD. DEVELOPMENT LENGTH = 21.35 INCH                        |
 |----------------------------------------------------------------|

  Cracked Moment of Inertia Iz at above location =    2640.84 inch^4
```

```
  3    1 + 6-1/2    6-NUM.4     17 + 7-1/2     20 + 0-0/0    NO   YES
 |-----------------------------------------------------------------|
 |   CRITICAL NEG MOMENT=     92.76 KIP-FT  AT 20.00 FT, LOAD    1|
 |   REQD STEEL=  1.14 IN2, ROW=0.0038, ROWMX=0.0214 ROWMN=0.0033 |
 |   MAX/MIN/ACTUAL BAR SPACING= 10.00/ 1.50/ 2.30 INCH           |
 |   REQD. DEVELOPMENT LENGTH = 12.37 INCH                        |
 |-----------------------------------------------------------------|

  Cracked Moment of Inertia Iz at above location =    2438.75 inch^4


 REQUIRED REINF. STEEL SUMMARY :
 -------------------------------
 SECTION     REINF STEEL(+VE/-VE)     MOMENTS(+VE/-VE)    LOAD(+VE/-VE)
 (FEET)         (SQ. INCH)               (KIP-FEET)

   0.00        0.000/    1.323         0.00/    105.46        0/    1
   1.67        0.289/    0.000        23.78/      0.00        1/    0
   3.33        1.644/    0.000       129.71/      0.00        1/    0
   5.00        2.793/    0.000       212.34/      0.00        1/    0
   6.67        3.679/    0.000       271.66/      0.00        1/    0
   8.33        4.248/    0.000       307.68/      0.00        1/    0
  10.00        4.455/    0.000       320.39/      0.00        1/    0
  11.67        4.282/    0.000       309.80/      0.00        1/    0
  13.33        3.745/    0.000       275.90/      0.00        1/    0
  15.00        2.885/    0.000       218.69/      0.00        1/    0
  16.67        1.758/    0.000       138.18/      0.00        1/    0
  18.33        0.419/    0.000        34.37/      0.00        1/    0
  20.00        0.000/    1.158         0.00/     92.76        0/    1

        B E A M  N O.    16 D E S I G N  R E S U L T S - SHEAR

  AT START SUPPORT - Vu=   71.60 KIP  Vc=   67.37 KIP  Vs=   28.09 KIP
  Tu=    0.03 KIP-FT  Tc=    6.50 KIP-FT  Ts=    0.00 KIP-FT  LOAD     1
  NO STIRRUPS ARE REQUIRED FOR TORSION.
  REINFORCEMENT IS REQUIRED FOR SHEAR.
  PROVIDE NUM. 4 2-LEGGED STIRRUPS AT  9.1 IN. C/C FOR  102. IN.

  AT END   SUPPORT - Vu=   70.33 KIP  Vc=   67.37 KIP  Vs=   26.40 KIP
  Tu=    0.03 KIP-FT  Tc=    6.50 KIP-FT  Ts=    0.00 KIP-FT  LOAD     1
  NO STIRRUPS ARE REQUIRED FOR TORSION.
  REINFORCEMENT IS REQUIRED FOR SHEAR.
  PROVIDE NUM. 4 2-LEGGED STIRRUPS AT  9.1 IN. C/C FOR  102. IN.


 ___  15J____________________  240.X  16.X  21_____________________  16J____
|                                                                           |
||=======                                                          =========||
| 3#6|H |18.   0.TO   28.                         6#4 H  18. 212.TO  240. |
| 13#4 C/C  9                                                  13#4 C/C  9  | |
| 3#11H | 3.   0.TO  240.                                             |  |  | |
||==========================================================================||
|                                                                           |
|___________________________________________________________________________|
 ___________     ___________     ___________     ___________     ___________
|           |   |           |   |           |   |           |   |           |
|   ooo     |   |           |   |           |   |           |   | oooooo    |
| 3#6       |   |           |   |           |   |           |   | 6#4       |
|           |   |           |   |           |   |           |   |           |
| 3#11      |   | 3#11      |   | 3#11      |   | 3#11      |   | 3#11      |
|   OOO     |   |   OOO     |   |   OOO     |   |   OOO     |   |   OOO     |
|           |   |           |   |           |   |           |   |           |
|___________|   |___________|   |___________|   |___________|   |___________|


 ********************END OF BEAM DESIGN**************************

  51. DESIGN COLUMN 2 5
```

```
====================================================================

     COLUMN  NO.     2  DESIGN PER ACI 318-05 - AXIAL + BENDING

FY - 60000  FC - 4000 PSI,  CIRC SIZE  12.00 INCHES DIAMETER  TIED
        AREA OF STEEL REQUIRED =   3.664  SQ. IN.

BAR CONFIGURATION       REINF PCT.   LOAD   LOCATION   PHI
----------------------------------------------------------

 12 - NUMBER  5           3.289        2      END     0.650
(EQUALLY SPACED)
TIE BAR NUMBER    4 SPACING   8.00 IN

====================================================================

     COLUMN  NO.     5  DESIGN PER ACI 318-05 - AXIAL + BENDING

FY - 60000  FC - 4000 PSI,  SQRE SIZE - 12.00 X 12.00 INCHES, TIED
        AREA OF STEEL REQUIRED =   7.790  SQ. IN.

BAR CONFIGURATION       REINF PCT.   LOAD   LOCATION   PHI
----------------------------------------------------------

  8 - NUMBER  9           5.556        2      STA     0.650
(PROVIDE EQUAL NUMBER OF BARS ON EACH FACE)
TIE BAR NUMBER    4 SPACING   8.00 IN


********************END OF COLUMN DESIGN RESULTS********************


 52. END CONCRETE DESIGN
 53. FINISH

          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE=             TIME=           ****

      ************************************************************
      *         For questions on STAAD.Pro, please contact       *
      *   Research Engineers Offices at the following locations  *
      *                                                          *
      *              Telephone                Email              *
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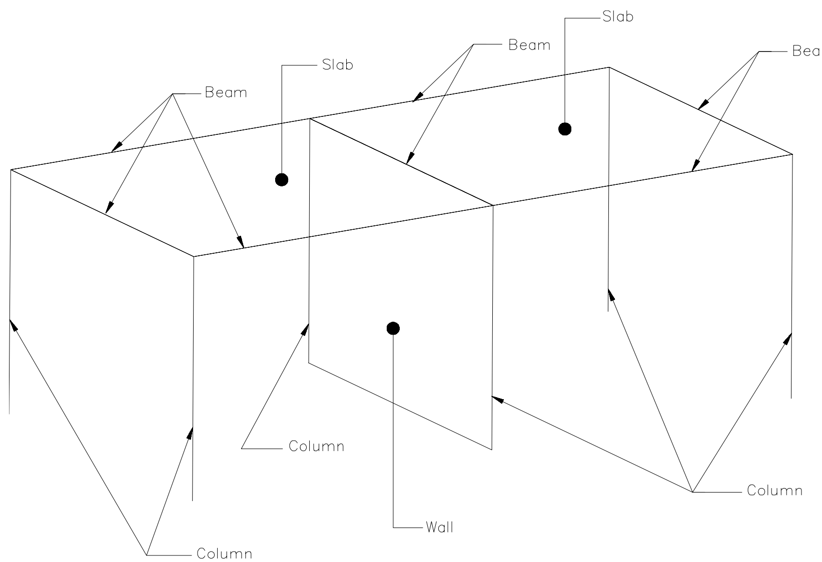
      *  UK        +44(1454)207-000       support@reel.co.uk     *
      *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
      *  GERMANY   +49/931/40468-71       info@reig.de           *
      *  NORWAY    +47 67 57 21 30        staad@edr.no           *
      *  SINGAPORE +65 6225-6158          support@bentley.com    *
      *  INDIA     +91(033)4006-2021      support@bentley.com    *
      *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
      *  CHINA     +86(411)363-1983       support@bentley.com    *
      *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
      *                                                          *
      *  North America                   support@bentley.com     *
      *  Europe                          support@bentley.com     *
      *  Asia                            support@bentley.com     *
      ************************************************************
```

NOTES

NOTES

Example Problem No. 9

The space frame structure in this example consists of frame members and finite elements (plates). The finite element part is used to model floor slabs and a shear wall. Concrete design of an element is performed.



Actual input is shown in bold lettering followed by explanation.

STAAD SPACE
*** EXAMPLE PROBLEM WITH FRAME MEMBERS AND FINITE ELEMENTS**

Every STAAD input file has to begin with the word STAAD. The word SPACE signifies that the structure is a space frame and the geometry is defined through X, Y and Z axes. The second line forms the title to identify this project.

UNIT FEET KIP

The units for the data that follows are specified above.

JOINT COORD
1 0 0 0 ; 2 0 0 20
REP ALL 2 20 0 0
7 0 15 0 11 0 15 20
12 5 15 0 14 15 15 0
15 5 15 20 17 15 15 20
18 20 15 0 22 20 15 20
23 25 15 0 25 35 15 0
26 25 15 20 28 35 15 20
29 40 15 0 33 40 15 20
34 20 3.75 0 36 20 11.25 0
37 20 3.75 20 39 20 11.25 20

The joint numbers and their coordinates are defined through the above set of commands. The automatic generation facility has been used several times in the above lines. Users may refer to section 5 of the Technical Reference Manual where the joint coordinate generation facilities are described.

MEMBER INCI
***COLUMNS**
1 1 7 ; 2 2 11
3 3 34 ; 4 34 35 ; 5 35 36 ; 6 36 18
7 4 37 ; 8 37 38 ; 9 38 39 ; 10 39 22
11 5 29 ; 12 6 33
***BEAMS IN Z DIRECTION AT X=0**

```
13 7 8 16
*BEAMS IN Z DIRECTION AT X=20
17 18 19 20
*BEAMS IN Z DIRECTION AT X=40
21 29 30 24
*BEAMS IN X DIRECTION AT Z = 0
25 7 12 ; 26 12 13 ; 27 13 14 ; 28 14 18
29 18 23 ; 30 23 24 ; 31 24 25 ; 32 25 29
*BEAMS IN X DIRECTION AT Z = 20
33 11 15 ; 34 15 16 ; 35 16 17 ; 36 17 22
37 22 26 ; 38 26 27 ; 39 27 28 ; 40 28 33
```

The member incidences are defined through the above set of commands. For some members, the member number followed by the start and end joint numbers are defined. In other cases, STAAD's automatic generation facilities are utilized. Section 5 of the Technical Reference Manual describes these facilities in detail.

```
DEFINE MESH
A JOINT 7
B JOINT 11
C JOINT 22
D JOINT 18
E JOINT 33
F JOINT 29
G JOINT 3
H JOINT 4
```

The above lines define the nodes of super-elements. Super-elements are plate/shell surfaces from which a number of individual plate/shell elements can be generated. In this case, the points describe the outer edges of a slab and that of a shear wall. Our goal is to define the slab and the wall as several plate/shell elements.

```
GENERATE ELEMENT
MESH ABCD 4 4
MESH DCEF 4 4
MESH DCHG 4 4
```

The above lines form the instructions to generate individual 4-noded elements from the superelement profiles. For example, the command MESH ABCD 4 4 means that STAAD has to generate 16 elements from the surface formed by the points A, B, C and D with 4 elements along the side AB & CD and 4 elements along the edges BC & DA.

```
MEMB PROP
1 TO 40 PRIS YD 1 ZD 1
```

Members 1 to 40 are defined as a rectangular prismatic section with 1 ft depth and 1 ft width.

```
ELEM PROP
41 TO 88 TH 0.5
```

Elements 41 to 88 are defined to be 0.5 ft thick.

```
UNIT INCH
CONSTANT
E 3000 ALL
POISSON CONCRETE ALL
```

The modulus of elasticity and Poisson’s ratio are defined above for all the members and elements following the keyword CONSTANT. Length units are changed to inches to facilitate the above input.

```
SUPPORT
1 TO 6 FIXED
```

Joints 1 to 6 are defined as fixed supported.

```
UNIT FEET
LOAD 1 DEAD LOAD FROM FLOOR
ELEMENT LOAD
41 TO 72 PRESSURE -1.0
```

Load 1 consists of a pressure load of 1 Kip/sq.ft. intensity on elements 41 to 72. The negative sign (and the default value for the axis) indicates that the load acts opposite to the positive direction of the element local z-axis.

```
LOAD 2 WIND LOAD
JOINT LOAD
11 33 FZ -20.
22 FZ -100.
```

Load 2 consists of joint loads in the Z direction at joints 11, 22 and 33.

```
LOAD COMB 3
1 0.9 2 1.3
```

Load 3 is a combination of 0.9 times load case 1 and 1.3 times load case 2.

```
PERFORM ANALYSIS
```

The command to perform a linear elastic analysis is specified above.

```
LOAD LIST 1 3
PRINT SUPP REAC
PRINT MEMBER FORCES LIST 27
PRINT ELEMENT STRESSES LIST 47
```

Support reactions, members forces and element stresses are printed for load cases 1 and 3.

```
START CONCRETE DESIGN
CODE ACI
DESIGN ELEMENT 47
END CONCRETE DESIGN
```

The above set of command form the instructions to STAAD to perform a concrete design on element 47. Design is done according to the ACI 318 code. Note that design will consist only of flexural reinforcement calculations in the longitudinal and transverse directions of the elements for the moments MX and MY.

```
FINI
```

The STAAD run is terminated.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

 1. STAAD SPACE
 2. * EXAMPLE PROBLEM WITH FRAME MEMBERS AND
 3. * FINITE ELEMENTS
 4. UNIT FEET KIP
 5. JOINT COORD
 6. 1 0 0 0 ; 2 0 0 20
 7. REP ALL 2 20 0 0
 8. 7 0 15 0 11 0 15 20
 9. 12 5 15 0 14 15 15 0
10. 15 5 15 20 17 15 15 20
11. 18 20 15 0 22 20 15 20
12. 23 25 15 0 25 35 15 0
13. 26 25 15 20 28 35 15 20
14. 29 40 15 0 33 40 15 20
15. 34 20 3.75 0 36 20 11.25 0
16. 37 20 3.75 20 39 20 11.25 20
17. MEMBER INCI
18. *COLUMNS
19. 1 1 7 ; 2 2 11
20. 3 3 34 ; 4 34 35 ; 5 35 36 ; 6 36 18
21. 7 4 37 ; 8 37 38 ; 9 38 39 ; 10 39 22
22. 11 5 29 ; 12 6 33
23. *BEAMS IN Z DIRECTION AT X=0
24. 13 7 8 16
25. *BEAMS IN Z DIRECTION AT X=20
26. 17 18 19 20
27. *BEAMS IN Z DIRECTION AT X=40
28. 21 29 30 24
29. *BEAMS IN X DIRECTION AT Z = 0
30. 25 7 12 ; 26 12 13 ; 27 13 14 ; 28 14 18
31. 29 18 23 ; 30 23 24 ; 31 24 25 ; 32 25 29
32. *BEAMS IN X DIRECTION AT Z = 20
33. 33 11 15 ; 34 15 16 ; 35 16 17 ; 36 17 22
34. 37 22 26 ; 38 26 27 ; 39 27 28 ; 40 28 33
35. DEFINE MESH
36. A JOINT 7
37. B JOINT 11
38. C JOINT 22
39. D JOINT 18
40. E JOINT 33
41. F JOINT 29
42. G JOINT 3
43. H JOINT 4
44. GENERATE ELEMENT
45. MESH ABCD 4 4
46. MESH DCEF 4 4
47. MESH DCHG 4 4
48. MEMB PROP
49. 1 TO 40 PRIS YD 1 ZD 1
50. ELEM PROP
51. 41 TO 88 TH 0.5
52. UNIT INCH
53. CONSTANT
54. E 3000 ALL
55. POISSON CONCRETE ALL
56. SUPPORT
57. 1 TO 6 FIXED
58. UNIT FEET
59. LOAD 1 DEAD LOAD FROM FLOOR
60. ELEMENT LOAD
61. 41 TO 72 PRESSURE -1.0
62. LOAD 2 WIND LOAD
63. JOINT LOAD
```

```
 64. 11 33 FZ -20.
 65. 22 FZ -100.
 66. LOAD COMB 3
 67. 1 0.9 2 1.3
 68. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------
  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    69/    88/     6
  ORIGINAL/FINAL BAND-WIDTH=    65/    12/     78 DOF
  TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =    390
  SIZE OF STIFFNESS MATRIX =       31 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.6/  40263.0 MB

 69. LOAD LIST 1 3
 70. PRINT SUPP REAC

SUPPORT REACTIONS -UNIT KIP  FEET    STRUCTURE TYPE = SPACE
-----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1      9.09     82.54     11.53     57.28     -0.01    -45.15
         3      8.21     74.61     10.72     54.41      0.03    -40.69
    2    1      9.09     82.54    -11.53    -57.28      0.01    -45.15
         3      8.16     73.97    -10.03    -48.56      0.18    -40.65
    3    1      0.00    234.92     75.29    -38.99      0.00      0.00
         3      0.00    345.07    160.00    -18.62      0.00      0.00
    4    1      0.00    234.92    -75.29     38.99      0.00      0.00
         3      0.00     77.77     20.61     51.08      0.00      0.00
    5    1     -9.09     82.54     11.53     57.28      0.01     45.15
         3     -8.21     74.61     10.72     54.41     -0.03     40.69
    6    1     -9.09     82.54    -11.53    -57.28     -0.01     45.15
         3     -8.16     73.97    -10.03    -48.56     -0.18     40.65

************** END OF LATEST ANALYSIS RESULT **************

 71. PRINT MEMBER FORCES LIST 27

MEMBER END FORCES    STRUCTURE TYPE = SPACE
-----------------
ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

   27    1    13      0.75    -13.27    -0.07     25.08      0.18     -80.09
              14     -0.75     13.27     0.07    -25.08      0.18      13.76
         3    13      5.45    -11.90    -0.21     22.72      0.52     -72.12
              14     -5.45     11.90     0.21    -22.72      0.54      12.61

************** END OF LATEST ANALYSIS RESULT **************
 72. PRINT ELEMENT STRESSES LIST 47

ELEMENT STRESSES    FORCE,LENGTH UNITS= KIP  FEET
----------------

         STRESS = FORCE/UNIT WIDTH/THICK, MOMENT = FORCE-LENGTH/UNIT WIDTH

ELEMENT  LOAD       SQX        SQY          MX          MY          MXY
                    VONT       VONB         SX          SY          SXY
                    TRESCAT    TRESCAB

   47      1        1.72       0.45      -11.60      -14.83         1.41
                  331.08     327.84       -1.19       -1.68         0.51
                  370.59     366.68
     TOP :  SMAX=  -266.63  SMIN=  -370.59  TMAX=    51.98  ANGLE=  20.7
     BOTT:  SMAX=   366.68  SMIN=   264.81  TMAX=    50.94  ANGLE=  20.4
           3        1.53       0.41      -10.47      -13.34         1.23
                  299.82     293.18       -1.78       -2.41         3.97
                  336.24     326.40
     TOP :  SMAX=  -239.54  SMIN=  -336.24  TMAX=    48.35  ANGLE=  22.0
     BOTT:  SMAX=   326.40  SMIN=   241.00  TMAX=    42.70  ANGLE=  18.5

        **** MAXIMUM STRESSES AMONG SELECTED PLATES AND CASES ****
           MAXIMUM       MINIMUM       MAXIMUM       MAXIMUM       MAXIMUM
          PRINCIPAL     PRINCIPAL       SHEAR       VONMISES       TRESCA
```

```
           STRESS        STRESS        STRESS        STRESS        STRESS

        3.666784E+02 -3.705869E+02  5.197746E+01  3.310845E+02  3.705869E+02
PLATE NO.      47            47            47            47            47
CASE  NO.       1             1             1             1             1


  *******************END OF ELEMENT FORCES********************


   73. START CONCRETE DESIGN
   74. CODE ACI
   75. DESIGN ELEMENT 47

  ELEMENT DESIGN SUMMARY
  ----------------------

  ELEMENT    LONG. REINF      MOM-X /LOAD    TRANS. REINF      MOM-Y /LOAD
             (SQ.IN/FT)     (K-FT/FT)        (SQ.IN/FT)     (K-FT/FT)

    47 TOP : Longitudinal direction - Only minimum steel required.
    47 TOP : Transverse direction   - Only minimum steel required.
    47 TOP :     0.130         0.00 /    0       0.130          0.00 /    0
       BOTT:     0.562        11.60 /    1       0.851         14.83 /    1


  **************************END OF ELEMENT DESIGN***************************

   76. END CONCRETE DESIGN
   77. FINI

            *********** END OF THE STAADD.Pro RUN ***********

              **** DATE=              TIME=        ****

        ************************************************************
        *         For questions on STAAD.Pro, please contact       *
        *   Research Engineers Offices at the following locations *
        *                                                          *
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        *  FRANCE    +33(0)1 64551084      support@reel.co.uk      *
        *  GERMANY   +49/931/40468-71      info@reig.de            *
        *  NORWAY    +47 67 57 21 30       staad@edr.no            *
        *  SINGAPORE +65 6225-6158         support@bentley.com     *
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        *  JAPAN     +81(03)5952-6500      eng-eye@crc.co.jp       *
        *  CHINA     +86(411)363-1983      support@bentley.com     *
        *  THAILAND  +66(0)2645-1018/19    support@bentley.com     *
        *                                                          *
        *  North America                  support@bentley.com      *
        *  Europe                         support@bentley.com      *
        *  Asia                           support@bentley.com      *
        ************************************************************
```

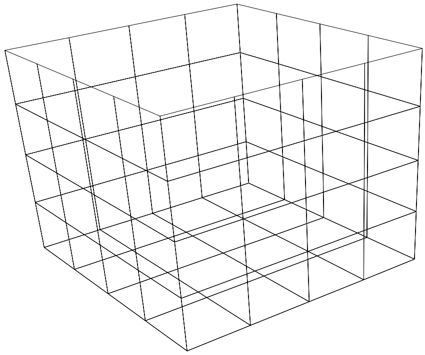
NOTES

NOTES

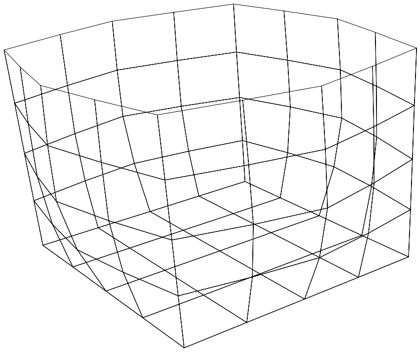
Example Problem No. 10

A tank structure is modeled with four-noded plate elements. Water pressure from inside is used as loading for the tank. Reinforcement calculations have been done for some elements.

Tank Model



Deflected Shape



Actual input is shown in bold lettering followed by explanation.

STAAD SPACE FINITE ELEMENT MODEL OF TANK

Every input has to start with the word STAAD. The word SPACE signifies that the structure is a space frame (3-D) structure.

UNITS FEET KIPS

Specifies the unit to be used for data to follow.

```
JOINT COORDINATES
1 0. 0. 0. 5 0. 20. 0.
REPEAT 4 5. 0. 0.
REPEAT 4 0. 0. 5.
REPEAT 4 -5. 0. 0.
REPEAT 3 0. 0. -5.
81 5. 0. 5. 83 5. 0. 15.
REPEAT 2 5. 0. 0.
```

Joint number followed by X, Y and Z coordinates are provided above. The REPEAT command generates joint coordinates by repeating the pattern of the previous line of joint coordinates. The number following the REPEAT command is the number of repetitions to be carried out. This is followed by X, Y and Z coordinate increments. This is explained in section 5 of the Technical Reference Manual.

```
ELEMENT INCIDENCES
1 1 2 7 6 TO 4 1 1
REPEAT 14 4 5
61 76 77 2 1 TO 64 1 1
65 1 6 81 76
66 76 81 82 71
67 71 82 83 66
68 66 83 56 61
69 6 11 84 81
70 81 84 85 82
71 82 85 86 83
72 83 86 51 56
73 11 16 87 84
74 84 87 88 85
75 85 88 89 86
```

```
76  86  89  46  51
77  16  21  26  87
78  87  26  31  88
79  88  31  36  89
80  89  36  41  46
```

Element connectivities are input as above by providing the element number followed by joint numbers defining the element. The REPEAT command generates element incidences by repeating the pattern of the previous line of element nodes. The number following the REPEAT command is the number of repetitions to be carried out and that is followed by element and joint number increments. This is explained in detail in Section 5 of the Technical Reference Manual.

```
UNIT INCHES
ELEMENT PROPERTIES
1 TO 80 TH 8.0
```

Element properties are provided by specifying that the elements are 8.0 inches THick.

```
CONSTANTS
E 3000. ALL
POISSON CONCRETE ALL
```

Material constants like E (modulus of elasticity) and Poisson’s ratio are provided following the keyword CONSTANTS.

```
SUPPORT
1 TO 76 BY  5  81 TO 89 PINNED
```

Pinned supports are specified at the joints listed above. No moments will be carried by these supports. The expression “1 TO 76 BY 5” means 1, 6, 11, etc. up to 76.

```
UNIT FT
LOAD 1
ELEMENT LOAD
4 TO 64 BY 4 PR 1.
3 TO 63 BY 4 PR 2.
2 TO 62 BY 4 PR 3.
```

1 TO 61 BY 4 PR 4.

Load case 1 is initiated. It consists of element loads in the form of uniform PRessure acting along the local z-axis on several elements.

PERFORM ANALYSIS

This command instructs the program to proceed with the analysis.

UNIT INCHES
PRINT JOINT DISPLACEMENTS LIST 5 25 45 65

The joint displacement values for the listed nodes will be reported in the output file as a result of the above command.

PRINT ELEM FORCE LIST 13 16
PRINT ELEM STRESS LIST 9 12

Two types of results are requested for elements. The first one requests the nodal point forces in the global axes directions to be reported for elements 13 and 16. The second one requests element centroid stresses in the element local axes directions to be reported for elements 9 and 12. These results will appear in a tabular form in the output file.

START CONCRETE DESIGN

The above command initiates concrete design.

CODE ACI
DESIGN SLAB 9 12

Slabs (i.e. elements) 9 and 12 will be designed and the reinforcement requirements obtained. In STAAD, elements are typically designed for the moments MX and MY at the centroid of the element.

END CONCRETE DESIGN

Terminates the concrete design operation.

FINISH

This command terminates the STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

 1. STAAD SPACE FINITE ELEMENT MODEL OF TANK STRUCTURE
 2. UNITS FEET KIPS
 3. JOINT COORDINATES
 4. 1 0. 0. 0. 5 0. 20. 0.
 5. REPEAT 4 5. 0. 0.
 6. REPEAT 4 0. 0. 5.
 7. REPEAT 4 -5. 0. 0.
 8. REPEAT 3 0. 0. -5.
 9. 81 5. 0. 5. 83 5. 0. 15.
10. REPEAT 2 5. 0. 0.
11. ELEMENT INCIDENCES
12. 1 1 2 7 6 TO 4 1 1
13. REPEAT 14 4 5
14. 61 76 77 2 1 TO 64 1 1
15. 65 1 6 81 76
16. 66 76 81 82 71
17. 67 71 82 83 66
18. 68 66 83 56 61
19. 69 6 11 84 81
20. 70 81 84 85 82
21. 71 82 85 86 83
22. 72 83 86 51 56
23. 73 11 16 87 84
24. 74 84 87 88 85
25. 75 85 88 89 86
26. 76 86 89 46 51
27. 77 16 21 26 87
28. 78 87 26 31 88
29. 79 88 31 36 89
30. 80 89 36 41 46
31. UNIT INCHES
32. ELEMENT PROPERTIES
33. 1 TO 80 TH 8.0
34. CONSTANTS
35. E 3000. ALL
36. POISSON CONCRETE ALL
37. SUPPORT
38. 1 TO 76 BY 5 81 TO 89 PINNED
39. UNIT FT
40. LOAD 1
41. ELEMENT LOAD
42. 4 TO 64 BY 4 PR 1.
43. 3 TO 63 BY 4 PR 2.
44. 2 TO 62 BY 4 PR 3.
45. 1 TO 61 BY 4 PR 4.
46. PERFORM ANALYSIS

       P R O B L E M   S T A T I S T I C S
       -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    89/    80/    25
 ORIGINAL/FINAL BAND-WIDTH=    80/    17/     87 DOF
 TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =    459
 SIZE OF STIFFNESS MATRIX =       40 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.8/   4238.4 MB

47. UNIT INCHES
48. PRINT JOINT DISPLACEMENTS LIST 5 25 45 65
```

```
  JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = SPACE
  ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    5    1   -0.00401   0.00025  -0.00401   0.00021   0.00000  -0.00021
   25    1    0.00401   0.00025  -0.00401   0.00021   0.00000   0.00021
   45    1    0.00401   0.00025   0.00401  -0.00021   0.00000   0.00021
   65    1   -0.00401   0.00025   0.00401  -0.00021   0.00000  -0.00021


  ************** END OF LATEST ANALYSIS RESULT **************


   49. PRINT ELEM FORCE LIST 13 16

  ELEMENT FORCES    FORCE,LENGTH UNITS= KIPS INCH
  --------------

    GLOBAL CORNER FORCES
JOINT     FX          FY          FZ          MX          MY          MZ

          ELE.NO.     13 FOR LOAD CASE     1
   16 -2.3394E+01 -1.8177E+01 -3.6992E+00 -1.2206E+02  2.3406E+02  1.3494E+02
   17 -7.8087E+00 -1.4952E+01 -1.7358E+01 -6.9992E+01 -2.7701E+01 -2.2052E+02
   22  4.0938E+01  5.9769E+00  1.8117E+01 -1.5118E+02  5.5766E+02  2.6685E+02
   21 -9.7352E+00  2.7152E+01  2.9396E+00  2.9766E+02  4.9940E+02 -1.8126E+02

          ELE.NO.     16 FOR LOAD CASE     1
   19 -3.7545E+01  3.4661E+00 -2.8314E+01 -2.3962E+02  1.9504E+02  2.4379E+02
   20 -3.6485E+01  5.3807E-01 -2.7070E+01  2.5526E+02  2.1809E+02 -4.0256E+02
   25  3.2481E+01 -3.9080E-14  2.6231E+01 -4.9113E+02  1.4410E+03  4.9113E+02
   24  4.1549E+01 -4.0042E+00  2.9153E+01  5.2581E+02  1.4689E+03 -3.3236E+02

 50. PRINT ELEM STRESS LIST 9 12

  ELEMENT STRESSES    FORCE,LENGTH UNITS= KIPS INCH
  ----------------

          STRESS = FORCE/UNIT WIDTH/THICK, MOMENT = FORCE-LENGTH/UNIT WIDTH

 ELEMENT  LOAD       SQX        SQY          MX          MY          MXY
                     VONT       VONB         SX          SY          SXY
                     TRESCAT    TRESCAB

    9      1         0.15       0.01       -5.45        5.60         5.38
                     1.32       1.18        0.02        0.08         0.03
                     1.53       1.36
     TOP :  SMAX=     0.82  SMIN=    -0.71  TMAX=     0.76  ANGLE= -22.1
     BOTT:  SMAX=     0.72  SMIN=    -0.64  TMAX=     0.68  ANGLE= -22.2

   12      1        -0.02      -0.04       -0.09       20.05        -0.22
                     2.05       1.72        0.00        0.16        -0.01
                     2.05       1.72
     TOP :  SMAX=     2.04  SMIN=    -0.01  TMAX=     1.03  ANGLE=   0.8
     BOTT:  SMAX=     0.01  SMIN=    -1.72  TMAX=     0.86  ANGLE=   0.5


         **** MAXIMUM STRESSES AMONG SELECTED PLATES AND CASES ****
            MAXIMUM       MINIMUM       MAXIMUM       MAXIMUM       MAXIMUM
           PRINCIPAL     PRINCIPAL       SHEAR       VONMISES       TRESCA
            STRESS        STRESS        STRESS        STRESS        STRESS

         2.044089E+00 -1.715872E+00  1.027224E+00  2.049288E+00  2.054448E+00
PLATE NO.      12            12            12            12            12
CASE  NO.       1             1             1             1             1

  ********************END OF ELEMENT FORCES********************

   51. START CONCRETE DESIGN
```

```
 52. CODE ACI
 53. DESIGN SLAB 9 12

ELEMENT DESIGN SUMMARY
----------------------

ELEMENT    LONG. REINF      MOM-X /LOAD    TRANS. REINF      MOM-Y /LOAD
           (SQ.IN/FT)     (K-FT/FT)        (SQ.IN/FT)     (K-FT/FT)

   9 TOP : Longitudinal direction - Only minimum steel required.
   9 BOTT: Transverse direction   - Only minimum steel required.
   9 TOP :     0.173          0.00 /    0       0.196          5.60 /    1
     BOTT:     0.176          5.45 /    1       0.173          0.00 /    0

  12 TOP : Longitudinal direction - Only minimum steel required.
  12 BOTT: Longitudinal direction - Only minimum steel required.
  12 BOTT: Transverse direction   - Only minimum steel required.
  12 TOP :     0.173          0.00 /    0       0.749         20.05 /    1
     BOTT:     0.173          0.09 /    1       0.173          0.00 /    0


***************************END OF ELEMENT DESIGN***************************

 54. END CONCRETE DESIGN
 55. FINISH

          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE=             TIME=           ****

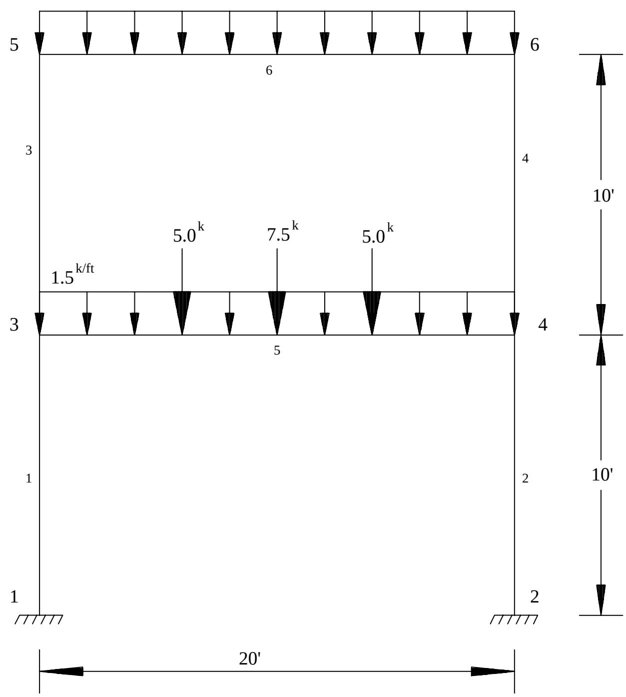
      ************************************************************
      *         For questions on STAAD.Pro, please contact       *
      *   Research Engineers Offices at the following locations  *
      *                                                          *
      *              Telephone               Email               *
      *  USA:      +1 (714)974-2500       support@bentley.com    *
      *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
      *  UK        +44(1454)207-000       support@reel.co.uk     *
      *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
      *  GERMANY   +49/931/40468-71       info@reig.de           *
      *  NORWAY    +47 67 57 21 30        staad@edr.no           *
      *  SINGAPORE +65 6225-6158          support@bentley.com    *
      *  INDIA     +91(033)4006-2021      support@bentley.com    *
      *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
      *  CHINA     +86(411)363-1983       support@bentley.com    *
      *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
      *                                                          *
      *  North America                   support@bentley.com     *
      *  Europe                          support@bentley.com     *
      *  Asia                            support@bentley.com     *
      ************************************************************
```

NOTES

NOTES

Example Problem No. 11

Dynamic analysis (Response Spectrum) is performed for a steel structure. Results of a static and dynamic analysis are combined. The combined results are then used for steel design.



Actual input is shown in bold lettering followed by explanation.

STAAD PLANE RESPONSE SPECTRUM ANALYSIS

Every input has to start with the word STAAD. The word PLANE signifies that the structure is a plane frame structure and the geometry is defined through X and Y axes.

UNIT FEET KIPS

Specifies the unit to be used for data to follow.

JOINT COORDINATES
1 0 0 0 ; 2 20 0 0
3 0 10 0 ; 4 20 10 0
5 0 20 0 ; 6 20 20 0

Joint number followed by X, Y and Z coordinates are provided above. Since this is a plane structure, the Z coordinates are all the same, in this case, zeros. Semicolon signs (;) are used as line separators to allow for input of multiple sets of data on one line.

MEMBER INCIDENCES
1 1 3 ; 2 2 4 ; 3 3 5 ; 4 4 6
5 3 4 ; 6 5 6

Defines the members by the joints they are connected to.

MEMBER PROPERTIES AMERICAN
1 TO 4 TA ST W10X33
5 TA ST W12X40
6 TA ST W8X40

Properties for all members are assigned from the American (AISC) steel table. The word ST stands for standard single section.

SUPPORTS
1 2 FIXED

Fixed supports are specified at joints 1 and 2.

```
UNIT INCH
CONSTANTS
E 29000. ALL
POISSON STEEL ALL
DEN 0.000283 ALL
```

Material constants such as E (modulus of elasticity), Poisson's ratio and DENsity are specified above. Length unit is changed from FT to INCH to facilitate the input.

```
CUT OFF MODE SHAPE 2
```

The number of mode shapes to be considered in dynamic analysis is set to 2. Without the above command, this will be set to the default which can be found in section 5 of the Technical Reference Manual.

```
* LOAD 1 WILL BE STATIC LOAD
UNIT FEET
LOAD 1 DEAD AND LIVE LOADS
```

Load case 1 is initiated along with an accompanying title. Prior to this, the length unit is changed to FEET for specifying distributed member loads. A line starting with an asterisk (*) mark indicates a comment line.

```
SELFWEIGHT Y -1.0
```

The above command indicates that the selfweight of the structure acting in the global Y direction is part of this load case. The factor of –1.0 is meant to indicate that the load acts opposite to the positive direction of global Y, hence downwards.

```
MEMBER LOADS
5  CON  GY  -5.0  6.0
5  CON  GY  -7.5  10.0
5  CON  GY  -5.0  14.0
5  6  UNI  Y  -1.5
```

Load 1 contains member loads also and they are applied on members 5 and 6. GY indicates that the load is in the global Y direction while Y indicates local Y direction. The word UNI stands for uniformly distributed load while CON stands for concentrated load. GY is followed by the value of the load and the distance at which it is applied.

```
* NEXT LOAD WILL BE RESPONSE SPECTRUM LOAD
* WITH MASSES PROVIDED IN TERMS OF LOAD.
LOAD 2 SEISMIC LOADING
```

The two lines which begin with the asterisk are comment lines which tell us the purpose of the next load case. Load case 2 is then initiated along with an optional title. This will be a dynamic load case. Permanent masses will be provided in the form of loads. These masses (in terms of loads) will be considered for the eigensolution. Internally, the program converts these loads to masses, hence it is best to specify them as absolute values (without a negative sign). Also, the direction (X, Y, Z etc.) of the loads will correspond to the dynamic degrees of freedom in which the masses are capable of vibrating. In a PLANE frame, only X and Y directions need to be considered. In a SPACE frame, masses (loads) should be provided in all three (X, Y and Z) directions if they are active along all three. The user has the freedom to restrict one or more directions.

```
SELFWEIGHT X 1.0
SELFWEIGHT Y 1.0
```

The above commands indicate that the selfweight of the structure acting in the global X and Y directions with a factor of 1.0 is taken into consideration for the mass matrix.

```
MEMBER LOADS
5  CON  GX  5.0  6.0
5  CON  GY  5.0  6.0
5  CON  GX  7.5  10.0
5  CON  GY  7.5  10.0
5  CON  GX  5.0  14.0
5  CON  GY  5.0  14.0
```

The mass matrix will also consist of terms derived from the above member loads. GX and GY indicate that the load, and hence the resulting mass, is capable of vibration along the global X and Y directions. The word CON stands for concentrated load. Concentrated forces of 5, 7.5, and 5 kips are located at 6ft, 10ft and 14ft from the start of member 5.

```
SPECTRUM CQC X 1.0 ACC DAMP 0.05 SCALE 32.2
0.03  1.00  ;  0.05  1.35
0.1  1.95  ;  0.2  2.80
0.5  2.80  ;  1.0  1.60
```

The above SPECTRUM command specifies that the modal responses be combined using the CQC method (alternatives being the SRSS method, ABS method, etc.). The spectrum effect is in the global X direction with a factor of 1.0. Since this spectrum is in terms of ACCeleration (the other possibility being displacement), the spectrum data is given as period vs. acceleration. Damping ratio of 0.05 (5%) and a scale factor of 32.2 are used. The scale factor is the quantity by which spectral accelerations (and spectral displacements) must be multiplied by before they are used in the calculations. The values of periods and the corresponding accelerations are given in the last 3 lines.

```
LOAD COMBINATION  3
1  0.75  2  0.75
LOAD COMBINATION  4
1  0.75  2  -0.75
```

In a response spectrum analysis, the sign of the forces cannot be determined, and hence are absolute numbers. Consequently, to account for the fact that the force could be positive or negative, it is necessary to create 2 load combination cases. That is what is being done above. Load combination case no. 3 consists of the sum of the static load case (1) with the positive direction of the dynamic load case (2). Load combination case no. 4 consists of the sum of the static load case (1) with the negative direction of the dynamic load case (2). In both cases, the result is factored by 0.75.

PERFORM ANALYSIS PRINT MODE SHAPES

This command instructs the program to proceed with the analysis. The PRINT command instructs the program to print mode shape values.

PRINT ANALYSIS RESULTS

Displacements, reactions and member forces are recorded in the output file using the above command.

LOAD LIST 1 3 4
PARAMETER
CODE AISC
SELECT ALL

A steel design in the form of a member selection is performed based on the rules of the American Code. Only the member forces resulting from load cases 1, 3 and 4 will be considered for these calculations.

FINISH

This command terminates the STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

 1. STAAD PLANE RESPONSE SPECTRUM ANALYSIS
 2. UNIT FEET KIPS
 3. JOINT COORDINATES
 4. 1 0 0 0 ; 2 20 0 0
 5. 3 0 10 0 ; 4 20 10 0
 6. 5 0 20 0 ; 6 20 20 0
 7. MEMBER INCIDENCES
 8. 1 1 3 ; 2 2 4 ; 3 3 5 ; 4 4 6
 9. 5 3 4 ; 6 5 6
10. MEMBER PROPERTIES AMERICAN
11. 1 TO 4 TA ST W10X33
12. 5 TA ST W12X40
13. 6 TA ST W8X40
14. SUPPORTS
15. 1 2 FIXED
16. UNIT INCH
17. CONSTANTS
18. E 29000. ALL
19. POISSON STEEL ALL
20. DEN 0.000283 ALL
21. CUT OFF MODE SHAPE 2
22. *LOAD 1 WILL BE STATIC LOAD
23. UNIT FEET
24. LOAD 1 DEAD AND LIVE LOADS
25. SELFWEIGHT Y -1.0
26. MEMBER LOADS
27. 5 CON GY -5.0  6.0
28. 5 CON GY -7.5 10.0
29. 5 CON GY -5.0 14.0
30. 5 6 UNI Y -1.5
31. * NEXT LOAD WILL BE RESPONSE SPECTRUM LOAD
32. * WITH MASSES PROVIDED IN TERMS OF LOAD.
33. LOAD 2 SEISMIC LOADING
34. SELFWEIGHT X 1.0
35. SELFWEIGHT Y 1.0
36. MEMBER LOADS
37. 5 CON GX 5.0 6.0
38. 5 CON GY 5.0 6.0
39. 5 CON GX 7.5 10.0
40. 5 CON GY 7.5 10.0
41. 5 CON GX 5.0 14.0
42. 5 CON GY 5.0 14.0
43. SPECTRUM CQC X 1.0 ACC DAMP 0.05 SCALE 32.2
44. 0.03 1.00 ; 0.05 1.35
45. 0.1 1.95 ; 0.2 2.80
46. 0.5 2.80 ; 1.0 1.60
47. LOAD COMBINATION 3
48. 1 0.75 2 0.75
49. LOAD COMBINATION 4
50. 1 0.75 2 -0.75
51. PERFORM ANALYSIS PRINT MODE SHAPES

        P R O B L E M   S T A T I S T I C S
        -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =      6/      6/      2
 ORIGINAL/FINAL BAND-WIDTH=     2/      2/      9 DOF
 TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =      12
 SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =     12.0/   4238.3 MB
```

```
NUMBER OF MODES REQUESTED             =     2
NUMBER OF EXISTING MASSES IN THE MODEL =    8
NUMBER OF MODES THAT WILL BE USED     =     2

              CALCULATED FREQUENCIES FOR LOAD CASE       2

      MODE           FREQUENCY(CYCLES/SEC)         PERIOD(SEC)      ACCURACY


        1                      4.488                  0.22280       7.404E-10
        2                     16.288                  0.06140       3.463E-07

    The following Frequencies are estimates that were calculated. These are for
    information only and will not be used. Remaining values are either above
    the cut off mode/freq values or are of low accuracy. To use these
    frequencies, rerun with a higher cutoff mode (or mode + freq) value.
              CALCULATED FREQUENCIES FOR LOAD CASE       2

      MODE           FREQUENCY(CYCLES/SEC)         PERIOD(SEC)      ACCURACY


        3                     47.724                  0.02095       1.434E-12

  MODE SHAPES
  -----------

 JOINT  MODE   X-TRANS   Y-TRANS   Z-TRANS    X-ROTAN    Y-ROTAN    Z-ROTAN

    1     1    0.00000   0.00000   0.00000  0.000E+00  0.000E+00  0.000E+00
    2     1    0.00000   0.00000   0.00000  0.000E+00  0.000E+00  0.000E+00
    3     1    0.67341   0.00308   0.00000  0.000E+00  0.000E+00 -3.348E-03
    4     1    0.67341  -0.00308   0.00000  0.000E+00  0.000E+00 -3.348E-03
    5     1    1.00000   0.00361   0.00000  0.000E+00  0.000E+00 -1.457E-03
    6     1    1.00000  -0.00361   0.00000  0.000E+00  0.000E+00 -1.457E-03


  MODE SHAPES
  -----------

 JOINT  MODE   X-TRANS   Y-TRANS   Z-TRANS    X-ROTAN    Y-ROTAN    Z-ROTAN

    1     2    0.00000   0.00000   0.00000  0.000E+00  0.000E+00  0.000E+00
    2     2    0.00000   0.00000   0.00000  0.000E+00  0.000E+00  0.000E+00
    3     2   -0.08809   0.00516   0.00000  0.000E+00  0.000E+00 -2.606E-03
    4     2   -0.08809  -0.00516   0.00000  0.000E+00  0.000E+00 -2.606E-03
    5     2    1.00000   0.00780   0.00000  0.000E+00  0.000E+00 -7.135E-03
    6     2    1.00000  -0.00780   0.00000  0.000E+00  0.000E+00 -7.135E-03


    RESPONSE LOAD CASE     2


    CQC           MODAL COMBINATION METHOD USED.

 DYNAMIC WEIGHT X Y Z   2.008538E+01  2.008538E+01  0.000000E+00 KIPS
    MISSING WEIGHT X Y Z  -9.465498E-05 -2.008538E+01  0.000000E+00 KIPS
      MODAL WEIGHT X Y Z   2.008528E+01  2.642837E-28  0.000000E+00 KIPS


          MODE                ACCELERATION-G     DAMPING
          ----                --------------     -------

             1                     2.80226       0.05000
             2                     1.48795       0.05000
```

MODAL BASE ACTIONS   FORCES IN KIPS LENGTH IN FEET

MOMENTS ARE ABOUT THE ORIGIN

MODE	PERIOD	FX	FY	FZ	MX	MY	MZ
1	0.223	55.63	0.00	0.00	0.00	0.00	-603.80
2	0.061	0.35	0.00	0.00	0.00	0.00	4.37

MASS PARTICIPATION FACTORS IN PERCENT   BASE SHEAR IN KIPS

MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z	X	Y	Z
1	98.83	0.00	0.00	98.834	0.000	0.000	55.63	0.00	0.00
2	1.17	0.00	0.00	99.999	0.000	0.000	0.35	0.00	0.00
				TOTAL SRSS	SHEAR		55.63	0.00	0.00
				TOTAL 10PCT	SHEAR		55.63	0.00	0.00
				TOTAL ABS	SHEAR		55.98	0.00	0.00
				TOTAL CQC	SHEAR		55.63	0.00	0.00

52. PRINT ANALYSIS RESULTS

JOINT DISPLACEMENT (INCH RADIANS)   STRUCTURE TYPE = PLANE

JOINT	LOAD	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	1	-0.00150	-0.01706	0.00000	0.00000	0.00000	-0.00248
	2	1.30898	0.00599	0.00000	0.00000	0.00000	0.00651
	3	0.98061	-0.00831	0.00000	0.00000	0.00000	0.00302
	4	-0.98286	-0.01729	0.00000	0.00000	0.00000	-0.00674
4	1	0.00150	-0.01706	0.00000	0.00000	0.00000	0.00248
	2	1.30898	0.00599	0.00000	0.00000	0.00000	0.00651
	3	0.98286	-0.00831	0.00000	0.00000	0.00000	0.00674
	4	-0.98061	-0.01729	0.00000	0.00000	0.00000	-0.00302
5	1	0.00313	-0.02370	0.00000	0.00000	0.00000	-0.00246
	2	1.94394	0.00701	0.00000	0.00000	0.00000	0.00284
	3	1.46030	-0.01251	0.00000	0.00000	0.00000	0.00029
	4	-1.45561	-0.02303	0.00000	0.00000	0.00000	-0.00397
6	1	-0.00313	-0.02370	0.00000	0.00000	0.00000	0.00246
	2	1.94394	0.00701	0.00000	0.00000	0.00000	0.00284
	3	1.45561	-0.01251	0.00000	0.00000	0.00000	0.00397
	4	-1.46030	-0.02303	0.00000	0.00000	0.00000	-0.00029

SUPPORT REACTIONS -UNIT KIPS FEET   STRUCTURE TYPE = PLANE

JOINT	LOAD	FORCE-X	FORCE-Y	FORCE-Z	MOM-X	MOM-Y	MOM Z
1	1	4.56	40.21	0.00	0.00	0.00	-14.29
	2	27.81	14.06	0.00	0.00	0.00	161.35
	3	24.28	40.70	0.00	0.00	0.00	110.30
	4	-17.44	19.61	0.00	0.00	0.00	-131.73
2	1	-4.56	40.21	0.00	0.00	0.00	14.29
	2	27.81	14.06	0.00	0.00	0.00	161.35
	3	17.44	40.70	0.00	0.00	0.00	131.73
	4	-24.28	19.61	0.00	0.00	0.00	-110.30

```
MEMBER END FORCES    STRUCTURE TYPE = PLANE
-----------------
ALL UNITS ARE -- KIPS FEET     (LOCAL )
```

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
1	1	1	40.21	-4.56	0.00	0.00	0.00	-14.29
		3	-39.88	4.56	0.00	0.00	0.00	-31.30
	2	1	14.06	27.81	0.00	0.00	0.00	161.35
		3	14.06	27.81	0.00	0.00	0.00	116.79
	3	1	40.70	17.44	0.00	0.00	0.00	110.30
		3	-19.37	24.28	0.00	0.00	0.00	64.12
	4	1	19.61	-24.28	0.00	0.00	0.00	-131.73
		3	-40.45	-17.44	0.00	0.00	0.00	-111.07
2	1	2	40.21	4.56	0.00	0.00	0.00	14.29
		4	-39.88	-4.56	0.00	0.00	0.00	31.30
	2	2	14.06	27.81	0.00	0.00	0.00	161.35
		4	14.06	27.81	0.00	0.00	0.00	116.79
	3	2	40.70	24.28	0.00	0.00	0.00	131.73
		4	-19.37	17.44	0.00	0.00	0.00	111.07
	4	2	19.61	-17.44	0.00	0.00	0.00	-110.30
		4	-40.45	-24.28	0.00	0.00	0.00	-64.12
3	1	3	15.73	-8.84	0.00	0.00	0.00	-44.28
		5	-15.40	8.84	0.00	0.00	0.00	-44.10
	2	3	2.40	2.28	0.00	0.00	0.00	2.54
		5	2.40	2.28	0.00	0.00	0.00	23.88
	3	3	13.59	-4.92	0.00	0.00	0.00	-31.31
		5	-9.75	8.34	0.00	0.00	0.00	-15.16
	4	3	10.00	-8.34	0.00	0.00	0.00	-35.11
		5	-13.35	4.92	0.00	0.00	0.00	-50.99
4	1	4	15.73	8.84	0.00	0.00	0.00	44.28
		6	-15.40	-8.84	0.00	0.00	0.00	44.10
	2	4	2.40	2.28	0.00	0.00	0.00	2.54
		6	2.40	2.28	0.00	0.00	0.00	23.88
	3	4	13.59	8.34	0.00	0.00	0.00	35.11
		6	-9.75	-4.92	0.00	0.00	0.00	50.99
	4	4	10.00	4.92	0.00	0.00	0.00	31.31
		6	-13.35	-8.34	0.00	0.00	0.00	15.16
5	1	3	-4.28	24.15	0.00	0.00	0.00	75.58
		4	4.28	24.15	0.00	0.00	0.00	-75.58
	2	3	0.00	11.55	0.00	0.00	0.00	115.46
		4	0.00	11.55	0.00	0.00	0.00	115.46
	3	3	-3.21	26.77	0.00	0.00	0.00	143.28
		4	3.21	26.77	0.00	0.00	0.00	29.91
	4	3	-3.21	9.45	0.00	0.00	0.00	-29.91
		4	3.21	9.45	0.00	0.00	0.00	-143.28
6	1	5	8.84	15.40	0.00	0.00	0.00	44.10
		6	-8.84	15.40	0.00	0.00	0.00	-44.10
	2	5	0.00	2.39	0.00	0.00	0.00	23.88
		6	0.00	2.39	0.00	0.00	0.00	23.88
	3	5	6.63	13.34	0.00	0.00	0.00	50.99
		6	-6.63	13.34	0.00	0.00	0.00	-15.16
	4	5	6.63	9.76	0.00	0.00	0.00	15.16
		6	-6.63	9.76	0.00	0.00	0.00	-50.99

```
************** END OF LATEST ANALYSIS RESULT **************

 53. LOAD LIST 1 3 4
 54. PARAMETER
 55. CODE AISC
 56. SELECT ALL
```

```
                    STAAD/Pro MEMBER SELECTION - (AISC 9TH EDITION)
                    **************************


 ALL UNITS ARE - KIPS FEET (UNLESS OTHERWISE NOTED)

 MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                          FX            MY             MZ       LOCATION
 =======================================================================

      1  ST   W21X48                  (AISC SECTIONS)
                            PASS     AISC- H1-3        0.899         4
                        19.61 C         0.00       -131.73        0.00
      2  ST   W21X48                  (AISC SECTIONS)
                            PASS     AISC- H1-2        0.943         3
                        40.70 C         0.00        131.73        0.00
      3  ST   W12X30                  (AISC SECTIONS)
                            PASS     AISC- H1-3        0.833         4
                        13.35 C         0.00         50.99       10.00
      4  ST   W12X26                  (AISC SECTIONS)
                            PASS     AISC- H1-3        0.992         3
                         9.75 C         0.00        -50.99       10.00
      5  ST   W14X61                  (AISC SECTIONS)
                            PASS     AISC- H2-1        0.872         3
                         3.21 T         0.00        143.28        0.00
      6  ST   W8X35                   (AISC SECTIONS)
                            PASS     AISC- H1-3        0.966         3
                         6.63 C         0.00         50.99        0.00

    57. FINISH

  ****************************************************************************
  **WARNING** SOME MEMBER SIZES HAVE CHANGED SINCE LAST ANALYSIS.
              IN THE POST PROCESSOR, MEMBER QUERIES WILL USE THE LAST
              ANALYSIS FORCES WITH THE UPDATED MEMBER SIZES.
              TO CORRECT THIS INCONSISTENCY, PLEASE DO ONE MORE ANALYSIS.
              FROM THE UPPER MENU, PRESS RESULTS, UPDATE PROPERTIES, THEN
              FILE SAVE; THEN ANALYZE AGAIN WITHOUT THE GROUP OR SELECT
              COMMANDS.
  ****************************************************************************

            *********** END OF THE STAAD.Pro RUN ***********

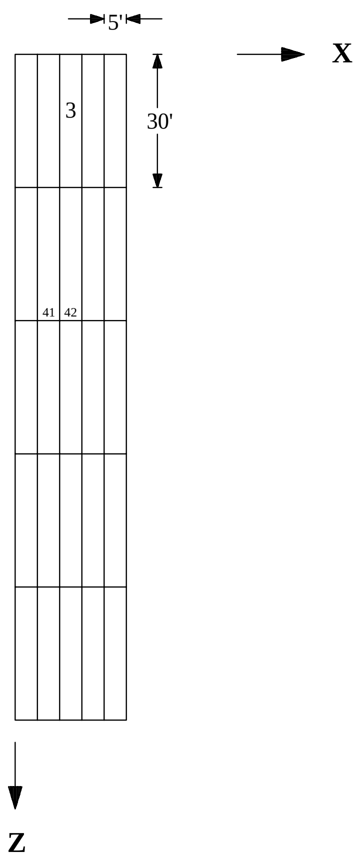
              **** DATE=            TIME=           ****

        ************************************************************
        *         For questions on STAAD.Pro, please contact       *
        *   Research Engineers Offices at the following locations  *
        *                                                          *
        *               Telephone                 Email            *
        *  USA:      +1 (714)974-2500       support@bentley.com    *
        *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
        *  UK        +44(1454)207-000       support@reel.co.uk     *
        *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
        *  GERMANY   +49/931/40468-71       info@reig.de           *
        *  NORWAY    +47 67 57 21 30        staad@edr.no           *
        *  SINGAPORE +65 6225-6158          support@bentley.com    *
        *  INDIA     +91(033)4006-2021      support@bentley.com    *
        *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
        *  CHINA     +86(411)363-1983       support@bentley.com    *
        *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
        *                                                          *
        *  North America                   support@bentley.com     *
        *  Europe                          support@bentley.com     *
        *  Asia                            support@bentley.com     *
        ************************************************************
```

NOTES

Example Problem No. 12

This example demonstrates generation of load cases for the type of loading known as a moving load. This type of loading occurs classically when the load-causing units move on the structure, as in the case of trucks on a bridge deck. The mobile loads are discretized into several individual immobile load cases at discrete positions. During this process, enormous number of load cases may be created resulting in plenty of output to be sorted. To avoid looking into a lot of output, the maximum force envelope is requested for a few specific members.



Actual input is shown in bold lettering followed by explanation.

STAAD FLOOR A SIMPLE BRIDGE DECK

Every input has to start with the word STAAD. The word FLOOR signifies that the structure is a floor structure and the geometry is defined through X and Z axis.

UNITS FEET KIPS

Specifies the unit to be used for data to follow.

JOINT COORDINATES
1 0 0 0 6 25 0 0
R 5 0 0 30

Joint number followed by X, Y and Z coordinates are provided above. Since this is a floor structure, the Y coordinates are given as all zeros. The first line generates joints 1 through 6. With the repeat (R) command, the coordinates of the next 30 joints are generated by repeating the pattern of the coordinates of the first 6 joints 5 times with X, Y and Z increments of 0,0 & 30 respectively.

MEMBER INCIDENCES
1 1 7 6
7 1 2 11
R A 4 11 6
56 31 32 60

Defines the members by the joints they are connected to. The fourth number indicates the final member number upto which they will be generated. Repeat all (abbreviated as R A) will create members by repeating the member incidence pattern of the previous 11 members. The number of repetitions to be carried out is provided after the R A command and the member number increment and joint number increment are defined as 11 and 6 respectively. The fifth line of input defines the member incidences for members 56 to 60.

```
MEMBER PROPERTIES AMERICAN
1 TO 60 TA ST W12X26
```

Member properties are assigned from the American AISC table for all members. The word ST stands for standard single section.

```
SUPPORTS
1  TO  6  31  TO  36  PINNED
```

Pinned supports are specified at the above joints. A pinned support is one which can resist only translational forces.

```
UNITS INCH
CONSTANTS
E 29000. ALL
POISSON STEEL ALL
DEN 0.283E-3 ALL
```

Material constants like E (modulus of elasticity), Poisson's ratio and DENsity are specified above following a change in the units of length from FT to INCH.

```
UNIT FEET KIP
DEFINE MOVING LOAD
TYPE 1 LOAD  20.  20.  10.  DISTANCE  10.  5.  WIDTH  10.0
```

The characteristics of the vehicle are defined above in FEET and KIP units. The above lines represent the first out of two sets of data required in moving load generation. The type number (1) is a label for identification of the load-causing unit, such as a truck. 3 axles (20 20 10) are specified with the LOAD command. The spacing between the axles in the direction of movement (longitudinal direction) is specified after the DISTANCE command. WIDTH is the spacing in the transverse direction, that is, it is the distance between the 2 prongs of an axle of the truck.

```
LOAD 1
```

Load case 1 is initiated.

SELF Y -1.0

Selfweight of the structure acting in the negative (due to the factor -1.0) global Y direction is the only component of load case 1.

LOAD GENERATION 10
TYPE 1 7.5 0. 0. ZI 10.

This constitutes the second of the two sets of data required for moving load generation. 10 load cases are generated using the Type 1 vehicle whose characteristics were described earlier. For the first of these load cases, the X, Y and Z location of the reference load (see section 5.31.1 of the Technical Reference Manual) have been specified after the command TYPE 1. The Z Increment of 10ft denotes that the vehicle moves along the Z direction and the individual positions which are 10ft apart will be used to generate the remaining 9 load cases.

The basis for determining the number of load cases to generate is as follows:

As seen in Section 5.31.1 of the Technical Reference manual, the reference wheel is on the last axle. The first load case which is generated will be the one for which the first axle is just about to enter the bridge. The last load case should be the one for which the last axle is just about to exit the bridge. Thus, the total distance travelled by the reference load will be the length of the vehicle (distance from first axle to last axle) plus the span of the bridge. In this problem, that comes to

(10+5) + 150 = 165 feet.

If we want the vehicle to move forward in 15 feet increments (each 15 foot increment will create a discrete position of the truck on the bridge), it would required 165/15+1 = 12 cases to be generated. As this example is for demonstration purposes only, 10 ft increments have been used, and 10 cases generated.

PERFORM ANALYSIS PRINT LOAD

The above command instructs the program to proceed with the analysis and print the values and positions of all the generated load cases.

PRINT MAXFORCE ENVELOP LIST 3 41 42

A maximum force envelope consisting of the highest forces for each degree of freedom on the listed members will be written into the output file.

FINISH

This command terminates the STAAD run.

```
 ****************************************************
 *                                                  *
 *           STAAD.Pro                              *
 *           Version          Bld                   *
 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=                                  *
 *           Time=                                  *
 *                                                  *
 *      USER ID:                                    *
 ****************************************************

  1. STAAD FLOOR A SIMPLE BRIDGE DECK
  2. UNITS FEET KIPS
  3. JOINT COORDINATES
  4. 1 0 0 0 6 25 0 0
  5. R 5 0 0 30
  6. MEMBER INCIDENCES
  7. 1 1 7 6
  8. 7 1 2 11
  9. R A 4 11 6
 10. 56 31 32 60
 11. MEMBER PROPERTIES AMERICAN
 12. 1 TO 60 TA ST W12X26
 13. SUPPORTS
 14. 1 TO 6 31 TO 36 PINNED
 15. UNITS INCH
 16. CONSTANTS
 17. E 29000. ALL
 18. POISSON STEEL ALL
 19. DEN 0.283E-3 ALL
 20. UNIT FEET KIP
 21. DEFINE MOVING LOAD
 22. TYPE 1 LOAD 20. 20. 10. DISTANCE 10. 5. WIDTH 10.
 23. LOAD 1
 24. SELF Y -1.0
 25. LOAD GENERATION 10
 26. TYPE 1 7.5 0. 0. ZI 10.
 27. PERFORM ANALYSIS PRINT LOAD

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    60/    12
  ORIGINAL/FINAL BAND-WIDTH=     6/     6/     21 DOF
  TOTAL PRIMARY LOAD CASES =   11, TOTAL DEGREES OF FREEDOM =     96
  SIZE OF STIFFNESS MATRIX =       3 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =    12.2/  3143.7 MB,  EXMEM =  568.2 MB

LOADING     1
-----------

    SELFWEIGHT  Y   -1.000

   ACTUAL WEIGHT OF THE STRUCTURE =      27.278 KIP

LOADING     2
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

   8                             -20.000 GY   2.50
  10                             -20.000 GY   2.50
   3                             -10.000 GY  10.00
   2                             -10.000 GY  10.00
   5                             -10.000 GY  10.00
   4                             -10.000 GY  10.00
   3                              -5.000 GY  15.00
   2                              -5.000 GY  15.00
   5                              -5.000 GY  15.00
   4                              -5.000 GY  15.00
```

```
LOADING     3
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

   3                            -10.000 GY  10.00
   2                            -10.000 GY  10.00
   5                            -10.000 GY  10.00
   4                            -10.000 GY  10.00
   3                            -10.000 GY  20.00
   2                            -10.000 GY  20.00
   5                            -10.000 GY  20.00
   4                            -10.000 GY  20.00
   3                             -5.000 GY  25.00
   2                             -5.000 GY  25.00
   5                             -5.000 GY  25.00
   4                             -5.000 GY  25.00

LOADING     4
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

   3                            -10.000 GY  20.00
   2                            -10.000 GY  20.00
   5                            -10.000 GY  20.00
   4                            -10.000 GY  20.00
  19                            -20.000 GY   2.50
  21                            -20.000 GY   2.50
  14                             -5.000 GY   5.00
  13                             -5.000 GY   5.00
  16                             -5.000 GY   5.00
  15                             -5.000 GY   5.00

LOADING     5
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

  19                            -20.000 GY   2.50
  21                            -20.000 GY   2.50
  14                            -10.000 GY  10.00
  13                            -10.000 GY  10.00
  16                            -10.000 GY  10.00
  15                            -10.000 GY  10.00
  14                             -5.000 GY  15.00
  13                             -5.000 GY  15.00
  16                             -5.000 GY  15.00
  15                             -5.000 GY  15.00

LOADING     6
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

  14                            -10.000 GY  10.00
  13                            -10.000 GY  10.00
  16                            -10.000 GY  10.00
  15                            -10.000 GY  10.00
  14                            -10.000 GY  20.00
  13                            -10.000 GY  20.00
  16                            -10.000 GY  20.00
  15                            -10.000 GY  20.00
  14                             -5.000 GY  25.00
  13                             -5.000 GY  25.00
  16                             -5.000 GY  25.00
  15                             -5.000 GY  25.00
```

```
LOADING     7
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1      L2      CON       L     LIN1     LIN2

  14                             -10.000 GY  20.00
  13                             -10.000 GY  20.00
  16                             -10.000 GY  20.00
  15                             -10.000 GY  20.00
  30                             -20.000 GY   2.50
  32                             -20.000 GY   2.50
  25                              -5.000 GY   5.00
  24                              -5.000 GY   5.00
  27                              -5.000 GY   5.00
  26                              -5.000 GY   5.00

LOADING     8
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1      L2      CON       L     LIN1     LIN2

  30                             -20.000 GY   2.50
  32                             -20.000 GY   2.50
  25                             -10.000 GY  10.00
  24                             -10.000 GY  10.00
  27                             -10.000 GY  10.00
  26                             -10.000 GY  10.00
  25                              -5.000 GY  15.00
  24                              -5.000 GY  15.00
  27                              -5.000 GY  15.00
  26                              -5.000 GY  15.00

LOADING     9
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1      L2      CON       L     LIN1     LIN2

  25                             -10.000 GY  10.00
  24                             -10.000 GY  10.00
  27                             -10.000 GY  10.00
  26                             -10.000 GY  10.00
  25                             -10.000 GY  20.00
  24                             -10.000 GY  20.00
  27                             -10.000 GY  20.00
  26                             -10.000 GY  20.00
  25                              -5.000 GY  25.00
  24                              -5.000 GY  25.00
  27                              -5.000 GY  25.00
  26                              -5.000 GY  25.00

LOADING    10
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1      L2      CON       L     LIN1     LIN2

  25                             -10.000 GY  20.00
  24                             -10.000 GY  20.00
  27                             -10.000 GY  20.00
  26                             -10.000 GY  20.00
  41                             -20.000 GY   2.50
  43                             -20.000 GY   2.50
  36                              -5.000 GY   5.00
  35                              -5.000 GY   5.00
  38                              -5.000 GY   5.00
  37                              -5.000 GY   5.00
```

```
LOADING    11
-----------

MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1      L2      CON       L     LIN1     LIN2

  41                             -20.000 GY   2.50
  43                             -20.000 GY   2.50
  36                             -10.000 GY  10.00
  35                             -10.000 GY  10.00
  38                             -10.000 GY  10.00
  37                             -10.000 GY  10.00
  36                              -5.000 GY  15.00
  35                              -5.000 GY  15.00
  38                              -5.000 GY  15.00
  37                              -5.000 GY  15.00

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

 28. PRINT MAXFORCE ENVELOP LIST 3 41 42

      MEMBER FORCE ENVELOPE
      ---------------------
      ALL UNITS ARE KIP  FEET

MAX AND MIN FORCE VALUES AMONGST ALL SECTION LOCATIONS

MEMB          FY/    DIST  LD        MZ/    DIST  LD
              FZ     DIST  LD        MY     DIST  LD        FX     DIST  LD

  3 MAX     18.03   0.00    3       0.02   0.00    4
             0.00   0.00    1       0.00   0.00    1      0.00     0.00    1
    MIN     -6.97  30.00    3    -373.90  30.00    5
             0.00  30.00   11       0.00  30.00   11      0.00    30.00   11

 41 MAX     16.33   0.00   10       6.80   5.00    5
             0.00   0.00    1       0.00   0.00    1      0.00     0.00    1
    MIN     -4.08   5.00   11    -109.08   2.50   10
             0.00   5.00   11       0.00   5.00   11      0.00     5.00   11

 42 MAX      0.06   0.00    1       6.80   0.00    5
             0.00   0.00    1       0.00   0.00    1      0.00     0.00    1
    MIN     -0.06   5.00    1     -99.89   5.00   10
             0.00   5.00   11       0.00   5.00   11      0.00     5.00   11

********** END OF FORCE ENVELOPE FROM INTERNAL STORAGE **********
 29. FINISH

          *********** END OF THE STAAD.Pro RUN ***********

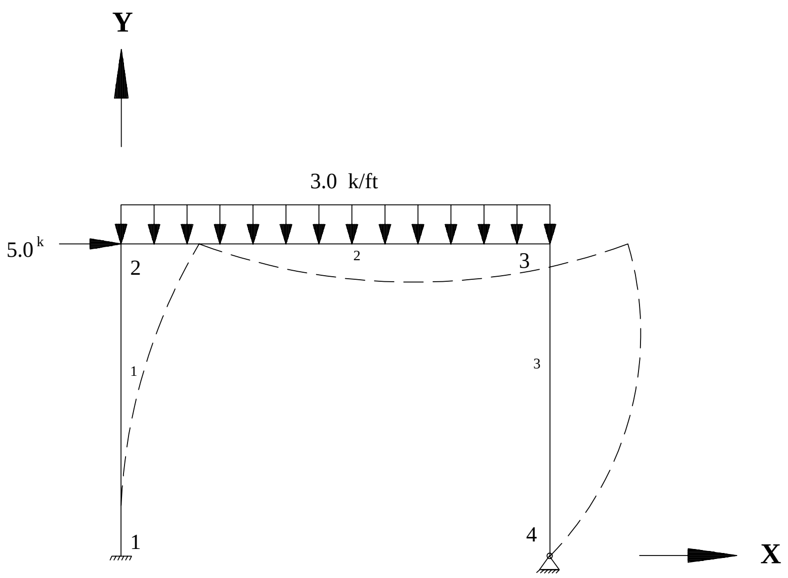
            **** DATE=              TIME=          ****

      ************************************************************
      *        For questions on STAAD.Pro, please contact        *
      *   Research Engineers Offices at the following locations  *
      *                                                          *
      *             Telephone                Email               *
      *  USA:      +1 (714)974-2500       support@bentley.com    *
      *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
      *  UK        +44(1454)207-000       support@reel.co.uk     *
      *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
      *  GERMANY   +49/931/40468-71       info@reig.de           *
      *  NORWAY    +47 67 57 21 30        staad@edr.no           *
      *  SINGAPORE +65 6225-6158          support@bentley.com    *
      *  INDIA     +91(033)4006-2021      support@bentley.com    *
      *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
      *  CHINA     +86(411)363-1983       support@bentley.com    *
      *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
      *                                                          *
      *  North America                   support@bentley.com     *
      *  Europe                          support@bentley.com     *
      *  Asia                            support@bentley.com     *
      ************************************************************
```

NOTES

Example Problem No. 13

Calculation of displacements at intermediate points of members of a plane frame is demonstrated in this example.



The dashed line represents the deflected shape of the structure. The shape is generated on the basis of displacements at the ends and several intermediate points of the members.

Actual input is shown in bold lettering followed by explanation.

STAAD PLANE TEST FOR SECTION DISPLACEMENT

Every input has to start with the word STAAD. The word PLANE signifies that the structure is a plane frame structure and the geometry is defined through X and Y axes.

UNIT KIP FEET

Specifies the unit to be used for data to follow.

JOINT COORDINATES
1 0. 0. ; 2 0. 15. ; 3 20. 15. ; 4 20. 0.

Joint number followed by X, and Y coordinates are provided above. Since this is a plane structure, the Z coordinates need not be provided. Semicolon signs (;) are used as line separators which allows us to provide multiple sets of data on one line.

MEMBER INCIDENCE
1 1 2 ; 2 2 3 ; 3 3 4

Defines the members by the joints they are connected to.

MEMBER PROPERTY AMERICAN
1 3 TABLE ST W8X18
2 TABLE ST W12X26

Properties for all members are assigned from the American AISC steel table. The word ST stands for standard single section.

UNIT INCHES
CONSTANTS
E 29000.0 ALL
POISSON STEEL ALL

In the above lines, material constants like E (modulus of elasticity) and Poisson's ratio are provided after the length unit is changed from FT to INCH.

```
SUPPORT
1 FIXED ; 4 PINNED
```

Joint 1 is restrained for all six degrees of freedom. At joint 4, all three translations are restrained.

```
UNIT FT
LOADING 1 DEAD + LIVE + WIND
```

Load case 1 is initiated along with an accompanying title.

```
JOINT LOAD
2 FX 5.
```

Load 1 contains a joint load of 5 kips at node 2. FX indicates that the load is a force in the global X direction.

```
MEMBER LOAD
2 UNI GY -3.0
```

Load 1 contains member loads also. GY indicates that the load is in the global Y direction. The word UNI stands for uniformly distributed load.

```
PERFORM ANALYSIS
```

This command instructs the program to proceed with the analysis.

```
PRINT MEMBER FORCES
```

The above PRINT command is self-explanatory.

```
*
* FOLLOWING PRINT COMMAND WILL PRINT
* DISPLACEMENTS OF THE MEMBERS
* CONSIDERING EVERY TWELVETH INTERMEDIATE
* POINTS (THAT IS TOTAL 13 POINTS). THESE
* DISPLACEMENTS ARE MEASURED IN GLOBAL X
* Y Z COORDINATE SYSTEM AND THE VALUES
* ARE FROM ORIGINAL COORDINATES (THAT IS
* UNDEFLECTED) OF CORRESPONDING TWELVETH
* POINTS.
```

```
*
* MAX LOCAL DISPLACEMENT IS ALSO PRINTED.
* THE LOCATION OF MAXIMUM INTERMEDIATE
* DISPLACEMENT IS DETERMINED. THIS VALUE IS
* MEASURED FROM ABOVE LOCATION TO THE
* STRAIGHT LINE JOINING START AND END
* JOINTS OF THE DEFLECTED MEMBER.
*
PRINT SECTION DISPLACEMENT
```

The above PRINT command is explained in the comment lines above.

```
FINISH
```

This command terminates the STAAD run.

```
 ****************************************************
 *                                                  *
 *           STAAD.Pro                              *
 *           Version          Bld                   *
 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=                                  *
 *           Time=                                  *
 *                                                  *
 *      USER ID:                                    *
 ****************************************************

  1. STAAD PLANE TEST FOR SECTION DISPLACEMENT
  2. UNIT KIP FEET
  3. JOINT COORDINATES
  4. 1 0. 0. ; 2 0. 15. ; 3 20. 15. ; 4 20. 0.
  5. MEMBER INCIDENCE
  6. 1 1 2 ; 2 2 3 ; 3 3 4
  7. MEMBER PROPERTY AMERICAN
  8. 1 3 TABLE ST W8X18
  9. 2 TABLE ST W12X26
 10. UNIT INCHES
 11. CONSTANTS
 12. E 29000.0 ALL
 13. POISSON STEEL ALL
 14. SUPPORT
 15. 1 FIXED ; 4 PINNED
 16. UNIT FT
 17. LOADING 1 DEAD + LIVE + WIND
 18. JOINT LOAD
 19. 2 FX 5.
 20. MEMBER LOAD
 21. 2 UNI GY -3.0
 22. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     4/     3/     2
  ORIGINAL/FINAL BAND-WIDTH=     1/     1/      6 DOF
  TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =      7
  SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =    12.0/  3143.3 MB,  EXMEM =  568.2 MB

 23. PRINT MEMBER FORCES

 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z


    1    1     1     27.37      0.97     0.00      0.00      0.00      22.49
               2    -27.37     -0.97     0.00      0.00      0.00      -7.88

    2    1     2      4.03     27.37     0.00      0.00      0.00       7.88
               3     -4.03     32.63     0.00      0.00      0.00     -60.39

    3    1     3     32.63      4.03     0.00      0.00      0.00      60.39
               4    -32.63     -4.03     0.00      0.00      0.00       0.00


 ************** END OF LATEST ANALYSIS RESULT **************


 24. *
 25. * FOLLOWING PRINT COMMAMND WILL PRINT DISPLACEMENTS
 26. * OF THE MEMBERS CONSIDERING EVERY TWELVETH INTERMEDIATE
 27. * POINTS (THAT IS TOTAL 13 POINTS). THESE DISPLACEMENTS
 28. * ARE MEASURED IN GLOBAL X Y Z COORDINATE SYSTEM AND
 29. * THE VALUES ARE FROM ORIGINAL COORDINATES (THAT IS
 30. * UNDEFLECTED) OF CORRESPONDING TWELVETH POINTS.
```

```
31. *
32. * MAX LOCAL DISPLACEMENT IS ALSO PRINTED. THE LOCATION
33. * OF THE MAXIMUM INTERMEDIATE DISPLACEMENT IS DETERMINED.
34. * THIS VALUE IS MEASURED FROM ABOVE LOCATION TO THE STRAIGHT
35. * LINE JOINING START AND END JOINTS OF THE DEFLECTED MEMBER.
36. *
37. PRINT SECTION DISPLACEMENT

 MEMBER SECTION DISPLACEMENTS
 ----------------------------
 UNIT =INCHES FOR FPS AND CM FOR METRICS/SI SYSTEM

 MEMB  LOAD     GLOBAL X,Y,Z DISPL FROM START TO END JOINTS AT 1/12TH PTS

   1     1       0.0000    0.0000    0.0000    0.0173   -0.0027    0.0000
                 0.0666   -0.0054    0.0000    0.1461   -0.0081    0.0000
                 0.2539   -0.0108    0.0000    0.3882   -0.0135    0.0000
                 0.5471   -0.0162    0.0000    0.7290   -0.0188    0.0000
                 0.9318   -0.0215    0.0000    1.1538   -0.0242    0.0000
                 1.3931   -0.0269    0.0000    1.6480   -0.0296    0.0000
                 1.9165   -0.0323    0.0000

 MAX LOCAL  DISP =    0.41111   AT      90.00  LOAD    1   L/DISP=    437

   2     1       1.9165   -0.0323    0.0000    1.9162   -0.3903    0.0000
                 1.9158   -0.7221    0.0000    1.9154   -1.0010    0.0000
                 1.9151   -1.2067    0.0000    1.9147   -1.3260    0.0000
                 1.9143   -1.3523    0.0000    1.9140   -1.2856    0.0000
                 1.9136   -1.1331    0.0000    1.9133   -0.9082    0.0000
                 1.9129   -0.6316    0.0000    1.9125   -0.3303    0.0000
                 1.9122   -0.0385    0.0000

 MAX LOCAL  DISP =    1.31688   AT     120.00  LOAD    1   L/DISP=    182

   3     1       1.9122   -0.0385    0.0000    2.0720   -0.0353    0.0000
                 2.1486   -0.0321    0.0000    2.1494   -0.0289    0.0000
                 2.0822   -0.0257    0.0000    1.9544   -0.0225    0.0000
                 1.7736   -0.0192    0.0000    1.5474   -0.0160    0.0000
                 1.2833   -0.0128    0.0000    0.9890   -0.0096    0.0000
                 0.6719   -0.0064    0.0000    0.3398   -0.0032    0.0000
                 0.0000    0.0000    0.0000

 MAX LOCAL  DISP =    0.83895   AT      75.00  LOAD    1   L/DISP=    214

     ************ END OF SECT DISPL RESULTS ***********
38. FINISH

         *********** END OF THE STAAD.Pro RUN ***********

           **** DATE=               TIME=          ****

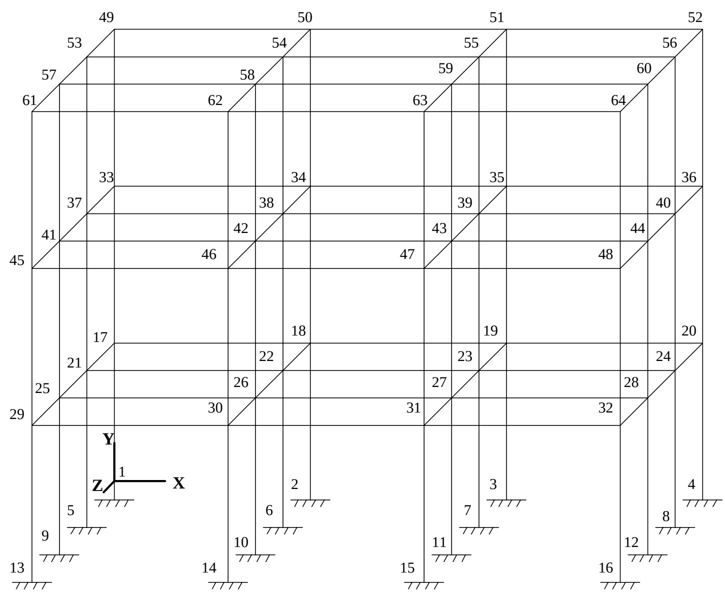
     ************************************************************
     *         For questions on STAAD.Pro, please contact       *
     *   Research Engineers Offices at the following locations  *
     *                                                          *
     *               Telephone                 Email            *
     *  USA:      +1 (714)974-2500       support@bentley.com    *
     *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
     *  UK        +44(1454)207-000       support@reel.co.uk     *
     *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
     *  GERMANY   +49/931/40468-71       info@reig.de           *
     *  NORWAY    +47 67 57 21 30        staad@edr.no           *
     *  SINGAPORE +65 6225-6158          support@bentley.com    *
     *  INDIA     +91(033)4006-2021      support@bentley.com    *
     *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
     *  CHINA     +86(411)363-1983       support@bentley.com    *
     *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
     *                                                          *
     *  North America                   support@bentley.com     *
     *  Europe                          support@bentley.com     *
     *  Asia                            support@bentley.com     *
     ************************************************************
```

NOTES

NOTES

Example Problem No. 14

A space frame is analyzed for seismic loads. The seismic loads are generated using the procedures of the 1994 UBC Code. A P-Delta analysis is peformed to obtain the secondary effects of the lateral and vertical loads acting simultaneously.



STAAD SPACE EXAMPLE PROBLEM FOR UBC LOAD

Every input has to start with the word STAAD. The word SPACE signifies that the structure is a space frame.

UNIT FEET KIP

Specifies the unit to be used for data to follow.

```
JOINT COORDINATES
1 0 0 0 4 30 0 0
REPEAT 3 0 0 10
REPEAT ALL 3 0 10 0
```

The X, Y and Z coordinates of the joints are specified here. First, coordinates of joints 1 through 4 are generated by taking advantage of the fact that they are equally spaced. Then, this pattern is REPEATed 3 times with a Z increment of 10 feet for each repetition to generate joints 5 to 16. The REPEAT ALL command will then repeat 3 times, the pattern of joints 1 to 16 to generate joints 17 to 64.

```
MEMBER INCIDENCES
* beams in x direction
101 17 18 103
104 21 22 106
107 25 26 109
110 29 30 112
REPEAT ALL 2 12 16
* beams in z direction
201 17 21 204
205 21 25 208
209 25 29 212
REPEAT ALL 2 12 16
* columns
301 1 17 348
```

Defines the members by the joints they are connected to. Following the specification of incidences for members 101 to 112, the REPEAT ALL command command is used to repeat the pattern and generate incidences for members 113 through 136. A similar logic is used in specification of incidences of members 201 through 212 and generation of incidences for members 213 to 236. Finally, members incidences of columns 301 to 348 are specified.

```
UNIT INCH
MEMBER PROPERTIES AMERICAN
101 TO 136 201 TO 236 PRIS YD 15 ZD 15
301 TO 348 TA ST W18X35
```

The beam members have prismatic member property specification (YD & ZD) while the columns (members 301 to 348) have their properties called from the built-in American (AISC) steel table.

```
CONSTANT
E STEEL MEMB 301 TO 348
E CONCRETE MEMB 101 TO 136 201 TO 236
DENSITY STEEL MEMB 301 TO 348
DENSITY CONCRETE MEMB 101 TO 136 201 TO 236
POISSON STEEL MEMB 301 TO 348
POISSON CONCRETE MEMB 101 TO 136 201 TO 236
```

In the specification of material constants, the default built-in values are used. The user may see these values with the help of the command PRINT MATERIAL PROPERTIES following the above commands.

```
SUPPORT
1 TO 16 FIXED
```

Indicates the joints where the supports are located as well as the type of support restraints.

```
UNIT FEET
DEFINE UBC LOAD
ZONE 0.2 I 1.0 RWX 9 RWZ 9 S 1.5 CT 0.032
SELFWEIGHT
JOINT WEIGHT
17 TO 48 WEIGHT 2.5
49 TO 64 WEIGHT 1.25
```

There are two stages in the command specification of the UBC loads. The first stage is initiated with the command DEFINE UBC LOAD. Here we specify parameters such as Zone factor, Importance factor, site coefficient for soil characteristics etc. and, the vertical loads (weights) from which the base shear will be calculated. The vertical loads may be specified in the form of selfweight, joint weights and/or member weights. Member weights are not shown in this example. It is important to note that these vertical loads are used purely in the determination of the horizontal base shear only. In other words, the structure is not analysed for these vertical loads.

```
LOAD 1
UBC LOAD X 0.75
SELFWEIGHT Y -1.0
JOINT LOADS
17 TO 48 FY -2.5
49 TO 64 FY -1.25
```

This is the second stage in which the UBC load is applied with the help of load case number, corresponding direction (X in the above case) and a factor by which the generated horizontal loads should be multiplied. Along with the UBC load, deadweight and other vertical loads are also added to the same load case. Since we will be doing second-order (PDELTA) analysis, it is important that we add horizontal and vertical loads in the same load case.

```
LOAD 2
UBC LOAD Z 0.75
SELFWEIGHT Y -1.0
JOINT LOADS
17 TO 48 FY -2.5
49 TO 64 FY -1.25
```

In load case 2, the UBC load is being applied in the Z direction. Vertical loads too are part of this case.

```
PDELTA ANALYSIS PRINT LOAD DATA
```

We are requesting a second-order analysis by specifying the command PDELTA ANALYSIS. PRINT LOAD DATA is used to obtain a report in the output file of all the applied and generated loadings.

```
PRINT SUPPORT REACTIONS
FINISH
```

The above commands are self-explanatory.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

 1. STAAD SPACE EXAMPLE PROBLEM FOR UBC LOAD
 2. UNIT FEET KIP
 3. JOINT COORDINATES
 4. 1 0 0 0 4 30 0 0
 5. REPEAT 3 0 0 10
 6. REPEAT ALL 3 0 10 0
 7. MEMBER INCIDENCES
 8. * BEAMS IN X DIRECTION
 9. 101 17 18 103
10. 104 21 22 106
11. 107 25 26 109
12. 110 29 30 112
13. REPEAT ALL 2 12 16
14. * BEAMS IN Z DIRECTION
15. 201 17 21 204
16. 205 21 25 208
17. 209 25 29 212
18. REPEAT ALL 2 12 16
19. * COLUMNS
20. 301 1 17 348
21. UNIT INCH
22. MEMBER PROPERTIES AMERICAN
23. 101 TO 136 201 TO 236 PRIS YD 15 ZD 15
24. 301 TO 348 TA ST W18X35
25. CONSTANT
26. E STEEL MEMB 301 TO 348
27. E CONCRETE MEMB 101 TO 136 201 TO 236
28. DENSITY STEEL MEMB 301 TO 348
29. DENSITY CONCRETE MEMB 101 TO 136 201 TO 236
30. POISSON STEEL MEMB 301 TO 348
31. POISSON CONCRETE MEMB 101 TO 136 201 TO 236
32. SUPPORT
33. 1 TO 16 FIXED
34. UNIT FEET
35. DEFINE UBC LOAD
36. ZONE 0.2 I 1.0 RWX 9 RWZ 9 S 1.5 CT 0.032
37. SELFWEIGHT
38. JOINT WEIGHT
39. 17 TO 48 WEIGHT 2.5
40. 49 TO 64 WEIGHT 1.25
41. LOAD 1
42. UBC LOAD X 0.75
43. SELFWEIGHT Y -1.0
44. JOINT LOADS
45. 17 TO 48 FY -2.5
46. 49 TO 64 FY -1.25
47. LOAD 2
48. UBC LOAD Z 0.75
49. SELFWEIGHT Y -1.0
50. JOINT LOADS
51. 17 TO 48 FY -2.5
52. 49 TO 64 FY -1.25
53. PDELTA ANALYSIS PRINT LOAD DATA
```

```
         P R O B L E M   S T A T I S T I C S
         -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    64/   120/    16
  ORIGINAL/FINAL BAND-WIDTH=    16/    14/     78 DOF
  TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =    288
  SIZE OF STIFFNESS MATRIX =      23 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =    12.4/  3143.3 MB,  EXMEM =  568.2 MB


LOADING     1
-----------

    SELFWEIGHT  Y   -1.000

   ACTUAL WEIGHT OF THE STRUCTURE =     185.529 KIP


JOINT LOAD - UNIT KIP  FEET

JOINT   FORCE-X   FORCE-Y     FORCE-Z     MOM-X     MOM-Y     MOM-Z

   17      0.00     -2.50        0.00      0.00      0.00      0.00
   18      0.00     -2.50        0.00      0.00      0.00      0.00
   19      0.00     -2.50        0.00      0.00      0.00      0.00
   20      0.00     -2.50        0.00      0.00      0.00      0.00
   21      0.00     -2.50        0.00      0.00      0.00      0.00
   22      0.00     -2.50        0.00      0.00      0.00      0.00
   23      0.00     -2.50        0.00      0.00      0.00      0.00
   24      0.00     -2.50        0.00      0.00      0.00      0.00
   25      0.00     -2.50        0.00      0.00      0.00      0.00
   26      0.00     -2.50        0.00      0.00      0.00      0.00
   27      0.00     -2.50        0.00      0.00      0.00      0.00
   28      0.00     -2.50        0.00      0.00      0.00      0.00
   29      0.00     -2.50        0.00      0.00      0.00      0.00
   30      0.00     -2.50        0.00      0.00      0.00      0.00
   31      0.00     -2.50        0.00      0.00      0.00      0.00
   32      0.00     -2.50        0.00      0.00      0.00      0.00
   33      0.00     -2.50        0.00      0.00      0.00      0.00
   34      0.00     -2.50        0.00      0.00      0.00      0.00
   35      0.00     -2.50        0.00      0.00      0.00      0.00
   36      0.00     -2.50        0.00      0.00      0.00      0.00
   37      0.00     -2.50        0.00      0.00      0.00      0.00
   38      0.00     -2.50        0.00      0.00      0.00      0.00
   39      0.00     -2.50        0.00      0.00      0.00      0.00
   40      0.00     -2.50        0.00      0.00      0.00      0.00
   41      0.00     -2.50        0.00      0.00      0.00      0.00
   42      0.00     -2.50        0.00      0.00      0.00      0.00
   43      0.00     -2.50        0.00      0.00      0.00      0.00
   44      0.00     -2.50        0.00      0.00      0.00      0.00
   45      0.00     -2.50        0.00      0.00      0.00      0.00
   46      0.00     -2.50        0.00      0.00      0.00      0.00
   47      0.00     -2.50        0.00      0.00      0.00      0.00
   48      0.00     -2.50        0.00      0.00      0.00      0.00
   49      0.00     -1.25        0.00      0.00      0.00      0.00
   50      0.00     -1.25        0.00      0.00      0.00      0.00
   51      0.00     -1.25        0.00      0.00      0.00      0.00
   52      0.00     -1.25        0.00      0.00      0.00      0.00
   53      0.00     -1.25        0.00      0.00      0.00      0.00
   54      0.00     -1.25        0.00      0.00      0.00      0.00
   55      0.00     -1.25        0.00      0.00      0.00      0.00
   56      0.00     -1.25        0.00      0.00      0.00      0.00
   57      0.00     -1.25        0.00      0.00      0.00      0.00
   58      0.00     -1.25        0.00      0.00      0.00      0.00
   59      0.00     -1.25        0.00      0.00      0.00      0.00
   60      0.00     -1.25        0.00      0.00      0.00      0.00
   61      0.00     -1.25        0.00      0.00      0.00      0.00
   62      0.00     -1.25        0.00      0.00      0.00      0.00
   63      0.00     -1.25        0.00      0.00      0.00      0.00
   64      0.00     -1.25        0.00      0.00      0.00      0.00
```

```
LOADING     2
-----------
    SELFWEIGHT  Y   -1.000

   ACTUAL WEIGHT OF THE STRUCTURE =     185.529 KIP

JOINT LOAD - UNIT KIP  FEET

JOINT   FORCE-X   FORCE-Y     FORCE-Z     MOM-X     MOM-Y     MOM-Z

   17      0.00     -2.50        0.00      0.00      0.00      0.00
   18      0.00     -2.50        0.00      0.00      0.00      0.00
   19      0.00     -2.50        0.00      0.00      0.00      0.00
   20      0.00     -2.50        0.00      0.00      0.00      0.00
   21      0.00     -2.50        0.00      0.00      0.00      0.00
   22      0.00     -2.50        0.00      0.00      0.00      0.00
   23      0.00     -2.50        0.00      0.00      0.00      0.00
   24      0.00     -2.50        0.00      0.00      0.00      0.00
   25      0.00     -2.50        0.00      0.00      0.00      0.00
   26      0.00     -2.50        0.00      0.00      0.00      0.00
   27      0.00     -2.50        0.00      0.00      0.00      0.00
   28      0.00     -2.50        0.00      0.00      0.00      0.00
   29      0.00     -2.50        0.00      0.00      0.00      0.00
   30      0.00     -2.50        0.00      0.00      0.00      0.00
   31      0.00     -2.50        0.00      0.00      0.00      0.00
   32      0.00     -2.50        0.00      0.00      0.00      0.00
   33      0.00     -2.50        0.00      0.00      0.00      0.00
   34      0.00     -2.50        0.00      0.00      0.00      0.00
   35      0.00     -2.50        0.00      0.00      0.00      0.00
   36      0.00     -2.50        0.00      0.00      0.00      0.00
   37      0.00     -2.50        0.00      0.00      0.00      0.00
   38      0.00     -2.50        0.00      0.00      0.00      0.00
   39      0.00     -2.50        0.00      0.00      0.00      0.00
   40      0.00     -2.50        0.00      0.00      0.00      0.00
   41      0.00     -2.50        0.00      0.00      0.00      0.00
   42      0.00     -2.50        0.00      0.00      0.00      0.00
   43      0.00     -2.50        0.00      0.00      0.00      0.00
   44      0.00     -2.50        0.00      0.00      0.00      0.00
   45      0.00     -2.50        0.00      0.00      0.00      0.00
   46      0.00     -2.50        0.00      0.00      0.00      0.00
   47      0.00     -2.50        0.00      0.00      0.00      0.00
   48      0.00     -2.50        0.00      0.00      0.00      0.00
   49      0.00     -1.25        0.00      0.00      0.00      0.00
   50      0.00     -1.25        0.00      0.00      0.00      0.00
   51      0.00     -1.25        0.00      0.00      0.00      0.00
   52      0.00     -1.25        0.00      0.00      0.00      0.00
   53      0.00     -1.25        0.00      0.00      0.00      0.00
   54      0.00     -1.25        0.00      0.00      0.00      0.00
   55      0.00     -1.25        0.00      0.00      0.00      0.00
   56      0.00     -1.25        0.00      0.00      0.00      0.00
   57      0.00     -1.25        0.00      0.00      0.00      0.00
   58      0.00     -1.25        0.00      0.00      0.00      0.00
   59      0.00     -1.25        0.00      0.00      0.00      0.00
   60      0.00     -1.25        0.00      0.00      0.00      0.00
   61      0.00     -1.25        0.00      0.00      0.00      0.00
   62      0.00     -1.25        0.00      0.00      0.00      0.00
   63      0.00     -1.25        0.00      0.00      0.00      0.00
   64      0.00     -1.25        0.00      0.00      0.00      0.00

***********************************************************
*                                                         *
*  X  DIRECTION : Ta =  0.410 Tb =  0.252 Tuser =  0.000  *
*  C =   2.7500, LOAD FACTOR =  0.750                     *
* UBC TYPE = 94                                           *
*  UBC FACTOR V =  0.0611 X    285.53 =     17.45 KIP     *
*                                                         *
***********************************************************
***********************************************************
*                                                         *
*  Z  DIRECTION : Ta =  0.410 Tb =  0.988 Tuser =  0.000  *
*  C =   2.7500, LOAD FACTOR =  0.750                     *
* UBC TYPE = 94                                           *
*  UBC FACTOR V =  0.0611 X    285.53 =     17.45 KIP     *
*                                                         *
***********************************************************
```

```
JOINT          LATERAL          TORSIONAL          LOAD -    1
               LOAD (KIP )      MOMENT (KIP -FEET) FACTOR -   0.750
-----          -------          ---------

  17     FX       0.125    MY       0.000
  18     FX       0.154    MY       0.000
  19     FX       0.154    MY       0.000
  20     FX       0.125    MY       0.000
  21     FX       0.154    MY       0.000
  22     FX       0.182    MY       0.000
  23     FX       0.182    MY       0.000
  24     FX       0.154    MY       0.000
  25     FX       0.154    MY       0.000
  26     FX       0.182    MY       0.000
  27     FX       0.182    MY       0.000
  28     FX       0.154    MY       0.000
  29     FX       0.125    MY       0.000
  30     FX       0.154    MY       0.000
  31     FX       0.154    MY       0.000
  32     FX       0.125    MY       0.000
            -----------       -----------
      TOTAL =     2.456             0.000 AT LEVEL    10.000 FEET

  33     FX       0.250    MY       0.000
  34     FX       0.307    MY       0.000
  35     FX       0.307    MY       0.000
  36     FX       0.250    MY       0.000
  37     FX       0.307    MY       0.000
  38     FX       0.364    MY       0.000
  39     FX       0.364    MY       0.000
  40     FX       0.307    MY       0.000
  41     FX       0.307    MY       0.000
  42     FX       0.364    MY       0.000
  43     FX       0.364    MY       0.000
  44     FX       0.307    MY       0.000
  45     FX       0.250    MY       0.000
  46     FX       0.307    MY       0.000
  47     FX       0.307    MY       0.000
  48     FX       0.250    MY       0.000
            -----------       -----------
      TOTAL =     4.912             0.000 AT LEVEL    20.000 FEET

  49     FX       0.273    MY       0.000
  50     FX       0.357    MY       0.000
  51     FX       0.357    MY       0.000
  52     FX       0.273    MY       0.000
  53     FX       0.357    MY       0.000
  54     FX       0.442    MY       0.000
  55     FX       0.442    MY       0.000
  56     FX       0.357    MY       0.000
  57     FX       0.357    MY       0.000
  58     FX       0.442    MY       0.000
  59     FX       0.442    MY       0.000
  60     FX       0.357    MY       0.000
  61     FX       0.273    MY       0.000
  62     FX       0.357    MY       0.000
  63     FX       0.357    MY       0.000
  64     FX       0.273    MY       0.000
            -----------       -----------
      TOTAL =     5.719             0.000 AT LEVEL    30.000 FEET
```

```
JOINT          LATERAL          TORSIONAL          LOAD -    2
               LOAD (KIP )      MOMENT (KIP -FEET) FACTOR -   0.750
-----          -------          ---------

  17     FZ        0.125    MY        0.000
  18     FZ        0.154    MY        0.000
  19     FZ        0.154    MY        0.000
  20     FZ        0.125    MY        0.000
  21     FZ        0.154    MY        0.000
  22     FZ        0.182    MY        0.000
  23     FZ        0.182    MY        0.000
  24     FZ        0.154    MY        0.000
  25     FZ        0.154    MY        0.000
  26     FZ        0.182    MY        0.000
  27     FZ        0.182    MY        0.000
  28     FZ        0.154    MY        0.000
  29     FZ        0.125    MY        0.000
  30     FZ        0.154    MY        0.000
  31     FZ        0.154    MY        0.000
  32     FZ        0.125    MY        0.000
             -----------          -----------
      TOTAL =      2.456              0.000 AT LEVEL    10.000 FEET

  33     FZ        0.250    MY        0.000
  34     FZ        0.307    MY        0.000
  35     FZ        0.307    MY        0.000
  36     FZ        0.250    MY        0.000
  37     FZ        0.307    MY        0.000
  38     FZ        0.364    MY        0.000
  39     FZ        0.364    MY        0.000
  40     FZ        0.307    MY        0.000
  41     FZ        0.307    MY        0.000
  42     FZ        0.364    MY        0.000
  43     FZ        0.364    MY        0.000
  44     FZ        0.307    MY        0.000
  45     FZ        0.250    MY        0.000
  46     FZ        0.307    MY        0.000
  47     FZ        0.307    MY        0.000
  48     FZ        0.250    MY        0.000
             -----------          -----------
      TOTAL =      4.912              0.000 AT LEVEL    20.000 FEET

  49     FZ        0.273    MY        0.000
  50     FZ        0.357    MY        0.000
  51     FZ        0.357    MY        0.000
  52     FZ        0.273    MY        0.000
  53     FZ        0.357    MY        0.000
  54     FZ        0.442    MY        0.000
  55     FZ        0.442    MY        0.000
  56     FZ        0.357    MY        0.000
  57     FZ        0.357    MY        0.000
  58     FZ        0.442    MY        0.000
  59     FZ        0.442    MY        0.000
  60     FZ        0.357    MY        0.000
  61     FZ        0.273    MY        0.000
  62     FZ        0.357    MY        0.000
  63     FZ        0.357    MY        0.000
  64     FZ        0.273    MY        0.000
             -----------          -----------
      TOTAL =      5.719              0.000 AT LEVEL    30.000 FEET



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

```
 54. PRINT SUPPORT REACTIONS


SUPPORT REACTIONS -UNIT KIP  FEET    STRUCTURE TYPE = SPACE
-----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z


   1    1     -0.61     12.05      0.01      0.05      0.00      4.36
        2      0.11     11.59     -0.80     -4.24      0.00     -0.33
   2    1     -0.90     17.36      0.01      0.05      0.00      5.25
        2      0.01     14.95     -0.80     -4.24      0.00     -0.02
   3    1     -0.92     17.10      0.01      0.05      0.00      5.30
        2     -0.01     14.95     -0.80     -4.24      0.00      0.02
   4    1     -0.82     15.69      0.01      0.05      0.00      5.02
        2     -0.11     11.59     -0.80     -4.24      0.00      0.33
   5    1     -0.62     16.62      0.00     -0.01      0.00      4.44
        2      0.11     19.41     -0.83     -4.38      0.00     -0.33
   6    1     -0.91     21.95      0.00     -0.01      0.00      5.34
        2      0.01     22.76     -0.82     -4.38      0.00     -0.02
   7    1     -0.93     21.69      0.00     -0.01      0.00      5.38
        2     -0.01     22.76     -0.82     -4.38      0.00      0.02
   8    1     -0.83     20.31      0.00     -0.01      0.00      5.10
        2     -0.11     19.41     -0.83     -4.38      0.00      0.33
   9    1     -0.62     16.62      0.00      0.01      0.00      4.44
        2      0.11     17.52     -0.83     -4.37      0.00     -0.33
  10    1     -0.91     21.95      0.00      0.01      0.00      5.34
        2      0.01     20.88     -0.82     -4.37      0.00     -0.02
  11    1     -0.93     21.69      0.00      0.01      0.00      5.38
        2     -0.01     20.88     -0.82     -4.37      0.00      0.02
  12    1     -0.83     20.31      0.00      0.01      0.00      5.10
        2     -0.11     17.52     -0.83     -4.37      0.00      0.33
  13    1     -0.61     12.05     -0.01     -0.05      0.00      4.36
        2      0.11     16.15     -0.82     -4.33      0.00     -0.33
  14    1     -0.90     17.36     -0.01     -0.05      0.00      5.25
        2      0.01     19.51     -0.82     -4.33      0.00     -0.02
  15    1     -0.92     17.10     -0.01     -0.05      0.00      5.30
        2     -0.01     19.51     -0.82     -4.33      0.00      0.02
  16    1     -0.82     15.69     -0.01     -0.05      0.00      5.02
        2     -0.11     16.15     -0.82     -4.33      0.00      0.33


************** END OF LATEST ANALYSIS RESULT **************

 55. FINISH

         *********** END OF THE STAAD.Pro RUN ***********

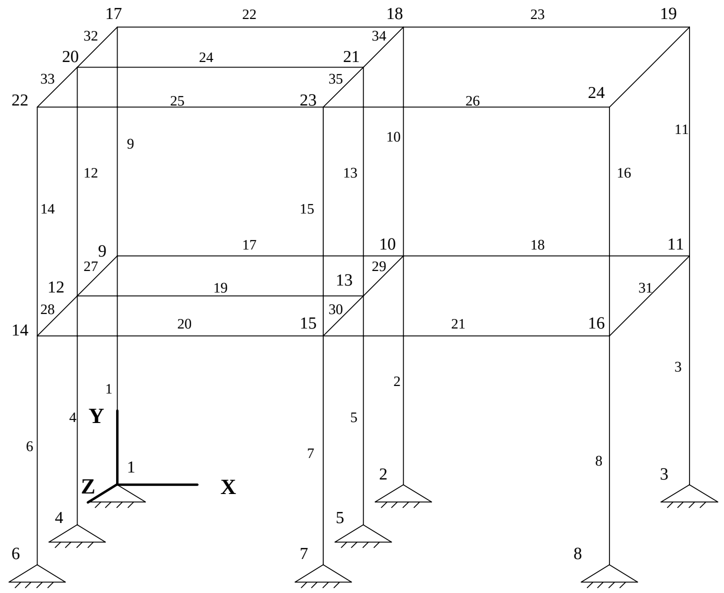
           **** DATE=               TIME=          ****

      ************************************************************
      *         For questions on STAAD.Pro, please contact       *
      *   Research Engineers Offices at the following locations  *
      *                                                          *
      *              Telephone                 Email             *
      *  USA:      +1 (714)974-2500       support@bentley.com    *
      *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
      *  UK        +44(1454)207-000       support@reel.co.uk     *
      *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
      *  GERMANY   +49/931/40468-71       info@reig.de           *
      *  NORWAY    +47 67 57 21 30        staad@edr.no           *
      *  SINGAPORE +65 6225-6158          support@bentley.com    *
      *  INDIA     +91(033)4006-2021      support@bentley.com    *
      *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
      *  CHINA     +86(411)363-1983       support@bentley.com    *
      *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
      *                                                          *
      *  North America                   support@bentley.com     *
      *  Europe                          support@bentley.com     *
      *  Asia                            support@bentley.com     *
      ************************************************************
```

NOTES

Example Problem No. 15

A space frame is analyzed for loads generated using the built-in wind and floor load generation facilities.



STAAD SPACE - WIND AND FLOOR LOAD GENERATION

This is a SPACE frame analysis problem. Every STAAD input has to start with the command STAAD. The SPACE specification is used to denote a SPACE frame.

UNIT FEET KIP

The UNIT specification is used to specify the length and/or force units to be used for data to follow.

```
JOINT COORDINATES
1 0 0 0
2 10 0 0
3 21 0 0
4 0 0 10
5 10 0 10
6 0 0 20
7 10 0 20
8 21 0 20
REPEAT ALL 2 0 12 0
```

The JOINT COORDINATE specification is used to specify the X, Y and Z coordinates of the JOINTs. Note that the REPEAT ALL command has been used to generate JOINTs for the two upper storeys each with a Y increment of 12 ft.

```
MEMBER INCIDENCES
* Columns
1 1 9 16
* Beams in the X direction
17 9 10 18
19 12 13
20 14 15 21
22 17 18 23
24 20 21
25 22 23 26
* Beams in the Z direction
27 9 12 ; 28 12 14 ; 29 10 13 ; 30 13 15 ; 31 11 16
32 17 20 ; 33 20 22 ; 34 18 21 ; 35 21 23 ; 36 19 24
```

The MEMBER INCIDENCE specification is used for specifying MEMBER connectivities.

```
UNIT INCH
MEMBER PROPERTIES AMERICAN
1 TO 16 TA ST W21X50
17 TO 26 TA ST W18X35
27 TO 36 TA ST W14X90
```

Properties for all members are specified from the built-in American (AISC) steel table. Three different sections have been used.

```
CONSTANT
E STEEL ALL
DENSITY STEEL ALL
POISSON STEEL ALL
```

The CONSTANT specification is used to specify material properties. In this case, the default values have been used.

```
SUPPORT
1 TO 8 FIXED BUT MX MZ
```

The SUPPORTs of the structure are defined through the SUPPORT specification. Here all the supports are FIXED with RELEASES specified in the MX (rotation about global X-axis) and MZ (rotation about global Z-axis) directions.

```
UNIT FEET
DEFINE WIND LOAD
TYPE 1
INTENSITY 0.1 0.15 HEIGHT 12 24
EXPOSURE 0.90 YRANGE 11 13
EXPOSURE 0.85 JOINT 17 20 22
```

When a structure has to be analysed for wind loading, the engineer is confronted with the task of first converting an abstract quantity like wind velocity or wind pressure into concentrated loads at joints, distributed loads on members, or pressure loads on plates. The large number of calculations involved in this conversion can be avoided by making use of STAAD’s wind load generation utility. This utility takes wind pressure at various heights as the input, and converts them to values that can then be used as concentrated forces known as joint loads in specific load cases.

The input specification is done in two stages. The first stage is initiated above through the DEFINE WIND LOAD command. The basic parameters of the WIND loading are specified here. All values need to be provided in the current UNIT system. Each wind category is identified with a TYPE number (an identification mark) which is used later to specify load cases.

In this example, two different wind intensities (0.1 Kips/sq. ft and 0.15 Kips/sq. ft) are specified for two different height zones (0 to 12 ft. and 12 to 24 ft.). The EXPOSURE specification is used to mitigate or magnify the effect at specific nodes due to special considerations like openings in the structure. In this case, two different exposure factors are specified. The first EXPOSURE specification specifies the exposure factor as 0.9 for all joints within the height range (defined as global Y-range) of 11 ft. - 13 ft. The second EXPOSURE specification specifies the exposure factor as 0.85 for joints 17, 20 and 22. In the EXPOSURE factor specification, the joints may be specified directly or through a vertical range specification.

```
LOAD 1 WIND LOAD IN X-DIRECTION
WIND LOAD X 1.2 TYPE 1
```

This is the second stage of input specification for the wind load generation. The term WIND LOAD and the direction term that follows are used to specify the WIND LOADING in a particular lateral direction. In this case, WIND loading TYPE 1, defined previously, is being applied in the global X-direction with a positive multiplication factor of 1.2 .

```
LOAD 2 FLOOR LOAD @ Y = 12 FT AND 24 FT
FLOOR LOAD
YRANGE 11.9 12.1 FLOAD -0.45 XRANGE 0.0 10.0 ZRANGE 0.0 20.0
YRANGE 11.9 12.1 FLOAD -0.25 XRANGE 10.0 21.0 ZRANGE 0.0 20.0
YRANGE 23.9 24.1 FLOAD -0.25
```

In load case 2 in this problem, a floor load generation is performed. In a floor load generation, a pressure load (force per unit area) is converted by the program into specific points forces and distributed forces on the members located in that region. The YRANGE, XRANGE and ZRANGE specifications are used to define the area of the structure on which the pressure is acting. The FLOAD specification is used to specify the value of that pressure. All values need to be provided in the current UNIT system. For example, in the first line in the above FLOOR LOAD specification, the region is defined as being located within the bounds YRANGE of 11.9-12.1 ft, XRANGE of 0.0-10.0 ft and ZRANGE of 0.0-20.0 ft. The -0.45 signifies that the pressure is 0.45 Kip/sq. ft in the negative global Y direction.

The program will identify the members lying within the specified region and derive MEMBER LOADS on these members based on two-way load distribution.

```
PERFORM ANALYSIS PRINT LOAD DATA
```

We can view the values and position of the generated loads with the help of the PRINT LOAD DATA command used above along with the PERFORM ANALYSIS command.

```
PRINT SUPPORT REACTION
FINISH
```

Above commands are self-explanatory.

```
          ****************************************************
          *                                                  *
          *           STAAD.Pro                              *
          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
          *           Date=                                  *
          *           Time=                                  *
          *                                                  *
          *      USER ID:                                    *
          ****************************************************
  1. STAAD SPACE
  2. UNIT FEET KIP
  3. JOINT COORDINATES
  4. 1 0 0 0
  5. 2 10 0 0
  6. 3 21 0 0
  7. 4 0 0 10
  8. 5 10 0 10
  9. 6 0 0 20
 10. 7 10 0 20
 11. 8 21 0 20
 12. REPEAT ALL 2 0 12 0
 13. MEMBER INCIDENCES
 14. * COLUMNS
 15. 1 1 9 16
 16. * BEAMS IN THE X DIRECTION
 17. 17 9 10 18
 18. 19 12 13
 19. 20 14 15 21
 20. 22 17 18 23
 21. 24 20 21
 22. 25 22 23 26
 23. * BEAMS IN THE Z DIRECTION
 24. 27 9 12 ; 28 12 14 ; 29 10 13 ; 30 13 15 ; 31 11 16
 25. 32 17 20 ; 33 20 22 ; 34 18 21 ; 35 21 23 ; 36 19 24
 26. UNIT INCH
 27. MEMBER PROPERTIES AMERICAN
 28. 1 TO 16 TA ST W21X50
 29. 17 TO 26 TA ST W18X35
 30. 27 TO 36 TA ST W14X90
 31. CONSTANT
 32. E STEEL ALL
 33. DENSITY STEEL ALL
 34. POISSON STEEL ALL
 35. SUPPORT
 36. 1 TO 8 FIXED BUT MX MZ
 37. UNIT FEET
 38. DEFINE WIND LOAD
 39. TYPE 1
 40. INTENSITY 0.1 0.15 HEIGHT 12 24
 41. EXPOSURE 0.90 YRANGE 11 13
 42. EXPOSURE 0.85 JOINT 17 20 22
 43. LOAD 1 WIND LOAD IN X-DIRECTION
 44. WIND LOAD X 1.2 TYPE 1
 45. LOAD 2 FLOOR LOAD @ Y = 12FT AND 24FT
 46. FLOOR LOAD
 47. YRANGE 11.9 12.1 FLOAD -0.45 XRANGE  0.0 10.0 ZRANGE 0.0 20.0
 48. YRANGE 11.9 12.1 FLOAD -0.25 XRANGE 10.0 21.0 ZRANGE 0.0 20.0
 49. YRANGE 23.9 24.1 FLOAD -0.25
 50. PERFORM ANALYSIS PRINT LOAD DATA

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    24/    36/     8
  ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
  TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =    112
  SIZE OF STIFFNESS MATRIX =       7 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =    12.1/  3143.1 MB,  EXMEM =  568.2 MB
```

```
LOADING     1  WIND LOAD IN X-DIRECTION
-----------
JOINT LOAD - UNIT KIP  FEET

JOINT   FORCE-X   FORCE-Y     FORCE-Z     MOM-X     MOM-Y     MOM-Z

    1      3.60      0.00        0.00      0.00      0.00      0.00
    4      7.20      0.00        0.00      0.00      0.00      0.00
    6      3.60      0.00        0.00      0.00      0.00      0.00
    9      8.10      0.00        0.00      0.00      0.00      0.00
   12     16.20      0.00        0.00      0.00      0.00      0.00
   14      8.10      0.00        0.00      0.00      0.00      0.00
   17      4.59      0.00        0.00      0.00      0.00      0.00
   20      9.18      0.00        0.00      0.00      0.00      0.00
   22      4.59      0.00        0.00      0.00      0.00      0.00

LOADING     2  FLOOR LOAD @ Y = 12FT AND 24FT
-----------
MEMBER LOAD - UNIT KIP  FEET

MEMBER     UDL      L1      L2       CON        L     LIN1     LIN2

  17                             -0.088 GY   0.42
  17                             -0.264 GY   0.97
  17                             -0.439 GY   1.58
  17                             -0.615 GY   2.20
  17                             -0.791 GY   2.82
  17                             -0.967 GY   3.45
  17                             -1.143 GY   4.07
  17                             -1.318 GY   4.69
  17                             -1.318 GY   5.31
  17                             -1.143 GY   5.93
  17                             -0.967 GY   6.55
  17                             -0.791 GY   7.18
  17                             -0.615 GY   7.80
  17                             -0.439 GY   8.42
  17                             -0.264 GY   9.03
  17                             -0.088 GY   9.58
  29                             -0.088 GY   0.42
  29                             -0.264 GY   0.97
  29                             -0.439 GY   1.58
  29                             -0.615 GY   2.20
  29                             -0.791 GY   2.82
  29                             -0.967 GY   3.45
  29                             -1.143 GY   4.07
  29                             -1.318 GY   4.69
  29                             -1.318 GY   5.31
  29                             -1.143 GY   5.93
  29                             -0.967 GY   6.55
  29                             -0.791 GY   7.18
  29                             -0.615 GY   7.80
  29                             -0.439 GY   8.42
  29                             -0.264 GY   9.03
  29                             -0.088 GY   9.58
  19                             -0.088 GY   0.42
  19                             -0.264 GY   0.97
  19                             -0.439 GY   1.58
  19                             -0.615 GY   2.20
  19                             -0.791 GY   2.82
  19                             -0.967 GY   3.45
  19                             -1.143 GY   4.07
  19                             -1.318 GY   4.69
  19                             -1.318 GY   5.31
  19                             -1.143 GY   5.93
  19                             -0.967 GY   6.55
  19                             -0.791 GY   7.18
  19                             -0.615 GY   7.80
  19                             -0.439 GY   8.42
  19                             -0.264 GY   9.03
  19                             -0.088 GY   9.58
  27                             -0.088 GY   0.42
  27                             -0.264 GY   0.97
  27                             -0.439 GY   1.58
  27                             -0.615 GY   2.20
  27                             -0.791 GY   2.82
```

```
MEMBER LOAD - UNIT KIP  FEET
MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

  27                             -0.967 GY   3.45
  27                             -1.143 GY   4.07
  27                             -1.318 GY   4.69
  27                             -1.318 GY   5.31
  27                             -1.143 GY   5.93
  27                             -0.967 GY   6.55
  27                             -0.791 GY   7.18
  27                             -0.615 GY   7.80
  27                             -0.439 GY   8.42
  27                             -0.264 GY   9.03
  27                             -0.088 GY   9.58
  19                             -0.088 GY   0.42
  19                             -0.264 GY   0.97
  19                             -0.439 GY   1.58
  19                             -0.615 GY   2.20
  19                             -0.791 GY   2.82
  19                             -0.967 GY   3.45
  19                             -1.143 GY   4.07
  19                             -1.318 GY   4.69
  19                             -1.318 GY   5.31
  19                             -1.143 GY   5.93
  19                             -0.967 GY   6.55
  19                             -0.791 GY   7.18
  19                             -0.615 GY   7.80
  19                             -0.439 GY   8.42
  19                             -0.264 GY   9.03
  19                             -0.088 GY   9.58
  30                             -0.088 GY   0.42
  30                             -0.264 GY   0.97
  30                             -0.439 GY   1.58
  30                             -0.615 GY   2.20
  30                             -0.791 GY   2.82
  30                             -0.967 GY   3.45
  30                             -1.143 GY   4.07
  30                             -1.318 GY   4.69
  30                             -1.318 GY   5.31
  30                             -1.143 GY   5.93
  30                             -0.967 GY   6.55
  30                             -0.791 GY   7.18
  30                             -0.615 GY   7.80
  30                             -0.439 GY   8.42
  30                             -0.264 GY   9.03
  30                             -0.088 GY   9.58
  20                             -0.088 GY   0.42
  20                             -0.264 GY   0.97
  20                             -0.439 GY   1.58
  20                             -0.615 GY   2.20
  20                             -0.791 GY   2.82
  20                             -0.967 GY   3.45
  20                             -1.143 GY   4.07
  20                             -1.318 GY   4.69
  20                             -1.318 GY   5.31
  20                             -1.143 GY   5.93
  20                             -0.967 GY   6.55
  20                             -0.791 GY   7.18
  20                             -0.615 GY   7.80
  20                             -0.439 GY   8.42
  20                             -0.264 GY   9.03
  20                             -0.088 GY   9.58
  28                             -0.088 GY   0.42
  28                             -0.264 GY   0.97
  28                             -0.439 GY   1.58
  28                             -0.615 GY   2.20
  28                             -0.791 GY   2.82
  28                             -0.967 GY   3.45
  28                             -1.143 GY   4.07
  28                             -1.318 GY   4.69
  28                             -1.318 GY   5.31
  28                             -1.143 GY   5.93
  28                             -0.967 GY   6.55
  28                             -0.791 GY   7.18
  28                             -0.615 GY   7.80
  28                             -0.439 GY   8.42
```

```
MEMBER LOAD - UNIT KIP  FEET
MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

  28                              -0.264 GY   9.03
  28                              -0.088 GY   9.58
  18                              -0.059 GY   0.46
  18                              -0.177 GY   1.07
  18                              -0.295 GY   1.74
  18                              -0.414 GY   2.42
  18                              -0.532 GY   3.11
  18                              -0.650 GY   3.79
  18                              -0.768 GY   4.48
  18                              -0.886 GY   5.16
  18                              -0.886 GY   5.84
  18                              -0.768 GY   6.52
  18                              -0.650 GY   7.21
  18                              -0.532 GY   7.89
  18                              -0.414 GY   8.58
  18                              -0.295 GY   9.26
  18                              -0.177 GY   9.93
  18                              -0.059 GY  10.54
  31                              -0.059 GY   0.46
  31                              -0.177 GY   1.07
  31                              -0.295 GY   1.74
  31                              -0.414 GY   2.42
  31                              -0.532 GY   3.11
  31                              -0.650 GY   3.79
  31                              -0.768 GY   4.48
  31                              -0.886 GY   5.16
  31    -1.375 GY   5.50   14.50
  31                              -0.886 GY  14.84
  31                              -0.768 GY  15.52
  31                              -0.650 GY  16.21
  31                              -0.532 GY  16.89
  31                              -0.414 GY  17.58
  31                              -0.295 GY  18.26
  31                              -0.177 GY  18.93
  31                              -0.059 GY  19.54
  21                              -0.059 GY   0.46
  21                              -0.177 GY   1.07
  21                              -0.295 GY   1.74
  21                              -0.414 GY   2.42
  21                              -0.532 GY   3.11
  21                              -0.650 GY   3.79
  21                              -0.768 GY   4.48
  21                              -0.886 GY   5.16
  21                              -0.886 GY   5.84
  21                              -0.768 GY   6.52
  21                              -0.650 GY   7.21
  21                              -0.532 GY   7.89
  21                              -0.414 GY   8.58
  21                              -0.295 GY   9.26
  21                              -0.177 GY   9.93
  21                              -0.059 GY  10.54
  30                              -0.886 GY   4.84
  30                              -0.768 GY   5.52
  30                              -0.650 GY   6.21
  30                              -0.532 GY   6.89
  30                              -0.414 GY   7.58
  30                              -0.295 GY   8.26
  30                              -0.177 GY   8.93
  30                              -0.059 GY   9.54
  30    -1.375 GY   0.00    4.50
  29                              -0.059 GY   0.46
  29                              -0.177 GY   1.07
  29                              -0.295 GY   1.74
  29                              -0.414 GY   2.42
  29                              -0.532 GY   3.11
  29                              -0.650 GY   3.79
  29                              -0.768 GY   4.48
  29                              -0.886 GY   5.16
  29    -1.375 GY   5.50   10.00
```

```
MEMBER LOAD - UNIT KIP  FEET
MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

  22                             -0.049 GY   0.42
  22                             -0.146 GY   0.97
  22                             -0.244 GY   1.58
  22                             -0.342 GY   2.20
  22                             -0.439 GY   2.82
  22                             -0.537 GY   3.45
  22                             -0.635 GY   4.07
  22                             -0.732 GY   4.69
  22                             -0.732 GY   5.31
  22                             -0.635 GY   5.93
  22                             -0.537 GY   6.55
  22                             -0.439 GY   7.18
  22                             -0.342 GY   7.80
  22                             -0.244 GY   8.42
  22                             -0.146 GY   9.03
  22                             -0.049 GY   9.58
  34                             -0.049 GY   0.42
  34                             -0.146 GY   0.97
  34                             -0.244 GY   1.58
  34                             -0.342 GY   2.20
  34                             -0.439 GY   2.82
  34                             -0.537 GY   3.45
  34                             -0.635 GY   4.07
  34                             -0.732 GY   4.69
  34                             -0.732 GY   5.31
  34                             -0.635 GY   5.93
  34                             -0.537 GY   6.55
  34                             -0.439 GY   7.18
  34                             -0.342 GY   7.80
  34                             -0.244 GY   8.42
  34                             -0.146 GY   9.03
  34                             -0.049 GY   9.58
  24                             -0.049 GY   0.42
  24                             -0.146 GY   0.97
  24                             -0.244 GY   1.58
  24                             -0.342 GY   2.20
  24                             -0.439 GY   2.82
  24                             -0.537 GY   3.45
  24                             -0.635 GY   4.07
  24                             -0.732 GY   4.69
  24                             -0.732 GY   5.31
  24                             -0.635 GY   5.93
  24                             -0.537 GY   6.55
  24                             -0.439 GY   7.18
  24                             -0.342 GY   7.80
  24                             -0.244 GY   8.42
  24                             -0.146 GY   9.03
  24                             -0.049 GY   9.58
  32                             -0.049 GY   0.42
  32                             -0.146 GY   0.97
  32                             -0.244 GY   1.58
  32                             -0.342 GY   2.20
  32                             -0.439 GY   2.82
  32                             -0.537 GY   3.45
  32                             -0.635 GY   4.07
  32                             -0.732 GY   4.69
  32                             -0.732 GY   5.31
  32                             -0.635 GY   5.93
  32                             -0.537 GY   6.55
  32                             -0.439 GY   7.18
  32                             -0.342 GY   7.80
  32                             -0.244 GY   8.42
  32                             -0.146 GY   9.03
  32                             -0.049 GY   9.58
  23                             -0.059 GY   0.46
  23                             -0.177 GY   1.07
  23                             -0.295 GY   1.74
  23                             -0.414 GY   2.42
  23                             -0.532 GY   3.11
  23                             -0.650 GY   3.79
  23                             -0.768 GY   4.48
  23                             -0.886 GY   5.16
  23                             -0.886 GY   5.84
```

```
MEMBER LOAD - UNIT KIP  FEET
MEMBER     UDL      L1     L2      CON       L     LIN1     LIN2

  23                              -0.768 GY   6.52
  23                              -0.650 GY   7.21
  23                              -0.532 GY   7.89
  23                              -0.414 GY   8.58
  23                              -0.295 GY   9.26
  23                              -0.177 GY   9.93
  23                              -0.059 GY  10.54
  36                              -0.059 GY   0.46
  36                              -0.177 GY   1.07
  36                              -0.295 GY   1.74
  36                              -0.414 GY   2.42
  36                              -0.532 GY   3.11
  36                              -0.650 GY   3.79
  36                              -0.768 GY   4.48
  36                              -0.886 GY   5.16
  36    -1.375 GY   5.50   14.50
  36                              -0.886 GY  14.84
  36                              -0.768 GY  15.52
  36                              -0.650 GY  16.21
  36                              -0.532 GY  16.89
  36                              -0.414 GY  17.58
  36                              -0.295 GY  18.26
  36                              -0.177 GY  18.93
  36                              -0.059 GY  19.54
  26                              -0.059 GY   0.46
  26                              -0.177 GY   1.07
  26                              -0.295 GY   1.74
  26                              -0.414 GY   2.42
  26                              -0.532 GY   3.11
  26                              -0.650 GY   3.79
  26                              -0.768 GY   4.48
  26                              -0.886 GY   5.16
  26                              -0.886 GY   5.84
  26                              -0.768 GY   6.52
  26                              -0.650 GY   7.21
  26                              -0.532 GY   7.89
  26                              -0.414 GY   8.58
  26                              -0.295 GY   9.26
  26                              -0.177 GY   9.93
  26                              -0.059 GY  10.54
  35                              -0.886 GY   4.84
  35                              -0.768 GY   5.52
  35                              -0.650 GY   6.21
  35                              -0.532 GY   6.89
  35                              -0.414 GY   7.58
  35                              -0.295 GY   8.26
  35                              -0.177 GY   8.93
  35                              -0.059 GY   9.54
  35    -1.375 GY   0.00    4.50
  34                              -0.059 GY   0.46
  34                              -0.177 GY   1.07
  34                              -0.295 GY   1.74
  34                              -0.414 GY   2.42
  34                              -0.532 GY   3.11
  34                              -0.650 GY   3.79
  34                              -0.768 GY   4.48
  34                              -0.886 GY   5.16
  34    -1.375 GY   5.50   10.00
  24                              -0.049 GY   0.42
  24                              -0.146 GY   0.97
  24                              -0.244 GY   1.58
  24                              -0.342 GY   2.20
  24                              -0.439 GY   2.82
  24                              -0.537 GY   3.45
  24                              -0.635 GY   4.07
  24                              -0.732 GY   4.69
  24                              -0.732 GY   5.31
  24                              -0.635 GY   5.93
  24                              -0.537 GY   6.55
  24                              -0.439 GY   7.18
  24                              -0.342 GY   7.80
  24                              -0.244 GY   8.42
  24                              -0.146 GY   9.03
```

```
MEMBER LOAD - UNIT KIP  FEET
MEMBER     UDL      L1      L2      CON         L     LIN1     LIN2

  24                              -0.049 GY   9.58
  35                              -0.049 GY   0.42
  35                              -0.146 GY   0.97
  35                              -0.244 GY   1.58
  35                              -0.342 GY   2.20
  35                              -0.439 GY   2.82
  35                              -0.537 GY   3.45
  35                              -0.635 GY   4.07
  35                              -0.732 GY   4.69
  35                              -0.732 GY   5.31
  35                              -0.635 GY   5.93
  35                              -0.537 GY   6.55
  35                              -0.439 GY   7.18
  35                              -0.342 GY   7.80
  35                              -0.244 GY   8.42
  35                              -0.146 GY   9.03
  35                              -0.049 GY   9.58
  25                              -0.049 GY   0.42
  25                              -0.146 GY   0.97
  25                              -0.244 GY   1.58
  25                              -0.342 GY   2.20
  25                              -0.439 GY   2.82
  25                              -0.537 GY   3.45
  25                              -0.635 GY   4.07
  25                              -0.732 GY   4.69
  25                              -0.732 GY   5.31
  25                              -0.635 GY   5.93
  25                              -0.537 GY   6.55
  25                              -0.439 GY   7.18
  25                              -0.342 GY   7.80
  25                              -0.244 GY   8.42
  25                              -0.146 GY   9.03
  25                              -0.049 GY   9.58
  33                              -0.049 GY   0.42
  33                              -0.146 GY   0.97
  33                              -0.244 GY   1.58
  33                              -0.342 GY   2.20
  33                              -0.439 GY   2.82
  33                              -0.537 GY   3.45
  33                              -0.635 GY   4.07
  33                              -0.732 GY   4.69
  33                              -0.732 GY   5.31
  33                              -0.635 GY   5.93
  33                              -0.537 GY   6.55
  33                              -0.439 GY   7.18
  33                              -0.342 GY   7.80
  33                              -0.244 GY   8.42
  33                              -0.146 GY   9.03
  33                              -0.049 GY   9.58

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

```
 51. PRINT SUPPORT REACTION

SUPPORT REACTIONS -UNIT KIP  FEET    STRUCTURE TYPE = SPACE
-----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1     -9.35    -16.17      0.00      0.00     -0.01      0.00
         2      0.30     15.66      0.03      0.00      0.00      0.00
    2    1     -7.26      2.45      0.01      0.00      0.00      0.00
         2     -0.15     29.65      0.04      0.00      0.00      0.00
    3    1     -5.57     14.22      0.00      0.00      0.00      0.00
         2     -0.25     27.41      0.17      0.00      0.00      0.00
    4    1    -14.03    -19.32      0.00      0.00      0.00      0.00
         2      0.74     38.49      0.00      0.00      0.00      0.00
    5    1     -6.76     18.33      0.00      0.00      0.00      0.00
         2     -0.57     66.05      0.00      0.00      0.00      0.00
    6    1     -9.35    -16.17      0.00      0.00      0.01      0.00
         2      0.30     15.66     -0.03      0.00      0.00      0.00
    7    1     -7.26      2.45     -0.01      0.00      0.00      0.00
         2     -0.15     29.65     -0.04      0.00      0.00      0.00
    8    1     -5.57     14.22      0.00      0.00      0.00      0.00
         2     -0.25     27.41     -0.17      0.00      0.00      0.00


************** END OF LATEST ANALYSIS RESULT **************


 52. FINISH


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE=              TIME=          ****

      ************************************************************
      *         For questions on STAAD.Pro, please contact       *
      *   Research Engineers Offices at the following locations  *
      *                                                          *
      *              Telephone              Email                *
      *  USA:      +1 (714)974-2500       support@bentley.com    *
      *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
      *  UK        +44(1454)207-000       support@reel.co.uk     *
      *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
      *  GERMANY   +49/931/40468-71       info@reig.de           *
      *  NORWAY    +47 67 57 21 30        staad@edr.no           *
      *  SINGAPORE +65 6225-6158          support@bentley.com    *
      *  INDIA     +91(033)4006-2021      support@bentley.com    *
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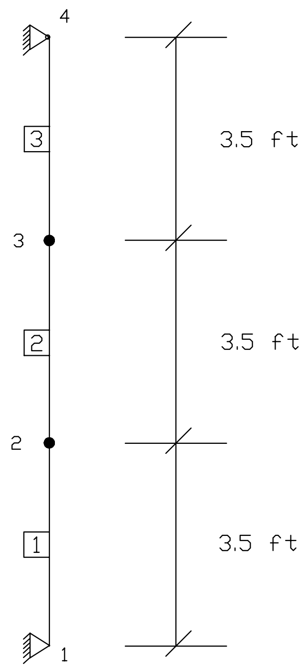
      *  CHINA     +86(411)363-1983       support@bentley.com    *
      *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
      *                                                          *
      *  North America                   support@bentley.com     *
      *  Europe                          support@bentley.com     *
      *  Asia                            support@bentley.com     *
      ************************************************************
```

NOTES

Example Problem No. 16

Dynamic Analysis (Time History) is performed for a 3 span beam with concentrated and distributed masses. The structure is subjected to "forcing function" and "ground motion" loading. The maxima of the joint displacements, member end forces and support reactions are determined.



STAAD PLANE EXAMPLE FOR TIME HISTORY ANALYSIS

Every input file has to start with the word STAAD. The word PLANE signifies that the structure is a plane frame.

UNITS FEET KIP

Specifies the units to be used for data to follow.

```
JOINT COORDINATES
1  0.0   0.0   0.0
2  0.0   3.5   0.0
3  0.0   7.0   0.0
4  0.0  10.5  0.0
```

Joint number followed by the X, Y and Z coordinates are specified above.

```
MEMBER INCIDENCES
1 1 2 3
```

Incidences of members 1 to 3 are specified above.

```
UNIT INCH
MEMBER PROPERTIES
1 2 3 PRIS AX 3.0 IZ 240.0
```

The PRISMATIC attribute is used for assigning properties for all the members. Since this is a PLANE frame, Area of cross section "AX", and Moment of Inertia "IZ" about the Z axis are adequate for the analysis.

```
SUPPORTS
1 4 PINNED
```

Pinned supports are located at nodes 1 and 4.

```
CONSTANTS
E 14000 ALL
DENSITY 0.0868E-3 ALL
POISSON CONCRETE ALL
```

The material constants defined include Young's Modulus "E", density and Poisson’s ratio.

```
DEFINE TIME HISTORY
TYPE 1 FORCE
0.0 -0.0001 0.5 0.0449 1.0 0.2244 1.5 0.2244 2.0 0.6731 2.5 -0.6731
TYPE 2 ACCELERATION
0.0 0.001 0.5 -7.721 1.0 -38.61 1.5 -38.61 2.0 -115.82 2.5 115.82
ARRIVAL TIMES
0.0
DAMPING 0.075
```

There are 2 stages in the command specification required for a time history analysis. The first stage is defined above. First, the characteristics of the time varying load are provided. The loading type may be a forcing function (vibrating machinery) or ground motion (earthquake). The former is input in the form of time-force pairs while the latter is in the form of time-acceleration pairs. Following this data, all possible arrival times for these loads on the structure as well as the modal damping ratio are specified. In this example, the damping ratio is the same (7.5%) for all modes.

```
UNIT FEET
LOAD 1 STATIC LOAD
MEMBER LOAD
1 2 3 UNI GX 0.5
```

Load case 1 above is a static load case. A uniformly distributed force of 0.5 kip/ft acts along the global X direction on all 3 members.

```
LOAD 2 TIME HISTORY LOAD
SELFWEIGHT X 1.0
SELFWEIGHT Y 1.0
JOINT LOAD
2 3 FX 2.5
TIME LOAD
2 3 FX 1 1
GROUND MOTION X 2 1
```

This is the second stage in the command specification for time history analysis. This involves the application of the time varying load on the structure. The masses that constitute the mass matrix of the structure are specified through the selfweight and joint load commands. The program will extract the lumped masses from these weights. Following that, both the "TIME LOAD" and "GROUND MOTION" are applied simultaneously. The user must note that this example is only for illustration purposes and that it may be unlikely that a "TIME FUNCTION" and a "GROUND MOTION" both act on the structure at the same time. The Time load command is used to apply the Type 1 force, acting in the global X direction, at arrival time number 1, at nodes 2 and 3. The Ground motion, namely, the Type 2 time history loading, is also in the global X direction at arrival time 1.

PERFORM ANALYSIS

The above command initiates the analysis process.

UNIT INCH
PRINT JOINT DISPLACEMENTS

During the analysis, the program calculates joint displacements for every time step. The absolute maximum value of the displacement for every joint is then extracted from this joint displacement history. So, the value printed using the above command is the absolute maximum value for each of the six degrees of freedom at each node.

UNIT FEET
PRINT MEMBER FORCES
PRINT SUPPORT REACTION

The member forces and support reactions too are calculated for every time step. For each degree of freedom, the maximum value of the member force and support reaction is extracted from these histories and reported in the output file using the above command.

FINISH

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************


    1. STAAD PLANE EXAMPLE FOR TIME HISTORY ANALYSIS
    2. UNITS FEET KIP
    3. JOINT COORDINATES
    4. 1  0.0   0.0  0.0
    5. 2  0.0   3.5  0.0
    6. 3  0.0   7.0  0.0
    7. 4  0.0  10.5  0.0
    8. MEMBER INCIDENCES
    9. 1 1 2 3
   10. UNIT INCH
   11. MEMBER PROPERTIES
   12. 1 2 3 PRIS AX 3.0 IZ 240.0
   13. SUPPORTS
   14. 1 4 PINNED
   15. CONSTANTS
   16. E 14000 ALL
   17. DENSITY 0.0868E-3 ALL
   18. POISSON CONCRETE ALL
   19. DEFINE TIME HISTORY
   20. TYPE 1 FORCE
   21. 0.0 -0.0001 0.5 0.0449 1.0 0.2244 1.5 0.2244 2.0 0.6731 2.5 -0.6731
   22. TYPE 2 ACCELERATION
   23. 0.0 0.001 0.5 -7.721 1.0 -38.61 1.5 -38.61 2.0 -115.82 2.5 115.82
   24. ARRIVAL TIMES
   25. 0.0
   26. DAMPING 0.075
   27. UNIT FEET
   28. LOAD 1 STATIC LOAD
   29. MEMBER LOAD
   30. 1 2 3 UNI GX 0.5
   31. LOAD 2 TIME HISTORY LOAD
   32. SELFWEIGHT X 1.0
   33. SELFWEIGHT Y 1.0
   34. JOINT LOAD
   35. 2 3 FX 2.5
   36. TIME LOAD
   37. 2 3 FX 1 1
   38. GROUND MOTION X 2 1
   39. PERFORM ANALYSIS

          P R O B L E M   S T A T I S T I C S
          -----------------------------------

    NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     4/     3/     2

          SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

    ORIGINAL/FINAL BAND-WIDTH=     1/     1/      6 DOF
    TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =      8
    SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
    REQRD/AVAIL. DISK SPACE  =     12.0/   3830.8 MB

MORE MODES WERE REQUESTED THAN THERE ARE FREE MASSES.
NUMBER OF MODES REQUESTED             =     6
NUMBER OF EXISTING MASSES IN THE MODEL =     4
NUMBER OF MODES THAT WILL BE USED      =     4
```

```
              CALCULATED FREQUENCIES FOR LOAD CASE       2

      MODE            FREQUENCY(CYCLES/SEC)         PERIOD(SEC)      ACCURACY


        1                       14.559                 0.06869       0.000E+00
        2                       56.387                 0.01773       3.745E-14
        3                      945.624                 0.00106       1.135E-08
        4                     1637.869                 0.00061       7.936E-08

                    MASS  PARTICIPATION FACTORS IN PERCENT
                    --------------------------------------

          MODE    X     Y     Z     SUMM-X   SUMM-Y   SUMM-Z

            1  100.00  0.00  0.00  100.000    0.000    0.000
            2    0.00  0.00  0.00  100.000    0.000    0.000
            3    0.00100.00  0.00  100.000  100.000    0.000
            4    0.00  0.00  0.00  100.000  100.000    0.000


   A C T U A L  MODAL  D A M P I N G  USED IN ANALYSIS

   MODE   DAMPING

      1    0.0750
      2    0.0750
      3    0.0750
      4    0.0750

  TIME STEP USED IN TIME HISTORY ANALYSIS = 0.00139 SECONDS
  NUMBER OF MODES WHOSE CONTRIBUTION IS CONSIDERED =   2
  WARNING-NUMBER OF MODES LIMITED TO A FREQUENCY OF   360.0 DUE TO THE DT VALUE
ENTERED.
  TIME DURATION OF TIME HISTORY ANALYSIS =    2.499 SECONDS
  NUMBER OF TIME STEPS IN THE SOLUTION PROCESS =    1799


  BASE SHEAR UNITS ARE -- KIP  FEET

  MAXIMUM BASE SHEAR  X=  -2.864822E+00  Y=   0.000000E+00  Z=   0.000000E+00
      AT TIMES              2.006944          0.000000          0.000000

   40. UNIT INCH
   41. PRINT JOINT DISPLACEMENTS

  JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = PLANE
  ------------------

 JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN


     1    1    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00103
          2    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00075
     2    1    0.03537   0.00000   0.00000   0.00000   0.00000  -0.00050
          2    0.02632   0.00000   0.00000   0.00000   0.00000  -0.00038
     3    1    0.03537   0.00000   0.00000   0.00000   0.00000   0.00050
          2    0.02632   0.00000   0.00000   0.00000   0.00000   0.00038
     4    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00103
          2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00075


  ************** END OF LATEST ANALYSIS RESULT **************


   42. UNIT FEET
   43. PRINT MEMBER FORCES
```

```
 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET     (LOCAL )

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z


    1    1     1      0.00      2.62     0.00      0.00      0.00       0.00
               2      0.00     -0.88     0.00      0.00      0.00       6.12
         2     1      0.00      1.43     0.00      0.00      0.00       0.00
               2      0.00     -1.43     0.00      0.00      0.00       5.01

    2    1     2      0.00      0.88     0.00      0.00      0.00      -6.12
               3      0.00      0.88     0.00      0.00      0.00       6.12
         2     2      0.00      0.00     0.00      0.00      0.00      -5.01
               3      0.00      0.00     0.00      0.00      0.00       5.01

    3    1     3      0.00     -0.88     0.00      0.00      0.00      -6.12
               4      0.00      2.62     0.00      0.00      0.00       0.00
         2     3      0.00     -1.43     0.00      0.00      0.00      -5.01
               4      0.00      1.43     0.00      0.00      0.00       0.00


 ************** END OF LATEST ANALYSIS RESULT **************


  44. PRINT SUPPORT REACTION


 SUPPORT REACTIONS -UNIT KIP  FEET    STRUCTURE TYPE = PLANE
 -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1     -2.62      0.00      0.00      0.00      0.00      0.00
         2     -1.43      0.00      0.00      0.00      0.00      0.00
    4    1     -2.62      0.00      0.00      0.00      0.00      0.00
         2     -1.43      0.00      0.00      0.00      0.00      0.00


 ************** END OF LATEST ANALYSIS RESULT **************


  45. FINISH
           *********** END OF THE STAAD.Pro RUN ***********

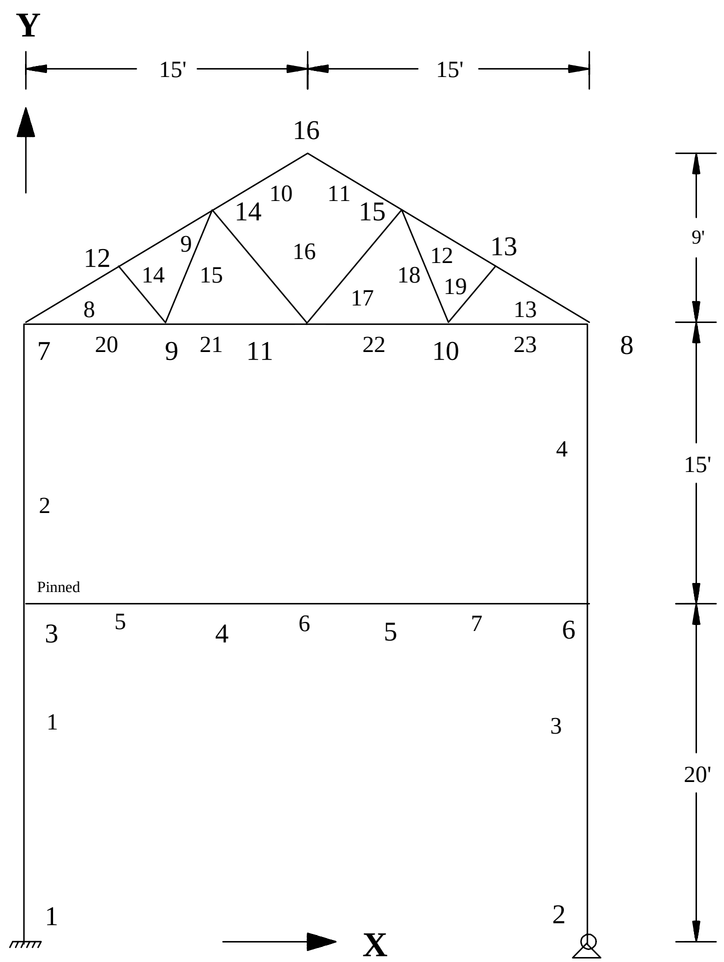
             **** DATE=              TIME=          ****

       ************************************************************
       *        For questions on STAAD.Pro, please contact        *
       *   Research Engineers Offices at the following locations  *
       *                                                          *
       *              Telephone               Email               *
       *  USA:      +1 (714)974-2500       support@bentley.com    *
       *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
       *  UK        +44(1454)207-000       support@reel.co.uk     *
       *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
       *  GERMANY   +49/931/40468-71       info@reig.de           *
       *  NORWAY    +47 67 57 21 30        staad@edr.no           *
       *  SINGAPORE +65 6225-6158          support@bentley.com    *
       *  INDIA     +91(033)4006-2021      support@bentley.com    *
       *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
       *  CHINA     +86(411)363-1983       support@bentley.com    *
       *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
       *                                                          *
       *  North America                   support@bentley.com     *
       *  Europe                          support@bentley.com     *
       *  Asia                            support@bentley.com     *
       ************************************************************
```

NOTES

Example Problem No. 17

The usage of User Provided Steel Tables is illustrated in this example for the analysis and design of a plane frame. User provided tables allow one to specify property data for sections not found in the built-in steel section tables.



Actual input is shown in bold lettering followed by explanation.

STAAD PLANE EXAMPLE FOR USER TABLE

Every input file has to start with the command STAAD. The PLANE command is used to designate the structure as a plane frame.

UNIT FT KIP

The UNIT command sets the length and force units to be used for data to follow.

JOINT COORDINATES
1 0. 0. ; 2 30 0 ; 3 0 20 0 6 30 20 0
7 0 35 ; 8 30 35 ; 9 7.5 35 ; 10 22.5 35.
11 15 35 ; 12 5. 38. ; 13 25 38 ; 14 10 41 ; 15 20 41
16 15 44

The above set of data is used to provide joint coordinates for the various joints of the structure. The cartesian system is being used here. The data consists of the joint number followed by global X and Y coordinates. Note that for a space frame, the Z coordinate(s) need to be provided also. In the above input, semicolon (;) signs are used as line separators. This allows the user to provide multiple sets of data on one line.

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

The above data set contains the member incidence information or the joint connectivity data for each member. This completes the geometry of the structure.

UNIT INCH
START USER TABLE

This command is utilized to set up a User Provided steel table. All user provided steel tables must start with this command.

TABLE 1

Each table needs a unique numerical identification. The above command starts setting up Table no. 1. Upto twenty tables may be specified per run.

WIDE FLANGE

This command is used to specify the section-type as WIDE FLANGE in this table. Note that several section-types (WIDE FLANGE, CHANNEL, ANGLE, TEE etc.) are available for specification (See section 5 of the Technical Reference Manual).

```
WFL14X30
8.85 13.84 .27 6.73 .385 291. 19.6 .38 4.0 4.1
WFL21X62
18.3 20.99 .4 8.24 .615 1330 57.5 1.83 0.84 7.0
WFL14X109
32. 14.32 .525 14.605 .86 1240 447 7.12 7.52 16.
```

The above data set is used to specify the properties of three wide flange sections. The data for each section consists of two parts. In the first line, the section-name is provided. The user is allowed to provide any section name within twelve characters. The second line contains the section properties required for the particular section-type. Each section-type requires a certain number of data (area of cross-section, depth, moment of inertias etc.) provided in a certain order. For example, in this case, for wide flanges, ten different properties are required. For detailed information on the various properties required for the different section-types and their order of specification, refer to Section 5.19 in the STAAD Technical Reference Manual. Without exception, all required properties for the particular section-type must be provided.

```
TABLE 2
ANGLES
LANG25255
2.5 2.5 .3125 .489 0 0
```

LANG40404
4 4 .25 .795 0 0

The above command and data lines set up another user provided table consisting of angle sections.

END

This command signifies the end of the user provided table data set. All user provided table related input must be terminated with this command.

MEMBER PROPERTIES
1 3 4 UPT 1 WFL14X109
2 UPT 1 WFL14X30 ; 5 6 7 UPT 1 WFL21X62
8 TO 13 UPT 1 WFL14X30
14 TO 23 UPT 2 LANG40404

In the above command lines, the member properties are being assigned from the user provided tables created earlier. The word UPT signifies that the properties are from the user provided table. This is followed by the table number and then the section name as specified in the user provided table. The numbers 1 or 2 following the word UPT indicate the table from which section names are fetched.

MEMBER TRUSS
14 TO 23

The above command is used to designate members 14 to 23 as truss members.

MEMBER RELEASE
5 START MZ

The MEMBER RELEASE command is used to release the MZ moment at the start joint of member no. 5.

UNIT INCH

This command resets the current length unit to inches.

```
CONSTANTS
E 29000. ALL
DEN 0.000283 ALL
POISSON STEEL ALL
BETA 90.0 MEMB 3 4
```

The above command set is used to specify modulus of elasticity, density, Poisson's ratio and beta angle values.

```
UNIT FT
```

The length unit is reset to feet using this command.

```
SUPPORT
1 FIXED ; 2 PINNED
```

The above command set is used to designate supports. Here, joint 1 is designated as a fixed support and joint 2 is designated as a pinned support.

```
LOADING 1 DEAD AND LIVE LOAD
SELFWEIGHT Y -1.0
JOINT LOAD
4 5 FY -15. ; 11 FY -35.
MEMB LOAD
8 TO 13 UNI Y -0.9 ; 6 UNI GY -1.2
```

The above command set is used to specify the loadings on the structure. In this case, dead and live loads are provided through load case 1. It consists of selfweight, concentrated loads at joints 4, 5 and 11, and distributed loads on members 6, and 8 to 13.

```
PERFORM ANALYSIS
```

This command instructs the program to execute the analysis at this point.

```
PARAMETER
CODE AISC
BEAM 1.0 ALL
NSF 0.85 ALL
```

KY 1.2 MEMB 3 4

The above commands are used to specify parameters for steel design.

SELECT MEMBER 3 6 9 19

This command will perform selection of members per the AISC ASD steel design code. For each member, the member selection will be performed from the table that was originally used for the specification of the member property. In this case, the selection will be from the respective user tables from which the properties were initially assigned. It may be noted that properties may be provided (and selection may be performed) from built-in steel tables and user provided tables in the same problem.

FINISH

This command terminates the STAAD run.

```
          ****************************************************
          *                                                  *
          *           STAAD.Pro                              *
          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
          *           Date=                                  *
          *           Time=                                  *
          *                                                  *
          *      USER ID:                                    *
          ****************************************************

 1. STAAD PLANE EXAMPLE FOR USER TABLE
 2. UNIT FT KIP
 3. JOINT COORDINATES
 4. 1 0. 0. ; 2 30 0 ; 3 0 20 0 6 30 20 0
 5. 7 0 35 ; 8 30 35 ; 9 7.5 35 ; 10 22.5 35.
 6. 11 15 35 ; 12 5. 38. ; 13 25 38 ; 14 10 41 ; 15 20 41
 7. 16 15 44
 8. MEMBER INCIDENCES
 9. 1 1 3 ; 2 3 7 ; 3 2 6 ; 4 6 8 ; 5 3 4
10. 6 4 5 ; 7 5 6 ; 8 7 12 ; 9 12 14
11. 10 14 16 ; 11 15 16 ; 12 13 15 ; 13 8 13
12. 14 9 12 ; 15 9 14 ; 16 11 14 ; 17 11 15
13. 18 10 15 ; 19 10 13 ; 20 7 9
14. 21 9 11 ; 22 10 11 ; 23 8 10
15. UNIT INCH
16. START USER TABLE
17. TABLE 1
18. WIDE FLANGE
19. WFL14X30
20. 8.85 13.84 .27 6.73 .385 291. 19.6 .38 4.0 4.1
21. WFL21X62
22. 18.3 20.99 .4 8.24 .615 1330 57.5 1.83 0.84 7.0
23. WFL14X109
24. 32. 14.32 .525 14.605 .86 1240 447 7.12 7.52 16.
25. TABLE 2
26. ANGLES
27. LANG25255
28. 2.5 2.5 .3125 .489 0 0
29. LANG40404
30. 4 4 .25 .795 0 0
31. END
32. MEMBER PROPERTIES
33. 1 3 4 UPT 1 WFL14X109
34. 2 UPT 1 WFL14X30 ; 5 6 7 UPT 1 WFL21X62
35. 8 TO 13 UPT 1 WFL14X30
36. 14 TO 23 UPT 2 LANG40404
37. MEMBER TRUSS
38. 14 TO 23
39. MEMBER RELEASE
40. 5 START MZ
41. UNIT INCH
42. CONSTANTS
43. E 29000 ALL
44. DEN 0.000283 ALL
45. POISSON STEEL ALL
46. BETA 90.0 MEMB 3 4
47. UNIT FT
48. SUPPORT
49. 1 FIXED ; 2 PINNED
50. LOADING 1 DEAD AND LIVE LOAD
51. SELFWEIGHT Y -1.0
52. JOINT LOAD
53. 4 5 FY -15. ; 11 FY -35.
54. MEMB LOAD
55. 8 TO 13 UNI Y -0.9 ; 6 UNI GY -1.2
56. PERFORM ANALYSIS
```

```
            P R O B L E M   S T A T I S T I C S
            -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    16/    23/     2
   ORIGINAL/FINAL BAND-WIDTH=     5/     4/     15 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     43
   SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =     12.0/  40262.3 MB


  ZERO STIFFNESS IN DIRECTION 6 AT JOINT      9 EQN.NO.      21
        LOADS APPLIED OR DISTRIBUTED HERE FROM ELEMENTS WILL BE IGNORED.
        THIS MAY BE DUE TO ALL MEMBERS AT THIS JOINT BEING RELEASED OR
        EFFECTIVELY RELEASED IN THIS DIRECTION.

  ZERO STIFFNESS IN DIRECTION 6 AT JOINT     11 EQN.NO.      31
  ZERO STIFFNESS IN DIRECTION 6 AT JOINT     10 EQN.NO.      37


  57. PARAMETER
  58. CODE AISC
  59. BEAM 1.0 ALL
  60. NSF 0.85 ALL
  61. KY 1.2 MEMB 3 4
  62. SELECT MEMB 3 6 9 19

                   STAAD.PRO MEMBER SELECTION - (AISC 9TH EDITION)
                   ***********************************************


ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)

MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                         FX            MY             MZ       LOCATION
=======================================================================

     3  ST   WFL14X109              (UPT)
                           PASS     AISC- H1-3        0.373         1
                       57.32 C      -35.68            0.00       20.00
     6  ST   WFL21X62               (UPT)
                           PASS     AISC- H2-1        0.845         1
                        3.81 T        0.00         -190.57        2.50
     9  ST   WFL14X30               (UPT)
                           PASS     AISC- H1-2        0.852         1
                       37.86 C        0.00          -54.46        5.83
    19  ST   LANG25255              (UPT)
                           PASS     AISC- H1-1        0.201         1
                        3.98 C        0.00            0.00        0.00
```

```
63. FINISH


*****************************************************************************
**WARNING** SOME MEMBER SIZES HAVE CHANGED SINCE LAST ANALYSIS.
            IN THE POST PROCESSOR, MEMBER QUERIES WILL USE THE LAST
            ANALYSIS FORCES WITH THE UPDATED MEMBER SIZES.
            TO CORRECT THIS INCONSISTENCY, PLEASE DO ONE MORE ANALYSIS.
            FROM THE UPPER MENU, PRESS RESULTS, UPDATE PROPERTIES, THEN
            FILE SAVE; THEN ANALYZE AGAIN WITHOUT THE GROUP OR SELECT
            COMMANDS.
*****************************************************************************


          *********** END OF THE STAAD.Pro RUN ***********

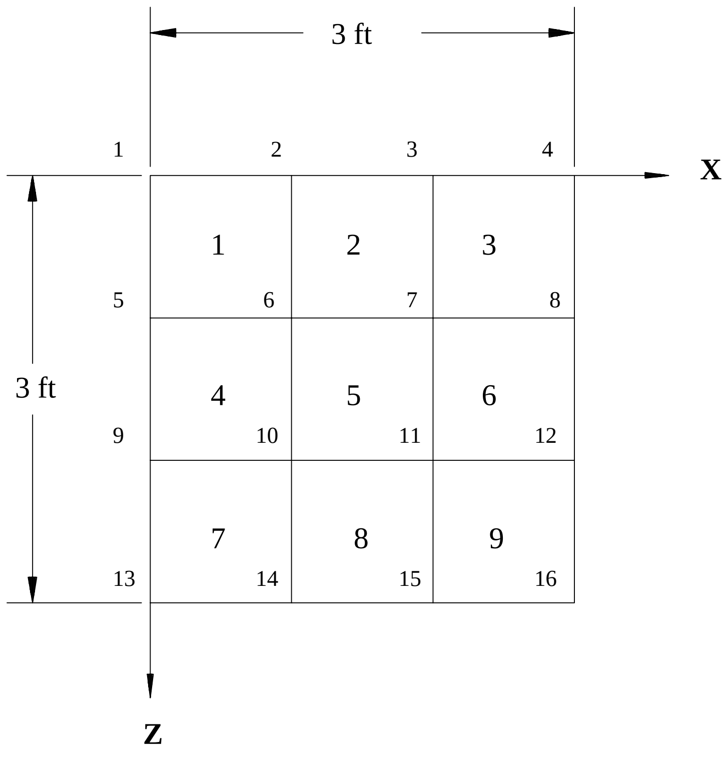
            **** DATE=            TIME=            ****

      ************************************************************
      *         For questions on STAAD.Pro, please contact       *
      *   Research Engineers Offices at the following locations  *
      *                                                          *
      *              Telephone                 Email             *
      *  USA:      +1 (714)974-2500      support@bentley.com    *
      *  CANADA    +1 (905)632-4771      detech@odandetech.com  *
      *  UK        +44(1454)207-000      support@reel.co.uk     *
      *  FRANCE    +33(0)1 64551084      support@reel.co.uk     *
      *  GERMANY   +49/931/40468-71      info@reig.de           *
      *  NORWAY    +47 67 57 21 30       staad@edr.no           *
      *  SINGAPORE +65 6225-6158         support@bentley.com    *
      *  INDIA     +91(033)4006-2021     support@bentley.com    *
      *  JAPAN     +81(03)5952-6500      eng-eye@crc.co.jp      *
      *  CHINA     +86(411)363-1983      support@bentley.com    *
      *  THAILAND  +66(0)2645-1018/19    support@bentley.com    *
      *                                                          *
      *  North America                  support@bentley.com     *
      *  Europe                         support@bentley.com     *
      *  Asia                           support@bentley.com     *
      ************************************************************
```

NOTES

Example Problem No. 18

This is an example which demonstrates the calculation of principal stresses on a finite element.



Fixed Supports at Joints 1, 2, 3, 4, 5, 9, 13
Load intensity = 1 pound/in^2 in negative global Y direction

Actual input is shown in bold lettering followed by explanation.

STAAD SPACE SAMPLE CALCULATION FOR
*** ELEMENT STRESSES**

Every input has to start with the word STAAD. The word SPACE signifies that the structure is a space frame (3-D structure).

UNIT KIP FEET

Specifies the unit to be used for data to follow.

JOINT COORDINATES
1 0 0 0 4 3 0 0
REPEAT 3 0 0 1

Joint number followed by X, Y and Z coordinates are provided above. The REPEAT command is used to generate coordinates of joints 5 to 16 based on the pattern of joints 1 to 4.

ELEMENT INCIDENCE
1 1 5 6 2 TO 3
REPEAT 2 3 4

Element connectivities of elements 1 to 3 are defined first, based on which, the connectivities of elements 4 to 9 are generated.

UNIT INCH
ELEMENT PROPERTIES
1 TO 9 THICK 1.0

Elements 1 to 9 have a thickness of 1 inch.

CONSTANTS
E CONCRETE ALL
POISSON CONCRETE ALL

Modulus of Elasticity and Poisson's ratio of all the elements is that of the built-in default value for concrete.

SUPPORT
1 TO 4 5 9 13 FIXED

"Fixed support" conditions exist at the above mentioned joints.

UNIT POUND
LOAD 1
ELEMENT LOAD
1 TO 9 PRESSURE -1.0

A uniform pressure of 1 pound/sq. in is applied on all the elements. In the absence of an explicit direction specification, the load is assumed to act along the local Z axis. The negative value indicates that the load acts opposite to the positive direction of the local Z.

PERFORM ANALYSIS

The above command instructs the program to proceed with the analysis.

PRINT SUPPORT REACTION

The above command is self-explanatory.

PRINT ELEMENT STRESSES LIST 4

Element stresses at the centroid of the element are printed using the above command. The output includes membrane stresses, shear stresses, bending moments per unit width and principal stresses.

FINISH

The STAAD run is terminated.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************


  1. STAAD SPACE SAMPLE CALCULATION FOR
  2. * ELEMENT STRESSES
  3. UNIT KIP FEET
  4. JOINT COORDINATES
  5. 1 0 0 0 4 3 0 0
  6. REPEAT 3 0 0 1
  7. ELEMENT INCIDENCE
  8. 1 1 5 6 2 TO 3
  9. REPEAT 2 3 4
 10. UNIT INCH
 11. ELEMENT PROPERTIES
 12. 1 TO 9 THICK 1.0
 13. CONSTANTS
 14. E CONCRETE ALL
 15. POISSON CONCRETE ALL
 16. SUPPORT
 17. 1 TO 4 5 9 13 FIXED
 18. UNIT POUND
 19. LOAD 1
 20. ELEMENT LOAD
 21. 1 TO 9 PRESSURE -1.0
 22. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    16/     9/     7
  ORIGINAL/FINAL BAND-WIDTH=     5/     5/     36 DOF
  TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     96
  SIZE OF STIFFNESS MATRIX =        4 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.1/  40262.2 MB


 23. PRINT SUPPORT REACTION

SUPPORT REACTIONS -UNIT POUN INCH    STRUCTURE TYPE = SPACE
-----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z


    1    1      0.00     -9.76      0.00    -12.51      0.00     12.51
    2    1      0.00     70.14      0.00   -853.81      0.00    -16.81
    3    1      0.00    301.41      0.00  -2821.43      0.00     95.50
    4    1      0.00    281.33      0.00  -2127.22      0.00   -769.09
    5    1      0.00     70.14      0.00     16.81      0.00    853.81
    9    1      0.00    301.41      0.00    -95.50      0.00   2821.43
   13    1      0.00    281.33      0.00    769.09      0.00   2127.22


************** END OF LATEST ANALYSIS RESULT **************
```

```
  24. PRINT ELEMENT STRESSES LIST 4

 ELEMENT STRESSES    FORCE,LENGTH UNITS= POUN INCH
 ----------------

          STRESS = FORCE/UNIT WIDTH/THICK, MOMENT = FORCE-LENGTH/UNIT WIDTH

ELEMENT  LOAD       SQX        SQY          MX          MY          MXY
                    VONT       VONB         SX          SY          SXY
                    TRESCAT    TRESCAB


    4      1       10.43      -9.94       16.90       85.81        36.43
                  605.39     605.39        0.00        0.00         0.00
                  608.99     608.99
     TOP :  SMAX=   608.99  SMIN=     7.25  TMAX=   300.87  ANGLE= -23.3
     BOTT:  SMAX=    -7.25  SMIN=  -608.99  TMAX=   300.87  ANGLE= -23.3


        **** MAXIMUM STRESSES AMONG SELECTED PLATES AND CASES ****
           MAXIMUM       MINIMUM       MAXIMUM       MAXIMUM       MAXIMUM
          PRINCIPAL     PRINCIPAL       SHEAR       VONMISES       TRESCA
           STRESS        STRESS        STRESS        STRESS        STRESS

        6.089873E+02 -6.089873E+02  3.008685E+02  6.053947E+02  6.089873E+02
PLATE NO.       4             4             4             4             4
CASE  NO.       1             1             1             1             1


 ********************END OF ELEMENT FORCES********************


  25. FINISH


           *********** END OF THE STAAD.Pro RUN ***********

             **** DATE=              TIME=           ****

       ************************************************************
       *         For questions on STAAD.Pro, please contact       *
       *   Research Engineers Offices at the following locations  *
       *                                                          *
       *              Telephone                 Email             *
       *  USA:      +1 (714)974-2500       support@bentley.com    *
       *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
       *  UK        +44(1454)207-000       support@reel.co.uk     *
       *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
       *  GERMANY   +49/931/40468-71       info@reig.de           *
       *  NORWAY    +47 67 57 21 30        staad@edr.no           *
       *  SINGAPORE +65 6225-6158          support@bentley.com    *
       *  INDIA     +91(033)4006-2021      support@bentley.com    *
       *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
       *  CHINA     +86(411)363-1983       support@bentley.com    *
       *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
       *                                                          *
       *  North America                   support@bentley.com     *
       *  Europe                          support@bentley.com     *
       *  Asia                            support@bentley.com     *
       ************************************************************
```

Calculation of principal stresses for element 4

Calculations are presented for the top surface only.

SX = 0.0 pound/inch^2
SY = 0.0 pound/inch^2
SXY = 0.0 pound/inch^2
MX = 16.90 pound-inch/inch
MY = 85.81 pound-inch/inch
MXY = 36.43 pound-inch/inch
S = 1/6t^2 = 1/6*1^2 = 0.1667 in^2 (Section Modulus)

$$\sigma x = SX + \frac{MX}{S} = 0.0 + \frac{16.90}{0.1667}$$

= 101.38 pounds/in^2

$$\sigma y = SY + \frac{MY}{S} = 0.0 + \frac{85.81}{0.1667}$$

= 514.75 pounds/in^2

$$\tau xy = SXY + \frac{MXY}{S} = 0.0 + \frac{36.43}{0.1667}$$

= 218.54 pounds/in^2

$$TMAX = \sqrt{\frac{(\sigma_x - \sigma_y)^2}{4} + \tau_{xy}^2}$$

$$TMAX = \sqrt{\frac{(101.38 - 514.75)^2}{4} + 218.54^2}$$

= 300.80 pounds/in^2

$$\text{SMAX} = \frac{(\sigma_x + \sigma_y)}{2} + \text{TMAX}$$

$$= \frac{(101.38 + 514.75)}{2} + 300.80$$

$$= 608.87 \text{ pounds/in}^2$$

$$\text{SMIN} = \frac{(\sigma_x + \sigma_y)}{2} - \text{TMAX}$$

$$= \frac{(101.38 + 514.75)}{2} - 300.80$$

$$= 7.27 \text{ pounds/in}^2$$

$$\text{Angle} = \frac{1}{2}\tan^{-1}\left\{\frac{2\tau_{xy}}{\sigma_x - \sigma_y}\right\}$$

$$= \frac{1}{2}\tan^{-1}\left\{\frac{2 * 218.54}{101.38 - 514.75}\right\}$$

$$= -23.30^{\circ}$$

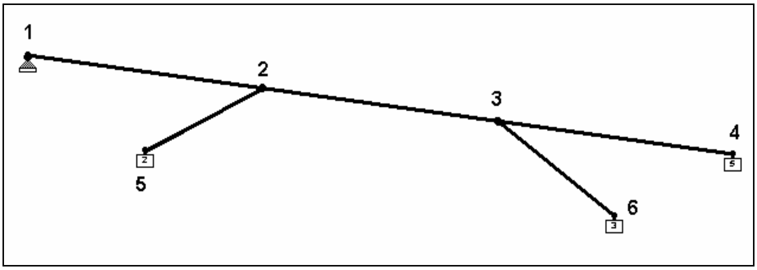
$$\text{VONT} = 0.707\sqrt{(\text{SMAX} - \text{SMIN})^2 + (\text{SMAX})^2 + (\text{SMIN})^2}$$

$$= 605.176 \text{ psi}$$

NOTES

Example Problem No. 19

This example demonstrates the usage of inclined supports. The word INCLINED refers to the fact that the restraints at a joint where such a support is specified are along a user-specified axis system instead of along the default directions of the global axis system. STAAD offers a few different methods for assigning inclined supports, and we examine those in this example.



Actual input is shown in bold lettering followed by explanation.

STAAD SPACE
INPUT WIDTH 79

Every input has to start with the word STAAD. The word SPACE signifies that the structure is a space frame structure (3-D) and the geometry is defined through X, Y and Z coordinates.

UNIT METER KN

Specifies the unit to be used for data to follow.

JOINT COORDINATES
1 0 5 0; 2 10 5 10; 3 20 5 20; 4 30 5 30; 5 5 0 5; 6 25 0 25;

Joint number followed by X, Y and Z coordinates are provided above. Semicolon signs (;) are used as line separators. That enables us to provide multiple sets of data on one line.

MEMBER INCIDENCES
1 1 2; 2 2 3; 3 3 4; 4 5 2; 5 6 3;

Defines the members by the joints they are connected to.

UNIT MMS KN
MEMBER PROPERTY AMERICAN
4 5 PRIS YD 800
1 TO 3 PRIS YD 750 ZD 500

Properties for all members of the model are provided using the PRISMATIC option. YD and ZD stand for depth and width. If ZD is not provided, a circular shape with diameter = YD is assumed for that cross section. All properties required for the analysis, such as, Area, Moments of Inertia, etc. are calculated automatically from these dimensions unless these are explicitly defined. The values are provided in MMS unit.

```
CONSTANTS
E CONCRETE ALL
POISSON CONCRETE ALL
DENSITY CONCRETE ALL
```

Material constants like E (modulus of elasticity) and Poisson's ratio are specified following the command CONSTANTS.

```
UNIT METER KN
SUPPORTS
5 INCLINED REF 10 5 10 FIXED BUT MX MY MZ KFX 30000
6 INCLINED REFJT 3 FIXED BUT MX MY MZ KFX 30000
1 PINNED
4 INCLINED 1 0 1 FIXED BUT FX MX MY MZ
```

We assign supports (restraints) at 4 nodes - 5, 6, 1 and 4. For 3 of those, namely, 5, 6 and 4, the node number is followed by the keyword INCLINED, signifying that an INCLINED support is defined there. For the remaining one - node 1 - that keyword is missing. Hence, the support at node 1 is a global direction support.

The most important aspect of inclined supports is their axis system. Each node where an inclined support is defined has its own distinct local X, local Y and local Z axes. In order to define the axis system, we first have to define a datum point. The support node and the datum point together help define the axis system.

3 different methods are shown in the above 3 instances for defining the datum point.

At node 5, notice the keyword REF followed by the numbers (10,5,10). This means that the datum point associated with node 5 is one which has the global coordinates of (10m, 5m, 10m). Coincidentally, this happens to be node 2.

At node 6, the keyword REFJT is used followed by the number 3. This means that the datum point for support node 6 is the joint number 3 of the model. The coordinates of the datum point are hence those of node 3, namely, (20m, 5m and 20m).

At node 4, the word INCLINED is merely followed by 3 numbers (1,0,1). In the absence of the words REF and REFJT, the program sets the datum point to be the following. It takes the coordinates of node 4, which are (30m,5m,30m) and adds to them, the 3 numbers which comes after the word INCLINED. Thus, the datum point becomes (31m, 5m and 31m).

Once the datum point is established, the local axis system is defined as follows. Local X is a straight line (vector) pointing from the support node towards the datum point. Local Z is the vector obtained by the cross product of local X and the global Y axis (unless the SET Z UP command is used in which case one would use global Z instead of global Y and that would yield local Y). Local Y is the vector resulting from the cross product of local Z and local X. The right hand rule must be used when performing these cross products.

Notice the unique nature of these datum points. The one for node 5 tells us that a line connecting nodes 5 to 2 is the local X axis, and is hence along the axis of member 4. By defining a KFX spring at that one, we are saying that the lower end of member 4 can move along its axis like the piston of a car engine. Think of a pile bored into rock with a certain amount of freedom to expand and contract axially.

The same is true for the support at the bottom of member 5. The local X axis of that support is along the axis of member 5. That also happens to be the case for the supported end of member 3. The line going from node 4 to the datum point (31,5,31) happens to be coincident with the axis of the member, or the traffic direction. The expression FIXED BUT FX MX MY MZ for that support indicates that it is free to translate along local X, suggesting that it is an expansion joint - free to expand or contract along the axis of member 3.

Since MX, MY and MZ are all released at these supports, no moment will be resisted by these supports.

```
LOAD 1 DEAD LOAD
SELFWEIGHT Y -1.2

LOAD 2 LIVE LOAD
MEMBER LOAD
1 TO 3 UNI GY -6

LOAD COMB 3
1 1.0 2 1.0
PERFORM ANALYSIS PRINT STATICS CHECK
```

3 load cases followed by the instruction for the type of analysis are specified. The PRINT STATICS CHECK option will instruct the program to produce a report consisting of total applied load versus total reactions from the supports for each primary load case.

```
PRINT SUPPORT REACTION
```

By default, support reactions are printed in the global axis directions. The above command is an instruction for such a report.

```
SET INCLINED REACTION
PRINT SUPPORT REACTION
```

Just earlier, we saw how to obtain support reactions in the global axis system. What if we need them in the inclined axis system? The “SET INCLINED REACTION” is a switch for that purpose. It tells the program that reactions should be reported in the inclined axis system instead of the global axis system. This has to be followed by the PRINT SUPPORT REACTIONS command.

```
PRINT MEMBER FORCES
PRINT JOINT DISP
FINISH
```

Member forces are reported in the local axis system of the members. Joint displacements at all joints are reported in the global axis system. Following this, the STAAD run is terminated.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

  1. STAAD SPACE
  2. INPUT WIDTH 79
  3. UNIT METER KN
  4. JOINT COORDINATES
  5. 1 0 5 0; 2 10 5 10; 3 20 5 20; 4 30 5 30; 5 5 0 5; 6 25 0 25
  6. MEMBER INCIDENCES
  7. 1 1 2; 2 2 3; 3 3 4; 4 5 2; 5 6 3
  8. UNIT MMS KN
  9. MEMBER PROPERTY AMERICAN
 10. 4 5 PRIS YD 800
 11. 1 TO 3 PRIS YD 750 ZD 500
 12. CONSTANTS
 13. E CONCRETE ALL
 14. POISSON CONCRETE ALL
 15. DENSITY CONCRETE ALL
 16. UNIT METER KN
 17. SUPPORTS
 18. 5 INC REF 10 5 10 FIXED BUT MX MY MZ KFX 30000
 19. 6 INC REFJT 3 FIXED BUT MX MY MZ KFX 30000
 20. 1 PINNED
 21. 4 INC 1 0 1FIXED BUT FX MX MY MZ
 22. LOAD 1 DEAD LOAD
 23. SELFWEIGHT Y -1.2
 24. LOAD 2 LIVE LOAD
 25. MEMBER LOAD
 26. 1 TO 3 UNI GY -6
 27. LOAD COMB 3
 28. 1 1.0 2 1.0
 29. PERFORM ANALYSIS PRINT STATICS CHECK


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     6/     5/     4
  ORIGINAL/FINAL BAND-WIDTH=     3/     3/     20 DOF
  TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =     27
  SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.0/  40262.2 MB

       STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     1
       DEAD LOAD


***TOTAL APPLIED LOAD ( KN   METE ) SUMMARY (LOADING    1 )
    SUMMATION FORCE-X =        0.00
    SUMMATION FORCE-Y =     -696.00
    SUMMATION FORCE-Z =        0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=       10439.93  MY=           0.00  MZ=      -10439.93


***TOTAL REACTION LOAD( KN   METE ) SUMMARY (LOADING     1 )
    SUMMATION FORCE-X =        0.00
    SUMMATION FORCE-Y =      696.00
    SUMMATION FORCE-Z =        0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=      -10439.93  MY=           0.00  MZ=       10439.93
```

```
 MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      1)
           MAXIMUMS    AT NODE
    X = -7.99237E-01       5
    Y = -2.49498E+00       3
    Z = -7.99237E-01       5
    RX= -2.66161E-03       4
    RY= -9.86155E-16       4
    RZ=  2.66161E-03       4


        STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     2
        LIVE LOAD


 ***TOTAL APPLIED LOAD ( KN   METE ) SUMMARY (LOADING    2 )
     SUMMATION FORCE-X =        0.00
     SUMMATION FORCE-Y =     -254.56
     SUMMATION FORCE-Z =        0.00

    SUMMATION OF MOMENTS AROUND THE ORIGIN-
    MX=        3818.38  MY=           0.00  MZ=       -3818.38


 ***TOTAL REACTION LOAD( KN   METE ) SUMMARY (LOADING     2 )
     SUMMATION FORCE-X =        0.00
     SUMMATION FORCE-Y =      254.56
     SUMMATION FORCE-Z =        0.00

    SUMMATION OF MOMENTS AROUND THE ORIGIN-
    MX=       -3818.38  MY=           0.00  MZ=        3818.38


 MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      2)
           MAXIMUMS    AT NODE
    X = -2.97411E-01       5
    Y = -9.31566E-01       3
    Z = -2.97411E-01       5
    RX= -1.18888E-03       4
    RY= -3.64127E-16       4
    RZ=  1.18888E-03       4


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


  30. PRINT SUPPORT REACTION


 SUPPORT REACTIONS -UNIT KN   METE    STRUCTURE TYPE = SPACE
 -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    5    1    215.36    288.60    215.36      0.00      0.00      0.00
         2     86.45     94.77     86.45      0.00      0.00      0.00
         3    301.81    383.37    301.81      0.00      0.00      0.00
    6    1   -212.20    286.84   -212.20      0.00      0.00      0.00
         2    -85.19     94.06    -85.19      0.00      0.00      0.00
         3   -297.39    380.91   -297.39      0.00      0.00      0.00
    1    1     -3.15     60.21     -3.15      0.00      0.00      0.00
         2     -1.27     32.84     -1.27      0.00      0.00      0.00
         3     -4.42     93.05     -4.42      0.00      0.00      0.00
    4    1      0.00     60.33      0.00      0.00      0.00      0.00
         2      0.00     32.89      0.00      0.00      0.00      0.00
         3      0.00     93.22      0.00      0.00      0.00      0.00


 ************** END OF LATEST ANALYSIS RESULT **************


  31. SET INCLINED REACTION
  32. PRINT SUPPORT REACTION
```

```
 SUPPORT REACTIONS -UNIT KN   METE    STRUCTURE TYPE = SPACE
 -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    5    1    415.30     59.81      0.00      0.00      0.00      0.00
         2    154.54      6.79      0.00      0.00      0.00      0.00
         3    569.83     66.60      0.00      0.00      0.00      0.00
    6    1    410.64     60.94      0.00      0.00      0.00      0.00
         2    152.67      7.25      0.00      0.00      0.00      0.00
         3    563.31     68.19      0.00      0.00      0.00      0.00
    1    1     -3.15     60.21     -3.15      0.00      0.00      0.00
         2     -1.27     32.84     -1.27      0.00      0.00      0.00
         3     -4.42     93.05     -4.42      0.00      0.00      0.00
    4    1      0.00     60.33      0.00      0.00      0.00      0.00
         2      0.00     32.89      0.00      0.00      0.00      0.00
         3      0.00     93.22      0.00      0.00      0.00      0.00


 ************** END OF LATEST ANALYSIS RESULT **************


  33. PRINT MEMBER FORCES


 MEMBER END FORCES    STRUCTURE TYPE = SPACE
 -----------------
 ALL UNITS ARE -- KN   METE

 MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

     1     1    1     -4.46     60.21     0.00      0.00      0.00       0.00
                2      4.46     89.73     0.00      0.00      0.00    -208.74
           2    1     -1.79     32.84     0.00      0.00      0.00       0.00
                2      1.79     52.01     0.00      0.00      0.00    -135.58
           3    1     -6.25     93.05     0.00      0.00      0.00       0.00
                2      6.25    141.75     0.00      0.00      0.00    -344.32

     2     1    2    300.10     75.79     0.00      0.00      0.00     125.95
                3   -300.10     74.15     0.00      0.00      0.00    -114.37
           2    2    120.47     42.75     0.00      0.00      0.00      76.77
                3   -120.47     42.10     0.00      0.00      0.00     -72.12
           3    2    420.57    118.55     0.00      0.00      0.00     202.71
                3   -420.57    116.25     0.00      0.00      0.00    -186.49

     3     1    3      0.00     89.61     0.00      0.00      0.00     207.02
                4      0.00     60.33     0.00      0.00      0.00       0.00
           2    3      0.00     51.96     0.00      0.00      0.00     134.89
                4      0.00     32.89     0.00      0.00      0.00       0.00
           3    3      0.00    141.58     0.00      0.00      0.00     341.90
                4      0.00     93.22     0.00      0.00      0.00       0.00

     4     1    5    415.30     59.81     0.00      0.00      0.00       0.00
                2   -344.24     40.69     0.00      0.00      0.00      82.79
           2    5    154.54      6.79     0.00      0.00      0.00       0.00
                2   -154.54     -6.79     0.00      0.00      0.00      58.81
           3    5    569.83     66.60     0.00      0.00      0.00       0.00
                2   -498.77     33.90     0.00      0.00      0.00     141.61

     5     1    6    410.64     60.94     0.00      0.00      0.00       0.00
                3   -339.58     39.55     0.00      0.00      0.00      92.64
           2    6    152.67      7.25     0.00      0.00      0.00       0.00
                3   -152.67     -7.25     0.00      0.00      0.00      62.77
           3    6    563.31     68.19     0.00      0.00      0.00       0.00
                3   -492.25     32.30     0.00      0.00      0.00     155.41


 ************** END OF LATEST ANALYSIS RESULT **************


  34. PRINT JOINT DISP
```

```
 JOINT DISPLACEMENT (CM   RADIANS)    STRUCTURE TYPE = SPACE
 ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

     1    1     0.0000    0.0000    0.0000    0.0026    0.0000   -0.0026
          2     0.0000    0.0000    0.0000    0.0012    0.0000   -0.0012
          3     0.0000    0.0000    0.0000    0.0038    0.0000   -0.0038
     2    1     0.0005   -2.4510    0.0005    0.0007    0.0000   -0.0007
          2     0.0002   -0.9139    0.0002    0.0003    0.0000   -0.0003
          3     0.0008   -3.3649    0.0008    0.0011    0.0000   -0.0011
     3    1    -0.0363   -2.4950   -0.0363   -0.0007    0.0000    0.0007
          2    -0.0146   -0.9316   -0.0146   -0.0003    0.0000    0.0003
          3    -0.0509   -3.4265   -0.0509   -0.0011    0.0000    0.0011
     4    1    -0.0363    0.0000   -0.0363   -0.0027    0.0000    0.0027
          2    -0.0146    0.0000   -0.0146   -0.0012    0.0000    0.0012
          3    -0.0509    0.0000   -0.0509   -0.0039    0.0000    0.0039
     5    1    -0.7992   -0.7992   -0.7992    0.0023    0.0000   -0.0023
          2    -0.2974   -0.2974   -0.2974    0.0007    0.0000   -0.0007
          3    -1.0966   -1.0966   -1.0966    0.0031    0.0000   -0.0031
     6    1     0.7903   -0.7903    0.7903   -0.0024    0.0000    0.0024
          2     0.2938   -0.2938    0.2938   -0.0008    0.0000    0.0008
          3     1.0841   -1.0841    1.0841   -0.0032    0.0000    0.0032


 ************** END OF LATEST ANALYSIS RESULT **************


  35. FINISH


           *********** END OF THE STAADD.Pro RUN ***********

             **** DATE=             TIME=           ****


       ************************************************************
       *          For questions on STAAD.Pro, please contact        *
       *   Research Engineers Offices at the following locations  *
       *                                                          *
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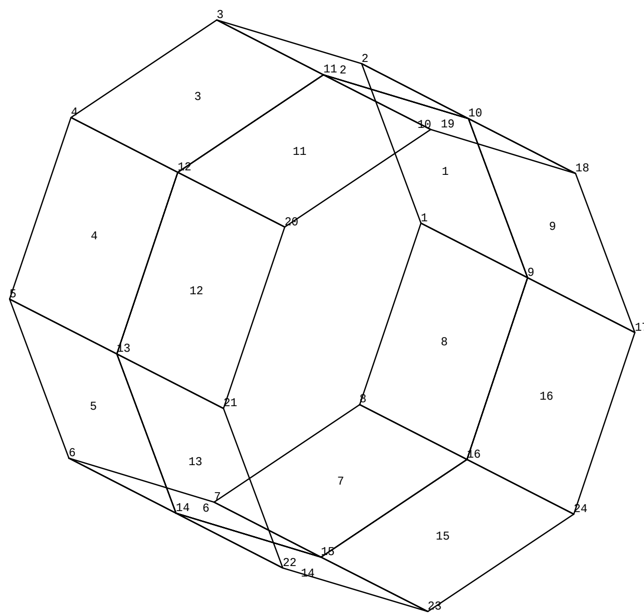
       *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
       *  UK        +44(1454)207-000       support@reel.co.uk     *
       *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
       *  GERMANY   +49/931/40468-71       info@reig.de           *
       *  NORWAY    +47 67 57 21 30        staad@edr.no           *
       *  SINGAPORE +65 6225-6158          support@bentley.com    *
       *  INDIA     +91(033)4006-2021      support@bentley.com    *
       *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
       *  CHINA     +86(411)363-1983       support@bentley.com    *
       *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
       *                                                          *
       *  North America                   support@bentley.com     *
       *  Europe                          support@bentley.com     *
       *  Asia                            support@bentley.com     *
       ************************************************************
```

NOTES

Example Problem No. 20

This example generates the geometry of a cylindrical tank structure using the cylindrical coordinate system. The tank lies on its side in this example.



In this example, a cylindrical tank is modeled using finite elements. The radial direction is in the XY plane and longitudinal direction is along the Z-axis. Hence, the coordinates in the XY plane are generated using the cylindrical coordinate system.

```
STAAD SPACE
UNIT KIP FEET
```

The type of structure (SPACE frame) and length and force units for data to follow are specified.

```
JOINT COORD CYLINDRICAL
```

The above command instructs the program that the coordinate data that follows is in the cylindrical coordinate system (r,theta,z).

```
1 10 0 0 8 10 315 0
```

Joint 1 has an 'r' of 10 feet, theta of 0 degrees and Z of 0 ft. Joint 8 has an 'r' of 10 feet, theta of 315 degrees and Z of 0 ft. The 315 degrees angle is measured counter-clockwise from the +ve direction of the X-axis. Joints 2 to 7 are generated by equal incrementation the coordinate values between joints 1 and 8.

```
REPEAT 2 0 0 8.5
```

The REPEAT command is used to generate joints 9 through 24 by repeating twice, the pattern of joints 1 to 8 at Z-increments of 8.5 feet for each REPEAT.

```
PRINT JOINT COORD
```

The above command is used to produce a report consisting of the coordinates of all the joints in the cartesian coordinate system. Note that even though the input data was in the cylindrical coordinate system, the output is in the cartesian coordinate system.

```
ELEMENT INCIDENCES
1 1 2 10 9 TO 7 1 1
8 8 1 9 16
REPEAT ALL 1 8 8
```

The above 4 lines identify the element incidences of all 16 elements. Incidences of element 1 is defined as 1 2 10 9. Incidences of element 2 is generated by incrementing the joint numbers of element 1 by 1, incidences of element 3 is generated by incrementing the incidences of element 2 by 1 and so on upto element 7. Incidences of element 8 has been defined above as 8 1 9 16. The REPEAT ALL command states that the pattern of ALL the elements defined by the previous 2 lines, namely elements 1 to 8, must be REPEATED once with an element number increment of 8 and a joint number increment of 8 to generate elements 9 through 16.

PRINT ELEMENT INFO

The above command is self-explanatory.

FINISH

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

  1. STAAD SPACE
  2. UNIT KIP FEET
  3. JOINT COORD CYLINDRICAL
  4. 1 10 0 0 8 10 315 0
  5. REPEAT 2 0 0 8.5
  6. PRINT JOINT COORD

JOINT COORDINATES
-----------------
COORDINATES ARE FEET UNIT

JOINT            X               Y               Z


    1          10.000           0.000           0.000
    2           7.071           7.071           0.000
    3           0.000          10.000           0.000
    4          -7.071           7.071           0.000
    5         -10.000           0.000           0.000
    6          -7.071          -7.071           0.000
    7           0.000         -10.000           0.000
    8           7.071          -7.071           0.000
    9          10.000           0.000           8.500
   10           7.071           7.071           8.500
   11           0.000          10.000           8.500
   12          -7.071           7.071           8.500
   13         -10.000           0.000           8.500
   14          -7.071          -7.071           8.500
   15           0.000         -10.000           8.500
   16           7.071          -7.071           8.500
   17          10.000           0.000          17.000
   18           7.071           7.071          17.000
   19           0.000          10.000          17.000
   20          -7.071           7.071          17.000
   21         -10.000           0.000          17.000
   22          -7.071          -7.071          17.000
   23           0.000         -10.000          17.000
   24           7.071          -7.071          17.000


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


  7. ELEMENT INCIDENCES
  8. 1 1 2 10 9 TO 7 1 1
  9. 8 8 1 9 16
 10. REPEAT ALL 1 8 8
```

```
 11. PRINT ELEMENT INFO

ELEMENT INFORMATION
-------------------

ELEMENT     INCIDENCES          THICK   POISS         E             G          AREA
   NO.                          (FEET)


   1     1     2     10      9    0.000  0.000       0.00          0.00       65.0562
   2     2     3     11     10    0.000  0.000       0.00          0.00       65.0562
   3     3     4     12     11    0.000  0.000       0.00          0.00       65.0562
   4     4     5     13     12    0.000  0.000       0.00          0.00       65.0562
   5     5     6     14     13    0.000  0.000       0.00          0.00       65.0562
   6     6     7     15     14    0.000  0.000       0.00          0.00       65.0562
   7     7     8     16     15    0.000  0.000       0.00          0.00       65.0562
   8     8     1      9     16    0.000  0.000       0.00          0.00       65.0562
   9     9    10     18     17    0.000  0.000       0.00          0.00       65.0562
  10    10    11     19     18    0.000  0.000       0.00          0.00       65.0562
  11    11    12     20     19    0.000  0.000       0.00          0.00       65.0562
  12    12    13     21     20    0.000  0.000       0.00          0.00       65.0562
  13    13    14     22     21    0.000  0.000       0.00          0.00       65.0562
  14    14    15     23     22    0.000  0.000       0.00          0.00       65.0562
  15    15    16     24     23    0.000  0.000       0.00          0.00       65.0562
  16    16     9     17     24    0.000  0.000       0.00          0.00       65.0562


******************END OF ELEMENT INFO******************


 12. FINISH


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE=              TIME=          ****

      ************************************************************
      *        For questions on STAAD.Pro, please contact       *
      *  Research Engineers Offices at the following locations  *
      *                                                          *
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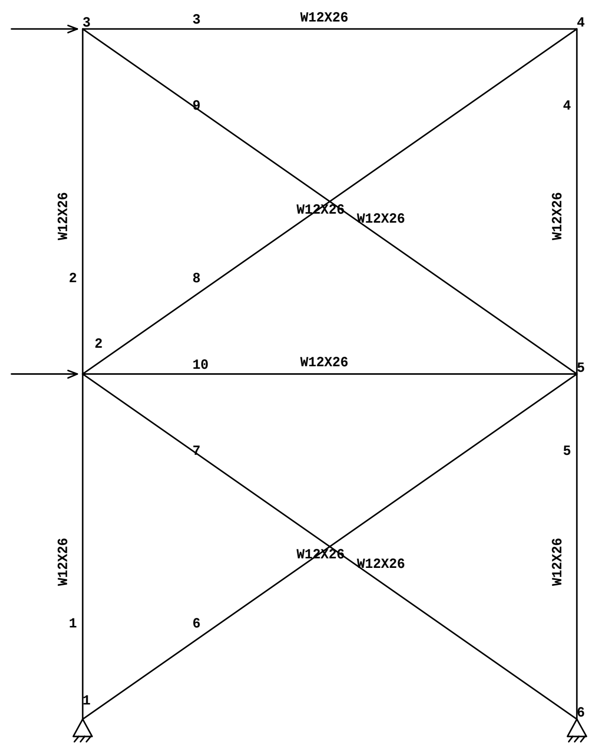
      *  CANADA    +1 (905)632-4771      detech@odandetech.com   *
      *  UK        +44(1454)207-000      support@reel.co.uk      *
      *  FRANCE    +33(0)1 64551084      support@reel.co.uk      *
      *  GERMANY   +49/931/40468-71      info@reig.de            *
      *  NORWAY    +47 67 57 21 30       staad@edr.no            *
      *  SINGAPORE +65 6225-6158         support@bentley.com     *
      *  INDIA     +91(033)4006-2021     support@bentley.com     *
      *  JAPAN     +81(03)5952-6500      eng-eye@crc.co.jp       *
      *  CHINA     +86(411)363-1983      support@bentley.com     *
      *  THAILAND  +66(0)2645-1018/19    support@bentley.com     *
      *                                                          *
      *  North America                  support@bentley.com      *
      *  Europe                         support@bentley.com      *
      *  Asia                           support@bentley.com      *
      ************************************************************
```

NOTES

Example Problem No. 21

This example illustrates the modeling of tension-only members using the MEMBER TENSION command.



This example has been created to illustrate the command specification for a structure with certain members capable of carrying tensile force only. It is important to note that the analysis can be done for only 1 load case at a time. This is because, the set of “active” members (and hence the stiffness matrix) is load case dependent.

STAAD PLANE EXAMPLE FOR TENSION-ONLY MEMBERS

The input data is initiated with the word STAAD. This structure is a PLANE frame.

UNIT FEET KIP

Units for the commands to follow are defined above.

SET NL 3

This structure has to be analysed for 3 primary load cases. Consequently, the modeling of our problem requires us to define 3 sets of data, with each set containing a load case and an associated analysis command. Also, the members which get switched off in the analysis for any load case have to be restored for the analysis for the subsequent load case. To accommodate these requirements, it is necessary to have 2 commands, one called “SET NL” and the other called “CHANGE”. The SET NL command is used above to indicate the total number of primary load cases that the file contains. The CHANGE command will come in later (after the PERFORM ANALYSIS command).

JOINT COORDINATES
1 0 0 ; 2 0 10 ; 3 0 20 ; 4 15 20 ; 5 15 10 ; 6 15 0

Joint coordintes of joints 1 to 6 are defined above.

MEMBER INCIDENCES
1 1 2 5
6 1 5;7 2 6;8 2 4;9 3 5;10 2 5

Incidences of members 1 to 10 are defined.

```
MEMBER TENSION
6 TO 9
```

Members 6 to 9 are defined as TENSION-only members. Hence for each load case, if during the analysis, any of the members 6 to 9 is found to be carrying a compressive force, it is disabled from the structure and the analysis is carried out again with the modified structure.

```
MEMBER PROPERTY AMERICAN
1 TO 10 TA ST W12X26
```

All members have been assigned a WIDE FLANGE section from the built in American table.

```
UNIT INCH
CONSTANTS
E 29000.0 ALL
POISSON STEEL ALL
```

Following the command CONSTANTS, material constants such as E (Modulus of Elasticity) and Poisson’s ratio are specified. The length units have been changed from feet to inch to facilitate the input of these values. We do not require DENSITY since selfweight is not one of the load cases considered.

```
SUPPORT
1 PINNED
6 PINNED
```

The supports are defined above.

```
LOAD 1
JOINT LOAD
2 FX 15
3 FX 10
```

Load 1 is defined above and consists of joint loads at joints 2 and 3.

```
PERFORM ANALYSIS
```

An analysis is carried out for load case 1.

```
CHANGE
MEMBER TENSION
6 TO 9
```

One or more among the members 6 to 9 may have been inactivated in the previous analysis. The CHANGE command restores the original structure to prepare it for the analysis for the next primary load case. The members with the tension-only attribute are specified again.

```
LOAD 2
JOINT LOAD
4 FX -10
5 FX -15
```

Load case 2 is described above.

```
PERFORM ANALYSIS
CHANGE
```

The instruction to analyze the structure is specified again. Next, any tension-only members that become inactivated during the second analysis (due to the fact that they were subjected to compressive axial forces) are re-activated with the CHANGE command. Without re-activation, these members cannot be accessed for any further operations.

```
MEMBER TENSION
6 TO 9
LOAD 3
REPEAT LOAD
1 1.0 2 1.0
```

Load case 3 illustrates the technique employed to instruct STAAD to create a load case which consists of data to be assembled from other load cases already specified earlier. We would like the program to analyze the structure for loads from cases 1 and 2 acting simultaneously. In other words, the above instruction is the same as the following:

```
LOAD 3
JOINT LOAD
2 FX 15
3 FX 10
4 FX -10
5 FX -15
```

PERFORM ANALYSIS

The analysis is carried out for load case 3.

CHANGE
LOAD LIST ALL

The members inactivated during the analysis of load 3 are re-activated for further processing. At the end of any analysis, only those load cases for which the analysis was done most recently, are recognized as the "active" load cases. The LOAD LIST command enables the above listed load cases to be made active for further processing.

PRINT ANALYSIS RESULTS
FINI

The analysis results are printed and the run terminated.

```
 ****************************************************
 *                                                  *
 *           STAAD.Pro                              *
 *           Version          Bld                   *
 *           Proprietary Program of                 *
 *           Research Engineers,  Intl.             *
 *           Date=                                  *
 *           Time=                                  *
 *                                                  *
 *      USER ID:                                    *
 ****************************************************

    1. STAAD PLANE EXAMPLE FOR TENSION-ONLY MEMBERS
    2. UNIT FEET KIP
    3. SET NL 3
    4. JOINT COORDINATES
    5. 1 0 0 ; 2 0 10 ; 3 0 20 ; 4 15 20 ; 5 15 10 ; 6 15 0
    6. MEMBER INCIDENCES
    7. 1 1 2 5
    8. 6 1 5 ; 7 2 6 ; 8 2 4 ; 9 3 5 ; 10 2 5
    9. MEMBER TENSION
   10. 6 TO 9
   11. MEMBER PROPERTY AMERICAN
   12. 1 TO 10 TA ST W12X26
   13. UNIT INCH
   14. CONSTANTS
   15. E 29000.0 ALL
   16. POISSON STEEL ALL
   17. SUPPORT
   18. 1 PINNED
   19. 6 PINNED
   20. LOAD 1
   21. JOINT LOAD
   22. 2 FX 15
   23. 3 FX 10
   24. PERFORM ANALYSIS

          P R O B L E M   S T A T I S T I C S
          -----------------------------------

    NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     6/    10/     2
    ORIGINAL/FINAL BAND-WIDTH=     4/     4/     13 DOF
    TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     14
    SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
    REQRD/AVAIL. DISK SPACE  =    12.0/  3142.8 MB,  EXMEM =  568.2 MB

 **START ITERATION NO.           2

 **NOTE-Tension/Compression converged after  2 iterations, Case=    1

   25. CHANGE
   26. MEMBER TENSION
   27. 6 TO 9
   28. LOAD 2
   29. JOINT LOAD
   30. 4 FX -10
   31. 5 FX -15
   32. PERFORM ANALYSIS
 **START ITERATION NO.           2

 **NOTE-Tension/Compression converged after  2 iterations, Case=    2

   33. CHANGE
   34. MEMBER TENSION
   35. 6 TO 9
   36. LOAD 3
   37. REPEAT LOAD
   38. 1 1.0 2 1.0
   39. PERFORM ANALYSIS
 **START ITERATION NO.           2
 **NOTE-Tension/Compression converged after  2 iterations, Case=    3
```

```
   40. CHANGE
   41. LOAD LIST ALL
   42. PRINT ANALYSIS RESULTS

  JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = PLANE
  ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    1    1    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00062
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00039
         3    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00007
    2    1    0.06285   0.00373   0.00000   0.00000   0.00000  -0.00030
         2   -0.04313  -0.01262   0.00000   0.00000   0.00000   0.00028
         3    0.00605   0.00000   0.00000   0.00000   0.00000  -0.00001
    3    1    0.09724   0.00387   0.00000   0.00000   0.00000  -0.00018
         2   -0.08929  -0.01613   0.00000   0.00000   0.00000   0.00029
         3    0.00408   0.00000   0.00000   0.00000   0.00000   0.00002
    4    1    0.08929  -0.01613   0.00000   0.00000   0.00000  -0.00029
         2   -0.09724   0.00387   0.00000   0.00000   0.00000   0.00018
         3   -0.00408   0.00000   0.00000   0.00000   0.00000  -0.00002
    5    1    0.04313  -0.01262   0.00000   0.00000   0.00000  -0.00028
         2   -0.06285   0.00373   0.00000   0.00000   0.00000   0.00030
         3   -0.00605   0.00000   0.00000   0.00000   0.00000   0.00001
    6    1    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00039
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00062
         3    0.00000   0.00000   0.00000   0.00000   0.00000   0.00007

  SUPPORT REACTIONS -UNIT KIP  INCH    STRUCTURE TYPE = PLANE
  -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1    -24.91    -23.33      0.00      0.00      0.00      0.00
         2      0.09     23.33      0.00      0.00      0.00      0.00
         3     -0.05      0.00      0.00      0.00      0.00      0.00
    6    1     -0.09     23.33      0.00      0.00      0.00      0.00
         2     24.91    -23.33      0.00      0.00      0.00      0.00
         3      0.05      0.00      0.00      0.00      0.00      0.00

  MEMBER END FORCES    STRUCTURE TYPE = PLANE
  -----------------
  ALL UNITS ARE -- KIP  INCH

 MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1     -6.90      0.26     0.00      0.00      0.00       0.00
               2      6.90     -0.26     0.00      0.00      0.00      31.66
         2     1     23.33     -0.09     0.00      0.00      0.00       0.00
               2    -23.33      0.09     0.00      0.00      0.00     -10.81
         3     1      0.00      0.05     0.00      0.00      0.00       0.00
               2      0.00     -0.05     0.00      0.00      0.00       5.46

    2    1     2     -0.24      0.20     0.00      0.00      0.00       6.07
               3      0.24     -0.20     0.00      0.00      0.00      18.43
         2     2      6.49     -0.43     0.00      0.00      0.00     -25.75
               3     -6.49      0.43     0.00      0.00      0.00     -25.59
         3     2      0.00     -0.05     0.00      0.00      0.00      -4.67
               3      0.00      0.05     0.00      0.00      0.00      -1.39

    3    1     3      9.80     -0.24     0.00      0.00      0.00     -18.43
               4     -9.80      0.24     0.00      0.00      0.00     -25.59
         2     3      9.80      0.24     0.00      0.00      0.00      25.59
               4     -9.80     -0.24     0.00      0.00      0.00      18.43
         3     3     10.05      0.00     0.00      0.00      0.00       1.39
               4    -10.05      0.00     0.00      0.00      0.00      -1.39

    4    1     4      6.49      0.43     0.00      0.00      0.00      25.59
               5     -6.49     -0.43     0.00      0.00      0.00      25.75
         2     4     -0.24     -0.20     0.00      0.00      0.00     -18.43
               5      0.24      0.20     0.00      0.00      0.00      -6.07
         3     4      0.00      0.05     0.00      0.00      0.00       1.39
               5      0.00     -0.05     0.00      0.00      0.00       4.67
```

```
 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  INCH

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    5    1     5     23.33      0.09     0.00      0.00      0.00      10.81
               6    -23.33     -0.09     0.00      0.00      0.00       0.00
         2     5     -6.90     -0.26     0.00      0.00      0.00     -31.66
               6      6.90      0.26     0.00      0.00      0.00       0.00
         3     5      0.00     -0.05     0.00      0.00      0.00      -5.46
               6      0.00      0.05     0.00      0.00      0.00       0.00

    6    1     1    -29.62      0.00     0.00      0.00      0.00       0.00
               5     29.62      0.00     0.00      0.00      0.00       0.00
         2     1      0.00      0.00     0.00      0.00      0.00       0.00
               5      0.00      0.00     0.00      0.00      0.00       0.00
         3     1      0.00      0.00     0.00      0.00      0.00       0.00
               5      0.00      0.00     0.00      0.00      0.00       0.00

    7    1     2      0.00      0.00     0.00      0.00      0.00       0.00
               6      0.00      0.00     0.00      0.00      0.00       0.00
         2     2    -29.62      0.00     0.00      0.00      0.00       0.00
               6     29.62      0.00     0.00      0.00      0.00       0.00
         3     2      0.00      0.00     0.00      0.00      0.00       0.00
               6      0.00      0.00     0.00      0.00      0.00       0.00

    8    1     2    -11.26      0.00     0.00      0.00      0.00       0.00
               4     11.26      0.00     0.00      0.00      0.00       0.00
         2     2      0.00      0.00     0.00      0.00      0.00       0.00
               4      0.00      0.00     0.00      0.00      0.00       0.00
         3     2      0.00      0.00     0.00      0.00      0.00       0.00
               4      0.00      0.00     0.00      0.00      0.00       0.00

    9    1     3      0.00      0.00     0.00      0.00      0.00       0.00
               5      0.00      0.00     0.00      0.00      0.00       0.00
         2     3    -11.26      0.00     0.00      0.00      0.00       0.00
               5     11.26      0.00     0.00      0.00      0.00       0.00
         3     3      0.00      0.00     0.00      0.00      0.00       0.00
               5      0.00      0.00     0.00      0.00      0.00       0.00

   10    1     2     24.31     -0.41     0.00      0.00      0.00     -37.73
               5    -24.31      0.41     0.00      0.00      0.00     -36.56
         2     2     24.31      0.41     0.00      0.00      0.00      36.56
               5    -24.31     -0.41     0.00      0.00      0.00      37.73
         3     2     14.90      0.00     0.00      0.00      0.00      -0.79
               5    -14.90      0.00     0.00      0.00      0.00       0.79

 ************** END OF LATEST ANALYSIS RESULT **************
  43. FINI

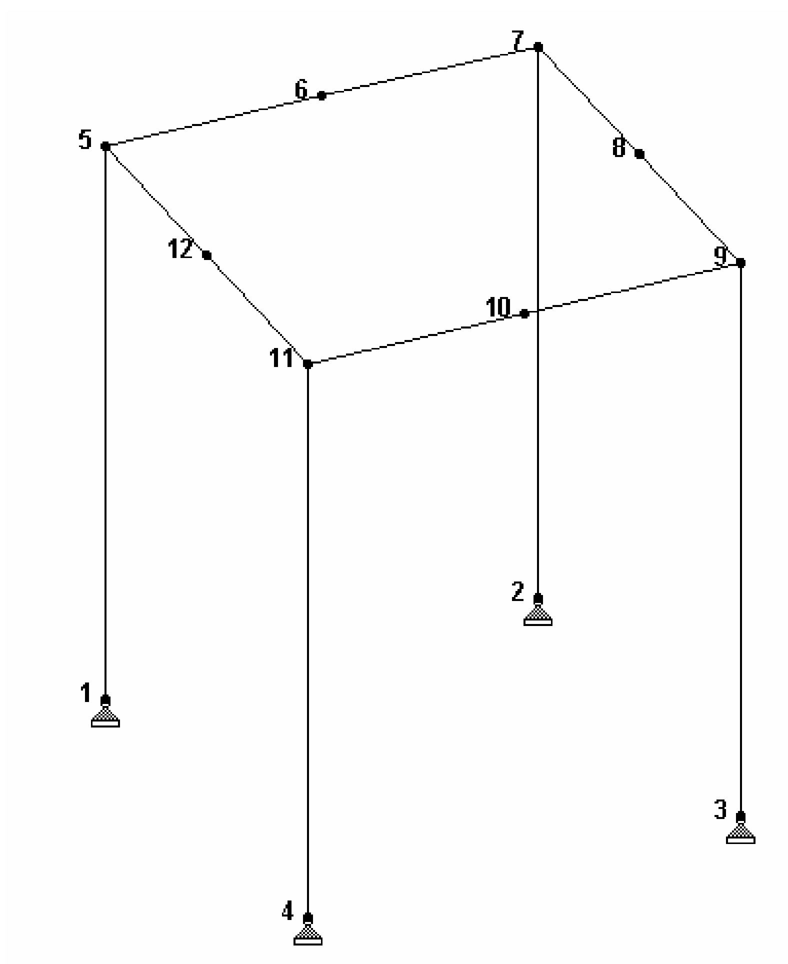
          *********** END OF THE STAAD.Pro RUN ***********
            **** DATE=              TIME=          ****
       ************************************************************
       *         For questions on STAAD.Pro, please contact       *
       *   Research Engineers Offices at the following locations  *
       *                                                          *
       *             Telephone              Email                 *
       *  USA:      +1 (714)974-2500      support@bentley.com     *
       *  CANADA    +1 (905)632-4771      detech@odandetech.com   *
       *  UK        +44(1454)207-000      support@reel.co.uk      *
       *  FRANCE    +33(0)1 64551084      support@reel.co.uk      *
       *  GERMANY   +49/931/40468-71      info@reig.de            *
       *  NORWAY    +47 67 57 21 30       staad@edr.no            *
       *  SINGAPORE +65 6225-6158         support@bentley.com     *
       *  INDIA     +91(033)4006-2021     support@bentley.com     *
       *  JAPAN     +81(03)5952-6500      eng-eye@crc.co.jp       *
       *  CHINA     +86(411)363-1983      support@bentley.com     *
       *  THAILAND  +66(0)2645-1018/19    support@bentley.com     *
       *                                                          *
       *  North America                  support@bentley.com      *
       *  Europe                         support@bentley.com      *
       *  Asia                           support@bentley.com      *
       ************************************************************
```

NOTES

NOTES

Example Problem No. 22

A space frame structure is subjected to a sinusoidal (dynamic) loading. The commands necessary to describe the sine function are demonstrated in this example. Time History analysis is performed on this model.



```
STAAD SPACE
*EXAMPLE FOR HARMONIC LOADING GENERATOR
```

Every STAAD input file has to begin with the word STAAD. The word SPACE signifies that the structure is a space frame and the geometry is defined through X, Y and Z axes. The comment line which begins with an asterisk is an optional title to identify this project.

```
UNIT KIP FEET
```

The units for the data that follows are specified above.

```
JOINT COORDINATES
1 0 0 0 ; 2 15 0 0 ; 3 15 0 15 ; 4 0 0 15
5 0 20 0 ; 6 7.5 20 0 ; 7 15 20 0 ; 8 15 20 7.5
9 15 20 15 ; 10 7.5 20 15 ; 11 0 20 15
12 0 20 7.5
```

The joint number followed by the X, Y and Z coordinates are specified above. Semicolon characters (;) are used as line separators to facilitate input of multiple sets of data on one line.

```
MEMBER INCIDENCES
1 1 5 ; 2 2 7 ; 3 3 9 ; 4 4 11 ; 5 5 6 ; 6 6 7
7 7 8 ; 8 8 9 ; 9 9 10 ; 10 10 11 ; 11 11 12 ; 12 12 5
```

The members are defined by the joints they are connected to.

```
UNIT INCH
MEMBER PROPERTIES
1 TO 12 PRIS YD 12 ZD 12
```

Members 1 to 12 are defined as PRISmatic sections with width and depth values of 12 inches. The UNIT command is specified to change the units for input from FEET to INCHes.

```
SUPPORTS
1 TO 4 PINNED
```

Joints 1 to 4 are declared to be pinned-supported.

```
CONSTANTS
E 3150 ALL
DENSITY 0.0868E-3 ALL
POISSON CONCRETE ALL
```

The modulus of elasticity (E), density and Poisson's ratio are specified following the command CONSTANTS. Built-in default value for concrete is used for the Poisson's Ratio.

```
DEFINE TIME HISTORY
TYPE 1 FORCE
* FOLLOWING LINES FOR HARMONIC LOADING GENERATOR
FUNCTION SINE
AMPLITUDE 6.2831 FREQUENCY 60 CYCLES 100
*
ARRIVAL TIMES
0.0
DAMPING 0.075
```

There are two stages in the command specification required for a time-history analysis. The first stage is defined above. Here, the parameters of the sinusoidal loading are provided.

Each data set is individually identified by the number that follows the TYPE command. In this file, only one data set is defined, which is apparent from the fact that only one TYPE is defined.

The word FORCE that follows the TYPE 1 command signifies that this data set is for a forcing function. (If one wishes to specify an earthquake motion, an ACCELERATION may be specified.)

The command FUNCTION SINE indicates that instead of providing the data set as discrete TIME-FORCE pairs, a sinusoidal function, which describes the variation of force with time, is provided.

The parameters of the sine function, such as FREQUENCY, AMPLITUDE, and number of CYCLES of application are then defined. STAAD internally generates discrete TIME-FORCE pairs of data from the sine function in steps of time defined by the default value (See section 5.31.6 of the Technical Reference Manual for more information). The arrival time value indicates the relative value of time at which the force begins to act upon the structure. The modal damping ratio for all the modes is set to 0.075.

```
LOAD 1 STATIC LOAD CASE
MEMBER LOAD
5 6 7 8 9 10 11 12 UNI GY -1.0
```

The above data describe a static load case. A uniformly distributed load of 1.0 kip/ft acting in the negative global Y direction is applied on some members.

```
LOAD 2 DYNAMIC LOAD CASE
SELFWEIGHT X 1.0
SELFWEIGHT Y 1.0
SELFWEIGHT Z 1.0
JOINT LOAD
8 12 FX 4.0
8 12 FY 4.0
8 12 FZ 4.0
TIME LOAD
8 12 FX 1 1
```

This is the second stage of command specification for time history analysis. The 2 sets of data specified here are a) the weights for generation of the mass matrix and b) the application of the time varying loads on the structure.

The weights (from which the masses for the mass matrix are obtained) are specified in the form of selfweight and joint loads.

Following that, the sinusoidal force is applied using the "TIME LOAD" command. The forcing function described by the TYPE 1 load is applied on joints 8 and 12 and it starts to act starting at a time defined by the 1st arrival time number.

```
PERFORM ANALYSIS
PRINT ANALYSIS RESULTS
FINI
```

The above commands are self explanatory. The FINISH command terminates the STAAD run.

```
                 ****************************************************
                 *                                                  *
                 *           STAAD.Pro                              *
                 *           Version          Bld                   *
                 *           Proprietary Program of                 *
                 *           Research Engineers,  Intl.             *
                 *           Date=                                  *
                 *           Time=                                  *
                 *                                                  *
                 *      USER ID:                                    *
                 ****************************************************

    1. STAAD SPACE EXAMPLE FOR HARMONIC LOADING GENERATOR
    2. UNIT KIP FEET
    3. JOINT COORDINATES
    4. 1 0 0 0 ; 2 15 0 0 ; 3 15 0 15 ; 4 0 0 15
    5. 5 0 20 0 ; 6 7.5 20 0 ; 7 15 20 0 ; 8 15 20 7.5
    6. 9 15 20 15 ; 10 7.5 20 15 ; 11 0 20 15
    7. 12 0 20 7.5
    8. MEMBER INCIDENCES
    9. 1 1 5 ; 2 2 7 ; 3 3 9 ; 4 4 11 ; 5 5 6 ; 6 6 7
   10. 7 7 8 ; 8 8 9 ; 9 9 10 ; 10 10 11 ; 11 11 12 ; 12 12 5
   11. UNIT INCH
   12. MEMBER PROPERTIES
   13. 1 TO 12 PRIS YD 12 ZD 12
   14. SUPPORTS
   15. 1 TO 4 PINNED
   16. CONSTANTS
   17. E 3150 ALL
   18. DENSITY 0.0868E-3 ALL
   19. POISSON CONCRETE ALL
   20. DEFINE TIME HISTORY
   21. TYPE 1 FORCE
   22. * FOLLOWING LINES FOR HARMONIC LOADING GENERATOR
   23. FUNCTION SINE
   24. AMPLITUDE 6.2831 FREQUENCY 60 CYCLES 100

  FOR SEQUENTIAL HARMONIC FORCING CURVE NUMBER=             1
  NUMBER OF POINTS IN DIGITIZED HARMONIC FUNCTION=       1201
  NUMBER OF POINTS PER QUARTER CYCLE OF HARMONIC FUNCTION=  3
  FORCE STEP DELTA TIME PER POINT                  1.38889E-03
  ENDING TIME FOR THIS DIGITIZED HARMONIC FUNCTION  1.66667E+00

   25. *
   26. ARRIVAL TIMES
   27. 0.0
   28. DAMPING 0.075
   29. LOAD 1 STATIC LOAD CASE
   30. MEMBER LOAD
   31. 5 6 7 8 9 10 11 12 UNI GY -1.0
   32. LOAD 2 DYNAMIC LOAD CASE
   33. SELFWEIGHT X 1.0
   34. SELFWEIGHT Y 1.0
   35. SELFWEIGHT Z 1.0
   36. JOINT LOAD
   37. 8 12 FX 4.0
   38. 8 12 FY 4.0
   39. 8 12 FZ 4.0
   40. TIME LOAD
   41. 8 12 FX 1 1
   42. PERFORM ANALYSIS

          P R O B L E M   S T A T I S T I C S
          -----------------------------------

    NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    12/    12/     4

          SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

    ORIGINAL/FINAL BAND-WIDTH=     7/     4/     24 DOF
    TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =     60
    SIZE OF STIFFNESS MATRIX =        2 DOUBLE  KILO-WORDS
NUMBER OF MODES REQUESTED              =     6
NUMBER OF EXISTING MASSES IN THE MODEL =    24
```

```
NUMBER OF MODES THAT WILL BE USED      =     6
```

CALCULATED FREQUENCIES FOR LOAD CASE 2

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)	ACCURACY
1	1.202	0.83191	1.121E-15
2	1.204	0.83057	4.966E-16
3	1.451	0.68908	1.367E-15
4	7.559	0.13229	2.086E-11
5	11.073	0.09031	0.000E+00
6	11.670	0.08569	1.015E-15

The following Frequencies are estimates that were calculated. These are for information only and will not be used. Remaining values are either above the cut off mode/freq values or are of low accuracy. To use these frequencies, rerun with a higher cutoff mode (or mode + freq) value.

CALCULATED FREQUENCIES FOR LOAD CASE 2

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)	ACCURACY
7	12.606	0.07932	1.015E-15
8	18.499	0.05406	5.386E-16
9	24.900	0.04016	2.973E-16
10	26.881	0.03720	0.000E+00
11	30.866	0.03240	3.869E-16
12	31.633	0.03161	7.367E-16
13	84.292	0.01186	5.874E-11
14	85.011	0.01176	1.836E-15
15	85.096	0.01175	2.036E-16
16	85.606	0.01168	5.835E-15
17	137.219	0.00729	1.594E-13
18	137.222	0.00729	1.477E-13
19	137.351	0.00728	5.088E-13
20	138.260	0.00723	1.666E-14
21	195.027	0.00513	6.363E-09
22	195.215	0.00512	6.718E-12

MASS PARTICIPATION FACTORS IN PERCENT

MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z
1	100.00	0.00	0.00	99.998	0.000	0.000
2	0.00	0.00	100.00	99.998	0.000	100.000
3	0.00	0.00	0.00	99.998	0.000	100.000
4	0.00	0.00	0.00	99.998	0.000	100.000
5	0.00	0.00	0.00	99.998	0.000	100.000
6	0.00	46.82	0.00	99.998	46.821	100.000

A C T U A L MODAL D A M P I N G USED IN ANALYSIS

MODE	DAMPING
1	0.0750
2	0.0750
3	0.0750
4	0.0750
5	0.0750
6	0.0750

```
TIME STEP USED IN TIME HISTORY ANALYSIS = 0.00139 SECONDS
NUMBER OF MODES WHOSE CONTRIBUTION IS CONSIDERED =   6
TIME DURATION OF TIME HISTORY ANALYSIS =    1.665 SECONDS
NUMBER OF TIME STEPS IN THE SOLUTION PROCESS =    1199
```

```
 BASE SHEAR UNITS ARE -- KIP  INCH

 MAXIMUM BASE SHEAR  X=  -2.228746E-01  Y=   0.000000E+00  Z=  -5.684342E-14
     AT TIMES              0.194444         0.000000          1.581944

   43. PRINT ANALYSIS RESULTS

  JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = SPACE
  ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    1    1    0.00000   0.00000   0.00000  -0.01045   0.00000   0.01045
         2    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00037
    2    1    0.00000   0.00000   0.00000  -0.01045   0.00000  -0.01045
         2    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00037
    3    1    0.00000   0.00000   0.00000   0.01045   0.00000  -0.01045
         2    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00037
    4    1    0.00000   0.00000   0.00000   0.01045   0.00000   0.01045
         2    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00037
    5    1    0.00118  -0.09524   0.00118   0.02103   0.00000  -0.02103
         2    0.06536   0.00008   0.00000   0.00000   0.00000  -0.00008
    6    1    0.00000  -1.56841   0.00118   0.02103   0.00000   0.00000
         2    0.06537   0.00000   0.00000   0.00000   0.00000   0.00004
    7    1   -0.00118  -0.09524   0.00118   0.02103   0.00000   0.02103
         2    0.06536  -0.00008   0.00000   0.00000   0.00000  -0.00008
    8    1   -0.00118  -1.56841   0.00000   0.00000   0.00000   0.02103
         2    0.06587  -0.00008   0.00000   0.00000   0.00000  -0.00008
    9    1   -0.00118  -0.09524  -0.00118  -0.02103   0.00000   0.02103
         2    0.06536  -0.00008   0.00000   0.00000   0.00000  -0.00008
   10    1    0.00000  -1.56841  -0.00118  -0.02103   0.00000   0.00000
         2    0.06537   0.00000   0.00000   0.00000   0.00000   0.00004
   11    1    0.00118  -0.09524  -0.00118  -0.02103   0.00000  -0.02103
         2    0.06536   0.00008   0.00000   0.00000   0.00000  -0.00008
   12    1    0.00118  -1.56841   0.00000   0.00000   0.00000  -0.02103
         2    0.06587   0.00008   0.00000   0.00000   0.00000  -0.00008

  SUPPORT REACTIONS -UNIT KIP  INCH    STRUCTURE TYPE = SPACE
  -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1       5.95    180.00      5.95      0.00      0.00      0.00
         2      -0.06     -0.15      0.00      0.00      0.00      0.00
    2    1      -5.95    180.00      5.95      0.00      0.00      0.00
         2      -0.06      0.15      0.00      0.00      0.00      0.00
    3    1      -5.95    180.00     -5.95      0.00      0.00      0.00
         2      -0.06      0.15      0.00      0.00      0.00      0.00
    4    1       5.95    180.00     -5.95      0.00      0.00      0.00
         2      -0.06     -0.15      0.00      0.00      0.00      0.00

  MEMBER END FORCES    STRUCTURE TYPE = SPACE
  -----------------
  ALL UNITS ARE -- KIP  INCH     (LOCAL )

 MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1    180.00     -5.95     5.95      0.00      0.00       0.00
               5   -180.00      5.95    -5.95      0.00  -1428.10   -1428.10
         2     1     -0.15      0.06     0.00      0.00      0.00       0.00
               5      0.15     -0.06     0.00      0.00      0.00      13.37

    2    1     2    180.00      5.95     5.95      0.00      0.00       0.00
               7   -180.00     -5.95    -5.95      0.00  -1428.10    1428.10
         2     2      0.15      0.06     0.00      0.00      0.00       0.00
               7     -0.15     -0.06     0.00      0.00      0.00      13.37

    3    1     3    180.00      5.95    -5.95      0.00      0.00       0.00
               9   -180.00     -5.95     5.95      0.00   1428.10    1428.10
         2     3      0.15      0.06     0.00      0.00      0.00       0.00
               9     -0.15     -0.06     0.00      0.00      0.00      13.37
```

```
MEMBER END FORCES    STRUCTURE TYPE = SPACE
-----------------
ALL UNITS ARE -- KIP  INCH     (LOCAL )

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    4    1     4    180.00     -5.95    -5.95      0.00      0.00       0.00
                11  -180.00      5.95     5.95      0.00   1428.10   -1428.10
         2     4     -0.15      0.06     0.00      0.00      0.00       0.00
                11     0.15     -0.06     0.00      0.00      0.00      13.37

    5    1     5      5.95     90.00     0.00      0.00      0.00    1428.10
                 6    -5.95      0.00     0.00      0.00      0.00    2621.90
         2     5     -0.01     -0.15    -0.01      0.00      0.84     -13.37
                 6     0.01      0.15     0.01      0.00      0.00       0.00

    6    1     6      5.95      0.00     0.00      0.00      0.00   -2621.90
                 7    -5.95     90.00     0.00      0.00      0.00   -1428.10
         2     6      0.01     -0.15    -0.01      0.00      0.00       0.00
                 7    -0.01      0.15     0.01      0.00      0.84     -13.37

    7    1     7      5.95     90.00     0.00      0.00      0.00    1428.10
                 8    -5.95      0.00     0.00      0.00      0.00    2621.90
         2     7     -0.01      0.00     0.02      0.00     -0.84       0.00
                 8     0.01      0.00    -0.02      0.00     -1.41       0.00

    8    1     8      5.95      0.00     0.00      0.00      0.00   -2621.90
                 9    -5.95     90.00     0.00      0.00      0.00   -1428.10
         2     8     -0.01      0.00    -0.02      0.00      1.41       0.00
                 9     0.01      0.00     0.02      0.00      0.84       0.00

    9    1     9      5.95     90.00     0.00      0.00      0.00    1428.10
                10    -5.95      0.00     0.00      0.00      0.00    2621.90
         2     9      0.01      0.15     0.01      0.00     -0.84      13.37
                10    -0.01     -0.15    -0.01      0.00      0.00       0.00

   10    1    10      5.95      0.00     0.00      0.00      0.00   -2621.90
                11    -5.95     90.00     0.00      0.00      0.00   -1428.10
         2    10     -0.01      0.15     0.01      0.00      0.00       0.00
                11     0.01     -0.15    -0.01      0.00     -0.84      13.37

   11    1    11      5.95     90.00     0.00      0.00      0.00    1428.10
                12    -5.95      0.00     0.00      0.00      0.00    2621.90
         2    11      0.01      0.00    -0.02      0.00      0.84       0.00
                12    -0.01      0.00     0.02      0.00      1.41       0.00

   12    1    12      5.95      0.00     0.00      0.00      0.00   -2621.90
                 5    -5.95     90.00     0.00      0.00      0.00   -1428.10
         2    12      0.01      0.00     0.02      0.00     -1.41       0.00
                 5    -0.01      0.00    -0.02      0.00     -0.84       0.00


************** END OF LATEST ANALYSIS RESULT **************
```

```
44. FINI

         *********** END OF THE STAAD.Pro RUN ***********

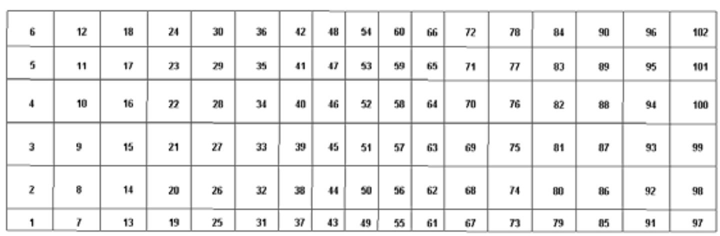
           **** DATE=               TIME=          ****

     ************************************************************
     *         For questions on STAAD.Pro, please contact       *
     *    Research Engineers Offices at the following locations  *
     *                                                          *
     *              Telephone                  Email            *
     *  USA:       +1 (714)974-2500      support@bentley.com    *
     *  CANADA     +1 (905)632-4771      detech@odandetech.com  *
     *  UK         +44(1454)207-000      support@reel.co.uk     *
     *  FRANCE     +33(0)1 64551084      support@reel.co.uk     *
     *  GERMANY    +49/931/40468-71      info@reig.de           *
     *  NORWAY     +47 67 57 21 30       staad@edr.no           *
     *  SINGAPORE  +65 6225-6158         support@bentley.com    *
     *  INDIA      +91(033)4006-2021     support@bentley.com    *
     *  JAPAN      +81(03)5952-6500      eng-eye@crc.co.jp      *
     *  CHINA      +86(411)363-1983      support@bentley.com    *
     *  THAILAND   +66(0)2645-1018/19    support@bentley.com    *
     *                                                          *
     *  North America                   support@bentley.com     *
     *  Europe                          support@bentley.com     *
     *  Asia                            support@bentley.com     *
     ************************************************************
```

Example Problem No. 23

This example illustrates the usage of commands necessary to utilize the built-in generation facility to generate spring supports for a slab on grade. The slab is subjected to various types of loading and analysis of the structure is performed.

The numbers shown in the diagram below are the element numbers.



```
STAAD SPACE SLAB ON GRADE
```

Every STAAD input file has to begin with the word STAAD. The word SPACE signifies that the structure is a space frame and the geometry is defined through X, Y and Z axes. The remainder of the words form a title to identify this project.

```
UNIT FEET KIP
```

The units for the data that follows are specified above.

```
JOINT COORDINATES
1 0.0 0.0 40.0
2 0.0 0.0 36.0
3 0.0 0.0 28.167
4 0.0 0.0 20.333
5 0.0 0.0 12.5
6 0.0 0.0  6.5
7 0.0 0.0  0.0
REPEAT ALL 3 8.5 0.0 0.0
REPEAT 3 8.0 0.0 0.0
REPEAT 5 6.0 0.0 0.0
REPEAT 3 8.0 0.0 0.0
REPEAT 3 8.5 0.0 0.0
```

For joints 1 through 7, the joint number followed by the X, Y and Z coordinates are specified above. The coordinates of these joints is used as a basis for generating 21 more joints by incrementing the X coordinate of each of these 7 joints by 8.5 feet, 3 times. REPEAT commands are used to generate the remaining joints of the structure. The results of the generation may be visually verified using the STAAD graphical viewing facilities.

```
ELEMENT INCIDENCES
1 1 8 9 2 TO 6
REPEAT 16 6 7
```

The incidences of element number 1 is defined and that data is used as a basis for generating the 2nd through the 6th element. The incidence pattern of the first 6 elements is then used to generate the incidences of 96 (= 16 x 6) more elements using the REPEAT command.

UNIT INCH
ELEMENT PROPERTIES
1 TO 102 TH 5.5

The thickness of elements 1 to 102 is specified as 5.5 inches following the command ELEMENT PROPERTIES.

UNIT FEET
CONSTANTS
E 420000. ALL
POISSON 0.12 ALL

The modulus of elasticity (E) and Poisson's Ratio are specified following the command CONSTANTS.

SUPPORTS
1 TO 126 ELASTIC MAT DIRECTION Y SUB 10.0

The above command is used to instruct STAAD to generate supports with springs which are effective in the global Y direction. These springs are located at nodes 1 to 126. The subgrade modulus of the soil is specified as 10 kip/cu.ft. The program will determine the area under the influence of each joint and multiply the influence area by the subgrade modulus to arrive at the spring stiffness for the "FY" degree of freedom at the joint. Additional information on this feature may be found in the STAAD Technical Reference Manual.

PRINT SUPP INFO

This command will enable us to obtain the details of the support springs which were generated using the earlier commands.

LOAD 1 WEIGHT OF MAT & EARTH
ELEMENT LOAD
1 TO 102 PR GY -1.55

The above data describe a static load case. A pressure load of 1.55 kip/sq.ft acting in the negative global Y direction is applied on all the 102 elements.

```
LOAD 2 'COLUMN LOAD-DL+LL'
JOINT LOADS
1 2 FY -217.
8 9 FY -109.
5 FY -308.7
6 FY -617.4
22 23 FY -410.
29 30 FY -205.
26 FY -542.7
27 FY -1085.4
43 44 50 51 71 72 78 79 FY -307.5
47 54 82 FY -264.2
48 55 76 83 FY -528.3
92 93 FY -205.0
99 100 FY -410.0
103 FY -487.0
104 FY -974.0
113 114 FY -109.0
120 121 FY -217.0
124 FY -273.3
125 FY -546.6
```

Load case 2 consists of several joint loads acting in the negative global Y direction.

```
LOADING COMBINATION 101 TOTAL LOAD
1 1. 2 1.
```

A load combination case, identified with load case number 101, is specified above. It instructs STAAD to factor loads 1 and 2 by a value of 1.0 and then algebraically add the results.

```
PERFORM ANALYSIS
```

The analysis is initiated using the above command.

LOAD LIST 101
PRINT JOINT DISPLACEMENTS LIST 33 56
PRINT ELEMENT STRESSES LIST 34 67

Joint displacements for joints 33 and 56, and element stresses for elements 34 and 67, for load case 101, is obtained with the help of the above commands.

FINISH

The STAAD run is terminated.

```
           ****************************************************
           *                                                  *
           *           STAAD.Pro                              *
           *           Version          Bld                   *
           *           Proprietary Program of                 *
           *           Research Engineers,  Intl.             *
           *           Date=                                  *
           *           Time=                                  *
           *                                                  *
           *      USER ID:                                    *
           ****************************************************
  1. STAAD SPACE SLAB ON GRADE
  2. UNIT FEET KIP
  3. JOINT COORDINATES
  4. 1 0.0 0.0 40.0
  5. 2 0.0 0.0 36.0
  6. 3 0.0 0.0 28.167
  7. 4 0.0 0.0 20.333
  8. 5 0.0 0.0 12.5
  9. 6 0.0 0.0  6.5
 10. 7 0.0 0.0  0.0
 11. REPEAT ALL 3 8.5 0.0 0.0
 12. REPEAT 3 8.0 0.0 0.0
 13. REPEAT 5 6.0 0.0 0.0
 14. REPEAT 3 8.0 0.0 0.0
 15. REPEAT 3 8.5 0.0 0.0
 16. ELEMENT INCIDENCES
 17. 1 1 8 9 2 TO 6
 18. REPEAT 16 6 7
 19. UNIT INCH
 20. ELEMENT PROPERTIES
 21. 1 TO 102 TH 5.5
 22. UNIT FEET
 23. CONSTANTS
 24. E 420000. ALL
 25. POISSON 0.12 ALL
 26. SUPPORTS
 27. 1 TO 126  ELASTIC MAT DIRECTION Y SUBGRADE 10.0
 28. PRINT SUPP INFO

SUPPORT INFORMATION (1=FIXED, 0=RELEASED)
-------------------
UNITS FOR SPRING CONSTANTS ARE KIP  FEET DEGREES

JOINT   FORCE-X/   FORCE-Y/   FORCE-Z/   MOM-X/   MOM-Y/   MOM-Z/
          KFX        KFY        KFZ       KMX      KMY      KMZ
   1       1          0          1         0        1        0
                0.0      85.0        0.0      0.0      0.0      0.0
   2       1          0          1         0        1        0
                0.0     251.5        0.0      0.0      0.0      0.0
   3       1          0          1         0        1        0
                0.0     332.9        0.0      0.0      0.0      0.0
   4       1          0          1         0        1        0
                0.0     332.9        0.0      0.0      0.0      0.0
   5       1          0          1         0        1        0
                0.0     294.0        0.0      0.0      0.0      0.0
   6       1          0          1         0        1        0
                0.0     265.6        0.0      0.0      0.0      0.0
   7       1          0          1         0        1        0
                0.0     138.1        0.0      0.0      0.0      0.0
   8       1          0          1         0        1        0
                0.0     170.0        0.0      0.0      0.0      0.0
   9       1          0          1         0        1        0
                0.0     502.9        0.0      0.0      0.0      0.0
  10       1          0          1         0        1        0
                0.0     665.8        0.0      0.0      0.0      0.0
  11       1          0          1         0        1        0
                0.0     665.8        0.0      0.0      0.0      0.0
  12       1          0          1         0        1        0
                0.0     587.9        0.0      0.0      0.0      0.0
  13       1          0          1         0        1        0
                0.0     531.2        0.0      0.0      0.0      0.0
```

JOINT	FORCE-X/ KFX	FORCE-Y/ KFY	FORCE-Z/ KFZ	MOM-X/ KMX	MOM-Y/ KMY	MOM-Z/ KMZ
14	1	0	1	0	1	0
	0.0	276.2	0.0	0.0	0.0	0.0
15	1	0	1	0	1	0
	0.0	170.0	0.0	0.0	0.0	0.0
16	1	0	1	0	1	0
	0.0	502.9	0.0	0.0	0.0	0.0
17	1	0	1	0	1	0
	0.0	665.8	0.0	0.0	0.0	0.0
18	1	0	1	0	1	0
	0.0	665.8	0.0	0.0	0.0	0.0
19	1	0	1	0	1	0
	0.0	587.9	0.0	0.0	0.0	0.0
20	1	0	1	0	1	0
	0.0	531.2	0.0	0.0	0.0	0.0
21	1	0	1	0	1	0
	0.0	276.2	0.0	0.0	0.0	0.0
22	1	0	1	0	1	0
	0.0	165.0	0.0	0.0	0.0	0.0
23	1	0	1	0	1	0
	0.0	488.1	0.0	0.0	0.0	0.0
24	1	0	1	0	1	0
	0.0	646.3	0.0	0.0	0.0	0.0
25	1	0	1	0	1	0
	0.0	646.3	0.0	0.0	0.0	0.0
26	1	0	1	0	1	0
	0.0	570.6	0.0	0.0	0.0	0.0
27	1	0	1	0	1	0
	0.0	515.6	0.0	0.0	0.0	0.0
28	1	0	1	0	1	0
	0.0	268.1	0.0	0.0	0.0	0.0
29	1	0	1	0	1	0
	0.0	160.0	0.0	0.0	0.0	0.0
30	1	0	1	0	1	0
	0.0	473.3	0.0	0.0	0.0	0.0
31	1	0	1	0	1	0
	0.0	626.7	0.0	0.0	0.0	0.0
32	1	0	1	0	1	0
	0.0	626.7	0.0	0.0	0.0	0.0
33	1	0	1	0	1	0
	0.0	553.3	0.0	0.0	0.0	0.0
34	1	0	1	0	1	0
	0.0	500.0	0.0	0.0	0.0	0.0
35	1	0	1	0	1	0
	0.0	260.0	0.0	0.0	0.0	0.0
36	1	0	1	0	1	0
	0.0	160.0	0.0	0.0	0.0	0.0
37	1	0	1	0	1	0
	0.0	473.3	0.0	0.0	0.0	0.0
38	1	0	1	0	1	0
	0.0	626.7	0.0	0.0	0.0	0.0
39	1	0	1	0	1	0
	0.0	626.7	0.0	0.0	0.0	0.0
40	1	0	1	0	1	0
	0.0	553.3	0.0	0.0	0.0	0.0
41	1	0	1	0	1	0
	0.0	500.0	0.0	0.0	0.0	0.0
42	1	0	1	0	1	0
	0.0	260.0	0.0	0.0	0.0	0.0
43	1	0	1	0	1	0
	0.0	140.0	0.0	0.0	0.0	0.0
44	1	0	1	0	1	0
	0.0	414.2	0.0	0.0	0.0	0.0
45	1	0	1	0	1	0
	0.0	548.3	0.0	0.0	0.0	0.0
46	1	0	1	0	1	0
	0.0	548.3	0.0	0.0	0.0	0.0
47	1	0	1	0	1	0
	0.0	484.2	0.0	0.0	0.0	0.0
48	1	0	1	0	1	0
	0.0	437.5	0.0	0.0	0.0	0.0
49	1	0	1	0	1	0
	0.0	227.5	0.0	0.0	0.0	0.0

JOINT	FORCE-X/ KFX	FORCE-Y/ KFY	FORCE-Z/ KFZ	MOM-X/ KMX	MOM-Y/ KMY	MOM-Z/ KMZ
50	1	0	1	0	1	0
	0.0	120.0	0.0	0.0	0.0	0.0
51	1	0	1	0	1	0
	0.0	355.0	0.0	0.0	0.0	0.0
52	1	0	1	0	1	0
	0.0	470.0	0.0	0.0	0.0	0.0
53	1	0	1	0	1	0
	0.0	470.0	0.0	0.0	0.0	0.0
54	1	0	1	0	1	0
	0.0	415.0	0.0	0.0	0.0	0.0
55	1	0	1	0	1	0
	0.0	375.0	0.0	0.0	0.0	0.0
56	1	0	1	0	1	0
	0.0	195.0	0.0	0.0	0.0	0.0
57	1	0	1	0	1	0
	0.0	120.0	0.0	0.0	0.0	0.0
58	1	0	1	0	1	0
	0.0	355.0	0.0	0.0	0.0	0.0
59	1	0	1	0	1	0
	0.0	470.0	0.0	0.0	0.0	0.0
60	1	0	1	0	1	0
	0.0	470.0	0.0	0.0	0.0	0.0
61	1	0	1	0	1	0
	0.0	415.0	0.0	0.0	0.0	0.0
62	1	0	1	0	1	0
	0.0	375.0	0.0	0.0	0.0	0.0
63	1	0	1	0	1	0
	0.0	195.0	0.0	0.0	0.0	0.0
64	1	0	1	0	1	0
	0.0	120.0	0.0	0.0	0.0	0.0
65	1	0	1	0	1	0
	0.0	355.0	0.0	0.0	0.0	0.0
66	1	0	1	0	1	0
	0.0	470.0	0.0	0.0	0.0	0.0
67	1	0	1	0	1	0
	0.0	470.0	0.0	0.0	0.0	0.0
68	1	0	1	0	1	0
	0.0	415.0	0.0	0.0	0.0	0.0
69	1	0	1	0	1	0
	0.0	375.0	0.0	0.0	0.0	0.0
70	1	0	1	0	1	0
	0.0	195.0	0.0	0.0	0.0	0.0
71	1	0	1	0	1	0
	0.0	120.0	0.0	0.0	0.0	0.0
72	1	0	1	0	1	0
	0.0	355.0	0.0	0.0	0.0	0.0
73	1	0	1	0	1	0
	0.0	470.0	0.0	0.0	0.0	0.0
74	1	0	1	0	1	0
	0.0	470.0	0.0	0.0	0.0	0.0
75	1	0	1	0	1	0
	0.0	415.0	0.0	0.0	0.0	0.0
76	1	0	1	0	1	0
	0.0	375.0	0.0	0.0	0.0	0.0
77	1	0	1	0	1	0
	0.0	195.0	0.0	0.0	0.0	0.0
78	1	0	1	0	1	0
	0.0	140.0	0.0	0.0	0.0	0.0
79	1	0	1	0	1	0
	0.0	414.2	0.0	0.0	0.0	0.0
80	1	0	1	0	1	0
	0.0	548.3	0.0	0.0	0.0	0.0
81	1	0	1	0	1	0
	0.0	548.3	0.0	0.0	0.0	0.0
82	1	0	1	0	1	0
	0.0	484.2	0.0	0.0	0.0	0.0
83	1	0	1	0	1	0
	0.0	437.5	0.0	0.0	0.0	0.0
84	1	0	1	0	1	0
	0.0	227.5	0.0	0.0	0.0	0.0
85	1	0	1	0	1	0
	0.0	160.0	0.0	0.0	0.0	0.0

JOINT	FORCE-X/ KFX	FORCE-Y/ KFY	FORCE-Z/ KFZ	MOM-X/ KMX	MOM-Y/ KMY	MOM-Z/ KMZ
86	1	0	1	0	1	0
	0.0	473.3	0.0	0.0	0.0	0.0
87	1	0	1	0	1	0
	0.0	626.7	0.0	0.0	0.0	0.0
88	1	0	1	0	1	0
	0.0	626.7	0.0	0.0	0.0	0.0
89	1	0	1	0	1	0
	0.0	553.3	0.0	0.0	0.0	0.0
90	1	0	1	0	1	0
	0.0	500.0	0.0	0.0	0.0	0.0
91	1	0	1	0	1	0
	0.0	260.0	0.0	0.0	0.0	0.0
92	1	0	1	0	1	0
	0.0	160.0	0.0	0.0	0.0	0.0
93	1	0	1	0	1	0
	0.0	473.3	0.0	0.0	0.0	0.0
94	1	0	1	0	1	0
	0.0	626.7	0.0	0.0	0.0	0.0
95	1	0	1	0	1	0
	0.0	626.7	0.0	0.0	0.0	0.0
96	1	0	1	0	1	0
	0.0	553.3	0.0	0.0	0.0	0.0
97	1	0	1	0	1	0
	0.0	500.0	0.0	0.0	0.0	0.0
98	1	0	1	0	1	0
	0.0	260.0	0.0	0.0	0.0	0.0
99	1	0	1	0	1	0
	0.0	165.0	0.0	0.0	0.0	0.0
100	1	0	1	0	1	0
	0.0	488.1	0.0	0.0	0.0	0.0
101	1	0	1	0	1	0
	0.0	646.3	0.0	0.0	0.0	0.0
102	1	0	1	0	1	0
	0.0	646.3	0.0	0.0	0.0	0.0
103	1	0	1	0	1	0
	0.0	570.6	0.0	0.0	0.0	0.0
104	1	0	1	0	1	0
	0.0	515.6	0.0	0.0	0.0	0.0
105	1	0	1	0	1	0
	0.0	268.1	0.0	0.0	0.0	0.0
106	1	0	1	0	1	0
	0.0	170.0	0.0	0.0	0.0	0.0
107	1	0	1	0	1	0
	0.0	502.9	0.0	0.0	0.0	0.0
108	1	0	1	0	1	0
	0.0	665.8	0.0	0.0	0.0	0.0
109	1	0	1	0	1	0
	0.0	665.8	0.0	0.0	0.0	0.0
110	1	0	1	0	1	0
	0.0	587.9	0.0	0.0	0.0	0.0
111	1	0	1	0	1	0
	0.0	531.2	0.0	0.0	0.0	0.0
112	1	0	1	0	1	0
	0.0	276.2	0.0	0.0	0.0	0.0
113	1	0	1	0	1	0
	0.0	170.0	0.0	0.0	0.0	0.0
114	1	0	1	0	1	0
	0.0	502.9	0.0	0.0	0.0	0.0
115	1	0	1	0	1	0
	0.0	665.8	0.0	0.0	0.0	0.0
116	1	0	1	0	1	0
	0.0	665.8	0.0	0.0	0.0	0.0
117	1	0	1	0	1	0
	0.0	587.9	0.0	0.0	0.0	0.0
118	1	0	1	0	1	0
	0.0	531.2	0.0	0.0	0.0	0.0
119	1	0	1	0	1	0
	0.0	276.2	0.0	0.0	0.0	0.0
120	1	0	1	0	1	0
	0.0	85.0	0.0	0.0	0.0	0.0
121	1	0	1	0	1	0
	0.0	251.5	0.0	0.0	0.0	0.0

```
JOINT   FORCE-X/   FORCE-Y/   FORCE-Z/   MOM-X/   MOM-Y/   MOM-Z/
          KFX        KFY        KFZ       KMX      KMX      KMZ
 122       1          0          1         0        1        0
              0.0      332.9        0.0      0.0      0.0      0.0
 123       1          0          1         0        1        0
              0.0      332.9        0.0      0.0      0.0      0.0
 124       1          0          1         0        1        0
              0.0      294.0        0.0      0.0      0.0      0.0
 125       1          0          1         0        1        0
              0.0      265.6        0.0      0.0      0.0      0.0
 126       1          0          1         0        1        0
              0.0      138.1        0.0      0.0      0.0      0.0


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


 29. LOAD 1 'WEIGHT OF MAT & EARTH'
 30. ELEMENT LOAD
 31. 1 TO 102 PR GY -1.55
 32. LOAD 2 'COLUMN LOAD-DL+LL'
 33. JOINT LOADS
 34. 1 2   FY -217.
 35. 8 9   FY -109.
 36. 5     FY -308.7
 37. 6     FY -617.4
 38. 22 23 FY -410.
 39. 29 30 FY -205.
 40. 26    FY -542.7
 41. 27    FY -1085.4
 42. 43 44 50 51 71 72 78 79 FY -307.5
 43. 47 54 82    FY -264.2
 44. 48 55 76 83 FY -528.3
 45. 92 93       FY -205.0
 46. 99 100      FY -410.0
 47. 103         FY -487.0
 48. 104         FY -974.0
 49. 113 114     FY -109.0
 50. 120 121     FY -217.0
 51. 124         FY -273.3
 52. 125         FY -546.6
 53. LOADING COMBINATION 101 TOTAL LOAD
 54. 1 1. 2 1.
 55. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =   126/   102/   126
  ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
  TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =    756
  SIZE OF STIFFNESS MATRIX =       41 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     13.0/  40261.3 MB


 56. LOAD LIST 101
 57. PRINT JOINT DISPLACEMENTS LIST 33 56


JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = SPACE
------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN


   33  101    0.00000  -4.73107   0.00000  -0.03221   0.00000   0.06208
   56  101    0.00000  -5.62691   0.00000   0.07125   0.00000   0.03192


************** END OF LATEST ANALYSIS RESULT **************


 58. PRINT ELEMENT STRESSES LIST 34 67
```

```
 ELEMENT STRESSES    FORCE,LENGTH UNITS= KIP  FEET
 ----------------

          STRESS = FORCE/UNIT WIDTH/THICK, MOMENT = FORCE-LENGTH/UNIT WIDTH

ELEMENT  LOAD       SQX        SQY          MX          MY          MXY
                    VONT       VONB         SX          SY          SXY
                    TRESCAT    TRESCAB


   34    101       -6.22      -8.28        0.83        4.63        10.63
                  539.95     539.95        0.00        0.00         0.00
                  616.96     616.96
     TOP :  SMAX=   386.38  SMIN=  -230.57  TMAX=   308.48  ANGLE= -39.9
     BOTT:  SMAX=   230.57  SMIN=  -386.38  TMAX=   308.48  ANGLE= -39.9

   67    101       71.92       7.69       15.09        9.75        21.67
                 1136.72    1136.72        0.00        0.00         0.00
                 1247.03    1247.03
     TOP :  SMAX=   978.22  SMIN=  -268.81  TMAX=   623.51  ANGLE=  41.5
     BOTT:  SMAX=   268.81  SMIN=  -978.22  TMAX=   623.51  ANGLE=  41.5


         **** MAXIMUM STRESSES AMONG SELECTED PLATES AND CASES ****
            MAXIMUM       MINIMUM       MAXIMUM       MAXIMUM       MAXIMUM
           PRINCIPAL     PRINCIPAL       SHEAR       VONMISES       TRESCA
            STRESS        STRESS        STRESS        STRESS        STRESS

         9.782190E+02 -9.782190E+02  6.235143E+02  1.136717E+03  1.247029E+03
PLATE NO.      67            67            67            67            67
CASE  NO.     101           101           101           101           101


 ********************END OF ELEMENT FORCES********************


  59. FINISH


            *********** END OF THE STAAD.Pro RUN ***********

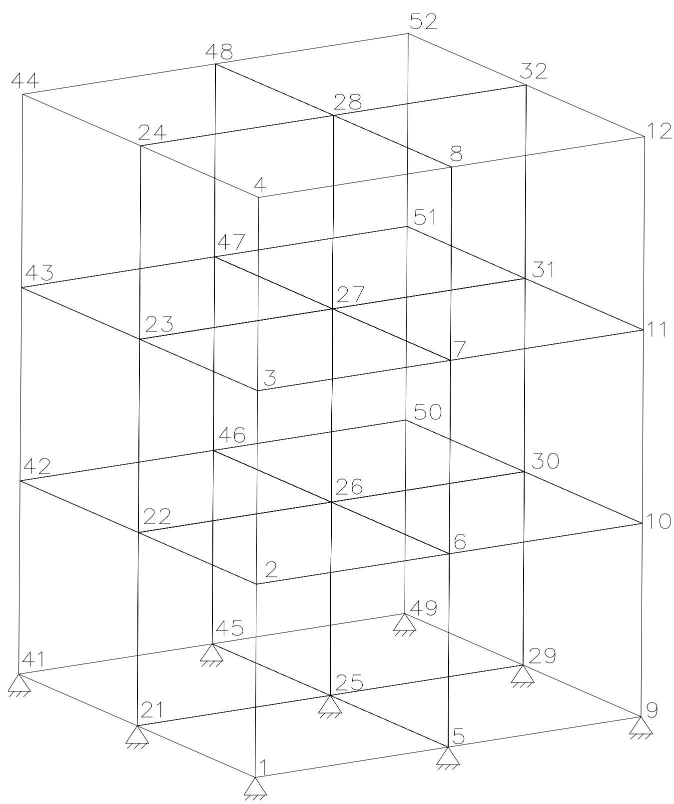
              **** DATE=            TIME=            ****

          ************************************************************
          *         For questions on STAAD.Pro, please contact       *
          *   Research Engineers Offices at the following locations  *
          *                                                          *
          *              Telephone                 Email             *
          *  USA:      +1 (714)974-2500       support@bentley.com    *
          *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
          *  UK        +44(1454)207-000       support@reel.co.uk     *
          *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
          *  GERMANY   +49/931/40468-71       info@reig.de           *
          *  NORWAY    +47 67 57 21 30        staad@edr.no           *
          *  SINGAPORE +65 6225-6158          support@bentley.com    *
          *  INDIA     +91(033)4006-2021      support@bentley.com    *
          *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
          *  CHINA     +86(411)363-1983       support@bentley.com    *
          *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
          *                                                          *
          *  North America                   support@bentley.com     *
          *  Europe                          support@bentley.com     *
          *  Asia                            support@bentley.com     *
          ************************************************************
```

NOTES

Example Problem No. 24

This is an example of the analysis of a structure modelled using "SOLID" finite elements. This example also illustrates the method for applying an "enforced" displacement on the structure.



```
STAAD SPACE
*EXAMPLE PROBLEM USING SOLID ELEMENTS
```

Every STAAD input file has to begin with the word STAAD. The word SPACE signifies that the structure is a space frame and the geometry is defined through X, Y and Z axes. The comment line which begins with an asterisk is an optional title to identify this project.

```
UNIT KNS MET
```

The units for the data that follows are specified above.

```
JOINT COORDINATES
 1  0.0  0.0  2.0   4  0.0  3.0  2.0
 5  1.0  0.0  2.0   8  1.0  3.0  2.0
 9  2.0  0.0  2.0  12  2.0  3.0  2.0
21  0.0  0.0  1.0  24  0.0  3.0  1.0
25  1.0  0.0  1.0  28  1.0  3.0  1.0
29  2.0  0.0  1.0  32  2.0  3.0  1.0
41  0.0  0.0  0.0  44  0.0  3.0  0.0
45  1.0  0.0  0.0  48  1.0  3.0  0.0
49  2.0  0.0  0.0  52  2.0  3.0  0.0
```

The joint number followed by the X, Y and Z coordinates are specified above. The coordinates of some of those nodes are generated utilizing the fact that they are equally spaced between the extremities.

```
ELEMENT INCIDENCES SOLID
 1   1  5  6  2 21 25 26 22  TO  3
 4  21 25 26 22 41 45 46 42  TO  6 1 1
 7   5  9 10  6 25 29 30 26  TO  9 1 1
10  25 29 30 26 45 49 50 46  TO 12 1 1
```

The incidences of solid elements are defined above. The word SOLID is used to signify that these are 8-noded solid elements as opposed to 3-noded or 4-noded plate elements. Each line contains the data for generating 3 elements. For example, element number 1 is first defined by all of its 8 nodes. Then, increments of 1 to the joint number and 1 to the element number (the defaults) are used for generating incidences for elements 2 and 3. Similarly, incidences of elements 4, 7 and 10 are defined while those of 5, 6, 8, 9, 11 and 12 are generated.

```
CONSTANTS
E   2.1E7 ALL
POIS 0.25 ALL
DENSITY 7.5 ALL
```

Following the command CONSTANTS above, the material constants such as E (Modulus of Elasticity), Poisson's Ratio, and Density are specified.

```
PRINT ELEMENT INFO SOLID LIST 1 TO 5
```

This command will enable us to obtain, in a tabular form, the details of the incidences and material property values of elements 1 to 5.

```
SUPPORTS
1  5  21  25  29  41  45  49  PINNED
9 ENFORCED
```

The above lines contain the data for supports for the model. The ENFORCED support condition is used to declare a point at which an enforced displacement load is applied later (see load case 3).

```
LOAD 1
SELF Y -1.0
JOINT LOAD
28 FY -1000.0
```

The above data describe a static load case. It consists of selfweight loading and a joint load, both in the negative global Y direction.

```
LOAD 2
JOINT LOADS
2 TO 4 22 TO 24  42 TO 44 FX 100.0
```

Load case 2 consists of several joint loads acting in the positive global X direction.

```
LOAD 3
SUPPORT DISPLACEMENT
9 FX 0.0011
```

Load case 3 consists of an enforced displacement along the global X direction at node 9. The displacement in the other enforced support degrees of freedom will default to zero.

```
UNIT POUND FEET
LOAD 4
ELEMENT LOAD SOLIDS
3 6 9 12 FACE 4 PRE GY -500.0
```

In Load case 4, a pressure load of 500 pounds/sq.ft is applied on Face # 4 of solid elements 3, 6, 9 and 12. Face 4 is defined as shown in the following table :

FACE NUMBER	SURFACE JOINTS			
	f_1	f_2	f_3	f_4
1 front	Jt 1	Jt 4	Jt 3	Jt 2
2 bottom	Jt 1	Jt 2	Jt 6	Jt 5
3 left	Jt 1	Jt 5	Jt 8	Jt 4
4 top	Jt 4	Jt 8	Jt 7	Jt 3
5 right	Jt 2	Jt 3	Jt 7	Jt 6
6 back	Jt 5	Jt 6	Jt 7	Jt 8

The above table, and other details of this type of loading can be found in section 5.32.3.2 of the STAAD.Pro Technical Reference manual.

```
UNIT KNS MMS
LOAD 5
REPEAT LOAD
1 1.0 2 1.0 3 1.0 4 1.0
```

Load case 5 illustrates the technique employed to instruct STAAD to create a load case which consists of data to be assembled from other load cases already specified earlier. We would like the program to analyze the structure for loads from cases 1 through 4 acting simultaneously. In other words, the above instruction is the same as the following:

```
LOAD 5
SELF Y -1.0
JOINT LOAD
28 FY -1000.0
2 TO 4 22 TO 24  42 TO 44 FX 100.0
SUPPORT DISPLACEMENT
9 FX .0011
ELEMENT LOAD SOLIDS
3 6 9 12 FACE 4 PRE GY -500.0
```

```
LOAD COMB 10
1 1.0 2 1.0
```

Load case 10 is a combination load case, which combines the effects of cases 1 & 2. While the syntax of this might look very similar to that of the REPEAT LOAD case shown in case 5, there is a fundamental difference. In a REPEAT LOAD case, the program computes the displacements by multiplying the inverted stiffness matrix by the load vector built for the REPEAT LOAD case. But in solving load combination cases, the program merely calculates the end results (displacements, forces, reactions) by gathering up the corresponding values from the individual components of the combination case, factoring them, and then algebraically summing them up. This difference in approach is quite important in that non-linear problems such as PDELTA ANALYSIS, MEMBER TENSION and MEMBER COMPRESSION situations, changes in support conditions etc. should be handled using REPEAT LOAD cases, not load combination cases.

```
PERFORM ANALYSIS PRINT STATICS CHECK
```

A static equilibrium report, consisting of total applied loading and total support reactions from each primary load case is requested along with the instructions to carry out a linear static analysis.

PRINT JOINT DISPLACEMENTS LIST 8 9

Global displacements at nodes 8 and 9 are obtained using the above command.

UNIT KNS METER
PRINT SUPPORT REACTIONS

Reactions at the supports are obtained using the above command.

UNIT NEWTON MMS
PRINT ELEMENT JOINT STRESS SOLID LIST 4 6

This command requests the program to provide the element stress results at the nodes of elements 4 and 6. The results will be printed for all the load cases. The word SOLID is used to signify that these are solid elements as opposed to plate or shell elements.

FINISH

The STAAD run is terminated.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

     1. STAAD SPACE EXAMPLE PROBLEM USING SOLID ELEMENTS
     2. UNIT KNS MET
     3. JOINT COORDINATES
     4. 1  0.0  0.0  2.0   4  0.0  3.0  2.0
     5. 5  1.0  0.0  2.0   8  1.0  3.0  2.0
     6. 9  2.0  0.0  2.0  12  2.0  3.0  2.0
     7. 21  0.0  0.0  1.0  24  0.0  3.0  1.0
     8. 25  1.0  0.0  1.0  28  1.0  3.0  1.0
     9. 29  2.0  0.0  1.0  32  2.0  3.0  1.0
    10. 41  0.0  0.0  0.0  44  0.0  3.0  0.0
    11. 45  1.0  0.0  0.0  48  1.0  3.0  0.0
    12. 49  2.0  0.0  0.0  52  2.0  3.0  0.0
    14. ELEMENT INCIDENCES SOLID
    15. 1    1   5   6   2  21  25  26  22   TO   3
    16. 4   21  25  26  22  41  45  46  42   TO   6  1 1
    17. 7    5   9  10   6  25  29  30  26   TO   9  1 1
    18. 10   25  29  30  26  45  49  50  46   TO  12  1 1
    20. CONSTANTS
    21. E   2.1E7 ALL
    22. POIS 0.25 ALL
    23. DENSITY 7.5 ALL
    25. PRINT ELEMENT INFO SOLID LIST 1 TO 5

ELEMENT NODE-1  NODE-2  NODE-3  NODE-4  NODE-5  NODE-6  NODE-7  NODE-8

      1      1       5       6       2      21      25      26      22
      2      2       6       7       3      22      26      27      23
      3      3       7       8       4      23      27      28      24
      4     21      25      26      22      41      45      46      42
      5     22      26      27      23      42      46      47      43

   MATERIAL PROPERTIES
   --------------------
   ALL UNITS ARE - KNS  MET

 ELEMENT   YOUNG'S MODULUS   MODULUS OF RIGIDITY    DENSITY        ALPHA


      1      2.1000002E+07         0.0000000E+00  7.5000E+00   0.0000E+00
      2      2.1000002E+07         0.0000000E+00  7.5000E+00   0.0000E+00
      3      2.1000002E+07         0.0000000E+00  7.5000E+00   0.0000E+00
      4      2.1000002E+07         0.0000000E+00  7.5000E+00   0.0000E+00
      5      2.1000002E+07         0.0000000E+00  7.5000E+00   0.0000E+00
    27. SUPPORTS
    28. 1  5   21  25  29  41  45  49  PINNED
    29. 9 ENFORCED
    31. LOAD 1
    32. SELF Y -1.0
    33. JOINT LOAD
    34. 28 FY -1000.0
    36. LOAD 2
    37. JOINT LOADS
    38. 2 TO 4 22 TO 24  42 TO 44 FX 100.0
    40. LOAD 3
    41. SUPPORT DISPLACEMENT
    42. 9 FX .0011
    44. UNIT POUND FEET
    45. LOAD 4
    46. ELEMENT LOAD SOLIDS
    47. 3 6 9 12 FACE 4 PRE GY -500.0
    49. UNIT KNS MMS
```

```
   51. LOAD 5
   52. REPEAT LOAD
   53. 1 1.0 2 1.0 3 1.0 4 1.0
   55. LOAD COMB 10
   56. 1 1.0 2 1.0
   58. PERFORM ANALYSIS PRINT STAT CHECK

           P R O B L E M   S T A T I S T I C S
           -----------------------------------

    NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    36/    12/     9
    ORIGINAL/FINAL BAND-WIDTH=    17/    17/     48 DOF
    TOTAL PRIMARY LOAD CASES =    5, TOTAL DEGREES OF FREEDOM =     87
    SIZE OF STIFFNESS MATRIX =        5 DOUBLE  KILO-WORDS
    REQRD/AVAIL. DISK SPACE  =     12.1/   4235.7 MB

   ZERO STIFFNESS IN DIRECTION 4 AT JOINT      9 EQN.NO.      22
         LOADS APPLIED OR DISTRIBUTED HERE FROM ELEMENTS WILL BE IGNORED.
         THIS MAY BE DUE TO ALL MEMBERS AT THIS JOINT BEING RELEASED OR
         EFFECTIVELY RELEASED IN THIS DIRECTION.
   Note - Some or all of the rotational zero stiffness warnings may be due to solid
          elements in the model. Solids do not have rotational stiffnesses at
nodes.
   ZERO STIFFNESS IN DIRECTION 5 AT JOINT      9 EQN.NO.      23
   ZERO STIFFNESS IN DIRECTION 6 AT JOINT      9 EQN.NO.      24

         STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     1


  ***TOTAL APPLIED LOAD ( KNS  MMS  ) SUMMARY (LOADING    1 )
      SUMMATION FORCE-X =        0.00
      SUMMATION FORCE-Y =    -1090.00
      SUMMATION FORCE-Z =        0.00

     SUMMATION OF MOMENTS AROUND THE ORIGIN-
     MX=     1089999.98  MY=          0.00  MZ=    -1089999.98


  ***TOTAL REACTION LOAD( KNS  MMS  ) SUMMARY (LOADING     1 )
      SUMMATION FORCE-X =        0.00
      SUMMATION FORCE-Y =     1090.00
      SUMMATION FORCE-Z =        0.00

     SUMMATION OF MOMENTS AROUND THE ORIGIN-
     MX=    -1089999.98  MY=          0.00  MZ=     1089999.98


  MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      1)
            MAXIMUMS    AT NODE
     X = -1.12983E-03      23
     Y = -1.01204E-02      28
     Z =  1.12983E-03       7
     RX=  0.00000E+00       0
     RY=  0.00000E+00       0
     RZ=  0.00000E+00       0

         STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     2

  ***TOTAL APPLIED LOAD ( KNS  MMS  ) SUMMARY (LOADING    2 )
      SUMMATION FORCE-X =      900.00
      SUMMATION FORCE-Y =        0.00
      SUMMATION FORCE-Z =        0.00

     SUMMATION OF MOMENTS AROUND THE ORIGIN-
     MX=           0.00  MY=      899999.97  MZ=    -1799999.93

   ***TOTAL REACTION LOAD( KNS  MMS  ) SUMMARY (LOADING     2 )
      SUMMATION FORCE-X =     -900.00
      SUMMATION FORCE-Y =        0.00
      SUMMATION FORCE-Z =        0.00

     SUMMATION OF MOMENTS AROUND THE ORIGIN-
     MX=           0.00  MY=     -899999.97  MZ=     1799999.93


  MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      2)
```

```
          MAXIMUMS    AT NODE
   X =  2.22892E-02       4
   Y =  7.83934E-03       4
   Z =  9.49033E-04      10
   RX=  0.00000E+00       0
   RY=  0.00000E+00       0
   RZ=  0.00000E+00       0

       STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     3

***TOTAL APPLIED LOAD ( KNS  MMS  ) SUMMARY (LOADING    3 )
    SUMMATION FORCE-X =        0.00
    SUMMATION FORCE-Y =        0.00
    SUMMATION FORCE-Z =        0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=           0.00  MY=           0.00  MZ=           0.00

***TOTAL REACTION LOAD( KNS  MMS  ) SUMMARY (LOADING     3 )
    SUMMATION FORCE-X =        0.00
    SUMMATION FORCE-Y =        0.00
    SUMMATION FORCE-Z =        0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=           0.00  MY=           0.00  MZ=           0.00

MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      3)
          MAXIMUMS    AT NODE
   X =  1.10000E-01       9
   Y = -1.21497E-02       6
   Z =  1.61372E-02      24
   RX=  0.00000E+00       0
   RY=  0.00000E+00       0
   RZ=  0.00000E+00       0

       STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     4

 ***TOTAL APPLIED LOAD ( KNS  MMS  ) SUMMARY (LOADING    4 )
    SUMMATION FORCE-X =        0.00
    SUMMATION FORCE-Y =      -95.76
    SUMMATION FORCE-Z =        0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=       95760.52  MY=           0.00  MZ=      -95760.52


***TOTAL REACTION LOAD( KNS  MMS  ) SUMMARY (LOADING     4 )
    SUMMATION FORCE-X =        0.00
    SUMMATION FORCE-Y =       95.76
    SUMMATION FORCE-Z =        0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=      -95760.52  MY=           0.00  MZ=       95760.52


MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      4)
          MAXIMUMS    AT NODE
   X =  3.17652E-05      50
   Y = -3.35288E-04      28
   Z = -3.17652E-05      50
   RX=  0.00000E+00       0
   RY=  0.00000E+00       0
   RZ=  0.00000E+00       0

       STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     5

***TOTAL APPLIED LOAD ( KNS  MMS  ) SUMMARY (LOADING    5 )
    SUMMATION FORCE-X =      900.00
    SUMMATION FORCE-Y =    -1185.76
    SUMMATION FORCE-Z =        0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=     1185760.50  MY=      899999.97  MZ=    -2985760.43

***TOTAL REACTION LOAD( KNS  MMS  ) SUMMARY (LOADING     5 )
    SUMMATION FORCE-X =     -900.00
```

```
      SUMMATION FORCE-Y =      1185.76
      SUMMATION FORCE-Z =         0.00

     SUMMATION OF MOMENTS AROUND THE ORIGIN-
     MX=    -1185760.50  MY=     -899999.97  MZ=     2985760.43

   MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      5)
            MAXIMUMS    AT NODE
     X =  1.10000E-01       9
     Y = -1.66887E-02      12
     Z =  1.62734E-02       4
     RX=  0.00000E+00       0
     RY=  0.00000E+00       0
     RZ=  0.00000E+00       0

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

   60. PRINT JOINT DISPLACEMENTS LIST 8 9

  JOINT DISPLACEMENT (CM   RADIANS)    STRUCTURE TYPE = SPACE
  ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    8    1     0.0000   -0.0010   -0.0008    0.0000    0.0000    0.0000
         2     0.0200    0.0001    0.0000    0.0000    0.0000    0.0000
         3     0.0193   -0.0049    0.0089    0.0000    0.0000    0.0000
         4     0.0000   -0.0003    0.0000    0.0000    0.0000    0.0000
         5     0.0393   -0.0062    0.0081    0.0000    0.0000    0.0000
        10     0.0200   -0.0009   -0.0009    0.0000    0.0000    0.0000
    9    1     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
         2     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
         3     0.1100    0.0000    0.0000    0.0000    0.0000    0.0000
         4     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
         5     0.1100    0.0000    0.0000    0.0000    0.0000    0.0000
        10     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

  ************** END OF LATEST ANALYSIS RESULT **************


   62. UNIT KNS METER
   63. PRINT SUPPORT REACTIONS

  SUPPORT REACTIONS -UNIT KNS  METE    STRUCTURE TYPE = SPACE
  -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1      16.05     74.37    -16.05      0.00      0.00      0.00
         2     -72.24   -232.67     42.18      0.00      0.00      0.00
         3    -202.27    -30.20   -119.24      0.00      0.00      0.00
         4       1.52      6.63     -1.52      0.00      0.00      0.00
         5    -256.94   -181.87    -94.63      0.00      0.00      0.00
        10     -56.19   -158.30     26.13      0.00      0.00      0.00
    5    1       0.00    135.25    -31.85      0.00      0.00      0.00
         2     -62.32     11.42     -0.05      0.00      0.00      0.00
         3   -1641.00    743.48   -228.79      0.00      0.00      0.00
         4       0.00     11.97     -2.98      0.00      0.00      0.00
         5   -1703.32    902.13   -263.67      0.00      0.00      0.00
        10     -62.32    146.68    -31.90      0.00      0.00      0.00
   21    1      31.85    135.25      0.00      0.00      0.00      0.00
         2    -159.92   -450.84      0.00      0.00      0.00      0.00
         3    -334.17   -292.36   -187.70      0.00      0.00      0.00
         4       2.98     11.97      0.00      0.00      0.00      0.00
         5    -459.26   -595.97   -187.70      0.00      0.00      0.00
        10    -128.07   -315.58      0.00      0.00      0.00      0.00
   25    1       0.00    251.52      0.00      0.00      0.00      0.00
         2    -138.00      9.51      0.00      0.00      0.00      0.00
         3   -1919.80    524.87  -1097.52      0.00      0.00      0.00
         4       0.00     21.34      0.00      0.00      0.00      0.00
         5   -2057.79    807.24  -1097.52      0.00      0.00      0.00
        10    -138.00    261.03      0.00      0.00      0.00      0.00
```

```
  SUPPORT REACTIONS -UNIT KNS  METE    STRUCTURE TYPE = SPACE
  -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    29    1    -31.85    135.25      0.00      0.00      0.00      0.00
          2   -170.27    431.34      0.00      0.00      0.00      0.00
          3    390.27     51.20    384.26      0.00      0.00      0.00
          4     -2.98     11.97      0.00      0.00      0.00      0.00
          5    185.18    629.77    384.26      0.00      0.00      0.00
         10   -202.12    566.59      0.00      0.00      0.00      0.00
    41    1     16.05     74.37     16.05      0.00      0.00      0.00
          2    -72.24   -232.67    -42.18      0.00      0.00      0.00
          3    -89.12   -273.99   -159.85      0.00      0.00      0.00
          4      1.52      6.63      1.52      0.00      0.00      0.00
          5   -143.78   -425.66   -184.46      0.00      0.00      0.00
         10    -56.19   -158.30    -26.13      0.00      0.00      0.00
    45    1      0.00    135.25     31.85      0.00      0.00      0.00
          2    -62.32     11.42      0.05      0.00      0.00      0.00
          3    -43.04    -75.25    -23.76      0.00      0.00      0.00
          4      0.00     11.97      2.98      0.00      0.00      0.00
          5   -105.36     83.40     11.12      0.00      0.00      0.00
         10    -62.32    146.68     31.90      0.00      0.00      0.00
    49    1    -16.05     74.37     16.05      0.00      0.00      0.00
          2    -81.35    226.24     45.03      0.00      0.00      0.00
          3    -77.83    207.38    119.24      0.00      0.00      0.00
          4     -1.52      6.63      1.52      0.00      0.00      0.00
          5   -176.75    514.62    181.84      0.00      0.00      0.00
         10    -97.40    300.61     61.08      0.00      0.00      0.00
     9    1    -16.05     74.37    -16.05      0.00      0.00      0.00
          2    -81.35    226.24    -45.03      0.00      0.00      0.00
          3   3916.95   -855.13   1313.37      0.00      0.00      0.00
          4     -1.52      6.63     -1.52      0.00      0.00      0.00
          5   3818.02   -547.89   1250.77      0.00      0.00      0.00
         10    -97.40    300.61    -61.08      0.00      0.00      0.00

  ************** END OF LATEST ANALYSIS RESULT **************

   65. UNIT NEWTON MMS
   66. PRINT ELEMENT JOINT STRESS SOLID LIST 4 6

ELEMENT STRESSES        UNITS= NEWTMMS
--------------------------------------------------------------------------------
             NODE/          NORMAL STRESSES              SHEAR STRESSES
ELEMENT LOAD CENTER       SXX        SYY        SZZ        SXY        SYZ        SZX
--------------------------------------------------------------------------------


    4    1      21      -0.088     -0.280     -0.098      0.001     -0.003      0.000
    4    1      25      -0.076     -0.204     -0.076     -0.003     -0.003      0.005
    4    1      26      -0.008     -0.214     -0.008      0.004      0.004      0.005
    4    1      22      -0.011     -0.280     -0.002      0.009     -0.011      0.009
    4    1      41      -0.095     -0.311     -0.095     -0.008     -0.008     -0.005
    4    1      45      -0.098     -0.280     -0.088     -0.003      0.001      0.000
    4    1      46      -0.002     -0.280     -0.011     -0.011      0.009      0.009
    4    1      42       0.011     -0.301      0.011     -0.016     -0.016      0.014

    4    1 CENTER       -0.046     -0.269     -0.046     -0.003     -0.003      0.005
             S1=      -0.041   S2=      -0.051   S3=      -0.269   SE=       0.223
             DC=        0.707     -0.021      0.707     -0.707      0.000      0.707

    4    2      21       0.176      1.021      0.284      0.217      0.014      0.005
    4    2      25       0.154     -0.006      0.022      0.251      0.014     -0.029
    4    2      26      -0.028      0.053     -0.015      0.253      0.016     -0.002
    4    2      22      -0.054      1.031      0.103      0.219      0.012     -0.036
    4    2      41       0.189      1.034      0.321      0.258      0.038      0.029
    4    2      45       0.162     -0.006      0.054      0.223     -0.010     -0.005
    4    2      46      -0.225     -0.016     -0.051      0.221     -0.008     -0.026
    4    2      42      -0.247      0.976      0.071      0.255      0.036     -0.060

    4    2 CENTER        0.016      0.511      0.099      0.237      0.014     -0.015
             S1=       0.606   S2=       0.101   S3=      -0.082   SE=       0.617
             DC=        0.372      0.928      0.014     -0.106      0.027      0.994
```

```
ELEMENT STRESSES       UNITS= NEWTMMS
-------------------------------------------------------------------------------
             NODE/          NORMAL STRESSES                 SHEAR STRESSES
ELEMENT LOAD CENTER      SXX        SYY        SZZ        SXY        SYZ        SZX
-------------------------------------------------------------------------------

    4    3      21      0.090      0.518      0.188      0.499      0.506      0.040
    4    3      25     -0.089     -0.574     -0.129      0.661      0.143     -0.123
    4    3      26      0.525     -0.328      0.365      0.565      0.047      0.327
    4    3      22      0.538      0.597      0.183      0.403      0.602      0.165
    4    3      41      0.215      0.951      0.255      0.011      0.589      0.123
    4    3      45      0.228      0.435      0.129     -0.152      0.060     -0.040
    4    3      46     -0.133      0.355      0.298     -0.056     -0.036      0.244
    4    3      42     -0.313      0.705     -0.076      0.107      0.685      0.082

    4    3 CENTER      0.132      0.332      0.152      0.255      0.324      0.102
             S1=      0.703   S2=      0.041   S3=     -0.128   SE=       0.760
             DC=       0.425      0.744      0.516      0.809     -0.055     -0.586

    4    4      21     -0.008     -0.024     -0.008     -0.001     -0.001      0.000
    4    4      25     -0.008     -0.022     -0.008     -0.001     -0.001      0.000
    4    4      26      0.001     -0.022      0.001     -0.001     -0.001      0.000
    4    4      22      0.001     -0.024      0.001     -0.001     -0.001      0.000
    4    4      41     -0.008     -0.026     -0.008     -0.001     -0.001      0.000
    4    4      45     -0.008     -0.024     -0.008     -0.001     -0.001      0.000
    4    4      46      0.001     -0.024      0.001     -0.001     -0.001      0.000
    4    4      42      0.001     -0.026      0.001     -0.001     -0.001      0.000

    4    4 CENTER     -0.004     -0.024     -0.004     -0.001     -0.001      0.000
             S1=     -0.003   S2=     -0.004   S3=     -0.024   SE=       0.021
             DC=       0.705     -0.070      0.705     -0.707      0.000      0.707

    4    5      21      0.170      1.235      0.366      0.716      0.515      0.045
    4    5      25     -0.019     -0.806     -0.191      0.908      0.153     -0.147
    4    5      26      0.490     -0.512      0.343      0.822      0.066      0.330
    4    5      22      0.474      1.324      0.285      0.630      0.602      0.138
    4    5      41      0.300      1.649      0.472      0.259      0.618      0.147
    4    5      45      0.283      0.125      0.087      0.067      0.050     -0.045
    4    5      46     -0.360      0.035      0.238      0.153     -0.036      0.228
    4    5      42     -0.548      1.354      0.007      0.345      0.704      0.036

    4    5 CENTER      0.099      0.551      0.201      0.487      0.334      0.092
             S1=      1.000   S2=      0.093   S3=     -0.243   SE=       1.114
             DC=       0.469      0.795      0.386     -0.452     -0.160      0.878

    4   10      21      0.088      0.741      0.186      0.218      0.011      0.005
    4   10      25      0.078     -0.210     -0.054      0.247      0.011     -0.024
    4   10      26     -0.036     -0.161     -0.022      0.257      0.020      0.003
    4   10      22     -0.065      0.751      0.102      0.228      0.001     -0.027
    4   10      41      0.093      0.724      0.225      0.249      0.030      0.024
    4   10      45      0.064     -0.286     -0.034      0.220     -0.009     -0.005
    4   10      46     -0.227     -0.296     -0.062      0.210      0.001     -0.016
    4   10      42     -0.236      0.675      0.082      0.240      0.020     -0.046

    4   10 CENTER     -0.030      0.242      0.053      0.234      0.011     -0.011
             S1=      0.376   S2=      0.054   S3=     -0.165   SE=       0.472
             DC=       0.498      0.867      0.012     -0.064      0.023      0.998


    6    1      23      0.317      0.428      0.402     -0.043     -0.126     -0.060
    6    1      27     -0.082     -1.708     -0.082     -0.098     -0.098     -0.005
    6    1      28     -0.670     -1.819     -0.670     -0.552     -0.552     -0.005
    6    1      24     -0.160      0.428      0.146     -0.497      0.329      0.051
    6    1      43     -0.108     -0.163     -0.108     -0.181     -0.181     -0.115
    6    1      47      0.402      0.428      0.317     -0.126     -0.043     -0.060
    6    1      48      0.146      0.428     -0.160      0.329     -0.497      0.051
    6    1      44     -0.253     -0.052     -0.253      0.273      0.273      0.106

    6    1 CENTER     -0.051     -0.254     -0.051     -0.112     -0.112     -0.005
             S1=      0.032   S2=     -0.046   S3=     -0.341   SE=       0.341
             DC=       0.619     -0.484      0.619     -0.707      0.000      0.707
```

```
ELEMENT STRESSES        UNITS= NEWTMMS
-------------------------------------------------------------------------------
             NODE/          NORMAL STRESSES              SHEAR STRESSES
ELEMENT LOAD CENTER      SXX        SYY        SZZ        SXY        SYZ        SZX
-------------------------------------------------------------------------------

    6    2      23     -0.032      0.112     -0.001      0.030     -0.002      0.016
    6    2      27     -0.001     -0.025     -0.046      0.073     -0.013     -0.027
    6    2      28     -0.096     -0.003     -0.065      0.083     -0.003     -0.035
    6    2      24     -0.085      0.177      0.109      0.040     -0.012     -0.078
    6    2      43     -0.152      0.158      0.052      0.136     -0.023     -0.005
    6    2      47     -0.140     -0.041     -0.013      0.092      0.008     -0.049
    6    2      48     -0.496     -0.105     -0.119      0.082      0.019     -0.014
    6    2      44     -0.464      0.136      0.076      0.125     -0.033     -0.057

    6    2 CENTER     -0.183      0.051     -0.001      0.083     -0.007     -0.031
             S1=       0.081   S2=     -0.001   S3=     -0.213   SE=       0.263
             DC=       0.314      0.928     -0.202     -0.060      0.232      0.971

    6    3      23     -0.274     -0.053     -0.004     -0.033     -0.047      0.041
    6    3      27     -0.314     -0.056     -0.102      0.064      0.030     -0.056
    6    3      28      0.182      0.057      0.061      0.040      0.006      0.021
    6    3      24      0.190      0.028      0.065     -0.057     -0.023     -0.076
    6    3      43      0.064     -0.048      0.069     -0.003     -0.031      0.056
    6    3      47      0.072      0.094      0.019     -0.100      0.014     -0.041
    6    3      48     -0.014      0.013     -0.012     -0.076     -0.010      0.006
    6    3      44     -0.053     -0.160     -0.056      0.021     -0.007     -0.091

    6    3 CENTER     -0.018     -0.016      0.005     -0.018     -0.009     -0.017
             S1=       0.014   S2=     -0.001   S3=     -0.042   SE=       0.051
             DC=      -0.484      0.038      0.874     -0.507      0.802     -0.316

    6    4      23      0.000     -0.024      0.000      0.000      0.000      0.000
    6    4      27      0.000     -0.024      0.000      0.000      0.000      0.000
    6    4      28      0.000     -0.024      0.000      0.000      0.000      0.000
    6    4      24      0.000     -0.024      0.000      0.000      0.000      0.000
    6    4      43      0.000     -0.024      0.000      0.000      0.000      0.000
    6    4      47      0.000     -0.024      0.000      0.000      0.000      0.000
    6    4      48      0.000     -0.024      0.000      0.000      0.000      0.000
    6    4      44      0.000     -0.024      0.000      0.000      0.000      0.000

    6    4 CENTER      0.000     -0.024      0.000      0.000      0.000      0.000
             S1=       0.000   S2=      0.000   S3=     -0.024   SE=       0.024
             DC=      -0.707      0.000      0.707      0.707     -0.002      0.707

    6    5      23      0.010      0.463      0.397     -0.046     -0.174     -0.003
    6    5      27     -0.397     -1.813     -0.230      0.039     -0.081     -0.088
    6    5      28     -0.585     -1.789     -0.674     -0.429     -0.550     -0.018
    6    5      24     -0.055      0.609      0.320     -0.514      0.294     -0.103
    6    5      43     -0.196     -0.077      0.014     -0.049     -0.236     -0.064
    6    5      47      0.334      0.458      0.323     -0.134     -0.020     -0.149
    6    5      48     -0.363      0.312     -0.291      0.335     -0.489      0.043
    6    5      44     -0.770     -0.101     -0.233      0.420      0.233     -0.042

    6    5 CENTER     -0.253     -0.242     -0.047     -0.047     -0.128     -0.053
             S1=       0.019   S2=     -0.210   S3=     -0.351   SE=       0.323
             DC=      -0.102     -0.422      0.901      0.819     -0.550     -0.165

    6   10      23      0.285      0.540      0.401     -0.013     -0.128     -0.044
    6   10      27     -0.083     -1.733     -0.129     -0.025     -0.111     -0.032
    6   10      28     -0.766     -1.822     -0.735     -0.469     -0.555     -0.039
    6   10      24     -0.245      0.605      0.255     -0.457      0.317     -0.028
    6   10      43     -0.259     -0.005     -0.055     -0.046     -0.204     -0.120
    6   10      47      0.262      0.388      0.304     -0.034     -0.034     -0.108
    6   10      48     -0.350      0.323     -0.279      0.411     -0.479      0.037
    6   10      44     -0.717      0.084     -0.177      0.399      0.240      0.049

    6   10 CENTER     -0.234     -0.203     -0.052     -0.029     -0.119     -0.036
             S1=       0.015   S2=     -0.206   S3=     -0.298   SE=       0.278
             DC=      -0.070     -0.472      0.879      0.822     -0.526     -0.217
```

```
67. FINISH


         *********** END OF THE STAAD.Pro RUN ***********

           **** DATE=                     TIME=  ****

     ************************************************************
     *         For questions on STAAD.Pro, please contact       *
     *   Research Engineers Offices at the following locations  *
     *                                                          *
     *              Telephone                 Email             *
     *  USA:      +1 (714)974-2500       support@bentley.com    *
     *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
     *  UK        +44(1454)207-000       support@reel.co.uk     *
     *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
     *  GERMANY   +49/931/40468-71       info@reig.de           *
     *  NORWAY    +47 67 57 21 30        staad@edr.no           *
     *  SINGAPORE +65 6225-6158          support@bentley.com    *
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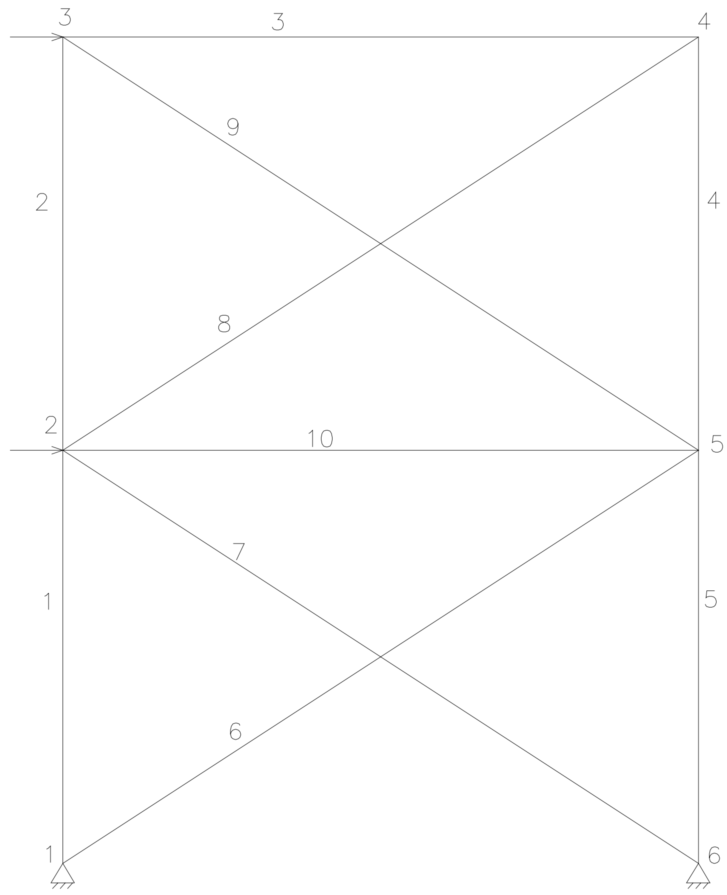
     *  CHINA     +86(411)363-1983       support@bentley.com    *
     *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
     *                                                          *
     *  North America                   support@bentley.com     *
     *  Europe                          support@bentley.com     *
     *  Asia                            support@bentley.com     *
     ************************************************************
```

NOTES

NOTES

Example Problem No. 25

This example demonstrates the usage of compression-only members. Since the structural condition is load dependent, the PERFORM ANALYSIS command is specified once for each primary load case.



This example has been created to illustrate the command specification for a structure with certain members capable of carrying compressive force only. It is important to note that the analysis can be done for only 1 load case at a time. This is because, the set of ‘active’ members (and hence the stiffness matrix) is load case dependent.

STAAD PLANE
*** EXAMPLE PROBLEM FOR COMPRESSION MEMBERS**

The input data is initiated with the word STAAD. This structure is a PLANE frame. The second line is an optional comment line.

UNIT FEET KIP

Units for the commands to follow are specified above.

SET NL 3

This structure has to be analysed for 3 primary load cases. Consequently, the modeling of our problem requires us to define 3 sets of data, with each set containing a load case and an associated analysis command. Also, the members which get switched off in the analysis for any load case have to be restored for the analysis for the subsequent load case. To accommodate these requirements, it is necessary to have 2 commands, one called “SET NL” and the other called “CHANGE”. The SET NL command is used above to indicate the total number of primary load cases that the file contains. The CHANGE command will come in later (after the PERFORM ANALYSIS command).

JOINT COORDINATES
1 0 0 ; 2 0 10 ; 3 0 20 ; 4 15 20 ; 5 15 10 ; 6 15 0

Joint coordinates of joints 1 to 6 are defined above.

```
MEMBER INCIDENCES
1 1 2 5
6 1 5 ; 7 2 6 ; 8 2 4 ; 9 3 5 ; 10 2 5
```

Member numbers, and the joints between which they are connected, are defined above. This model contains 10 members.

```
MEMBER COMPRESSION
6 TO 9
```

Members 6 to 9 are defined as COMPRESSION-only members. Hence for each load case, if during the analysis, any of the members 6 to 9 is found to be carrying a tensile force, it is disabled from the structure and the analysis is carried out again with the modified structure.

```
MEMBER PROPERTY AMERICAN
1 TO 10 TA ST W12X26
```

Properties for members 1 to 10 are defined as the STandard W12X26 section from the American AISC steel table.

```
UNIT INCH
CONSTANTS
E 29000.0 ALL
POISSON STEEL ALL
```

Following the command CONSTANTS, material constants such as E (Modulus of Elasticity) and Poisson’s ratio are specified. DENSITY is not specified since selfweight does not happen to be one of the load cases being solved for. The length units have been changed from feet to inch to facilitate the input of E.

```
SUPPORT
1 6 PINNED
```

Joints 1 and 6 are declared as pinned-supported.

```
LOAD 1
JOINT LOAD
2 FX 15
3 FX 10
```

Load 1 is defined above and consists of joint loads in the global X direction at joints 2 and 3.

PERFORM ANALYSIS

The above structure is analyzed for load case 1.

CHANGE
MEMBER COMPRESSION
6 TO 9

One or more among the members 6 to 9 may have been in-activated in the previous analysis. The CHANGE command restores the original structure to prepare it for the analysis for the next primary load case. The members with the compression-only attribute are specified again.

LOAD 2
JOINT LOAD
4 FX -10
5 FX -15

In load case 2, joint loads are applied in the negative global X direction at joints 4 and 5.

PERFORM ANALYSIS
CHANGE

The instruction to analyze the structure is specified again. Next, any compression-only members that were inactivated during the second analysis (due to the fact that they were subjected to tensile axial forces) are re-activated with the CHANGE command. Without the re-activation, these members cannot be accessed for further processing.

MEMBER COMPRESSION
6 TO 9

Members 6 to 9 are once again declared compression-only for the load case to follow.

LOAD 3
REPEAT LOAD
1 1.0 2 1.0

Load case 3 illustrates the technique employed to instruct STAAD to create a load case which consists of data to be assembled from other load cases already specified earlier. We would like the program to analyze the structure for loads from cases 1 and 2 acting simultaneously. In other words, the above instruction is the same as the following:

LOAD 3
JOINT LOAD
2 FX 15
3 FX 10
4 FX -15
5 FX –10

PERFORM ANALYSIS

The analysis is carried out for load case 3.

CHANGE

The members inactivated during the analysis of load case 3 are re-activated for further processing.

LOAD LIST ALL

At the end of any analysis, only those load cases for which the analysis was done most recently, are recognized as the "active" load cases. The LOAD LIST ALL command enables all the load cases in the structure to be made active for further processing.

PRINT ANALYSIS RESULTS

The program is instructed to write the joint displacements, support reactions and member forces to the output file.

FINISH

The STAAD run is terminated.

```
            ****************************************************
            *                                                  *
            *           STAAD.Pro                              *
            *           Version          Bld                   *
            *           Proprietary Program of                 *
            *           Research Engineers,  Intl.             *
            *           Date=                                  *
            *           Time=                                  *
            *                                                  *
            *      USER ID:                                    *
            ****************************************************

    1. STAAD PLANE EXAMPLE FOR COMPRESSION-ONLY MEMBERS
    2. UNIT FEET KIP
    3. SET NL 3
    4. JOINT COORDINATES
    5. 1 0 0 ; 2 0 10 ; 3 0 20 ; 4 15 20 ; 5 15 10 ; 6 15 0
    6. MEMBER INCIDENCES
    7. 1 1 2 5
    8. 6 1 5 ; 7 2 6 ; 8 2 4 ; 9 3 5 ; 10 2 5
    9. MEMBER COMPRESSION
   10. 6 TO 9
   11. MEMBER PROPERTY AMERICAN
   12. 1 TO 10 TA ST W12X26
   13. UNIT INCH
   14. CONSTANTS
   15. E 29000.0 ALL
   16. POISSON STEEL ALL
   17. SUPPORT
   18. 1 6 PINNED
   19. LOAD 1
   20. JOINT LOAD
   21. 2 FX 15
   22. 3 FX 10
   23. PERFORM ANALYSIS

           P R O B L E M   S T A T I S T I C S
           -----------------------------------

    NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     6/    10/     2
    ORIGINAL/FINAL BAND-WIDTH=     4/     4/     13 DOF
    TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     14
    SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
    REQRD/AVAIL. DISK SPACE  =    12.0/  3142.3 MB,  EXMEM =  568.1 MB

 **START ITERATION NO.           2

 **NOTE-Tension/Compression converged after  2 iterations, Case=    1

   24. CHANGE
   25. MEMBER COMPRESSION
   26. 6 TO 9
   27. LOAD 2
   28. JOINT LOAD
   29. 4 FX -10
   30. 5 FX -15
   31. PERFORM ANALYSIS
 **START ITERATION NO.           2

 **NOTE-Tension/Compression converged after  2 iterations, Case=    2

   32. CHANGE
   33. MEMBER COMPRESSION
   34. 6 TO 9
   35. LOAD 3
   36. REPEAT LOAD
   37. 1 1.0 2 1.0
   38. PERFORM ANALYSIS

 **NOTE-Tension/Compression converged after  1 iterations, Case=    3

   39. CHANGE
   40. LOAD LIST ALL
```

```
  41. PRINT ANALYSIS RESULTS

 JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = PLANE
 ------------------
JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    1    1    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00041
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00050
         3    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00004
    2    1    0.04314   0.01262   0.00000   0.00000   0.00000  -0.00025
         2   -0.05088  -0.00373   0.00000   0.00000   0.00000   0.00024
         3    0.00364   0.00080   0.00000   0.00000   0.00000  -0.00001
    3    1    0.07775   0.01618   0.00000   0.00000   0.00000  -0.00022
         2   -0.07766  -0.00381   0.00000   0.00000   0.00000   0.00015
         3    0.00255   0.00215   0.00000   0.00000   0.00000   0.00001
    4    1    0.07766  -0.00381   0.00000   0.00000   0.00000  -0.00015
         2   -0.07775   0.01618   0.00000   0.00000   0.00000   0.00022
         3   -0.00255   0.00215   0.00000   0.00000   0.00000  -0.00001
    5    1    0.05088  -0.00373   0.00000   0.00000   0.00000  -0.00024
         2   -0.04314   0.01262   0.00000   0.00000   0.00000   0.00025
         3   -0.00364   0.00080   0.00000   0.00000   0.00000   0.00001
    6    1    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00050
         2    0.00000   0.00000   0.00000   0.00000   0.00000   0.00041
         3    0.00000   0.00000   0.00000   0.00000   0.00000   0.00004

 SUPPORT REACTIONS -UNIT KIP  INCH    STRUCTURE TYPE = PLANE
 -----------------
JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1      -0.13    -23.33      0.00      0.00      0.00      0.00
         2      24.87     23.33      0.00      0.00      0.00      0.00
         3       2.18      0.00      0.00      0.00      0.00      0.00
    6    1     -24.87     23.33      0.00      0.00      0.00      0.00
         2       0.13    -23.33      0.00      0.00      0.00      0.00
         3      -2.18      0.00      0.00      0.00      0.00      0.00

 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  INCH

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1    -23.33      0.13     0.00      0.00      0.00       0.00
               2     23.33     -0.13     0.00      0.00      0.00      15.88
         2     1      6.90     -0.22     0.00      0.00      0.00       0.00
               2     -6.90      0.22     0.00      0.00      0.00     -25.90
         3     1     -1.47      0.03     0.00      0.00      0.00       0.00
               2      1.47     -0.03     0.00      0.00      0.00       3.24

    2    1     2     -6.58      0.24     0.00      0.00      0.00      12.73
               3      6.58     -0.24     0.00      0.00      0.00      15.70
         2     2      0.15     -0.11     0.00      0.00      0.00      -2.32
               3     -0.15      0.11     0.00      0.00      0.00     -11.30
         3     2     -2.50     -0.03     0.00      0.00      0.00      -2.74
               3      2.50      0.03     0.00      0.00      0.00      -0.79

    3    1     3      0.11     -0.15     0.00      0.00      0.00     -15.70
               4     -0.11      0.15     0.00      0.00      0.00     -11.30
         2     3      0.11      0.15     0.00      0.00      0.00      11.30
               4     -0.11     -0.15     0.00      0.00      0.00      15.70
         3     3      6.28      0.00     0.00      0.00      0.00       0.79
               4     -6.28      0.00     0.00      0.00      0.00      -0.79

    4    1     4      0.15      0.11     0.00      0.00      0.00      11.30
               5     -0.15     -0.11     0.00      0.00      0.00       2.32
         2     4     -6.58     -0.24     0.00      0.00      0.00     -15.70
               5      6.58      0.24     0.00      0.00      0.00     -12.73
         3     4     -2.50      0.03     0.00      0.00      0.00       0.79
               5      2.50     -0.03     0.00      0.00      0.00       2.74

    5    1     5      6.90      0.22     0.00      0.00      0.00      25.90
               6     -6.90     -0.22     0.00      0.00      0.00       0.00
         2     5    -23.33     -0.13     0.00      0.00      0.00     -15.88
               6     23.33      0.13     0.00      0.00      0.00       0.00
         3     5     -1.47     -0.03     0.00      0.00      0.00      -3.24
               6      1.47      0.03     0.00      0.00      0.00       0.00
```

```
 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  INCH

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    6    1     1      0.00      0.00     0.00      0.00      0.00       0.00
               5      0.00      0.00     0.00      0.00      0.00       0.00
         2     1     29.63      0.00     0.00      0.00      0.00       0.00
               5    -29.63      0.00     0.00      0.00      0.00       0.00
         3     1      2.66      0.00     0.00      0.00      0.00       0.00
               5     -2.66      0.00     0.00      0.00      0.00       0.00

    7    1     2     29.63      0.00     0.00      0.00      0.00       0.00
               6    -29.63      0.00     0.00      0.00      0.00       0.00
         2     2      0.00      0.00     0.00      0.00      0.00       0.00
               6      0.00      0.00     0.00      0.00      0.00       0.00
         3     2      2.66      0.00     0.00      0.00      0.00       0.00
               6     -2.66      0.00     0.00      0.00      0.00       0.00

    8    1     2      0.00      0.00     0.00      0.00      0.00       0.00
               4      0.00      0.00     0.00      0.00      0.00       0.00
         2     2     11.60      0.00     0.00      0.00      0.00       0.00
               4    -11.60      0.00     0.00      0.00      0.00       0.00
         3     2      4.51      0.00     0.00      0.00      0.00       0.00
               4     -4.51      0.00     0.00      0.00      0.00       0.00

    9    1     3     11.60      0.00     0.00      0.00      0.00       0.00
               5    -11.60      0.00     0.00      0.00      0.00       0.00
         2     3      0.00      0.00     0.00      0.00      0.00       0.00
               5      0.00      0.00     0.00      0.00      0.00       0.00
         3     3      4.51      0.00     0.00      0.00      0.00       0.00
               5     -4.51      0.00     0.00      0.00      0.00       0.00

   10    1     2     -9.55     -0.32     0.00      0.00      0.00     -28.60
               5      9.55      0.32     0.00      0.00      0.00     -28.22
         2     2     -9.55      0.32     0.00      0.00      0.00      28.22
               5      9.55     -0.32     0.00      0.00      0.00      28.60
         3     2      8.98      0.00     0.00      0.00      0.00      -0.50
               5     -8.98      0.00     0.00      0.00      0.00       0.50


 ************** END OF LATEST ANALYSIS RESULT **************

  42. FINISH

           *********** END OF THE STAAD.Pro RUN ***********

             **** DATE=               TIME=          ****

       ************************************************************
       *         For questions on STAAD.Pro, please contact       *
       *   Research Engineers Offices at the following locations  *
       *                                                          *
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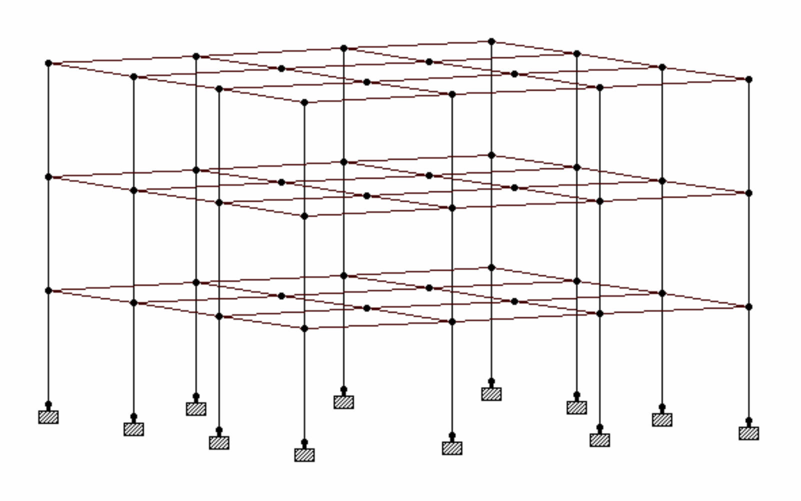
       *  UK        +44(1454)207-000       support@reel.co.uk     *
       *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
       *  GERMANY   +49/931/40468-71       info@reig.de           *
       *  NORWAY    +47 67 57 21 30        staad@edr.no           *
       *  SINGAPORE +65 6225-6158          support@bentley.com    *
       *  INDIA     +91(033)4006-2021      support@bentley.com    *
       *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
       *  CHINA     +86(411)363-1983       support@bentley.com    *
       *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
       *                                                          *
       *  North America                   support@bentley.com     *
       *  Europe                          support@bentley.com     *
       *  Asia                            support@bentley.com     *
       ************************************************************
```

NOTES

Example Problem No. 26

The structure in this example is a building consisting of member columns as well as floors made up of beam members and plate elements. Using the master-slave command, the floors are specified to be rigid diaphragms for inplane actions but flexible for bending actions.



```
STAAD SPACE
*MODELING RIGID DIAPHRAGMS USING MASTER SLAVE
```

Every STAAD input file has to begin with the word STAAD. The word SPACE signifies that the structure is a space frame and the geometry is defined through X, Y and Z axes. The second line is an optional title to identify this project.

```
UNITS KIP FT
```

Specify units for the data to follow.

```
JOINT COORD
1 0 0 0 4 0 48 0
REPEAT 3 24 0 0
REPEAT ALL 3 0 0 24
DELETE JOINT 21 25 37 41
```

The joint numbers and coordinates are specified above. The unwanted joints, created during the generation process used above, are then deleted.

```
MEMBER INCI
1 1 2 3 ; 4 5 6 6 ; 7 9 10 9 ; 10 13 14 12
13 17 18 15 ; 22 29 30 24 ; 25 33 34 27
34 45 46 36 ; 37 49 50 39 ; 40 53 54 42
43 57 58 45 ; 46 61 62 48 ; 49 2 6 51
52 6 10 54 ; 55 10 14 57 ; 58 18 22 60
61 22 26 63 ; 64 26 30 66 ; 67 34 38 69
70 38 42 72 ; 73 42 46 75 ; 76 50 54 78
79 54 58 81 ; 82 58 62 84 ; 85 18 2 87
88 22 6 90 ; 91 26 10 93 ; 94 30 14 96
97 34 18 99 ; 100 38 22 102 ; 103 42 26 105
106 46 30 108 ; 109 50 34 111 ; 112 54 38 114
115 58 42 117 ; 118 62 46 120
```

The MEMBER INCIDENCE specification is used for specifying MEMBER connectivities.

```
ELEMENT INCI
152 50 34 38 54 TO 154
155 54 38 42 58 TO 157
158 58 42 46 62 TO 160
161 34 18 22 38 TO 163
164 38 22 26 42 TO 166
167 42 26 30 46 TO 169
170 18  2  6 22 TO 172
173 22  6 10 26 TO 175
176 26 10 14 30 TO 178
```

The ELEMENT INCIDENCE specification is used for specifying plate element connectivities.

```
MEMBER PROPERTIES AMERICAN
1 TO 15 22 TO 27 34 TO 48 TA ST W14X90
49 TO 120 TABLE ST W27X84
```

All members are WIDE FLANGE sections whose properties are obtained from the built in American table.

```
ELEMENT PROP
152 TO 178 THICK 0.75
```

The thickness of the plate elements is specified above.

```
CONSTANTS
E STEEL MEMB 1 TO 15 22 TO 27 34 TO 120
DENSITY STEEL MEMB 1 TO 15 22 TO 27 34 TO 120
POISSON STEEL MEMB 1 TO 15 22 TO 27 34 TO 120
BETA 90.0 MEMB 13 14 15 22 TO 27 34 TO 39
E CONCRETE MEMB 152 TO 178
DENSITY CONCRETE MEMB 152 TO 178
POISSON CONCRETE MEMB 152 TO 178
```

Following the command CONSTANTS above, the material constants such as E (Modulus of Elasticity), Poisson's Ratio, and Density are specified. Built-in default values for steel and concrete for these quantities are assigned. The orientation of some of the members is set using the BETA angle command.

```
SUPPORTS
1 TO 17 BY 4 29 33 45 TO 61 BY 4 FIXED
```

The supports at the above mentioned joints are declared as fixed.

```
SLAVE DIA ZX MASTER 22 JOINTS YR 15.0 17.0
SLAVE DIA ZX MASTER 23 JOINTS YR 31.0 33.0
SLAVE DIA ZX MASTER 24 JOINTS YR 47.0 49.0
```

The 3 floors of the structure are specified to act as rigid diaphragms in the ZX plane with the corresponding master joint specified. The associated slave joints in a floor are specified by the YRANGE parameter. The floors may still resist out-of-plane bending actions flexibly.

```
LOADING 1 LATERAL LOADS
JOINT LOADS
2 3 4 14 15 16 50 51 52 62 63 64 FZ 10.0
6 7 8 10 11 12 18 19 20 30 31 32 FZ 20.0
34 35 36 46 47 48 54 55 56 58 59 60 FZ 20.0
22 23 24 26 27 28 38 39 40 42 43 44 FZ 40.0
```

The above data describe a static load case. It consists of joint loads in the global Z direction.

```
LOADING 2 TORSIONAL LOADS
JOINT LOADS
2 3 4 50 51 52 FZ 5.0
14 15 16 62 63 64 FZ 15.0
6 7 8 18 19 20 FZ 10.0
10 11 12 30 31 32 FZ 30.0
34 35 36 54 55 56 FZ 10.0
46 47 48 58 59 60 FZ 30.0
22 23 24 38 39 40 FZ 20.0
26 27 28 42 43 44 FZ 60.0
```

The above data describe a second static load case. It consists of joint loads that create a torsional loading on the structure.

```
LOADING 3 DEAD LOAD
ELEMENT LOAD
152 TO 178 PRESS GY -1.0
```

In the above static load case, plate element pressure loading on a floor is applied in the negative global Y direction.

```
PERFORM ANALYSIS
```

The above command instructs the program to proceed with the analysis.

```
PRINT JOINT DISP LIST 4 TO 60 BY 8
PRINT MEMBER FORCES LIST 116 115
PRINT SUPPORT REACTIONS LIST 9 57
```

Print displacements at selected joints, then print member forces for two members, then print support reactions at selected joints.

```
FINISH
```

The STAAD run is terminated.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

 1. STAAD SPACE
 2. *MODELING RIGID DIAPHRAGMS USING MASTER SLAVE
 3. UNITS KIP FT
 5. JOINT COORD
 6. 1 0 0 0 4 0 48 0
 7. REPEAT 3 24 0 0
 8. REPEAT ALL 3 0 0 24
 9. DELETE JOINT 21 25 37 41
11. MEMBER INCI
12. 1 1 2 3 ; 4 5 6 6 ; 7 9 10 9 ; 10 13 14 12
13. 13 17 18 15 ; 22 29 30 24 ; 25 33 34 27
14. 34 45 46 36 ; 37 49 50 39 ; 40 53 54 42
15. 43 57 58 45 ; 46 61 62 48 ; 49 2 6 51
16. 52 6 10 54 ; 55 10 14 57 ; 58 18 22 60
17. 61 22 26 63 ; 64 26 30 66 ; 67 34 38 69
18. 70 38 42 72 ; 73 42 46 75 ; 76 50 54 78
19. 79 54 58 81 ; 82 58 62 84 ; 85 18 2 87
20. 88 22 6 90 ; 91 26 10 93 ; 94 30 14 96
21. 97 34 18 99 ; 100 38 22 102 ; 103 42 26 105
22. 106 46 30 108 ; 109 50 34 111 ; 112 54 38 114
23. 115 58 42 117 ; 118 62 46 120
25. ELEMENT INCI
26. 152 50 34 38 54 TO 154
27. 155 54 38 42 58 TO 157
28. 158 58 42 46 62 TO 160
29. 161 34 18 22 38 TO 163
30. 164 38 22 26 42 TO 166
31. 167 42 26 30 46 TO 169
32. 170 18  2  6 22 TO 172
33. 173 22  6 10 26 TO 175
34. 176 26 10 14 30 TO 178
36. MEMBER PROPERTIES AMERICAN
37. 1 TO 15 22 TO 27 34 TO 48 TA ST W14X90
38. 49 TO 120 TABLE ST W27X84
39. ELEMENT PROP
40. 152 TO 178 THICK 0.75
42. CONSTANTS
43. E STEEL MEMB 1 TO 15 22 TO 27 34 TO 120
44. DENSITY STEEL MEMB 1 TO 15 22 TO 27 34 TO 120
45. POISSON STEEL MEMB 1 TO 15 22 TO 27 34 TO 120
46. BETA 90.0 MEMB 13 14 15 22 TO 27 34 TO 39
47. E CONCRETE MEMB 152 TO 178
48. DENSITY CONCRETE MEMB 152 TO 178
49. POISSON CONCRETE MEMB 152 TO 178
51. SUPPORTS
52. 1 TO 17 BY 4 29 33 45 TO 61 BY 4 FIXED
54. SLAVE DIA ZX MASTER 22 JOINTS YR 15.0 17.0
55. SLAVE DIA ZX MASTER 23 JOINTS YR 31.0 33.0
56. SLAVE DIA ZX MASTER 24 JOINTS YR 47.0 49.0
58. LOADING 1 LATERAL LOADS
59. JOINT LOADS
60. 2 3 4 14 15 16 50 51 52 62 63 64 FZ 10.0
61. 6 7 8 10 11 12 18 19 20 30 31 32 FZ 20.0
62. 34 35 36 46 47 48 54 55 56 58 59 60 FZ 20.0
63. 22 23 24 26 27 28 38 39 40 42 43 44 FZ 40.0
65. LOADING 2 TORSIONAL LOADS
66. JOINT LOADS
67. 2 3 4 50 51 52 FZ 5.0
68. 14 15 16 62 63 64 FZ 15.0
69. 6 7 8 18 19 20 FZ 10.0
70. 10 11 12 30 31 32 FZ 30.0
71. 34 35 36 54 55 56 FZ 10.0
72. 46 47 48 58 59 60 FZ 30.0
```

```
 73. 22 23 24 38 39 40 FZ 20.0
 74. 26 27 28 42 43 44 FZ 60.0
 76. LOADING 3 DEAD LOAD
 77. ELEMENT LOAD
 78. 152 TO 178 PRESS GY -1.0
 80. PERFORM ANALYSIS

        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    60/   135/    12
  ORIGINAL/FINAL BAND-WIDTH=    20/    17/    113 DOF
  TOTAL PRIMARY LOAD CASES =    3, TOTAL DEGREES OF FREEDOM =    153
  SIZE OF STIFFNESS MATRIX =      18 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =    12.5/  3142.2 MB,  EXMEM =  568.1 MB


 82. PRINT JOINT DISP LIST 4 TO 60 BY 8

 JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = SPACE
 ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    4    1    0.23216   0.04609   8.13263   0.00108  -0.00056  -0.00008
         2    1.49676   0.04919   6.87442   0.00090  -0.00363  -0.00046
         3    0.02679  -0.19716  -0.32921   0.00792  -0.00041  -0.00625
   12    1    0.23216   0.02166   8.45739   0.00159  -0.00056   0.00014
         2    1.49676   0.02716   8.96702   0.00166  -0.00363   0.00000
         3    0.02679  -0.86713  -0.09027   0.07454  -0.00041   0.00495
   20    1    0.06978  -0.00054   8.13263   0.00120  -0.00056  -0.00025
         2    0.45046   0.00140   6.87442   0.00103  -0.00363  -0.00031
         3   -0.09268  -0.88242  -0.32921   0.00452  -0.00041  -0.07454
   28    1    0.06978  -0.07792   8.45739  -0.00058  -0.00056   0.00024
         2    0.45046  -0.07823   8.96702  -0.00059  -0.00363   0.00028
         3   -0.09268 -21.50252  -0.09027   0.04716  -0.00041   0.04703
   36    1   -0.09261   0.02065   8.13263   0.00102  -0.00056   0.00030
         2   -0.59584   0.01536   6.87442   0.00088  -0.00363   0.00036
         3   -0.21215  -0.86781  -0.32921  -0.00503  -0.00041  -0.07452
   44    1   -0.09261   0.08468   8.45739  -0.00057  -0.00056  -0.00028
         2   -0.59584   0.08128   8.96702  -0.00059  -0.00363  -0.00031
         3   -0.21215 -21.51350  -0.09027  -0.04712  -0.00041   0.04704
   52    1   -0.25499  -0.06556   8.13263   0.00245  -0.00056  -0.00002
         2   -1.64214  -0.06312   6.87442   0.00207  -0.00363   0.00017
         3   -0.33161  -0.19363  -0.32921  -0.00649  -0.00041  -0.00791
   60    1   -0.25499  -0.02115   8.45739   0.00162  -0.00056  -0.00014
         2   -1.64214  -0.02678   8.96702   0.00167  -0.00363   0.00001
         3   -0.33161  -0.86677  -0.09027  -0.07468  -0.00041   0.00504

 ************** END OF LATEST ANALYSIS RESULT **************

 83. PRINT MEMBER FORCES LIST 116 115

 MEMBER END FORCES    STRUCTURE TYPE = SPACE
 -----------------
 ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z


  116    1    59      0.00      4.73     0.00      0.00      0.00     198.84
              43      0.00     -4.73     0.00      0.00      0.00     -85.38
         2    59      0.00      5.10     0.00     -0.01      0.00     208.23
              43      0.00     -5.10     0.00      0.01      0.00     -85.83
         3    59      0.00    129.34     0.00      0.32      0.00    1407.27
              43      0.00   -129.34     0.00     -0.32      0.00    1696.94

  115    1    58      0.00      7.70     0.00     -0.01      0.00     322.14
              42      0.00     -7.70     0.00      0.01      0.00    -137.41
         2    58      0.00      8.32     0.00     -0.01      0.00     336.88
              42      0.00     -8.32     0.00      0.01      0.00    -137.13
         3    58      0.00    125.39     0.00      0.34      0.00    1173.82
              42      0.00   -125.39     0.00     -0.34      0.00    1835.58


 ************** END OF LATEST ANALYSIS RESULT **************
```

```
 84. PRINT SUPPORT REACTIONS LIST 9 57

 SUPPORT REACTIONS -UNIT KIP  FEET    STRUCTURE TYPE = SPACE
 -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

     9    1     -6.98    -54.60    -54.87   -470.13      0.01     50.69
          2    -28.54    -69.17    -58.55   -500.63      0.03    231.31
          3    -14.10   1732.37     92.25    487.26      0.00     70.68
    57    1      7.65     53.36    -54.76   -469.56      0.01    -55.90
          2     31.74     68.14    -58.52   -500.47      0.03   -257.51
          3    -11.82   1731.53    -91.91   -483.96      0.00     51.09


 ************** END OF LATEST ANALYSIS RESULT **************


 86. FINISH

          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE=               TIME=          ****

       ************************************************************
       *         For questions on STAAD.Pro, please contact       *
       *   Research Engineers Offices at the following locations  *
       *                                                          *
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       *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
       *  GERMANY   +49/931/40468-71       info@reig.de           *
       *  NORWAY    +47 67 57 21 30        staad@edr.no           *
       *  SINGAPORE +65 6225-6158          support@bentley.com    *
       *  INDIA     +91(033)4006-2021      support@bentley.com    *
       *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
       *  CHINA     +86(411)363-1983       support@bentley.com    *
       *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
       *                                                          *
       *  North America                   support@bentley.com     *
       *  Europe                          support@bentley.com     *
       *  Asia                            support@bentley.com     *
       ************************************************************
```

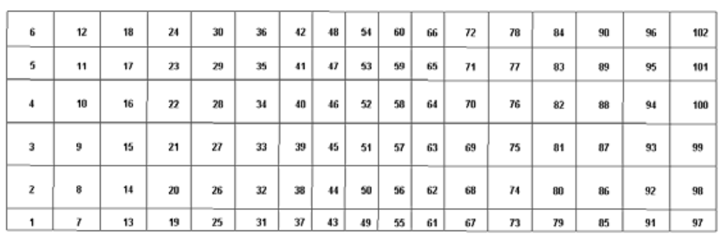
NOTES

NOTES

Example Problem No. 27

This example illustrates the usage of commands necessary to apply the compression only attribute to spring supports for a slab on grade. The spring supports themselves are generated utilizing the built-in support generation facility. The slab is subjected to pressure and overturning loading. A tension/compression only analysis of the structure is performed.

The numbers shown in the diagram below are the element numbers.



```
STAAD SPACE SLAB ON GRADE
* SPRING COMPRESSION EXAMPLE
```

Every STAAD input file has to begin with the word STAAD. The word SPACE signifies that the structure is a space frame and the geometry is defined through X, Y and Z axes. An optional title to identify this project is provided in the second line.

```
SET  NL  3
```

This structure has to be analysed for 3 primary load cases. Consequently, the modeling of our problem requires us to define 3 sets of data, with each set containing a load case and an associated analysis command. Also, the supports which get switched off in the analysis for any load case have to be restored for the analysis for the subsequent load case. To accommodate these requirements, it is necessary to have 2 commands, one called “SET NL” and the other called “CHANGE”. The SET NL command is used above to indicate the total number of primary load cases that the file contains. The CHANGE command will come in later (after the PERFORM ANALYSIS command).

```
UNIT FEET KIP
JOINT COORDINATES
1 0.0 0.0 40.0
2 0.0 0.0 36.0
3 0.0 0.0 28.167
4 0.0 0.0 20.333
5 0.0 0.0 12.5
6 0.0 0.0  6.5
7 0.0 0.0  0.0
REPEAT ALL 3 8.5 0.0 0.0
REPEAT 3 8.0 0.0 0.0
REPEAT 5 6.0 0.0 0.0
REPEAT 3 8.0 0.0 0.0
REPEAT 3 8.5 0.0 0.0
```

For joints 1 through 7, the joint number followed by the X, Y and Z coordinates are specified above. The coordinates of these joints is used as a basis for generating 21 more joints by incrementing the X coordinate of each of these 7 joints by 8.5 feet, 3 times.

REPEAT commands are used to generate the remaining joints of the structure. The results of the generation may be visually verified using the STAAD graphical viewing facilities.

```
ELEMENT INCIDENCES
1 1 8 9 2 TO 6
REPEAT 16 6 7
```

The incidences of element number 1 is defined and the data is used as the basis for generating the 2nd through the 6th element. The incidence pattern of the first 6 elements is then used to generate the incidences of 96 more elements using the REPEAT command.

```
UNIT INCH
ELEMENT PROPERTIES
1 TO 102 TH 8.0
```

The thickness of elements 1 to 102 is specified as 8.0 inches following the command ELEMENT PROPERTIES.

```
CONSTANTS
E 4000.0 ALL
POISSON 0.12 ALL
```

The modulus of elasticity (E) and Poisson's Ratio are specified following the command CONSTANTS.

```
SPRING COMPRESSION
1 TO 126 KFY
```

The above two lines declare the spring supports at nodes 1 to 126 as having the compression-only attribute. The supports themselves are being generated later (see the ELASTIC MAT command which appears later).

```
UNIT FEET
SUPPORTS
1 TO 126  ELASTIC MAT DIRECTION Y SUBGRADE 12.0
```

The above command is used to instruct STAAD to generate support springs which are effective in the global Y direction. These springs are located at nodes 1 to 126. The subgrade modulus of the soil is specified as 12 kip/cu.ft. The program will determine the area under the influence of each joint and multiply the influence area by the subgrade modulus to arrive at the spring stiffness for the "FY" degree of freedom at the joint. Units for length are changed to FEET to facilitate the input of subgrade modulus of soil. Additional information on this feature may be found in the STAAD Technical Reference Manual.

```
LOAD 1 'WEIGHT OF MAT & EARTH'
ELEMENT LOAD
1 TO 102 PR GY -1.50
```

The above data describe a static load case. A pressure load of 1.50 kip/sq.ft acting in the negative global Y direction is applied on all the elements.

```
PERFORM ANALYSIS PRINT STATICS CHECK
CHANGE
```

Tension/compression cases must each be followed by PERFORM ANALYSIS and CHANGE commands. The CHANGE command restores the original structure to prepare it for the analysis for the next primary load case.

```
LOAD 2 'COLUMN LOAD-DL+LL'
JOINT LOADS
1 2   FY -217.
8 9   FY -109.
5     FY -308.7
6     FY -617.4
22 23 FY -410.
29 30 FY -205.
26    FY -542.7
27    FY -1085.4
43 44 50 51 71 72 78 79 FY -307.5
47 54 82    FY -264.2
```

```
48 55 76 83 FY -528.3
92 93       FY -205.0
99 100      FY -410.0
103         FY -487.0
104         FY -974.0
113 114     FY -109.0
120 121     FY -217.0
124         FY -273.3
125         FY -546.6

PERFORM ANALYSIS PRINT STATICS CHECK
CHANGE
```

Load case 2 consists of several joint loads acting in the negative global Y direction. This is followed by another ANALYSIS command. The CHANGE command restores the original structure once again for the forthcoming load case.

```
LOAD 3 'COLUMN OVERTURNING LOAD'
ELEMENT LOAD
1 TO 102 PR GY -1.50
JOINT LOADS
1 2   FY -100.
8 9   FY -50.
5     FY -150.7
6     FY -310.4
22 23 FY -205.
29 30 FY -102.
26    FY -271.7
27    FY -542.4
43 44 50 51 71 72 78 79 FY -153.5
47 54 82    FY -132.2
48 55 76 83 FY -264.3
92 93       FY 102.0
99 100      FY 205.0
103         FY 243.0
104         FY 487.0
113 114     FY 54.0
120 121     FY 108.0
```

```
124         FY 136.3
125         FY 273.6

PERFORM ANALYSIS PRINT STATICS CHECK
```

Load case 3 consists of several joint loads acting in the upward direction at one end and downward on the other end to apply an overturning moment that will lift off one end. The CHANGE command is not needed after the last analysis.

```
LOAD LIST 3
PRINT JOINT DISPLACEMENTS LIST 113 114 120 121
PRINT ELEMENT STRESSES LIST 34 67
PRINT SUPPORT REACTIONS LIST 5 6 12 13
```

A list of joint displacements, element stresses for elements 34 and 67, and support reactions at a list of joints, are obtained for load case 3, with the help of the above commands.

```
FINISH
```

The STAAD run is terminated.

```
           ****************************************************
           *                                                  *
           *           STAAD.Pro                              *
           *           Version          Bld                   *
           *           Proprietary Program of                 *
           *           Research Engineers,  Intl.             *
           *           Date=                                  *
           *           Time=                                  *
           *                                                  *
           *      USER ID:                                    *
           ****************************************************

   1. STAAD SPACE SLAB ON GRADE
   2. * SPRING COMPRESSION EXAMPLE
   3. SET NL 3
   4. UNIT FEET KIP
   6. JOINT COORDINATES
   7. 1 0.0 0.0 40.0
   8. 2 0.0 0.0 36.0
   9. 3 0.0 0.0 28.167
  10. 4 0.0 0.0 20.333
  11. 5 0.0 0.0 12.5
  12. 6 0.0 0.0  6.5
  13. 7 0.0 0.0  0.0
  14. REPEAT ALL 3 8.5 0.0 0.0
  15. REPEAT 3 8.0 0.0 0.0
  16. REPEAT 5 6.0 0.0 0.0
  17. REPEAT 3 8.0 0.0 0.0
  18. REPEAT 3 8.5 0.0 0.0
  20. ELEMENT INCIDENCES
  21. 1 1 8 9 2 TO 6
  22. REPEAT 16 6 7
  24. UNIT INCH
  25. ELEMENT PROPERTIES
  26. 1 TO 102 TH 8.0
  28. CONSTANTS
  29. E 4000.0 ALL
  30. POISSON 0.12 ALL
  32. SPRING COMPRESSION
  33. 1 TO 126 KFY
  35. UNIT FEET
  36. SUPPORTS
  37. 1 TO 126  ELASTIC MAT DIRECTION Y SUBGRADE 12.0
  39. LOAD 1 'WEIGHT OF MAT & EARTH'
  40. ELEMENT LOAD
  41. 1 TO 102 PR GY -1.50
  43. PERFORM ANALYSIS PRINT STATICS CHECK

          P R O B L E M   S T A T I S T I C S
          -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =   126/   102/   126
   ORIGINAL/FINAL BAND-WIDTH=     8/     8/     54 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =    756
   SIZE OF STIFFNESS MATRIX =       41 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =     13.0/  40260.7 MB

**NOTE-Tension/Compression converged after  1 iterations, Case=    1

        STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     1
        'WEIGHT OF MAT & EARTH'

 ***TOTAL APPLIED LOAD ( KIP  FEET ) SUMMARY (LOADING    1 )
     SUMMATION FORCE-X =        0.00
     SUMMATION FORCE-Y =    -7740.00
     SUMMATION FORCE-Z =        0.00

    SUMMATION OF MOMENTS AROUND THE ORIGIN-
    MX=      154800.01  MY=           0.00  MZ=     -499230.03

 ***TOTAL REACTION LOAD( KIP  FEET ) SUMMARY (LOADING     1 )
     SUMMATION FORCE-X =        0.00
     SUMMATION FORCE-Y =     7740.00
     SUMMATION FORCE-Z =        0.00
    SUMMATION OF MOMENTS AROUND THE ORIGIN-
```

```
   MX=     -154800.01  MY=           0.00  MZ=      499230.02

MAXIMUM DISPLACEMENTS ( INCH /RADIANS) (LOADING      1)
          MAXIMUMS    AT NODE
   X =  0.00000E+00       0
   Y = -1.50000E+00       1
   Z =  0.00000E+00       0
   RX=  9.51342E-10     121
   RY=  0.00000E+00       0
   RZ= -4.19726E-10      80

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

 44. CHANGE
 46. LOAD 2 'COLUMN LOAD-DL+LL'
 47. JOINT LOADS
 48. 1 2   FY -217.
 49. 8 9   FY -109.
 50. 5     FY -308.7
 51. 6     FY -617.4
 52. 22 23 FY -410.
 53. 29 30 FY -205.
 54. 26    FY -542.7
 55. 27    FY -1085.4
 56. 43 44 50 51 71 72 78 79 FY -307.5
 57. 47 54 82    FY -264.2
 58. 48 55 76 83 FY -528.3
 59. 92 93       FY -205.0
 60. 99 100      FY -410.0
 61. 103         FY -487.0
 62. 104         FY -974.0
 63. 113 114     FY -109.0
 64. 120 121     FY -217.0
 65. 124         FY -273.3
 66. 125         FY -546.6
 68. PERFORM ANALYSIS PRINT STATICS CHECK

**NOTE-Tension/Compression converged after  1 iterations, Case=    2

        STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     2
        'COLUMN LOAD-DL+LL'


***TOTAL APPLIED LOAD ( KIP  FEET ) SUMMARY (LOADING    2 )
    SUMMATION FORCE-X =        0.00
    SUMMATION FORCE-Y =   -13964.90
    SUMMATION FORCE-Z =        0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=      301253.66  MY=           0.00  MZ=     -884991.47


***TOTAL REACTION LOAD( KIP  FEET ) SUMMARY (LOADING     2 )
    SUMMATION FORCE-X =        0.00
    SUMMATION FORCE-Y =    13964.90
    SUMMATION FORCE-Z =        0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=     -301253.66  MY=           0.00  MZ=      884991.47


MAXIMUM DISPLACEMENTS ( INCH /RADIANS) (LOADING      2)
          MAXIMUMS    AT NODE
   X =  0.00000E+00       0
   Y = -1.09725E+01     120
   Z =  0.00000E+00       0
   RX=  7.89606E-02      99
   RY=  0.00000E+00       0
   RZ=  9.69957E-02       6



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

 69. CHANGE
 71. LOAD 3 'COLUMN OVERTURNING LOAD'
```

```
 72. ELEMENT LOAD
 73. 1 TO 102 PR GY -1.50
 74. JOINT LOADS
 75. 1 2   FY -100.
 76. 8 9   FY -50.
 77. 5     FY -150.7
 78. 6     FY -310.4
 79. 22 23 FY -205.
 80. 29 30 FY -102.
 81. 26    FY -271.7
 82. 27    FY -542.4
 83. 43 44 50 51 71 72 78 79 FY -153.5
 84. 47 54 82    FY -132.2
 85. 48 55 76 83 FY -264.3
 86. 92 93       FY 102.0
 87. 99 100      FY 205.0
 88. 103         FY 243.0
 89. 104         FY 487.0
 90. 113 114     FY 54.0
 91. 120 121     FY 108.0
 92. 124         FY 136.3
 93. 125         FY 273.6
 95. PERFORM ANALYSIS PRINT STATICS CHECK
**START ITERATION NO.           2
**START ITERATION NO.           3
**START ITERATION NO.           4
**START ITERATION NO.           5

**NOTE-Tension/Compression converged after  5 iterations, Case=    3

        STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     3
        'COLUMN OVERTURNING LOAD'


 ***TOTAL APPLIED LOAD ( KIP  FEET ) SUMMARY (LOADING    3 )
     SUMMATION FORCE-X =        0.00
     SUMMATION FORCE-Y =   -10533.10
     SUMMATION FORCE-Z =        0.00

    SUMMATION OF MOMENTS AROUND THE ORIGIN-
    MX=      213519.36  MY=           0.00  MZ=     -478687.78


 ***TOTAL REACTION LOAD( KIP  FEET ) SUMMARY (LOADING     3 )
     SUMMATION FORCE-X =        0.00
     SUMMATION FORCE-Y =    10533.10
     SUMMATION FORCE-Z =        0.00

    SUMMATION OF MOMENTS AROUND THE ORIGIN-
    MX=     -213519.36  MY=           0.00  MZ=      478687.78


 MAXIMUM DISPLACEMENTS ( INCH /RADIANS) (LOADING      3)
           MAXIMUMS    AT NODE
    X =  0.00000E+00       0
    Y =  2.83669E+01     120
    Z =  0.00000E+00       0
    RX= -1.22268E-01     120
    RY=  0.00000E+00       0
    RZ=  1.09786E-01     125



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


 97. LOAD LIST 3
 98. PRINT JOINT DISPLACEMENTS LIST 113 114 120 121
```

```
  JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = SPACE
  ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

   113    3    0.00000  19.17264   0.00000  -0.09579   0.00000   0.06945
   114    3    0.00000  14.53915   0.00000  -0.09437   0.00000   0.06506
   120    3    0.00000  28.36691   0.00000  -0.12227   0.00000   0.10056
   121    3    0.00000  22.49737   0.00000  -0.11615   0.00000   0.08912


  ************** END OF LATEST ANALYSIS RESULT **************


   99. PRINT ELEMENT STRESSES LIST 34 67

  ELEMENT STRESSES    FORCE,LENGTH UNITS= KIP  FEET
  ----------------

           STRESS = FORCE/UNIT WIDTH/THICK, MOMENT = FORCE-LENGTH/UNIT WIDTH

 ELEMENT  LOAD       SQX        SQY          MX          MY          MXY
                     VONT       VONB         SX          SY          SXY
                     TRESCAT    TRESCAB


    34      3       -4.50      -6.74        2.45        7.99         6.96
                   188.81     188.81        0.00        0.00         0.00
                   202.25     202.25
      TOP :  SMAX=   171.62  SMIN=   -30.64  TMAX=   101.13  ANGLE= -34.2
      BOTT:  SMAX=    30.64  SMIN=  -171.62  TMAX=   101.13  ANGLE= -34.2

    67      3       37.83       6.21      -57.38        5.58        43.51
                  1303.44    1303.44        0.00        0.00         0.00
                  1449.91    1449.91
      TOP :  SMAX=   375.29  SMIN= -1074.62  TMAX=   724.96  ANGLE= -27.1
      BOTT:  SMAX=  1074.62  SMIN=  -375.29  TMAX=   724.96  ANGLE= -27.1


         **** MAXIMUM STRESSES AMONG SELECTED PLATES AND CASES ****
            MAXIMUM       MINIMUM       MAXIMUM       MAXIMUM       MAXIMUM
           PRINCIPAL     PRINCIPAL       SHEAR       VONMISES       TRESCA
            STRESS        STRESS        STRESS        STRESS        STRESS

         1.074621E+03 -1.074621E+03  7.249564E+02  1.303438E+03  1.449913E+03
PLATE NO.      67            67            67            67            67
CASE  NO.       3             3             3             3             3


  ********************END OF ELEMENT FORCES********************


  100. PRINT SUPPORT REACTIONS LIST 5 6 12 13


  SUPPORT REACTIONS -UNIT KIP  FEET    STRUCTURE TYPE = SPACE
  -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

     5    3      0.00    148.06      0.00      0.00      0.00      0.00
     6    3      0.00    168.10      0.00      0.00      0.00      0.00
    12    3      0.00    149.08      0.00      0.00      0.00      0.00
    13    3      0.00    153.60      0.00      0.00      0.00      0.00


  ************** END OF LATEST ANALYSIS RESULT **************
```

```
101. FINISH


          *********** END OF THE STAAD.Pro RUN ***********

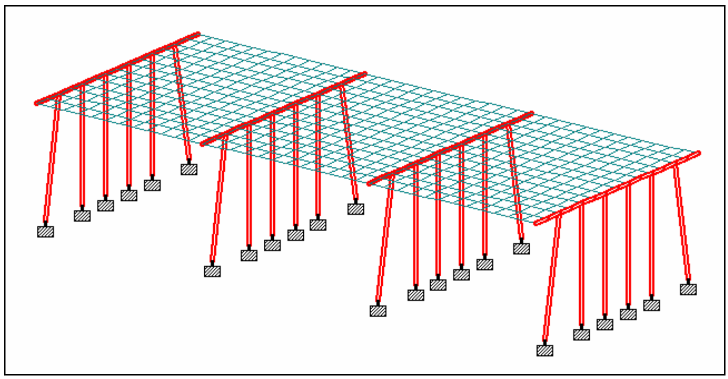
            **** DATE=            TIME=            ****

     ************************************************************
     *         For questions on STAAD.Pro, please contact       *
     *   Research Engineers Offices at the following locations  *
     *                                                          *
     *              Telephone                Email              *
     *  USA:      +1 (714)974-2500       support@bentley.com    *
     *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
     *  UK        +44(1454)207-000       support@reel.co.uk     *
     *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
     *  GERMANY   +49/931/40468-71       info@reig.de           *
     *  NORWAY    +47 67 57 21 30        staad@edr.no           *
     *  SINGAPORE +65 6225-6158          support@bentley.com    *
     *  INDIA     +91(033)4006-2021      support@bentley.com    *
     *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
     *  CHINA     +86(411)363-1983       support@bentley.com    *
     *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
     *                                                          *
     *  North America                   support@bentley.com     *
     *  Europe                          support@bentley.com     *
     *  Asia                            support@bentley.com     *
     ************************************************************
```

NOTES

Example Problem No. 28

This example demonstrates the input required for obtaining the modes and frequencies of the skewed bridge shown in the figure below. The structure consists of piers, pier-cap girders and a deck slab.



STAAD SPACE FREQUENCIES OF VIBRATION OF A SKEWED BRIDGE

Every STAAD input file has to begin with the word STAAD. The word SPACE signifies that the structure is a space frame and the geometry is defined through X, Y and Z axes. The remainder of the words forms a title to identify this project.

IGNORE LIST

Further below in this file, we will call element lists in which some element numbers may not actually be present in the structure. We do so because it minimizes the effort involved in fetching the desired elements and reduces the size of the respective commands. To prevent the program from treating that condition (referring to elements which do not exist) as an error, the above command is required.

UNIT METER KN

The units for the data that follows are specified above.

JOINT COORDINATES
1 0 0 0; 2 4 0 0; 3 6.5 0 0; 4 9 0 0; 5 11.5 0 0; 6 15.5 0 0;
11 -1 10 0 25 16.5 10 0
REPEAT ALL 3 4 0 14

For joints 1 through 6, the joint number followed by the X, Y and Z coordinates are specified first.

Next, using the coordinates of joints 11 and 25 as the basis, joints 12 through 24 are generated using linear interpolation.

Following this, using the data of these 21 joints (1 through 6 and 11 through 25), 63 new joints are generated. To achieve this, the X coordinate of these 21 joints is incremented by 4 meters and the Z coordinate is incremented by 14 meters, in 3 successive operations.

The REPEAT ALL command is used for the generation. Details of this command is available in Section 5.11 of the Technical Reference manual. The results of the generation may be visually verified using STAAD.Pro's graphical viewing facilities.

```
MEMBER INCI
1 1 13 ; 2 2 15 ; 3 3 17 ; 4 4 19 ; 5 5 21 ; 6 6 23
26 26 34 ; 27 27 36 ; 28 28 38 ; 29 29 40 ; 30 30 42 ; 31 31 44
47 47 55 ; 48 48 57 ; 49 49 59 ; 50 50 61 ; 51 51 63 ; 52 52 65
68 68 76 ; 69 69 78 ; 70 70 80 ; 71 71 82 ; 72 72 84 ; 73 73 86
```

The member connectivity data (joint numbers between which members are connected) is specified for the 24 columns for the structure. The above method, where the member number is followed by the 2 node numbers, is the explicit definition method. No generation is involved here.

```
101 11 12 114
202 32 33 215
303 53 54 316
404 74 75 417
```

The member connectivity data is specified for the pier cap beams for the structure. The above method is a combination of explicit definition and generation. For example, member 101 is defined as connected between 11 & 12. Then, by incrementing those nodes by 1 unit at a time (which is the default increment), the incidences of members 102 to 114 are generated. Similarly, we create members 202 to 215, 303 to 316, and, 404 to 417.

```
DEFINE MESH
A JOINT 11
B JOINT 25
C JOINT 46
D JOINT 32
E JOINT 67
F JOINT 53
G JOINT 88
H JOINT 74
```

The next step is to generate the deck slab which will be modeled using plate elements. For this, we use a technique called mesh generation. Mesh generation is a process of generating several "child" elements from a "parent" or "super" element. The above set of commands defines the corner nodes of the super-element. Details of the above can be found in Section 5.14 of the Technical Reference manual.

Note that instead of elaborately defining the coordinates of the corner nodes of the super-elements, we have taken advantage of the fact that the coordinates of these joints (A through H) have already been defined or generated earlier. Thus, A is the same as joint 11 while D is the same as joint 32. Alternatively, we could have defined the super-element nodes as A -1 10 0 ; B 16.5 10 0 ; C 20.5 10 14 ; D 3 10 14 ; etc.

```
GENERATE ELEMENT
MESH ABCD 14 12
MESH DCEF 14 12
MESH FEGH 14 12
```

The above lines are the instructions for generating the “child” elements from the super-elements. For example, from the super-element bound by the corners A, B, C and D (which in turn are nodes 11, 25, 46 and 32), we generate a total of 14X12=168 elements, with 14 divisions along the edges AB and CD, and 12 along the edges BC and DA. These are the elements which make up the first span.

Similarly, 168 elements are created for the 2nd span, and another 168 for the 3rd span.

It may be noted here that we have taken great care to ensure that the resulting elements and the piercap beams form a perfect fit. In other words, there is no overlap between the two in a manner that nodes of the beams are at a different point in space than nodes of elements. At every node along their common boundary, plates and beams are properly connected. This is absolutely essential to ensure proper transfer of load and stiffness from beams to plates and vice versa. The tools of the graphical user interface may be used to confirm that beam-plate connectivity is proper for this model.

```
START GROUP DEFINITION
MEMBER
_GIRDERS 101 TO 114 202 TO 215 303 TO 316 404 TO 417
_PIERS 1 TO 6 26 TO 31 47 TO 52 68 TO 73

ELEMENT
_P1 447 TO 450 454 TO 457 461 TO 464 468 TO 471
_P2 531 TO 534 538 TO 541 545 TO 548 552 TO 555
_P3 615 TO 618 622 TO 625 629 TO 632 636 TO 639
_P4 713 TO 716 720 TO 723 727 TO 730 734 TO 737
_P5 783 TO 786 790 TO 793 797 TO 800 804 TO 807
_P6 881 TO 884 888 TO 891 895 TO 898 902 TO 905

END GROUP DEFINITION
```

The above block of data is referred to as formation of groups. Group names are a mechanism by which a single moniker can be used to refer to a cluster of entities, such as members. For our structure, the piercap beams are being grouped to a name called GIRDERS, the pier columns are assigned the name PIERS, and so on. For the deck, a few selected elements are chosen into a few selective groups. The reason is that these elements happen to be right beneath wheels of vehicles whose weight will be used in the frequency calculation.

```
MEMBER PROPERTY
_GIRDERS PRIS YD 0.6 ZD 0.6
_PIERS PRIS YD 1.0
```

Member properties are assigned as prismatic rectangular sections for the girders, and prismatic circular sections for the columns.

```
ELEMENT PROPERTY
YRA 9 11 TH 0.375
```

The plate elements of the deck slab, which happen to be at a Y elevation of 10 metres (between a YRANGE of 9 metres and 11 metres) are assigned a thickness of 375 mms.

```
UNIT NEWTON MMS
CONSTANTS
E 21000 ALL
POISSON CONCRETE ALL
```

The Modulus of elasticity (E) is set to 21000 N/sq.mm for all members. The keyword CONSTANTS has to precede this data. Built-in default value for Poisson's ratio for concrete is also assigned to ALL members and elements.

```
UNIT KNS METER
CONSTANTS
DENSITY 24 ALL
```

Following a change of units, density of concrete is specified.

```
SUPPORTS
1 TO 6 26 TO 31 47 TO 52 68 TO 73 FIXED
```

The base nodes of the piers are fully restrained (FIXED supports).

```
CUT OFF MODE SHAPE 65
```

Theoretically, a structure has as many modes of vibration as the number of degrees of freedom in the model. However, the limitations of the mathematical process used in extracting modes may limit the number of modes that can actually be extracted. In a large structure, the extraction process can also be very time consuming. Further, not all modes are of equal importance. (One measure of the importance of modes is the participation factor of that mode.) In many cases, the first few modes may be sufficient to obtain a significant portion of the total dynamic response.

Due to these reasons, in the absence of any explicit instruction, STAAD calculates only the first 6 modes. This is like saying that the command CUT OFF MODE SHAPE 6 has been specified.

(Versions of STAAD prior to STAAD.Pro 2000 calculated only 3 modes by default).

If the inspection of the first 6 modes reveals that the overall vibration pattern of the structure has not been obtained, one may ask STAAD to compute a larger (or smaller) number of modes with the help of this command. The number that follows this command is the number of modes being requested. In our example, we are asking for 65 modes by specifying CUT OFF MODE SHAPE 65.

```
UNIT KGS METER
LOAD 1 FREQUENCY CALCULATION
SELFWEIGHT X 1.0
SELFWEIGHT Y 1.0
SELFWEIGHT Z 1.0

* PERMANENT WEIGHTS ON DECK
ELEMENT LOAD
YRA 9 11 PR GX 200
YRA 9 11 PR GY 200
YRA 9 11 PR GZ 200

* VEHICLES ON SPANS - ONLY Y & Z EFFECT CONSIDERED
ELEMENT LOAD
_P1 PR GY 700
_P2 PR GY 700
_P3 PR GY 700
_P4 PR GY 700
_P5 PR GY 700
_P6 PR GY 700

_P1 PR GZ 700
_P2 PR GZ 700
_P3 PR GZ 700
_P4 PR GZ 700
_P5 PR GZ 700
_P6 PR GZ 700
```

The mathematical method that STAAD uses is called the eigen extraction method. Some information on this is available in Section 1.18.3 of the STAAD.Pro Technical Reference Manual.

The method involves 2 matrices - the stiffness matrix, and the mass matrix.

The stiffness matrix, usually called the [K] matrix, is assembled using data such as member and element lengths, member and element properties, modulus of elasticty, Poisson's ratio, member and element releases, member offsets, support information, etc.

For assembling the mass matrix, called the [M] matrix, STAAD uses the load data specified in the load case in which the MODAL CAL REQ command is specified. So, some of the important aspects to bear in mind are :

1. The input you specify is weights, not masses. Internally, STAAD will convert weights to masses by dividing the input by "g", the acceleration due to gravity.

2. If the structure is declared as a PLANE frame, there are 2 possible directions of vibration - global X, and global Y. If the structure is declared as a SPACE frame, there are 3 possible directions - global X, global Y and global Z. However, this does not guarantee that STAAD will automatically consider the masses for vibration in all the available directions.

   You have control over and are responsible for specifying the directions in which the masses ought to vibrate. In other words, if a weight is not specified along a certain direction, the corresponding degrees of freedom (such as for example, global X at node 34 hypothetically) will not receive a contribution in the mass matrix. The mass matrix is assembled using only the masses from the weights and directions specified by the user.

   In our example, notice that we are specifying the selfweight along global X, Y and Z directions. Similarly, a 200 kg/sq.m pressure load is also specified along all 3 directions on the deck.

But for the truck loads, we choose to apply it on just a few elements in the global Y and Z directions only. The reasoning is something like - for the X direction, the mass is not capable of vibrating because the tires allow the truck to roll along X. Remember, this is just a demonstration example, not necessarily what you may wish to do.

The point we wish to illustrate is that if a user wishes to restrict a certain weight to certain directions only, all he/she has to do is not provide the directions in which those weights cannot vibrate in.

3. As much as possible, provide absolute values for the weights. STAAD is programmed to algebraically add the weights at nodes. So, if some weights are specified as positive numbers and others as negative, the total weight at a given node is the algebraic summation of all the weights in the global directions at that node and the mass is then derived from this algebraic resultant.

MODAL CALCULATION REQUESTED

This is the command which tells the program that frequencies and modes should be calculated. It is specified inside a load case. In other words, this command accompanies the loads that are to be used in generating the mass matrix.

Frequencies and modes have to be calculated also when dynamic analysis such as response spectrum or time history analysis is carried out. But in such analyses, the MODAL CALCULATION REQUESTED command is not explicitly required. When STAAD encounters the commands for response spectrum (see example 11) and time history (see examples 16 and 22), it automatically will carry out a frequency extraction without the help of the MODAL .. command.

PERFORM ANALYSIS

This initiates the processes which are required to obtain the frequencies. Frequencies, periods and participation factors are automatically reported in the output file when the operation is completed.

FINISH

This terminates the STAAD run.

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

 1. STAAD SPACE FREQUENCIES OF VIBRATION OF A SKEWED BRIDGE
 2. IGNORE LIST
 4. UNIT METER KN
 5. JOINT COORDINATES
 6. 1 0 0 0; 2 4 0 0; 3 6.5 0 0; 4 9 0 0; 5 11.5 0 0; 6 15.5 0 0
 7. 11 -1 10 0 25 16.5 10 0
 8. REPEAT ALL 3 4 0 14
10. MEMBER INCI
11. 1 1 13 ; 2 2 15 ; 3 3 17 ; 4 4 19 ; 5 5 21 ; 6 6 23
12. 26 26 34 ; 27 27 36 ; 28 28 38 ; 29 29 40 ; 30 30 42 ; 31 31 44
13. 47 47 55 ; 48 48 57 ; 49 49 59 ; 50 50 61 ; 51 51 63 ; 52 52 65
14. 68 68 76 ; 69 69 78 ; 70 70 80 ; 71 71 82 ; 72 72 84 ; 73 73 86
16. 101 11 12 114
17. 202 32 33 215
18. 303 53 54 316
19. 404 74 75 417
21. DEFINE MESH
22. A JOINT 11
23. B JOINT 25
24. C JOINT 46
25. D JOINT 32
26. E JOINT 67
27. F JOINT 53
28. G JOINT 88
29. H JOINT 74
30. GENERATE ELEMENT
31. MESH ABCD 14 12
32. MESH DCEF 14 12
33. MESH FEGH 14 12
35. START GROUP DEFINITION
36. MEMBER
37. _GIRDERS 101 TO 114 202 TO 215 303 TO 316 404 TO 417
38. _PIERS 1 TO 6 26 TO 31 47 TO 52 68 TO 73
40. ELEMENT
41. _P1 447 TO 450 454 TO 457 461 TO 464 468 TO 471
42. _P2 531 TO 534 538 TO 541 545 TO 548 552 TO 555
43. _P3 615 TO 618 622 TO 625 629 TO 632 636 TO 639
44. _P4 713 TO 716 720 TO 723 727 TO 730 734 TO 737
45. _P5 783 TO 786 790 TO 793 797 TO 800 804 TO 807
46. _P6 881 TO 884 888 TO 891 895 TO 898 902 TO 905
48. END GROUP DEFINITION
50. MEMBER PROPERTY
51. _GIRDERS PRIS YD 0.6 ZD 0.6
52. _PIERS PRIS YD 1.0
54. ELEMENT PROPERTY
55. YRA 9 11 TH 0.375
57. UNIT NEWTON MMS
58. CONSTANTS
59. E 21000 ALL
60. POISSON CONCRETE ALL
62. UNIT KNS METER
63. CONSTANTS
64. DENSITY 24 ALL
66. SUPPORTS
67. 1 TO 6 26 TO 31 47 TO 52 68 TO 73 FIXED
69. CUT OFF MODE SHAPE 65
71. UNIT KGS METER
72. LOAD 1 FREQUENCY CALCULATION
73. SELFWEIGHT X 1.0
74. SELFWEIGHT Y 1.0
```

```
  75. SELFWEIGHT Z 1.0
  77. * PERMANENT WEIGHTS ON DECK
  78. ELEMENT LOAD
  79. YRA 9 11 PR GX 200
  80. YRA 9 11 PR GY 200
  81. YRA 9 11 PR GZ 200
  83. * VEHICLES ON SPANS - ONLY Y & Z EFFECT CONSIDERED
  84. ELEMENT LOAD
  85. _P1 PR GY 700
  86. _P2 PR GY 700
  87. _P3 PR GY 700
  88. _P4 PR GY 700
  89. _P5 PR GY 700
  90. _P6 PR GY 700
  92. _P1 PR GZ 700
  93. _P2 PR GZ 700
  94. _P3 PR GZ 700
  95. _P4 PR GZ 700
  96. _P5 PR GZ 700
  97. _P6 PR GZ 700
  99. MODAL CALCULATION REQUESTED
 100. PERFORM ANALYSIS
          P R O B L E M   S T A T I S T I C S
          -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =   579/   584/    24
   ORIGINAL/FINAL BAND-WIDTH=   496/    24/    150 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =   3330
   SIZE OF STIFFNESS MATRIX =      500 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =     23.4/   4235.0 MB

 ** WARNING: PRESSURE LOADS ON ELEMENTS OTHER THAN PLATE ELEMENTS
             ARE IGNORED. ELEM.NO.   101

 ** WARNING: PRESSURE LOADS ON ELEMENTS OTHER THAN PLATE ELEMENTS
             ARE IGNORED. ELEM.NO.   101

 ** WARNING: PRESSURE LOADS ON ELEMENTS OTHER THAN PLATE ELEMENTS
             ARE IGNORED. ELEM.NO.   101
 NUMBER OF MODES REQUESTED             =    65
 NUMBER OF EXISTING MASSES IN THE MODEL =  1665
 NUMBER OF MODES THAT WILL BE USED      =    65

            CALCULATED FREQUENCIES FOR LOAD CASE       1
      MODE          FREQUENCY(CYCLES/SEC)         PERIOD(SEC)      ACCURACY
        1                    1.636                  0.61111       1.479E-15
        2                    2.602                  0.38433       1.276E-15
        3                    2.882                  0.34695       3.466E-16
        4                    3.754                  0.26636       6.129E-16
        5                    4.076                  0.24532       8.665E-16
        6                    4.373                  0.22869       0.000E+00
        7                    4.519                  0.22130       4.231E-16
        8                    4.683                  0.21355       1.313E-16
        9                    5.028                  0.19889       6.835E-16
       10                    7.189                  0.13911       1.337E-15
       11                    7.238                  0.13815       2.199E-16
       12                    7.363                  0.13582       6.374E-16
       13                   10.341                  0.09671       6.464E-16
       14                   10.734                  0.09316       7.998E-16
       15                   11.160                  0.08961       5.549E-16
       16                   11.275                  0.08869       1.812E-16
       17                   11.577                  0.08638       6.876E-16
       18                   11.829                  0.08454       4.939E-16
       19                   11.921                  0.08388       1.621E-16
       20                   12.085                  0.08275       4.733E-16
       21                   12.488                  0.08007       4.431E-16
       22                   13.677                  0.07311       0.000E+00
       23                   14.654                  0.06824       6.437E-16
       24                   14.762                  0.06774       8.458E-16
       25                   15.125                  0.06612       4.028E-16
       26                   17.308                  0.05778       0.000E+00
       27                   17.478                  0.05721       6.033E-16
       28                   17.747                  0.05635       4.389E-16
       29                   19.725                  0.05070       1.184E-16
```

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)	ACCURACY
30	19.921	0.05020	1.161E-16
31	20.536	0.04869	8.740E-16
32	20.618	0.04850	2.168E-16
33	20.845	0.04797	1.060E-15
34	21.146	0.04729	0.000E+00
35	21.426	0.04667	0.000E+00
36	21.801	0.04587	3.878E-16
37	22.070	0.04531	9.459E-16
38	23.153	0.04319	6.876E-16
39	23.518	0.04252	8.330E-16
40	23.985	0.04169	1.602E-16
41	24.655	0.04056	1.819E-15
42	25.469	0.03926	4.262E-16
43	26.002	0.03846	4.089E-16
44	26.422	0.03785	1.003E-14
45	26.808	0.03730	1.026E-15
46	27.305	0.03662	8.405E-15
47	27.776	0.03600	2.914E-14
48	28.972	0.03452	1.322E-13
49	29.550	0.03384	6.269E-14
50	29.804	0.03355	2.282E-13
51	30.992	0.03227	3.947E-12
52	31.501	0.03174	7.133E-12
53	31.690	0.03156	1.366E-11
54	32.009	0.03124	3.471E-12
55	32.574	0.03070	1.186E-10
56	32.863	0.03043	6.803E-11
57	34.101	0.02932	1.277E-10
58	34.923	0.02863	3.012E-09
59	35.162	0.02844	2.272E-09
60	35.411	0.02824	9.878E-09
61	35.928	0.02783	1.082E-08
62	36.529	0.02738	4.701E-09
63	38.585	0.02592	2.902E-07
64	38.826	0.02576	6.399E-07
65	39.494	0.02532	2.540E-07

```
The following Frequencies are estimates that were calculated. These are for
information only and will not be used. Remaining values are either above
the cut off mode/freq values or are of low accuracy. To use these
frequencies, rerun with a higher cutoff mode (or mode + freq) value.
```

CALCULATED FREQUENCIES FOR LOAD CASE 1

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)	ACCURACY
66	40.013	0.02499	4.013E-06
67	40.518	0.02468	3.403E-06
68	40.924	0.02444	6.088E-06
69	41.523	0.02408	6.986E-06
70	42.110	0.02375	9.985E-06
71	42.318	0.02363	2.559E-07
72	42.701	0.02342	1.154E-05
73	42.891	0.02331	1.442E-05
74	44.395	0.02253	4.132E-05
75	45.025	0.02221	7.723E-05
76	45.134	0.02216	6.369E-05

MASS PARTICIPATION FACTORS IN PERCENT

MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z
1	0.01	0.00	99.04	0.012	0.000	99.042
2	99.14	0.00	0.02	99.151	0.000	99.061
3	0.00	0.23	0.00	99.151	0.229	99.062
4	0.00	3.27	0.00	99.151	3.496	99.062
5	0.00	0.04	0.05	99.151	3.536	99.112
6	0.05	0.04	0.02	99.202	3.575	99.135
7	0.00	26.42	0.00	99.204	30.000	99.135
8	0.00	25.59	0.00	99.204	55.587	99.136
9	0.53	0.15	0.19	99.735	55.740	99.326

MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z
10	0.00	0.13	0.00	99.736	55.871	99.326
11	0.00	0.06	0.00	99.736	55.927	99.326
12	0.00	0.04	0.00	99.736	55.969	99.326
13	0.00	0.00	0.56	99.740	55.969	99.889
14	0.00	0.01	0.01	99.740	55.979	99.898
15	0.00	0.37	0.01	99.740	56.349	99.909
16	0.00	0.00	0.01	99.740	56.354	99.923
17	0.00	0.00	0.00	99.741	56.354	99.923
18	0.01	0.00	0.01	99.753	56.355	99.937
19	0.00	0.00	0.00	99.753	56.358	99.937
20	0.00	0.01	0.00	99.754	56.364	99.939
21	0.00	0.00	0.00	99.754	56.364	99.940
22	0.01	0.00	0.00	99.765	56.364	99.940
23	0.00	0.00	0.01	99.766	56.368	99.947
24	0.00	0.01	0.00	99.766	56.383	99.948
25	0.00	0.00	0.02	99.767	56.384	99.965
26	0.00	0.18	0.00	99.767	56.562	99.965
27	0.00	0.03	0.00	99.768	56.591	99.965
28	0.00	1.09	0.00	99.768	57.676	99.965
29	0.06	0.53	0.00	99.829	58.205	99.970
30	0.00	3.53	0.00	99.832	61.732	99.971
31	0.02	0.01	0.00	99.852	61.737	99.971
32	0.00	3.48	0.00	99.854	65.214	99.971
33	0.00	0.09	0.00	99.854	65.308	99.971
34	0.00	0.01	0.00	99.855	65.319	99.972
35	0.00	0.42	0.00	99.856	65.736	99.972
36	0.00	0.00	0.00	99.856	65.736	99.972
37	0.00	2.19	0.00	99.856	67.926	99.972
38	0.00	0.01	0.00	99.856	67.932	99.972
39	0.00	0.03	0.00	99.856	67.967	99.972
40	0.00	0.00	0.00	99.856	67.969	99.972
41	0.00	0.15	0.00	99.856	68.116	99.973
42	0.00	4.79	0.00	99.856	72.905	99.973
43	0.00	0.07	0.00	99.857	72.980	99.973
44	0.00	0.05	0.00	99.857	73.033	99.973
45	0.00	0.02	0.00	99.857	73.057	99.973
46	0.00	0.17	0.00	99.857	73.226	99.973
47	0.00	0.00	0.00	99.858	73.226	99.973
48	0.00	0.38	0.00	99.858	73.610	99.973
49	0.00	0.00	0.00	99.858	73.611	99.973
50	0.00	0.00	0.00	99.858	73.611	99.973
51	0.00	0.01	0.00	99.858	73.622	99.973
52	0.00	0.00	0.00	99.858	73.623	99.974
53	0.00	0.11	0.00	99.858	73.730	99.974
54	0.00	0.01	0.00	99.859	73.736	99.974
55	0.00	0.02	0.00	99.859	73.758	99.974
56	0.00	0.06	0.00	99.859	73.823	99.974
57	0.00	0.01	0.00	99.859	73.831	99.974
58	0.00	0.14	0.00	99.860	73.968	99.975
59	0.00	0.00	0.00	99.860	73.970	99.976
60	0.00	0.04	0.00	99.861	74.006	99.981
61	0.00	0.14	0.00	99.865	74.144	99.984
62	0.00	0.26	0.00	99.868	74.407	99.985
63	0.00	0.06	0.00	99.868	74.467	99.985
64	0.00	0.30	0.00	99.868	74.764	99.985
65	0.00	0.15	0.00	99.869	74.911	99.986

```
102. FINISH

          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE=             TIME=           ****

      ************************************************************
      *         For questions on STAAD.Pro, please contact       *
      *   Research Engineers Offices at the following locations  *
      *                                                          *
      *              Telephone                 Email             *
      *  USA:      +1 (714)974-2500       support@bentley.com    *
      *  CANADA    +1 (905)632-4771       detech@odandetech.com  *
      *  UK        +44(1454)207-000       support@reel.co.uk     *
      *  FRANCE    +33(0)1 64551084       support@reel.co.uk     *
      *  GERMANY   +49/931/40468-71       info@reig.de           *
      *  NORWAY    +47 67 57 21 30        staad@edr.no           *
      *  SINGAPORE +65 6225-6158          support@bentley.com    *
      *  INDIA     +91(033)4006-2021      support@bentley.com    *
      *  JAPAN     +81(03)5952-6500       eng-eye@crc.co.jp      *
      *  CHINA     +86(411)363-1983       support@bentley.com    *
      *  THAILAND  +66(0)2645-1018/19     support@bentley.com    *
      *                                                          *
      *  North America                   support@bentley.com     *
      *  Europe                          support@bentley.com     *
      *  Asia                            support@bentley.com     *
      ************************************************************
```

Understanding the output:

After the analysis is complete, look at the output file. (This file can be viewed from File - View - Output File - STAAD output).

(i) Mode number and corresponding frequencies and periods

Since we asked for 65 modes, we obtain a report, a portion of which is as shown:

CALCULATED FREQUENCIES FOR LOAD CASE 1

MODE	FREQUENCY (CYCLES/SEC)	PERIOD (SEC)	ACCURACY
1	1.636	0.61111	1.344E-16
2	2.602	0.38433	0.000E+00
3	2.882	0.34695	8.666E-16
4	3.754	0.26636	0.000E+00
5	4.076	0.24532	3.466E-16
6	4.373	0.22870	6.025E-16
7	4.519	0.22130	5.641E-16
8	4.683	0.21355	5.253E-16
9	5.028	0.19889	0.000E+00
10	7.189	0.13911	8.916E-16
11	7.238	0.13815	0.000E+00
12	7.363	0.13582	0.000E+00

(ii) Participation factors in Percentage

MASS PARTICIPATION FACTORS IN PERCENT

MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z
1	0.01	0.00	99.04	0.012	0.000	99.042
2	99.14	0.00	0.02	99.151	0.000	99.061
3	0.00	0.23	0.00	99.151	0.229	99.062
4	0.00	3.27	0.00	99.151	3.496	99.062
5	0.00	0.04	0.05	99.151	3.536	99.112
6	0.05	0.04	0.02	99.202	3.575	99.135
7	0.00	26.42	0.00	99.204	30.000	99.135
8	0.00	25.59	0.00	99.204	55.587	99.136
9	0.53	0.15	0.19	99.735	55.740	99.326
10	0.00	0.13	0.00	99.736	55.871	99.326
11	0.00	0.06	0.00	99.736	55.927	99.326
12	0.00	0.04	0.00	99.736	55.969	99.326

In the explanation earlier for the CUT OFF MODE command, we said that one measure of the importance of a mode is the participation factor of that mode. We can see from the above report that for vibration along Z direction, the first mode has a 99.04 percent participation. It is also apparent that the 7th mode is primarily a Y direction mode with a 26.42 % participation along Y and 0 in X and Z.

The SUMM-X, SUMM-Y and SUMM-Z columns show the cumulative value of the participation of all the modes upto and including a given mode. One can infer from those terms that if one is interested in 95% participation along X, the first 2 modes are sufficient.

But for the Y direction, even with 10 modes, we barely obtained 60%. The reason for this can be understood by an examination of the nature of the structure. The deck slab is capable of vibrating in several low energy and primarily vertical direction modes. The out-of-plane flexible nature of the slab enables it to vibrate in a manner resembling a series of wave like curves. Masses on either side of the equilibrium point have opposing eigenvector values leading to a lot of cancellation of the contribution from the respective masses. Localized modes, where small pockets in the structure undergo flutter due to their relative weak stiffness compared to the rest of the model, also result in small participation factors.

(iii) Viewing the mode shapes

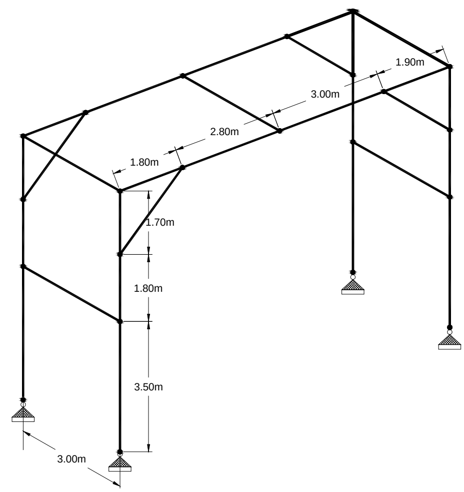
After the analysis is completed, select Post-processing from the mode menu. This screen contains facilities for graphically examining the shape of the mode in static and animated views. The Dynamics page on the left side of the screen is available for viewing the shape of the mode statically. The Animation option of the Results menu can be used for animating the mode. The mode number can be selected from the “Loads and Results” tab of the “Diagrams” dialog box which comes up when the Animation option is chosen. The size to which the mode is drawn is controlled using the “Scales” tab of the “Diagrams” dialog box.

NOTES

NOTES

Example Problem No. 29

Analysis and design of a structure for seismic loads is demonstrated in this example. The elaborate dynamic analysis procedure called time history analysis is used. In this model, static load cases are solved along with the seismic load case. For the seismic case, the maximum values of displacements, forces and reactions are obtained. The results of the dynamic case are combined with those of the static cases and steel design is performed on the combined cases.



Actual input is shown in bold lettering followed by explanation.

STAAD SPACE DYNAMIC ANALYSIS FOR SEISMIC LOADS

Every STAAD input file has to begin with the word STAAD. The word SPACE signifies that the structure is a space frame and the geometry is defined through X, Y and Z axes. The remainder of the words form a title to identify this project.

UNIT METER KNS

The units for the data that follows are specified above.

JOINT COORDINATES
1 0 0 0 ; 2 0 3.5 0 ; 3 0 5.3 0 ; 4 0 7 0
REPEAT ALL 1 9.5 0 0
REPEAT ALL 1 0 0 3
17 1.8 7 0 ; 18 4.6 7 0 ; 19 7.6 7 0
REPEAT ALL 1 0 0 3

For joints 1 through 4, the joint number is followed by the X, Y and Z coordinates as specified above. The coordinates of these joints are used as a basis for generating 12 more joints by incrementing the X & Z coordinates by specific amounts. REPEAT ALL commands are used for the generation. Details of these commands are available in Section 5.11 of the Technical Reference manual. Following this, another round of explicit definition (joints 17, 18 & 19) and generation (20, 21 & 22) is carried out. The results of the generation may be visually verified using STAAD.Pro's graphical viewing facilities.

MEMBER INCIDENCES
1 1 2 3
REPEAT 1 3 4
7 9 10 9
10 13 14 12
13 4 17; 14 17 18; 15 18 19; 16 19 8
17 12 20; 18 20 21; 19 21 22; 20 22 16
21 2 10; 22 4 12; 23 6 14
24 8 16; 25 3 17; 26 7 19; 27 11 20; 28 15 22; 29 18 21

A mixture of explicit definition and generation of member connectivity data (joint numbers between which members are connected) is used to generate 29 members for the structure.

```
START GROUP DEFINITION
MEMBER
_VERTICAL 1 TO 12
_XBEAM 13 TO 20
_ZBEAM 21 TO 24 29
_BRACE 25 TO 28
END GROUP DEFINITION
```

The above block of data is referred to as formation of groups. Group names are a mechanism by which a single moniker can be used to refer to a cluster of entities, such as members. For our structure, the columns are being grouped to a name called VERTICAL, the beams running along the X direction are assigned the name XBEAM, and so on.

```
MEMBER PROPERTIES CANADIAN
_VERTICAL TA ST W310X97
_XBEAM TA ST W250X39
_ZBEAM TA ST C200X17
_BRACE TA ST L152X152X13
```

Member properties are assigned from the Canadian steel table. The members which receive these properties are those embedded within the respective group names. The benefit of using the group name is apparent here. Just from the looks of the command, we can understand that the diagonal braces are being assigned a single angle. The alternative, which would be

```
25 TO 28 TA ST L152X152X13
```

would have required us to go to the graphical tools to get a sense of what members 25 to 28 are.

```
UNIT KNS MMS
CONSTANT
E 200 ALL
```

The Modulus of elasticity (E) is set to 200 kN/sq.mm for all members. The keyword CONSTANTS has to precede this data.

```
UNIT KGS METER
CONSTANT
DENSITY 7800 ALL
POISSON STEEL ALL
BETA 180 MEMB 21 22
```

Density and Poisson for all members is set using the above commands. The BETA angle for the channels along the left edge is set to 180 so their legs point toward the interior of the structure.

```
SUPPORTS
1 5 9 13 PINNED
```

The bottom ends of the columns of the platform are pinned supported.

```
CUT OFF MODE SHAPE 30
```

The above command is a critical command if one wishes to override the default number of modes computed and used in a dynamic analysis. The default, which is 6, may not always be sufficient to capture a significant portion of the structural response in a response spectrum or time history analysis, and hence the need to override the default. This command is explained in Section 5.30 of the Technical Reference manual.

```
UNIT METER
DEFINE TIME HISTORY
TYPE 1 ACCELERATION
READ EQDATA.TXT
ARRIVAL TIME
0.0
DAMPING 0.05
```

There are two stages in the command specification required for a time-history analysis. The first stage is defined above. Here, the parameters of the earthquake (ground acceleration) are provided.

Each data set is individually identified by the number that follows the TYPE command. In this file, only one data set is defined, which is apparent from the fact that only one TYPE is defined.

The word FORCE that follows the TYPE 1 command signifies that this data set is for a ground acceleration. (If one wishes to specify a forcing function, the keyword FORCE must be used instead.)

Notice the expression "READ EQDATA.TXT". It means that we have chosen to specify the time vs. ground acceleration data in the file called EQDATA.TXT. That file must reside in the same folder as the one in which the data file for this structure resides. As explained in the small examples shown in Section 5.31.4 of the Technical Reference manual, the EQDATA.TXT file is a simple text file containing several pairs of time-acceleration data. A sample portion of that file is as shown below.

```
0.0000   0.006300
0.0200   0.003640
0.0400   0.000990
0.0600   0.004280
0.0800   0.007580
0.1000   0.010870
```

While it may not be apparent from the above numbers, it may also be noted that the geological data for the site the building sits on indicate that the above acceleration values are a fraction of "g", the acceleration due to gravity. Thus, for example, at 0.02 seconds, the acceleration is 0.00364 multiplied by 9.806 m/sec^2 (or 0.00364 multiplied by 32.2 ft/sec^2). Consequently, the burden of informing the program that the values need to be multiplied by "g" is upon us, and we shall be doing so at a later step.

The arrival time value indicates the relative value of time at which the earthquake begins to act upon the structure. We have chosen 0.0, as there is no other dynamic load on the structure from the relative time standpoint. The modal damping ratio for all the modes is set to 0.05.

```
LOAD 1 WEIGHT OF STRUCTURE ACTING STATICALLY
SELFWEIGHT Y -1.0
```

The above data describe a static load case. The selfweight of the structure is acting in the negative global Y direction.

```
LOAD 2 PLATFORM LEVEL LOAD ACTING STATICALLY FLOOR LOAD
YRA 6.9 7.1 FLOAD -500
```

Load case 2 is also a static load case. At the Y=7.0m elevation, our structure has a floor slab. But, it is a non-structural entity which, though capable of carrying the loads acting on itself, is not meant to be an integral part of the framing system. It merely transmits the load to the beam-column grid.

There are uniform area loads on the floor (think of the load as wooden pallets supporting boxes of paper). Since the slab is not part of the structural model, how do we tell the program to transmit the imposed load from the slab to the beams without manually converting them to distributed beam loads ourselves? That is where the floor load utility comes in handy. It is a facility where we specify the load as a pressure, and the program converts the pressure to individual beam loads. Thus, the input required from the user is very simple - load intensity in the form of pressure, and the region of the structure in terms of X, Y and Z coordinates in space, of the area over which the pressure acts.

In the process of converting the pressure to beam loads, STAAD will consider the empty space between criss-crossing beams (in plan view) to be panels, similar to the squares of a chess board. The load on each panel is then tranferred to beams surrounding the panel, using a triangular or trapezoidal load distribution method.

```
LOAD 3 DYNAMIC LOAD
* MASSES
SELFWEIGHT X 1.0
SELFWEIGHT Y 1.0
SELFWEIGHT Z 1.0

FLOOR LOAD
YRANGE 6.9 7.1 FLOAD 500 GX
YRANGE 6.9 7.1 FLOAD 500 GY
YRANGE 6.9 7.1 FLOAD 500 GZ
```

Load case 3 is the dynamic load case, the one which contains the second part of the instruction set for a dynamic analysis to be performed. The data here are

a. loads which will yield the mass values which will populate the mass matrix
b. the directions of the loads, which will yield the degree of freedom numbers of the mass matrix for being populated.

Thus, the selfweight, as well as the imposed loads on the non-structural slab are to be considered as participating in the vibration along all the global directions.

```
GROUND MOTION X 1 1 9.806
```

The above command too is part of load case 3. Here we say that the seismic force, whose characteristics are defined by the TYPE 1 time history input data, acting at arrival time 1, is to be applied along the X direction. We mentioned earlier that the acceleration input data was specified as a fraction of “g”. The number 9.806 indicates the value which the accleration data, as read from EQDATA.TXT are to be factored by before they are used.

LOAD COMBINATION 11 (STATIC + POSITIVE OF DYNAMIC)
1 1.0 2 1.0 3 1.0

LOAD COMBINATION 12 (STATIC + NEGATIVE OF DYNAMIC)
1 1.0 2 1.0 3 -1.0

In a time history analysis, the member forces FX thru MZ each have a value for every time step. If there are a 1000 time steps, there will be 1000 values of FX, 1000 for FY etc. for that load case. Not all of them can be used in a further calculation like a steel or concrete design. However, the maximum from among those time steps is available. If we wish to do a design, one way to make sure that the structure is not under-designed is to create 2 load combination cases involving the dynamic case, a positive combination, and a negative combination.

That is what is being done above. Load combination case no. 11 consists of the sum of the static load cases (1 & 2) with the positive direction of the dynamic load case (3). Load combination case no. 12 consists of the sum of the static load cases (1 & 2) with the negative direction of the dynamic load case (3). The user has discretion on what load factors to use with these combinations. We have chosen the factors to be 1.0.

PERFORM ANALYSIS

The above is the instruction to perform the analysis related calculations. That means, computing nodal displacements, support reactions, etc.

PRINT ANALYSIS RESULTS

The above command is an instruction to the program to produce a report of the joint displacements, support reactions and member end forces in the output file. As mentioned earlier, for the dynamic case, these will be just the maximum values, not the ones generated for every time step. If the user wishes to see the results for each time step, he/she may do so by using STAAD's Post-processing facilities.

```
LOAD LIST 11 12
PARAMETER
CODE CANADA
CHECK CODE ALL
```

A steel design - code check - is done according to the Canadian code for load cases 11 and 12.

```
FINISH
```

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

 1. STAAD SPACE DYNAMIC ANALYSIS FOR SEISMIC LOADS
 3. UNIT METER KNS
 4. JOINT COORDINATES
 5. 1 0 0 0 ; 2 0 3.5 0 ; 3 0 5.3 0 ; 4 0 7 0
 6. REPEAT ALL 1 9.5 0 0
 7. REPEAT ALL 1 0 0 3
 8. 17 1.8 7 0 ; 18 4.6 7 0 ; 19 7.6 7 0
 9. REPEAT ALL 1 0 0 3
11. MEMBER INCIDENCES
12. 1 1 2 3
13. REPEAT 1 3 4
14. 7 9 10 9
15. 10 13 14 12
16. 13 4 17; 14 17 18; 15 18 19; 16 19 8
17. 17 12 20; 18 20 21; 19 21 22; 20 22 16
18. 21 2 10; 22 4 12; 23 6 14
19. 24 8 16; 25 3 17; 26 7 19; 27 11 20; 28 15 22; 29 18 21
21. START GROUP DEFINITION
22. MEMBER
23. _VERTICAL 1 TO 12
24. _XBEAM 13 TO 20
25. _ZBEAM 21 TO 24 29
26. _BRACE 25 TO 28
27. END GROUP DEFINITION
29. MEMBER PROPERTIES CANADIAN
30. _VERTICAL TA ST W310X97
31. _XBEAM TA ST W250X39
32. _ZBEAM TA ST C200X17
33. _BRACE TA ST L152X152X13
35. UNIT KNS MMS
36. CONSTANT
37. E 200 ALL
39. UNIT KGS METER
40. CONSTANT
41. DENSITY 7800 ALL
42. POISSON STEEL ALL
43. BETA 180 MEMB 21 22
45. SUPPORTS
46. 1 5 9 13 PINNED
48. CUT OFF MODE SHAPE 30
51. UNIT METER
52. DEFINE TIME HISTORY
53. TYPE 1 ACCELERATION
54. READ EQDATA.TXT
55. ARRIVAL TIME
56. 0.0
57. DAMPING 0.05
60. LOAD 1 WEIGHT OF STRUCTURE ACTING STATICALLY
61. SELFWEIGHT Y -1.0
63. LOAD 2 PLATFORM LEVEL LOAD ACTING STATICALLY
64. FLOOR LOAD
65. YRA 6.9 7.1 FLOAD -500
67. LOAD 3 DYNAMIC LOAD
68. * MASSES
69. SELFWEIGHT X 1.0
70. SELFWEIGHT Y 1.0
71. SELFWEIGHT Z 1.0
73. FLOOR LOAD
74. YRANGE 6.9 7.1 FLOAD 500 GX
75. YRANGE 6.9 7.1 FLOAD 500 GY
```

```
   76. YRANGE 6.9 7.1 FLOAD 500 GZ
   78. GROUND MOTION X 1 1 9.806
   80. LOAD COMBINATION 11 (STATIC + POSITIVE OF DYNAMIC)
   81. 1 1.0 2 1.0 3 1.0
   83. LOAD COMBINATION 12 (STATIC + NEGATIVE OF DYNAMIC)
   84. 1 1.0 2 1.0 3 -1.0
   86. PERFORM ANALYSIS

           P R O B L E M   S T A T I S T I C S
           -----------------------------------

    NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    22/    29/     4

          SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

    ORIGINAL/FINAL BAND-WIDTH=    14/     4/     27 DOF
    TOTAL PRIMARY LOAD CASES =    3, TOTAL DEGREES OF FREEDOM =    120
    SIZE OF STIFFNESS MATRIX =        4 DOUBLE  KILO-WORDS
    REQRD/AVAIL. DISK SPACE  =     12.1/   3981.4 MB

NUMBER OF MODES REQUESTED             =    30
NUMBER OF EXISTING MASSES IN THE MODEL =    54
NUMBER OF MODES THAT WILL BE USED      =    30

             CALCULATED FREQUENCIES FOR LOAD CASE       3

      MODE            FREQUENCY(CYCLES/SEC)         PERIOD(SEC)      ACCURACY


        1                        0.693                1.44201       1.123E-15
        2                        1.224                0.81697       4.805E-16
        3                        1.370                0.73010       1.919E-16
        4                        1.567                0.63818       2.052E-15
        5                        2.082                0.48034       1.661E-16
        6                        3.047                0.32823       9.308E-16
        7                        4.220                0.23695       6.467E-16
        8                        4.281                0.23360       6.286E-16
        9                        5.553                0.18008       3.175E-15
       10                        5.559                0.17990       3.728E-16
       11                        5.736                0.17433       1.050E-15
       12                       12.880                0.07764       1.250E-15
       13                       12.888                0.07759       1.248E-15
       14                       15.228                0.06567       1.987E-16
       15                       15.285                0.06542       1.183E-15
       16                       16.567                0.06036       3.358E-16
       17                       16.574                0.06034       6.542E-15
       18                       45.644                0.02191       6.015E-15
       19                       45.667                0.02190       1.541E-10
       20                       49.158                0.02034       1.220E-15
       21                       49.187                0.02033       4.808E-10
       22                       52.323                0.01911       2.289E-15
       23                       52.470                0.01906       8.033E-16
       24                       54.972                0.01819       2.391E-14
       25                       56.110                0.01782       1.569E-14
       26                       56.126                0.01782       3.557E-10
       27                       65.939                0.01517       2.204E-15
       28                       66.102                0.01513       3.039E-11
       29                       87.835                0.01139       8.027E-15
       30                       88.053                0.01136       7.226E-14

   The following Frequencies are estimates that were calculated. These are for
    information only and will not be used. Remaining values are either above
    the cut off mode/freq values or are of low accuracy. To use these
    frequencies, rerun with a higher cutoff mode (or mode + freq) value.
```

CALCULATED FREQUENCIES FOR LOAD CASE 3

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)	ACCURACY
31	88.328	0.01132	1.129E-08
32	89.173	0.01121	4.079E-15
33	89.191	0.01121	6.413E-14
34	89.464	0.01118	6.166E-07
35	93.821	0.01066	1.960E-14
36	93.846	0.01066	4.411E-08
37	151.190	0.00661	8.801E-13
38	151.195	0.00661	1.163E-09
39	158.382	0.00631	2.747E-12
40	158.389	0.00631	1.304E-07
41	165.553	0.00604	9.317E-14
42	165.556	0.00604	1.764E-14
43	182.919	0.00547	7.102E-12
44	182.930	0.00547	4.726E-09
45	185.671	0.00539	5.856E-13
46	185.682	0.00539	1.788E-07
47	350.608	0.00285	9.655E-11
48	350.808	0.00285	3.925E-11
49	351.834	0.00284	3.549E-09

MASS PARTICIPATION FACTORS IN PERCENT

MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z
1	0.00	0.00	85.38	0.000	0.000	85.379
2	98.05	0.00	0.00	98.051	0.000	85.379
3	0.00	0.00	0.01	98.051	0.000	85.384
4	0.00	0.00	0.03	98.051	0.000	85.411
5	0.00	0.00	13.41	98.051	0.000	98.816
6	0.00	0.00	0.00	98.051	0.000	98.816
7	0.00	0.00	0.00	98.051	0.000	98.816
8	0.00	0.00	0.01	98.051	0.000	98.827
9	0.00	51.86	0.00	98.051	51.860	98.827
10	0.00	0.00	0.00	98.051	51.860	98.829
11	0.00	0.00	0.23	98.051	51.860	99.059
12	1.68	0.25	0.00	99.731	52.110	99.059
13	0.00	0.00	0.00	99.731	52.110	99.059
14	0.00	0.00	0.39	99.731	52.110	99.453
15	0.00	0.00	0.52	99.731	52.110	99.977
16	0.03	7.02	0.00	99.761	59.126	99.977
17	0.00	0.00	0.00	99.761	59.126	99.977
18	0.00	10.52	0.00	99.762	69.646	99.977
19	0.00	0.00	0.00	99.762	69.646	99.977
20	0.23	0.06	0.00	99.991	69.706	99.977
21	0.00	0.00	0.00	99.991	69.706	99.977
22	0.00	0.00	0.00	99.991	69.706	99.977
23	0.00	0.00	0.00	99.991	69.706	99.977
24	0.00	0.00	0.00	99.991	69.706	99.977
25	0.00	2.48	0.00	99.991	72.186	99.977
26	0.00	0.00	0.00	99.991	72.186	99.977
27	0.00	0.00	0.01	99.991	72.186	99.989
28	0.00	0.00	0.01	99.991	72.186	100.000
29	0.00	0.00	0.00	99.991	72.186	100.000
30	0.00	9.74	0.00	99.995	81.929	100.000

A C T U A L MODAL D A M P I N G USED IN ANALYSIS

MODE	DAMPING
1	0.0500
2	0.0500
3	0.0500
4	0.0500
5	0.0500
6	0.0500

```
 MODE   DAMPING

    7    0.0500
    8    0.0500
    9    0.0500
   10    0.0500
   11    0.0500
   12    0.0500
   13    0.0500
   14    0.0500
   15    0.0500
   16    0.0500
   17    0.0500
   18    0.0500
   19    0.0500
   20    0.0500
   21    0.0500
   22    0.0500
   23    0.0500
   24    0.0500
   25    0.0500
   26    0.0500
   27    0.0500
   28    0.0500
   29    0.0500
   30    0.0500

 TIME STEP USED IN TIME HISTORY ANALYSIS = 0.00139 SECONDS
 NUMBER OF MODES WHOSE CONTRIBUTION IS CONSIDERED =  30
 TIME DURATION OF TIME HISTORY ANALYSIS =   31.160 SECONDS
 NUMBER OF TIME STEPS IN THE SOLUTION PROCESS =   22435

BASE SHEAR UNITS ARE -- KGS  METE

MAXIMUM BASE SHEAR  X=  -9.249216E+03  Y=  -5.280377E+01  Z=  -8.158461E-07
    AT TIMES              5.802778           2.445833           2.762500

  87. PRINT ANALYSIS RESULTS

 JOINT DISPLACEMENT (CM   RADIANS)    STRUCTURE TYPE = SPACE
 ------------------
JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    1    1     0.0000    0.0000    0.0000    0.0000    0.0000    0.0001
         2     0.0000    0.0000    0.0000    0.0000    0.0000    0.0015
         3     0.0000    0.0000    0.0000    0.0000    0.0000   -0.0167
        11     0.0000    0.0000    0.0000    0.0000    0.0000   -0.0151
        12     0.0000    0.0000    0.0000    0.0000    0.0000    0.0184
    2    1    -0.0283   -0.0011    0.0000    0.0000    0.0000    0.0000
         2    -0.4133   -0.0050   -0.0004   -0.0001    0.0000    0.0004
         3     5.5307    0.0045    0.0000    0.0000    0.0000   -0.0136
        11     5.0891   -0.0016   -0.0005   -0.0001    0.0000   -0.0133
        12    -5.9724   -0.0106   -0.0005   -0.0001    0.0000    0.0140
    3    1    -0.0242   -0.0015   -0.0002    0.0000    0.0000   -0.0001
         2    -0.3559   -0.0075   -0.0122    0.0000   -0.0001   -0.0012
         3     7.6673    0.0068    0.0000    0.0000    0.0000   -0.0097
        11     7.2871   -0.0022   -0.0124    0.0000   -0.0001   -0.0109
        12    -8.0475   -0.0159   -0.0124    0.0000   -0.0001    0.0084
    4    1    -0.0029   -0.0016    0.0000    0.0000    0.0000   -0.0001
         2    -0.0438   -0.0076    0.0004    0.0002    0.0000   -0.0020
         3     9.0199    0.0025    0.0000    0.0000    0.0000   -0.0079
        11     8.9732   -0.0067    0.0004    0.0002    0.0000   -0.0100
        12    -9.0665   -0.0117    0.0004    0.0002    0.0000    0.0058
    5    1     0.0000    0.0000    0.0000    0.0000    0.0000   -0.0001
         2     0.0000    0.0000    0.0000    0.0000    0.0000   -0.0014
         3     0.0000    0.0000    0.0000    0.0000    0.0000   -0.0168
        11     0.0000    0.0000    0.0000    0.0000    0.0000   -0.0183
        12     0.0000    0.0000    0.0000    0.0000    0.0000    0.0153
```

JOINT DISPLACEMENT (CM RADIANS) STRUCTURE TYPE = SPACE

JOINT	LOAD	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
6	1	0.0256	-0.0011	0.0000	0.0000	0.0000	0.0000
	2	0.3722	-0.0050	-0.0004	-0.0001	0.0000	-0.0002
	3	5.5469	-0.0045	0.0000	0.0000	0.0000	-0.0136
	11	5.9447	-0.0106	-0.0005	-0.0001	0.0000	-0.0139
	12	-5.1491	-0.0016	-0.0005	-0.0001	0.0000	0.0134
7	1	0.0201	-0.0015	-0.0002	0.0000	0.0000	0.0001
	2	0.2936	-0.0075	-0.0122	0.0000	0.0001	0.0013
	3	7.6810	-0.0068	0.0000	0.0000	0.0000	-0.0096
	11	7.9947	-0.0159	-0.0124	0.0000	0.0001	-0.0082
	12	-7.3672	-0.0023	-0.0124	0.0000	0.0001	0.0110
8	1	-0.0026	-0.0016	0.0000	0.0000	0.0000	0.0001
	2	-0.0387	-0.0077	0.0004	0.0002	0.0000	0.0021
	3	9.0211	-0.0027	0.0000	0.0000	0.0000	-0.0078
	11	8.9799	-0.0120	0.0004	0.0002	0.0000	-0.0056
	12	-9.0624	-0.0066	0.0004	0.0002	0.0000	0.0101
9	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0015
	3	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0167
	11	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0151
	12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0184
10	1	-0.0283	-0.0011	0.0000	0.0000	0.0000	0.0000
	2	-0.4133	-0.0050	0.0004	0.0001	0.0000	0.0004
	3	5.5307	0.0045	0.0000	0.0000	0.0000	-0.0136
	11	5.0891	-0.0016	0.0005	0.0001	0.0000	-0.0133
	12	-5.9724	-0.0106	0.0005	0.0001	0.0000	0.0140
11	1	-0.0242	-0.0015	0.0002	0.0000	0.0000	-0.0001
	2	-0.3559	-0.0075	0.0122	0.0000	0.0001	-0.0012
	3	7.6673	0.0068	0.0000	0.0000	0.0000	-0.0097
	11	7.2871	-0.0022	0.0124	0.0000	0.0001	-0.0109
	12	-8.0475	-0.0159	0.0124	0.0000	0.0001	0.0084
12	1	-0.0029	-0.0016	0.0000	0.0000	0.0000	-0.0001
	2	-0.0438	-0.0076	-0.0004	-0.0002	0.0000	-0.0020
	3	9.0199	0.0025	0.0000	0.0000	0.0000	-0.0079
	11	8.9732	-0.0067	-0.0004	-0.0002	0.0000	-0.0100
	12	-9.0665	-0.0117	-0.0004	-0.0002	0.0000	0.0058
13	1	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
	2	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0014
	3	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0168
	11	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0183
	12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0153
14	1	0.0256	-0.0011	0.0000	0.0000	0.0000	0.0000
	2	0.3722	-0.0050	0.0004	0.0001	0.0000	-0.0002
	3	5.5469	-0.0045	0.0000	0.0000	0.0000	-0.0136
	11	5.9447	-0.0106	0.0005	0.0001	0.0000	-0.0139
	12	-5.1491	-0.0016	0.0005	0.0001	0.0000	0.0134
15	1	0.0201	-0.0015	0.0002	0.0000	0.0000	0.0001
	2	0.2936	-0.0075	0.0122	0.0000	-0.0001	0.0013
	3	7.6810	-0.0068	0.0000	0.0000	0.0000	-0.0096
	11	7.9947	-0.0159	0.0124	0.0000	-0.0001	-0.0082
	12	-7.3672	-0.0023	0.0124	0.0000	-0.0001	0.0110
16	1	-0.0026	-0.0016	0.0000	0.0000	0.0000	0.0001
	2	-0.0387	-0.0077	-0.0004	-0.0002	0.0000	0.0021
	3	9.0211	-0.0027	0.0000	0.0000	0.0000	-0.0078
	11	8.9799	-0.0120	-0.0004	-0.0002	0.0000	-0.0056
	12	-9.0624	-0.0066	-0.0004	-0.0002	0.0000	0.0101
17	1	-0.0026	-0.0261	0.0000	0.0000	0.0000	-0.0002
	2	-0.0388	-0.3675	0.0008	0.0001	0.0000	-0.0025
	3	9.0035	-1.3394	0.0000	0.0000	0.0000	-0.0033
	11	8.9621	-1.7331	0.0008	0.0001	0.0000	-0.0059
	12	-9.0449	0.9458	0.0008	0.0001	0.0000	0.0007
18	1	-0.0027	-0.0630	0.0000	0.0001	0.0000	0.0000
	2	-0.0412	-0.9611	0.0000	0.0038	0.0000	-0.0003
	3	9.0055	-0.0712	0.0000	0.0000	0.0000	0.0083
	11	8.9615	-1.0952	0.0000	0.0039	0.0000	0.0080
	12	-9.0494	-0.9529	0.0000	0.0039	0.0000	-0.0086

```
   JOINT DISPLACEMENT (CM   RADIANS)    STRUCTURE TYPE = SPACE
   ------------------
JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    19    1    -0.0029   -0.0289    0.0000    0.0000    0.0000    0.0002
          2    -0.0438   -0.4095    0.0009    0.0001    0.0000    0.0025
          3     9.0035    1.3991    0.0000    0.0000    0.0000   -0.0031
         11     8.9568    0.9607    0.0009    0.0001    0.0000   -0.0004
         12    -9.0503   -1.8375    0.0009    0.0001    0.0000    0.0057
    20    1    -0.0026   -0.0261    0.0000    0.0000    0.0000   -0.0002
          2    -0.0388   -0.3675   -0.0008   -0.0001    0.0000   -0.0025
          3     9.0035   -1.3394    0.0000    0.0000    0.0000   -0.0033
         11     8.9621   -1.7331   -0.0008   -0.0001    0.0000   -0.0059
         12    -9.0449    0.9458   -0.0008   -0.0001    0.0000    0.0007
    21    1    -0.0027   -0.0630    0.0000   -0.0001    0.0000    0.0000
          2    -0.0412   -0.9611    0.0000   -0.0038    0.0000   -0.0003
          3     9.0055   -0.0712    0.0000    0.0000    0.0000    0.0083
         11     8.9615   -1.0952    0.0000   -0.0039    0.0000    0.0080
         12    -9.0494   -0.9529    0.0000   -0.0039    0.0000   -0.0086
    22    1    -0.0029   -0.0289    0.0000    0.0000    0.0000    0.0002
          2    -0.0438   -0.4095   -0.0009   -0.0001    0.0000    0.0025
          3     9.0035    1.3991    0.0000    0.0000    0.0000   -0.0031
         11     8.9568    0.9607   -0.0009   -0.0001    0.0000   -0.0004
         12    -9.0503   -1.8375   -0.0009   -0.0001    0.0000    0.0057

   SUPPORT REACTIONS -UNIT KGS  METE    STRUCTURE TYPE = SPACE
   -----------------

 JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

     1    1      60.22    989.78      0.96      0.00      0.00      0.00
          2     873.60   3562.50    -19.74      0.00      0.00      0.00
          3   -2294.73  -3225.14      0.00      0.00      0.00      0.00
         11   -1360.90   1327.14    -18.78      0.00      0.00      0.00
         12    3228.55   7777.43    -18.78      0.00      0.00      0.00
     5    1     -60.22    989.93      0.96      0.00      0.00      0.00
          2    -873.60   3562.50    -19.74      0.00      0.00      0.00
          3   -2329.88   3221.91      0.00      0.00      0.00      0.00
         11   -3263.71   7774.34    -18.78      0.00      0.00      0.00
         12    1396.06   1330.52    -18.78      0.00      0.00      0.00
     9    1      60.22    989.78     -0.96      0.00      0.00      0.00
          2     873.60   3562.50     19.74      0.00      0.00      0.00
          3   -2294.73  -3225.14      0.00      0.00      0.00      0.00
         11   -1360.90   1327.14     18.78      0.00      0.00      0.00
         12    3228.55   7777.43     18.78      0.00      0.00      0.00
    13    1     -60.22    989.93     -0.96      0.00      0.00      0.00
          2    -873.60   3562.50     19.74      0.00      0.00      0.00
          3   -2329.88   3221.91      0.00      0.00      0.00      0.00
         11   -3263.71   7774.34     18.78      0.00      0.00      0.00
         12    1396.06   1330.52     18.78      0.00      0.00      0.00


   MEMBER END FORCES    STRUCTURE TYPE = SPACE
   -----------------
   ALL UNITS ARE -- KGS  METE     (LOCAL )

  MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

     1    1     1    989.78    -60.22     0.96      0.00      0.00       0.00
                2   -653.99     60.22    -0.96      0.00     -3.36    -210.78
          2     1   3562.50   -873.60   -19.74      0.00      0.00       0.00
                2  -3562.50    873.60    19.74      0.00     69.09   -3057.61
          3     1  -3225.14   2294.73     0.00      0.00      0.00       0.00
                2   3225.14  -2294.73     0.00      0.00      0.00    8031.54
         11     1   1327.14   1360.90   -18.78      0.00      0.00       0.00
                2   -991.35  -1360.90    18.78      0.00     65.73    4763.16
         12     1   7777.43  -3228.55   -18.78      0.00      0.00       0.00
                2  -7441.64   3228.55    18.78      0.00     65.73  -11299.93
```

MEMBER END FORCES   STRUCTURE TYPE = SPACE

ALL UNITS ARE -- KGS METE   (LOCAL)

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
2	1	2	628.60	-60.22	5.86	0.01	-8.86	210.78
		3	-455.91	60.22	-5.86	-0.01	-1.69	-319.18
	2	2	3562.50	-873.60	112.31	0.22	-79.35	3057.61
		3	-3562.50	873.60	-112.31	-0.22	-122.81	-4630.10
	3	2	-3225.15	2195.71	0.00	0.00	0.00	-8031.54
		3	3225.15	-2195.71	0.00	0.00	0.00	11983.79
	11	2	965.95	1261.88	118.17	0.23	-88.20	-4763.16
		3	-793.26	-1261.88	-118.17	-0.23	-124.50	7034.51
	12	2	7416.26	-3129.53	118.17	0.23	-88.20	11299.93
		3	-7243.56	3129.53	-118.17	-0.23	-124.50	-16933.06
3	1	3	187.97	179.52	5.85	-0.01	1.67	298.15
		4	-24.88	-179.52	-5.85	0.01	-11.61	7.04
	2	3	56.29	2785.04	111.62	-0.33	122.15	4496.67
		4	-56.29	-2785.04	-111.62	0.33	-311.90	237.90
	3	3	6354.83	-8591.51	0.00	0.00	0.00	-12019.14
		4	-6354.83	8591.51	0.00	0.00	0.00	-2586.45
	11	3	6599.09	-5626.95	117.47	-0.34	123.83	-7224.32
		4	-6435.99	5626.95	-117.47	0.34	-323.52	-2341.51
	12	3	-6110.57	11556.08	117.47	-0.34	123.83	16813.97
		4	6273.67	-11556.08	-117.47	0.34	-323.52	2831.39
4	1	5	989.93	60.22	0.96	0.00	0.00	0.00
		6	-654.14	-60.22	-0.96	0.00	-3.36	210.78
	2	5	3562.50	873.60	-19.74	0.00	0.00	0.00
		6	-3562.50	-873.60	19.74	0.00	69.08	3057.61
	3	5	3221.91	2329.88	0.00	0.00	0.00	0.00
		6	-3221.91	-2329.88	0.00	0.00	0.00	8154.58
	11	5	7774.34	3263.71	-18.78	0.00	0.00	0.00
		6	-7438.55	-3263.71	18.78	0.00	65.72	11422.97
	12	5	1330.52	-1396.06	-18.78	0.00	0.00	0.00
		6	-994.73	1396.06	18.78	0.00	65.72	-4886.20
5	1	6	628.75	60.22	5.86	-0.01	-8.86	-210.78
		7	-456.06	-60.22	-5.86	0.01	-1.69	319.18
	2	6	3562.50	873.60	112.27	-0.21	-79.33	-3057.61
		7	-3562.50	-873.60	-112.27	0.21	-122.76	4630.10
	3	6	3221.81	2230.25	0.00	0.00	0.00	-8154.58
		7	-3221.81	-2230.25	0.00	0.00	0.00	12168.93
	11	6	7413.06	3164.08	118.13	-0.22	-88.19	-11422.97
		7	-7240.36	-3164.08	-118.13	0.22	-124.45	17118.20
	12	6	969.44	-1296.43	118.13	-0.22	-88.19	4886.20
		7	-796.75	1296.43	-118.13	0.22	-124.45	-7219.66
6	1	7	201.36	-175.80	5.85	0.01	1.67	-296.62
		8	-38.27	175.80	-5.85	-0.01	-11.61	-2.23
	2	7	261.23	-2741.58	111.62	0.31	122.16	-4487.62
		8	-261.23	2741.58	-111.62	-0.31	-311.91	-173.07
	3	7	-6030.00	-8753.57	0.00	0.00	0.00	-12207.02
		8	6030.00	8753.57	0.00	0.00	0.00	-2674.35
	11	7	-5567.41	-11670.94	117.46	0.32	123.84	-16991.27
		8	5730.51	11670.94	-117.46	-0.32	-323.52	-2849.65
	12	7	6492.59	5836.19	117.46	0.32	123.84	7422.78
		8	-6329.49	-5836.19	-117.46	-0.32	-323.52	2499.06
7	1	9	989.78	-60.22	-0.96	0.00	0.00	0.00
		10	-653.99	60.22	0.96	0.00	3.36	-210.78
	2	9	3562.50	-873.60	19.74	0.00	0.00	0.00
		10	-3562.50	873.60	-19.74	0.00	-69.09	-3057.61
	3	9	-3225.14	2294.73	0.00	0.00	0.00	0.00
		10	3225.14	-2294.73	0.00	0.00	0.00	8031.54
	11	9	1327.14	1360.90	18.78	0.00	0.00	0.00
		10	-991.35	-1360.90	-18.78	0.00	-65.73	4763.16
	12	9	7777.42	-3228.55	18.78	0.00	0.00	0.00
		10	-7441.64	3228.55	-18.78	0.00	-65.73	-11299.93

MEMBER END FORCES   STRUCTURE TYPE = SPACE

ALL UNITS ARE -- KGS METE   (LOCAL)

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
8	1	10	628.60	-60.22	-5.86	-0.01	8.86	210.78
		11	-455.91	60.22	5.86	0.01	1.69	-319.18
	2	10	3562.50	-873.60	-112.31	-0.22	79.35	3057.61
		11	-3562.50	873.60	112.31	0.22	122.81	-4630.10
	3	10	-3225.15	2195.71	0.00	0.00	0.00	-8031.54
		11	3225.15	-2195.71	0.00	0.00	0.00	11983.79
	11	10	965.95	1261.88	-118.17	-0.23	88.20	-4763.16
		11	-793.26	-1261.88	118.17	0.23	124.50	7034.51
	12	10	7416.26	-3129.53	-118.17	-0.23	88.20	11299.93
		11	-7243.56	3129.53	118.17	0.23	124.50	-16933.06
9	1	11	187.97	179.52	-5.85	0.01	-1.67	298.15
		12	-24.88	-179.52	5.85	-0.01	11.61	7.04
	2	11	56.29	2785.04	-111.62	0.33	-122.15	4496.67
		12	-56.29	-2785.04	111.62	-0.33	311.90	237.90
	3	11	6354.83	-8591.51	0.00	0.00	0.00	-12019.14
		12	-6354.83	8591.51	0.00	0.00	0.00	-2586.45
	11	11	6599.09	-5626.95	-117.47	0.34	-123.83	-7224.32
		12	-6435.99	5626.95	117.47	-0.34	323.52	-2341.51
	12	11	-6110.57	11556.08	-117.47	0.34	-123.83	16813.97
		12	6273.67	-11556.08	117.47	-0.34	323.52	2831.39
10	1	13	989.93	60.22	-0.96	0.00	0.00	0.00
		14	-654.14	-60.22	0.96	0.00	3.36	210.78
	2	13	3562.50	873.60	19.74	0.00	0.00	0.00
		14	-3562.50	-873.60	-19.74	0.00	-69.08	3057.61
	3	13	3221.91	2329.88	0.00	0.00	0.00	0.00
		14	-3221.91	-2329.88	0.00	0.00	0.00	8154.58
	11	13	7774.34	3263.71	18.78	0.00	0.00	0.00
		14	-7438.55	-3263.71	-18.78	0.00	-65.72	11422.97
	12	13	1330.52	-1396.06	18.78	0.00	0.00	0.00
		14	-994.73	1396.06	-18.78	0.00	-65.72	-4886.20
11	1	14	628.75	60.22	-5.86	0.01	8.86	-210.78
		15	-456.06	-60.22	5.86	-0.01	1.69	319.18
	2	14	3562.50	873.60	-112.27	0.21	79.33	-3057.61
		15	-3562.50	-873.60	112.27	-0.21	122.76	4630.10
	3	14	3221.81	2230.25	0.00	0.00	0.00	-8154.58
		15	-3221.81	-2230.25	0.00	0.00	0.00	12168.93
	11	14	7413.06	3164.08	-118.13	0.22	88.19	-11422.97
		15	-7240.36	-3164.08	118.13	-0.22	124.45	17118.20
	12	14	969.44	-1296.43	-118.13	0.22	88.19	4886.20
		15	-796.75	1296.43	118.13	-0.22	124.45	-7219.66
12	1	15	201.36	-175.80	-5.85	-0.01	-1.67	-296.62
		16	-38.27	175.80	5.85	0.01	11.61	-2.23
	2	15	261.23	-2741.58	-111.62	-0.31	-122.16	-4487.62
		16	-261.23	2741.58	111.62	0.31	311.91	-173.07
	3	15	-6030.00	-8753.57	0.00	0.00	0.00	-12207.02
		16	6030.00	8753.57	0.00	0.00	0.00	-2674.35
	11	15	-5567.41	-11670.94	-117.46	-0.32	-123.84	-16991.27
		16	5730.51	11670.94	117.46	0.32	323.52	-2849.65
	12	15	6492.59	5836.19	-117.46	-0.32	-123.84	7422.78
		16	-6329.49	-5836.19	117.46	0.32	323.52	2499.06
13	1	4	-179.52	-0.51	-0.01	0.00	-0.01	-7.04
		17	179.52	69.59	0.01	0.00	0.03	-56.05
	2	4	-2785.04	-506.21	-0.70	0.08	-0.27	-237.90
		17	2785.04	1293.71	0.70	-0.08	1.54	-1157.03
	3	4	9119.87	6354.47	0.00	0.00	0.00	2586.45
		17	-9119.87	-6354.47	0.00	0.00	0.00	8851.60
	11	4	6155.30	5847.75	-0.71	0.09	-0.28	2341.51
		17	-6155.30	-4991.17	0.71	-0.09	1.57	7638.51
	12	4	-12084.44	-6861.20	-0.71	0.09	-0.28	-2831.39
		17	12084.44	7717.78	0.71	-0.09	1.57	-10064.69

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MEMBER END FORCES    STRUCTURE TYPE = SPACE
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ALL UNITS ARE -- KGS  METE     (LOCAL )
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MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
14	1	17	60.22	126.89	0.00	-0.03	0.01	66.67
		18	-60.22	-19.44	0.00	0.03	-0.01	138.20
	2	17	873.60	2212.50	-0.01	-1.76	0.26	1198.97
		18	-873.60	-675.00	0.01	1.76	-0.24	2337.28
	3	17	-707.62	-3344.18	0.00	0.00	0.00	-9748.53
		18	707.62	3344.18	0.00	0.00	0.00	385.43
	11	17	226.20	-1004.78	-0.01	-1.79	0.27	-8482.89
		18	-226.20	2649.74	0.01	1.79	-0.24	2860.91
	12	17	1641.45	5683.57	-0.01	-1.79	0.27	11014.17
		18	-1641.45	-4038.62	0.01	1.79	-0.24	2090.04
15	1	18	60.22	-5.95	0.00	0.03	0.01	-138.20
		19	-60.22	121.08	0.00	-0.03	-0.01	-52.34
	2	18	873.60	-450.00	0.01	1.64	0.24	-2337.28
		19	-873.60	2137.50	-0.01	-1.64	-0.26	-981.47
	3	18	651.61	-3354.44	0.00	0.00	0.00	-385.43
		19	-651.61	3354.44	0.00	0.00	0.00	-9678.42
	11	18	1585.43	-3810.39	0.01	1.67	0.24	-2860.91
		19	-1585.43	5613.02	-0.01	-1.67	-0.26	-10712.23
	12	18	282.22	2898.49	0.01	1.67	0.24	-2090.04
		19	-282.22	-1095.86	-0.01	-1.67	-0.26	8644.60
16	1	19	-175.80	60.04	0.01	0.00	-0.03	42.58
		8	175.80	12.88	-0.01	0.00	0.01	2.23
	2	19	-2741.58	1163.77	0.67	-0.08	-1.52	965.60
		8	2741.58	-301.27	-0.67	0.08	0.25	173.07
	3	19	-9298.97	6030.38	0.00	0.00	0.00	8783.37
		8	9298.97	-6030.38	0.00	0.00	0.00	2674.35
	11	19	-12216.35	7254.19	0.68	-0.08	-1.54	9791.55
		8	12216.35	-6318.78	-0.68	0.08	0.26	2849.65
	12	19	6381.59	-4806.57	0.68	-0.08	-1.54	-7775.19
		8	-6381.59	5741.98	-0.68	0.08	0.26	-2499.06
17	1	12	-179.52	-0.51	0.01	0.00	0.01	-7.04
		20	179.52	69.59	-0.01	0.00	-0.03	-56.05
	2	12	-2785.04	-506.21	0.70	-0.08	0.27	-237.90
		20	2785.04	1293.71	-0.70	0.08	-1.54	-1157.03
	3	12	9119.87	6354.47	0.00	0.00	0.00	2586.45
		20	-9119.87	-6354.47	0.00	0.00	0.00	8851.60
	11	12	6155.30	5847.75	0.71	-0.09	0.28	2341.51
		20	-6155.30	-4991.17	-0.71	0.09	-1.57	7638.51
	12	12	-12084.44	-6861.20	0.71	-0.09	0.28	-2831.39
		20	12084.44	7717.78	-0.71	0.09	-1.57	-10064.69
18	1	20	60.22	126.89	0.00	0.03	-0.01	66.67
		21	-60.22	-19.44	0.00	-0.03	0.01	138.20
	2	20	873.60	2212.50	0.01	1.76	-0.26	1198.97
		21	-873.60	-675.00	-0.01	-1.76	0.24	2337.28
	3	20	-707.62	-3344.18	0.00	0.00	0.00	-9748.53
		21	707.62	3344.18	0.00	0.00	0.00	385.43
	11	20	226.20	-1004.78	0.01	1.79	-0.27	-8482.89
		21	-226.20	2649.74	-0.01	-1.79	0.24	2860.91
	12	20	1641.45	5683.57	0.01	1.79	-0.27	11014.17
		21	-1641.45	-4038.62	-0.01	-1.79	0.24	2090.04
19	1	21	60.22	-5.95	0.00	-0.03	-0.01	-138.20
		22	-60.22	121.08	0.00	0.03	0.01	-52.34
	2	21	873.60	-450.00	-0.01	-1.64	-0.24	-2337.28
		22	-873.60	2137.50	0.01	1.64	0.26	-981.47
	3	21	651.61	-3354.44	0.00	0.00	0.00	-385.43
		22	-651.61	3354.44	0.00	0.00	0.00	-9678.42
	11	21	1585.43	-3810.39	-0.01	-1.67	-0.24	-2860.91
		22	-1585.43	5613.02	0.01	1.67	0.26	-10712.23
	12	21	282.22	2898.49	-0.01	-1.67	-0.24	-2090.04
		22	-282.22	-1095.86	0.01	1.67	0.26	8644.60

```
MEMBER END FORCES    STRUCTURE TYPE = SPACE
-----------------
ALL UNITS ARE -- KGS  METE     (LOCAL )

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

   20    1    22   -175.80     60.04    -0.01      0.00      0.03      42.58
              16    175.80     12.88     0.01      0.00     -0.01       2.23
         2    22  -2741.58   1163.77    -0.67      0.08      1.52     965.60
              16   2741.58   -301.27     0.67     -0.08     -0.25     173.07
         3    22  -9298.97   6030.38     0.00      0.00      0.00    8783.37
              16   9298.97  -6030.38     0.00      0.00      0.00    2674.35
        11    22 -12216.35   7254.19    -0.68      0.08      1.54    9791.55
              16  12216.35  -6318.78     0.68     -0.08     -0.26    2849.65
        12    22   6381.59  -4806.57    -0.68      0.08      1.54   -7775.19
              16  -6381.59   5741.98     0.68     -0.08     -0.26   -2499.06

   21    1     2     -4.90    -25.39     0.00      0.00      0.01     -12.22
              10      4.90    -25.39     0.00      0.00     -0.01      12.22
         2     2   -132.05      0.00     0.00      0.00      0.22     -10.26
              10    132.05      0.00     0.00      0.00     -0.22      10.26
         3     2      0.00      0.00     0.00      0.00      0.00       0.00
              10      0.00      0.00     0.00      0.00      0.00       0.00
        11     2   -136.95    -25.39     0.00      0.00      0.23     -22.48
              10    136.95    -25.39     0.00      0.00     -0.23      22.48
        12     2   -136.95    -25.39     0.00      0.00      0.23     -22.48
              10    136.95    -25.39     0.00      0.00     -0.23      22.48

   22    1     4      5.86    -25.39     0.00      0.00      0.00     -11.62
              12     -5.86    -25.39     0.00      0.00      0.00      11.62
         2     4    112.32   -562.50     0.00      0.00      0.06    -311.99
              12   -112.32   -562.50     0.00      0.00     -0.06     311.99
         3     4      0.00      0.00     0.00      0.00      0.00       0.00
              12      0.00      0.00     0.00      0.00      0.00       0.00
        11     4    118.18   -587.89     0.00      0.00      0.06    -323.60
              12   -118.18   -587.89     0.00      0.00     -0.06     323.60
        12     4    118.18   -587.89     0.00      0.00      0.06    -323.60
              12   -118.18   -587.89     0.00      0.00     -0.06     323.60

   23    1     6     -4.90     25.39     0.00      0.00      0.01      12.22
              14      4.90     25.39     0.00      0.00     -0.01     -12.22
         2     6   -132.01      0.00     0.00      0.00      0.21      10.26
              14    132.01      0.00     0.00      0.00     -0.21     -10.26
         3     6      0.00      0.00     0.00      0.00      0.00       0.00
              14      0.00      0.00     0.00      0.00      0.00       0.00
        11     6   -136.91     25.39     0.00      0.00      0.22      22.47
              14    136.91     25.39     0.00      0.00     -0.22     -22.47
        12     6   -136.91     25.39     0.00      0.00      0.22      22.47
              14    136.91     25.39     0.00      0.00     -0.22     -22.47

   24    1     8      5.86     25.39     0.00      0.00      0.00      11.62
              16     -5.86     25.39     0.00      0.00      0.00     -11.62
         2     8    112.28    562.50     0.00      0.00      0.06     311.99
              16   -112.28    562.50     0.00      0.00     -0.06    -311.99
         3     8      0.00      0.00     0.00      0.00      0.00       0.00
              16      0.00      0.00     0.00      0.00      0.00       0.00
        11     8    118.14    587.89     0.00      0.00      0.06     323.61
              16   -118.14    587.89     0.00      0.00     -0.06    -323.61
        12     8    118.14    587.89     0.00      0.00      0.06     323.61
              16   -118.14    587.89     0.00      0.00     -0.06    -323.61

   25    1     3    358.27     30.18     0.01      0.00      0.02      21.02
              17   -309.21     21.77    -0.01      0.00     -0.05     -10.61
         2     3   5067.33     36.95     0.69     -0.10      0.86     133.43
              17  -5067.33    -36.95    -0.69      0.10     -2.58     -41.94
         3     3 -14349.94    376.57     0.00      0.00      0.00      35.76
              17  14349.94   -376.57     0.00      0.00      0.00     896.93
        11     3  -8924.33    443.70     0.71     -0.10      0.88     190.21
              17   8973.40   -391.75    -0.71      0.10     -2.62     844.38
        12     3  19775.54   -309.44     0.71     -0.10      0.88     118.68
              17 -19726.48    361.39    -0.71      0.10     -2.62    -949.48
```

```
MEMBER END FORCES    STRUCTURE TYPE = SPACE
-----------------
ALL UNITS ARE -- KGS  METE     (LOCAL )

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

   26    1     7    345.72     32.43    -0.01      0.00     -0.02      22.55
              19   -296.66     22.40     0.01      0.00      0.05      -9.76
         2     7   4895.46     49.66    -0.66      0.10     -0.79     142.48
              19  -4895.46    -49.66     0.66     -0.10      2.47     -15.87
         3     7  14281.34   -366.12     0.00      0.00      0.00     -38.95
              19 -14281.34    366.12     0.00      0.00      0.00    -895.05
        11     7  19522.52   -284.03    -0.67      0.10     -0.81     126.08
              19 -19473.46    338.87     0.67     -0.10      2.52    -920.68
        12     7  -9040.17    448.22    -0.67      0.10     -0.81     203.97
              19   9089.23   -393.38     0.67     -0.10      2.52     869.42

   27    1    11    358.27     30.18    -0.01      0.00     -0.02      21.02
              20   -309.21     21.77     0.01      0.00      0.05     -10.61
         2    11   5067.33     36.95    -0.69      0.10     -0.86     133.43
              20  -5067.33    -36.95     0.69     -0.10      2.58     -41.94
         3    11 -14349.94    376.57     0.00      0.00      0.00      35.76
              20  14349.94   -376.57     0.00      0.00      0.00     896.93
        11    11  -8924.33    443.70    -0.71      0.10     -0.88     190.21
              20   8973.40   -391.75     0.71     -0.10      2.62     844.38
        12    11  19775.54   -309.44    -0.71      0.10     -0.88     118.68
              20 -19726.48    361.39     0.71     -0.10      2.62    -949.48

   28    1    15    345.72     32.43     0.01      0.00      0.02      22.55
              22   -296.66     22.40    -0.01      0.00     -0.05      -9.76
         2    15   4895.46     49.66     0.66     -0.10      0.79     142.48
              22  -4895.46    -49.66    -0.66      0.10     -2.47     -15.87
         3    15  14281.34   -366.12     0.00      0.00      0.00     -38.95
              22 -14281.34    366.12     0.00      0.00      0.00    -895.05
        11    15  19522.52   -284.03     0.67     -0.10      0.81     126.08
              22 -19473.46    338.87    -0.67      0.10     -2.52    -920.68
        12    15  -9040.17    448.22     0.67     -0.10      0.81     203.97
              22   9089.23   -393.38    -0.67      0.10     -2.52     869.42

   29    1    18      0.00     25.39     0.00      0.00      0.00       0.06
              21      0.00     25.39     0.00      0.00      0.00      -0.06
         2    18     -0.02   1125.00     0.00      0.00      0.00       3.40
              21      0.02   1125.00     0.00      0.00      0.00      -3.40
         3    18      0.00      0.00     0.00      0.00      0.00       0.00
              21      0.00      0.00     0.00      0.00      0.00       0.00
        11    18     -0.02   1150.39     0.00      0.00      0.00       3.46
              21      0.02   1150.39     0.00      0.00      0.00      -3.46
        12    18     -0.02   1150.39     0.00      0.00      0.00       3.46
              21      0.02   1150.39     0.00      0.00      0.00      -3.46


************** END OF LATEST ANALYSIS RESULT **************


 89. LOAD LIST 11 12
 90. PARAMETER
 91. CODE CANADA
 92. CHECK CODE ALL
```

```
                    STAAD.PRO CODE CHECKING - (CAN/CSA-S16-01  )
                    ********************************************

 ALL UNITS ARE - KNS  MET  (UNLESS OTHERWISE NOTED)

 MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                         FX            MY              MZ       LOCATION
 =======================================================================

       1 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.3B        0.316        12
                       72.98 C         -0.64         110.81        3.50
       2 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.3B        0.458        12
                       71.04 C          1.22         166.06        1.80
       3 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.9.A         0.452        12
                       59.92 T          1.21         164.89        0.00
       4 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.3B        0.319        11
                       72.95 C         -0.64        -112.02        3.50
       5 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.3B        0.463        11
                       71.00 C          1.22        -167.87        1.80
       6 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.9.A         0.454        11
                       54.60 T          1.21        -166.63        0.00
       7 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.3B        0.316        12
                       72.98 C          0.64         110.81        3.50
       8 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.3B        0.458        12
                       71.04 C         -1.22         166.06        1.80
       9 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.9.A         0.452        12
                       59.92 T         -1.21         164.89        0.00
      10 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.3B        0.319        11
                       72.95 C          0.64        -112.02        3.50
      11 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.3B        0.463        11
                       71.00 C         -1.22        -167.87        1.80
      12 ST   W310X97                 (CANADIAN SECTIONS)
                           PASS     CSA-13.9.A         0.454        11
                       54.60 T         -1.21        -166.63        0.00
      13 ST   W250X39                 (CANADIAN SECTIONS)
                           PASS     CSA-13.9.A         0.804        12
                      118.51 T         -0.02          98.70        1.80
      14 ST   W250X39                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.2+        0.831        12
                       16.10 C          0.00         108.01        0.00
      15 ST   W250X39                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.2+        0.831        11
                       15.55 C          0.00         105.05        3.00
      16 ST   W250X39                 (CANADIAN SECTIONS)
                           PASS     CSA-13.9.A         0.786        11
                      119.80 T         -0.02          96.02        0.00
      17 ST   W250X39                 (CANADIAN SECTIONS)
                           PASS     CSA-13.9.A         0.804        12
                      118.51 T          0.02          98.70        1.80
      18 ST   W250X39                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.2+        0.831        12
                       16.10 C          0.00         108.01        0.00
      19 ST   W250X39                 (CANADIAN SECTIONS)
                           PASS     CSA-13.8.2+        0.831        11
                       15.55 C          0.00         105.05        3.00
      20 ST   W250X39                 (CANADIAN SECTIONS)
                           PASS     CSA-13.9.A         0.786        11
                      119.80 T          0.02          96.02        0.00
      21 ST   C200X17                 (CANADIAN SECTIONS)
                           PASS     CSA-13.9.A         0.009        11
                        1.34 T          0.00          -0.22        0.00
```

```
 ALL UNITS ARE - KNS  MET  (UNLESS OTHERWISE NOTED)

MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                         FX            MY             MZ       LOCATION
=======================================================================

     22 ST   C200X17                     (CANADIAN SECTIONS)
                          PASS     CSA-13.8.3C        0.145        11
                       1.16 C         0.00           -3.17        0.00
     23 ST   C200X17                     (CANADIAN SECTIONS)
                          PASS     CSA-13.9.A         0.009        11
                       1.34 T         0.00            0.22        0.00
     24 ST   C200X17                     (CANADIAN SECTIONS)
                          PASS     CSA-13.8.3C        0.145        11
                       1.16 C         0.00            3.17        0.00
*    25 ST   L152X152X13                 (CANADIAN SECTIONS)
                          FAIL     CLASS 4 SECT       2.000
                       0.00           0.00            0.00
*    26 ST   L152X152X13                 (CANADIAN SECTIONS)
                          FAIL     CLASS 4 SECT       2.000
                       0.00           0.00            0.00
*    27 ST   L152X152X13                 (CANADIAN SECTIONS)
                          FAIL     CLASS 4 SECT       2.000
                       0.00           0.00            0.00
*    28 ST   L152X152X13                 (CANADIAN SECTIONS)
                          FAIL     CLASS 4 SECT       2.000
                       0.00           0.00            0.00
     29 ST   C200X17                     (CANADIAN SECTIONS)
                          PASS     CSA-13.8.3C        0.499        11
                       0.00 C         0.00          -11.19        1.50
   93. FINISH
       *********** END OF THE STAAD.Pro RUN ***********

         **** DATE=             TIME=          ****

   ************************************************************
   *         For questions on STAAD.Pro, please contact       *
   *   Research Engineers Offices at the following locations  *
   *                                                          *
   *               Telephone               Email              *
   *  USA:      +1 (714)974-2500      support@bentley.com     *
   *  CANADA    +1 (905)632-4771      detech@odandetech.com   *
   *  UK        +44(1454)207-000      support@reel.co.uk      *
   *  FRANCE    +33(0)1 64551084      support@reel.co.uk      *
   *  GERMANY   +49/931/40468-71      info@reig.de            *
   *  NORWAY    +47 67 57 21 30       staad@edr.no            *
   *  SINGAPORE +65 6225-6158         support@bentley.com     *
   *  INDIA     +91(033)4006-2021     support@bentley.com     *
   *  JAPAN     +81(03)5952-6500      eng-eye@crc.co.jp       *
   *  CHINA     +86(411)363-1983      support@bentley.com     *
   *  THAILAND  +66(0)2645-1018/19    support@bentley.com     *
   *                                                          *
   *  North America                  support@bentley.com      *
   *  Europe                         support@bentley.com      *
   *  Asia                           support@bentley.com      *
   ************************************************************
```

NOTES

NOTES

PART – II

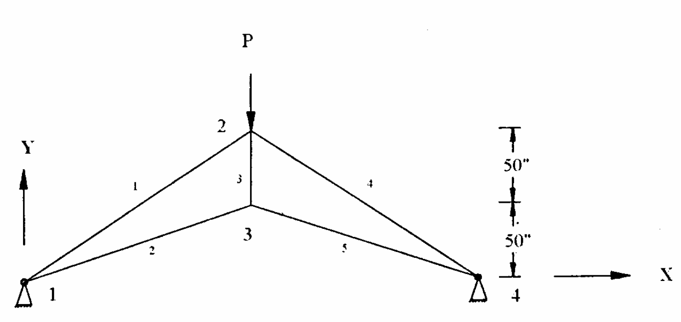
VERIFICATION PROBLEMS

Verification Problem No. 1

OBJECTIVE: To find the support reactions due to a joint load in a plane truss.

REFERENCE: Timoshenko, S., "Strength of Materials," Part 1, D. Van Nostrand Co., Inc., 3rd edition, 1956, page 346, problem 3.

PROBLEM: Determine the horizontal reaction at support 4 of the system.



COMPARISON:

Support Reaction, Kips

Solution	R_4
Theory	8.77
STAAD	8.77
Difference	None

```
          ****************************************************
          *                                                  *
          *           STAAD.Pro                              *
          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
          *           Date=                                  *
          *           Time=                                  *
          *                                                  *
          *      USER ID:                                    *
          ****************************************************

   1. STAAD TRUSS VERIFICATION PROBLEM NO. 1
   2. *
   3. *  REFERENCE `STRENGTH OF MATERIALS' PART-1 BY S. TIMOSHENKO
   4. *  PAGE 346 PROBLEM NO. 3. THE ANSWER IS REACTION = 0.877P.
   5. *  THEREFORE IF P=10, REACTION = 8.77
   6. *
   7. UNITS INCH KIP
   8. JOINT COORD
   9. 1 0. 0. ; 2 150. 100. ; 3 150. 50. ; 4 300. 0.
  10. MEMBER INCI
  11. 1 1 2 ; 2 1 3 ; 3 2 3 ; 4 2 4 ; 5 3 4
  12. MEMB PROP
  13. 1 4 PRIS AX 5.0 ; 2 5 PRIS AX 3.0 ; 3 PRIS AX 2
  14. CONSTANT
  15. E 30000. ALL
  16. POISSON STEEL ALL
  17. SUPPORT ; 1 4 PINNED
  18. LOADING 1
  19. JOINT LOAD ; 2 FY -10.
  20. PERFORM ANALYSIS
         P R O B L E M   S T A T I S T I C S
         -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     4/     5/     2
   ORIGINAL/FINAL BAND-WIDTH=     2/     2/      4 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =      4
   SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.0/  3123.9 MB,  EXMEM =  568.6 MB



  21. PRINT REACTION

 SUPPORT REACTIONS -UNIT KIP  INCH    STRUCTURE TYPE = TRUSS
 -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1      8.77      5.00      0.00      0.00      0.00      0.00
    4    1     -8.77      5.00      0.00      0.00      0.00      0.00


 ************** END OF LATEST ANALYSIS RESULT **************

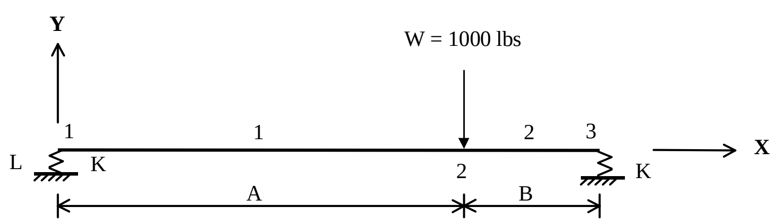

  22. FINISH
```

Verification Problem No. 2

OBJECTIVE: To find the period of free vibration for a beam supported on two springs with a point mass.

REFERENCE: Timoshenko, S., Young, D., and Weaver, W., “Vibration Problems in Engineering,” John Wiley & Sons, 4th edition, 1974. page 11, problem 1.1-3.

PROBLEM: A simple beam is supported by two spring as shown in the figure. Neglecting the distributed mass of the beam, calculate the period of free vibration of the beam subjected to a load of W.



GIVEN: EI = 30000.0 ksi
A = 7.0 ft
B = 3.0 ft.
K = 300.0 lb/in.

COMPARISON:

Solution	Period, sec
Theory	0.533
STAAD	0.533
Difference	None

```
          ****************************************************
          *                                                  *
          *           STAAD.Pro                              *
          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
          *           Date=                                  *
          *           Time=                                  *
          *                                                  *
          *      USER ID:                                    *
          ****************************************************

    1. STAAD PLANE  VERIFICATION PROBLEM NO 2
    2. *
    3. *  REFERENCE 'VIBRATION PROBLEMS IN ENGINEERING' BY
    4. *  TIMOSHENKO,YOUNG,WEAVER. (4TH EDITION, PAGE 11, PROB 1.1-3)
    5. *  THE ANSWER IN THE BOOK IS T = 0.533 SEC., VIZ., F = 1.876 CPS
    6. *
    7. UNIT POUND FEET
    8. JOINT COORD ; 1 0. 0. ; 2 7. 0. ; 3 10. 0.
    9. MEMB INCI ; 1 1 2 2
   10. UNIT INCH
   11. SUPPORT
   12. 1 3 FIXED BUT MZ KFY 300.
   13. MEMB PROP ; 1 2 PRIS AX 1. IZ 1.
   14. CONSTANT
   15. E 30E6 ALL
   16. POISSON STEEL ALL
   17. CUT OFF MODE SHAPE 1
   18. LOADING 1 1000 LB LOAD AT JOINT 2
   19. JOINT LOAD ; 2 FY -1000.
   20. MODAL CALCULATION
   21. PERFORM ANALYS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

    NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     3/     2/     2
    ORIGINAL/FINAL BAND-WIDTH=     1/     1/      5 DOF
    TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =      7
    SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
    REQRD/AVAIL. DISK SPACE  =    12.0/  3123.9 MB,  EXMEM =  568.6 MB

 NUMBER OF MODES REQUESTED             =     1
 NUMBER OF EXISTING MASSES IN THE MODEL =     1
 NUMBER OF MODES THAT WILL BE USED      =     1

   *** EIGENSOLUTION : SUBSPACE METHOD ***
            CALCULATED FREQUENCIES FOR LOAD CASE       1

      MODE           FREQUENCY(CYCLES/SEC)         PERIOD(SEC)      ACCURACY


        1                      1.876                0.53317       0.000E+00


PARTICIPATION FACTORS

                     MASS  PARTICIPATION FACTORS IN PERCENT
                     --------------------------------------

          MODE    X     Y     Z     SUMM-X   SUMM-Y   SUMM-Z

            1    0.00100.00  0.00    0.000  100.000    0.000

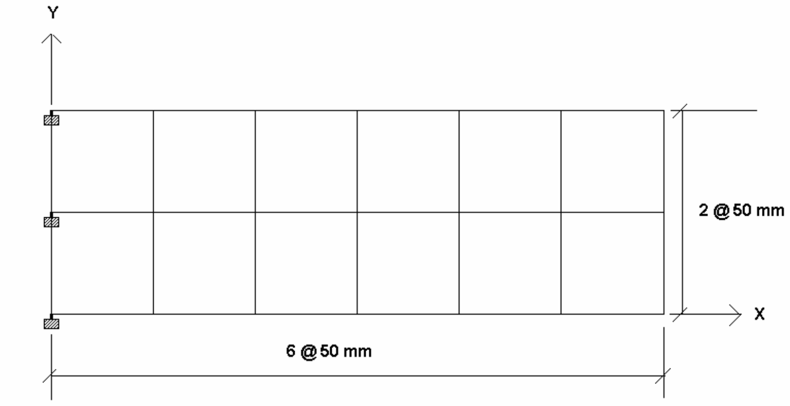
   22. FINISH
```

Verification Problem No. 3

TYPE: Deflection and moments for plate-bending finite element.

REFERENCE: Simple hand calculation by considering the entire structure as a cantilever beam.

PROBLEM: A simple cantilever plate is divided into 12 4-noded finite elements. A uniform pressure load is applied and the maximum deflection at the tip of the cantilever and the maximum bending at the support are calculated.



GIVEN: Plate thickness = 25mm,
Uniform pressure= 5N/sq.mm

HAND CALCULATION:

Max. deflection = $WL^3/8EI$, where
$WL^3=(5x300x100) \times (300)^3 = 405x10^{10}$
$8EI=8x(210x10^3 N/sq.mm)x(100x25^3/12)$
$= 21875x10^7$
Deflection = 18.51mm
Max. moment = WL/2 = (5x300x100)x300/2
$= 22.5x10^6$ N.mm = 22.5KN.m

SOLUTION COMPARISON:

	Max. Defl.	Max Moment
Hand calculation	18.51 mm	22.50 kNm
STAAD	18.20 mm	22.50 kNm

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   1. STAAD SPACE FINITE ELEMENT VERIFICATION
   2. UNIT MM KN
   3. JOINT COORDINATES
   4. 1 0 0 0 7 300 0 0
   5. REPEAT 2 0 50 0
   6. ELEMENT INCIDENCE
   7. 1 1 2 9 8 TO 6
   8. REPEAT 1 6 7
   9. ELEMENT PROP
  10. 1 TO 12 THICK 25.0
  11. CONSTANT
  12. E 210.0 ALL
  13. POISSON STEEL ALL
  14. SUPPORT
  15. 1 8 15 FIXED
  16. UNIT NEWTON
  17. LOAD 1 5N/SQ.MM. UNIFORM LOAD
  18. ELEMENT LOAD
  19. 1 TO 12 PRESSURE 5.0
  20. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    21/    12/     3
   ORIGINAL/FINAL BAND-WIDTH=     8/     5/     36 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =    126
   SIZE OF STIFFNESS MATRIX =       5 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.1/  3123.6 MB,  EXMEM =  568.6 MB

  21. PRINT DISPLACEMENT LIST 14

 JOINT DISPLACEMENT (CM   RADIANS)    STRUCTURE TYPE = SPACE
 ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

   14    1     0.0000    0.0000    1.8159    0.0000   -0.0813    0.0000

 ************** END OF LATEST ANALYSIS RESULT **************

  22. UNIT KN METER
  23. PRINT REACTION

 SUPPORT REACTIONS -UNIT KN   METE    STRUCTURE TYPE = SPACE
 -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    1    1      0.00      0.00    -18.91     -1.54      5.47      0.00
    8    1      0.00      0.00   -112.19      0.00     11.56      0.00
   15    1      0.00      0.00    -18.91      1.54      5.47      0.00

 ************** END OF LATEST ANALYSIS RESULT **************

  24. FINISH
```

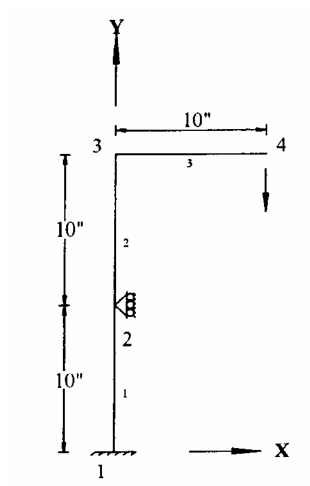
NOTES

Verification Problem No. 4

OBJECTIVE: To find the support reactions due to a load at the free end of a cantilever plane bent with an intermediate support.

REFERENCE: Timoshenko, S., "Strength of Materials," Part 1, D. Van Nostrand Co., Inc., 3rd edition, 1956, page 346, problem 2.

PROBLEM: Determine the reaction of the system as shown in the figure.



COMPARISON:

Reaction, Kip

Solution	R_X
Theory	1.5
STAAD	1.5
Differenc e	None

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   1. STAAD PLANE  VERIFICATION PROBLEM NO. 4
   2. *
   3. *  REFERENCE 'STRENGTH OF MATERIALS' PART-1 BY S. TIMOSHENKO
   4. *  PAGE 346 PROBLEM NO. 2. THE ANSWER IN THE BOOK AFTER
   5. *  RECALCULATION = 1.5
   6. *
   7. UNIT INCH KIP
   8. JOINT COORD
   9. 1 0. 0. ; 2 0. 10. ; 3 0. 20. ; 4 10. 20.
  10. MEMB INCI
  11. 1 1 2 3
  12. MEMB PROP ; 1 2 3 PRIS AX 10. IZ 100.
  13. CONSTANT
  14. E 3000. ALL
  15. POISSON CONCRETE ALL
  16. SUPPORT
  17. 1 FIXED ; 2 FIXED BUT FY MZ
  18. LOADING 1
  19. JOINT LOAD ; 4 FY -1.
  20. PERFORM ANALYS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     4/     3/     2
   ORIGINAL/FINAL BAND-WIDTH=     1/     1/      6 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =      8
   SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.0/  3123.9 MB,  EXMEM =  568.6 MB



  21. PRINT REACTION


 SUPPORT REACTIONS -UNIT KIP  INCH    STRUCTURE TYPE = PLANE
 -----------------

JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z


    1    1      1.50      1.00      0.00      0.00      0.00     -5.00
    2    1     -1.50      0.00      0.00      0.00      0.00      0.00


 ************** END OF LATEST ANALYSIS RESULT **************

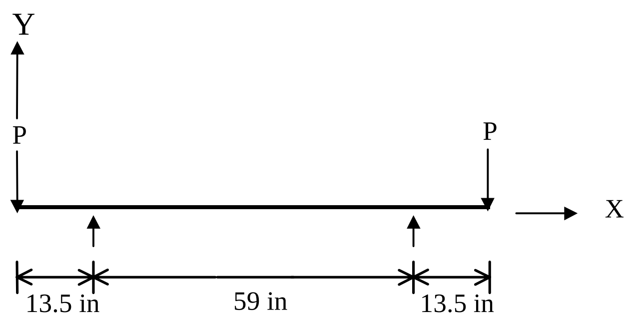

  22. FINI
```

Verification Problem No. 5

OBJECTIVE: To find deflections and stress at the center of a locomotive axle.

REFERENCE: Timoshenko, S.,"Strength of Materials," Part- 1, D. Van Nostrand Co., 3rd edition, 1956. page 97, problems 1, 2.

PROBLEM: Determine the maximum stress in a locomotive axle (as shown in the figure) as well as the deflection at the middle of the axle.



GIVEN: Diameter = 10 in.,
P = 26000 lb,
E = 30E6 psi

COMPARISON:

Stress (σ), psi, and Deflection (δ), in

Solution	σ	δ
Theory	3575.*	0.01040
STAAD	3575.	0.01037
Difference	None	None

* The value is recalculated.

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   1. STAAD PLANE VERIFICATION PROBLEM NO. 5
   2. *
   3. *  REFERENCE 'STRENGTH OF MATERIALS' PART-1 BY S. TIMOSHENKO
   4. *  PAGE 97 PROBLEM NO. 1 AND 2. ANSWERS ARE 3580 FOR MAX. STRESS
   5. *  AND 0.104 INCH FOR MAX. DEFLECTION.
   6. *
   7. UNIT INCH POUND
   8. JOINT COORD
   9. 1 0. 0. ; 2 13.5 0. ; 3 43. 0. ; 4 72.5 0. ; 5 86. 0.
  10. MEMB INCI ; 1 1 2 4
  11. MEMB PROP ; 1 TO 4 TABLE ST PIPE OD 10. ID 0.
  12. CONSTANT
  13. E 30E6 ALL
  14. POISSON STEEL ALL
  15. SUPPORT ; 2 4 PINNED
  16. LOADING 1
  17. JOINT LOAD ; 1 5 FY -26000.
  18. PERFORM ANALYSIS

          P R O B L E M   S T A T I S T I C S
          -----------------------------------
   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     5/     4/     2
   ORIGINAL/FINAL BAND-WIDTH=     1/     1/      4 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     11
   SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.0/  3123.9 MB,  EXMEM =  568.7 MB

  19. PRINT MEMBER STRESSES

 MEMBER STRESSES
 ---------------
 ALL UNITS ARE POUN/SQ INCH
MEMB   LD  SECT    AXIAL    BEND-Y     BEND-Z   COMBINED  SHEAR-Y  SHEAR-Z

     1    1   .0      0.0        0.0        0.0        0.0    441.4      0.0
            1.00      0.0        0.0     3575.3     3575.3    441.4      0.0

     2    1   .0      0.0        0.0     3575.3     3575.3      0.0      0.0
            1.00      0.0        0.0     3575.3     3575.3      0.0      0.0

     3    1   .0      0.0        0.0     3575.3     3575.3      0.0      0.0
            1.00      0.0        0.0     3575.3     3575.3      0.0      0.0

     4    1   .0      0.0        0.0     3575.3     3575.3    441.4      0.0
            1.00      0.0        0.0        0.0        0.0    441.4      0.0
  ************** END OF LATEST ANALYSIS RESULT **************
  20. PRINT DISPLACEMENTS

  JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = PLANE
  ------------------
JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

     1    1    0.00000  -0.01138   0.00000   0.00000   0.00000   0.00086
     2    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00070
     3    1    0.00000   0.01037   0.00000   0.00000   0.00000   0.00000
     4    1    0.00000   0.00000   0.00000   0.00000   0.00000  -0.00070
     5    1    0.00000  -0.01138   0.00000   0.00000   0.00000  -0.00086

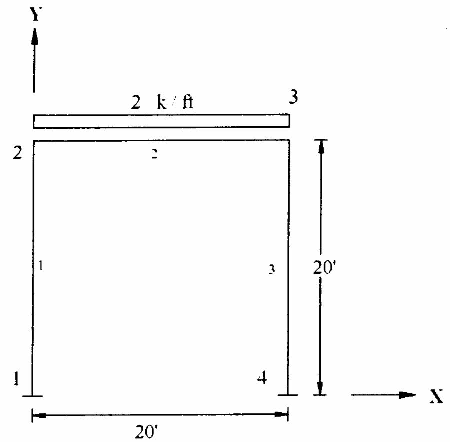
 ************** END OF LATEST ANALYSIS RESULT **************
  21. FINISH
```

Verification Problem No. 6

OBJECTIVE: To find the maximum moment due to a uniform load on the horizontal member in a 1x1 bay plane frame.

REFERENCE: McCormack, J. C., "Structural Analysis," Intext Educational Publishers, 3rd edition, 1975, page 383, example 22 - 5.

PROBLEM: Determine the maximum moment in the frame.



GIVEN: E and I same for all members.

COMPARISON:

Moment, Kip-ft

Solution	M_{Max}
Theory	44.40
STAAD	44.44
Difference	Small

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   1. STAAD PLANE  VERIFICATION PROBLEM NO. 6
   2. *
   3. *  REFERENCE 'STRUCTURAL ANALYSIS' BY JACK C. MCCORMACK,
   4. *  PAGE 383 EXAMPLE 22-5, PLANE FRAME WITH NO SIDESWAY
   5. *  ANSWER - MAX BENDING = 44.4 FT-KIP
   6. *
   7. UNIT FT KIP
   8. JOINT COORD
   9. 1 0. 0. ; 2 0. 20. ; 3 20. 20. ; 4 20. 0.
  10. MEMB INCI ; 1 1 2 3
  11. MEMB PROP ; 1 2 3 PRIS AX 1. IZ 0.05
  12. CONSTANT
  13. E 4132E3 ALL
  14. POISSON STEEL ALL
  15. SUPPORT ; 1 4 FIXED
  16. LOADING 1 ; MEMB LOAD ; 2 UNI Y -2.0
  17. PERFORM ANAL


       P R O B L E M   S T A T I S T I C S
       -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     4/     3/     2
   ORIGINAL/FINAL BAND-WIDTH=     1/     1/      6 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =      6
   SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.0/  3123.8 MB,  EXMEM =  568.7 MB


  18. PRINT FORCES

 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z


    1    1     1     20.00     -3.33     0.00      0.00      0.00     -22.21
               2    -20.00      3.33     0.00      0.00      0.00     -44.44

    2    1     2      3.33     20.00     0.00      0.00      0.00      44.44
               3     -3.33     20.00     0.00      0.00      0.00     -44.44

    3    1     3     20.00      3.33     0.00      0.00      0.00      44.44
               4    -20.00     -3.33     0.00      0.00      0.00      22.21


 ************** END OF LATEST ANALYSIS RESULT **************

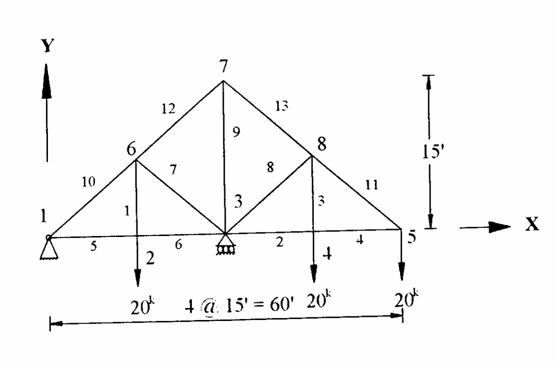

  19. FINISH
```

Verification Problem No. 7

OBJECTIVE: To find the joint deflection due to joint loads in a plane truss.

REFERENCE: McCormack, J. C., “Structural Analysis,” Intext Educational Publishers, 3rd edition, 1975, page 271, example 18 - 2.

PROBLEM: Determine the vertical deflection at point 5 of the plane truss structure shown in the figure.



GIVEN: $A_{X\,1\text{-}4} = 1\ in^2$, $A_{X\,5\text{-}6} = 2\ in^2$, $A_{X\,7\text{-}8} = 1.5\ in^2$, $A_{X\,9\text{-}11} = 3\ in^2$, $A_{X\,12\text{-}13} = 4\ in^2$, $E = 30E3$ ksi

COMPARISON:

Deflection, in.

Solution	δ_5
Theory	2.63
STAAD	2.63
Difference	None

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    1. STAAD TRUSS  VERIFICATION PROBLEM NO. 7
    2. *
    3. *  REFERENCE 'STRUCTURAL ANALYSIS' BY JACK MCCORMACK, PAGE
    4. *  271 EXAMPLE 18-2. ANSWER - Y-DISP AT JOINT 5 = 2.63 INCH
    5. *
    6. UNIT FT KIP
    7. JOINT COORD
    8. 1 0 0 0 5 60 0 0
    9. 6 15. 7.5 ; 7 30. 15. ; 8 45. 7.5
   10. MEMB INCI
   11. 1 2 6 ; 2 3 4 ; 3 4 8 ; 4 4 5 ; 5 1 2
   12. 6 2 3 ; 7 3 6 ; 8 3 8 ; 9 3 7
   13. 10 1 6 ; 11 5 8 ; 12 6 7 13
   14. UNIT INCH
   15. MEMB PROP
   16. 1 TO 4 PRI AX 1.0
   17. 5 6 PRIS AX 2.
   18. 7 8 PRI AX  1.5
   19. 9 10 11 PRI AX 3.
   20. 12 13 PRI AX 4.
   21. CONSTANT
   22. E 30E3 ALL
   23. POISSON STEEL ALL
   24. SUPPORT
   25. 1 PINNED ; 3 FIXED BUT FX MZ
   26. LOAD 1 VERTICAL LOAD
   27. JOINT LOAD
   28. 2 4 5 FY -20.0
   29. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

    NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     8/    13/     2
    ORIGINAL/FINAL BAND-WIDTH=     5/     5/     11 DOF
    TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     13
    SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
    REQRD/AVAIL. DISK SPACE  =    12.0/  3123.8 MB,  EXMEM =  568.7 MB

   30. PRINT DISPLACEMENTS

  JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = TRUSS
  ------------------
JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

     1    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
     2    1   -0.12000   0.18000   0.00000   0.00000   0.00000   0.00000
     3    1   -0.24000   0.00000   0.00000   0.00000   0.00000   0.00000
     4    1   -0.48000  -0.89516   0.00000   0.00000   0.00000   0.00000
     5    1   -0.72000  -2.63033   0.00000   0.00000   0.00000   0.00000
     6    1   -0.00820   0.24000   0.00000   0.00000   0.00000   0.00000
     7    1    0.29758  -0.12000   0.00000   0.00000   0.00000   0.00000
     8    1    0.06578  -0.83516   0.00000   0.00000   0.00000   0.00000

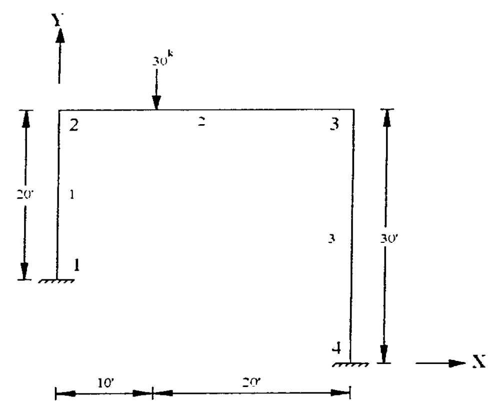
  ************** END OF LATEST ANALYSIS RESULT **************
   31. FINISH
```

Verification Problem No. 8

OBJECTIVE: To find the maximum moment due to a concentrated load on the horizontal member in a 1x1 bay plane frame.

REFERENCE: McCormack, J. C., "Structural Analysis," Intext Educational Publishers, 3rd edition, 1975, page 385, problem 22 - 6.

PROBLEM: Determine the maximum moment in the structure.



GIVEN: E and I same for all members

COMPARISON:

Moment, Kip-ft

Solution	M_{Max}
Theory	69.40
STAAD	69.44
Difference	Small

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          *           Research Engineers,  Intl.             *
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          *           Time=                                  *
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   1. STAAD PLANE  VERIFICATION PROBLEM NO. 8
   2. *
   3. * PLANE FRAME WITH SIDESWAY. REFERENCE 'STRUCTURAL ANALYSIS'
   4. * BY JACK MCCORMACK. PAGE 385 PROB 22-6.
   5. * ANSWER - MAX BENDING IN MEMB 1 = 69.4 KIP-FT
   6. *
   7. UNIT FT KIP
   8. JOINT COORD
   9. 1 0. 10. ; 2 0 30 ; 3 30 30 ; 4 30 0
  10. MEMB INCI
  11. 1 1 2 3
  12. MEMB PROP AMERICAN
  13. 1 2 3 TAB ST W12X26
  14. CONSTANT
  15. E 4176E3
  16. POISSON STEEL ALL
  17. SUPPORT ; 1 4 FIXED
  18. LOAD 1 VERTICAL LOAD
  19. MEMBER LOAD
  20. 2 CON Y -30. 10.
  21. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     4/     3/     2
   ORIGINAL/FINAL BAND-WIDTH=     1/     1/      6 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =      6
   SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.0/  3123.8 MB,  EXMEM =  568.7 MB


  22. PRINT FORCES

 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1     20.09     -3.74     0.00      0.00      0.00      -5.34
               2    -20.09      3.74     0.00      0.00      0.00     -69.44

    2    1     2      3.74     20.09     0.00      0.00      0.00      69.44
               3     -3.74      9.91     0.00      0.00      0.00     -66.66

    3    1     3      9.91      3.74     0.00      0.00      0.00      66.66
               4     -9.91     -3.74     0.00      0.00      0.00      45.51


 ************** END OF LATEST ANALYSIS RESULT **************

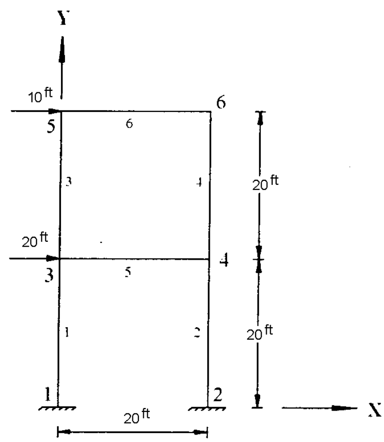

  23. FINISH
```

Verification Problem No. 9

OBJECTIVE: To find the maximum moment due to lateral joint loads in a 1x2 bay plane frame.

REFERENCE: McCormack, J. C., "Structural Analysis," Intext Educational Publishers, 3rd edition, 1975, page 388, example 22 - 7.

PROBLEM: Determine the maximum moment in the frame.



GIVEN: E and I same for all members.

COMPARISON:

Moment, Kip-ft

Solution	M_{Max}
Theory	176.40
STAAD	178.01
Difference	0.91%

```
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          *                                                  *
          *           STAAD.Pro                              *
          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
          *           Date=                                  *
          *           Time=                                  *
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   1. STAAD PLANE VERIFICATION PROB NO. 9
   2. *
   3. * MULTIPLE LEVEL PLANE FRAME WITH HORIZONTAL LOAD.
   4. * REFERENCE 'STRUCTURAL ANALYSIS' BY JACK MCCORMACK,
   5. * PAGE 388, PROB 22-7. ANSWER - MAX MOM IN MEMB 1 = 176.4 K-F
   6. *
   7. UNIT FT KIP
   8. JOINT COORD
   9. 1 0 0 0 5 0 40 0 2 ; 2 20 0 0 6 20 40 0 2
  10. MEMB INCI
  11. 1 1 3 2 ; 3 3 5 4 ; 5 3 4 ; 6 5 6
  12. MEMB PROP
  13. 1 TO 6 PRI AX .2 IZ .1
  14. CONSTANT
  15. E 4176E3
  16. POISSON STEEL ALL
  17. SUPPORT ; 1 2 FIXED
  18. LOAD 1 HORIZONTAL LOAD
  19. JOINT LOAD
  20. 3 FX 20 ; 5 FX 10
  21. PERFORM ANALYS

          P R O B L E M   S T A T I S T I C S
          -----------------------------------
   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =      6/      6/      2
   ORIGINAL/FINAL BAND-WIDTH=     3/     3/      9 DOF
   TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =      12
   SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.0/  3123.8 MB,  EXMEM =  568.7 MB
  22. PRINT FORCES

 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1    -22.26     15.06     0.00      0.00      0.00     178.01
               3     22.26    -15.06     0.00      0.00      0.00     123.16

    2    1     2     22.26     14.94     0.00      0.00      0.00     176.73
               4    -22.26    -14.94     0.00      0.00      0.00     122.10

    3    1     3     -6.51      4.97     0.00      0.00      0.00      34.49
               5      6.51     -4.97     0.00      0.00      0.00      64.93

    4    1     4      6.51      5.03     0.00      0.00      0.00      35.34
               6     -6.51     -5.03     0.00      0.00      0.00      65.24

    5    1     3      9.91    -15.75     0.00      0.00      0.00    -157.65
               4     -9.91     15.75     0.00      0.00      0.00    -157.44

    6    1     5      5.03     -6.51     0.00      0.00      0.00     -64.93
               6     -5.03      6.51     0.00      0.00      0.00     -65.24

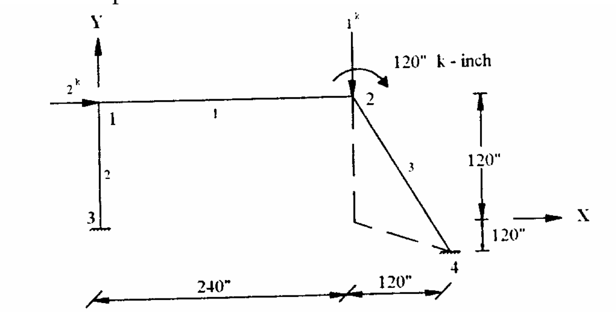
 ************** END OF LATEST ANALYSIS RESULT **************
  23. FINISH
```

Verification Problem No. 10

OBJECTIVE: To find the maximum axial force and moment due to load and moment applied at a joint in a space frame.

REFERENCE: Weaver Jr., W., "Computer Programs for Structural Analysis," page 146, problem 8.

PROBLEM: Determine the maximum axial force and moment in the space structure.



GIVEN:
E = 30E3 ksi,
AX = 11 in^2
IX = 83 in^4
IY = 56 in^4
IZ = 56 in^4

COMPARISON:

Solution	F_{Max} (kips)	$M_{Y,Max}$ (kip-in)	$M_{Z,Max}$ (kip-in)
Reference	1.47	84.04	95.319
STAAD	1.47	84.04	96.120
Difference	None	None	Small

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          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
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   1. STAAD SPACE  VERIFICATION PROB NO. 10
   2. *
   3. * REFERENCE 'COMPUTER PROGRAMS FOR STRUCTURAL ANALYSIS'
   4. * BY WILLIAM WEAVER JR. PAGE 146 STRUCTURE NO. 8.
   5. * ANSWER - MAX AXIAL FORCE= 1.47 (MEMB 3)
   6. * MAX BEND-Y= 84.04, BEND-Z= 95.319 (BOTH MEMB 3)
   7. *
   8. UNIT INCH KIP
   9. JOINT COORD
  10. 1 0 120 0 ; 2 240 120 0
  11. 3 0 0 0 ; 4 360 0 120
  12. MEMB INCI
  13. 1 1 2 ; 2 3 1 ; 3 2 4
  14. MEMB PROP
  15. 1 2 3 PRIS AX 11. IX 83. IY 56. IZ 56
  16. CONSTANT ; E 30000. ALL
  17. POISS .25 ALL
  18. SUPPORT
  19. 3 4 FIXED
  20. LOAD 1 JOINT LOAD
  21. JOINT LOAD
  22. 1 FX 2. ; 2 FY -1. ; 2 MZ -120.
  23. PERFORM ANAL


         P R O B L E M   S T A T I S T I C S
         -----------------------------------
   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =      4/      3/      2
   ORIGINAL/FINAL BAND-WIDTH=      2/      2/      12 DOF
   TOTAL PRIMARY LOAD CASES =     1, TOTAL DEGREES OF FREEDOM =      12
   SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.0/  3123.8 MB,  EXMEM =  568.7 MB


  24. PRINT ANALYSIS RESULT

 JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = SPACE
 ------------------
JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

    1    1    0.22267   0.00016  -0.17182  -0.00255   0.00217  -0.00213
    2    1    0.22202  -0.48119  -0.70161  -0.00802   0.00101  -0.00435
    3    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
    4    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000


 SUPPORT REACTIONS -UNIT KIP  INCH    STRUCTURE TYPE = SPACE
 -----------------
JOINT  LOAD   FORCE-X   FORCE-Y   FORCE-Z     MOM-X     MOM-Y     MOM Z

    3    1     -1.10     -0.43      0.22     48.78    -17.97     96.12
    4    1     -0.90      1.43     -0.22    123.08     47.25    -11.72
```

```
 MEMBER END FORCES    STRUCTURE TYPE = SPACE
 -----------------
 ALL UNITS ARE -- KIP  INCH

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1      0.90     -0.43     0.22     22.71    -17.97     -36.37
               2     -0.90      0.43    -0.22    -22.71    -34.18     -67.36

    2    1     3     -0.43      1.10     0.22    -17.97    -48.78      96.12
               1      0.43     -1.10    -0.22     17.97     22.71      36.37

    3    1     2      1.47     -0.71    -0.48    -37.02     15.69     -53.28
               4     -1.47      0.71     0.48     37.02     84.04     -95.32


 ************** END OF LATEST ANALYSIS RESULT **************



  25. FINISH
```

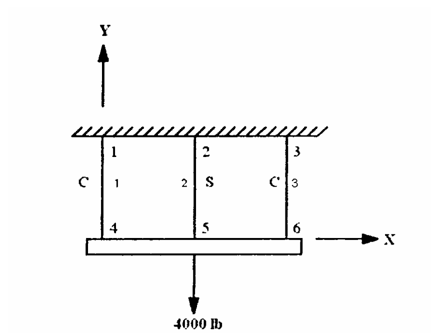
NOTES

Verification Problem No. 11

OBJECTIVE: **A** rigid bar is suspended by two copper wires and one steel wire. Find the stresses in the wires due to a rise in temperature.

REFERENCE: Timoshenko, S., "Strength of Materials," Part 1, D. Van Nostrand Co., 3rd edition, 1956, page 30, problem 9.

PROBLEM: Assuming the horizontal member to be very rigid, determine the stresses in the copper and steel wires if the temperature rise is 10° F.



GIVEN: E_{steel} = 30E6 psi, E_{copper} = 16E6 psi
α_{steel} = 70E-7 in/in/°F, α_{copper} = 92E-7 in/in/°F
$A_X = 0.1$ in^2

MODELLING HINT: Assume a large moment of inertia for the horizontal rigid member and distribute of the concentrated load as uniform.

COMPARISON:

Stress (σ), psi

Solution	σ_{Steel}	σ_{Copper}
Theory	19695	10152
STAAD	19698	10151
Difference	Small	Small

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          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
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          *                                                  *
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   1. STAAD PLANE  VERIFICATION PROB NO 11
   2. *
   3. *  THIS EXAMPLE IS TAKEN FROM 'STRENGTH OF MATERIALS' BY
   4. *  TIMOSHENKO (PART 1), PAGE 30, PROB 9.
   5. *  THE ANSWERS ARE 19695 PSI AND 10152 PSI.
   6. *
   7. UNIT INCH POUND
   8. JOINT COORD
   9. 1 0. 20. ; 2 5. 20. ; 3 10. 20.
  10. 4 0. 0. ; 5 5. 0. ; 6 10. 0.
  11. MEMB INCI
  12. 1 1 4 3 ; 4 4 5 5
  13. MEMB PROP
  14. 1 2 3 PRI AX 0.1 ; 4 5 PRI AX 1. IZ 100.
  15. CONSTANT ; E 30E6 MEMB 2 4 5
  16. E 16E6 MEMB 1 3
  17. POISSON 0.15 ALL
  18. ALPHA 92E-7 MEMB 1 3 ; ALPHA 70E-7 MEMB 2
  19. MEMB TRUSS ; 1 2 3
  20. SUPPORT ; 1 2 3 PINNED
  21. LOADING 1 VERT LOAD + TEMP LOAD
  22. MEMB LOAD ;4 5 UNI Y -400.
  23. TEMP LOAD ; 1 2 3 TEMP 10.
  24. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     6/     5/     3
   ORIGINAL/FINAL BAND-WIDTH=     3/     3/     10 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =     12
   SIZE OF STIFFNESS MATRIX =       1 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.0/  3123.8 MB,  EXMEM =  568.6 MB

  ZERO STIFFNESS IN DIRECTION 6 AT JOINT      1 EQN.NO.       1

        LOADS APPLIED OR DISTRIBUTED HERE FROM ELEMENTS WILL BE IGNORED.
        THIS MAY BE DUE TO ALL MEMBERS AT THIS JOINT BEING RELEASED OR
        EFFECTIVELY RELEASED IN THIS DIRECTION.
  ZERO STIFFNESS IN DIRECTION 6 AT JOINT      2 EQN.NO.       2
  ZERO STIFFNESS IN DIRECTION 6 AT JOINT      3 EQN.NO.       3

***WARNING -  INSTABILITY AT JOINT     6   DIRECTION = FX
 PROBABLE CAUSE SINGULAR-ADDING WEAK SPRING
 K-MATRIX DIAG=  6.0000004E+03 L-MATRIX DIAG=  0.0000000E+00 EQN NO      10
 ***NOTE - VERY WEAK SPRING ADDED FOR STABILITY

  **NOTE** STAAD DETECTS INSTABILITIES AS EXCESSIVE LOSS OF SIGNIFICANT DIGITS
           DURING DECOMPOSITION. WHEN A DECOMPOSED DIAGONAL IS LESS THAN THE
           BUILT-IN REDUCTION FACTOR TIMES THE ORIGINAL STIFFNESS MATRIX DIAGONAL,
           STAAD PRINTS A SINGULARITY NOTICE. THE BUILT-IN REDUCTION FACTOR
           IS   1.000E-09

           THE ABOVE CONDITIONS COULD ALSO BE CAUSED BY VERY STIFF OR VERY WEAK
           ELEMENTS AS WELL AS TRUE SINGULARITIES.
```

```
  25. PRINT STRESSES

 MEMBER STRESSES
 ---------------
 ALL UNITS ARE POUN/SQ INCH

MEMB   LD  SECT    AXIAL    BEND-Y     BEND-Z   COMBINED  SHEAR-Y  SHEAR-Z


     1    1   .0  10150.8 T      0.0       0.0   10150.8      0.0      0.0
            1.00  10150.8 T      0.0       0.0   10150.8      0.0      0.0

     2    1   .0  19698.3 T      0.0       0.0   19698.3      0.0      0.0
            1.00  19698.3 T      0.0       0.0   19698.3      0.0      0.0

     3    1   .0  10150.8 T      0.0       0.0   10150.8      0.0      0.0
            1.00  10150.8 T      0.0       0.0   10150.8      0.0      0.0

     4    1   .0      0.0        0.0       0.0       0.0   1522.6      0.0
            1.00      0.0        0.0       3.8       3.8   1477.4      0.0

     5    1   .0      0.0        0.0       3.8       3.8   1477.4      0.0
            1.00      0.0        0.0       0.0       0.0   1522.6      0.0


  ************** END OF LATEST ANALYSIS RESULT **************


  26. FINISH
```

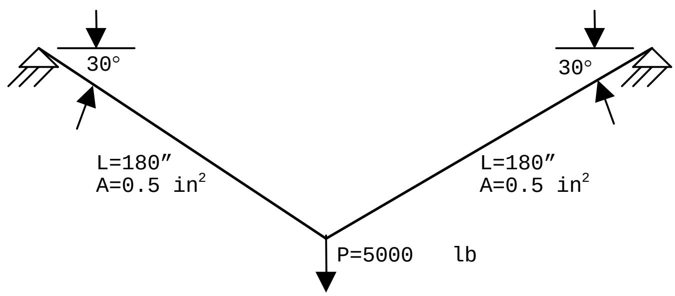
NOTES

Verification Problem No. 12

OBJECTIVE: To find the joint deflection and member stress due to a joint load in a plane truss.

REFERENCE: Timoshenko, S., "Strength of Materials," Part 1, D. Van Nostrand Co., Inc., 3rd edition, 1956, page 10, problem 2.

PROBLEM: Determine the vertical deflection at point A and the member stresses.



GIVEN: $A_X = 0.5\ in^2$, $E = 30E6$ psi

COMPARISON:

Stress (σ), psi and Deflection (δ), in.

Solution	σ_A	δ_A
Theory	10000.	0.12
STAAD	10000.	0.12
Difference	None	None

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          *                                                  *
          *           STAAD.Pro                              *
          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
          *           Date=                                  *
          *           Time=                                  *
          *                                                  *
          *      USER ID:                                    *
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   1. STAAD TRUSS  VERIFICATION PROBLEM NO 12
   2. *
   3. *  THIS EXAMPLE IS TAKEN FROM 'STRENGTH OF MATERIALS'
   4. *  (PART 1) BY TIMOSHENKO, PAGE 10 PROB 2.
   5. *  THE ANSWER IN THE BOOK , DEFLECTION = 0.12 INCH
   6. *  AND STRESS =10000 PSI
   7. *
   8. UNIT INCH POUND
   9. JOINT COORD
  10. 1 0. 0. ; 2 155.88457 -90. ; 3 311.76914 0.
  11. MEMB INCI ; 1 1 2 2
  12. MEMB PROP
  13. 1 2 PRIS AX 0.5
  14. CONSTANT
  15. E 30E6
  16. POISSON 0.15 ALL
  17. SUPPORT ; 1 3 PINNED
  18. LOAD 1 VERT LOAD
  19. JOINT LOAD ; 2 FY -5000.
  20. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

   NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     3/     2/     2
   ORIGINAL/FINAL BAND-WIDTH=     1/     1/      2 DOF
   TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =      2
   SIZE OF STIFFNESS MATRIX =       0 DOUBLE  KILO-WORDS
   REQRD/AVAIL. DISK SPACE  =    12.0/  3123.7 MB,  EXMEM =  568.6 MB

  21. PRINT DISPLACEMENTS

 JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = TRUSS
 ------------------

JOINT  LOAD   X-TRANS   Y-TRANS   Z-TRANS   X-ROTAN   Y-ROTAN   Z-ROTAN

     1    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
     2    1    0.00000  -0.12000   0.00000   0.00000   0.00000   0.00000
     3    1    0.00000   0.00000   0.00000   0.00000   0.00000   0.00000

 ************** END OF LATEST ANALYSIS RESULT **************
  22. PRINT STRESSES

 MEMBER STRESSES
 ---------------
 ALL UNITS ARE POUN/SQ INCH

MEMB   LD  SECT    AXIAL    BEND-Y     BEND-Z   COMBINED  SHEAR-Y  SHEAR-Z

     1    1   .0  10000.0 T      0.0       0.0   10000.0      0.0      0.0
            1.00  10000.0 T      0.0       0.0   10000.0      0.0      0.0

     2    1   .0  10000.0 T      0.0       0.0   10000.0      0.0      0.0
            1.00  10000.0 T      0.0       0.0   10000.0      0.0      0.0

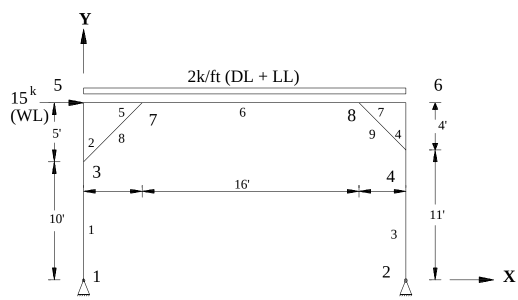
 ************** END OF LATEST ANALYSIS RESULT **************
  23. FINISH
```

Verification Problem No. 13

TYPE: Steel Design.

REFERENCE: Attached step by step hand calculation as per 1989 AISC ASD code. Ninth Edition.

PROBLEM: Determine the allowable stresses (per 1989 AISC code) for the members of the structure as shown in figure. Also, perform a code check for these members based on the results of the analysis.



Members 1, 2 = W12X26, Members 3, 4 = W14X43
Members 5, 6, 7 = W16X36, Memb 8= L40404,
Memb 9 = L50506

SOLUTION COMPARISON:

Governing ratios for the members									
Member No.	1	2	3	4	5	6	7	8	9
Hand Calculation	1.1576	.914	1.117	0.936	.579	1.119	.668	1.024	.823
STAAD. PRO	1.157	.916	1.117	0.936	.582	1.119	.668	1.025	.823

VERIFICATION PROBLEM 13 HAND CALCULATION

Manual / Code refers to AISC Manual of Steel Construction, Allowable Stress Design, ninth edition.

Steel Design -

Member 1, Size W 12X26, L = 10 ft., a = 7.65 in^2, Sz = 33.39 in^3

From clause F1-2, page 5-45 of Manual, L_c = 6.85 ft.

From observation Load case 1 will govern,

Fx = 25.0 kip (compression), Mz = 56.5 k-ft

Area of compressive flange = 6.49*0.38 = 2.466 sq.in.

Allowable bending stress = $F_b = \dfrac{12. \times 1000 \times 1.0}{10 \times 12 \times (12.22/2.466)} = 20.1817$ ksi [Clause F1-8 page 5-47 of Manual]

(kl/r)y = 120/1.5038 = 79.8, so Fa = 15.38 ksi (Table C-36 page 3-16 of manual)

fa = 25./7.65 = 3.268, fb = 56.5 x 12/33.39 = 20.31 ksi

(kl/r)z = 120/5.1639 = 23.238, so F'ez = 276.54 ksi

Try formula H1-1, page 5-54 of Manual

$$\frac{3.268}{15.38} + \frac{0.85 \times 20.31}{(1-3.268/276.54) \times 20.1817} = 1.078$$

Try formula H1-2, page 5-54 of Manual.

$$\frac{3.268}{0.6 \times 36} + \frac{20.31}{20.1817} = 1.1576$$

Therefore formula H1-2 governs and ratio = **1.1576**

Member 2, Size W12X26, L = 5 ft., a = 7.65 in^2, Sz = 33.39 in^3

From observation load case 1 will govern,

Fx = 8.71 kip (compression), Mz = 56.50 k-ft

Since L is less than L_c (6.85ft) [Clause F1-2 page 5-45 of Manual]

Fb = 0.66x36 = 23.76 ksi (Clause F1-1 page 5-45 of Manual)

(kl/r)y = 60/1.5038 = 39.90, so Fa = 19.19 ksi Table C-36 page 3-16 of Manual

fa = 8.71/7.65 = 1.1385, fb = 56.5 x 12/33.39 = 20.31 ksi

Since fa/Fa less than 0.15, apply formula H1-3, page 5-54 of Manual

$$\frac{1.1385}{19.19} + \frac{20.31}{23.76} = .0593 + .8548 = \mathbf{0.9141}$$

Member 3, Size W14X43, L = 11ft., a = 12.6 in^2, Sz = 62.7 in^3

From observation load case 3 will govern,

Fx = 25.5 kip (compression), Mz = 112.173 k-ft

Refering to clause F1-2, page 5-45 of Manual.

L_c = 8.4 ft. Therefore, Fb = 0.6 x 36 = 21.6 ksi

(kl/r)y = 132/1.8941 = 69.69, so Fa = 16.46 ksi [Table C-36 page 3-16 of Manual]

fa = 25.5/12.6 = 2.024, fb = 112.173 x 12/62.66 = 21.48 ksi

since fa/Fa less than 0.15, use formula H1-3, page 5-54 of Manual

$\frac{2.024}{16.46} + \frac{21.48}{21.6} = 0.123 + 0.994$ **= 1.117**

Member 4, Size W14X43, L = 4ft, a = 12.6 in^2, Sz = 62.7 in^3

From observation, load case 3 will govern,

Fx = 8.75 kip (tension), Mz = 112.173 k-ft

L_c = 8.4 ft

Since L is less than L_c

Fb = 0.66 x 36 = 23.76 ksi [Clause F1-1 page 5-45 of Manual]

f_a = 8.75/12.6 = 0.694, f_b = 112.73x12/62.66 = 21.48 ksi

Combined tension and bending, use formula H 2-1, page 5-55 of Manual.

$\frac{0.694}{0.6 \times 36} + \frac{21.48}{23.76} = 0.032 + 0.904$ **= 0.936**

Member 5, Size W16X36, L = 5ft, a = 10.6 in^2, Sz = 56.49 in^3

L_c=7.37 ft, [Clause F1-2 page 5-45 of Manual.

From observation, load case 3 will govern.

Fx = 14.02 kip (compression), Mz =57.04 k-ft

Since L is less than L_c,

Fb = 0.66 x 36 = 23.76 ksi

(kl/r)y = 60./1.52 = 39.47, so Fa = 19.23 ksi [Table C-36 page 3-16 of Manual]

fa = 14.02/10.6 = 1.32, fb = 57.04 x 12/56.5 = 12.12 ksi

Since fa/Fa less than 0.15, use formula H1-3, page 5-54 of Manual

$\frac{1.32}{19.23} + \frac{12.12}{23.76}$ = 0.069 + 0.510 **= 0.579**

Member 6, Size W16X36, L = 16ft, a = 10.6 in^2, Sz = 56.49 in^3

From observation, load case 1 will govern. Forces at midspan are

Fx = 5.65 kip (compression), Mz = 71.25 k-ft

From Chapter F of the AISC ASD 9th ed. specs., with Cb = 1.0,

sqrt(102,000C_b/$F_{y)}$ =53.229

sqrt(510,000C_b/$F_{y)}$ =119.02

L/r_T = 192/1.79 = 107.26

53.229 < 107.26 < 119.02

Therefore F_b (as per F1-6, page 5-47 of Manual)

[(2/3) – 36*107.26*107.26/(1530,000)]*36 = 14.25 ksi

(Kl/r)y = 192/1.5203 = 126.29, so Fa = 9.36 [Table C-36 page 3-16 of Manual]

fa = 5.65/10.6 = 0.533, fb = 71.25x12/56.49 = 15.14 ksi

Since fa/Fa less than 0.15 use formula [H1-3, page 5-54 of Manual]

0.533/9.36 + 15.14/14.25 = 0.057 + 1.062 **= 1.119**

Member 7, Size W16X36, L =4ft, a = 10.6in^2, Sz =56.49in^3

Lc = 7.37ft (Clause F1-2 page 5-45 of Manual)

From observation load case 3 will govern, Fx = 24.06 kip (tension), M_z = 62.96 k-ft

From Clause F1-1, Fb = 0.66 Fy = 23.76 ksi = allowable compressive stress.

Since section is in tension, Fb = 0.60X36 = 21.60 Ksi [Clause F1-5, page5-45 of Manual].

Choosing the larger of above 2 values, Fb = 23.76 Ksi

fa = 24.06/10.6 = 2.2698, fb = 62.96X12/56.49 = 13.37

Since combined tension and bending, use formula H 2-1, page 5-55 of the AISC ASD 9th ed. specs.

$$\frac{2.2698}{0.6 \times 36} + \frac{13.37}{23.76} = 0.105 + 0.5627 \mathbf{= 0.6677}$$

Member 8, Size L4x4x1/4, L = 7.071 ft, a = 1.94 in^2

From observation load case 1 will govern, Fx = 23.04 kip (Comp.)

Fa is computed as per page 5-310 of the AISC ASD 9th ed.specs.

Qs = 1.34 – 0.00447*(4/0.25)*sqrt(36) = 0.9108

Qa = 1.0, Q = Qs * Qa = 0.9108

Cc = sqrt(2.0*pi*pi*E/(Q*Fy)) = sqrt(2.0*pi*pi*29000/(0.9108*36)) = 132.1241

$$Kl/r = \frac{7.071 \times 12}{0.795} = 106.73$$ is less than Cc.

Hence, Fa = 11.6027 ksi (computed per equation 4-1)

Actual compressive stress fa = 23.04/1.94 = 11.876 ksi

Therefore, Ratio = fa/Fa = 11.876/11.602 **= 1.024**

Member 9, Size L5x5x3/8, L = 5.657 ft, a = 3.61 in^2

From observation, load case 1 governs, Fx = 48.44 kip (Comp.)

Fa is computed as per page 5-310 of the AISC ASD 9th ed.specs.

Qs = 1.34 – 0.00447*(5/0.375)*sqrt(36) = 0.9824

Qa = 1.0, Q = Qs * Qa = 0.9824

Cc = sqrt(2.0*pi*pi*E/(Q*Fy)) =
sqrt(2.0*pi*pi*29000/(0.9824*36)) = 127.2238

$(Kl/r)_{min} = \frac{5.657 \times 12}{0.99} = 68.57$ is less than Cc.

Hence, Fa = 16.301 ksi (computed per equation 4-1)

Actual compressive stress fa = 48.44/3.61 = 13.418 ksi

Therefore Ratio = fa/Fa = 13.418/16.301 **= 0.823**

```
          ****************************************************
          *                                                  *
          *           STAAD.Pro                              *
          *           Version          Bld                   *
          *           Proprietary Program of                 *
          *           Research Engineers,  Intl.             *
          *           Date=                                  *
          *           Time=                                  *
          *                                                  *
          *      USER ID:                                    *
          ****************************************************

  1. STAAD PLANE  VERIFICATION PROBLEM NO 13
  2. *
  3. *  THIS DESIGN EXAMPLE IS VERIFIED BY HAND CALCULATION
  4. *  FOLLOWING AISC-89 CODE.
  5. *
  6. UNIT FEET KIP
  7. JOINT COORD
  8. 1 0 0 ; 2 25 0 ; 3 0 10 ; 4 25 11
  9. 5 0 15 ; 6 25 15 ; 7 5 15 ; 8 21 15
 10. MEMB INCI
 11. 1 1 3 ; 2 3 5 ; 3 2 4 ; 4 4 6
 12. 5 5 7 ; 6 7 8 ; 7 8 6 ; 8 3 7 ; 9 4 8
 13. MEMB PROP AMERICAN
 14. 1 2 TA ST W12X26 ; 3 4 TA ST W14X43
 15. 5 6 7 TA ST W16X36 ; 8 TA ST L40404 ; 9 TA ST L50506
 16. MEMB TRUSS ; 8 9
 17. CONSTANT
 18. E 4176E3 ALL
 19. POISSON STEEL ALL
 20. SUPPORT ; 1 2 PINNED
 21. LOADING 1 DL + LL
 22. MEMB LOAD ; 5 6 7 UNI Y -2.0
 23. LOADING 2 WIND FROM LEFT
 24. JOINT LOAD ; 5 FX 15.
 25. LOAD COMB 3 ; 1 0.75 2 0.75
 26. PERFORM ANALYSIS

         P R O B L E M   S T A T I S T I C S
         -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =      8/     9/     2
  ORIGINAL/FINAL BAND-WIDTH=     4/     4/     15 DOF
  TOTAL PRIMARY LOAD CASES =    2, TOTAL DEGREES OF FREEDOM =     20
  SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.0/  40242.2 MB

 27. LOAD LIST 1 3
 28. PRINT FORCES
MEMBER END FORCES    STRUCTURE TYPE = PLANE
-----------------
ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1     25.00     -5.65     0.00      0.00      0.00       0.00
               3    -25.00      5.65     0.00      0.00      0.00     -56.50
         3     1     12.00      1.05     0.00      0.00      0.00       0.00
               3    -12.00     -1.05     0.00      0.00      0.00      10.52

    2    1     3      8.71     10.64     0.00      0.00      0.00      56.50
               5     -8.71    -10.64     0.00      0.00      0.00      -3.29
         3     3     15.83     -2.77     0.00      0.00      0.00     -10.52
               5    -15.83      2.77     0.00      0.00      0.00      -3.34

    3    1     2     25.00      5.65     0.00      0.00      0.00       0.00
               4    -25.00     -5.65     0.00      0.00      0.00      62.15
         3     2     25.50     10.20     0.00      0.00      0.00       0.00
               4    -25.50    -10.20     0.00      0.00      0.00     112.17
```

```
  MEMBER END FORCES    STRUCTURE TYPE = PLANE
  -----------------
  ALL UNITS ARE -- KIP  FEET

 MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

     4    1     4      6.50    -12.85     0.00      0.00      0.00     -62.15
                6     -6.50     12.85     0.00      0.00      0.00      10.76
          3     4     -8.75    -24.06     0.00      0.00      0.00    -112.17
                6      8.75     24.06     0.00      0.00      0.00      15.95

     5    1     5    -10.64      8.71     0.00      0.00      0.00       3.29
                7     10.64      1.29     0.00      0.00      0.00      15.25
          3     5     14.02     15.83     0.00      0.00      0.00       3.34
                7    -14.02     -8.33     0.00      0.00      0.00      57.04

     6    1     7      5.65     15.00     0.00      0.00      0.00     -15.25
                8     -5.65     17.00     0.00      0.00      0.00      -0.75
          3     7     10.20      4.50     0.00      0.00      0.00     -57.04
                8    -10.20     19.50     0.00      0.00      0.00     -62.96

     7    1     8    -12.85      1.50     0.00      0.00      0.00       0.75
                6     12.85      6.50     0.00      0.00      0.00     -10.76
          3     8    -24.06     14.75     0.00      0.00      0.00      62.96
                6     24.06     -8.75     0.00      0.00      0.00     -15.95

     8    1     3     23.04      0.00     0.00      0.00      0.00       0.00
                7    -23.04      0.00     0.00      0.00      0.00       0.00
          3     3     -5.41      0.00     0.00      0.00      0.00       0.00
                7      5.41      0.00     0.00      0.00      0.00       0.00

     9    1     4     26.16      0.00     0.00      0.00      0.00       0.00
                8    -26.16      0.00     0.00      0.00      0.00       0.00
          3     4     48.44      0.00     0.00      0.00      0.00       0.00
                8    -48.44      0.00     0.00      0.00      0.00       0.00

  ************** END OF LATEST ANALYSIS RESULT **************
   29. PARAMETER
   30. CODE AISC
   31. TRACK 1.0 ALL
   32. CHECK CODE ALL

                      STAAD.PRO CODE CHECKING - (AISC 9TH EDITION)
                      ********************************************
 ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)

 MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                          FX            MY            MZ       LOCATION
 =======================================================================
 *    1  ST   W12X26                   (AISC SECTIONS)
                          FAIL     AISC- H1-2         1.157         1
                      25.00 C         0.00          56.50       10.00
  -----------------------------------------------------------------------
 | MEM=     1, UNIT KIP-INCH, L= 120.0 AX=   7.65 SZ=    33.4 SY=     5.3|
 | KL/R-Y=  79.8  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 20.18 |
 | FTZ= 21.60  FCY= 27.00  FTY= 27.00  FC= 15.26  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
      2  ST   W12X26                   (AISC SECTIONS)
                          PASS     AISC- H1-3         0.916         1
                       8.71 C         0.00          56.50        0.00
  -----------------------------------------------------------------------
 | MEM=     2, UNIT KIP-INCH, L=  60.0 AX=   7.65 SZ=    33.4 SY=     5.3|
 | KL/R-Y=  39.9  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
 | FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 18.61  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
 *    3  ST   W14X43                   (AISC SECTIONS)
                          FAIL     AISC- H1-3         1.117         3
                      25.50 C         0.00        -112.17       11.00
  -----------------------------------------------------------------------
 | MEM=     3, UNIT KIP-INCH, L= 132.0 AX=  12.60 SZ=    62.7 SY=    11.3|
 | KL/R-Y=  69.7  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 21.60 |
 | FTZ= 21.60  FCY= 27.00  FTY= 27.00  FC= 16.46  FT= 21.60  FV= 14.40   |
  -----------------------------------------------------------------------
ALL UNITS ARE - KIP  FEET (UNLESS OTHERWISE NOTED)
```

```
MEMBER     TABLE       RESULT/   CRITICAL COND/     RATIO/     LOADING/
                         FX           MY             MZ       LOCATION
=======================================================================
     4  ST   W14X43                   (AISC SECTIONS)
                         PASS     AISC- H2-1        0.936        3
                      8.75 T          0.00       -112.17        0.00
 -----------------------------------------------------------------------
| MEM=     4, UNIT KIP-INCH, L=  48.0 AX=  12.60 SZ=    62.7 SY=    11.3|
| KL/R-Y=  25.3  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
| FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 20.26  FT= 21.60  FV= 14.40   |
 -----------------------------------------------------------------------
     5  ST   W16X36                   (AISC SECTIONS)
                         PASS     AISC- H1-3        0.582        3
                     14.02 C          0.00        -57.04        5.00
 -----------------------------------------------------------------------
| MEM=     5, UNIT KIP-INCH, L=  60.0 AX=  10.60 SZ=    56.5 SY=     7.0|
| KL/R-Y=  39.5  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
| FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 18.39  FT= 21.60  FV= 14.40   |
 -----------------------------------------------------------------------
*    6  ST   W16X36                   (AISC SECTIONS)
                         FAIL     AISC- H1-3        1.119        1
                      5.65 C          0.00        -71.25        8.00
 -----------------------------------------------------------------------
| MEM=     6, UNIT KIP-INCH, L= 192.0 AX=  10.60 SZ=    56.5 SY=     7.0|
| KL/R-Y= 126.3  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 14.25 |
| FTZ= 21.60  FCY= 27.00  FTY= 27.00  FC=  9.36  FT= 21.60  FV= 14.40   |
 -----------------------------------------------------------------------
     7  ST   W16X36                   (AISC SECTIONS)
                         PASS     AISC- H2-1        0.668        3
                     24.06 T          0.00         62.96        0.00
 -----------------------------------------------------------------------
| MEM=     7, UNIT KIP-INCH, L=  48.0 AX=  10.60 SZ=    56.5 SY=     7.0|
| KL/R-Y=  31.6  CB=  1.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ= 23.76 |
| FTZ= 23.76  FCY= 27.00  FTY= 27.00  FC= 18.87  FT= 21.60  FV= 14.40   |
 -----------------------------------------------------------------------
*    8  ST   L40404                   (AISC SECTIONS)
                         FAIL     AISC- H1-1        1.025        1
                     23.04 C          0.00          0.00        0.00
 -----------------------------------------------------------------------
| MEM=     8, UNIT KIP-INCH, L=  84.9 AX=   1.94 SZ=     0.8 SY=     1.7|
| KL/R- = 106.7  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
| FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC= 11.60  FT= 21.60  FV=  0.00   |
 -----------------------------------------------------------------------
     9  ST   L50506                   (AISC SECTIONS)
                         PASS     AISC- H1-1        0.823        3
                     48.44 C          0.00          0.00        0.00
 -----------------------------------------------------------------------
| MEM=     9, UNIT KIP-INCH, L=  67.9 AX=   3.61 SZ=     1.8 SY=     3.9|
| KL/R- =  69.0  CB=  0.00  YLD= 36.00  ALLOWABLE STRESSES:  FCZ=  0.00 |
| FTZ=  0.00  FCY=  0.00  FTY=  0.00  FC= 16.30  FT= 21.60  FV=  0.00   |
 -----------------------------------------------------------------------

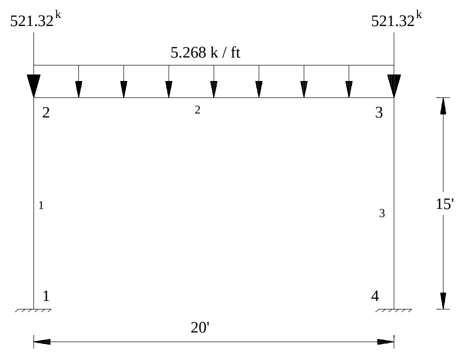
   33. FINISH
```

Verification Problem No. 14

TYPE: Concrete design as per ACI code.

REFERENCE: CRSI Handbook and Notes on ACI-318 from ACI.

PROBLEM: A plane frame is created with such loading as to create 138 Kip-Ft moment on beam and 574 Kip of axial load coupled with above moment on column.



GIVEN: Size of beam is 10 x 16 inch, column 14 x 16 inch.

SOLUTION COMPARISON:

	Area of Steel in beam	Area of Steel in column
ACI notes	2.78 sq.in.	X
CRSI Handbook	X	4.01%
STAAD	2.792 sq.in	4.09% required 4.23% provided

```
**************************************************** 
*                                                  *
*           STAAD.Pro                              *
*           Version          Bld                   *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=                                  *
*           Time=                                  *
*                                                  *
*      USER ID:                                    *
****************************************************

  1. STAAD PLANE VERIFICATION FOR CONCRETE DESIGN
  2. UNIT KIP FEET
  3. JOINT COORDINATES
  4. 1 0. 0. ; 2 0. 15. ; 3 20. 15. ; 4 20. 0.
  5. MEMBER INCIDENCE
  6. 1 1 2 ; 2 2 3 ; 3 3 4
  7. UNIT INCH
  8. MEMBER PROPERTY
  9. 1 3 PRISMATIC YD 16. ZD 14.
 10. 2 PRISM YD 16. ZD 10.
 11. CONSTANTS
 12. E CONCRETE ALL
 13. POISSON CONCRETE ALL
 14. SUPPORT
 15. 1 4 FIXED
 16. UNIT FT
 17. LOADING 1 DEAD + LIVE
 18. JOINT LOAD
 19. 2 3 FY -521.32
 20. MEMBER LOAD
 21. 2 UNI GY -5.268
 22. PERFORM ANALYSIS

        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     4/     3/     2
  ORIGINAL/FINAL BAND-WIDTH=     1/     1/      6 DOF
  TOTAL PRIMARY LOAD CASES =    1, TOTAL DEGREES OF FREEDOM =      6
  SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.0/  40242.1 MB

 23. PRINT MEMBER FORCES

 MEMBER END FORCES    STRUCTURE TYPE = PLANE
 -----------------
 ALL UNITS ARE -- KIP  FEET

MEMBER  LOAD  JT     AXIAL   SHEAR-Y  SHEAR-Z   TORSION     MOM-Y      MOM-Z

    1    1     1    574.00    -13.69     0.00      0.00      0.00     -67.44
               2   -574.00     13.69     0.00      0.00      0.00    -137.87

    2    1     2     13.69     52.68     0.00      0.00      0.00     137.87
               3    -13.69     52.68     0.00      0.00      0.00    -137.87

    3    1     3    574.00     13.69     0.00      0.00      0.00     137.87
               4   -574.00    -13.69     0.00      0.00      0.00      67.44

 ************** END OF LATEST ANALYSIS RESULT **************

 24. UNIT INCH
 25. START CONC DESIGN
 26. CODE ACI 1999
 27. TRACK 1.0 MEMB 2
 28. FYMAIN 60.0 ALL
 29. FC 4.0 ALL
 30. CLB 1.4375 ALL
```

```
 31. DESIGN BEAM 2
======================================================================

       BEAM  NO.     2 DESIGN RESULTS - FLEXURE PER CODE ACI 318-99

LEN -  20.00FT.  FY - 60000.  FC - 4000.  SIZE - 10.00 X 16.00 INCHES

LEVEL    HEIGHT     BAR INFO       FROM           TO         ANCHOR
       FT.    IN.              FT.     IN.     FT.     IN.   STA  END
______________________________________________________________________

  1    0 + 2-5/8    2-NUM.10     0 + 0-0/0     20 + 0-0/0    YES  YES
 |----------------------------------------------------------------|
 |   CRITICAL POS MOMENT=    125.53 KIP-FT  AT 10.00 FT, LOAD    1|
 |   REQD STEEL=  2.48 IN2, ROW=0.0185, ROWMX=0.0214 ROWMN=0.0033 |
 |   MAX/MIN/ACTUAL BAR SPACING= 10.16/ 2.54/ 4.73 INCH           |
 |   REQD. DEVELOPMENT LENGTH = 48.52 INCH                        |
 |----------------------------------------------------------------|

  Cracked Moment of Inertia Iz at above location =    1837.17 inch^4

*** A SUITABLE BAR ARRANGEMENT COULD NOT BE DETERMINED.
REQD. STEEL =  2.792 IN2,  MAX. STEEL PERMISSIBLE =  2.873 IN2
MAX NEG MOMENT =    137.87 KIP-FT,  LOADING    1

*** A SUITABLE BAR ARRANGEMENT COULD NOT BE DETERMINED.
REQD. STEEL =  2.792 IN2,  MAX. STEEL PERMISSIBLE =  2.873 IN2
MAX NEG MOMENT =    137.87 KIP-FT,  LOADING    1

___   2J____________________  240.X  10.X  16_____________________   3J____
|                                                                          |
|                                                                          |
|                                                                          |
|                                                                          |
| 2#10H   3.   0.TO  240.                                                  |
||========================================================================||
|                                                                          |
|__________________________________________________________________________|
 _________    _________    _________    _________    _________     _________
|         |  |         |  |         |  |         |  |         |   |         |
|         |  |         |  |         |  |         |  |         |   |         |
|         |  |         |  |         |  |         |  |         |   |         |
|         |  |         |  |         |  |         |  |         |   |         |
| 2#10    |  | 2#10    |  | 2#10    |  | 2#10    |  | 2#10    |   | 2#10    |
|   OO    |  |   OO    |  |   OO    |  |   OO    |  |   OO    |   |   OO    |
|         |  |         |  |         |  |         |  |         |   |         |
|_________|  |_________|  |_________|  |_________|  |_________|   |_________|


********************END OF BEAM DESIGN**************************

 32. DESIGN COLUMN 1
=====================================================================

     COLUMN  NO.     1  DESIGN PER ACI 318-99 - AXIAL + BENDING


FY - 60000  FC - 4000 PSI,  RECT SIZE - 14.00 X 16.00 INCHES, TIED
        AREA OF STEEL REQUIRED =   9.164  SQ. IN.

BAR CONFIGURATION       REINF PCT.   LOAD   LOCATION   PHI
----------------------------------------------------------

 12 - NUMBER  8           4.232        1      END     0.700
(PROVIDE EQUAL NUMBER OF BARS ON EACH FACE)
TIE BAR NUMBER    3 SPACING  14.00 IN

********************END OF COLUMN DESIGN RESULTS********************

 33. END CONC DESIGN
 34. FINISH
```

NOTES

STAAD reports that it is unable to find a suitable bar arrangement to satisfy the reinforcement requirement for the negative moment at the two ends of beam 2. However, this does not mean that it is impossible to come up with a bar arrangement. When STAAD looks for a bar arrangement, it uses only bars of the same size. It begins with the bar size corresponding to the parameter MINMAIN. If an arrangement is not possible with that bar, it tries with the next larger bar size. If all the permissible bar sizes are exhausted, the program reports that it could not come up with a bar arrangement. However, the user may be able to satisfy the requirement by mixing bars of various diameters. For example, 3 # 11 bars and 2 # 10 bars may satisfy the requirement. The program is not equipped with facilities to come up with such combinations of bar sizes.

NOTES

N
o
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s