Chapter 1

PRIMER

1.1 Scope of STRESS

The STRESS system is presently implemented to perform the linear analysis of elastic, statically loaded, framed structures. Analysis means the computation of joint displacements, member distortions, member end forces and reactions for a structure, given the makeup and orientation of all the members, and the type, position, and magnitude of all the applied loads, displacements, and distortions. The term "framed," or "lumped parameter," structure is used to denote structures composed of slender elements, that is, members that can be represented by their centroidal axis and analyzed as line elements. The structure itself may extend in two or three dimensions, and at any joint the members may be pinned or rigidly connected.

At present STRESS uses only the stiffness (displacement) method of analysis. This restriction, however, has no effect on the user who desires to obtain results for a particular structure.

Any structure that can be described by the language can be analyzed. Some computations may have to be performed outside of the STRESS system to analyze a structure that cannot be completely described by the language. For example, the load-deflection properties of a curved member could be supplied as either the member stiffness or flexibility matrices since STRESS cannot as yet determine these properties. Similarly, a shear wall could be approximated by a lattice analogy and the lattice members used to describe the structure. In most cases, however, no external computations are necessary.

1.2 Coordinate Systems

The analysis of framed structures deals with forces (force resultants, actions) and displacements or distortions. In STRESS, all components of force and displacement vectors are described in right-handed, orthogonal Cartesian coordinate systems. Such a coordinate system is shown in Figure 1.1, where x, y, and z denote coordinate directions and u_1

through u_6 denote the six components of a force or displacement vector.

In dealing with the description of a problem (input data) and the results produced by STRESS (output data), it is necessary to distinguish between global and local coordinate systems.

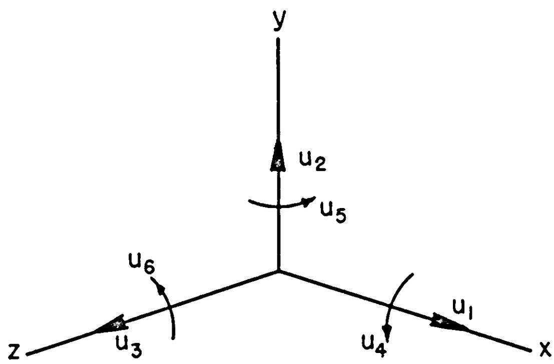


Figure 1.1. Coordinate system.

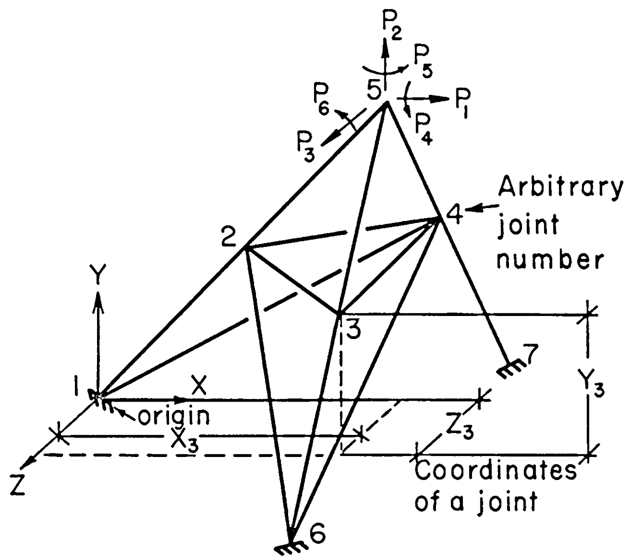
The global coordinate system is an arbitrary system, usually chosen so that the direction of the axes coincide with the major dimensions of the structure. All joint data are specified in terms of the global system; and the computed joint displacements and reactions are similarly output in the same system. The joint coordinates are specified with respect to an arbitrary origin, which may (but need not) be chosen at one of the support points.

Figure 1.2 illustrates the use of global coordinates for a space and a plane structure. A plane structure must be located in the X-Y plane of the three-dimensional coordinate system.

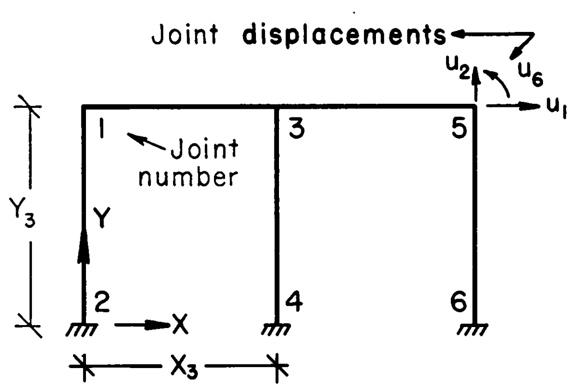
A local coordinate system is associated with each member, and all member data are specified in terms of this system. The local x axis coincides with the axis of the member, and its direction is from the start of the member to its end where "START" and "END" are specified in the input data. (See Section 2.4.3, MEMBER INCIDENCES). The y and z axes coincide with the principal axes of the member, as shown in Figure 1.3. For plane structures, it is assumed that one of the principal axes of the member lies in the global X-Y plane of the structure. (This is required in order to avoid out-of-plane deformations in a plane frame or in-plane deformations in a plane grid.)

1.3 Relationship Between Global and Local Coordinates

The position of a member in space is determined by the global coordinates of its end points. However, unless the member is axially symmetric, there is one unspecified degree of freedom, that is, the rotation



a. Space truss



b. Plane frame

Figure 1.2. Use of global coordinates.

of the principal axes of the member from the global axes. This additional quantity is called the angle β, BETA (see Figure 1.3.)

For differentiation, call X, Y, Z a global coordinate system and x, y, z a member system. Let A be a plane containing the member x axis and a line parallel to the global Y axis (therefore perpendicular to the X-Z plane). Let y' be a coordinate in this plane and perpendicular to the x axis. The direction of y' must be taken so that the projection of y' on the Y axis is in the positive Y direction. Then β is the angle from y' to y, positive by the right-hand rule around x. This definition is not sufficient if the x axis

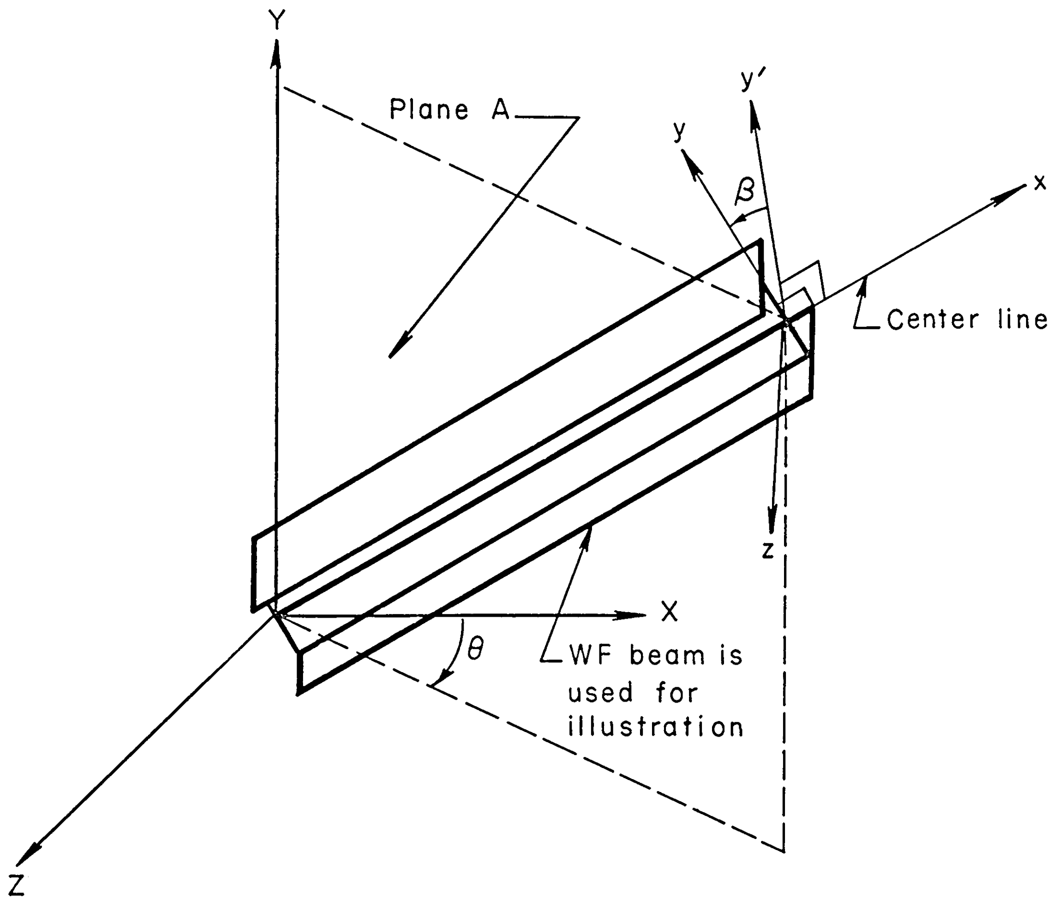


Figure 1.3. Local coordinates for a member.

is parallel to the Y axis, in which case the plane A is indeterminate. Then β is the angle from the $-X$ axis to the y axis if the x axis is in the same direction as the Y axis and from the $+X$ axis if not.

For plane structures, the definition is taken that when $\beta = 0$, the member z axis is parallel to and in the same direction as the Z axis. For plane structures, β must be either zero or a multiple of 90°; β is given in decimal degrees.

1.4 Structural Types

STRESS allows considerable flexibility and simplification in the analysis of plane frames or grids and plane or space trusses. This is done by omitting the components of the general six-dimensional force or displacement vector that do not enter into the analysis. The number of degrees of freedom (that is, the size of the vectors) thus varies from 2 for plane trusses to 6 for space frames.

The vector components used throughout the system are given in Table 1.1 for the available structural types. In the table, u_1, u_2, u_3 denote forces or displacements in a right-handed coordinate system, and u_4, u_5, u_6 denote moments or rotations about the axes as shown in Figure 1.1. These components pertain to both member and joint quantities, except for truss members. For plane and space trusses, the vector components shown are those for global coordinates. For local coordinates, obviously there is only one component, u_1, the axial force or distortion of the member. For any structural type, it is necessary to specify only those input quantities (loads, displacements, member section properties, and so forth) corresponding to the vector components listed for the particular type.

Table 1.1. Vector Components for Structural Types

Type of Structure	Degrees of Freedom (JF)	Components Used
Plane Truss	2	u_1 u_2
Plane Frame	3	u_1 u_2 u_6
Plane Grid	3	u_3 u_4 u_5
Space Truss	3	u_1 u_2 u_3
Space Frame	6	u_1 u_2 u_3 u_4 u_5 u_6

For plane frames, the use of local components u_2 and u_6 implies that the local y axis is in the plane of the structure. A moment on a member is then about the z axis, and the quantities A_X (cross-sectional area), A_Y (shear area), and I_Z (moment of inertia about z axis) are needed to define the properties of a cross section. It is possible to specify $\beta = 90°$ and reverse these last subscripts. The plane grid, with the same axis arrangement ($\beta = 90°$), requires A_Y, I_Z, and I_X (torsional constant). For plane structures, a β angle is needed and can be used only if steel section names are used.

1.5 The Use of Releases

STRESS assumes that all force or displacement vector components of a member or joint are related by identical continuity and equilibrium equations. For example, a support joint in a space frame provides force and moment reactions in all three component directions, or the equilibrium equation at a joint in a plane frame involves displacement components in the X and Y directions as well as rotation about the Z axis.

In many structures, local deviations from this pattern may occur. The introduction of hinges, rollers, and so forth, makes certain force components equal to zero.

In order to avoid ambiguities in designations such as hinges or rollers, in the STRESS language the word RELEASE is used to specify zero force components.

Two types of releases are implemented in STRESS.

Joint releases may be specified at support joints to indicate zero reaction components, that is, joint displacement components which are not prescribed. Released components need not be in global coordinate directions, but must be orthogonal at a joint.

The joint release orientation is shown in Figure 1.4 by the x', y', z' coordinate system. The rotation of this system from the global coordinate system is given by the angles θ_1, θ_2, θ_3 as follows:

1. θ_1 is the angle from the X axis to the projection of the x' axis on the X-Y plane.
2. θ_2 is the angle from the projection of the x' axis on the X-Y plane to the x' axis. The positive direction is measured from the X-Y plane toward the Z axis.
3. θ_3 is measured from a plane including the x' and Z axes, from the projection of the z' axis on this plane to the z' axis. The positive direction is measured about the x' axis by the right-hand rule.

A joint release does not concern the fixity of the members at that joint, only the fixity of the joint to the support, as shown in Figure 1.5.

Member releases may be specified only at the member ends. A member release indicates that a force component is zero. Released components must be in the local member coordinate system. Member release information at the member end must be given if full fixity of the member connection is not desired. In the case when full fixity does not exist at a support joint incident to only one member, member release at that end has the same meaning as a joint release. One restriction on this alternate specification exists, and it arises from checking load data for consistency. Joint loads can be given only at joints that are free to displace. A support joint that has certain released components has such freedom. Therefore, joint releases must be specified for any support joints carrying applied loads.

For structures with members and joints corresponding to more than one type, such as a truss with certain joints rigidly connected, STRESS requires that the type with the greater number of components be specified and that local deviations from this type be specified separately. Thus, if the structure contains one or more rigid joints, it would be classified as a frame and the hinges introduced by means of RELEASE statements.

1.6 Units

At present, STRESS performs no conversions of units. Thus, all lengths and forces must be input in consistent units. For example, dimensions, applied displacements, and other length data may be in inches,

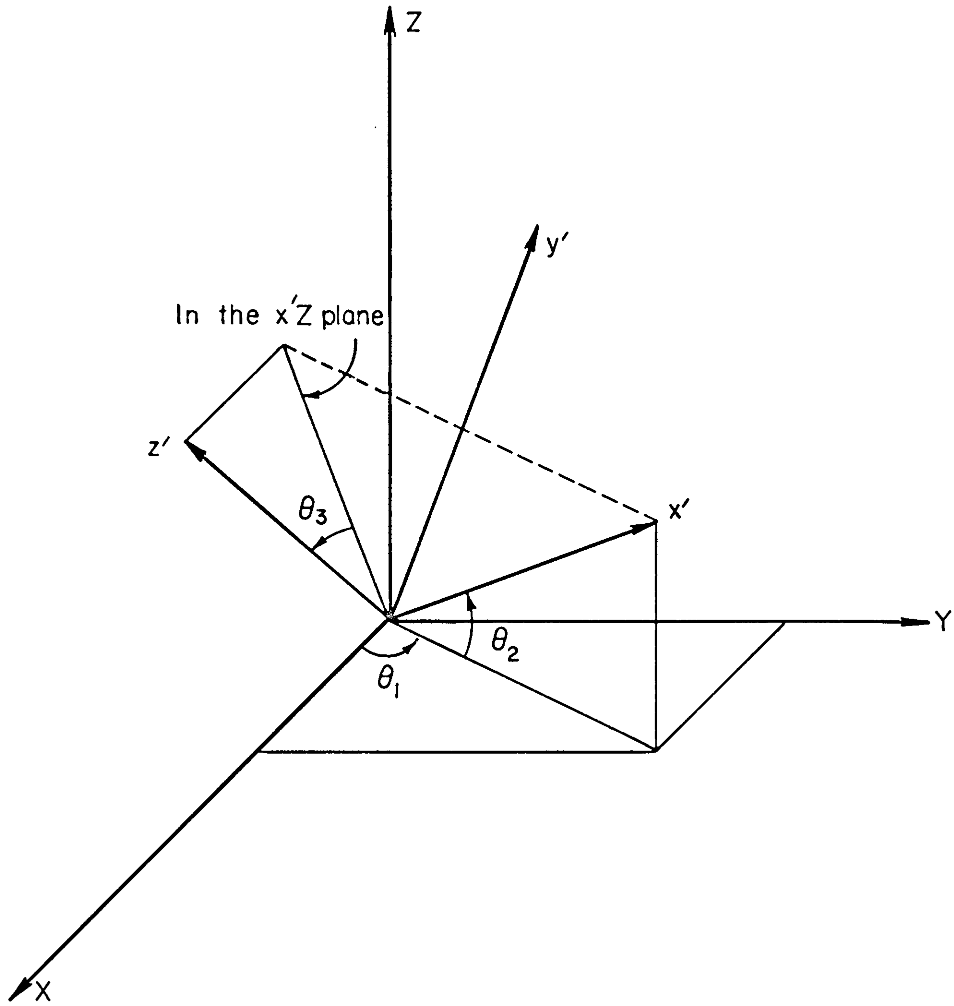


Figure 1.4. Specification of joint release orientation.

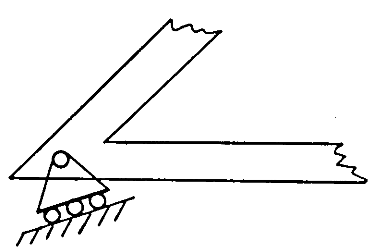


Figure 1.5. Member fixity with joint releases.

concentrated forces in kips, moments in inch-kips, distributed loads in kips/inch, and so forth. The computed results will be in the corresponding units.

The modulus of elasticity E is taken as 1.0, and the shearing modulus G as 0.4, if not given, but may be specified by the CONSTANTS Statement (see Section 2.4.7). Therefore, if E is not given, input displacements and distortions must be multiplied by E, and displacement and distortion results divided by E.

1.7 Identification of Joints, Members, and Data

In STRESS, joints and members are referred to by identification numbers assigned by the user. Numbering and ordering of data for members and joints are arbitrary with one restriction: for an initial problem (that is, not a modification), member and joint identification numbers may not exceed the specified number of members and joints, respectively. Any member or joint identification number may be used with modifications, but, for efficiency, it is best to keep these numbers as low as possible.

For member and joint information, a tabular form or input is generally used. A heading statement described in Sections 2.4 and 2.5 initiates the tabular input mode. When this mode is used, a member or joint number must be the first item in subsequent statements. The tabular mode is terminated when the first item is not an integer number. The data associated with the various statements (such as joint coordinates, member properties) are generally identified by appropriate labels. Two deviations are permitted. For the various types of member and joint information, a descriptive rather than a tabular form may be used. For the data, labels may be omitted provided that a fixed order is maintained. These alternate forms are described in Section 2.7.

1.8 Statement Types

Input to the STRESS system consists of problem-oriented statements using common engineering terminology. The usual distinction between process descriptors (FORTRAN source language) and data has been completely eliminated, and the majority of statements contain both kinds of information.

The following classification is intended primarily to indicate the scope of the system. The exact function of each statement is described in detail in Chapter 2.

Header statement. The word STRUCTURE followed by any identifying information serves to start a new problem.

Size descriptors. Several statements are needed to define the size of the problem to be handled. These include:

NUMBER OF JOINTS

NUMBER OF SUPPORTS
NUMBER OF MEMBERS
NUMBER OF LOADINGS

Process descriptors. Statements in this category give information about the procedures to be used for a particular problem. These statements include:

TYPE
METHOD
TABULATE
SELECTIVE OUTPUT
PRINT

Structural data descriptors. To describe completely a framed structure, it is necessary to provide information about its geometry, topology (interconnection of members and joints), mechanical properties (load-deflection relationships of the members), and the presence of local releases (such as hinges or rollers). Six types of statements are provided:

1. Geometry is specified in terms of joint coordinates by the statement

   JOINT COORDINATES

   followed by the X, Y, Z coordinates of each joint (or X, Y for plane structures). These statements are also used to describe the status (that is, free or support) of the joints.
2. The presence of hinges or rollers at support joints is given as

   JOINT RELEASES

   followed by the joint numbers and the designation and orientation of the released (zero) force components.
3. The interconnection of the members is specified by the statement

   MEMBER INCIDENCES

   followed by a list giving the starting and ending joint of each member. The meaning of this statement is best illustrated by the descriptive input form, which for a typical member may be MEMBER 17 GOES FROM JOINT 10 TO JOINT 7.
4. The load-deflection properties of the members are specified as

   MEMBER PROPERTIES

   followed by a statement for each member giving the type of member, and the labels and numerical values of the properties.
5. The presence of hinges in the members is given as

   MEMBER RELEASES

   followed by the member numbers and the position and orientation of the released force components.
6. Constants associated with the members are specified by the

CONSTANTS

statement.

Loading data descriptors. The loading applied to the structure is specified in terms of loading condition descriptors, descriptors of individual loads, and descriptors of groups of loads, as follows:

1. The word

   LOADING

   followed by any identifying information delineates groups of loads, together comprising a loading condition, and serves as a loading condition header.
2. Individual loads are specified by statements such as

   JOINT LOADS

   followed by the joint numbers and the components of applied load,

   JOINT DISPLACEMENTS,

   MEMBER DISTORTIONS, and

   MEMBER LOADS

   followed by a statement for each load giving the member number, the orientation, magnitude, and type of the load.
3. Certain loading specifications involve general information such as

   COMBINE

   followed by a list of loading conditions to be combined.

Modification descriptors. To permit rapid evaluation of alternate designs, the following statements can be used after an initial problem has been defined:

MODIFICATION	with information for output identification
ADDITIONS CHANGES DELETIONS	interspersed with pertinent statements of all the above types describing the modification

Termination statements. These statements terminate the input of portions or all of the statements of a problem. They are

SOLVE
SOLVE THIS PART
FINISH

1.9 A Sample Problem - Initial Specification

As an introduction to the scope and capability of STRESS, the simple plane frame shown in Figure 1.6 will be analyzed for two loading conditions: (1) uniform load of 1.2 kip/ft (= 0.1 kip/inch) on all horizontal members, and (2) horizontal loads of 20 kips on the two floors, as shown in the figure. The entire STRESS program is developed in this section, and Section 1.10 shows how a problem may be modified. It is suggested that the reader return to this section after he has studied the specific description of the statements in Chapter 2.

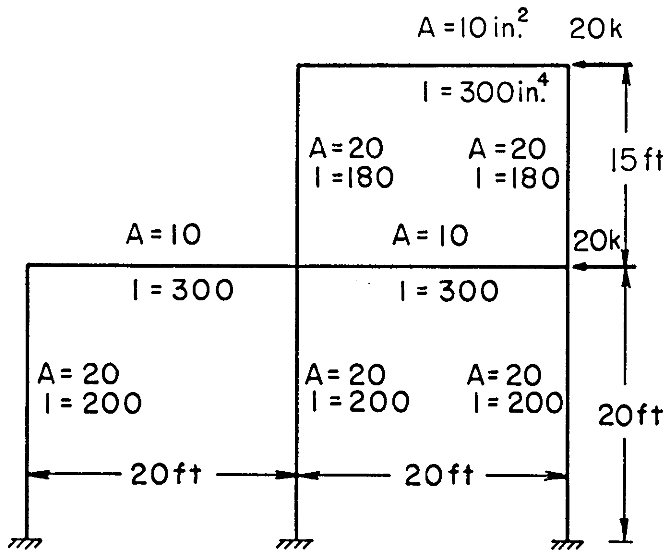


Figure 1.6. Sample structure.

The first step is to number the joints and members as shown in Figure 1.7. The directions shown for the members are arbitrary and chosen for convenience. Similarly, the origin of global coordinates is arbitrarily chosen at joint 5. Consistent units are chosen as inches for length and kips for force, requiring the dimension changes illustrated in Figure 1.7. The description of the problem follows closely the order of statement types given in Section 1.8, although such an order is not mandatory. The header and size descriptors can be written down immediately:

```
STRUCTURE  SAMPLE STRUCTURE
NUMBER OF JOINTS     8
NUMBER OF SUPPORTS   3
NUMBER OF MEMBERS    8
NUMBER OF LOADINGS   2
```

The structure is a plane frame and is to be analyzed by the stiffness method. The next two statements are therefore

```
TYPE PLANE FRAME
METHOD STIFFNESS
```

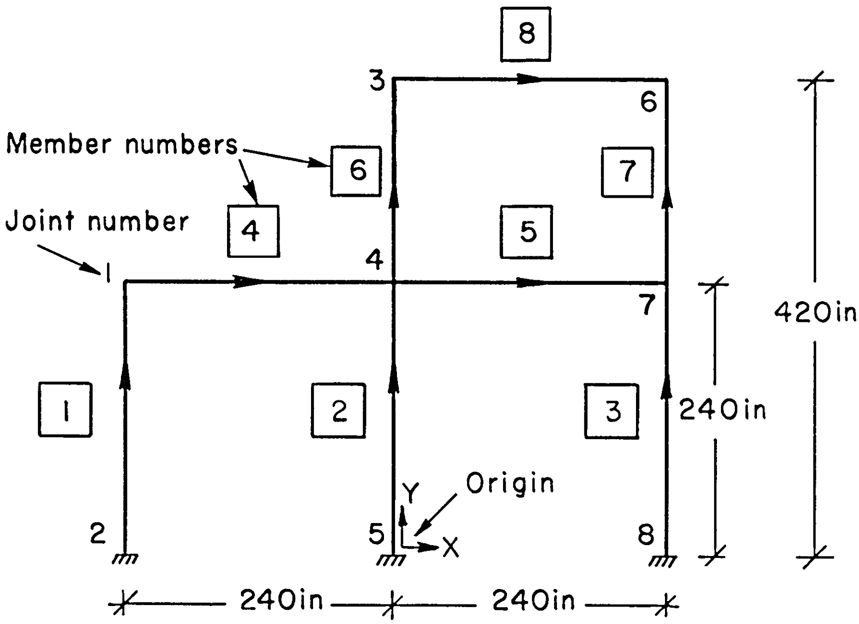


Figure 1.7. Numbering of members and joints.

Let us assume that member forces and reactions are desired for both loading cases. We therefore insert the statement

TABULATE FORCES, REACTIONS

at this point, before any individual loading has been identified. Additional output requests will be handled later.

We are now ready to describe the geometry of the structure by specifying the coordinates of all joints. We write the tabular header statement

JOINT COORDINATES

and follow by giving for each joint its number, X and Y coordinates, and status label (FREE, F, or blank for free joints, SUPPORT or S for fixed joints):

```
1 X -240. Y 240. FREE
2 X -240. Y   0. SUPPORT
5 X    0. Y   0. S
8 X  240. Y   0. S
4 X    0. Y 240.
7 X  240. Y 240.
3 X    0. Y 420.
6 X  240. Y 420.
```

Note that the order of the joints is immaterial. Since there are no joint releases (all supports are fixed), we can proceed to the description of member incidences. We again use a header statement, followed by tabular input in the order: member number, joint number as start of member, joint number at end of member.

```
MEMBER INCIDENCES
1 2 1
2 5 4
3 8 7
4 1 4
5 4 7
6 4 3
7 7 6
8 3 6
```

The member properties can now be specified. We assume that all members are prismatic. Furthermore, since this is a plane frame (and in subsequent modifications we do not intend to analyze it as part of a larger space frame), we need only to specify the cross-sectional area A_x and moment of inertia I_z of the members. Following the appropriate header statement

```
MEMBER PROPERTIES
```

we write for a typical member

```
8 PRISMATIC AX 10.0 IZ 300.0
```

Since we have not labeled and given AY, A_y is set to zero, indicating that shearing deformations are to be neglected. The same result can be achieved for the next member by writing

```
4 PRISMATIC AX 10.0 AY 0.0 IZ 300.0
```

For the columns, we may use a new header, putting in the header the designation common to all the members:

```
MEMBER PROPERTIES, PRISMATIC
1 AX 20.   IZ 200.
2 AX 20.   IZ 200.
3 AX 20.   IZ 200.
5 AX 10.   IZ 300.
6  IZ 180. AX  20.
7  IZ 180. AX  20.
```

Obviously, all members could have been included in the second tabular form.

If we assume the structure to be steel, the modulus of elasticity can be specified for all members as

```
CONSTANTS E, 30000., ALL
```

This completes the description of the structure. The loading data for the first loading are specified as

```
LOADING 1 UNIFORM LOAD ALL BEAMS
MEMBER LOADS
8 FORCE Y, UNIFORM, -0.1
4 FORCE Y, UNIFORM, -0.1
5 FORCE Y, UNIFORM, -0.1
```

Note that the distributed load acts in the member y direction and that, with the member orientations shown in Figure 1.7, a downward load acts in the negative y direction. Also, omitting the distances to the start and end of the load means that the load extends over the entire member.

The second loading condition can be similarly described:

```
LOADING 2 WIND FROM RIGHT
JOINT LOADS
6 FORCE X -20.0
7 FORCE X -20.0
```

For this loading only, suppose we are also interested in joint displacements, so we add

```
TABULATE DISPLACEMENTS
```

This concludes the description of the problem, so we write

```
SOLVE THIS PART
```

If we want selective output in addition to the quantities requested, we might add, for example, the following statements:

```
SELECTIVE OUTPUT
LOADING 1
PRINT DISPLACEMENTS 6, 7, DISTORTIONS 8
LOADING 2
PRINT DISTORTIONS 8
```

The problem description is now complete except for the

```
FINISH
```

statement. Figure 1.8 shows the complete STRESS program. The results obtained are shown in Figure 1.9. Figure 1.10 shows both the selective output requests and results.

1.10 Sample Problem - Modifications

In order to illustrate the facility with which modifications can be performed in STRESS, assume that the structure analyzed previously is also to be analyzed with the following changes:

a. The second floor lowered to 30 feet above ground.
b. Column 1 battered on a 4 to 1 slope and hinged at the bottom.

```
STRUCTURE SAMPLE STRUCTURE
NUMBER OF JOINTS 8
NUMBER OF SUPPORTS 3
NUMBER OF MEMBERS 8
NUMBER OF LOADINGS 2
TYPE PLANE FRAME
METHOD STIFFNESS
TABULATE FORCES, REACTIONS
JOINT COORDINATES
1 X -240. Y 240. FREE
2 X -240. Y  0. SUPPORT
5 X   0. Y  0. S
8 X  240. Y  0. S
4 X   0. Y 240.
7 X 240. Y 240.
3 X   0. Y 420.
6 X 240. Y 420.
MEMBER INCIDENCES
1 2 1
2 5 4
3 8 7
4 1 4
5 4 7
6 4 3
7 7 6
8 3 6
MEMBER PROPERTIES
8 PRISMATIC AX 10.0 IZ 300.0
4 PRISMATIC AX 10.0 AY 0.0 IZ 300.0
MEMBER PROPERTIES, PRISMATIC
1 AX 20. IZ 200.
2 AX 20. IZ 200.
3 AX 20. IZ 200.
5 AX 10. IZ 300.
6 IZ 180. AX 20.
7 IZ 180. AX 20.
CONSTANTS E, 30000., ALL
LOADING 1 UNIFORM ALL BEAMS
MEMBER LOADS
8 FORCE Y UNIFORM, -0.1
4 FORCE Y UNIFORM, -0.1
5 FORCE Y UNIFORM, -0.1
LOADING 2 WIND FROM RIGHT
JOINT LOADS
6 FORCE X -20.
7 FORCE X -20.
TABULATE DISPLACEMENTS
SOLVE THIS PART
```

Figure 1.8. Initial problem specification.

Figure 1.9. Initial problem results.

STRUCTURE SAMPLE STRUCTURE

LOADING 1 UNIFORM ALL BEAMS
MEMBER FORCES

MEMBER	JOINT	AXIAL FORCE	SHEAR FORCE	BENDING MOMENT
1	2	10.5446852	-1.2292451	-92.6043816
1	1	-10.5446852	1.2292451	-202.4144402
2	5	38.9818921	0.4814302	44.0447655
2	4	-38.9818921	-0.4814302	71.4984941
3	8	22.4734185	0.7478165	65.6633883
3	7	-22.4734185	-0.7478165	113.8125582
4	1	1.2292448	10.5446855	202.4144363
4	4	-1.2292448	13.4553142	-551.6899033
5	4	-1.8463720	13.3659654	628.3942719
5	7	1.8463720	10.6340343	-300.5625610
6	4	12.1606119	-2.5941878	-148.2028809
6	3	-12.1606119	2.5941878	-318.7509308
7	7	11.8393848	2.5941872	186.7499962
7	6	-11.8393848	-2.5941872	280.2036972
8	3	2.5941897	12.1606133	318.7509384
8	6	-2.5941897	11.8393863	-280.2037277

LOADING 1 UNIFORM ALL BEAMS

JOINT	X FORCE	Y FORCE	BENDING MOMENT
		SUPPORT REACTIONS	
2	1.2292451	10.5446852	-92.6043816
5	-0.4814302	38.9818921	44.0447655
8	-0.7478165	22.4734185	65.6633883
		APPLIED JOINT LOADS	
1	-0.0000003	0.0000002	-0.0000038
3	0.0000019	0.0000017	0.0000076
4	0.0000013	-0.0000010	-0.0000153
6	-0.0000025	0.0000018	-0.0000305
7	0.0000013	0.0000004	-0.0000057

LOADING 2 WIND FROM RIGHT
MEMBER FORCES

MEMBER	JOINT	AXIAL FORCE	SHEAR FORCE	BENDING MOMENT
1	2	11.1952969	-13.3343194	-1776.2674866
1	1	-11.1952969	13.3343194	-1423.9691467
2	5	10.3773841	-14.7321048	-1890.3127136
2	4	-10.3773841	14.7321048	-1645.3924255
3	8	-21.5726805	-11.9339367	-1669.2037506
3	7	21.5726805	11.9339367	-1194.9410553
4	1	13.3343413	11.1952968	1423.9691315
4	4	-13.3343413	-11.1952968	1262.9020844
5	4	16.4668262	13.3848399	1434.1739960
5	7	-16.4668262	-13.3848399	1778.1875763
6	4	8.1878413	-11.5994368	-1051.6837006
6	3	-8.1878413	11.5994368	-1036.2149200
7	7	-8.1878405	-8.4006306	-583.2465439
7	6	8.1878405	8.4006306	-928.8669662
8	3	11.5995109	8.1878411	1036.2148895
8	6	-11.5995109	-8.1878411	928.8669586

LOADING 2 WIND FROM RIGHT

JOINT	X FORCE	Y FORCE	BENDING MOMENT
		SUPPORT REACTIONS	
2	13.3343194	11.1952969	-1776.2674866
5	14.7321048	10.3773841	-1890.3127136
8	11.9339367	-21.5726805	-1669.2037506
		APPLIED JOINT LOADS	
1	0.0000219	-0.0000001	-0.0000153
3	0.0000741	0.	-0.0000305
4	-0.0001831	0.0000002	-0.0000458
6	-20.0001414	-0.0000008	-0.0000076
7	-20.0001321	0.0000004	-0.0000229

LOADING 2 WIND FROM RIGHT
JOINT DISPLACEMENTS

JOINT	X DISPLACEMENT	Y DISPLACEMENT	ROTATION
		FREE JOINT DISPLACEMENTS	
1	-3.4057056	-0.0044781	0.0070460
3	-5.3652391	-0.0066073	0.0051562
4	-3.4163731	-0.0041509	0.0048984
6	-5.3745187	0.0110854	0.0037249
7	-3.4295466	0.0086291	0.0094853

PART 1 OF PROBLEM COMPLETED.

```
SELECTIVE OUTPUT
LOADING 1
PRINT DISPLACEMENTS 6,7, DISTORTIONS 8
```

Figure 1.10. Selective output of additional results.

```
STRUCTURE SAMPLE STRUCTURE
LOADING 1 UNIFORM ALL BEAMS

JOINT DISPLACEMENTS

JOINT            X DISPLACEMENT   Y DISPLACEMENT        ROTATION

                                  FREE JOINT DISPLACEMENTS
  6                 -0.0520179      -0.0125412       0.0025205
  7                  0.0280228      -0.0089894       0.0009630

MEMBER DISTORTIONS

MEMBER          AXIAL DISTORTION SHEAR DISTORTION BENDING ROTATION
  8                 -0.0020754       0.5571141       0.0048139

LOADING 2
PRINT DISTORTIONS 8

STRUCTURE SAMPLE STRUCTURE
LOADING 2 WIND FROM RIGHT

MEMBER DISTORTIONS

MEMBER          AXIAL DISTORTION SHEAR DISTORTION BENDING ROTATION
  8                 -0.0092796      -1.2198004      -0.0014313
```

```
MODIFICATION OF FIRST PART - INVESTIGATE ALTERNATE LAYOUT
CHANGES
JOINT COORDINATES
3 X 0. Y 360.
6 X 240. Y 360.
2 X -300.0
ADDITIONS
JOINT RELEASES
2 MOMENT Z
MEMBER RELEASES
2 END MOMENT Z START MOMENT Z
CHANGES
MEMBER PROPERTIES
5 PRISMATIC IZ 600.
LOADING 1
DELETIONS
MEMBER LOADS
8  1
ADDITIONS
MEMBER LOADS
8 FORCE Y LINEAR 0. -0.2
PRINT DATA
```

Figure 1.11. Modification specification and data from internal storage.

Figure 1.11 continued.

```
PROBLEM DATA FROM INTERNAL STORAGE

STRUCTURE SAMPLE STRUCTURE

*  1*TH MODIFICATION OF INITIAL PROBLEM.

STRUCTURAL DATA

TYPE  PLANE FRAME

METHOD STIFFNESS
NUMBER OF JOINTS     8
          MEMBERS    8
          SUPPORTS   3
          LOADINGS   2

JOINT COORDINATES

JOINT      X          Y                    STATUS
   1   -240.000    240.000
   2   -300.000      0.                    SUPPORT
   3      0.       360.000
   4      0.       240.000
   5      0.         0.                    SUPPORT
   6    240.000    360.000
   7    240.000    240.000
   8    240.000      0.                    SUPPORT

JOINT RELEASES

 JOINT     FORCE     MOMENT        THETA
NUMBER     X  Y  Z  X  Y  Z        1        2        3
   2                       *       0.       0.       0.

MEMBER  START  END  TYPE             SEGMENT    AX        AY       AZ       IX       IY       IZ        L      BETA
   1      2     1   PRISMATIC
                                        1     20.000    0.       0.       0.       0.      200.00
   2      5     4   PRISMATIC
                                        1     20.000    0.       0.       0.       0.      200.00
   3      8     7   PRISMATIC
                                        1     20.000    0.       0.       0.       0.      200.00
   4      1     4   PRISMATIC
                                        1     10.000    0.       0.       0.       0.      300.00
   5      4     7   PRISMATIC
                                        1     10.000    0.       0.       0.       0.      600.00
   6      4     3   PRISMATIC
                                        1     20.000    0.       0.       0.       0.      180.00
   7      7     6   PRISMATIC
                                        1     20.000    0.       0.       0.       0.      180.00
   8      3     6   PRISMATIC
                                        1     10.000    0.       0.       0.       0.      300.00

MEMBER RELEASES

MEMBER        START              END
        FORCE   MOMENT     FORCE   MOMENT
        X  Y  Z  X  Y  Z  X  Y  Z  X  Y  Z
   2                   *                 *

YOUNG-S MODULI
      30000.00 VALUE FOR ALL MEMBERS

LOADING DATA

GIVEN IN TABULAR FORM,WITHOUT LABELS

LOADING 1 UNIFORM ALL BEAMS

TABULATE
        FORCES
        REACTIONS
MEMBER   4 LOAD FORCE  Y UNIFORM        -0.1000     0.          0.          0.
MEMBER   5 LOAD FORCE  Y UNIFORM        -0.1000     0.          0.          0.
MEMBER   8 LOAD FORCE  Y LINEAR          0.        -0.2000      0.          0.

LOADING 2 WIND FROM RIGHT

TABULATE
        FORCES
        REACTIONS
        DISPLACEMENTS
JOINT    6 LOADS                       -20.0000     0.          0.          0.          0.          0.
JOINT    7 LOADS                       -20.0000     0.          0.          0.          0.          0.

     SOLVE
```

STRUCTURE SAMPLE STRUCTURE

MODIFICATION OF FIRST PART - INVESTIGATE ALTERNATE LAYOUT

LOADING 1 UNIFORM ALL BEAMS
MEMBER FORCES

MEMBER	JOINT	AXIAL FORCE	SHEAR FORCE	BENDING MOMENT
1	2	9.8051310	-0.1657431	0.0002613
1	1	-9.8051310	0.1657431	-41.0028343
2	5	35.9713774	0.0000000	-0.0000000
2	4	-35.9713774	-0.0000000	0.0000026
3	8	26.5564461	2.5389214	308.1137924
3	7	-26.5564461	-2.5389214	301.2273331
4	1	2.5388785	9.4721752	41.0028305
4	4	-2.5388785	14.5278245	-647.6807632
5	4	-0.8783489	13.4536604	735.5987930
5	7	0.8783489	10.5463393	-386.7202797
6	4	7.9898897	-3.4172440	-87.9180145
6	3	-7.9898897	3.4172440	-322.1512642
7	7	16.0101073	3.4172501	85.4929314
7	6	-16.0101073	-3.4172501	324.5770836
8	3	3.4172367	7.9898925	322.1512604
8	6	-3.4172367	16.0101070	-324.5770874

MODIFICATION OF FIRST PART - INVESTIGATE ALTERNATE LAYOUT

LOADING 1 UNIFORM ALL BEAMS

JOINT	X FORCE	Y FORCE	BENDING MOMENT
		SUPPORT REACTIONS	
2	2.5388879	9.4721755	0.0002613
5	-0.0000000	35.9713774	-0.0000000
8	-2.5389214	26.5564461	308.1137924
		APPLIED JOINT LOADS	
1	-0.0000094	-0.0000002	-0.0000038
3	-0.0000073	0.0000029	-0.0000038
4	0.0000166	-0.0000027	0.0000229
6	0.0000134	-0.0000002	-0.0000038
7	0.0000202	0.0000005	-0.0000153

MODIFICATION OF FIRST PART - INVESTIGATE ALTERNATE LAYOUT

LOADING 2 WIND FROM RIGHT
MEMBER FORCES

MEMBER	JOINT	AXIAL FORCE	SHEAR FORCE	BENDING MOMENT
1	2	15.1927054	-7.4319584	-0.0026093
1	1	-15.1927054	7.4319584	-1838.5623627
2	5	5.1893103	-0.0000001	0.
2	4	-5.1893103	0.0000001	-0.0000283
3	8	-18.1258667	-29.1056440	-3768.9490356
3	7	18.1258667	29.1056440	-3216.4055176
4	1	10.8948350	12.9365537	1838.5623932
4	4	-10.8948350	-12.9365537	1266.2104950
5	4	-9.9171698	12.8879122	410.2637939
5	7	9.9171698	-12.8879122	2682.8351135
6	4	5.2379517	-20.8117938	-1676.4742584
6	3	-5.2379517	20.8117938	-820.9409943
7	7	-5.2379531	0.8116925	533.5706177
7	6	5.2379531	-0.8116925	-436.1675262
8	3	20.8118558	5.2379527	820.9411697
8	6	-20.8118558	-5.2379527	436.1674728

MODIFICATION OF FIRST PART - INVESTIGATE ALTERNATE LAYOUT

LOADING 2 WIND FROM RIGHT

JOINT	X FORCE	Y FORCE	BENDING MOMENT
		SUPPORT REACTIONS	
2	10.8948308	12.9365745	-0.0026093
5	0.0000001	5.1893103	0.
8	29.1056440	-18.1258667	-3768.9490356
		APPLIED JOINT LOADS	
1	0.0000042	-0.0000207	0.0000305
3	0.0000620	0.0000010	0.0001755
4	-0.0002110	-0.0000002	-0.
6	-20.0001633	0.0000004	-0.0000534
7	-20.0001667	0.0000014	0.0002136

MODIFICATION OF FIRST PART - INVESTIGATE ALTERNATE LAYOUT

LOADING 2 WIND FROM RIGHT
JOINT DISPLACEMENTS

JOINT	X DISPLACEMENT	Y DISPLACEMENT	ROTATION
		SUPPORT DISPLACEMENTS	
2	-0.	-0.	0.0414346
5	-0.	-0.	-0.
8	-0.	-0.	-0.
		FREE JOINT DISPLACEMENTS	
1	-6.9136064	1.7219447	0.0035318
3	-7.5557066	-0.0031233	0.0054063
4	-6.9223223	-0.0020757	-0.0040996
6	-7.5723561	0.0082979	0.0002760
7	-6.9143885	0.0072503	0.0110509

PROBLEM COMPLETED.
TIME USED 26 SECONDS.

Figure 1.12. Modification results.

c. Column 2 hinged at both ends.
d. The moment of inertia of beam 5 doubled.
e. The uniform load on beam 4 changed to a triangular loading with zero intensity at joint 1 and 0.2 kip/inch intensity at joint 4.

To accomplish both analyses in one run, the FINISH statement has to be removed, and the following statements added. Note that the SOLVE THIS PART statement enables the modifications to be read in immediately after the last statement of the original problem. The statements specifying the modifications should be self-explanatory, but they are marked with the letters a through e to identify the changes just described.

```
   MODIFICATION OF FIRST PART - INVESTIGATE
     ALTERNATE LAYOUT
a. CHANGES
   JOINT COORDINATES
   3 X     0. Y 360.
   6 X   240. Y 360.
b. 2 X -300.0          (CHANGE still governs)
   ADDITIONS
   JOINT RELEASES
   2 MOMENT Z
c. MEMBER RELEASES
   2 END MOMENT Z, START MOMENT Z
d. CHANGES
   MEMBER PROPERTIES
   5 PRISMATIC IZ 600.
e. LOADING 1
   DELETIONS
   MEMBER LOADS
   8 1 (first load on member 8 in loading condition 1)
   ADDITIONS
   MEMBER LOADS
   8, FORCE Y, LINEAR 0. -0.2
```

This completes the description of changes. To provide a check on the structure analyzed, we can request a description of the modified structure and loading by using the statement

```
PRINT DATA
```

The program is terminated by the two statements

```
SOLVE
FINISH
```

The affected portion of the STRESS program is shown in Figure 1.11, and the additional results in Figure 1.12. Note that in this case output was obtained only for the quantities requested by the original TABULATE statements, and not for those requested by the SELECTIVE OUTPUT statement.