LINEARLY ELASTIC ANALYSIS OF PLANE FRAMES SUBJECTED TO COMPLEX LOADING CONDITIONS

by

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Development of Methods for Computer Simulation
of Beam-Columns and Grid-Beam and Slab Systems

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PREFACE

This report presents an analytical tool for the solution of plane-frame structures. The computer program developed for the solution is intended to be well suited for solving complex structures with a minimum of hand calculations.

The solution techniques developed rely on the linearly elastic behavior that many plane frames exhibit under design loads. This linearity allows the user to solve a structure for many loading cases and combinations of loading cases at a cost only slightly greater than that of a single solution.

This is the twenty-first in a series of reports that describe work under Research Project No. 3-5-63-56, "Development of Methods for Computer Simulation of Beam-Columns and Grid-Beam and Slab Systems". Reports No. 56-1, 56-3, 56-4, 56-7, and 56-14 provide background information for this report.

Duplicate copies of the program deck and test data cards for the example problems in this report may be obtained from the Center for Highway Research, The University of Texas at Austin.

Thanks are due to the members of the staff of the Center for Highway Research for their assistance in producing this report.

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LIST OF REPORTS

Report No. 56-1, "A Finite-Element Method of Solution for Linearly Elastic Beam-Columns" by Hudson Matlock and T. Allan Haliburton, presents a finite-element solution for beam-columns that is a basic tool in subsequent reports.

Report No. 56-2, "A Computer Program to Analyze Bending of Bent Caps" by Hudson Matlock and Wayne B. Ingram, describes the application of the beam-column solution to the particular problem of bent caps.

Report No. 56-3, "A Finite-Element Method of Solution for Structural Frames" by Hudson Matlock and Berry Ray Grubbs, describes a solution for frames with no sway.

Report No. 56-4, "A Computer Program to Analyze Beam-Columns under Movable Loads" by Hudson Matlock and Thomas P. Taylor, describes the application of the beam-column solution to problems with any configuration of movable non-dynamic loads.

Report No. 56-5, "A Finite-Element Method for Bending Analysis of Layered Structural Systems" by Wayne B. Ingram and Hudson Matlock, describes an alternating-direction iteration method for solving two-dimensional systems of layered grids-over-beams and plates-over-beams.

Report No. 56-6, "Discontinuous Orthotropic Plates and Pavement Slabs" by W. Ronald Hudson and Hudson Matlock, describes an alternating-direction iteration method for solving complex two-dimensional plate and slab problems with emphasis on pavement slabs.

Report No. 56-7, "A Finite-Element Analysis of Structural Frames" by T. Allan Haliburton and Hudson Matlock, describes a method of analysis for rectangular plane frames with three degrees of freedom at each joint.

Report No. 56-8, "A Finite-Element Method for Transverse Vibrations of Beams and Plates" by Harold Salani and Hudson Matlock, describes an implicit procedure for determining the transient and steady-state vibrations of beams and plates, including pavement slabs.

Report No. 56-9, "A Direct Computer Solution for Plates and Pavement Slabs" by C. Fred Stelzer, Jr., and W. Ronald Hudson, describes a direct method for solving complex two-dimensional plate and slab problems.

Report No. 56-10, "A Finite-Element Method of Analysis for Composite Beams" by Thomas P. Taylor and Hudson Matlock, describes a method of analysis for composite beams with any degree of horizontal shear interaction.

Report No. 56-11, "A Discrete-Element Solution of Plates and Pavement Slabs Using a Variable-Increment-Length Model" by Charles M. Pearre, III, and W. Ronald Hudson, presents a method of solving for the deflected shape of freely discontinuous plates and pavement slabs subjected to a variety of loads.

Report No. 56-12, "A Discrete-Element Method of Analysis for Combined Bending and Shear Deformations of a Beam" by David F. Tankersley and William P. Dawkins, presents a method of analysis for the combined effects of bending and shear deformations.

Report No. 56-13, "A Discrete-Element Method of Multiple-Loading Analysis for Two-Way Bridge Floor Slabs" by John J. Panak and Hudson Matlock, includes a procedure for analysis of two-way bridge floor slabs continuous over many supports.

Report No. 56-14, "A Direct Computer Solution for Plane Frames" by William P. Dawkins and John R. Ruser, Jr., presents a direct method of solution for the computer analysis of plane frame structures.

Report No. 56-15, "Experimental Verification of Discrete-Element Solutions for Plates and Slabs" by Sohan L. Agarwal and W. Ronald Hudson, presents a comparison of discrete-element solutions with the small-dimension test results for plates and slabs, along with some cyclic data on the slab.

Report No. 56-16, "Experimental Evaluation of Subgrade Modulus and Its Application in Model Slab Studies" by Qaiser S. Siddiqi and W. Ronald Hudson, describes an experimental program developed in the laboratory for the evaluation of the coefficient of subgrade reaction for use in the solution of small dimension slabs on layered foundations based on the discrete-element method.

Report No. 56-17, "Dynamic Analysis of Discrete-Element Plates on Nonlinear Foundations" by Allen E. Kelly and Hudson Matlock, presents a numerical method for the dynamic analysis of plates on nonlinear foundations.

Report No. 56-18, "Discrete-Element Analysis for Anisotropic Skew Plates and Grids" by Mahendrakumar R. Vora and Hudson Matlock, describes a tridirectional model and a computer program for the analysis of anisotropic skew plates or slabs with grid-beams.

Report No. 56-19, "An Algebraic Equation Solution Process Formulated in Anticipation of Banded Linear Equations" by Frank L. Endres and Hudson Matlock, describes a system of equation-solving routines that may be applied to a wide variety of problems by utilizing them within appropriate programs.

Report No. 56-20, "Finite-Element Method of Analysis for Plane Curved Girders" by William P. Dawkins, presents a method of analysis that may be applied to plane-curved highway bridge girders and other structural members composed of straight and curved sections.

Report No. 56-21, "Linearly Elastic Analysis of Plane Frames Subjected to Complex Loading Conditions" by Clifford O. Hays and Hudson Matlock, presents a design-oriented computer solution of plane frame structures that has the capability to economically analyze skewed frames and trusses with variable cross-section members randomly loaded and supported for a large number of loading conditions.

ABSTRACT

A linearly elastic solution for the computer-aided analysis of plane frames is presented. The computer program which is developed features input formats which greatly reduce the manual preparation of data.

The solution uses a variation of the basic discrete-element beam-column model for the evaluation of member stiffness and fixed-end-force properties. The new discrete-element model allows flexural and axial rigidity as well as lateral, axial, and rotational values of loading and elastic restraint to vary randomly along the length of the member. Input is not restricted to values lumped at certain discrete stations but may be input in normal engineering values at any point on the member. In addition, options provided do not require the transferring of loads and dimensions from one axis to another by the user.

Frame displacements are obtained by standard matrix techniques modified to utilize the time and storage reductions possible for linearly elastic plane frames. The frame geometry may vary randomly and still be input in a simple and straightforward manner.

Options are provided to permit the analysis of a structure for several loading cases and combinations of cases with a minimum of new input and computer time.

KEY WORDS: structural engineering, frame analysis, plane frames, computer program, discrete element, soil-structure interaction, matrix analysis.

SUMMARY

A computer program for the direct linearly elastic analysis of complex bridge bents and other highway structures has been developed and is reported herein. Rigid frames, trusses, continuous beams, and other planar structures may be analyzed using the program.

The beam-column model previously reported has been modified so that loads and restraints may act both normal and parallel to the members of the frame. This allows the designer to consider vertical or inclined piles as an integral part of the frame, even if the pile is supported by lateral and axial soil restraints.

The description of loads, cross-sectional properties, and soil supports is completely general as in previous beam-column models. In addition, the loads and changes in cross-sectional properties and soil supports may be specified at any point along the member.

The geometry of the frame and the directions of the loads may be input in a manner both natural and convenient to the designer.

Options are provided that permit the designer to analyze structures for the multitude of loading cases required by the AASHO code. These options allow the designer to consider a large number of loading conditions economically.

IMPLEMENTATION STATEMENT

An extremely useful tool for the analysis of highway bridge structures has been developed in this study. The computer program described in the report is capable of handling large, skewed, randomly loaded plane-frame structures, and smaller and more regular structures may be input quickly for an economical solution. Rigid frames, beams, and trusses are analyzed by the same program.

In developing the program, emphasis was placed on maintaining complete generality of input. A skewed bridge bent with piles on lateral and axial soil supports can be easily input. At the same time, it was recognized that many frames are more regular and have simpler support conditions. These simpler problems can also be solved efficiently by the designer using the program.

One outstanding design-oriented feature of the program is its ability to superimpose the effects of a large number of loading conditions. A designer may consecutively run a dead-load analysis, a live-load analysis, a wind-load analysis, etc.; a program option then allows him to ask for any linear combination of these loadings he desires. Designers who have manually checked all the group loadings required by the AASHO specifications at their various unit stresses will appreciate this feature.

Further research in the area of linear analysis of planar structures does not appear warranted at this time. Future areas of research will be in nonlinear analysis and extensions to three-dimensional structures.

It is recommended that designers who have need for this program code some simple example problems in order to become familiar with its use. In addition, informal training sessions conducted by the research personnel would be extremely useful in implementing this work for immediate use by the Texas Highway Department.

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NOMENCLATURE

Symbol	Typical Units	Definition
A	in^2	Cross-sectional area of member
AE	lb	Axial rigidity of continuous element at any point
AE_i	lb	Axial rigidity of continuous element i at midpoint, used for discrete-element i
$\overline{AE}$, AE_1, AE_2	lb	Effective value of AE and values of AE over partial lengths of elements
α	--	Cosine of angle between the x' and x-axes
β	--	Cosine of angle between the x' and y-axes
c	inches	Distance from nearest station to left of concentrated load to the load
c_1, c_2	inches	Distance on element over which AE_1, AE_2, EI_1, and EI_2 are acting
C_1, C_2	--	Constants of integration
E	lb/in^2	Modulus of elasticity
EI	$lb\text{-}in^2$	Flexural rigidity of continuous element at any point
EI_i	$lb\text{-}in^2$	Flexural rigidity of continuous element i at midpoint, used for discrete-element i
$\overline{EI}$, EI_1, EI_2	$lb\text{-}in^2$	Effective values of EI and values of EI over partial lengths of element
ϵ	inches	Diameter of circle which contains loads which are being astatically equivalenced

Symbol	Typical Units	Definition
ϵ	inches and radians	Error term which represents the difference in displacements for a member composed of discrete-elements versus continuous-line elements
ϵ^*	inches and radians	Error term which represents the difference in displacements for one discrete element versus one continuous element
$\{f\}_i$	lb and lb-in	(6 x 1) matrix of end-forces on element i
$\{F\}_k$	lb and lb-in	(6 x 1) matrix of member-end-forces for member k measured in member coordinates
$\{F_i\}_k$, $\{F_j\}_k$	lb and lb-in	(3 x 1) matrix of member-end-forces at joint i , j for member k measured in member coordinates
F_i^1, F_i^2, F_i^3, F_j^1, F_j^2, F_j^3	lb and lb-in	Member-end-forces at joint i , j, measured in member coordinates (x′-force, y′-force, and moment about z′-axis, respectively)
$\{\overline{F}_i\}_k$	lb and lb-in	(3 x 1) matrix of member-end-forces at joint i for member k measured in structure coordinates
$\{\tilde{F}\}$	lb and lb-in	(3N x 1) matrix of frame joint loads measured in structure coordinates
$\{\tilde{F}_i\}$	lb and lb-in	(3 x 1) matrix of frame joint loads for joint i measured in structure coordinates
$\{FF\}_k$	lb and lb-in	(6 x 1) matrix of member fixed-end-forces measured in member coordinates
$\{FF_i\}_k$, $\{FF_j\}_k$	lb and lb-in	(3 x 1) matrix of member fixed-end-forces at joint i , j for member k measured in member coordinates
$\{\overline{FF}_i\}_k$	lb and lb-in	(3 x 1) matrix of member fixed-end-forces at joint i for member k measured in structure coordinates
h	inches	Distance between concentrated springs in discrete-element model, one-half of element's length

Symbol	Typical Units	Definition
i	--	Integer index
I	in^4	Moment of inertia of cross-section about member's z'-axis
j	--	Integer index
k	--	Integer index
$[k]_i$	lb/in and lb-in/rad	(6 x 6) element stiffness matrix for element i of member
$[k_{i-1,i-1}]_i$, $[k_{i-1,i}]_i$, $[k_{i,i-1}]_i$, $[k_{i,i}]_i$	lb/in and lb-in/rad	(3 x 3) submatrices of $[k]_i$ which relate forces at station of first inner subscript to displacements at station of second inner subscript
k_{pq}	lb/in and lb-in/rad	Element of stiffness matrix $[k]_i$ which represents the force corresponding to the p^{th} displacement due to a unit value of the q^{th} displacement
$[K]_k$	lb/in and lb-in/rad	(6 x 6) member stiffness matrix for member k measured in member coordinates
K_{pq}	lb/in and lb-in/rad	Element of stiffness matrix $[K]_k$ which represents the force corresponding to the p^{th} displacement due to a unit value of the q^{th} displacement
$[K_{ii}]_k$, $[K_{jj}]_k$	lb/in and lb-in/rad	(3 x 3) member stiffness matrix for member k measured in member coordinates which represents forces at i , j due to unit displacements at i , j
$[\bar{K}_{ii}]_k$	lb/in and lb-in/rad	(3 x 3) member stiffness matrix for member k measured in structure coordinates which represents forces at i due to unit displacement at i

Symbol	Typical Units	Definition
$[K_{ij}]_k$, $[K_{ji}]_k$	lb/in and lb-in/rad	(3 x 3) member stiffness matrix for member k measured in member coordinates which represents the forces at i , j due to unit displacements at j , i
$[\bar{K}_{ij}]_k$	lb/in and lb-in/rad	(3 x 3) member stiffness matrix for member k measured in structure coordinates which represents the forces at i due to unit displacements at j
$[\tilde{K}]$	lb/in and lb-in/rad	(3N x 3N) structure stiffness matrix measured in structure coordinates
$[\tilde{K}_{ii}]$	lb/in and lb-in/rad	(3 x 3) diagonal submatrix of $[\tilde{K}]$ which represents the forces at i due to the loads at i measured in structure coordinates
$[\tilde{K}_{ij}]$	lb/in and lb-in/rad	(3 x 3) off-diagonal submatrix of $[K]$ which represents the forces at i due to the loads at j measured in structure coordinates
γ	1/in	Slope of EI line divided by EI_i
L	inches	Length of member
m	--	Number of discrete-elements in frame member
M	--	Number of members intersecting at a joint
M	lb-in	Bending moment at any point in continuous element
M_1, M_2	lb-in	Bending moments at location of first and second rotational springs in discrete-element model
N	--	Number of joints in frame
P	--	Integer index
$\{\tilde{P}_i\}$	lb and lb-in	(3 x 1) matrix of forces acting at station i on member measured in member coordinates

Symbol	Typical Units	Definition
$\tilde{p}^1_i$, $\tilde{p}^2_i$, $\tilde{p}^3_i$	lb and lb-in	Concentrated forces acting at station i on a member, measured in member coordinates (x'-force, y'-force, and moment about z'-axis, respectively)
$\{\tilde{P}_i\}$	lb and lb-in	(3×1) matrix of applied forces at joint i measured in structure coordinates
$\tilde{P}^1_i$, $\tilde{P}^2_i$, $\tilde{P}^3_i$	lb and lb-in	Applied forces at joint i measured in structure coordinates (x-force, y-force, and moment about z-axis, respectively)
Ψ_1, Ψ_2	radians	Concentrated curvature (discrete angle changes) at first and second rotational springs in discrete-element model
q	--	Integer index
q_{ab}	lb/in and lb-in/in	Distributed load in the direction of the a-axis with its intensity per unit of length referenced to the b-axis, as $q_{x'x'}$, $q_{y'x'}$, $q_{z'x'}$, $q_{xx'}$, $q_{yx'}$, $q_{z'x'}$, q_{xy}, q_{yx}, and $q_{z'x'}$
Q_a	lb and lb-in	Concentrated load in the direction of the a-axis, as Q_x, $Q_{x'}$, Q_y, $Q_{y'}$, and Q_z, and $Q_{z'}$
RM, RO	--	Recursion multipliers used in recursion-inversion solution of simultaneous equations
$s_{x'}$, $s_{y'}$, $s_{z'}$	lb/in^2 and lb/rad	Distributed elastic spring restraints parallel to members x'-axis, y'-axis, and acting about z'-axis
$\tilde{s}^1_i$, $\tilde{s}^2_i$, $\tilde{s}^3_i$	lb/in and lb-in/rad	Concentrated elastic spring restraints at station i on a member, measured in member coordinate (x'-restraint, y'-restraint, and rotational restraint about z'-axis, respectively)

Symbol	Typical Units	Definition
$\tilde{S}_i^1, \tilde{S}_i^2, \tilde{S}_i^3$	lb/in and lb-in/rad	Concentrated elastic spring restraints acting at frame joint i expressed in structure coordinates (x-restraint, y-restraint, and rotational restraint about the z-axis, respectively)
SMMT	lb/in and lb-in/rad	(13 x 1) storage matrix used by program to store 13 constants needed to generate $[K]_k$
$[T]_k$	--	(3 x 3) coordinate transformation matrix for member k
$[T]_k^t$	--	(3 x 3) matrix which is the transpose of $[T]_k$
T	lb	Value of thrust at any point in continuous element
T_i	lb	Axial thrust in discrete-element i
V_1, V_2	lb	Shear forces at locations of first and second rotational springs in discrete-element model
$\{w\}_i$	inches and radians	(6 x 1) matrix of end displacements for element i
$\{\tilde{w}_i\}$	inches and radians	(3 x 1) matrix of element displacements at station i measured in member coordinates
$\tilde{w}_i^1 , \tilde{w}_i^2, \tilde{w}_i^3$	inches and radians	Displacements of station i measured in member coordinates (distances along x' , y' , and rotation about z' , respectively)
$\{W\}_k$	inches and radians	(6 x 1) matrix of member-end-displacements for member k measured in member coordinates
$\{W_i\}_k, \{W_j\}_k$	inches and radians	(3 x 1) matrix of member-end-displacements at joint i , j for member k measured in member coordinates
$W_i^1, W_i^2, W_i^3,$ W_j^1, W_j^2, W_j^3	inches and radians	Member-end displacements at joint i , j measured in member coordinates (distances along x' , y' , and rotation about z'-axis, respectively)

Symbol	Typical Units	Definition
$\{\bar{W}_i\}_k$	inches and radians	(3 x 1) matrix of member-end-displacements at joint i for member k measured in structure coordinates
$\{\tilde{W}\}$	inches and radians	(3N x 1) matrix of frame joint displacement measured in structure coordinates
$\{\tilde{W}_i\}$	inches and radians	(3 x 1) matrix of frame joint displacements at joint i measured in structure coordinates
$\tilde{W}_i^1$, $\tilde{W}_i^2$, $\tilde{W}_i^3$	inches and radians	Displacements of joint i measured in structure coordinates (distance along x and y , and rotation about z-axis, respectively)
x, y, z	inches	Cartesian coordinate axes for frame structure coordinates
x, y	inches	Distance along structure coordinate axes to change in loading or stiffness (referenced from members "From" joint)
x', y', z'	inches	Cartesian coordinate axes for member
x'	inches	Distance along member coordinate axis to change in loading or stiffness
x'', y'', x''	inches	Cartesian coordinate axes for element
x_i, y_i, x_j, y_j	inches	Structural coordinates of joints i , j
x_o, y_o	inches	x , y offset of joint j from joint i , projection of line going from joint i to joint j on the structure x-axis , y-axis

CHAPTER 1. INTRODUCTION

Statement of Problem

Many highway structures such as bridge bents and freeway overpasses are designed as plane frames. These structures may be composed of nonprismatic elastically restrained members and may be subjected to several complicated loading conditions. A thorough elastic analysis is economically feasible only with the aid of a digital computer program that is both versatile and convenient.

Most existing frame analysis programs are difficult or impossible to use for such real problems. Three frame solutions (Refs 2, 5, and 7) which incorporate the versatility of the discrete-element beam-column model (Refs 8 and 9) have been reported previously. References 5 and 7 use an alternating-direction iterative solution for the simultaneous equations which occur in the analysis. Recent developments in the direct solution of simultaneous equations (Ref 3) have made ADI solutions relatively less attractive on the present generation of computers. In addition, the solutions found in Refs 5 and 7 are restricted to rectangular frames.

Reference 2 gives a direct solution for linearly elastic frames and also permits an iterative investigation of the interaction of axial loads and lateral displacements. This solution while more versatile than previous ones still does not provide the designer with the convenience needed for a routine linear analysis, i.e., it allows members of the frame to be at any angle relative to the frame coordinate system, but it requires an orthogonal grid with intersections at all joints.

Purpose of Study

The primary purpose of this study is to develop a computer solution for plane frames that has the maximum convenience for the user consistent with generality of member arrangement and loading. The program is intended for routine use in a design office and has the following distinguishable features:

(1) Input of both regular and irregular frame geometries is simple and quick.

(2) Members may be either rigidly connected or pinned to joints.

(3) Loads and elastic restraints may act both normal and parallel to members and may be input in the most convenient coordinate system.

(4) Member stiffness properties and loadings may be input in normal engineering terms rather than as concentrated values at discrete stations.

(5) Solutions of dead, live, wind, and other loads may be multiplied by appropriate load factors and superimposed to satisfy code loading requirements.

A secondary purpose of this report is to develop a solution of the frame members by the direct stiffness method (Ref 6) using a modification of the discrete-element model previously reported.

Assumptions and Limitations of the Proposed Solution

The solution developed is for the linearly elastic analysis of plane frames subjected to static inplane loads and displacements and has the following restrictions of conventional plane frame analysis:

(1) Members are represented as straight-line elements intersecting at joints of infinitesimal size and are either rigidly connected or pinned to the joints.

(2) Members are made of a linearly elastic material.

(3) Displacements and deformations are small enough that the equilibrium equations can be formulated on the undeformed structure. Thus, the interaction of axial loads and lateral displacements is neglected.

(4) Shearing deformations are neglected.

Outline of Report

The conventional theory of the direct stiffness method is presented in Chapter 2, and the method is applied to develop the joint equilibrium equations for the frame solution. Chapter 3 develops the equilibrium equations for the frame members by the direct stiffness method and discusses how they are used to obtain the member properties required for the frame solution and the member results. In Chapter 4 the equations needed to internally transform the engineering data into discretized station values are given.

The organization of and the input for the computer program are discussed in Chapter 5. Several example problems are presented in Chapter 6 to illustrate the features of the program. The results of this study are given in Chapter 7.

Appendix 1 gives a theoretical justification of the discrete-element model developed in the report. The remaining appendices have the input guides, flow charts, FORTRAN notation, FORTRAN listing of the program, and input and selected output for the example problems.

CHAPTER 2. LINEAR MATRIX ANALYSIS OF STATICALLY LOADED PLANE FRAMES

General Theory

Most methods of structural analysis can be classified as either displacement or force methods. The classification is based on whether the basic unknowns are displacements[*] or forces[**]. The force or flexibility method has advantages for certain structures but is not as easy to formulate in general terms as the displacement method. Hence, the displacement or the stiffness method is the only one considered in this report.

For the purpose of a stiffness analysis, a structure may be visualized as a group of elements connected at a finite number of nodal points. Each nodal point can undergo one or more pertinent displacements. For each of these displacements, there is a corresponding force. A force and a displacement are said to correspond if they act at the same nodal point, have the same line of action, and their product has the units of work. The total number of nodal point displacements for a structure is said to be the degree of kinematic indeterminacy or the number of degrees of freedom of the structure.

The elastic analysis of a statically loaded structure is basically a problem in satisfying simultaneously four sets of conditions. The governing conditions are the equations of nodal point equilibrium, compatibility of nodal point displacement, any boundary conditions applied at the nodal points, and the elements force-displacement relations. It is assumed that the force-displacement relations used for the elements insure that equilibrium, compatibility, any boundary conditions applied to the elements, and the constitutive laws for the element are satisfied continuously throughout the element.

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[*] Throughout this report, the word "displacement" should be considered to mean either a translation or a rotation.

[**] Throughout this report, the word "force" implies either a translational force or a moment.

In many cases some approximation is actually made in developing the force-displacement relations as discussed in Chapter 3. The direct stiffness method, as described by Martin (Ref 6) is the most widely used technique for applying these four governing conditions to obtain the structures equilibrium equations.

A direct stiffness analysis of a structure can be separated somewhat arbitrarily into nine steps as outlined below. The general method is independent of the type of structure to which it is applied. Note that in the outline, the word matrix is not mentioned. This is done to emphasize that the basic ideas are not dependent on matrix algebra. However, matrix algebra is a powerful tool that enables the method to be developed concisely and implemented on a digital computer with ease.

Outline of the Direct Stiffness Method

(1) Select nodal point displacements that insure nodal point compatibility is satisfied.

(2) Calculate the force-displacement equations for all elements in their element coordinate systems.

(3) Transform these equations into the structure coordinate system.

(4) Sum up the nodal point forces corresponding to each nodal point displacement from the equations developed in Step 3. This gives the nodal point equilibrium equations in terms of element properties, nodal point forces, and nodal point displacements.

(5) Modify the equations as necessary for support (displacement type boundary) conditions at the nodal points.

(6) Solve the equations developed in Step 5 for the nodal point displacements. For the usual assumption of linearly elastic elements and small displacements, the equations are a set of linear simultaneous equations.

(7) Transform the nodal point displacements into element displacements.

(8) Solve for element forces from the force-displacement equations of Step 2.

(9) Solve for nodal point reactions and check nodal point equilibrium.

The direct stiffness method, as outlined above, will be applied to a plane frame to obtain a solution for the joint (nodal point) displacements in the remainder of this chapter. The solutions of the individual frame members (elements) needed for the frame solution is accomplished by another application of the direct stiffness method to a general frame member in Chapter 3.

Plane Frame Definition

Consider a plane frame as shown in Fig 1. It is assumed that the frame is composed of members that may be treated as straight-line elements. All of the elements lie in a plane and all loads and displacements occur in that plane, which for convenience is taken to be the x-y plane of a right-hand Cartesian coordinate system.

The end of a member or the intersection of two or more members forms a joint and this joint is assumed to be rigid and to have negligible dimensions. A member may be either rigidly connected or pinned to the joint. When a member is rigidly connected to a joint, it and all other members also rigidly connected to the joint rotate through the same angle and transmit moment to one another. When a member is pinned to a joint, it is free to rotate independently of the joint and other members intersecting at that joint. Thus, no moment is transferred from a pinned-end member to any member at the joint.

Joint (Nodal Point) Displacements

Each joint (i) will in general have three degrees of freedom, $\widetilde{W}_i^1$, $\widetilde{W}_i^2$, and $\widetilde{W}_i^3$ as shown in Fig 1. Translational displacements $\widetilde{W}_i^1$ and $\widetilde{W}_i^2$ must be equal (compatible) for all members intersecting at a joint. The rotational displacement may not be the same for all members at a joint, since some or all of the members may be pinned to the joint. Hence $\widetilde{W}_i^3$ is defined as being the rotation of the joint, and the pin is assumed to be a part of the member* occurring at an infinitesimal distance inside the member. Thus, $\widetilde{W}_i^3$ is equal (compatible) for all members intersecting at a joint. $\widetilde{W}_i^1$, $\widetilde{W}_i^2$, and $\widetilde{W}_i^3$ compose a vector $\left\{\widetilde{W}_i\right\}$ where $\left\{\widetilde{W}_i\right\}$ is a (3×1) matrix of structure displacements measured in structure coordinates.

A frame with N joints has a structure displacement vector $\left\{\widetilde{W}\right\}$ where $\left\{\widetilde{W}\right\}$ is a $(3N \times 1)$ matrix of structure displacements measured in structure coordinates. $\left\{\widetilde{W}\right\}$ then is composed of N submatrices $\left\{\widetilde{W}_i\right\}$. The basic equation of nodal point compatibility is

$$\left\{\widetilde{W}_i\right\} = \left\{\overline{W}_i\right\}_k \qquad (2.1)$$

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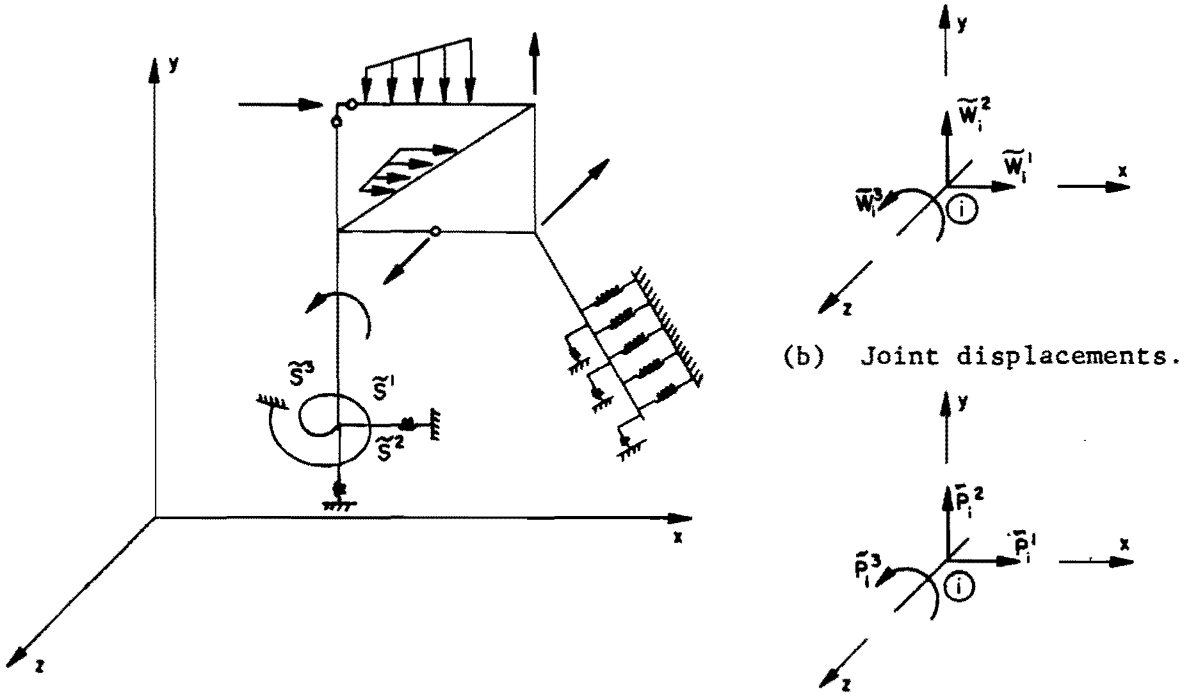
* The special force-displacement equations needed for members with pinned ends are discussed in the next section.

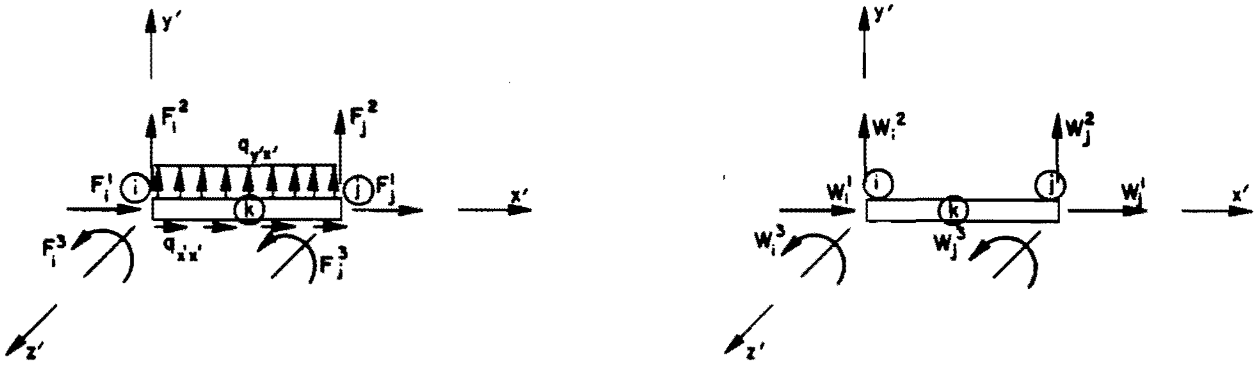


(a) Plane frame.

(b) Joint displacements.

(c) Joint forces.

Fig 1. Plane frame.



(a) Forces.

(b) Displacements.

Fig 2. Prismatic, uniformly loaded
plane frame member.

where

$\left\{\bar{W}_i\right\}_k$ = (3 x 1) matrix of member-end-displacements measured in structure coordinates for member k which has one of its joints at joint i .

Member (Element) Force-Displacement Equations

Consider a prismatic member as shown in Fig 2. Member (k) has its own local right-hand Cartesian coordinate system x'-y'-z' . The members x'-axis is directed along the members centroidal axis. To satisfy the assumption of planar behavior, the members y'-axis and z'-axis must be the members principle axes and the y'-axis must lie in the structure x-y plane. All member loads and restraints must also act in the x-y plane.

The prismatic member is assumed to have only uniform loads $q_{y'x'}$ and $q_{x'x'}$ acting on its full length as shown in Fig 2. The reason for the double subscripting will be discussed in Chapter 4. Neglecting the effect of shearing deformations and finite displacements, the following force-displacement equation (Ref 4) is derivable.

$$\begin{bmatrix} F_i^1 \\ F_i^2 \\ F_i^3 \\ \hline F_j^1 \\ F_j^2 \\ F_j^3 \end{bmatrix} = \left[\begin{array}{ccc|ccc} \frac{AE}{L} & 0 & 0 & -\frac{AE}{L} & 0 & 0 \\ 0 & \frac{12EI}{L^3} & \frac{6EI}{L^2} & 0 & -\frac{12EI}{L^3} & \frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{4EI}{L} & 0 & -\frac{6EI}{L^2} & \frac{2EI}{L} \\ \hline -\frac{AE}{L} & 0 & 0 & \frac{AE}{L} & 0 & 0 \\ 0 & -\frac{12EI}{L^3} & -\frac{6EI}{L^2} & 0 & \frac{12EI}{L^3} & -\frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{2EI}{L} & 0 & -\frac{6EI}{L^2} & \frac{4EI}{L} \end{array}\right] \cdot \begin{bmatrix} W_i^1 \\ W_i^2 \\ W_i^3 \\ \hline W_j^1 \\ W_j^2 \\ W_j^3 \end{bmatrix} + \begin{bmatrix} -q_{x'x'}\frac{L}{2} \\ -q_{y'x'}\frac{L}{2} \\ -q_{y'x'}\frac{L^2}{12} \\ \hline -q_{x'x'}\frac{L}{2} \\ -q_{y'x'}\frac{L}{2} \\ +q_{y'x'}\frac{L^2}{12} \end{bmatrix} \qquad (2.2)$$

where

A = cross-sectional area of the member,

E = modulus of elasticity,

L = length of member, and

I = moment of inertia of cross-section about z'-axis.

The forces F , loads q , and displacements W are defined in Fig 2. In matrix notation, Eq 2.2 may be expressed as

$$\{F\}_k = [K]_k \{W\}_k + \{FF\}_k \tag{2.3}$$

where

$\{F\}_k$ = (6 x 1) matrix of member-end-forces due to loads and displacements,

$[K]_k$ = (6 x 6) member stiffness matrix,

$\{W\}_k$ = (6 x 1) matrix of member-end-displacements, and

$\{FF\}_k$ = (6 x 1) matrix of member-end-forces due to loads only (fixed-end-force-matrix).

All of the above are for member k derived in the members coordinate system.

For nonprismatic members or nonuniform loads, the member-force-displacement equations can still be expressed in matrix form by Eq 2.3, but $[K]_k$ and $\{FF\}_k$ will not be the same as in Eq 2.2.

In general, $\{FF\}_k$ is the matrix of fixed-end-forces for member k and can be found by working a fixed-end-member problem.

A typical element of $\begin{bmatrix} K \end{bmatrix}_k$ is K_{pq}. The p represents the p^{th} row and q represents the q^{th} column of $\begin{bmatrix} K \end{bmatrix}_k$. The range of p and q is from 1 to 6. For a linearly elastic member, K_{pq} represents the force corresponding to the p^{th} displacement due to a unit value of the q^{th} displacement. Thus, the q^{th} column of $\begin{bmatrix} K \end{bmatrix}_k$ is the collection of member-end-forces due to a unit value of the q^{th} displacement. This is illustrated for ($q = 2$ and $W_i^2 = 1$) in Fig 3.

Chapter 3 presents the discrete-element technique for analyzing nonprismatic or nonuniformly loaded members and obtaining $\begin{bmatrix} K \end{bmatrix}_k$ and $\begin{Bmatrix} FF \end{Bmatrix}_k$. In the rest of this chapter, it is assumed that they have been found correctly and no distinction is made between prismatic and nonprismatic members.

Members with pinned ends are treated as follows in order to maintain compatibility of rotational displacements at a joint. The pin is assumed to be located just inside the member at a negligible distance from the joint. Special stiffness matrices $\begin{bmatrix} K \end{bmatrix}_k$ and fixed-end-force matrices $\begin{Bmatrix} FF \end{Bmatrix}_k$ will be used for the k^{th} member. Reference 4 gives these matrices for prismatic members and a solution technique to develop them for other members is given in Chapter 3.

Since forces will be superimposed separately at each joint, it is convenient to partition $\begin{bmatrix} K \end{bmatrix}_k$, $\begin{Bmatrix} F \end{Bmatrix}_k$, and $\begin{Bmatrix} FF \end{Bmatrix}_k$ as suggested by the dashed lines in Eq 2.2. This then gives

$$\begin{bmatrix} F_i \\ \hline F_j \end{bmatrix}_k = - \left[\begin{array}{c|c} K_{ii} & K_{ij} \\ \hline K_{ji} & K_{jj} \end{array}\right]_k \cdot \begin{bmatrix} W_i \\ \hline W_j \end{bmatrix}_k + \begin{bmatrix} FF_i \\ \hline FF_j \end{bmatrix}_k \tag{2.4}$$

where

$\begin{Bmatrix} F_i \end{Bmatrix}_k$ = (3 x 1) matrix of member-end-forces at joint i,

$\begin{bmatrix} K_{ii} \end{bmatrix}_k$ = (3 x 3) member stiffness matrix which represents the forces at i due to unit displacements at i ,

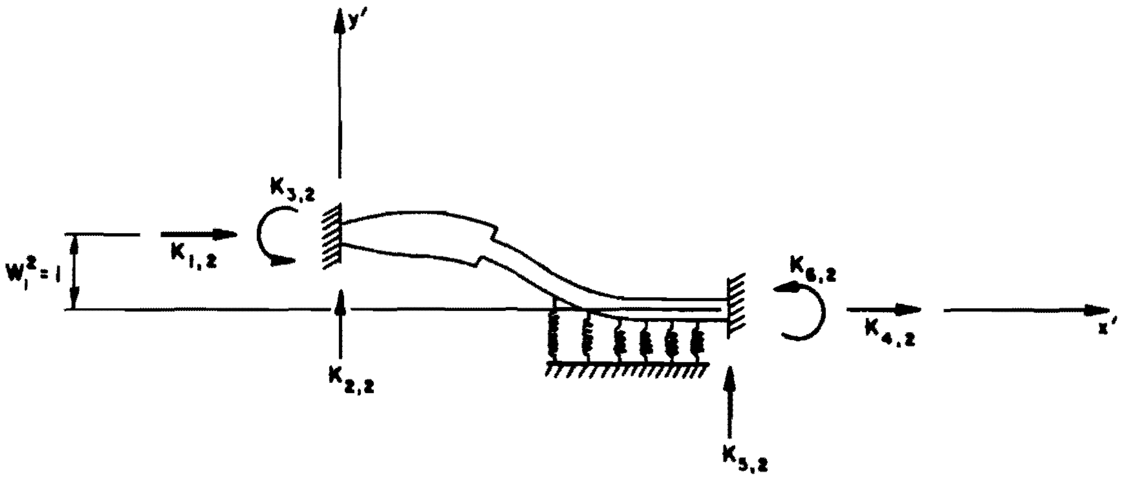


Fig 3. Nonprismatic elastic plane frame member subjected to unit displacement W_i^2 .

$\left[K_{ij}\right]_k$ = (3 x 3) member stiffness matrix in member coordinates which represents the forces at i due to unit displacements at j ,

$\left\{W_i\right\}_k$ = (3 x 1) matrix of member displacements at joint i, and

$\left\{FF_i\right\}_k$ = (3 x 1) matrix of member fixed-end-forces at joint i.

All of the above are for member k derived in the members coordinates.

The matrices on the second row of Eq 2.4 are defined as above except i and j are interchanged.

Equation 2.4 represents two matrix equations, the first of which is

$$\left\{F_i\right\}_k = \left[K_{ii}\right]_k \left\{W_i\right\}_k + \left[K_{ij}\right]_k \left\{W_j\right\}_k + \left\{FF_i\right\}_k \qquad (2.5)$$

Equation 2.5 gives the member-end-forces acting at joint i in member coordinates. The forces and displacement in Eq 2.5 must be expressed in structure coordinates before $\left\{F_i\right\}_k$ can be added to other forces which are acting at the joint.

Transformation of Member (Element) Force-Displacement Equations into Structure Coordinates

The transformation at joint i, for member k , of member displacements in structure coordinates $\left\{\bar{W}_i\right\}_k$ to member displacement in member coordinates $\left\{W_i\right\}_k$ is given by

$$\left\{W_i\right\}_k = \left[T\right]_k \left\{\bar{W}_i\right\}_k \qquad (2.6)$$

The transformation matrix for member k, $\left[T\right]_k$, is given by Eq 2.7 (Ref 4).

$$\left[T\right]_k = \begin{bmatrix} \alpha & \beta & 0 \\ -\beta & \alpha & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad (2.7)$$

where

α = cosine of angle between the x′-axis and x-axis, and

β = cosine of angle between the x′-axis and y-axis.

Similarly, the transformation of member forces in structure coordinates $\left\{\bar{F}_i\right\}_k$ to member forces in member coordinates $\left\{F_i\right\}_k$ is given by Eq 2.8

$$\left\{F_i\right\}_k = \left[T\right]_k \left\{\bar{F}_i\right\}_k \tag{2.8}$$

where for member k

$\left\{F_i\right\}_k$ = (3 x 1) matrix of member-end-forces at joint i in member coordinates,

$\left\{\bar{F}_i\right\}_k$ = (3 x 1) matrix of member-end-forces at joint i in structure coordinates, and

$\left[T\right]_k$ = the previously defined coordinate transformation matrix.

Since $\left[T\right]_k$ is an orthogonal matrix, it possesses the special properties that its transpose $\left[T\right]_k^t$ is also its inverse $\left[T\right]_k^{-1}$ and that the product of $\left[T\right]_k$ and $\left[T\right]_k^t$ in any order is equal to the identity matrix $\left[I\right]$. Therefore

$$\left\{\bar{W}_i\right\}_k = \left[T\right]_k^t \left\{W_i\right\}_k \tag{2.9}$$

and

$$\left\{\bar{F}_i\right\}_k = \left[T\right]_k^t \left\{F_i\right\}_k \tag{2.10}$$

Substituting Eq 2.6 into Eq 2.5 for $\{W_i\}_k$ and $\{W_j\}_k$, premultiplying both sides of Eq 2.5 by $[T]_k^t$ and using Eq 2.10 gives

$$\{\bar{F}_i\}_k = [T]_k^t [K_{ii}]_k [T]_k \{\bar{W}_i\}_k + [T]_k^t [K_{ij}]_k [T]_k \{\bar{W}_j\}_k$$

$$+ [T]_k^t \{FF\}_k \tag{2.11}$$

Let

$$[\bar{K}_{ii}]_k = [T]_k^t [K_{ii}]_k [T]_k \tag{2.12}$$

$$[\bar{K}_{ij}]_k = [T]_k^t [K_{ij}]_k [T]_k \tag{2.13}$$

$$\{\overline{FF}_i\}_k = [T]_k^t \{FF_i\}_k \tag{2.14}$$

then for member k

$[\bar{K}_{ii}]_k$ = (3 x 3) member stiffness matrix in structure coordinates which represent the forces at i due to unit displacements at i ,

$[\bar{K}_{ij}]_k$ = (3 x 3) member stiffness matrix in structure coordinates which represents the forces at i due to unit displacements at j , and

$\{\overline{FF}_i\}_k$ = (3 x 1) matrix of member-fixed-end-forces in structure coordinates.

Then Eq 2.11 can be rewritten as

$$\left\{\bar{F}_i\right\}_k = \left[\bar{K}_{ii}\right]_k \left\{\bar{W}_i\right\}_k + \left[\bar{K}_{ij}\right]_k \left\{\bar{W}_j\right\}_k + \left\{\overline{FF}_i\right\}_k \tag{2.15}$$

To satisfy the compatibility requirement, Eq 2.1 can be substituted into Eq 2.15 for $\left\{\bar{W}_i\right\}_k$ and $\left\{\bar{W}_j\right\}_k$, to give

$$\left\{\bar{F}_i\right\}_k = \left[\bar{K}_{ii}\right]_k \left\{\tilde{W}_i\right\} + \left[\bar{K}_{ij}\right] \left\{\tilde{W}_j\right\} + \left\{\overline{FF}_i\right\}_k \tag{2.16}$$

Summation of Joint (Nodal Point) Forces

Each joint must be in static equilibrium due to the forces imparted to it by each of the M members acting there, any applied joint forces, and any support reactions. The effect of the support reactions will be considered in the next section. The applied joint forces $\tilde{P}_i^1$, $\tilde{P}_i^2$, and $\tilde{P}_i^3$ at joint i represent a vector $\left\{\tilde{P}_i\right\}$ (see Fig 1)

where

$\left\{\tilde{P}_i\right\}$ = (3 x 1) matrix of applied joint forces at joint i.

Thus, temporarily neglecting the support reactions at joint i, $\left\{\tilde{P}_i\right\}$ is equal to the sum of $\left\{\tilde{F}_i\right\}$ from Eq 2.16 for all M members.

$$\left\{\tilde{P}_i\right\} = \left(\sum_{k=1}^{M} \left[\bar{K}_{ii}\right]_k\right) \left\{\tilde{W}_i\right\} + \sum_{k=1}^{M} \left(\left[\bar{K}_{ij}\right]_k \left\{\tilde{W}_j\right\} \right)$$

$$+ \sum_{k=1}^{M} \left\{\overline{FF}_i\right\}_k \tag{2.17}$$

Equation 2.17 can be rearranged to have all loads on the right-hand side as follows:

$$\left(\sum_{k=1}^{M}\left[\bar{K}_{ii}\right]_k\right)\left\{\tilde{W}_i\right\} + \sum_{k=1}^{M}\left(\left[\bar{K}_{ij}\right]_k \cdot \left\{\tilde{W}_j\right\}\right) = \left\{\tilde{P}_i\right\} - \sum_{k=1}^{M}\left\{\overline{FF}_i\right\}_k \tag{2.18}$$

Equation 2.18 can be applied now to all N joints $(i = 1,N)$ to form the structure equilibrium equations which can be expressed as

$$\left[\tilde{K}\right] \cdot \left\{\tilde{W}\right\} = \left\{\tilde{F}\right\} \tag{2.19}$$

where

$\left[\tilde{K}\right]$ = (3N x 3N) structure stiffness matrix,
$\left\{\tilde{W}\right\}$ = (3N x 1) structure displacement matrix,
$\left\{\tilde{F}\right\}$ = (3N x 1) structure load matrix.

Clearly $\left[\tilde{K}\right]$ can be partitioned into $N^2 (3 \times 3)$ submatrices $\left[\tilde{K}_{ij}\right]$ and from Eq 2.18.

$$\left[\tilde{K}_{ii}\right] = \sum_{k=1}^{M}\left[\bar{K}_{ii}\right]_k \tag{2.20}$$

and

$$\left[\tilde{K}_{ij}\right] = \left[\bar{K}_{ij}\right]_k \qquad i \neq j \tag{2.21}$$

Thus the structure stiffness matrix is easily composed from the individual member stiffness matrices expressed in structure coordinates. Similarly the (3×1) load matrix at the i^{th} joint $\left\{\tilde{F}\right\}$ is given by Eq 2.18 as,

$$\left\{\tilde{F}_i\right\} = \left\{\tilde{P}_i\right\} - \sum_{k=1}^{M}\left\{\overline{FF}_i\right\}_k \tag{2.22}$$

Joint Supports (Displacement Type Boundary Conditions)

Suppose that any joint i has three linearly elastic support springs, with spring constants $\tilde{S}_i^1$, $\tilde{S}_i^2$, and $\tilde{S}_i^3$, as shown in Fig 1. Any of these can be zero as a lower limit and approach infinity as an upper limit. If a joint undergoes displacement during the application of loads, then support reactions will be generated equal to the negative of the displacements times the corresponding spring constants. Clearly these reactions must be considered in writing the joint equilibrium equations. If these terms are added to equations, the effect on $\left[\tilde{K}\right]$ is to add the corresponding spring term to the diagonal of the matrix.

The effect of the other matrix terms becomes negligible as the spring term becomes very large compared to the other terms in any row of $\left[\tilde{K}\right]$. Similarly the load term for that row becomes negligible.

Thus, a zero displacement can be obtained by specifying a very large spring restraint. Likewise, a specified displacement may be obtained by specifying a large spring restraint and a correspondingly large joint force equal to the desired displacement times the spring restraint.

Handling specified displacements in this way allows both real problems where supports have some reasonable value of restraint and other problems with infinitely stiff supports to be solved by the same technique.

When all members at a joint are hinged to the joint, the rotational stiffness at the joint is zero. This causes a singular set of equations for which the solution process as discussed in the next section will either cause an arithmetic error on the computer due to the attempt to divide by zero or give extremely large displacements.

One method of solving structures with such pinned joints is to renumber the joint equilibrium equations allowing only two degrees of freedom at the pinned joints. This loses much of the generality built into the equations of this chapter. Instead, the present computer program places a unit value on the diagonal of $\left[\tilde{K}\right]$ and a very large value in the load matrix. This gives, then, a very large displacement for the rotation of such a joint which indicates that it is undefined.

Similarly, when a joint is deleted in a series of problems by removing all the members intersecting at the joint, all three of the displacements of such a joint are undefined and the program handles such a joint the same way.

Unit values are placed on the diagonal for all three of the zero stiffnesses and three large values are placed in the load matrix for the three undefined displacements.

Since for both the pinned joint and the joint with all members deleted setting the displacements equal to a large value has no physical effect on the structure, the rest of the solution is valid. However, the large displacements should occur only for the rotation of joints with all members pinned or a joint that is deleted. Any other large displacements are an indication that an unstable or nearly unstable structure has been described. The user will be aware that he has such a joint so no misunderstanding of the results should occur.

Solution of Joint (Nodal Point) Equilibrium Equations

The equations developed in the preceeding section are a system of linear-simultaneous equations which can be solved efficiently using a recursion-inversion process previously developed (Ref 3).

The solution of Ref 3 considers the banding of the stiffness matrix inherent in structural problems. It also takes advantage of the symmetry of the structure stiffness matrix.

The second and succeeding solutions of a structure (for additional load cases) are obtained in far less time than the initial solution. This is possible since the stiffness matrix for a linearly-elastic structure is independent of the loading, therefore the elimination process need not be repeated after the first solution.

Member (Element) Displacements from Joint (Nodal Point) Displacements

Once joint displacements are found, the member displacements can be obtained from Eqs 2.6 and 2.1. Note that for a member with a pinned end this will give the displacement on the joint side of the pin (which is actually the joint displacement). However, as outlined in the next section, this will not affect the solution of member-end-forces.

Member (Element) Forces

For prismatic members with only uniform loads the member-end-forces can be found by using Eq 2.2 or for such members with pinned ends the special equations in Ref 4 can be used. For nonprismatic members or nonuniformly loaded members, the member-end-forces can be found by the solution developed in Chapter 3. This solution can also be used for cases in which more complete output of forces and displacements throughout the member is desired.

Joint (Nodal Point) Reactions and Check of Joint Equilibrium Equations

Once the member-end-forces have been calculated, they can be converted to structure coordinates by Eq 2.10. With all supports specified as linearly-elastic springs the joint reactions can be found merely by multiplying the spring constants times the negative of the corresponding displacements. If the proper solution of the equilibrium equations has been found, the sum of the member-end-forces applied to the joint should equal the applied joint forces plus the joint reactions. Any difference between the joint forces and the member forces is an indication of the roundoff error developed in the solution of the equations. Generally this error (joint equilibrium error) will be a very small quantity.

There is one case in which the joint equilibrium error is not a valid indication of the accuracy of the solution. When a specified displacement is enforced at a joint by an artificially large restraint and a correspondingly large force the joint equilibrium error will be as many orders of magnitude less than the artificial load as the computer is inaccurate in subtracting two numbers. This is not an indication that the solution is in error but only that the estimate of the error is invalid. This occurs only when artificially large values are used to specify displacements and has never occurred on the CDC 6600 with approximately 15 significant digits for any physical values of restraint and load.

Superposition Solution

Under sufficiently small loads structures behave in a linear manner. Thus the results of several linear solutions may be stored and combined by simple superposition to form any linear combination of loadings desired. Naturally the designer must check the results to insure that the stresses in the structure are small enough for the superposition solution to be valid.

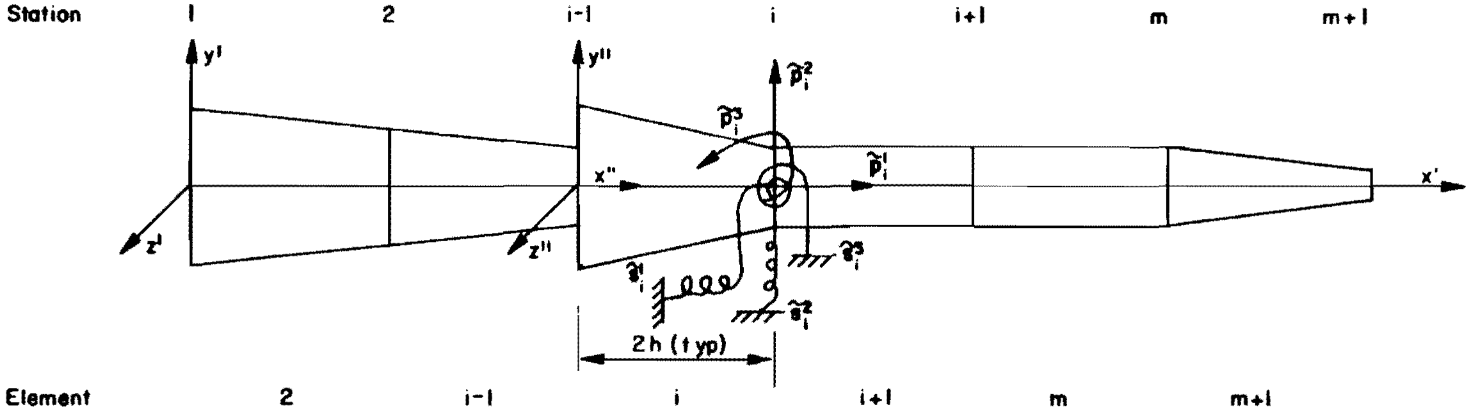
CHAPTER 3. NEW DISCRETE-ELEMENT TECHNIQUE FOR SOLUTIONS OF GENERAL FRAME MEMBERS

As previously discussed, solutions for the members stiffness matrix $\left[K\right]_k$ and the members fixed-end-force matrix $\left\{FF\right\}_k$ are required for nonprismatic, elastically restrained, and nonuniformly loaded members. The discrete-element formulation from Ref 9 was used in Ref 2 to obtain $\left[K\right]_k$ and $\left\{FF\right\}_k$. This discrete-element model does not provide for loads or restraints acting parallel to the member. This causes problems in coding frames with members that are not horizontal but have significant vertical (gravity) loads. Frames with friction piles are also difficult to input.

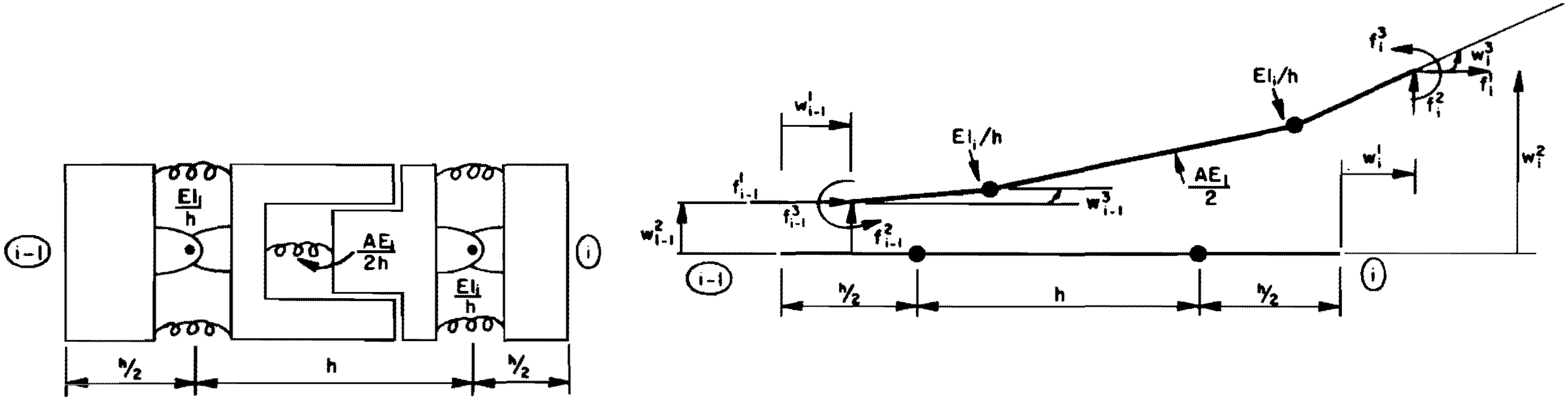
The basic element of the discrete-element beam column model (Ref 9) is a rigid bar with one degree of freedom at each end (lateral displacement). If the bar were made axially deformable it would have four degrees of freedom (a lateral and an axial displacement at each end). The stiffness or equilibrium equations for a member composed of a number of such elements connected by rotational springs could be formulated in the same manner as was done for the discrete-element in Ref 9. However, the member equilibrium equations are developed formally by the direct stiffness method (Ref 6) using a modification of the discrete-element technique proposed herein.

Frame Member with Discretized Effects

A general frame member is shown in Fig 4(a). The member is general in that at any station i, forces $\tilde{p}_i^1$, $\tilde{p}_i^2$, and $\tilde{p}_i^3$ may act, elastic restraints $\tilde{s}_i^1$, $\tilde{s}_i^2$, and $\tilde{s}_i^3$ may exist, and changes in cross-sectional properties may occur. Each continuous element i between stations i-1 and i is assumed to have a linear variation in cross-sectional properties. The term AE_i is the axial rigidity of the element at mid-element and EI_i is the flexural rigidity of the element at the midpoint. The terms A , E , and I are as previously defined. The member is further generalized in Chapter 4 to make it more convenient for the user by allowing loads, restraints, and changes in cross-section



(a) Frame member with discretized loads, restraints, and stiffness changes.



(b) Mechanical model of element i .

(c) Discrete-line-element model of element i .

Fig 4. Frame member and discrete-element representation of one of its continuous elements.

to occur at any point in the member. Distributed values of load and restraint are permitted and loads may be input in either frame or member coordinates. Chapter 4 presents the method of handling such effects, therefore, in this chapter the discrete station values are assumed to be available.

Application of the Direct Stiffness Method to Frame Members

The frame member may now be considered to be a structure composed of m elements, which for convenience are numbered from 2 to $m+1$ in Fig 4a. Each of the $m+1$ stations (nodal points) of the frame member has three displacements (axial displacement $\tilde{w}_i^1$, lateral displacement $\tilde{w}_i^2$, and rotational displacement $\tilde{w}_i^3$). These displacements should be equal for both elements intersecting at a station. Thus, there is no difference between the frame analysis and the member analysis other than some simplifications because of the simplified geometry of the member. (The frame member's axes x'-y'-z' and the element's axes x''-y''-z'' are parallel as shown in Fig 4a, hence no transformation of coordinates is required.) This means no distinction need be made between properties measured in element coordinates and properties measured in the frame member's coordinates. Therefore, the element stiffness matrix can be derived with reference to its own coodinates and used in Eq 2.18.

Discrete-Element Model

The stiffness matrix for a continuous element with linearly varying stiffness properties could be derived, but to work with it would be difficult. Instead, the stiffness matrix of the element will be derived for the discrete-element shown in Figs 4b and 4c, and in Appendix 1 it is shown that the discrete-element model is an adequate representation of the continuous element. That is to say that, as the number of elements used increases, the answers obtained by the discrete-element approaches as a limit the "exact" solution.

A mechanical model of the discrete-element whose length is $2h$ is shown in Fig 4b. It is composed of two rigid end blocks, two rotational springs with spring constants EI_i/h and a rigid piston with an axial spring whose spring constant is $AE_i/2h$. The term EI_i is the product of the modulus of elasticity and the moment of inertia at the center of the continuous element. The term AE_i is the product of the cross-sectional area and the modulus of elasticity at the center of the continuous element.

The mechanical model of Fig 4b may be shown more conveniently as a discrete-line element model in Fig 4c. There the element is composed of three one-dimensional bars which are rigid in bending and connected by rotational springs with spring constants EI_i/h . The end bars are axially rigid but the center bar of length h is axially deformable and has an axial rigidity of $AE_i/2$. The two models are mathematically equivalent and hereafter the discrete-line element model will be shown for convenience and will be referred to as the discrete-element model.

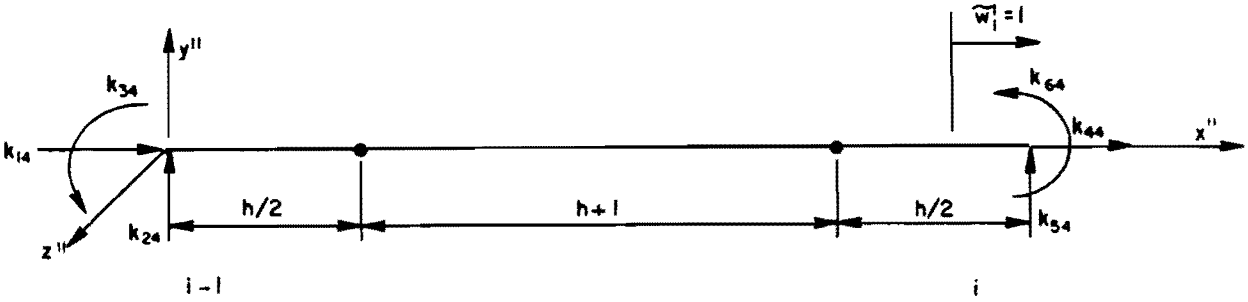
Element Stiffness Matrix

The discrete-element i has three degrees of freedom at each station and will have a (6×6) element stiffness matrix $[k]_i$, which relates forces and displacement at stations i and i-1. As mentioned in Chapter 2, the q^{th} column of a stiffness matrix is the set of reactions corresponding to the displacements due to a unit value of the q^{th} displacement. This is illustrated in Fig 5 for element i , q = 4, 5, and 6.

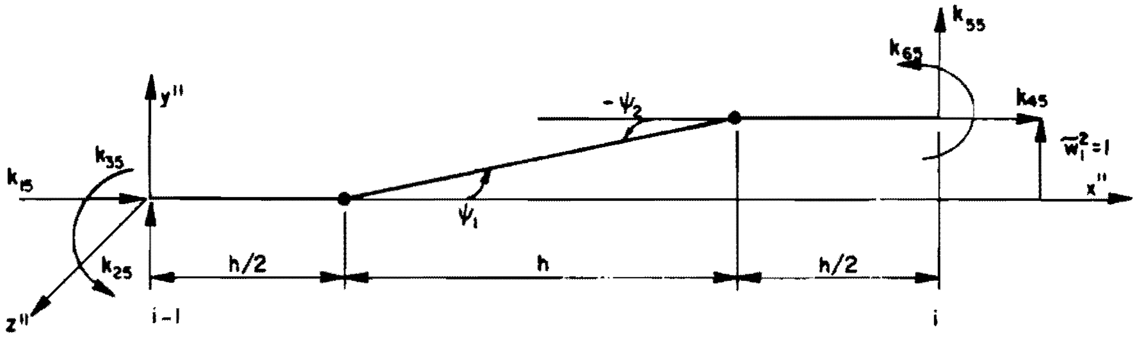
For each of the six unit displacements, the discrete angle changes and changes in length of the deformable bar may be found geometrically. The internal spring moments and the axial force can then be computed. Next a freebody analysis can be made and the forces acting on the ends of the element can be found. These forces are the desired stiffness terms. Assuming negligible displacements, the freebody analysis can be made on the undeformed element, thus neglecting the effect of the secondary moment caused by axial forces acting on lateral displacements. This secondary moment could be included in the analysis but would then require a nonlinear solution since, in general, the effect of axial forces is not linear. Therefore, in the development of this design oriented linear analysis program it is not considered. However, in the future it probably will be incorporated in nonlinear studies.

In Fig 5a $(q = 4$ and $\tilde{w}_i^1 = 1)$ the axially deformable bar extends one inch, thus the force T_i in the bar is given by Eq 3.1

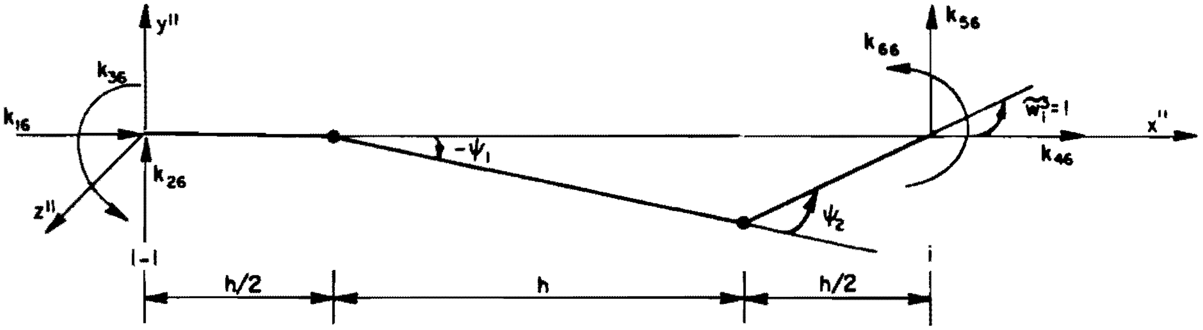
$$T_i = \frac{AE_i(1)}{2h} = \frac{AE_i}{2h} \tag{3.1}$$



(a) Fourth column of element stiffness matrix.



(b) Fifth column of element stiffness matrix.



(c) Sixth column of element stiffness matrix.

Fig 5. Unit displacements at station i on element i .

For equilibrium of forces parallel to x''

$$k_{44} = \frac{AE_i}{2h} \tag{3.2}$$

and

$$k_{14} = \frac{-AE_i}{2h} \tag{3.3}$$

All other forces are zero because of the assumed small displacements.

In Fig 5b ($q = 5$ and $\tilde{w}_i^2 = 1$) concentrated curvatures* Ψ_1 and Ψ_2 are developed at the spring locations. For the unit displacement shown in Fig 5b

$$\Psi_1 = \frac{1}{h} \tag{3.4}$$

$$\Psi_2 = \frac{-1}{h} \tag{3.5}$$

The internal moments corresponding to Ψ_1 and Ψ_2 are M_1 and M_2 where

$$M_1 = \frac{EI_i\Psi_1}{h} = \frac{EI_i}{h^2} \tag{3.6}$$

$$M_2 = \frac{EI_i\Psi_2}{h} = \frac{-EI_i}{h^2} \tag{3.7}$$

---

* The sign of the curvature and corresponding moment is positive if it produces compression on the positive y'' side of the member.

Shears* V_1 and V_2 will be developed at the two spring locations and can be found from a freebody analysis of the axially deformable center bar.

$$V_1 = \frac{(M_2 - M_1)}{h} = -\frac{2EI_i}{h^3} \qquad (3.8)$$

$$V_2 = -V_1 = \frac{2EI_i}{h^3} \qquad (3.9)$$

Summing forces and moments on freebodies of the two end bars yields

$$\begin{bmatrix} k_{15} \\ k_{25} \\ k_{35} \\ k_{45} \\ k_{55} \\ k_{65} \end{bmatrix} = \begin{bmatrix} 0 \\ -\frac{2EI_i}{h^3} \\ -\frac{2EI_i}{h^2} \\ 0 \\ \frac{2EI_i}{h^3} \\ -\frac{2EI_i}{h^2} \end{bmatrix} \qquad (3.10)$$

In Fig 5c $(q = 6$ and $\tilde{w}_i^3 = 1)$ concentrated curvatures Ψ_1 and Ψ_2 are developed where

$$\Psi_1 = -\frac{1}{2} \qquad (3.11)$$

---

[*] Positive shear acts in the direction of positive y' on the face of the freebody closest to the member axis.

$$\Psi_2 = \frac{3}{2} \tag{3.12}$$

hence

$$M_1 = -\frac{EI_i}{2h} \tag{3.13}$$

$$M_2 = \frac{3EI_i}{2h} \tag{3.14}$$

and

$$V_1 = \frac{2EI_i}{h^2} \tag{3.15}$$

$$V_2 = -\frac{2EI_i}{h^2} \tag{3.16}$$

Summing forces and moments on the end bars yields

$$\begin{bmatrix} k_{16} \\ k_{26} \\ k_{36} \\ k_{46} \\ k_{56} \\ k_{66} \end{bmatrix} = \begin{bmatrix} 0 \\ \dfrac{2EI_i}{h^2} \\ \dfrac{1.5EI_i}{h} \\ 0 \\ -\dfrac{2EI_i}{h^2} \\ \dfrac{2.5EI_i}{h} \end{bmatrix} \tag{3.17}$$

Similarly, by applying unit displacements at i-1 the first three columns of the element stiffness matrix may be obtained. Thus,

$$\left[k\right]_i = \begin{bmatrix} \frac{AE_i}{2h} & 0 & 0 & -\frac{AE_i}{2h} & 0 & 0 \\ 0 & \frac{2EI_i}{h^3} & \frac{2EI_i}{h^2} & 0 & -\frac{2EI_i}{h^3} & \frac{2EI_i}{h^2} \\ 0 & \frac{2EI_i}{h^2} & \frac{2.5EI_i}{h} & 0 & -\frac{2EI_i}{h^2} & \frac{1.5EI_i}{h} \\ -\frac{AE_i}{2h} & 0 & 0 & \frac{AE_i}{2h} & 0 & 0 \\ 0 & -\frac{2EI_i}{h^3} & -\frac{2EI_i}{h^2} & 0 & \frac{2EI_i}{h^3} & -\frac{2EI_i}{h^2} \\ 0 & \frac{2EI_i}{h^2} & \frac{1.5EI_i}{h} & 0 & -\frac{2EI_i}{h^2} & \frac{2.5EI_i}{h} \end{bmatrix} \qquad (3.18)$$

The element end forces $\left\{f\right\}_i$ are related to the element end displacements $\left\{w\right\}_i$ as shown in Eq 3.19.*

$$\left\{f\right\}_i = \left[k\right]_i \left\{w\right\}_i \qquad (3.19)$$

The matrix $\left[k\right]_i$ can be subdivided into four 3 by 3 submatrices as was done in Chapter 2 for $\left[K\right]_k$:

---

* Loads acting between the nodal points are transformed into equivalent nodal point loads, hence, no fixed-end-forces act as in Eq 2.3.

$$\left[k\right]_i = \left[\begin{array}{c|c} k_{i-1,i-1} & k_{i-1,i} \\ \hline k_{i,i-1} & k_{i,i} \end{array}\right]_i \qquad (3.20)$$

where the submatrices are given by Eq 3.18.

Similarly, the element stiffness matrix for element $i+1$, which connects with element i at station i, can be divided into four 3 by 3 submatrices:

$$\left[k\right]_{i+1} = \left[\begin{array}{c|c} k_{i,i} & k_{i,i+1} \\ \hline k_{i+1,i} & k_{i+1,i+1} \end{array}\right]_{i+1} \qquad (3.21)$$

The submatrices of Eq 3.21 are given by the terms in Eq 3.18 except AE_i is replaced by AE_{i+1} and EI_i is replaced by EI_{i+1} .

Substituting the appropriate submatrices from Eqs 3.20 and 3.21 into Eq 2.18 (M = 2) yields

$$\left(\left[k_{i,i}\right]_i + \left[k_{i,i}\right]_{i+1} \right)\left\{\tilde{w}_i\right\} + \left[k_{i,i-1}\right]_{i-1} \left\{\tilde{w}_{i-1}\right\}$$

$$+ \left[k_{i,i+1}\right]_{i+1} \left\{\tilde{w}_{i+1}\right\} = \left\{\tilde{p}_i\right\} \qquad (3.22)$$

Substituting into Eq 3.22 the appropriate submatrices as given by Eq 3.18 and adding in the effect of the elastic restraints $\left\{\tilde{s}_i\right\}$ gives

$$\left(\begin{bmatrix} \frac{AE_i}{2h} & 0 & 0 \\ 0 & \frac{2EI_i}{h^3} & -\frac{2EI_i}{h^2} \\ 0 & -\frac{2EI_i}{h^2} & \frac{2.5EI_i}{h} \end{bmatrix} + \begin{bmatrix} \frac{AE_{i+1}}{2h} & 0 & 0 \\ 0 & \frac{2EI_{i+1}}{h^3} & \frac{2EI_{i+1}}{h^2} \\ 0 & \frac{2EI_{i+1}}{h^2} & \frac{2.5EI_{i+1}}{h} \end{bmatrix} \right.$$

$$+ \begin{bmatrix} \tilde{s}_i^1 & 0 & 0 \\ 0 & \tilde{s}_i^2 & 0 \\ 0 & 0 & \tilde{s}_i^3 \end{bmatrix} \Bigg) \cdot \begin{bmatrix} \tilde{w}_i^1 \\ \tilde{w}_i^2 \\ \tilde{w}_i^3 \end{bmatrix} + \begin{bmatrix} -\frac{AE_i}{2h} & 0 & 0 \\ 0 & -\frac{2EI_i}{h^3} & -\frac{2EI_i}{h^2} \\ 0 & \frac{2EI_i}{h^2} & \frac{1.5EI_i}{h} \end{bmatrix}$$

$$\cdot \begin{bmatrix} \tilde{w}_{i-1}^1 \\ \tilde{w}_{i-1}^2 \\ \tilde{w}_{i-1}^3 \end{bmatrix} + \begin{bmatrix} -\frac{AE_{i+1}}{2h} & 0 & 0 \\ 0 & -\frac{2EI_{i+1}}{h^3} & \frac{2EI_{i+1}}{h^2} \\ 0 & -\frac{2EI_{i+1}}{h^2} & \frac{1.5EI_{i+1}}{h} \end{bmatrix}$$

$$\cdot \begin{bmatrix} \tilde{w}_{i+1}^1 \\ \tilde{w}_{i+1}^2 \\ \tilde{w}_{i+1}^3 \end{bmatrix} = \begin{bmatrix} \tilde{p}_i^1 \\ \tilde{p}_i^2 \\ \tilde{p}_i^3 \end{bmatrix} \tag{3.23}$$

Summing up the matrices of Eq 3.23 and multiplying the first row by h and the second and the third rows by h^3 and rearranging yields

$$\begin{bmatrix} -\frac{AE_i}{2} & 0 & 0 \\ 0 & -2EI_i & -2hEI_i \\ 0 & 2hEI_i & 1.5h^2EI_i \end{bmatrix} \cdot \begin{bmatrix} \tilde{w}^1_{i-1} \\ \tilde{w}^2_{i-1} \\ \tilde{w}^3_{i-1} \end{bmatrix}$$

$$+ \begin{bmatrix} \frac{AE_i+AE_{i+1}}{2}+\tilde{s}^1 h & 0 & 0 \\ 0 & 2(EI_i+EI_{i+1})+\tilde{s}^2_i\, h^3 & 2h(EI_{i+1}-EI_i) \\ 0 & 2h(EI_{i+1}-EI_i) & 2.5h^2(EI_i+EI_{i+1})+\tilde{s}^3_i h^3 \end{bmatrix} \cdot \begin{bmatrix} \tilde{w}^1_i \\ \tilde{w}^2_i \\ \tilde{w}^3_i \end{bmatrix}$$

$$+ \begin{bmatrix} -\frac{AE_{i+1}}{2} & 0 & 0 \\ 0 & -2EI_{i+1} & 2hEI_{i+1} \\ 0 & -2hEI_{i+1} & 1.5h^2EI_{i+1} \end{bmatrix} \cdot \begin{bmatrix} \tilde{w}^1_{i+1} \\ \tilde{w}^2_{i+1} \\ \tilde{w}^3_{i+1} \end{bmatrix} = \begin{bmatrix} \tilde{p}^1_i h \\ \tilde{p}^2_i h^3 \\ \tilde{p}^3_i h^3 \end{bmatrix} \qquad (3.24)$$

Equation 3.24 may be applied at the $m+1$ nodal points to form the member equilibrium equation.* Since Eq 3.24 represents three scalar equations this will yield $3(m+1)$ simultaneous equations. These equations will be symmetric and have a band width of nine. Noting that the axial $(\tilde{w}^1)$ and lateral $(\tilde{w}^2$ and $\tilde{w}^3)$ displacements are uncoupled in Eq 3.24 the solution may be separated into $m+1$ axial equations with a band width of three and $2(m+1)$ lateral equations with a band width of seven.

---

* In order to apply Eqs 3.24, 3.25, 3.26, and 3.27 at nodal points $i = 1$ and $i = m+1$, fictious elements $i = 1$, and $i = m+2$ must be assigned zero stiffness.

The axial equations are given by the m+1 application of Eq 3.25

$$-\frac{AE_i}{2}\tilde{w}_{i-1} + \left(\frac{AE_i}{2} + \frac{AE_{i+1}}{2} + \tilde{s}^1_i h\right)\tilde{w}^1_i - \frac{AE_{i+1}}{2}\tilde{w}_{i+1}$$

$$= \tilde{p}^1_i h \qquad (3.25)$$

The lateral equations are generated by m+1 applications of Eqs 3.26 and 3.27.

$$-(2EI_i)\,\tilde{w}^2_{i-1} - (2hEI_i)\,\tilde{w}^3_{i-1} + [2(EI_i+EI_{i+1}) + \tilde{s}^2_i h^3]\,\tilde{w}^2_i$$

$$+ [2h(EI_{i+1}-EI_i)]\,\tilde{w}^3_i - (2EI_{i+1})\,\tilde{w}^2_{i+1} + (2hEI_{i+1})\,\tilde{w}^3_{i+1}$$

$$= \tilde{p}^2_i h^3 \qquad (3.26)$$

$$(2hEI_i)\,\tilde{w}^2_{i-1} + (1.5h^2EI_i)\,\tilde{w}^3_{i-1} + [2h(EI_{i+1}-EI_i)]\,\tilde{w}^2_i$$

$$+ [2.5h^2(EI_i+EI_{i+1}) + \tilde{s}^3_i h]\,\tilde{w}^3_i - (2hEI_{i+1})\,\tilde{w}^2_{i+1}$$

$$+ (1.5h^2EI_{i+1})\,\tilde{w}^3_{i+1} = \tilde{p}^3_i h^3 \qquad (3.27)$$

Both the axial and lateral equations are easily solvable by the method in Ref 3.

Once the nodal point displacements have been found they may be substituted into Eq 3.19 to find the member-end-forces. The elastic support forces may be found by multiplying the spring constants times the negative of the nodal point displacements. Then the nodal point equilibrium error (the nodal point forces minus the element forces) may be calculated. This should be a negligible quantity except for the cases where a specified displacement is enforced by a large spring value and a correspondingly large force as discussed in Chapter 2.

Calculation of Member Fixed-End-Force Vector

The fixed-end-forces $\left\{FF\right\}_k$ for each nonprismatic or nonuniformly loaded member in the frame may be obtained by a discrete-element solution of the member. The member is subjected to all its member loads and elastic restraints and the end displacements are set equal to zero by using three large spring values at stations 1 and $m+1$. The end forces acting on the member at stations 1 and $m+1$ are the desired fixed-end-forces. The member-end-forces are essentially equal to the forces acting on the end elements of the member. However, when the member has a discretized load or elastic restraint at the end of the member, the member-end-force is equal to [(the element-end-force) - (the discretized load) + (the spring restraint) x (the element-end-displacement)].

For members with pinned ends, the rotational spring restraint is not set equal to a large value, thus leaving it free to rotate.

Calculation of Member Stiffness Matrix

The stiffness matrix $\left[K\right]_k$ for each nonprismatic member in the frame may be obtained by six discrete-element solutions of the member. The member is subject to all its member elastic restraints and in turn six unit displacements are introduced corresponding to the three degrees of freedom at station 1 and station $m+1$.

The unit displacements are obtained by using three large springs at stations 1 and $m+1$ and six correspondingly large forces. Two of the solutions will be axial solutions as generated by Eq 3.24 and four of the solutions will be lateral solutions as generated by Eqs 3.25 and 3.26. The stiffness of the member does not change, hence the second axial solution and the second, third, and fourth lateral solutions do not require an elimination of the stiffness matrix. This saves a relatively small amount of time when considering the generation of a single member stiffness matrix, but when multiplied by a large number of members represents a sizable saving.

The member-end-forces at stations 1 and $m+1$ for each of the six solutions are the six columns of the member stiffness matrix. Actually only 13 of these 36 forces need be calculated and stored. Since $\left[K\right]_k$ is always symmetrical, only 21 of its coefficients need be known. For a plane frame member subject to small displacements, 8 of these 21 will always be zero. Thus, only 13 member-end-forces need be calculated and stored to generate $\left[K\right]_k$. The savings in calculations are insignificant but the savings in storage are considerable. Further reductions can be made if the member is assumed to have no elastic restraints acting between its ends. This was not done here to maintain the generality of the solution.

For pinned-end members, the corresponding rotational spring is not set to a large value and no moment is applied at the pinned end to enforce the unit rotation.

Calculation of Member Results

Once the frame joint displacements have been found by the solution of Chapter 2, they can be transformed into member-end-displacements. Then any frame member may be analyzed as a member subject to the member-end-displacements, applied member loads, and elastic restraints. The solution is similar to the solutions for $\left[K\right]_k$ and $\left\{FF\right\}_k$ just discussed.

The displacements of all the stations will be found from such a solution. Then the spring support reactions may be found by multiplying the spring constants times the negative of the appropriate displacement. The element-end-forces may be found from Eq 3.19. Then the nodal point equilibrium error may be evaluated.

Shears, moments, and axial forces in the member can now be found by statics at any point desired. The output used in the program is the average value of shear, moment, and axial force at every other nodal point.

Comparison of Finite-Element and Discrete-Element Methods

For an "exact" solution of a member, nodal point equilibrium, compatibility, and boundary conditions must be satisfied at the $m+1$ nodal points (stations) and the force-displacement equations for the m elements must be satisfied. The exact force-displacement equations may not be known and are often obtained by an approximate method. The difference between the finite-element method and the discrete-element method is the way in which the elements force-displacement equations are approximated.

The element force-displacement equations obtained by the finite-element method (Ref 13) satisfy the constitutive relations and compatibility throughout the element and approximately satisfy equilibrium and the boundary conditions throughout the element. The discrete-element method satisfies the constitutive relations and equilibrium throughout the element but only approximates compatibility and the boundary conditions throughout the element. For certain special cases either method may give the "exact" force-displacement equations.

CHAPTER 4. CONVERSION OF ENGINEERING INPUT

Much of the data describing a plane frame readily available to an engineer is not in the form needed to solve the computer model of the frame. Thus either the engineer has to perform the tedious and repetitive calculations necessary to convert the data, or this conversion can be incorporated into the computer program. The equations needed for converting the engineering data into a form compatible with the theory presented in Chapters 2 and 3 are given here and are made internally in the computer program discussed in the next chapter.

Joint Coordinates

The coordinates of each joint in the frame are used to calculate the direction cosines of the frame members. The engineer is more likely to have the projections of the members on the coordinate axes than the actual coordinates of each joint. Thus the offsets or projections x_o and y_o as shown in Fig 6 are a more logical choice for the input of the frame geometry.

If the coordinates of one reference joint are given, then the coordinates of a second joint can be computed by adding the appropriate offsets to the coordinates of the first joint. A third joint can be referenced by offsets to either of the first two, etc. In general, if joint i has been located and has coordinates x_i and y_i then the coordinates of joint j, x_j and y_j are given by

$$x_j = x_i + x_o \tag{4.1}$$

and

$$y_j = y_i + y_o \tag{4.2}$$

The member's direction cosines α and β are given by

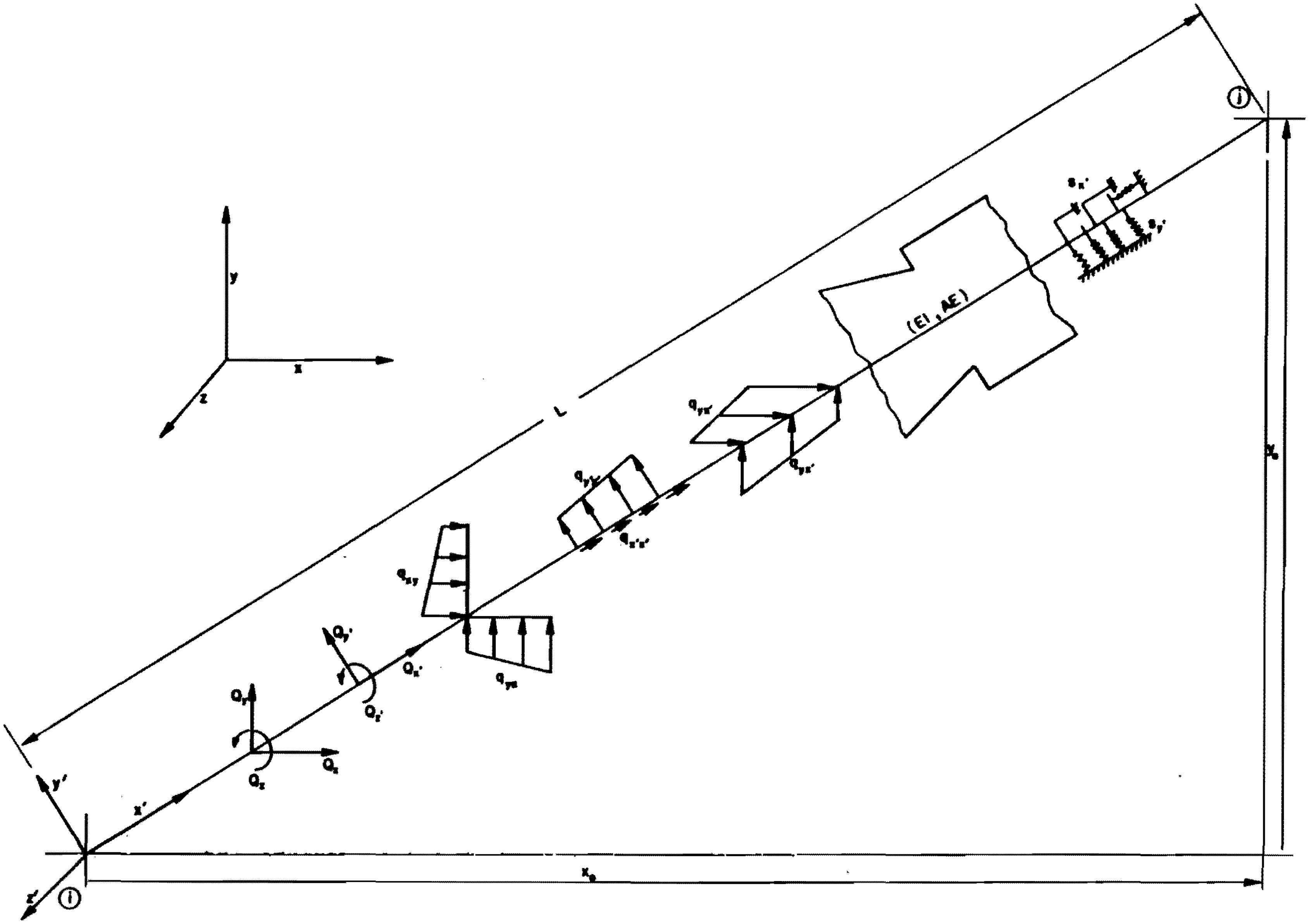


Fig 6. General frame member.

$$\alpha = (x_j - x_i)/L \qquad (4.3)$$

and

$$\beta = (y_j - y_i)/L \qquad (4.3)$$

where the length of the member L is given by

$$L = \sqrt{(x_j - x_i)^2 + (y_j - y_i)^2} \qquad (4.5)$$

Equations 4.3 and 4.4 assume that the member x'-axis is directed from joint i to joint j. The program directs the member x'-axis in the direction that the member stiffness and load types are input.

Member Stiffness and Load Types

Many frames have several members with the same stiffness properties and/or loadings. The terms "stiffness type" and "load type" are used in the program to avoid duplication of input for such members. Two or more members have the same stiffness type if they have the same stiffness properties (length, distribution of axial and flexural rigidities and distribution of elastic restraints) and have their member axes parallel and similarly directed. Two or more members have the same load type if they have the same loadings, length, and similarly directed parallel member axes.

Member Load Data

Consider a member subjected to a variety of loads as illustrated in Fig 6. In general, Q_a is a concentrated load in the direction of the a-axis. Thus $Q_{x'}$ is a concentrated load in the direction of the member x'-axis, and Q_z is the concentrated moment about the z-axis. And in general, q_{ab} is a distributed loading in the direction of the a-axis and has its intensity per unit of length along the b-axis. Hence $q_{yx'}$ is a load in the direction of the structure y-axis and has its intensity per unit of length along the member x′-axis. Such a load might be the member's own weight, if the structure y-axis is vertical.

A load is positive if directed in the positive sense of the direction axis or, in the case of a moment, if it is counterclockwise in the x-y plane.

Describing member loads in terms of Q_a and q_{ab}, giving the distance from a reference point to Q_a and the distance from a reference point to the starting and stopping points of q_{ab} is a convenient method of inputting member loads. However, the discrete-element model of Chapter 3 requires loads to be in the direction of the member axes and acting only at stations. Thus general member loads must be transformed into member coordinates and discretized to station values. The transformation of concentrated loads from the structure axes to member axes is accomplished by multiplying by the appropriate direction cosines α and β and summing as follows:

$$Q_{x'} = \alpha Q_x + \beta Q_y \tag{4.6}$$

$$Q_{y'} = -\beta Q_x + \alpha Q_y \tag{4.7}$$

and

$$Q_{z'} = Q_z \tag{4.8}$$

Distributed loads in the direction of the structure axes but with their intensity per unit of length along the member x′-axis transform in the same manner:

$$q_{x'x'} = \alpha q_{xx} + \beta q_{yx} \tag{4.9}$$

$$q_{y'x'} = -\beta q_{xx} + \alpha q_{yx} \tag{4.10}$$

and

$$q_{z'x'} = q_{zx} \tag{4.11}$$

The term $q_{z'x'}$ (not shown in Fig 6) is a moment per unit of length and probably not useful for normal design but is included for generality.

Distributed loads directed in one structure direction per unit of length in the other structure direction are transformed by Eqs 4.9 and 4.10 and then multiplied by the absolute value of the direction cosine between the member axis and the axis to which the intensity is referenced to give

$$q_{x'x'} = \alpha q_{xy}\left|\beta\right| + \beta q_{yx}\left|\alpha\right| \tag{4.12}$$

and

$$q_{y'x'} = -\beta q_{xy}\left|\beta\right| + \alpha q_{yx}\left|\alpha\right| \tag{4.13}$$

Distances to concentrated loads, etc., may be input in structure coordinates, x and y, and then divided by the appropriate direction cosine to give the distance along the member axis, x', as follows:

$$x' = \frac{x}{\alpha} \tag{4.14}$$

or

$$x' = \frac{y}{\beta} \tag{4.15}$$

Discretizing Member Loads

The idea of replacing a complicated loading system with a simpler statically equivalent system is not new. Newmark's classic paper (Ref 12) gives a good practical discussion of the concept and a theoretical treatment is given in a paper by Mises (Ref 11). Mises points out the lack of generality of St. Venant's principle and gives a better criteria for the replacement of one load system by another.

Using Mises criteria a system of loads may be replaced by an equivalent system if the static difference of the two systems is zero and remains zero when the two systems are rotated through an arbitrary angle. Such systems are said to be astatically equivalent. Then, if the real loading system and the astatically equivalent loading system are contained within a circle of diameter ϵ , the error in replacing the original system with the equivalent system will be of order ϵ^2 .

Consider a concentrated load Q_y' as shown in Fig 7(a). The load may be imagined to be applied to a simple stringer supported at stations i and i+1. Such a stringer would give reactions at i and i+1 as follows:

$$\tilde{P}_i^2 = Q_y'(2h - c)/2h \tag{4.16}$$

and

$$\tilde{P}_{i+1}^2 = Q_y'c/2h \tag{4.17}$$

The terms $\tilde{P}_i^2$ and $\tilde{P}_{i+1}^2$ are the concentrated station loads required for the member analysis of Chapter 3 and are astatically equivalent to the actual load Q_y' . Both loading systems are contained within a circle of diameter 2h thus the error is of the order $(2h)^2$.

A load parallel to the member Q_x' could be arbitrarily transferred to either station i or i+1 and it would still be statically equivalent to the original load but it would violate the principle of astatic equivalence. However, if formulas similar to Eqs 4.16 and 4.17 are used, the desired results are obtained. That is:

$$\tilde{P}_i^1 = Q_x'(2h - c)/2h \tag{4.18}$$

$$\tilde{P}_{i+1}^1 = Q_x'c/2h \tag{4.19}$$

A couple can be considered to be a system composed of two equal and oppositely directed forces a small distance apart. The forces may be transferred by Eqs 4.16 and 4.17 which has the effect of transferring the couple by Eqs 4.20 and 4.21.

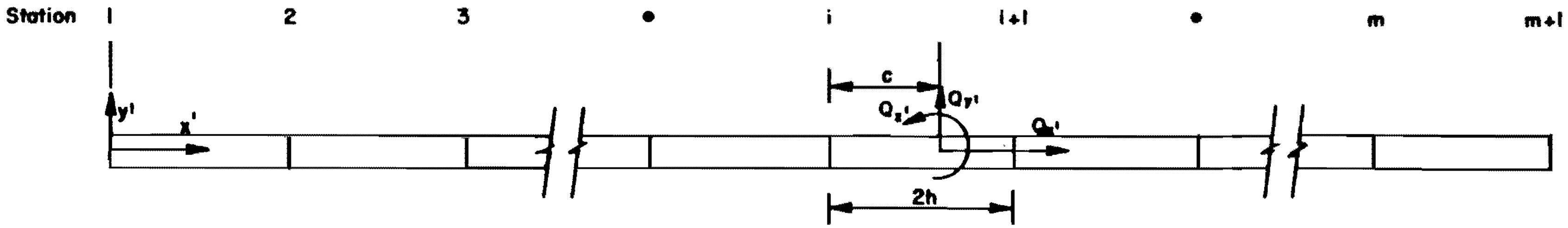
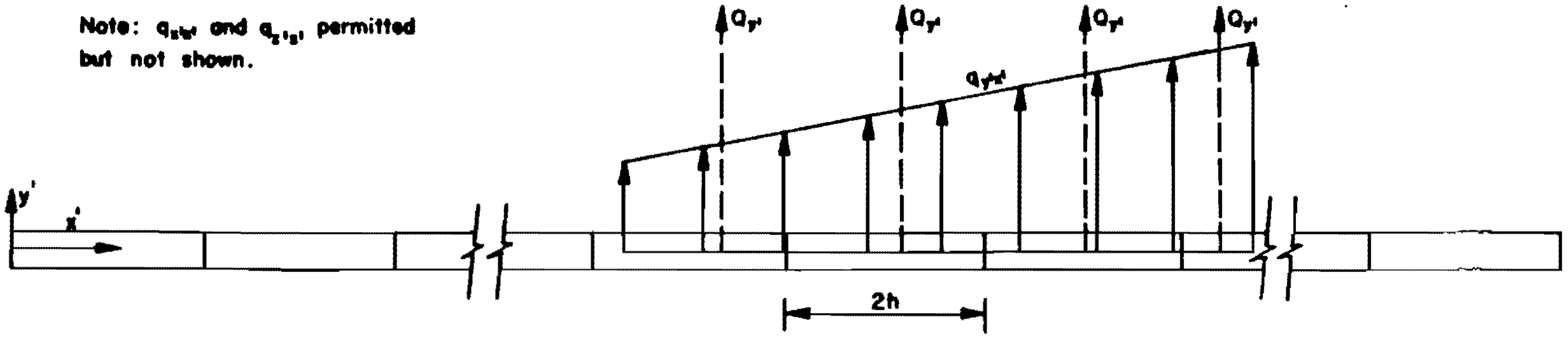


Fig 7(a). Concentrated loads.



Note: $q_{x'x'}$ and $q_{z'z'}$ permitted but not shown.

Fig 7(b). Distributed Loads.

Fig 7. Member loads in member coordinates.

$$\tilde{P}_i^3 = Q_{z'}(2h - c)/2h \tag{4.20}$$

$$\tilde{P}_{i+1}^3 = Q_{z'}c/2h \tag{4.21}$$

Linearly distributed loads such as $q_{y'x'}$ (shown in Fig 7(b)) may be first transformed into equivalent concentrated loads as suggested in the figure. A concentrated load is calculated for each element of the member that has any of the distributed loading acting on it. The formulae for the resultant of a linear load and its location may be found in any standard handbook. The concentrated loads thus found may be distributed by formulas 4.16 and 4.17. Higher ordered load distributions may be represented by the user as a series of linear loadings.

Distributed axial loadings $q_{x'x'}$ and distributed rotation loadings $q_{z'x'}$ may be handled in a similar manner. The similarity of the techniques is such that the computer program developed uses the same subroutines for all three types of loads (lateral, axial, and rotational).

Discretizing Member Stiffness Data

All member stiffness data are assumed to be given with respect to the member axes, as shown in Fig 6. That is, the cross-sectional area A is normal to the member x′-axis, the moment of inertia I is about the member z′-axis, $s_{x'}$ is a distributed elastic spring restraint acting parallel to the member x′-axis, $s_{y'}$ is a distributed elastic restraint acting parallel to the member y′-axis, and $s_{z'}$ is a distributed rotational elastic restraint acting about the member z′-axis. Concentrated values of elastic restraint are not permitted.

It is shown in Appendix 1 that using the average values of EI and AE for a linear variation of these properties over an element gives a solution with second order converging properties. A second order converging solution is one in which the error decreases in proportion to the square of the element size. This is compatible with the astatic equivalencing of loads just described. Higher order variations in EI and AE may be specified by the user as a series of linear variations to achieve any desired degree of accuracy.

A jump in EI or AE in an element, as occurs at a cover plate, could for all practical purposes be handled by using the average values of EI and

AE for the element. However, this does not give second order convergence. To achieve this the M/EI and T/AE diagrams for an element may be balanced by choosing appropriate effective values of EI and AE to be used for the element. The term M is the bending moment at any point in the element and T is the axial thrust at any point in the element. Thus the M/EI diagram is the curvature diagram and the T/AE diagram is the axial strain diagram. These effective values should be chosen such that the errors in the positive area of the curvature and strain diagrams are balanced or offset by equal negative areas. This criteria gives

$$\overline{EI} = \frac{2hEI_1EI_2}{c_2EI_1 + c_1EI_2} \tag{4.22}$$

and

$$\overline{AE} = \frac{2hAE_1AE_2}{c_2AE_1 + c_1AE_2} \tag{4.23}$$

The terms $\overline{EI}$ and $\overline{AE}$ are the effective values to be used for the element of length 2h . The terms EI_1 and AE_1 are the actual values of EI and AE for a distance c_1 , and EI_2 and AE_2 are the actual values for a distance c_2 .

Positive values of EI and AE throughout the element are assumed in obtaining Eqs 4.22 and 4.23. A zero value of EI which corresponds to an idealized pinned connection is not allowed interior to a member. However, this is not a practical limitation as a hinge can occur at any structural joint. Hence a structural joint may be defined at the location of the hinge and a member specified on both sides of the hinge.

A more realistic way of handling a reduction in moment resistance, which can only approach an idealized hinge, is to put in a reduced value of EI for a short distance around the hinge.

The discretizing of elastic spring restraints can be done in a fairly complicated manner. However, if the restraints are restricted to distributed values, then a second order converging solution can be obtained by handling the springs exactly as distributed loads. That is by first obtaining equivalent concentrated values and then distributing these to the stations. The same formulae as used for loads can be used here. Concentrated elastic restraints, particularly very large values which might be used to set a displacement, cannot be handled in this manner without introducing unacceptable errors. Hence, the program accepts concentrated spring restraints only at structural joints where they are handled "exactly."

CHAPTER 5. COMPUTER PROGRAM

The computer program FRAME 11 has been written for the linearly elastic analysis of plane frames subjected to static inplane loads and has the restrictions outlined in the Introduction (Chapter 1).

The frame, its supports and loads are specified in input Tables 1 through 7. The results are given in output Tables 8, 9, and 10. These tables will be described after a short discussion of the four problem types the program works. A description of the internal workings of the program concludes this chapter. Chapter 6 gives the example problems of the report and additional details on the program are given in the appendices.

The program solves four distinct types of problems. The distinction of problem types is necessary both to increase computer efficiency and decrease the volume of input the user must supply. All problem types are related to the definition of a structure and its loads. For the purpose of defining the problem types, a structure should be considered to include the members of the frame, the member supports, and the joint supports. Any change in the members, their arrangement, or the supports creates a new structure.

Problem Type 1 - Regular Problem

When a structure is to be analyzed for only one loading it should be input as a problem Type 1 for the most efficient solution.

Problem Type 2 - Parent Problem

When a structure is to be analyzed for more than one loading condition, economics in computer time and man hours may be made by making the first solution a Type 2 problem.

Problem Type 3 - Offspring Problem

A structure previously analyzed as a Type 2 problem may be analyzed more economically for another loading condition by running it as a Type 3 problem.

Up to 20 Type 3 problems may follow a Type 2 problem. Type 3 problems must follow a Type 2 or a Type 3 problem. Only loads can be changed in a Type 3 problem. A computer diagnostic will appear if an attempt is made to change the structure in a Type 3 problem.

Problem Type 4 - Family Problem

When one structure is solved for several load conditions starting with a Type 2 problem the results are stored. This allows the designer to solve a structure for several basic load cases and then combine the results in a linear manner. (Exp. 1.5 dead load + 1.8 live load, etc.) Type 4 problems require only input Tables 1 and 7 and may not follow a Type 1 problem.

Input Tables

A detailed input guide is provided in Appendix 2.

Table 1. Program Control Data - consists of two cards which are required for all problems. The first card specifies the problem type, the tables for which data are held and allows the user to suppress output. The second card specifies the number of data cards in Tables 2 through 7. Data may be held for all types of problems but cannot be held on the first problem of a computer run. Data is generally held from the previous problem but after a Type 4 problem the data from the last problem other than a Type 4 problem may be held.

Table 2. Frame Geometry Data - defines the location of the structural joints of the frame. Joints are required at the intersections of two or more members and at the ends of members. Joints need not be input at concentrated loads but are required at locations of supports (concentrated linearly elastic springs) and at hinges (points of zero flexural stiffness).

The first card of Table 2 gives the total number of frame joints, the reference joint, its coordinates, and the joint location tolerance. The reference joint may be any joint and it may have any coordinates except all joints must have coordinates less than 1.0E + 50. As many additional cards as necessary follow to specify the location of the remaining joints and check the location of as many joints as desired. When joints are located more than once the program compares the old and new coordinates. If the difference in either coordinate (x or y) is greater than the joint-location tolerance a computer diagnostic appears, otherwise the program averages the old and new coordinates and continues.

The second and succeeding cards give the offsets of new joints with reference to previously defined joints. For example, if joint 3 is the reference joint the second card could locate joint 7 with respect to joint 3. The next card could then locate joint 1 with respect to either joint 3 or joint 7. When several joints are in a straight line and have identical offsets, they may be located with only one card. Joint offsets need not be given where members are, but all joints must be located at least once. The input data is echo-printed in Table 2 and in addition the computed joint coordinates are given.

Table 3. Member-Type Location - locates the members of the frame between the joints defined in Table 2. The use of member stiffness and load types reduces the volume of input required for large frames with repeated members. Two or more members have the same stiffness type if they have the same stiffness properties (length, distribution of axial and flexural rigidities, and distribution of elastic restraints) and have their member axes parallel and similarly directed. Two or more members have the same load type if they have the same loadings, length and similarly directed parallel member axes.

The first card of Table 3 contains the total number of stiffness types and load types in the frame. The second and succeeding cards give the location of the members in the frame and their stiffness and load types.

The members are input going "From" one joint "To" another joint. This orients the member x'-axis in the direction of the "To" joint. The orientation is given with the member output for interpreting results.

When several members with the same stiffness and load type are connected in a straight line, they may be input with only one card.

The stiffness and load types on a data card replace the old values for a member if old values exist. Thus if only one member's stiffness and load type change from the previous problem the data may be held in Table 3 and only the new values of stiffness type and load types given. And obviously, both the stiffness and load types must be given even if only one of them changes.

The input data is echo-printed and in addition the computed member numbers, lengths, and offsets are printed in Table 3.

Table 4. Joint Loads and Restraints - gives joint loads and restraints in the structure x-y-z axes. Frame supports are specified as linearly elastic restraints (springs). Realistic values may be used where available or fictitiously large values may be used to simulate unyielding supports.

A completely fixed support is obtained by specifying large horizontal (x), vertical (y), and rotational (z) springs at a joint. A pinned support would omit the rotational restraint and the free end of a cantilever would have no restraints.

A specified displacement may be enforced by inputting a large spring and a correspondingly large force equal to the spring restraint times the desired displacement.

Each card of Table 4 contains joint loads and restraints for one joint. Only joints with nonzero values need have a data card. No special order of the joints is required in Table 4. The table is accumulative and in addition to the echo-print of the data the accumulated joint data is printed.

Loads are positive if in the direction of the structure axes, thus counterclockwise couples are positive loads. Springs corresponding to stable supports will always be positive.

Table 5. Member Stiffness Data - specifies the stiffness data for the various stiffness types in the frame. One or more data cards are required to define each new stiffness type. Stiffness types must be input in ascending order and when Table 5 is held from a prior problem the first new stiffness type must be one more than the last stiffness type in the prior problem.

Prismatic members without elastic spring restraints require only one data card. Members with variable cross-sections or elastic-spring restraints require two or more data cards and the first card indicates how many additional cards follow.

Connections of members to the joint may be either pinned or rigid and are indicated on the first card for each stiffness type. This option either pins or rigidly attaches the member to the joint but does not in any way serve as a support for the frame (i.e., when a member has a pinned support at its end it must be specified in Table 4 even if a pinned connection to the joint is provided in Table 5).

Distances to locations of changes in stiffness are given from the members "From" joint and may be in either member or structure coordinates depending upon the axis option chosen. Positive distances are in the direction of the chosen axis.

Either partial or complete member output may be requested in Table 5 for each stiffness type and all members with that stiffness type will have the specified output.

Table 6. Member Load Data - specifies the loadings for the various load types. One or more data cards are required to define each new load type. Load types must be input in ascending order and when Table 6 is held from a prior problem the first new load type must be one more than the last load type in the prior problem.

Members with only uniform loads over their full lengths may be input with only one data card. Other loadings require two or more cards and the first card indicates how many additional cards follow. Four axis options are provided which permit the user to describe the member loads in the most convenient manner. Loads are positive if they are in the direction of the chosen axes, thus, counterclockwise couples are always positive. Distances to concentrated loads and changes in distributed loads are given from the members "From" joint and are positive in the direction of the chosen axes.

Table 7. Compilation Table - specifies the problem numbers of previous problems and their appropriate load factor for a superposition solution. Table 7 has one data card for each previous problem which has a multiplier. No cards are input in Table 7 except for Type 4 problems.

A multiple of a Type 4 problem is not allowed but the data from the previous Type 4 problem may be held and combined with new multipliers. In addition to an echo-print of the data the accumulated multipliers are printed.

Output Tables

Table 8. Joint Displacements and Reactions - gives displacements and reactions for all frame joints. Only supported joints (those with elastic spring restraints) will have nonzero reactions.

Undefined displacements, such as the rotation of a joint to which all members are pinned, or all three displacements of a joint to which no members are connected, are indicated in the output by extremely large displacements. (Refer to example problem 1101.)

Joint displacements and reactions are in structure coordinates and positive in the positive coordinate directions. Thus positive rotations are counterclockwise.

Table 9. Member Results - gives, for all members, either member-end-forces or detailed output, as requested in Table 5. Member-end-force output consists of the axial forces, shears and bending moments at the ends of the member; complete member output lists the axial, lateral, and rotational displacements as well as the axial force, shear and bending moments at 21 equally spaced points along the member.

For either choice of output, the axial forces, shears, and bending moments are in normal member-sign convention (not a joint-sign convention). Positive axial force produces tension in the member, positive shear tends to raise the end of the member nearest the origin of the member's x'-axis, and positive bending moment produces tension on the bottom side of the member. Positive displacements are in the positive member axes directions, thus, positive rotations are counterclockwise. The direction of the member's x'-axis is as input in Table 3 and is given with the member output for convenience.

Distances to the 21 output points are given along the axis used to specify the members stiffness data and are positive if in the positive axis direction. Regardless of the input options used, the axial force is parallel to and the shear force is normal to the member's x'-axis.

The values of axial force, shear and bending moment are the normal engineering values except that average values are given when there is a double value at an interior point due to a concentrated load or couple.

The maximum equilibrium error in the member is also output with the member's results and should always be a negligible quantity.

Table 10. Joint-Equilibrium Errors - give the errors in equilibrium at the frame joints and should always be negligible except at a joint for which specified displacements are enforced. A valid check of such joints is not possible.

The equilibrium errors at other joints should be scanned by the designer to see that the program is working properly. In considering the relevance of an error the designer might ask what effect the error would have if applied to the joint as a load. Example problem 1201 has one of the largest joint equilibrium errors of the report, an error of 1.2 kip-inches. If this were applied to the joint as a load it would scarcely change the distribution of moments in the members of 8,539 and 8,540 kip-inches respectively.

Program Description

FRAME 11 is written in FORTRAN IV and conforms to the requirements of "American Standard FORTRAN" (Ref 1). The program has been implemented and thoroughly checked on the CDC 6600 computer at the Computation Center of The University of Texas at Austin. Only minor modifications are necessary to convert the program to other machines.

Program flow charts, the glossary of notation, and the FORTRAN listing of programs are in Appendices 3, 4, and 5 respectively. The reader interested in developing a full understanding of the program may wish to refer to these appendices as he reads the remainder of this chapter. In particular, the flow diagram for subroutine FRAM11 should prove helpful.

There are four more or less distinct paths through the program taken by the four problem types. The program will be explained by examining these paths.

Regular Problem

A Type 1 or regular problem is the analysis of a structure for one single loading condition. Type 1 problems, as all problems after the first problem of a run, start by reading in the problem number and problem identification card. The first problem of a run also contains two run identification cards. Then unless the problem number is equal to "CEASE" the program inputs Table 1.

For Type 1 problems, calls are then made successively to JTCORD, MEMLOC, JNTDAT, RDMST, and RDMLD which input Tables 2 through 6, echo-print the data, and after making preliminary computations, print the additional data described earlier in the chapter.

Subroutine RDMST and RDMLD convert the member stiffness and load data from the input coordinates to member coordinates and from that point on all member data is expressed in member coordinates. The transformation to discrete station values is not made at this time, in order to conserve storage.

Subroutine COMP is then called which prints out the table heading for input Table 7 and indicates that there is no data in the table.

In each of the routines which inputs data, checks are made for inconsistencies. If a data error is found the program stops processing that problem, prints out an appropriate error message and searches the remaining data cards for an independent problem. All intermediate cards are listed in the output.

The next step is the calculation of the member's stiffness and fixed-end-force matrices in member coordinates. Members with the same stiffness type will have the same member stiffness matrix; thus, member-stiffness matrices are computed and stored by stiffness type. Members with the same load type need not necessarily have the same stiffness type; hence, the member fixed-end-force matrices are computed and stored for each individual member.

Subroutine FORMST is called to calculate the member's stiffness matrix. FORMST calculates the stiffness matrix using known formulae for prismatic members not elastically restrained. Other members have their stiffness matrix generated by applying the appropriate unit displacements as discussed in Chapter 3.

Members which require the unit-displacement technique first have their stiffness data discretized to station values by subroutine DISCST. Then axial and lateral solutions are performed by subroutine AXIAL and GRIP2A.

Subroutine AXIAL is a short routine for solving the members axial equilibrium equations. The routine, which is a slight modification of previous beam-column solution routines (Ref 9), takes advantage of the fact that the band width of the axial equations are only three terms wide.

Subroutine GRIP2A is the general-simultaneous equations routine of the program and is used to solve the member-equilibrium equations for lateral displacements and rotations and also the joint-equilibrium equations for the joint displacements (vertical, horizontal, and rotational).

GRIP2A calls FSUB1 which calls FSUB12 to generate the member stiffness and load matrix one row at a time. (In the frame solution, GRIP2A calls FSUB1 which in turn calls FSUB11 for the appropriate frame coefficients.)

GRIP2A is a modification of the general recursion-inversion routine GRIP2 reported in Ref 3. The modification reduces the storage required for an incore solution which proves to be the most economical for small and medium sized frames.

Only 13 of the 36-member stiffness coefficients need be calculated and stored. SMMT is the storage vector used and the relation of SMMT to the member-stiffness matrix $[K]_k$ is given in Eq 5.1.

$$[K]_k = \left[\begin{array}{c|c|c|c|c|c} \text{SMMT}(1) & & & & & \\ 0 & \text{SMMT}(3) & & & & \\ 0 & \text{SMMT}(4) & \text{SMMT}(7) & \multicolumn{2}{c|}{(\text{SYMMETRIC})} & \\ \hline \text{SMMT}(2) & 0 & 0 & \text{SMMT}(10) & & \\ 0 & \text{SMMT}(5) & \text{SMMT}(8) & 0 & \text{SMMT}(11) & \\ 0 & \text{SMMT}(6) & \text{SMMT}(9) & 0 & \text{SMMT}(12) & \text{SMMT}(13) \end{array}\right] \tag{5.1}$$

Subroutine FORMLD is called to calculate the member fixed-end-force matrices. Prismatic members not elastically restrained have their fixed-end-force matrices calculated directly using known formulae. For other members, FORMLD does a member solution for the member subject to its member loads and zero-end displacements.

The member solutions are similar to those discussed in FORMST. Loads are discretized to concentrated station values by subroutine DISCLD.

The frame equilibrium equations are set up and solved by GRIP2A which calls FSUB1 which in turn calls FSUB11 to furnish the appropriate stiffness and load coefficients. FSUB11 is called for each row of equations but forms three rows of equations on every third call from GRIP2A in (3 x 3) and (3 x 1) submatrices following the procedure outlined in Chapter 3.

After the frame displacements are found, the corresponding reactions are then computed and the joint displacements and reactions are printed in Table 8.

The sum of the joint loads and reactions are then computed. (When the member-end-forces are subtracted away from these values, the remnants are the equilibrium errors at the joints.)

The member results are then found for each member in the frame by a call to MEMRES. Subroutine MEMRES solves each member for its member loads and the member-end displacements which are compatible with the joint displacements of the frame solution. Loads and stiffnesses are discretized in the same way as previously discussed. Subroutines AXIAL and GRIP2A are then called to solve for the member's axial, lateral, and rotational displacements at each station. The end forces on the ends of the member elements are then computed and an equilibrium check made at each station. The average value of axial force, shear, and bending moment is then computed at alternate stations. (Output is at every other station.)

Subroutine ADJNTER is then called to subtract the member's-end-forces from the partially computed joint equilibrium error. The remnant after all members have had their forces subtracted away should be extremely small and is an indication of how accurately the frame-joint displacements have been computed. It should be noted that some error is introduced due to using the standard stiffness matrices for prismatic members and then evaluating the member-end-forces by the discrete-element solution. This could be avoided by calculating member-end-forces in a different manner (matrix techniques of Chapter 2) for prismatic member. But this would needlessly complicate the program.

As now programmed, the joint equilibrium errors thus serve to indicate the errors both in the solution process and in the two different models (continuous line element versus discrete line element). As shown in the example problems, the errors are negligible.

The member results are printed in Table 9 by subroutine PRINT9. Either complete or partial output is printed, depending on which is requested in Table 3.

The joint equilibrium errors are then printed in Table 10 and the program returns for a new problem.

Parent Problem

A Type 2 or Parent Problem differs from a Type 1 problem only in the tape operations required for a Type 2 problem.

Subroutine COMP forms a list of problem numbers for which the results are saved for future Family Problems. The first problem of the list is the Parent Problem.

After the solution of the frame equilibrium equations by GRIP2A, the recursion multipliers RM and RO are stored on Tape 2 for a Parent Problem so they will be available for future Offspring (Type 2) Problems. Note that since RM and RO are kept in core, they would be available for future solutions except that the routine GRIP2A is used for solving both frame equations and member equations.

Then the frame displacements, reactions and joint loads are stored on Tape 1 for future Family (Type 4) problems. The tape is rewound prior to writing data on it since the Parent Problem is the first of a series for which the results are stored.

Similarly, Tape 4 is rewound and the results for six members are written on it at one time. The member results are grouped in order to decrease the number of records written, thus reducing the time for tape operations.

Offspring Problem

A Type 3 or Offspring Problem skips the formation of the member stiffness matrices, since the stiffness data must be identical to the last problem. However, the member-end-forces matrices must be formed as was done for regular and Parent Problems.

Prior to calling GRIP2A for the solution of frame equilibrium equations, RM and RO are retrieved from Tape 2. Then RM and RO need not be calculated again by GRIP2A, thus greatly reducing the solution time for the equations. After the solution, RM and RO are again stored on Tape 2 for additional Offspring Problems.

The frame-joint displacements, reactions, and loads are stored on Tape 1 as was done for the Parent Problem. And member results are stored on Tape 4.

Family Problem

A Type 4 or Family Problem has a completely different path through the program. Input Tables 2 through 6 are not read in. In subroutine COMP, the problem numbers and multipliers are read in and a check is made to see that the problem numbers are in the list of problems (parent and their offspring) for which the results have been saved.

A Family Problem then calls subroutine SUM1 for a superposition solution of frame displacements, reactions, and joint loads, and outputs the displacements and reactions in Table 8.

The preliminary computation of joint equilibrium error is made by adding reactions and loads, as was done for the other problem types, and subroutine SUM2 is called for a superposition solution of the members. SUM2 also calls ADJNTER to complete the joint equilibrium error calculations and PRINT9 to print the member results requested.

The joint equilibrium errors are printed in Table 10, and the program returns for a new problem.

CHAPTER 6. EXAMPLE PROBLEMS

A number of examples have been solved to check the accuracy and usefulness of the program. The results for the truss analyzed in problems 1101-1103 are found to be almost identical to an analysis by statics and virtual work found in Ref 10. Numerous other examples not reported were worked to check the accuracy of the computer solution. Example problems 1201-1207 illustrate the use of the program in a meaningful series of problems for a two-story, two-way bent similar to certain highway structures. The results of this series were compared with independent solutions where feasible, and agreement was obtained in all cases.

The units used for all example problems are kips and inches, though any consistent set of units may be used.

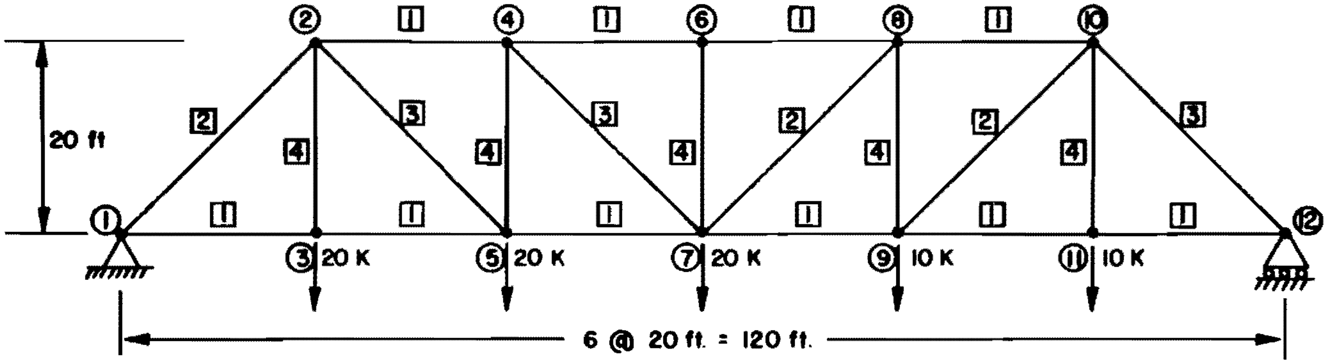
Problems 1101-1103 - Simple Truss

The truss of Fig 8 is analyzed in problems 1101-1103. This simple problem illustrates the savings in input possible when members are repeated in a structure.

In problem 1101, the joints are numbered 1 through 12 across the short direction of the truss. This numbering technique will generally give the most efficient computer solution. However, the program will accept any order of numbering as long as the difference between connected joints does not exceed nine and no joint numbers are omitted. The joints are located in Table 2, taking advantage of the uniform geometry of the problem.

All members are assumed unloaded in accordance with normal truss analysis techniques. Thus, all members are assigned zero load type. However, any member loads which might actually exist could be easily accommodated in a manner similar to the member loads of the bent problem.

All chord members have the same cross-section, modulus of elasticity, length, and orientation and hence are assigned a single-stiffness type, Type 1. Stiffness Type 1 is specified for all bottom chord members with a single card. The top chord is specified in a similar manner. All of the members with



Stiff Type	E (KSI.)	Prismatic I(in⁴)	Prismatic A(in²)
1	30,000	4.0	4.0
2	30,000	2.25	3.0
3	30,000	2.25	3.0
4	30,000	1.0	2.0

Legend :

○ - Joint Number

☐ - Stiffness Type

All Members Have Load Type 0

Fig 8. Truss with unsymmetrical loads.

stiffness Type 1 have their member x′-axis going from left to right because of the manner in which the stiffness types are input in Table 3.

All diagonal members have the same cross-section, modulus of elasticity, and length but they have two different orientations. Hence, two stiffness types are required. All vertical members are identical and thus have the same stiffness type.

Joint loads and restraints are input in Table 4. The restraints used are unrealistically large to mimic the idealized pin and roller supports shown.

The data describing the member stiffness types are input in Table 5 and the pinned-end connections are indicated here. Since the members are prismatic, only one card is required per stiffness type. The minimum output is selected for all members. Axis option 1 is used for all members but does not affect the input for prismatic members.

No cards are input for Tables 6 and 7.

Table 8 gives the joint reactions and displacements. The reactions are identical to the reactions of Ref 12 and the displacement of joint 9 of 1.399 inches compares favorably with the displacement of 1.4 inches found in Ref 10. The joint rotations are undefined since all members were specified as pinned-ended and the rotations of 1.0 E+99 indicate this. As anticipated, all shears and bending moments for the members are trivial. The axial forces can be easily verified by statics.

Table 10 gives the joint equilibrium errors and confirms that the solution is valid.

In problem 1102, the effects of rigid connections on the truss' behavior are examined. The stiffness types are modified to indicate rigid connections rather than pinned ones. The results are very similar to 1101 except for small bending moments and shears to which the members are subjected due to the continuity.

In problem 1103, the effects of the roller freezing on the truss of 1102 are investigated. As expected, the displacements and axial forces in the bottom chord are reduced but a large horizontal reaction is developed, which the foundation must resist.

Problems 1102 and 1103 required only a few additional data cards since most of the information could be held from problem 1101. Note, however, that neither 1102 or 1103 could be worked as an Offspring Problem, since the stiffness of the structure changed in both cases.

Problems 1201-1207 - Two-Story Bent

A two-story bent is analyzed in problem 1201 for the live loads shown in Fig 9. The two columns on the left side of the frame have the same length and cross-sectional properties and are input as the same stiffness type. In order to do this, the pin at joint 1 must be specified as a joint property in Table 4 rather than as a member property in Table 3.

The pinned support is specified in Table 4 by using large vertical and horizontal restraints and no rotational restraint. The fixed support at joint 6 requires all three restraints.

The girders are the only members loaded in problem 1201 and are assigned load Types 1 and 2, as shown in Fig 9(b). All other members are assigned zero load type.

The first five stiffness types are prismatic and require only one card in Table 5 to specify their stiffness data. Stiffness Type 6 requires additional data cards to specify its data. Axis option 2 is used for stiffness Type 6. Therefore, horizontal distances are given to the locations of changes in stiffness. The distances are referenced to the "From" joint as defined by the input of Table 3.

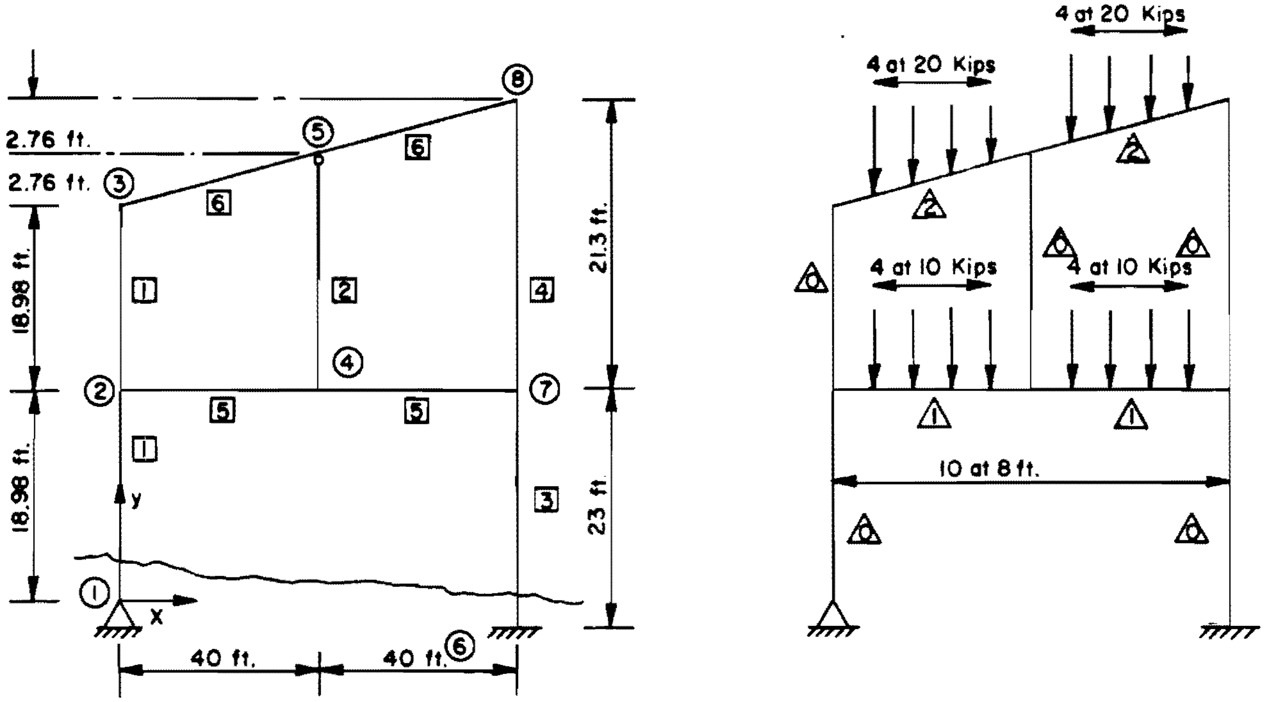
The concentrated live loads are input in Table 6 for load Types 1 and 2. Axis option 3 is used for both members so loads are input in the structure axes and distances are horizontal.

Table 8 gives the joint displacements and reactions. The reactions can be seen to be in equilibrium with the applied loads.

The member results are given in Table 9. Some of the members have only member-end-forces while others have complete output at the twentieth points, as requested in Table 3.

Table 10 gives the joint equilibrium errors, that is, the error in equilibrium of forces and moments at each joint. The maximum error is -1.2 kip-inches, which is negligible when compared with the moment in the members at the joint of 8,340 kip-inch.

In problem 1202, the frame of problem 1201 is modified by adding a column below joint 4, as shown in Fig 10. The resulting structure is analyzed for the live loads of problem 1201.



(a) Geometry and stiffness types.

(b) Live load.

Legend

○ – Joint Number

□ – Stiffness Type

△ – Load Type

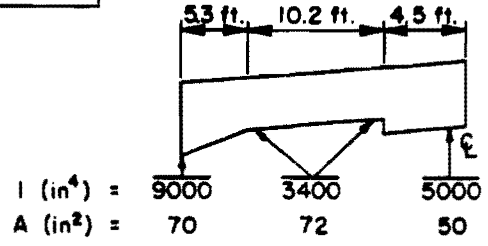
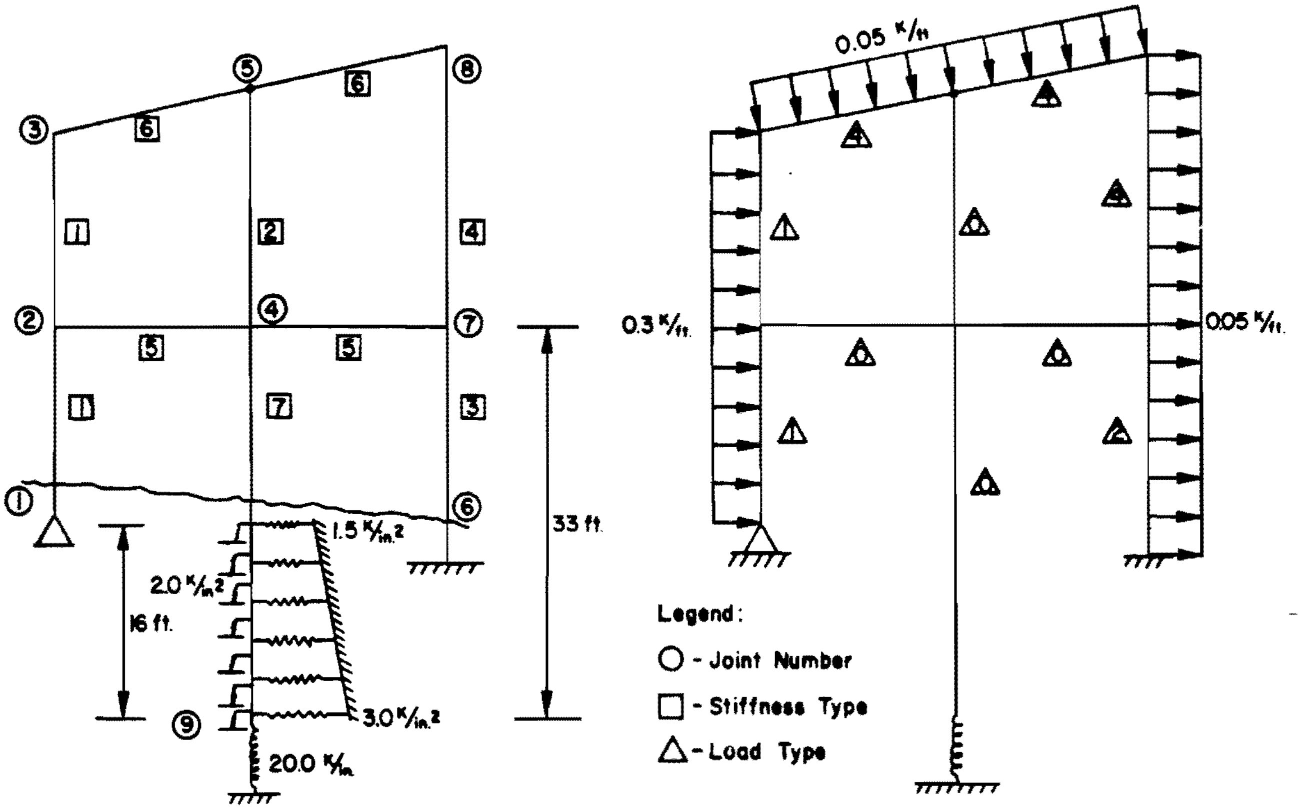
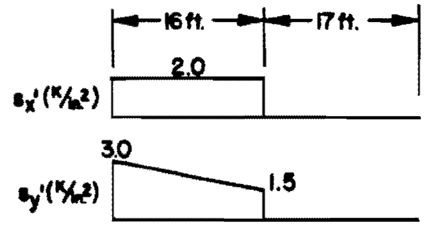
Stiff Type	E (K/in²)	Prismatic I (in 4)	Prismatic A (in 2)	Variable Stiffness
1	29,600	1050	28	———
2	29,600	1800	20	———
3	29,600	1050	28	———
4	29,600	1050	28	———
5	29,600	1800	24	———
6	29,600	———	———	

Fig 9. Two-story bent without interior column.



(a) Geometry and stiffness types.

(b) Wind load.

Stiffness Type	E (K/in.²)	Prismatic I(in.⁴)	Prismatic A(in.²)	Variable Stiffness
1-6	Same as Figure 9			
7	29,600	1050	28	

Dead Load:

Girders - 2.4 Kip/ft.
Columns - 0.6 Kip/ft.
16 Concentrated Loads of 4 Kips Each, Similar to Live Load

Fig 10. Two-story bent with interior column.

Only one additional joint has to be located in Table 2 and one additional member has to be located in Table 3. The member going from joint 9 to joint 4 is assigned stiffness Type 7 and load Type 0. Stiffness Type 7 is defined in Table 5. The end restraint on the column at joint 9 is input in Table 4.

The results of problem 1202 show that the displacements and bending moments are reduced by the addition of the column. The member results for the added member 10 show the variation in axial force, shear, and bending moment, as well as displacements, and could be extremely useful for design.

Problem 1202 was run as a Parent Problem since it was intended to be the first of a series in which the same structure (no change in stiffness properties) was analyzed for a group of loads. Problem 1203 is then an Offspring solution for the wind loads shown in Fig 10(b).

Four new load types are defined in problem 1203, as shown in Fig 10(b). To save the previous load types for future problems, hold Table 6 and define the new load types as 3-6. Note that in locating a new load type in Table 3, the corresponding stiffness type must also be input. And since problem 1203 is an Offspring Problem, the stiffness types must be identical to problem 1202 or a diagnostic message will occur.

Since all the wind loads shown in Fig 10(b) are normal to the members, axis option 1 is used for all load types. Only one data card is required for each load type since all loads are uniform over the full length of the members.

Problem 1204 is an Offspring solution of the frame defined in problem 1202 for the dead loads indicated in Fig 10. All of the members have a uniform gravity load (dead weight) and, in addition, the girders have concentrated gravity loads located at the same place as the live loads shown in Fig 9(b). Since all members are loaded, for convenience they are assigned a load type equal to their stiffness type. The load types are located in Table 3 and defined in Table 6 with all other data held.

All load types are input using axis option 2 which provides for loads acting in the direction of the structure axis. However, distributed loads have their intensity per unit of length along the member axis. The vertical and horizontal members could be defined using axis option 1 since their member axis coincides with one of the structure axes. If axis option 1 were used for the vertical members, the load would be $q_{x'x'}$ and be input in columns 31-40 instead of 41-50.

Problem 1205 is a superposition solution (Family Problem). A factor of 1.25 is applied to the dead load, live load, and wind load acting on the structure defined in 1202. The results could be obtained by hand from the results of 1202-1204, but the cost in man-hours would be far more than the computer costs for the Family Problem. Problem 1206 is a similar solution for 1.5 times the dead load plus 1.8 times the live load.

The column (pile) going from joint 9 to joint 4 is subdivided into two members at the point where the soil restraints start in problem 1207. The frame is then reanalyzed for the dead load and the results compared with problem 1204 (the previous dead-load solution). Subdividing the member into two elements gives a more accurate solution and an idea of the accuracy of the original solution in which the column with soil restraints over part of its length was input as one member.

Joint 10 is input at the ground line and all other joint coordinates are held. Stiffness Type 7 is deleted between joints 9 and 4 by specifying zero stiffness and stiffness Type 8 is input going from joint 10 to joint 4. Stiffness Types 9 and 10 are defined in Table 5.

The results of problems 1204 and 1207 agree within approximately one percent, except for a few locations where very small forces exist such as the tip reaction on the column-pile. Here most of the force has been removed by the axial restraints and the error is about 7 percent or approximately 1 kip. For normal design work, the original solution would certainly be accurate enough.

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

A direct matrix solution for plane frames has been developed that allows a designer to quickly solve problems that previously were difficult or impossible to solve.

A revision of the previous discrete element model was made to allow loads and restraints to act both parallel and normal to the members.

A computer program, FRAME 11, has been developed and is documented herein. The program has all the linear analysis capabilities of the program developed in Ref 2 and in addition to having the five features discussed in Chapter 1, on page 2, can work larger problems using the same amount of core storage. The program as presently dimensioned will work a frame with up to 75 joints and 150 members.

In order to satisfy the linear assumptions required for the superposition solutions, the beam-column effect of axial forces on lateral displacements was neglected as in normal practice under existing codes. However, various forms of nonlinear analysis are being more widely recognized by codes and the designer will soon need a more general nonlinear analysis program.

Preliminary studies indicate that the discrete-element model reported herein can be extended to include not only the beam-column effect, but other geometric and large displacement effects as well as nonlinear material properties.

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APPENDIX 1

ERROR ANALYSIS OF DISCRETE-ELEMENT MODEL

APPENDIX 1. ERROR ANALYSIS OF DISCRETE-ELEMENT MODEL

The error in a model (either physical or mathematical) may be estimated in several ways. One widely used method is to compare the results of the model analysis with the results of another model analysis, the other model being generally accepted as an adequate model of the prototype. An accepted mathematical model of a frame member is a continuous line element.

In this appendix, the discrete-element model is shown to give results that agree with the continuous line element to within a predictably small error. The difference in resulting displacements between the two models is shown to be a function of the square of the element's length, i.e., of the order $(2h)^2$. This error is compatible with the method of discretizing loads and elastic restraints discussed in Chapter 4. Thus, as the element size decreases, the difference in the results of the two models rapidly approaches zero.

Consider the discrete element shown in Fig 4 (Chapter 3). Assume that the element is fixed at its left end, i.e.,*

$$w^1_{i-1} = w^2_{i-1} = w^3_{i-1} = 0 \tag{A1.1}$$

Now consider the effect of load f^2_i only, the moment in the two springs M_1 and M_2 will be found by statics to be

$$M_1 = \frac{3f^2_i h}{2} \tag{A1.2}$$

$$M_2 = \frac{f^2_i h}{2} \tag{A1.3}$$

---

* The results of the derivation concern the change in displacements from one end of an element to the other; hence the actual starting values are immaterial.

These will produce corresponding angle changes Ψ_1 amd Ψ_2

$$\Psi_1 = \frac{3f_i^2h^2}{2EI_i} \tag{A1.4}$$

$$\Psi_2 = \frac{f_i^2h^2}{2EI_i} \tag{A1.5}$$

where EI_i is the flexural rigidity of the element at midpoint.

From the geometry of the model

$$w_i^3 = \Psi_1 + \Psi_2 = \frac{2f_i^2h^2}{EI_i} \tag{A1.6}$$

and

$$w_i^2 = \frac{3h\Psi_1}{2} + \frac{h\Psi_2}{2} = \frac{2.5f_i^2h^3}{EI_i} \tag{A1.7}$$

The corresponding displacements will now be derived for a continuous element. The governing flexural differential equation for a continuous line is

$$\frac{d^2y}{dx^2} = \frac{M}{EI} \tag{A1.8}$$

where y is the lateral displacement and x is the distance along the element measured from station i-1. Note that actually y'' and x'' are the element coordinates as given in Chapter 3 but are not used here in order to avoid confusion with the prime notation for derivatives.

The terms M and EI are the values of bending moment and flexural rigidity at any point along the element. The moment is easily found by statics to be

$$M = f_i^2(2h - x) \tag{A1.9}$$

For a linear variation in stiffness, EI may be expressed in terms of EI_i as

$$EI = EI_i(1 - \gamma h + \gamma x) \tag{A1.10}$$

where γ is the slope of the EI line divided by EI_i

Thus, Eq A1.8 gives

$$\frac{d^2y}{dx^2} = \frac{f_i^2(2h - x)}{EI_i(1 - \gamma h + \gamma x)} \tag{A1.11}$$

Integrating Eq A1.11 gives

$$\frac{dy}{dx} = \frac{f_i^2}{EI_i}\left(\int \frac{2hdx}{1 - \gamma h + \gamma x} - \int \frac{xdx}{1 - \gamma h + \gamma x}\right) \tag{A1.12}$$

$$\frac{EI_i}{f_i^2}\left(\frac{dy}{dx}\right) = \frac{-x}{\gamma} + \frac{(1 + \gamma h)}{\gamma^2} \ln (1 - \gamma h + \gamma x) + C_1 \tag{A1.13}$$

C_1 is constant which can be evaluated by using the boundary condition that at the left end the slope (dy/dx) is zero. Solving for C_1 and substituting in Eq A1.13 gives

$$\frac{EI_i}{f_i^2} = \left(\frac{dy}{dx}\right) = \frac{-x}{\gamma} + \frac{(1 + \gamma h)}{\gamma^2} \ln \left(\frac{1 - \gamma h + \gamma x}{1 - \gamma h}\right) \tag{A1.14}$$

Integrating Eq A1.14 and evaluating the constant of integration C_2 yields

$$\frac{EIy}{f_i^2} = \frac{-x^2}{2\gamma} + \frac{(1 + \gamma h)(1 - \gamma h + \gamma x)}{\gamma^3}\left[\ln\left(\frac{1 - \gamma h + \gamma x}{1 - \gamma h}\right)\right]$$

$$+ \frac{(1 - \gamma h)(1 + \gamma h)}{\gamma^3} \tag{A1.15}$$

At the right end of the element $(x = 2h)$, Eq A1.14 gives

$$\frac{dy}{dx} = \frac{f_i^2}{EI_i}\left[\frac{-2h}{\gamma} + \frac{(1 + \gamma h)}{\gamma h}\ln\left(\frac{1 + \gamma h}{1 - \gamma h}\right)\right] \tag{A1.16}$$

Expanding the natural logarithm function in a Taylor series gives

$$\frac{dy}{dx} = \frac{f_i^2}{EI_i}\left(2h^2 + \frac{2\gamma h^3}{3} + \text{higher-order terms}\right) \tag{A1.17}$$

This differs from the slope at the left end of the element in the discrete-element model as given in Eq A1.6 by the error term ϵ^* ,

$$\epsilon^* = \frac{2f_i^2\gamma h^3}{3EI_i} \tag{A1.18}$$

and this can be expressed in terms of the elements length $2h$ as

$$\epsilon^* = \frac{f_i^2\gamma(2h)^3}{4EI_i} \tag{A1.19}$$

When m of these elements are connected end to end where

$$m = L/2h \tag{A1.20}$$

the total error ϵ will be the sum of the m errors given by Eq A1.19 or Eq A1.21

$$\epsilon = \frac{Lf_i^2 \gamma (2h)^2}{4EI_i} \tag{A1.21}$$

Thus, the difference in the slope between the two ends of the element is a function of the square of the element size or of the second order.

Then evaluating the difference between the discrete element's displacement as given by Eq A1.7 and the continuous element's displacement at the right end of the element as given by Eq A1.15, yields an error term of

$$\epsilon = \frac{Lf_i^2 (2h)^2}{48EI_i} \tag{A1.22}$$

Similarly, the lateral displacement and rotation due to a moment, and the axial displacement due to a force parallel to the member, may be shown to give a second-order error term. Thus, as the number of elements increase, the difference between the discrete element and the continuous element rapidly approaches zero. This theory was checked for a large number of examples and confirmed.

APPENDIX 2

GUIDE FOR DATA INPUT

FRAME 11 GUIDE FOR DATA INPUT - Card Forms

Units of force (f) and distance (d) are indicated below all dimensional input.

IDENTIFICATION OF RUN (2 alphanumeric cards per run)

1	80

1	80

IDENTIFICATION OF PROBLEM (one alphanumeric card for each problem; program stops if problem number = CEASE)

Problem Number		Description of problem
1 - 5		11 - 80

TABLE 1. PROGRAM CONTROL DATA (2 cards per problem)

(1st card)

		Hold Options for Tables 2 through 7 Enter 1 to Hold Prior Data						Output Options for Tables 8 Through 10 Enter 1 to Suppress Output		
	PROB TYPE	TABLE 2	3	4	5	6	7	8	9	10
Columns	6 - 10	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45	51 - 55	56 - 60	61 - 65

(2nd card)

	Number of Cards added in Tables 2 through 7 for this problem					
	TABLE 2	3	4	5	6	7
Columns	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45

PROB TYPE 1 - Regular Problem - single solution of structure.

PROB TYPE 2 - Parent Problem - first of a series of solutions of one structure in which the stiffness properties of the structure do not change.

PROB TYPE 3 - Offspring Problem - a solution of a structure previously solved as a Parent Problem (PROB TYPE 2).

PROB TYPE 4 - Family Problem - a combination of multiples of Offspring Problems (PROB TYPE 3) and possibly their Parent Problem (PROB TYPE 2). A multiple of a Family Problem is not permitted but the previous Family Problem may be held.

TABLE 2. FRAME GEOMETRY DATA (number of cards per Table 1)

Num of Joints	Ref Joint	x-Coordinate	y-Coordinate	Joint Location Tolerance	(1st card)
11 15	21 25	31 (d) 40	d 50	61 (d) 70	

From Joint	x-Offset	y-Offset	To Joint	To Joint	To Joint	To Joint	To Joint	To Joint	To Joint	
11 15	21 (d) 30	(d) 40	46 50	55	60	65	70	75	80	(2nd and succeeding cards)

TABLE 3. MEMBER TYPE LOCATION (number of cards per Table 1)

Num of Stiffness Types	Num of Load Types	(1st card)
11 15	21 25	

From Joint	Stiffness Type	Load Type	To Joint	To Joint	To Joint	To Joint	To Joint	To Joint	To Joint	To Joint	To Joint	To Joint	
6 10	16 20	25	31 35	40	45	50	55	60	65	70	75	80	(2nd and succeeding cards)

TABLE 4. JOINT LOADS AND RESTRAINTS IN STRUCTURE x,y,z-AXES (number of cards per Table 1)

Joint	Load // to x-Axis	Load // to y-Axis	Moment about z-Axis	Restraint // to x-Axis	Restraint // to y-Axis	Rotational Restraint about z-Axis	(All cards)
6 10	(f) 20	(f) 30	(fd) 40	(f/d) 50	(f/d) 60	(fd) 70	

TABLE 5. MEMBER STIFFNESS DATA (number of cards as per Table 1; number of sets of cards equal to the number of stiffness types defined in this problem)

(1st card of set)	Stiffness Type	Modulus of Elasticity		←Blank, if 2nd Card Used→ Prismatic Moment of Inertia	←Blank, if 2nd Card Used→ Prismatic Area		Num Cards Follow	Axis Option	Output Option	Pin (From)	Pin (To)
								+	‡	‡‡	‡‡‡
	6 – 10	(f/d²) 20		31 (d⁴) 40	(d²) 50		56 – 60	65	70	75	80

(2nd and succeeding cards of set)	From (Distance)	To (Distance)	Moment of Inertia	Area	Restraint // to x′-Axis	Restraint // to y′-Axis	Rotational Restraint about z′-Axis
			I	A	$s_{x'}$	$s_{y'}$	$s_{z'}$
	11 (d) 20	(d) 30	(d⁴) 40	(d²) 50	(f/d²) 60	(f/d²) 70	(f) 80

\+ If equal to 1, distances are measured along the member x′-axis; if equal to 2, distances are measured along the structure x-axis; if equal to 3, distances are measured along the structure y-axis. Member output distances for shear diagram, etc. are controlled by this option. In all cases the restraints are with reference to the local member (primed) axis. See page 10 of this appendix for an example using the various axis options.

‡ If blank, detailed output is given; if equal to 1, only member-end-forces are given.

‡‡ If blank, the member is assumed rigidly connected to joint at "From" end. If equal to 1, the member is assumed pinned to joint at "From" end.

‡‡‡ If blank, the member is assumed rigidly connected to joint at "To" end. If equal to 1, the member is assumed pinned to joint at "To" end.

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TABLE 6. MEMBER LOAD DATA (number of cards per Table 1; number of sets of cards equal to the number of load types defined in this problem)

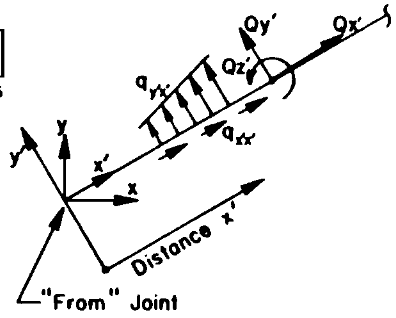
Member loads may be input by any one of the four axis options outlined below. Q_a is the concentrated load in the direction of the a-axis. q_{ab} is the distributed load in the direction of the a-axis and has its intensity per unit of length along the b-axis.

Note: Concentrated loads may not be input at a distance of 0.0.

AXIS OPTION 1

(1st card of set)	Load Type	←Blank, if 2nd card used	→	Num Cards Follow	Axis Option
		Uniform Load // to x′-Axis	Uniform Load // to y′-Axis		
		$q_{x'x'}$	$q_{y'x'}$		1
	6 10	31 (f/d) 40	(f/d) 50	56 60	65

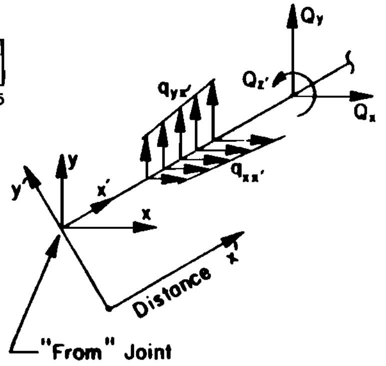
(2nd and succeeding cards of set)	From (Distance along Member)	To (Distance along Member)	Load // to x′-Axis	Load // to y′-Axis	Moment about z′-Axis
	x'	x'	$Q_{x'}$, $q_{x'x'}$	$Q_{y'}$, $q_{y'x'}$	$Q_{z'}$, $q_{z'x'}$
	11 (d) 20	(d) 30	(f), (f/d) 40	(f) , (f/d) 50	(fd) , (f) 60



AXIS OPTION 2

(1st card of set)	Load Type	←Blank, if 2nd Card used	→	Num Cards Follow	Axis Option
		Uniform Load // to x-Axis	Uniform Load // to y-Axis		
		$q_{xx'}$	$q_{yx'}$		2
	6 10	31 (f/d) 40	(f/d) 50	56 60	65

(2nd and succeeding cards of set)	From (Distance along Member)	To (Distance along Member)	Load // to x-Axis	Load // to y-Axis	Moment about z′-Axis
	x'	x'	Q_x , $q_{xx'}$	Q_y , $q_{yx'}$	$Q_{z'}$, $q_{z'x'}$
	11 (d) 20	(d) 30	(f), (f/d) 40	(f) , (f/d) 50	(fd) , (f) 60



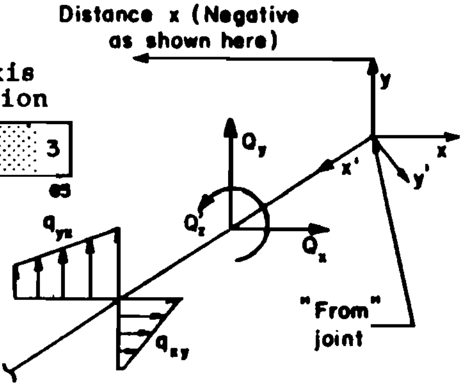
AXIS OPTION 3

(1st card of set)

Load Type	Uniform Load // to x-Axis (Blank if 2nd Card Used)	Uniform Load // to y-Axis (Blank if 2nd Card Used)	Num Cards Follow	Axis Option
	q_{xy} (f/d)	q_{yx} (f/d)		3
6–10	31–40	41–50	56–60	65

(2nd and succeeding cards of set)

From (Distance along Structure Axis)	To (Distance along Structure Axis)	Load // to x-Axis	Load // to y-Axis	Moment about z'-Axis
x (d)	x (d)	Q_x (f) , q_{xy} (f/d)	Q_y (f) , q_{yx} (f/d)	$Q_{z'}$ (fd) , $q_{z'x'}$ (f)
11–20	21–30	31–40	41–50	51–60



AXIS OPTION 4

Axis Option 4 is identical to Axis Option 3 except distances are in structure y-axis and 4 is input in column 65 of first card.

See page 11 of this appendix for an example using the various axis options.

The member x'-axis goes from the "From" joint to the "To" joint. The "From" and "To" joints are determined by input of Table 3.

TABLE 7. COMPILATION TABLE (number of cards per Table 1; no cards unless PROB TYPE 4)

(All cards)

Problem Number	Multiplier
6–10	21–30

GENERAL PROGRAM NOTES

The data cards must be stacked in proper order for the program to run.

A consistent system of units of force (f) and distance (d) must be used for all input data, i.e., pounds and inches.

All 5-space words are understood to be integers . . . . `+4321`

All 10-space words are floating point decimal numbers . . . . `-4.321E+03`

All numbers must be right justified.

The problem number may contain alphanumeric characters.

Blank fields on data cards, except the first five columns, may be used as desired to aid in coding problems. Information in these fields is ignored by the program.

TABLE 1. PROGRAM CONTROL DATA

Type 4 (Family) Problems require only the problem type on the first card and the number of cards in Table 7 on the second card.

Data are accumulated in Tables 2 through 7 until the corresponding Hold Option is left blank.

When a nonfamily problem follows a Family Problem the data in Tables 2 through 6 may be held from the last nonfamily problem worked.

The maximum number of cards accumulated in Table 5 is 75 plus the number of stiffness types.

The maximum number of cards accumulated in Table 6 is 150 plus the number of load types.

Type 1 (Regular) and Type 2 (Parent) Problems may appear at any location in a run. However, Type 3 (Offspring) Problems must follow either their Parent or a related Offspring. Type 4 (Family) Problems must follow either their Parent, a related Offspring, or another Family Problem.

TABLE 2. FRAME GEOMETRY DATA

The first card gives the total number of joints in the frame, which must not exceed 75.

The reference joint, its coordinates, and the joint location tolerance are given only if the Hold Option for Table 2 is not exercised.

A joint number may not be deleted in a series until the Hold Option is not used. However, the joint may be structurally deleted by removing all members intersecting at the joint.

The maximum difference in joint numbers, for joints that are connected by members is 9.

Joints are numbered from 1 to the total number of joints.

The reference joint may be any joint and it may have any coordinates, except that it and all other joints must have coordinates less than 1.0E50.

The second and succeeding cards in Table 2 specify the location of all additional joints in the frame at least once. If the Hold Option is used, only the new joints must be specified.

All offsets must be "From" a previously located joint "To" another joint. The "To" joint may be a previously defined joint. This allows the user to check the locations of the joints. If the error in the location of the joint is within the joint location tolerance then the solution continues; otherwise, the solution terminates with an appropriate diagnostic.

The joint location tolerance should allow for normal round-off error. If offsets are input to the nearest 0.01 foot then a joint location tolerance of 0.03 foot usually will be sufficient for a moderate sized frame.

The repetition of the "To" joint allows the user to locate up to seven joints with one card, if the offsets between each new "To" joint are the same as between the "From" joint and the first "To" joint.

It is not necessary for offsets to be given at locations where members are. However, the location of all joints must be specified at least once.

TABLE 3. MEMBER TYPE LOCATION

The first card in Table 3 gives the total number of stiffness types and the total number of load types.

Stiffness and load types (other than zero) are numbered from one to their total number. The total number of stiffness types must not exceed 50. The total number of load types must not exceed 50.

The total number of members in the frame must not exceed 150.

Type zero stiffness is used to delete a previously defined stiffness. Type zero load is used to indicate no load on a member. The restrictions on length, orientation, etc., outlined below do not apply to members with type zero stiffness and type zero load.

In order for two members to have the same stiffness type they must have the same length, the same angular orientation in the frame, and the same stiffness properties with respect to their "From" and "To" joints, i.e., they must have the same member stiffness matrix both in their member coordinate system and the global coordinate system.

In order for two members to have the same load type they must have the same length, the same angular orientation in the frame and the same loading with respect to their "From" and "To" joints.

The member coordinate axes are defined by the "From" and "To" joints specified. The member x′-axis starts at the "From" joint and goes to the "To" joint. The member y′-axis and z′-axis are located from the member x′-axis by the right hand rule.

All members in the frame must be assigned a stiffness type and a load type. This assignment is not accumulative for a member in the frame, i.e., the last values of stiffness type and load type specified replace the previous values.

Stiffness and load types for a member must be specified on the same card.

Up to ten members with the same stiffness and load type may be located with a single card if the "From" joint of each new member is the "To" joint of the previous one.

TABLE 4. JOINT LOADS AND RESTRAINTS

All joint loads and restraints are specified with respect to the structure axes.

Joint loads and restraints are accumulated in Table 4.

Structure supports are input as joint restraints (linearly elastic springs). Complete fixity of a joint may be achieved by putting in very large spring values. No round-off errors are encountered when extremely large values are used unless large values are input and then subtracted away.

Complete freedom of joint movements is obtained by not specifying any restraints at a joint.

A specified displacement may be obtained by specifying a very large restraint and a corresponding force equal to the specified displacement times the large restraint.

TABLE 5. MEMBER STIFFNESS DATA

Stiffness types must be input in ascending order. If Table 5 is held from the previous problem then the first new stiffness type in Table 5 (if any) must equal the number of stiffness types in the last problem plus one.

Prismatic members may be input with one card. Members with varying stiffness and/or elastic restraints along their length require two or more cards.

If more than one card is used to describe a member stiffness type, the prismatic stiffness properties must be left blank.

Variable stiffness properties must be input continuously in sections starting at the "From" joint and continuing uninterrupted to the "To" joint. This format is illustrated in page 10 of this appendix.

Distances are given from the "From" joint.

Each section must describe all of the stiffness properties of the member for a length greater than 1/40 of the member's length.

Constant values of stiffness require one card per section.

A linear variation in stiffness requires two cards per section.

Concentrated values of stiffness are not allowed. A point of zero flexural stiffness is input as a pin at a joint. A concentrated spring restraint must be input as a joint restraint.

TABLE 6. MEMBER LOAD DATA

Load types must be input in ascending order. If Table 6 is held from the previous problem then the first new load type in Table 6 (if any) must equal the number of load types in the last problem plus one.

Load types with only uniform loads over their full length may be input with only one card. Other loadings require two or more cards.

If more than one card is used to describe a member load type, the uniform loads on the first card must be left blank.

Variable, concentrated, and partial uniform loadings must be input in sections but need not be input consecutively and sections may overlap. This format is illustrated on page 11 of this appendix.

Section lengths must exceed 1/40 of the member's length except for concentrated loads where the "From" and "To" distances are equal. Concentrated loads may not be specified at a distance of 0.0.

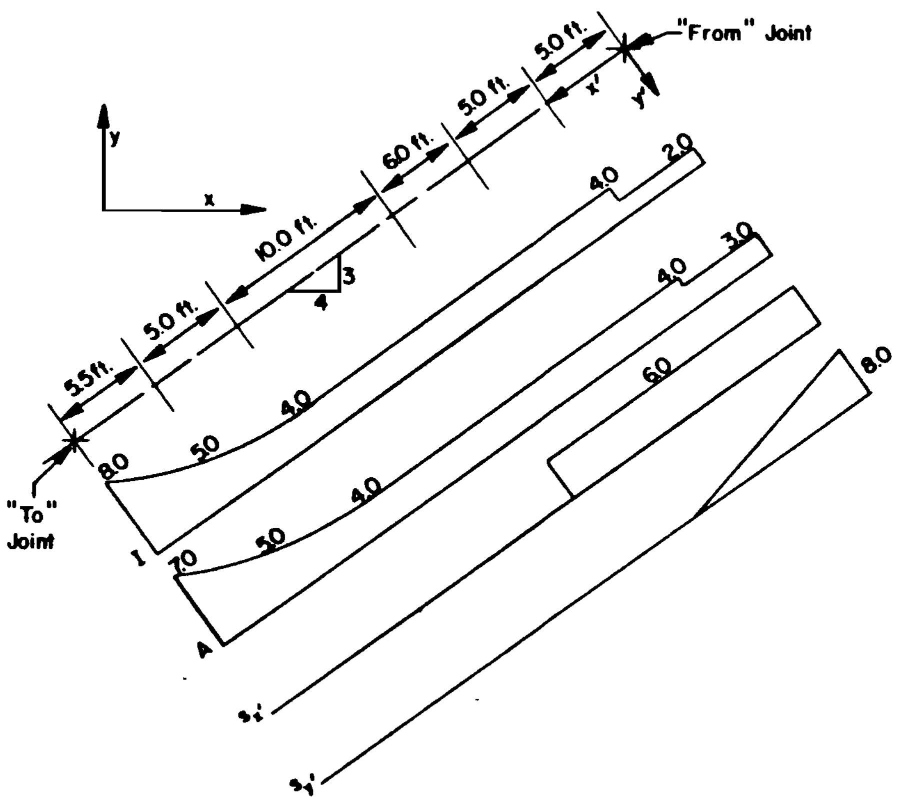
All sections except concentrated loads must have their "To" distance larger in absolute value than their "From" distance.

Concentrated loads and sections with constant loading require one card. A linear variation in loading requires two cards per section.

TABLE 7. COMPILATION TABLE

Each Parent Problem starts a series where the Parent solution and succeeding Offspring solutions are stored. Each of these solutions may be multiplied by a multiplier (load factor) and accumulated. The maximum number of consecutive Offspring problems is 20.

If the Hold Option is used the solution of the preceding Family Problem is added to the solutions of the additional load cases specified in the new Family Problem.



Notes: Sections must be input in order.

Linear format is required even if only one of the stiffness properties varies linearly.

A new section must be started when a change in the variation of any of the stiffness properties occurs.

There is no restriction on the length of a section except it must exceed 1/40 of members length.

"From" and "To" joints are set by input in Table 3.

Variable Member Stiffness

	From	To	I	A	$s_{x'}$	$s_{y'}$	$s_{z'}$
*	0.0		2.0	3.0	6.0	8.0	
		5.0	2.0	3.0	6.0	4.0	
*	5.0		4.0	4.0	6.0	4.0	
		10.0	4.0	4.0	6.0	0.0	
•	10.0	16.0	4.0	4.0	6.0		
•	16.0	26.0	4.0	4.0			
*	26.0		4.0	4.0			
		31.0	5.0	5.0			
*	31.0		5.0	5.0			
		36.5	8.0	7.0			

Axis Option 1

*	0.0		2.0	3.0	6.0	8.0	
		-4.0	2.0	3.0	6.0	4.0	
*	-4.0		4.0	4.0	6.0	4.0	
		-8.0	4.0	4.0	6.0	0.0	
•	-8.0	-12.8	4.0	4.0	6.0		
•	-12.8	-20.8	4.0	4.0			
*	-20.8		4.0	4.0			
		-24.8	5.0	5.0			
*	-24.8		5.0	5.0			
		-29.2	8.0	7.0			

Axis Option 2

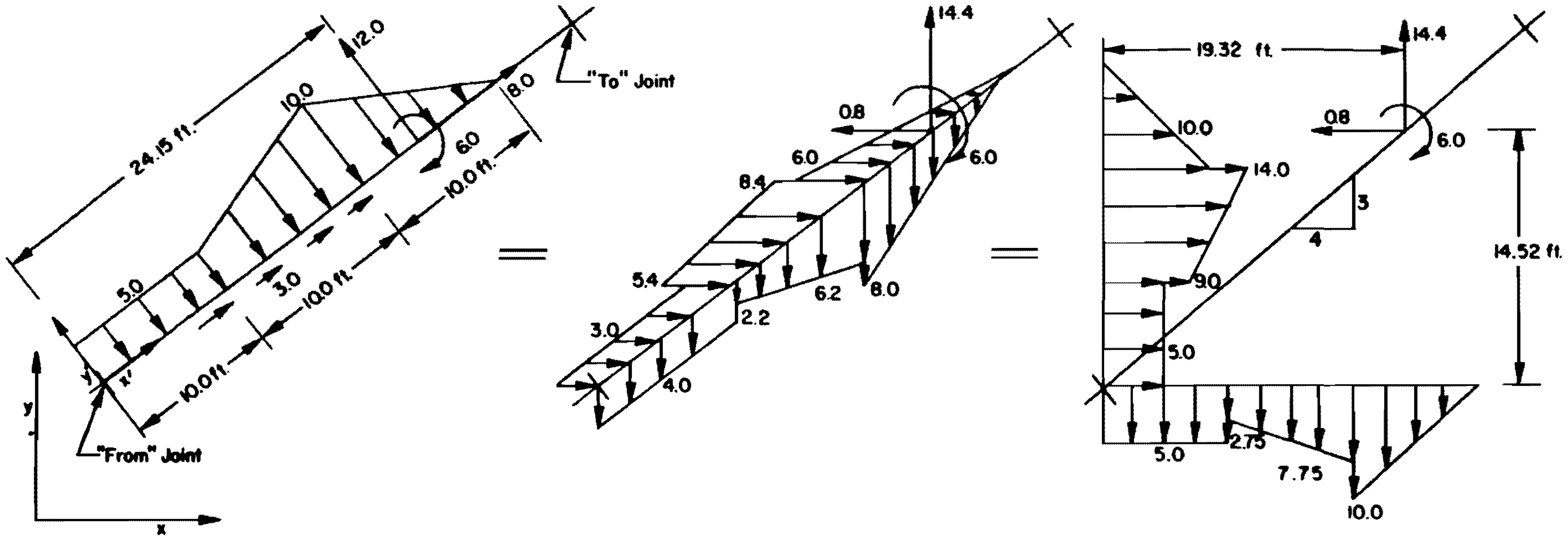
*	0.0		2.0	3.0	6.0	8.0	
		-3.0	2.0	3.0	6.0	4.0	
*	-3.0		4.0	4.0	6.0	4.0	
		-6.0	4.0	4.0	6.0	0.0	
•	-6.0	-9.6	4.0	4.0	6.0		
•	-9.6	-15.6	4.0	4.0			
*	-15.6		4.0	4.0			
		-18.6	5.0	5.0			
*	-18.6		5.0	5.0			
		-21.9	8.0	7.0			

Axis Option 3

* - Two Cards for Sections with Linearly Varying Stiffness

• - One Card for Sections with Constant Stiffness

Variable Member Loading



Axis Option 1

	From	To	$Q_{x'}, q_{x'x'}$	$Q_{y'}, q_{y'x'}$	$Q_{z'}, q_{z'x'}$
●	0.0	10.0		-5.0	
*	10.0		3.0	-5.0	
		20.0	3.0	-10.0	
○	24.15	24.15	8.0	12.0	-6.0
*	20.0			-10.0	
		30.0		0.0	

Axis Option 2

From	To	$Q_x, q_{xx'}$	$Q_y, q_{yx'}$	$Q_z, q_{zx'}$
0.0	10.0	3.0	-4.0	
10.0		5.4	-2.2	
	20.0	8.4	-6.2	
24.15	24.15	-0.8	14.4	-6.0
20.0		6.0	-8.0	
	30.0	0.0	0.0	

Axis Option 3

From	To	Q_x, q_{xy}	Q_y, q_{yx}	$Q_z, q_{z'x'}$
0.0	8.0	5.0	-5.0	
8.0		9.0	-2.75	
	16.0	14.0	-7.75	
19.32	19.32	-0.8	14.4	-6.0
16.0		10.0	-10.0	
	24.0	0.0	0.0	

Axis Option 4

From	To	Q_x, q_{xy}	Q_y, q_{yx}	$Q_z, q_{z'x'}$
0.0	6.0	5.0	-5.0	
6.0		9.0	-2.75	
	12.0	14.0	-7.75	
14.52	14.52	-0.8	14.4	-6.0
12.0		10.0	-10.0	
	18.0	0.0	0.0	

○ - One Card for Concentrated Loads

● - One Card for Sections with Uniform Loads

* - Two Cards for Sections with Linearly Varying Loads

Notes:

There is No Restriction on the Length of a Section Except that it Must Exceed 1/40 of the Member's Length.

"From" and "To" Joints Set by Input in Table 3.

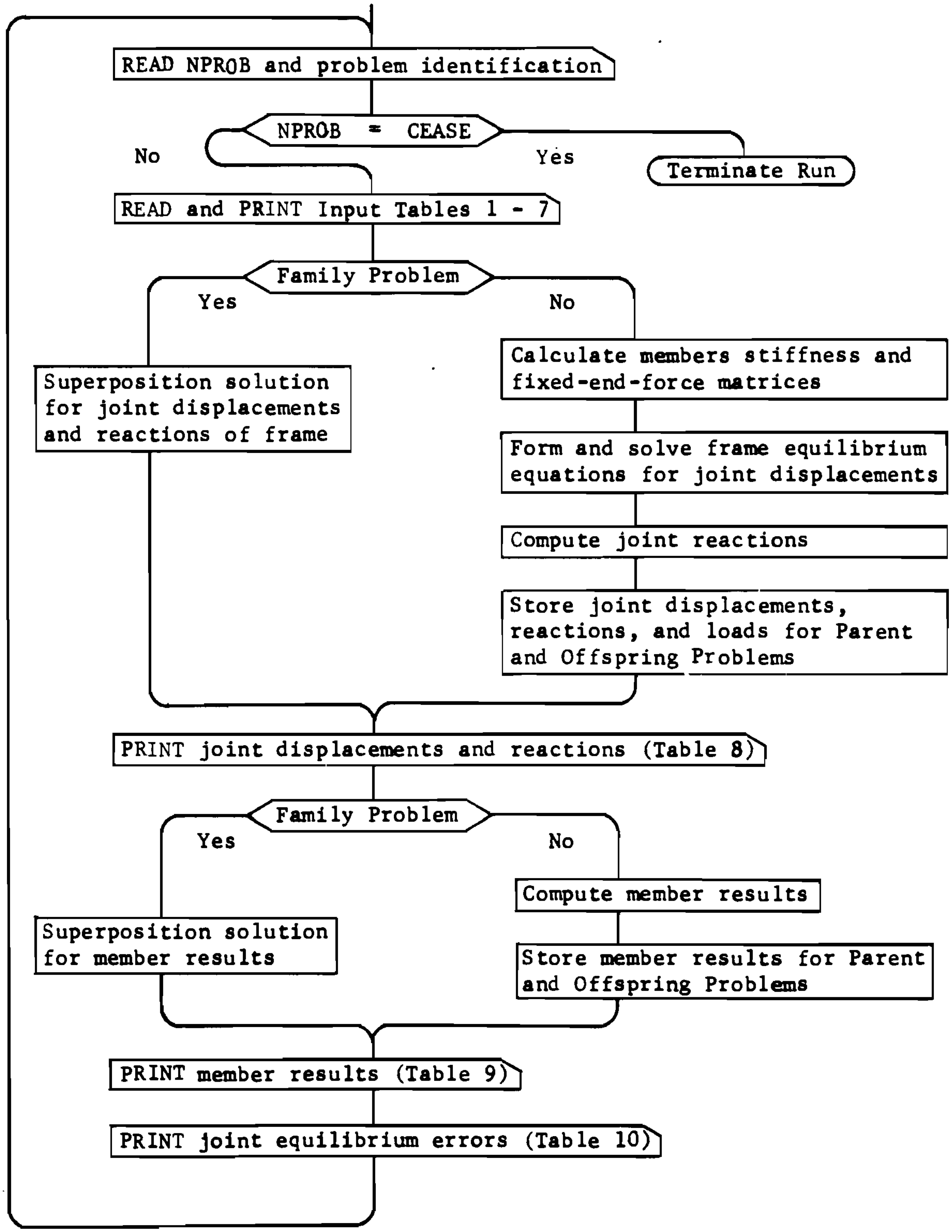
Sections Need Not be Input in Order.

Concentrated Loads May Not be Input at a Distance of 0.0.

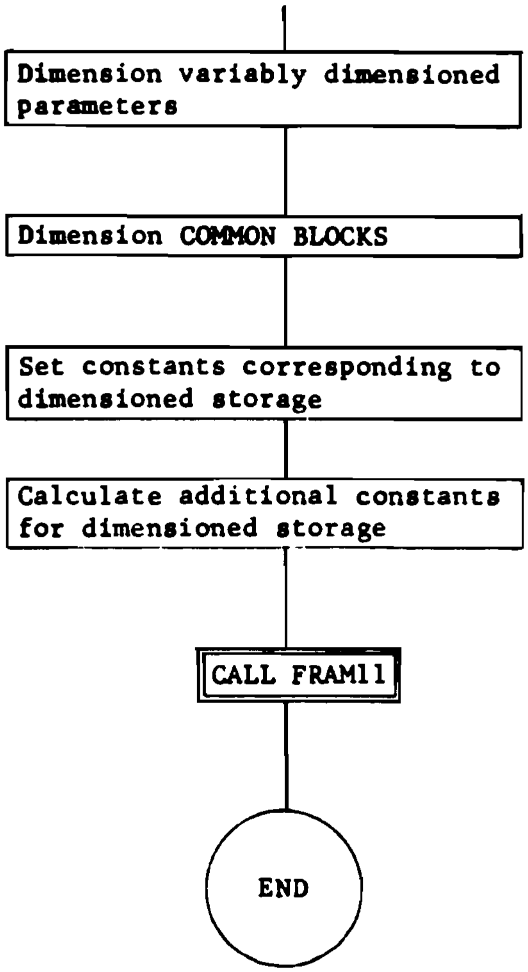
APPENDIX 3

PROGRAM FLOW CHARTS

SUMMARY FLOW DIAGRAM FOR FRAME 11



FLOW DIAGRAM FOR FRAME 11



Need be changed only in this routine

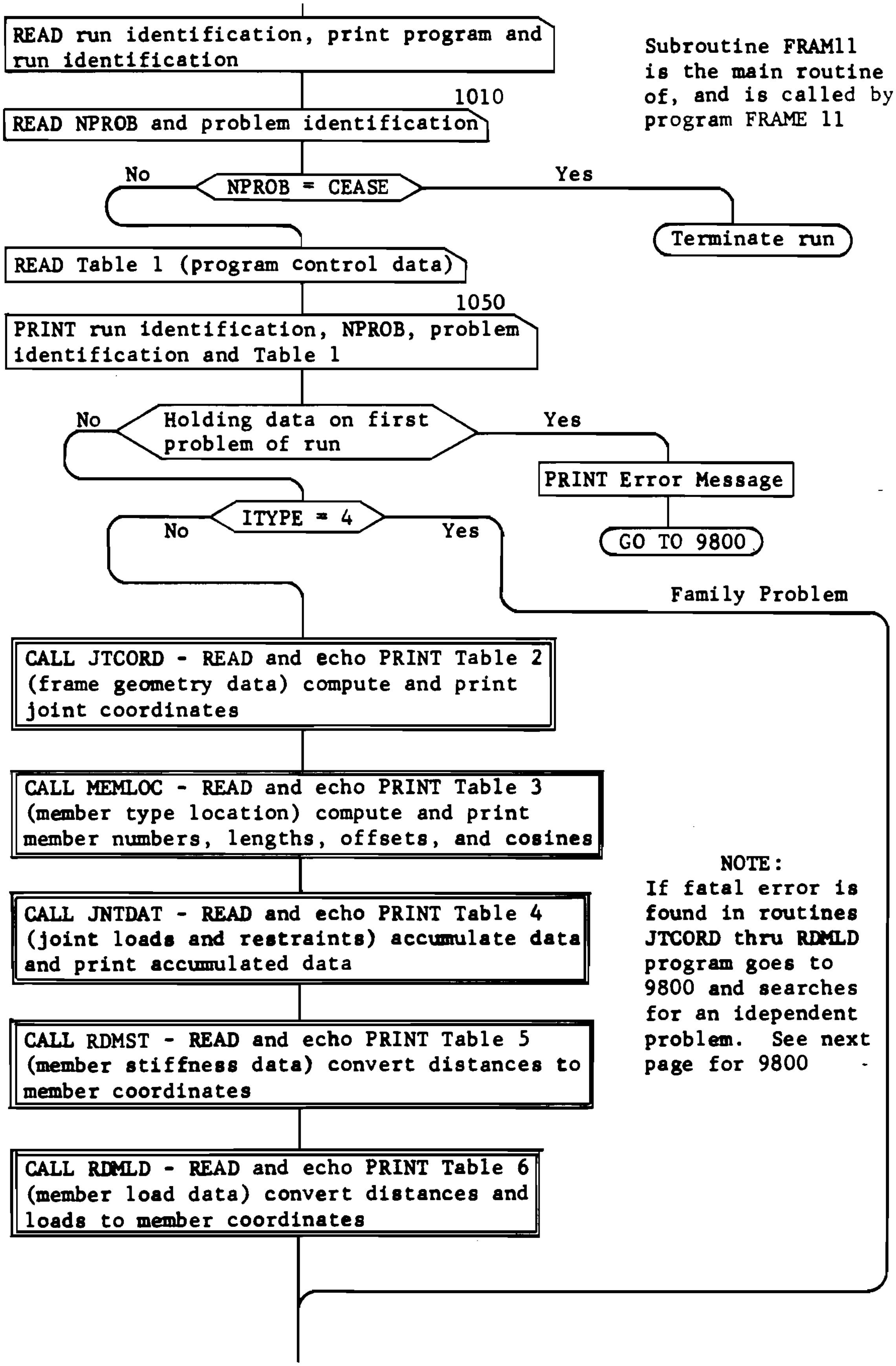
Change in all routines in which common blocks appear

Change to match above changes

Main subroutine

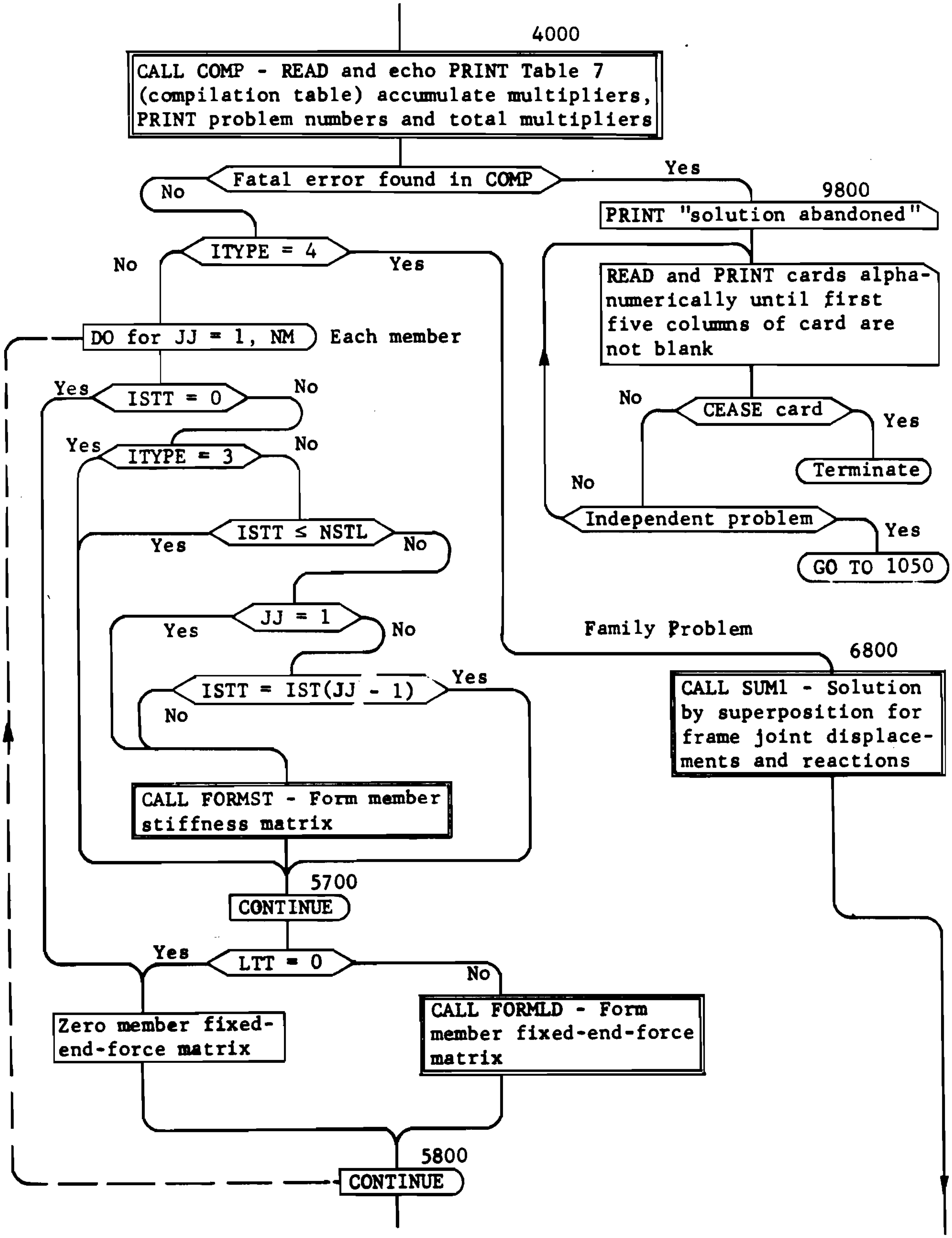
Program dimensions may be easily changed as indicated above. See the program listing and the notation.

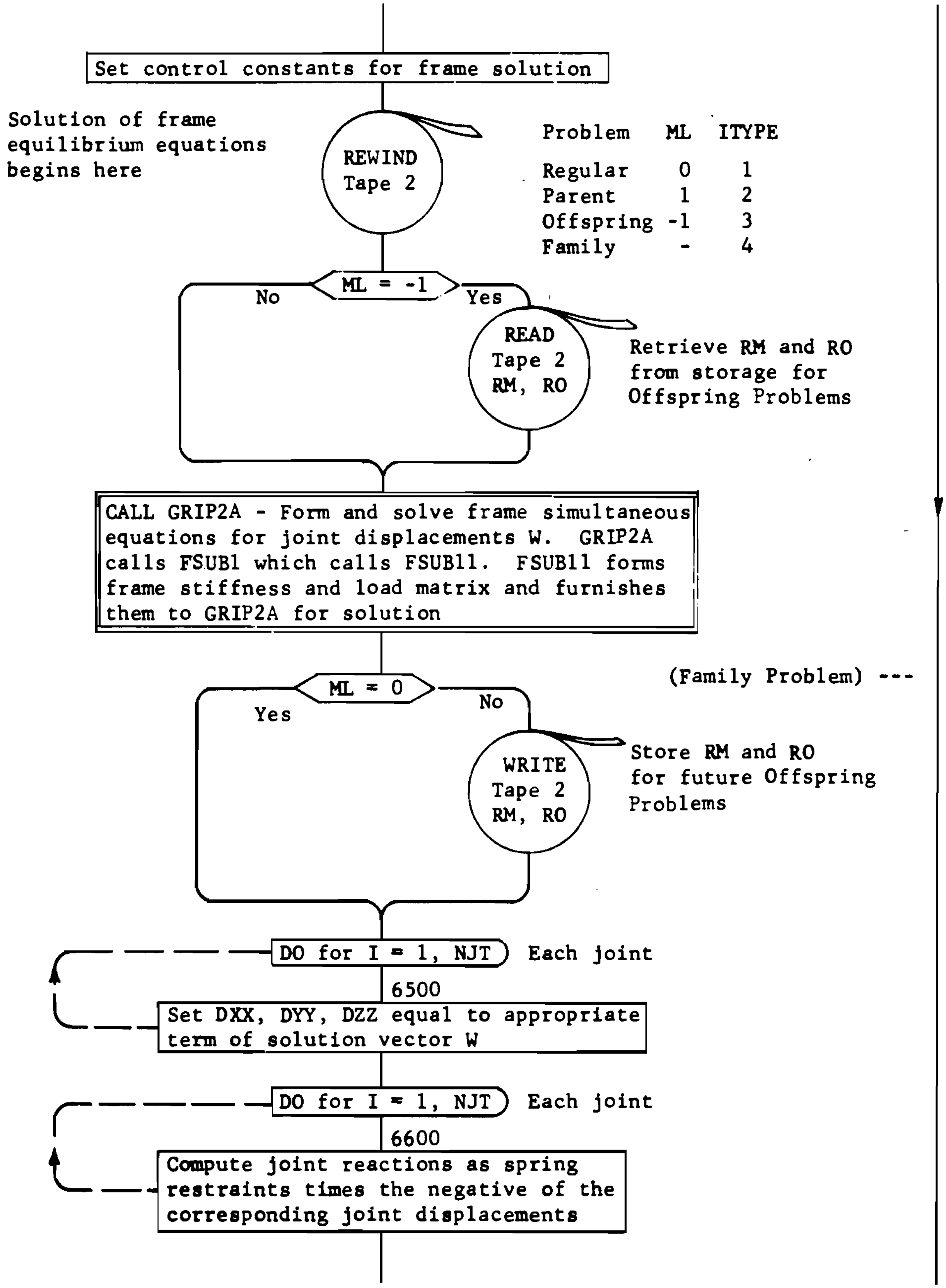
FLOW DIAGRAM FOR SUBROUTINE FRAM11

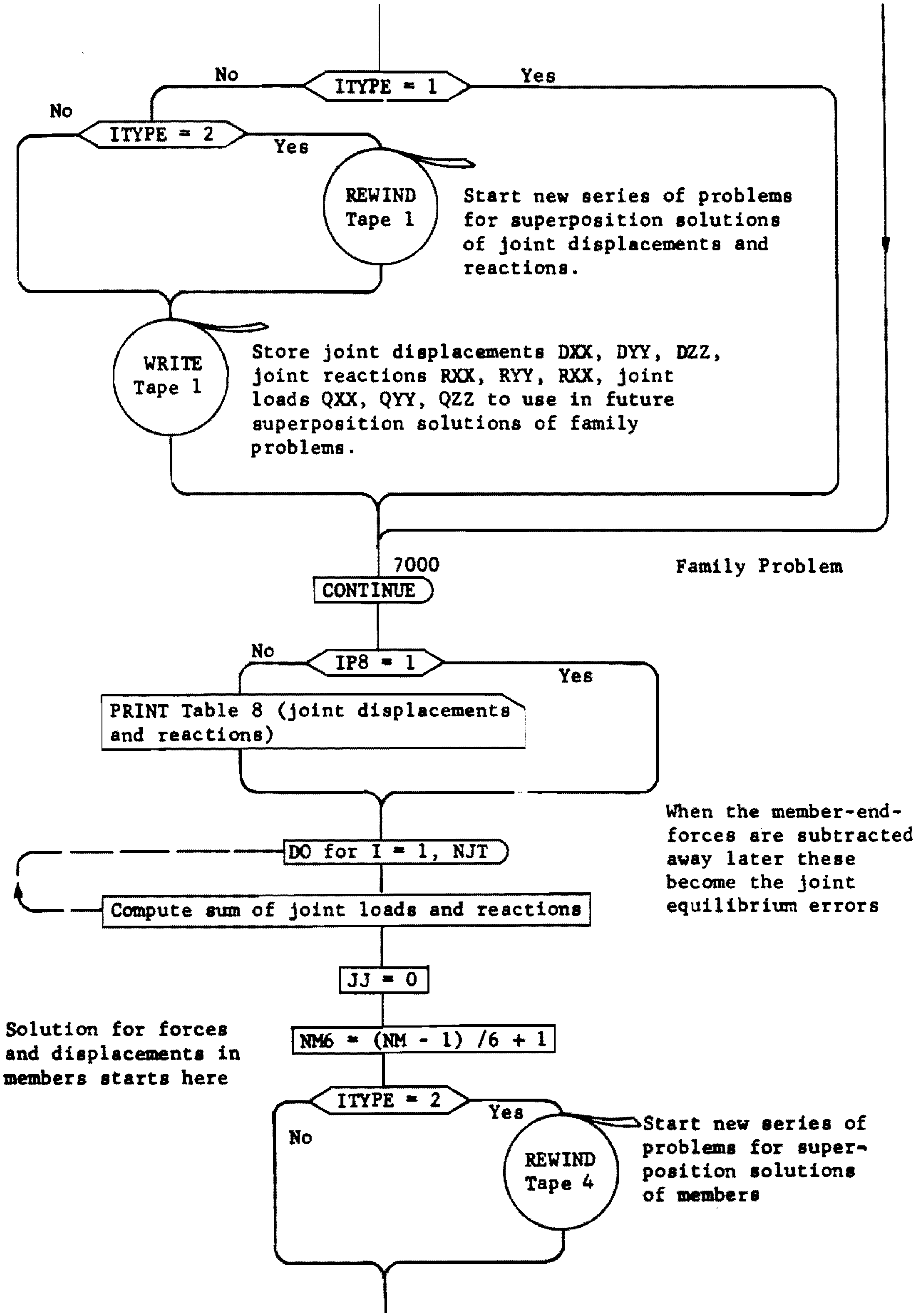


Subroutine FRAM11 is the main routine of, and is called by, program FRAME 11

NOTE:
If fatal error is found in routines JTCORD thru RDMLD program goes to 9800 and searches for an idependent problem. See next page for 9800


4000
CALL COMP - READ and echo PRINT Table 7 (compilation table) accumulate multipliers, PRINT problem numbers and total multipliers
Fatal error found in COMP
No
Yes
9800
PRINT "solution abandoned"
ITYPE = 4
No
Yes
READ and PRINT cards alphanumerically until first five columns of card are not blank
DO for JJ = 1, NM
Each member
ISTT = 0
Yes
No
No
CEASE card
Yes
ITYPE = 3
Yes
No
Terminate
No
Independent problem
Yes
ISTT ≤ NSTL
Yes
No
GO TO 1050
JJ = 1
Yes
No
Family Problem
6800
ISTT = IST(JJ - 1)
Yes
No
CALL SUM1 - Solution by superposition for frame joint displacements and reactions
CALL FORMST - Form member stiffness matrix
5700
CONTINUE
LTT = 0
Yes
No
Zero member fixed-end-force matrix
CALL FORMLD - Form member fixed-end-force matrix
5800
CONTINUE


Set control constants for frame solution
Solution of frame equilibrium equations begins here
REWIND Tape 2
Problem ML ITYPE
Regular 0 1
Parent 1 2
Offspring -1 3
Family - 4
ML = -1
No
Yes
READ Tape 2 RM, RO
Retrieve RM and RO from storage for Offspring Problems
CALL GRIP2A - Form and solve frame simultaneous equations for joint displacements W. GRIP2A calls FSUB1 which calls FSUB11. FSUB11 forms frame stiffness and load matrix and furnishes them to GRIP2A for solution
(Family Problem) ---
ML = 0
Yes
No
WRITE Tape 2 RM, RO
Store RM and RO for future Offspring Problems
DO for I = 1, NJT
Each joint
6500
Set DXX, DYY, DZZ equal to appropriate term of solution vector W
DO for I = 1, NJT
Each joint
6600
Compute joint reactions as spring restraints times the negative of the corresponding joint displacements



Start new series of problems for superposition solutions of joint displacements and reactions.

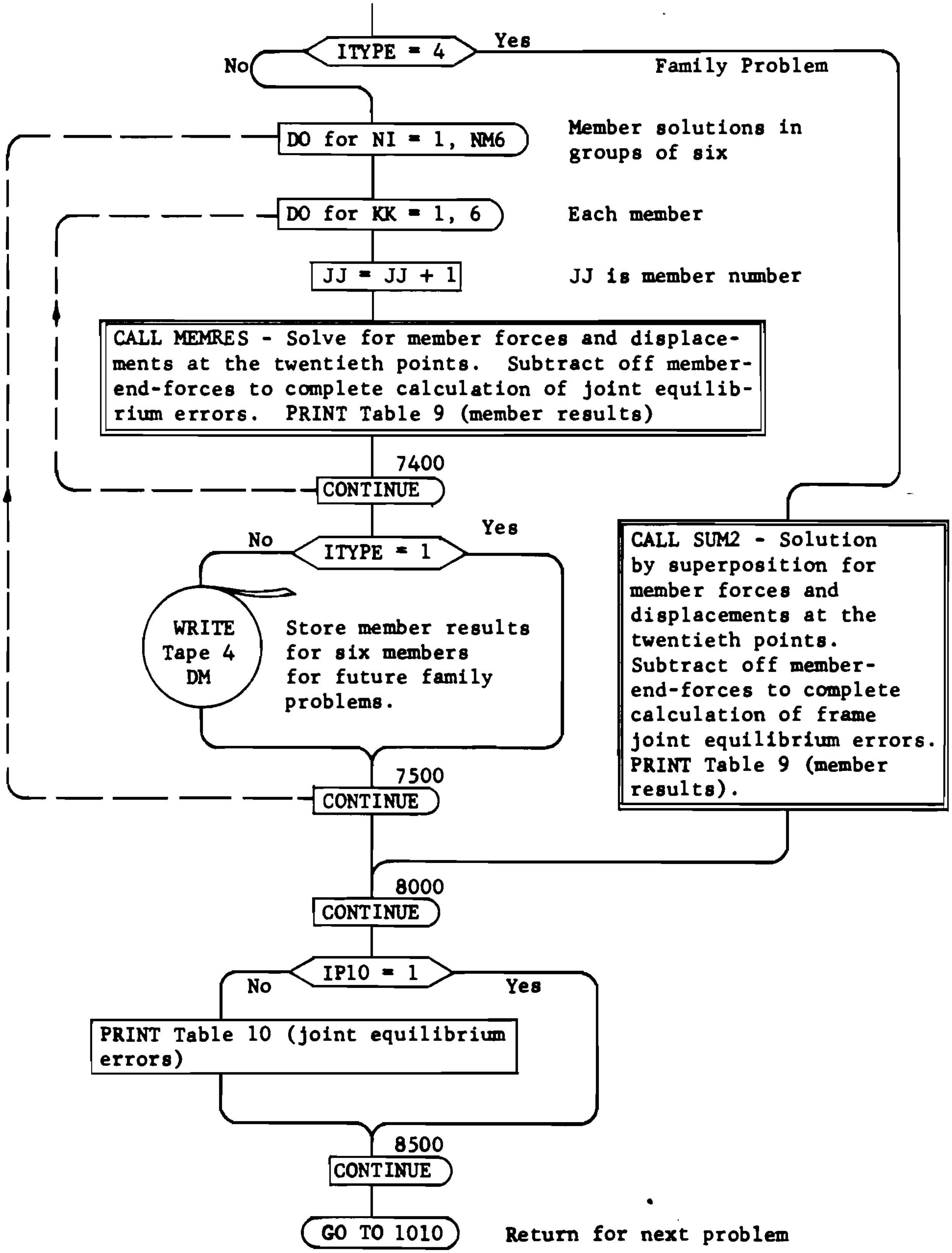
Store joint displacements DXX, DYY, DZZ, joint reactions RXX, RYY, RXX, joint loads QXX, QYY, QZZ to use in future superposition solutions of family problems.

Family Problem

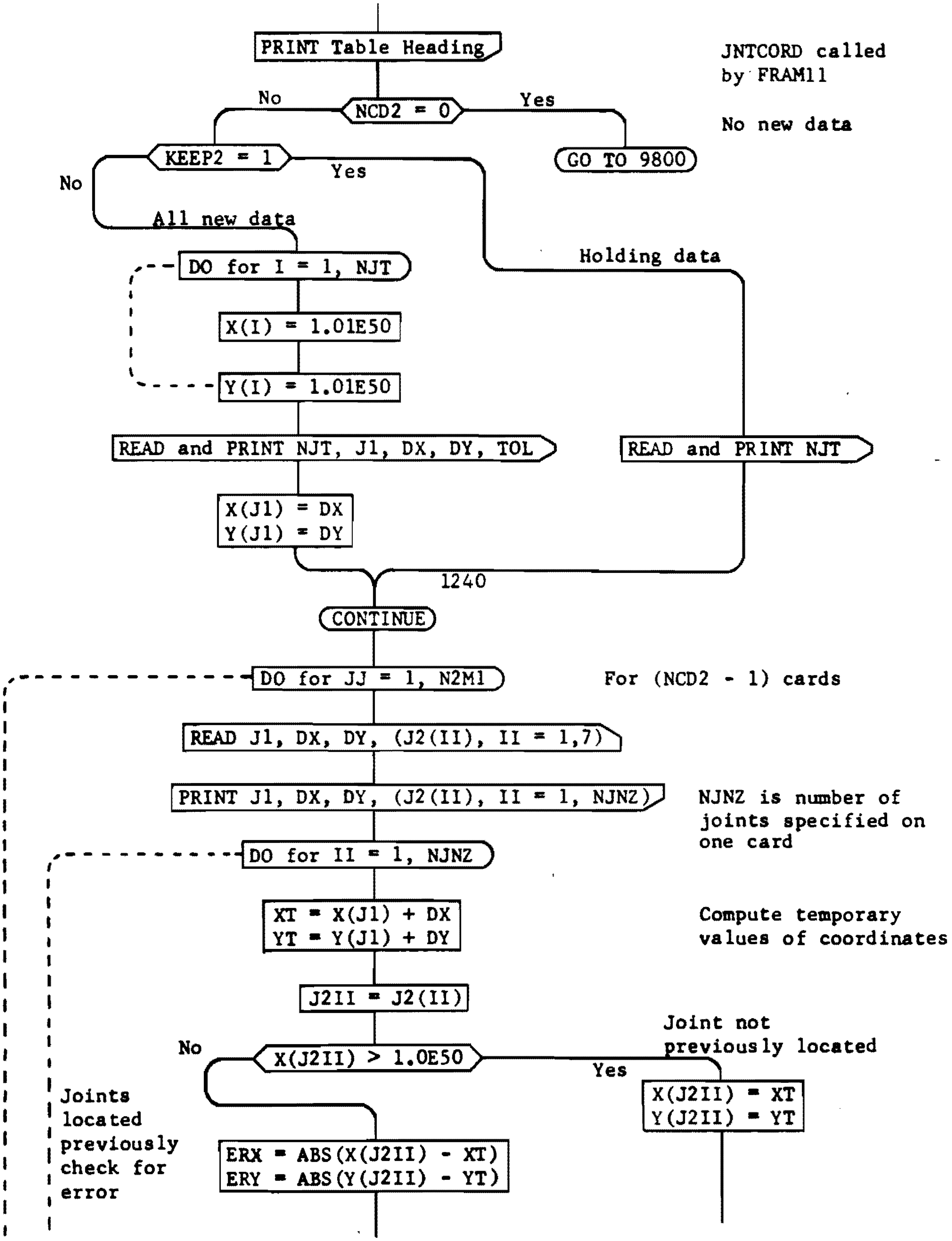
When the member-end-forces are subtracted away later these become the joint equilibrium errors

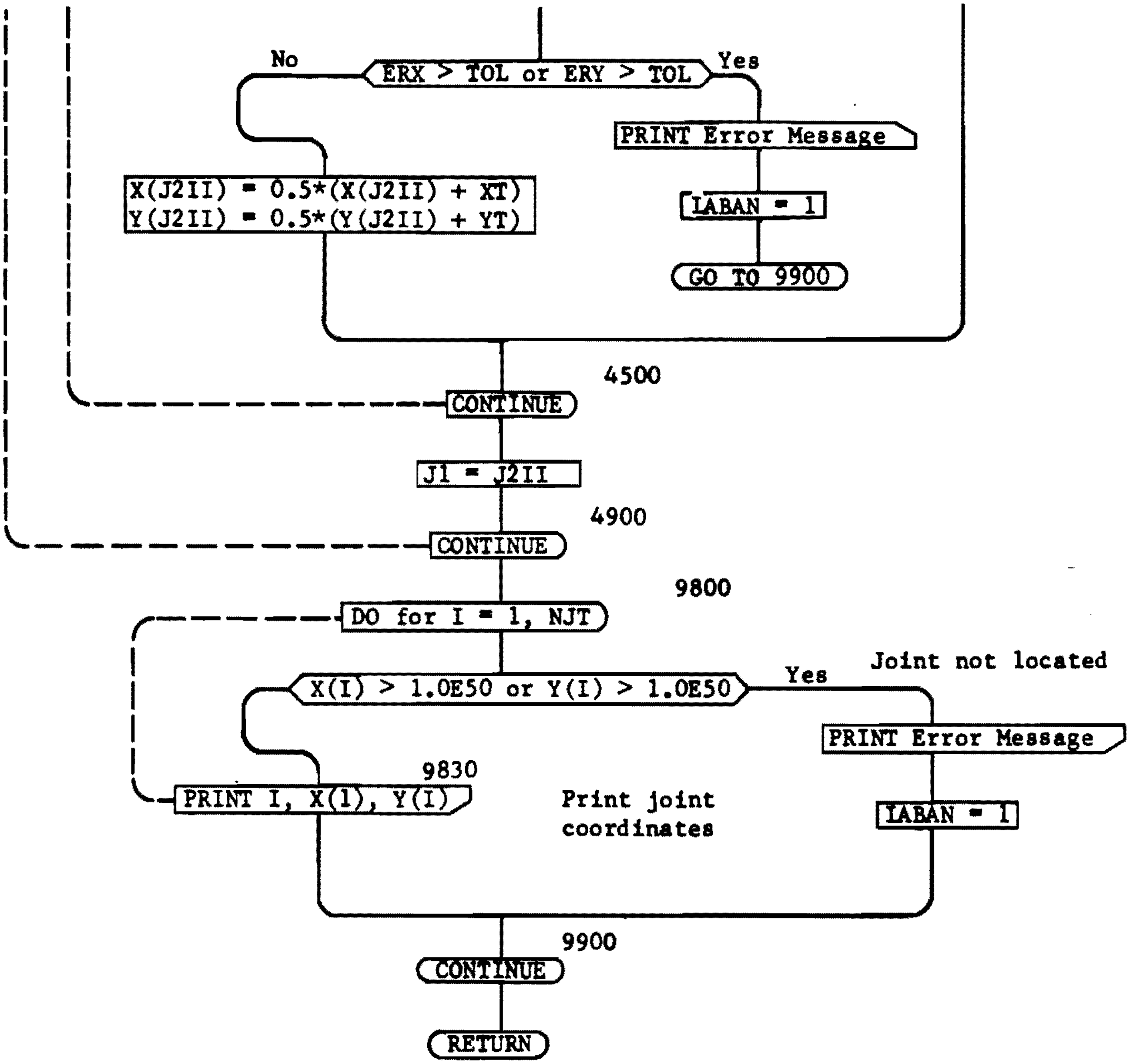
Solution for forces and displacements in members starts here

Start new series of problems for superposition solutions of members


ITYPE = 4
Yes
No
Family Problem
DO for NI = 1, NM6
Member solutions in groups of six
DO for KK = 1, 6
Each member
JJ = JJ + 1
JJ is member number
CALL MEMRES - Solve for member forces and displacements at the twentieth points. Subtract off member-end-forces to complete calculation of joint equilibrium errors. PRINT Table 9 (member results)
7400
CONTINUE
ITYPE = 1
No
Yes
WRITE Tape 4 DM
Store member results for six members for future family problems.
CALL SUM2 - Solution by superposition for member forces and displacements at the twentieth points. Subtract off member-end-forces to complete calculation of frame joint equilibrium errors. PRINT Table 9 (member results).
7500
CONTINUE
8000
CONTINUE
IP10 = 1
No
Yes
PRINT Table 10 (joint equilibrium errors)
8500
CONTINUE
GO TO 1010
Return for next problem

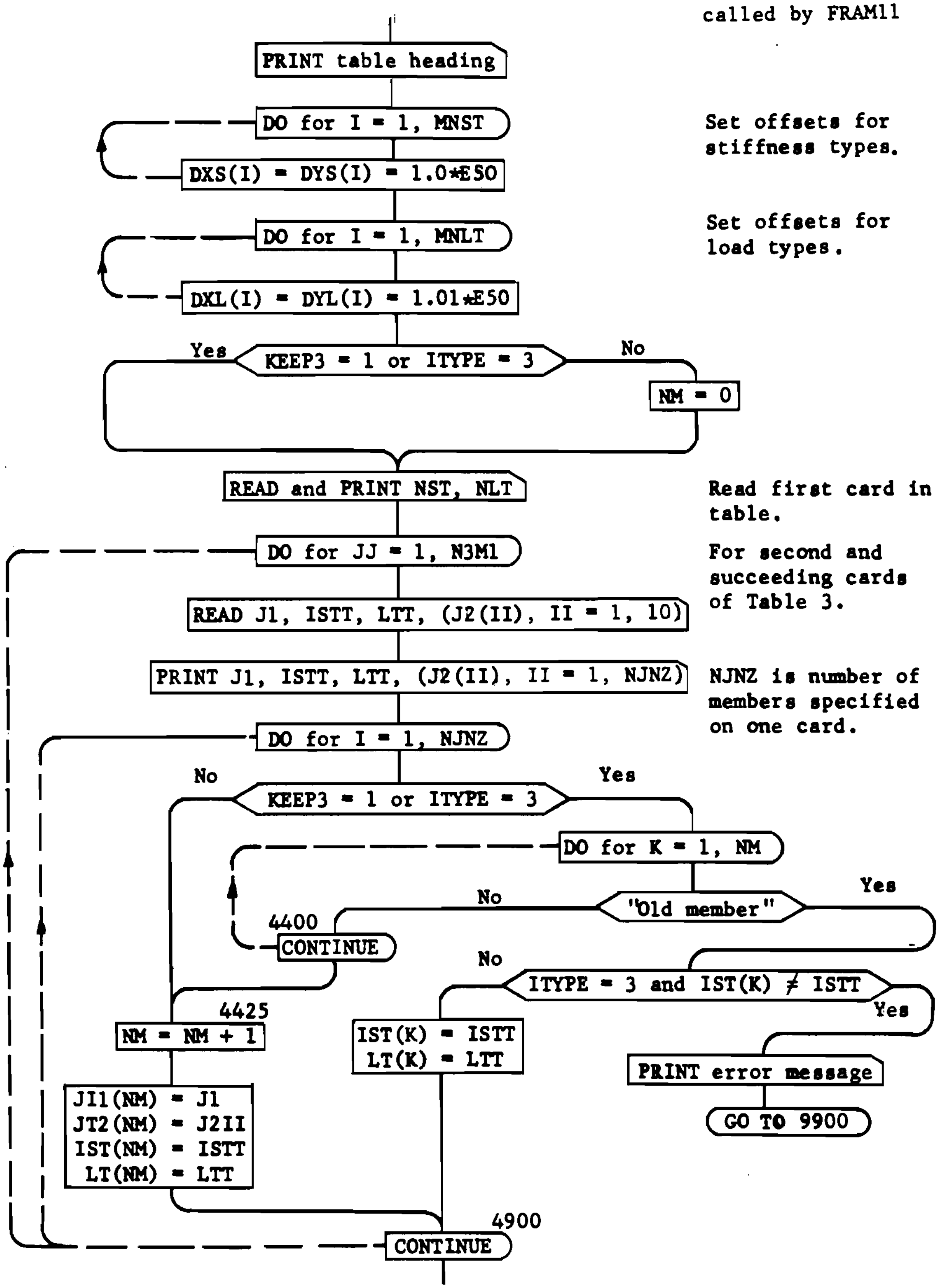
FLOW DIAGRAM FOR SUBROUTINE JNTCORD




No
ERX > TOL or ERY > TOL
Yes
PRINT Error Message
X(J2II) = 0.5*(X(J2II) + XT)
Y(J2II) = 0.5*(Y(J2II) + YT)
IABAN = 1
GO TO 9900
4500
CONTINUE
J1 = J2II
4900
CONTINUE
9800
DO for I = 1, NJT
Yes
Joint not located
X(I) > 1.0E50 or Y(I) > 1.0E50
PRINT Error Message
9830
PRINT I, X(I), Y(I)
Print joint
coordinates
IABAN = 1
9900
CONTINUE
RETURN

SUBROUTINE MEMLOC

Subroutine MEMLOC called by FRAM11



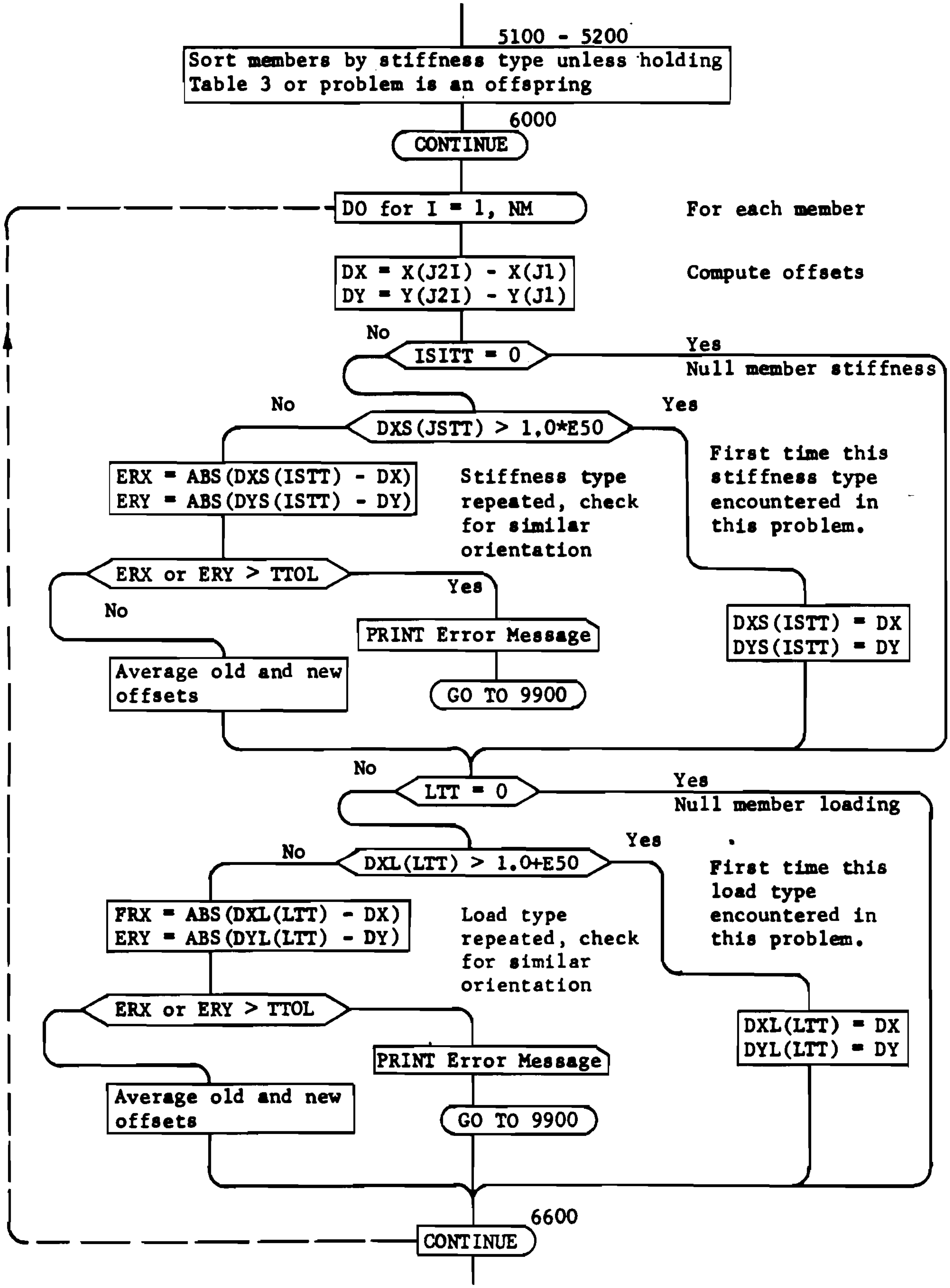
Set offsets for stiffness types.

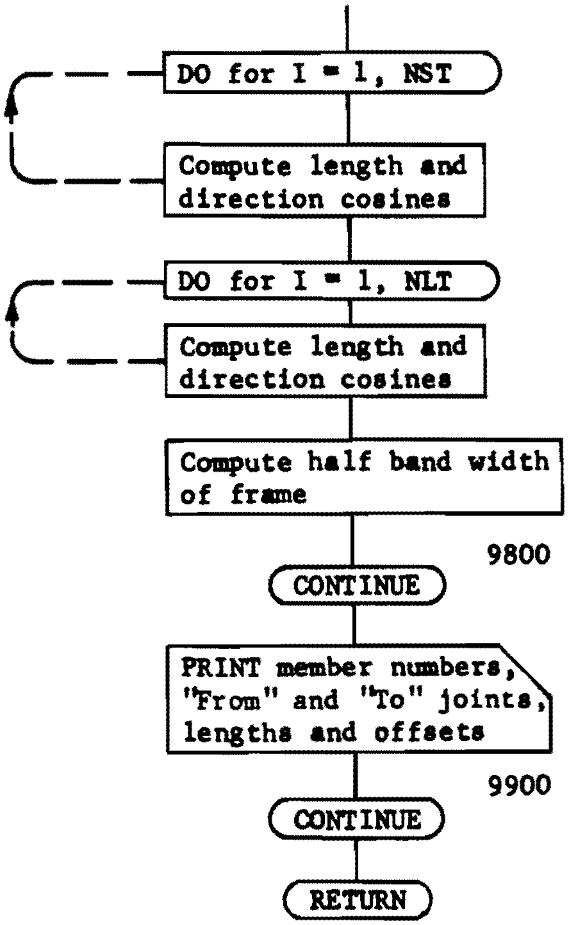
Set offsets for load types.

Read first card in table.

For second and succeeding cards of Table 3.

NJNZ is number of members specified on one card.


5100 - 5200
Sort members by stiffness type unless holding Table 3 or problem is an offspring
6000
CONTINUE
DO for I = 1, NM
For each member
DX = X(J2I) - X(J1)
DY = Y(J2I) - Y(J1)
Compute offsets
No
ISITT = 0
Yes
Null member stiffness
No
DXS(JSTT) > 1,0*E50
Yes
ERX = ABS(DXS(ISTT) - DX)
ERY = ABS(DYS(ISTT) - DY)
Stiffness type repeated, check for similar orientation
First time this stiffness type encountered in this problem.
ERX or ERY > TTOL
Yes
No
PRINT Error Message
DXS(ISTT) = DX
DYS(ISTT) = DY
Average old and new offsets
GO TO 9900
No
LTT = 0
Yes
Null member loading
Yes
No
DXL(LTT) > 1.0+E50
First time this load type encountered in this problem.
FRX = ABS(DXL(LTT) - DX)
ERY = ABS(DYL(LTT) - DY)
Load type repeated, check for similar orientation
ERX or ERY > TTOL
DXL(LTT) = DX
DYL(LTT) = DY
PRINT Error Message
Average old and new offsets
GO TO 9900
6600
CONTINUE

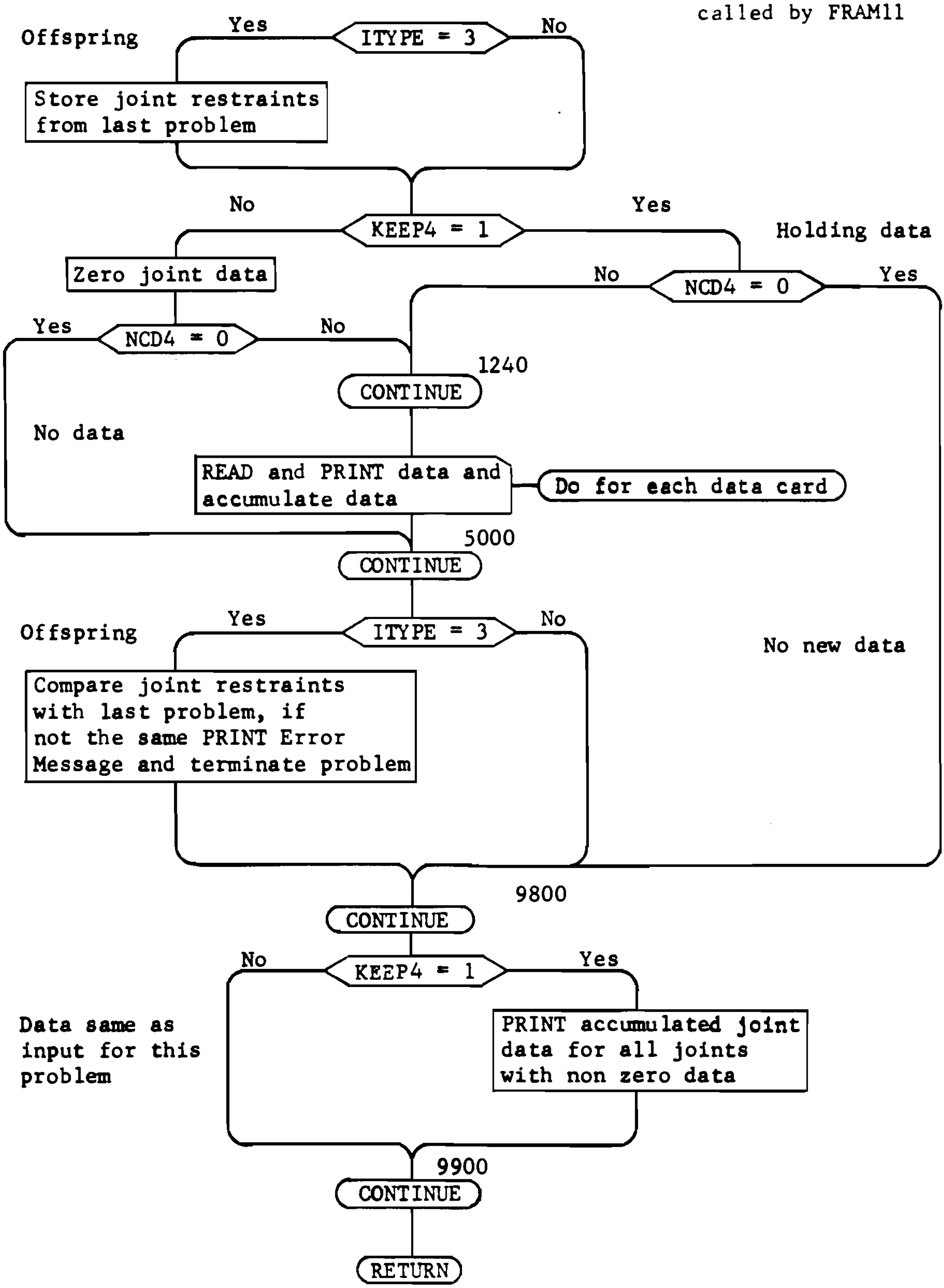


For each stiffness type

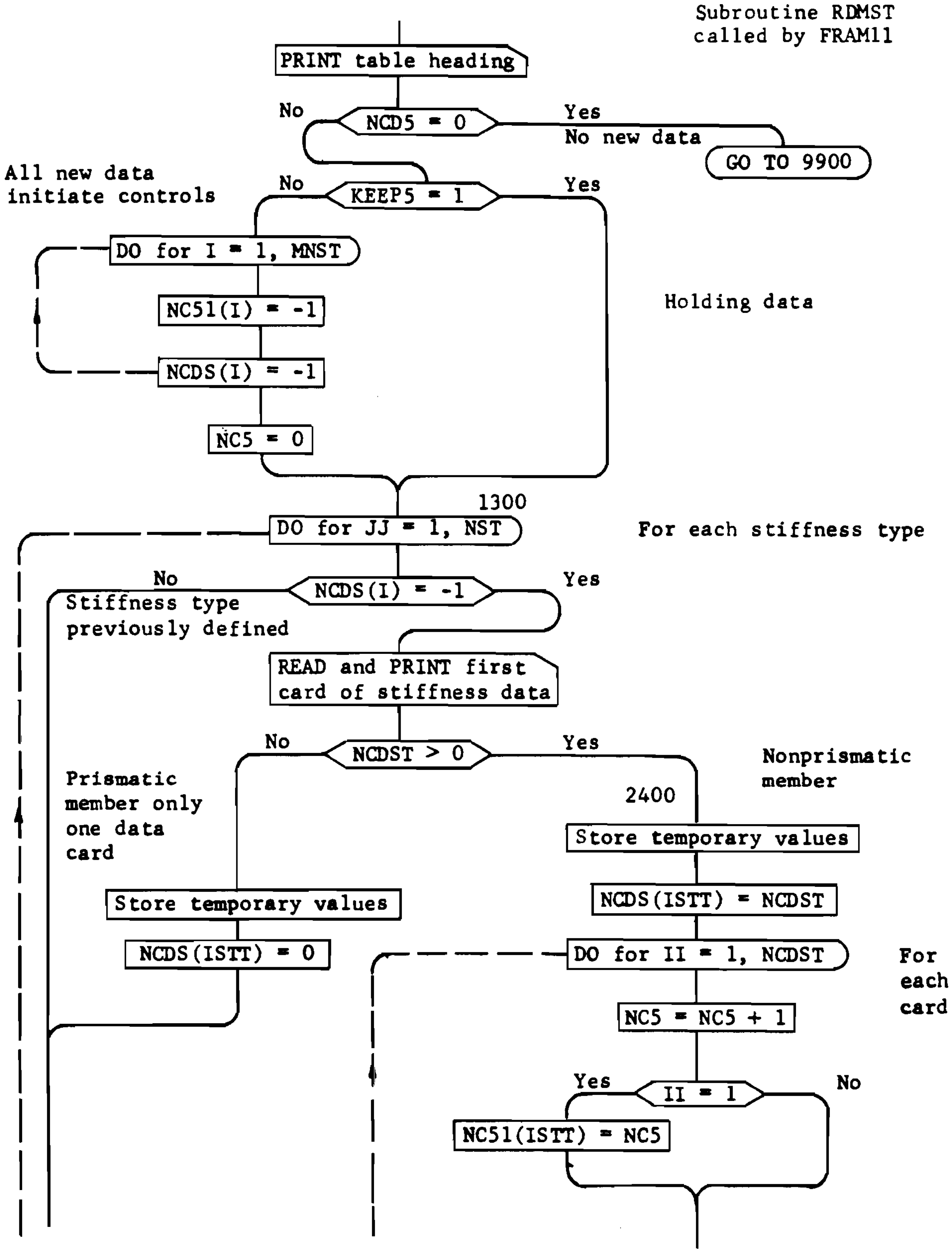
For each load type

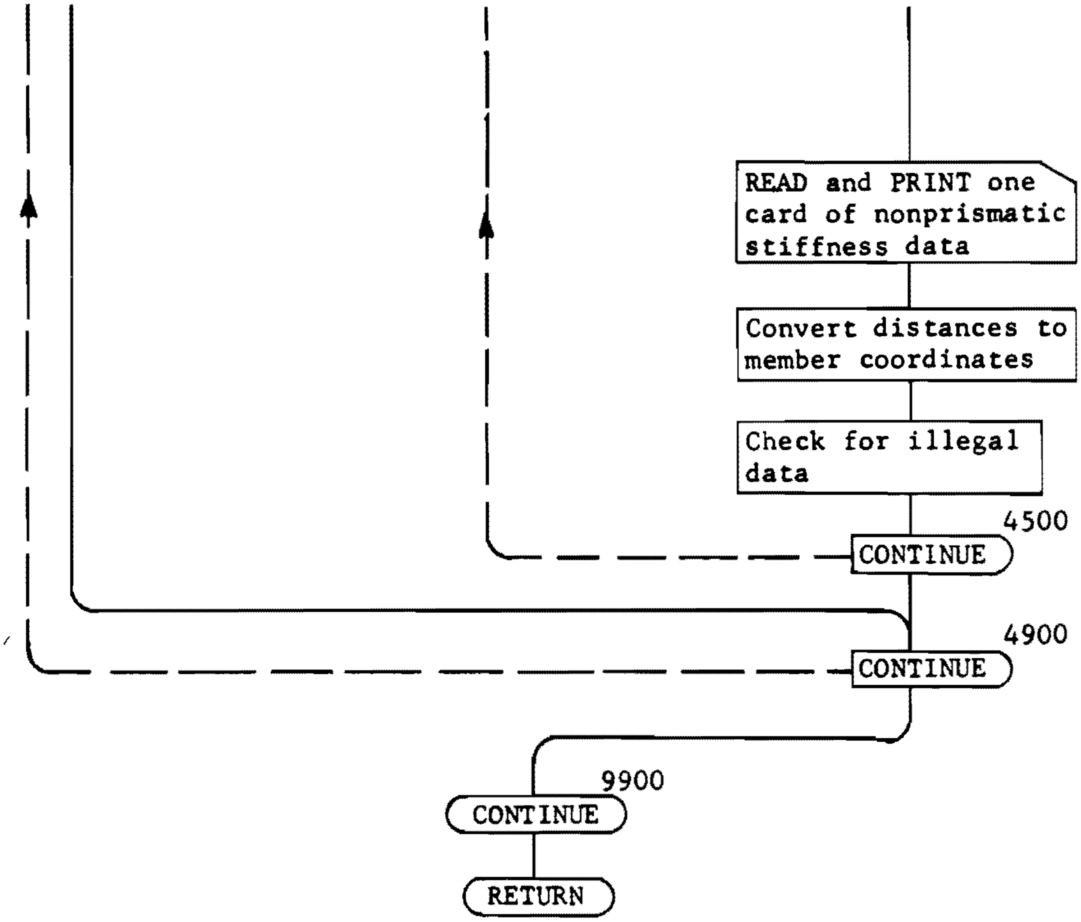
SUBROUTINE JNTDAT

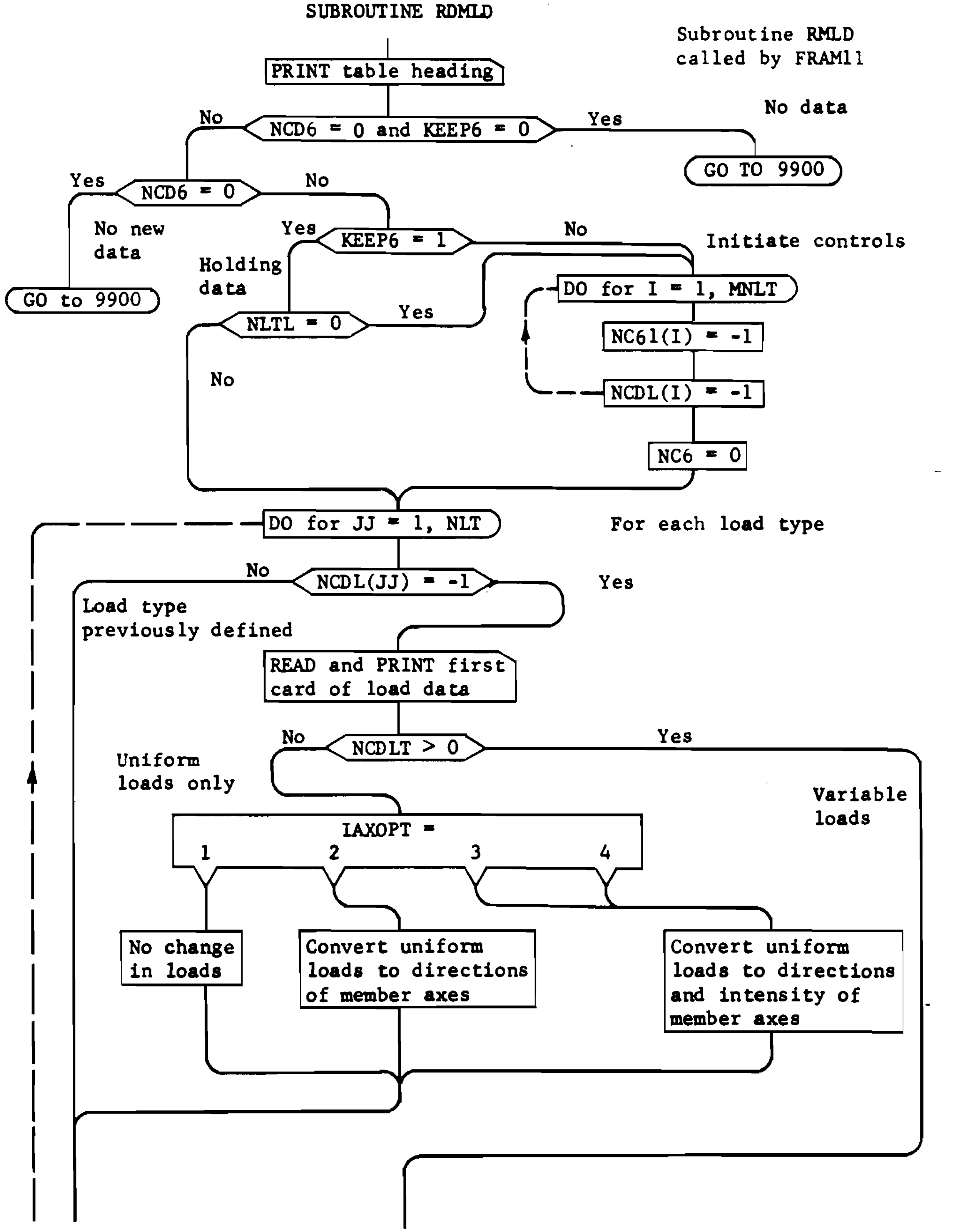
Subroutine JNTDAT
called by FRAM11

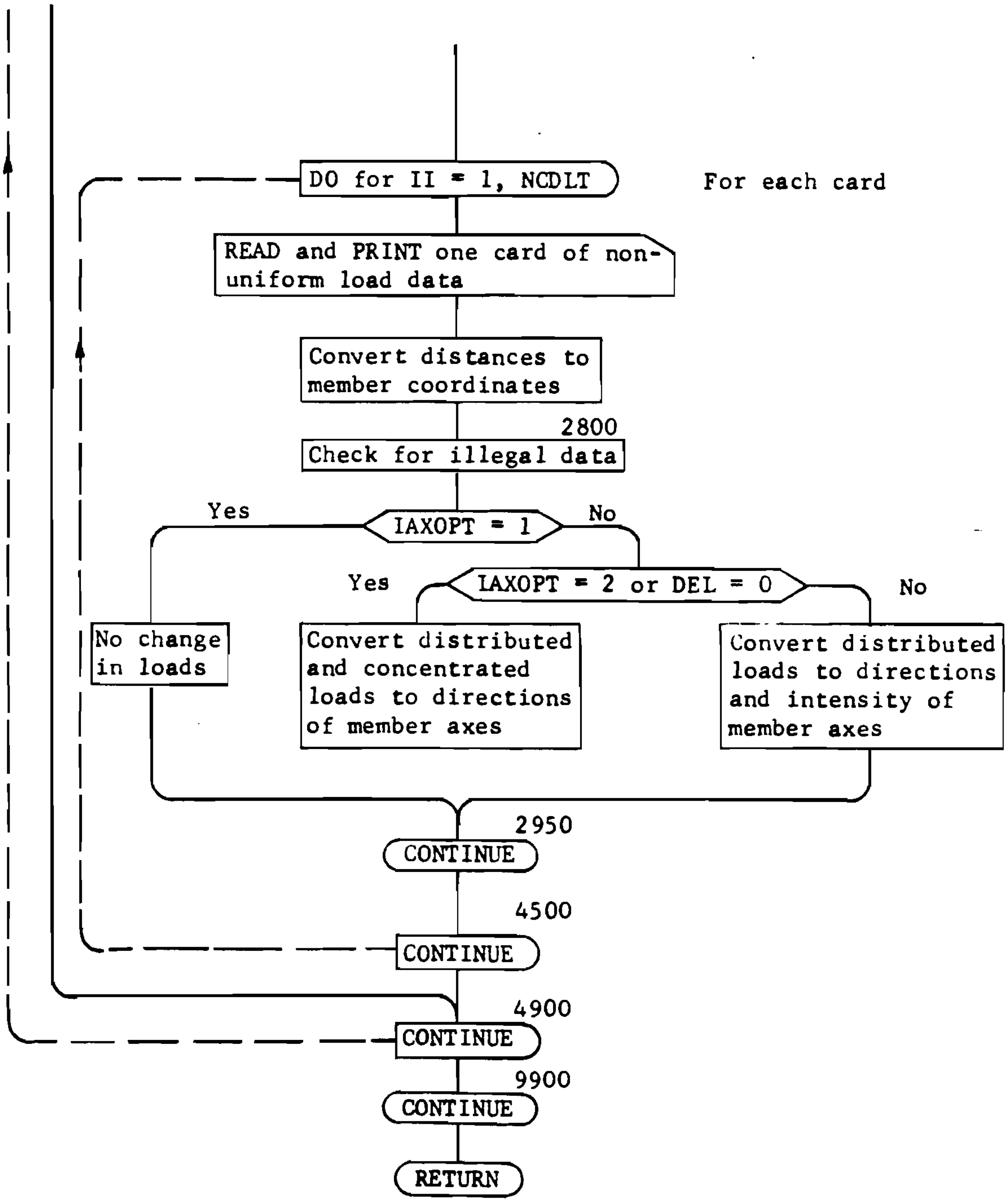


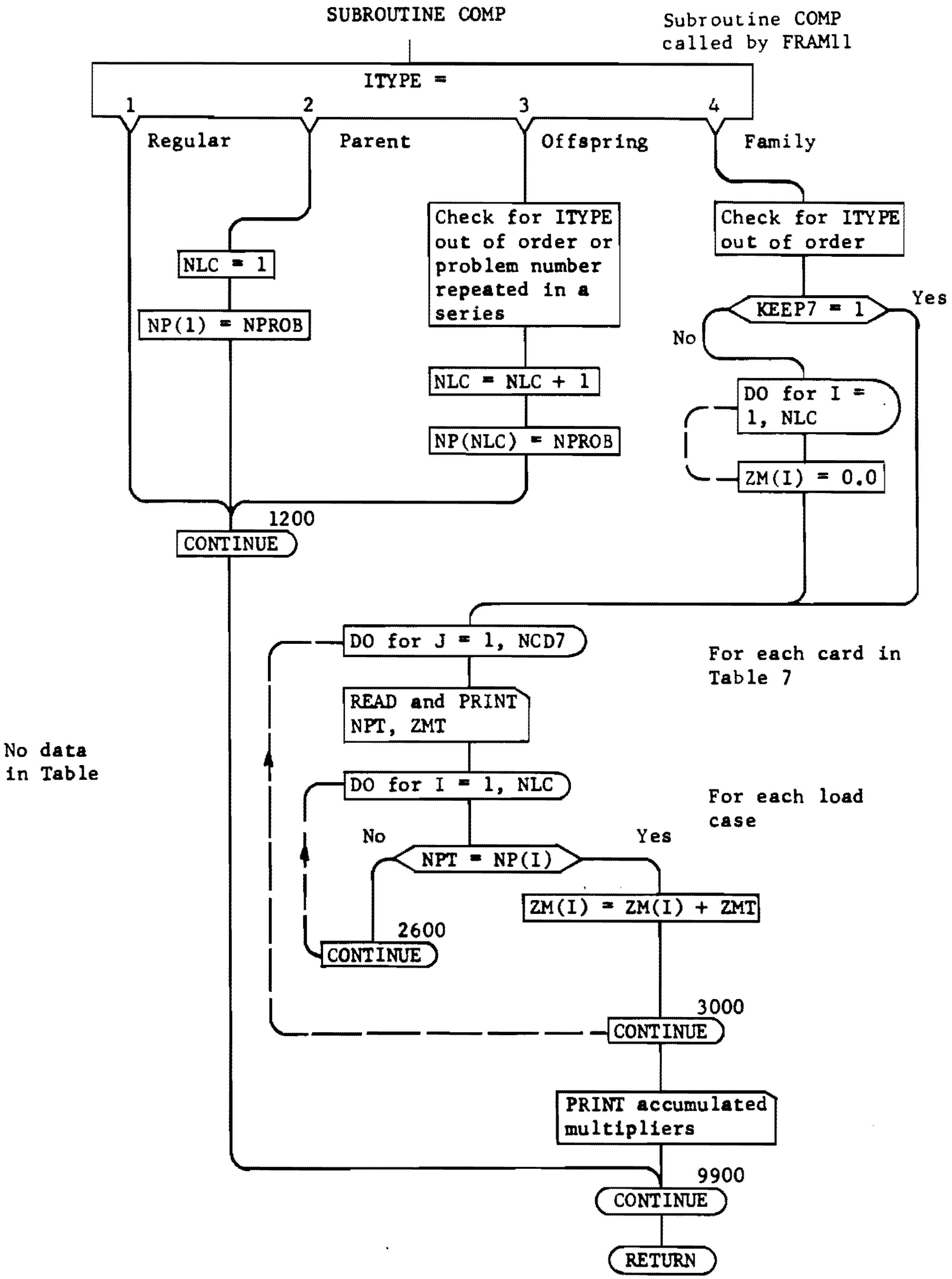
SUBROUTINE RDMST



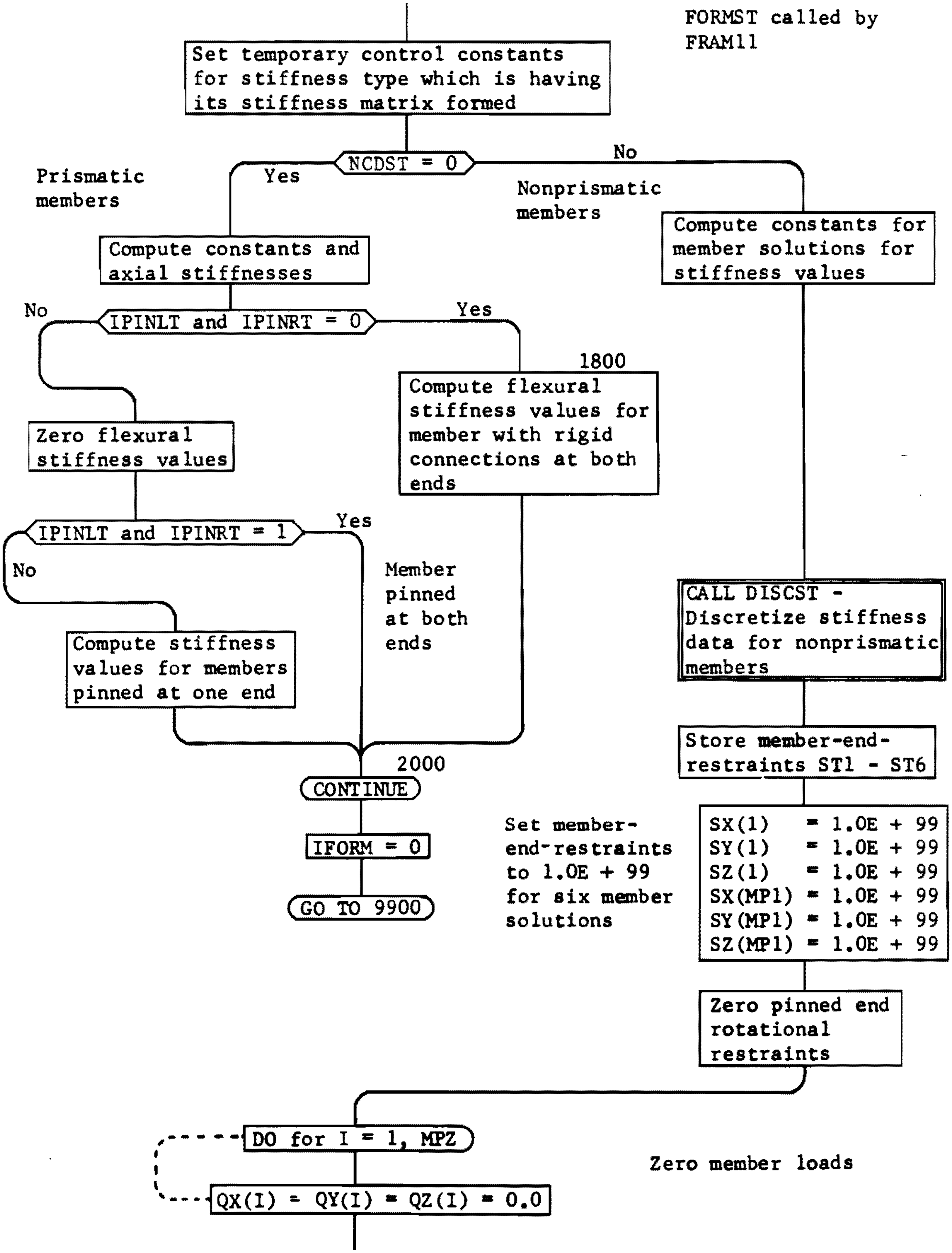

READ and PRINT one card of nonprismatic stiffness data
Convert distances to member coordinates
Check for illegal data
4500
CONTINUE
4900
CONTINUE
9900
CONTINUE
RETURN


SUBROUTINE RDMLD
Subroutine RMLD called by FRAM11
PRINT table heading
NCD6 = 0 and KEEP6 = 0
No
Yes
No data
GO TO 9900
NCD6 = 0
Yes
No
No new data
GO to 9900
KEEP6 = 1
Yes
No
Holding data
Initiate controls
NLTL = 0
Yes
No
DO for I = 1, MNLT
NC61(I) = -1
NCDL(I) = -1
NC6 = 0
DO for JJ = 1, NLT
For each load type
NCDL(JJ) = -1
No
Yes
Load type previously defined
READ and PRINT first card of load data
NCDLT > 0
No
Yes
Uniform loads only
Variable loads
IAXOPT =
1
2
3
4
No change in loads
Convert uniform loads to directions of member axes
Convert uniform loads to directions and intensity of member axes

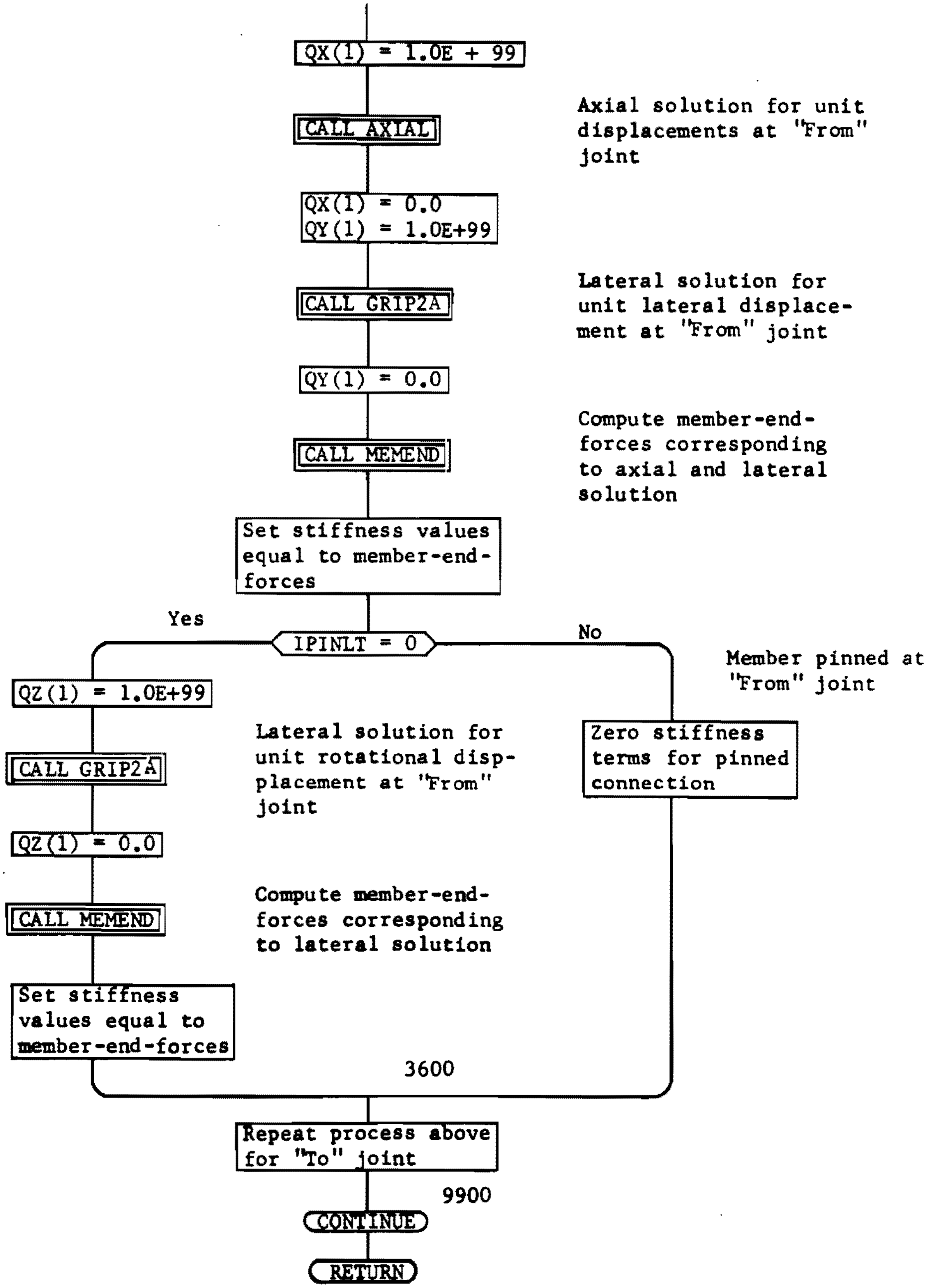

DO for II = 1, NCDLT
For each card
READ and PRINT one card of non-uniform load data
Convert distances to member coordinates
2800
Check for illegal data
Yes
IAXOPT = 1
No
Yes
IAXOPT = 2 or DEL = 0
No
No change in loads
Convert distributed and concentrated loads to directions of member axes
Convert distributed loads to directions and intensity of member axes
2950
CONTINUE
4500
CONTINUE
4900
CONTINUE
9900
CONTINUE
RETURN


SUBROUTINE COMP
Subroutine COMP called by FRAM11
ITYPE =
1
2
3
4
Regular
Parent
Offspring
Family
NLC = 1
NP(1) = NPROB
Check for ITYPE out of order or problem number repeated in a series
NLC = NLC + 1
NP(NLC) = NPROB
Check for ITYPE out of order
KEEP7 = 1
Yes
No
DO for I = 1, NLC
ZM(I) = 0.0
1200
CONTINUE
DO for J = 1, NCD7
For each card in Table 7
READ and PRINT NPT, ZMT
No data in Table
DO for I = 1, NLC
For each load case
No
Yes
NPT = NP(I)
ZM(I) = ZM(I) + ZMT
2600
CONTINUE
3000
CONTINUE
PRINT accumulated multipliers
9900
CONTINUE
RETURN

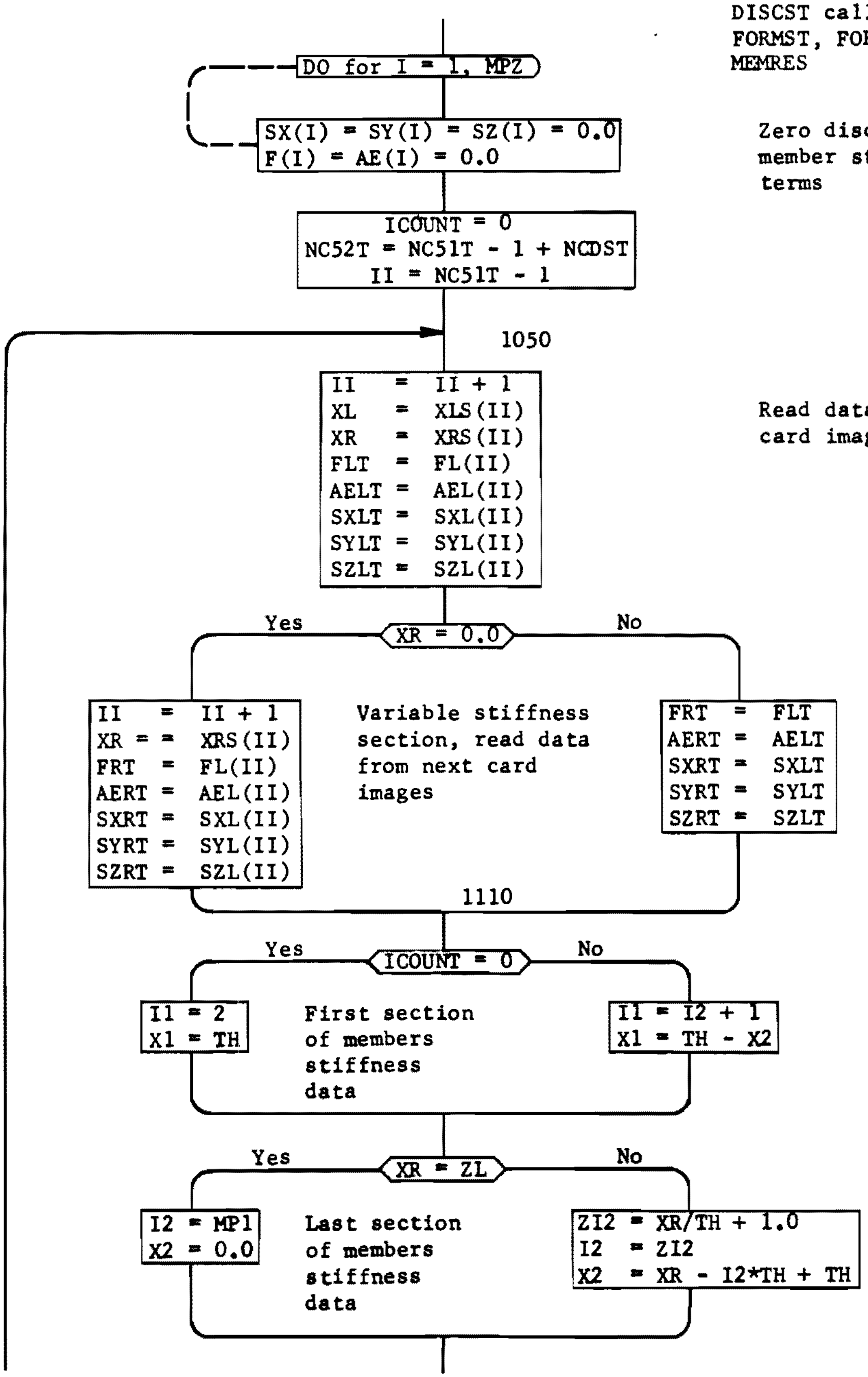
SUBROUTINE FORMST



FORMST called by FRAM11


QX(1) = 1.0E + 99
CALL AXIAL
Axial solution for unit displacements at "From" joint
QX(1) = 0.0
QY(1) = 1.0E+99
CALL GRIP2A
Lateral solution for unit lateral displacement at "From" joint
QY(1) = 0.0
CALL MEMEND
Compute member-end-forces corresponding to axial and lateral solution
Set stiffness values equal to member-end-forces
Yes
IPINLT = 0
No
Member pinned at "From" joint
QZ(1) = 1.0E+99
CALL GRIP2A
Lateral solution for unit rotational displacement at "From" joint
Zero stiffness terms for pinned connection
QZ(1) = 0.0
CALL MEMEND
Compute member-end-forces corresponding to lateral solution
Set stiffness values equal to member-end-forces
3600
Repeat process above for "To" joint
9900
CONTINUE
RETURN

SUBROUTINE DISCST



DISCST called by FORMST, FORMLD, MEMRES

Zero discretized member stiffness terms

Read data from one card image

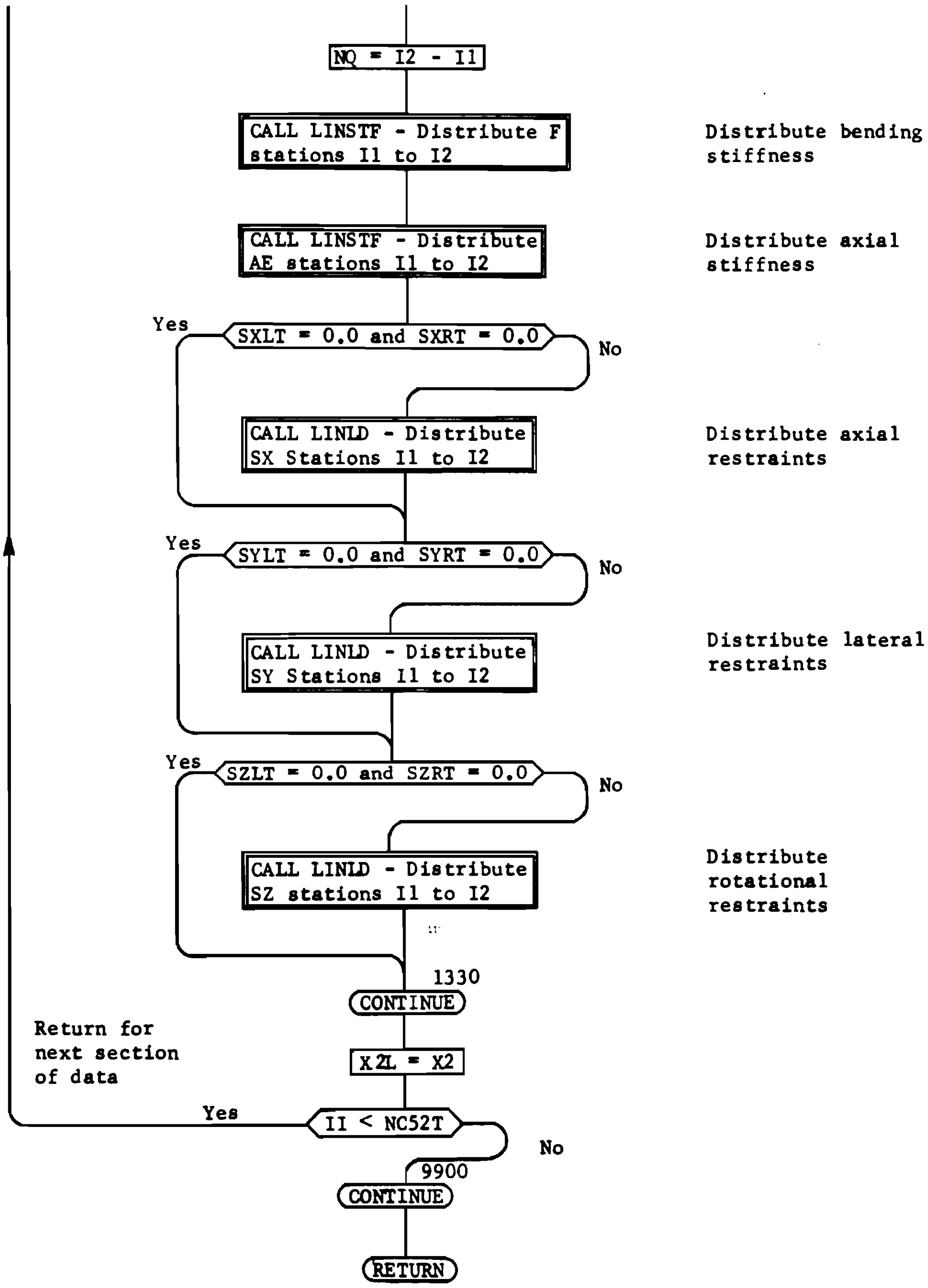
Variable stiffness section, read data from next card images

Uniform stiffness section

First section of members stiffness data

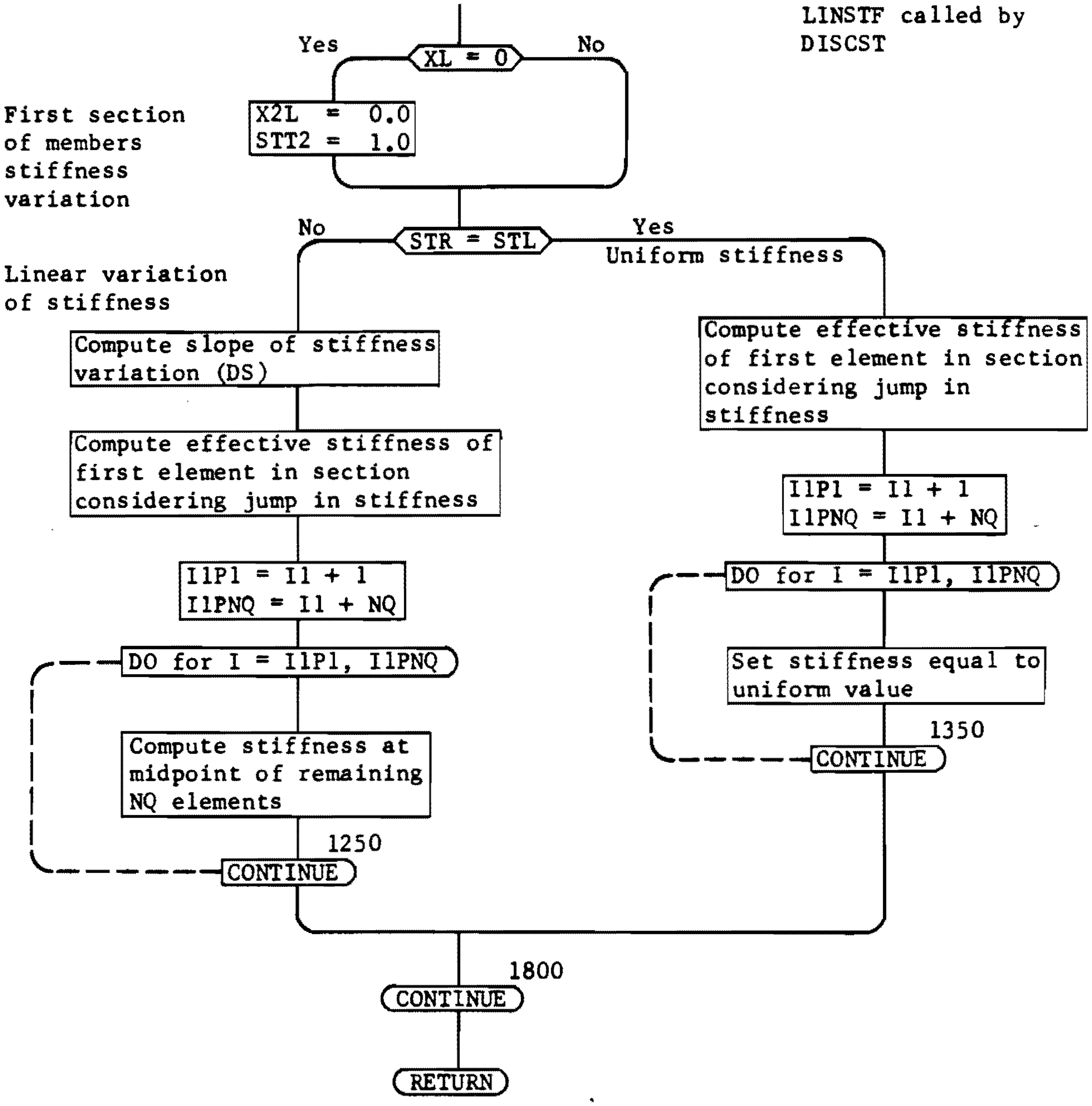
Last section of members stiffness data

Interior section


NQ = I2 - I1
CALL LINSTF - Distribute F stations I1 to I2
Distribute bending stiffness
CALL LINSTF - Distribute AE stations I1 to I2
Distribute axial stiffness
Yes
SXLT = 0.0 and SXRT = 0.0
No
CALL LINLD - Distribute SX Stations I1 to I2
Distribute axial restraints
Yes
SYLT = 0.0 and SYRT = 0.0
No
CALL LINLD - Distribute SY Stations I1 to I2
Distribute lateral restraints
Yes
SZLT = 0.0 and SZRT = 0.0
No
CALL LINLD - Distribute SZ stations I1 to I2
Distribute rotational restraints
1330
CONTINUE
Return for next section of data
X2L = X2
Yes
I1 < NC52T
No
9900
CONTINUE
RETURN

SUBROUTINE LINSTF

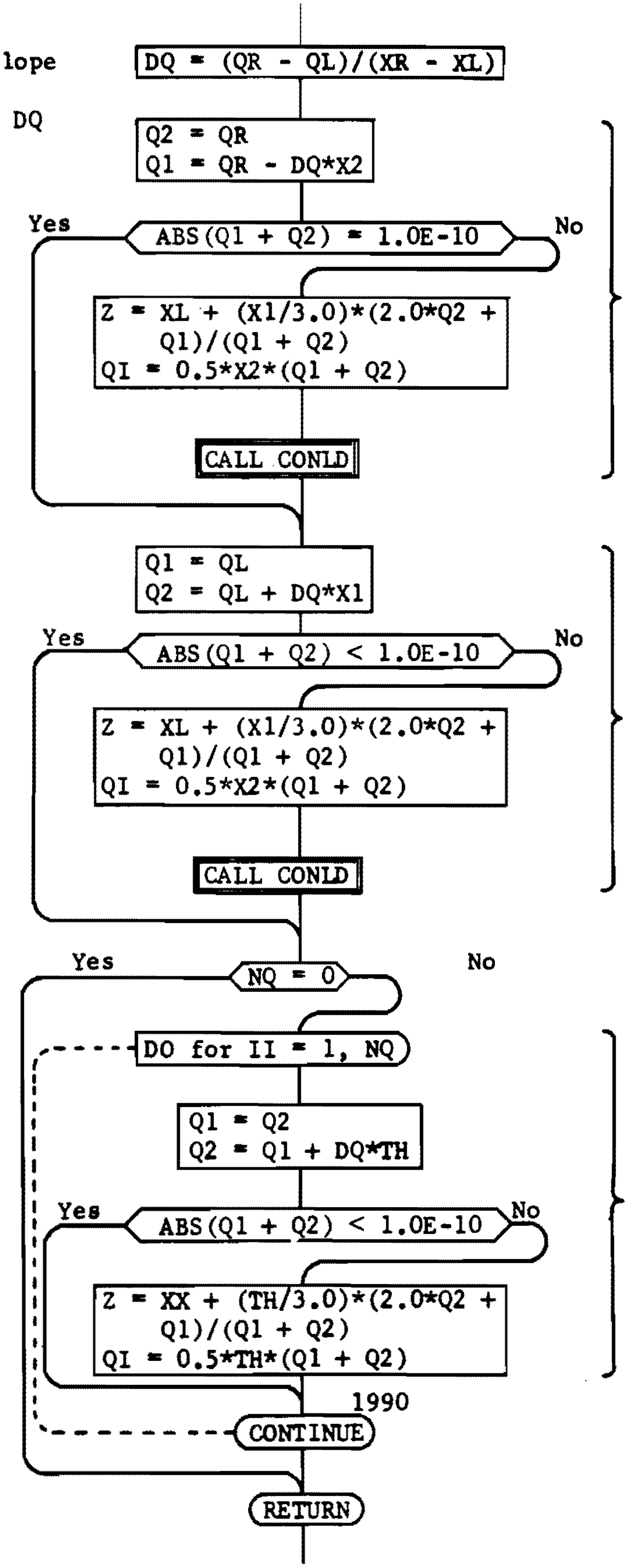
LINSTF called by
DISCST



SUBROUTINE LINLD

LINLD called by DISCLD, DISCST

Compute slope of linear variation DQ



Compute concentrated load or restraint for element at right end of section QI, distance to line of action Z and call CONLD to distribute to adjacent stations

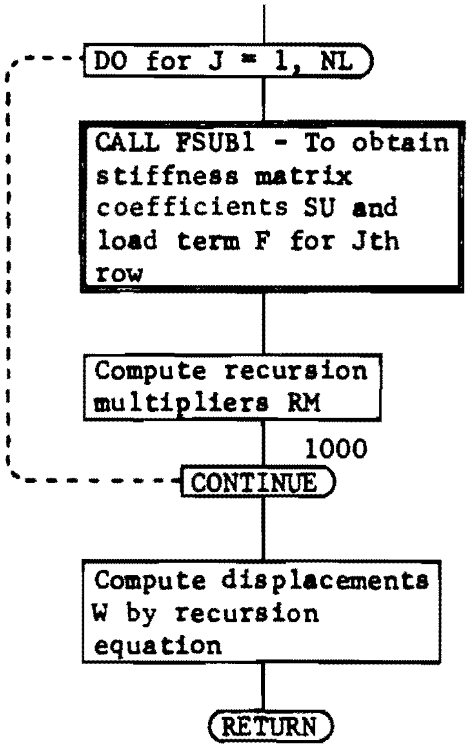
Same as above for element at left end of section

Same as above for remaining NQ elements

(XX is distance to left of element from the "From" joint)

SUBROUTINE GRIP2A

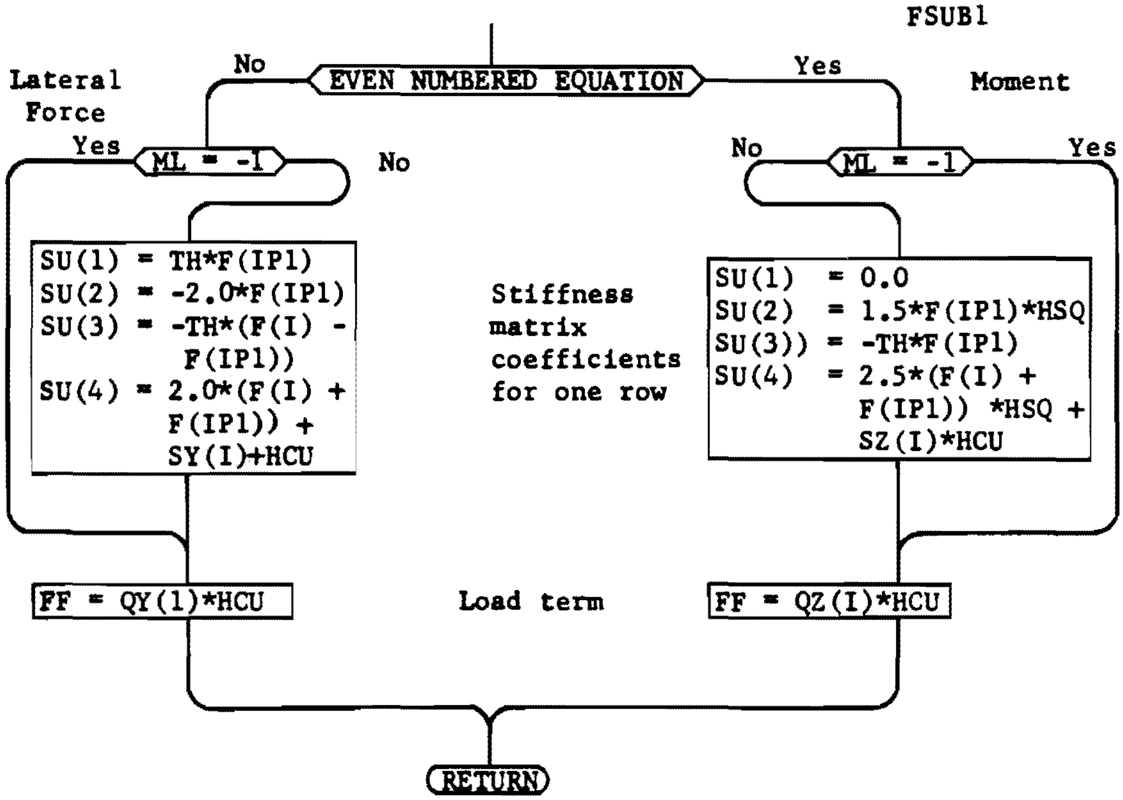
GRIP2A called by
FRAM11, FORMST,
FORMLD, MEMRES



FSUB1 calls FSUB11 to furnish SU and F for frame solution or FSUB12 to furnish SU and F for member solutions

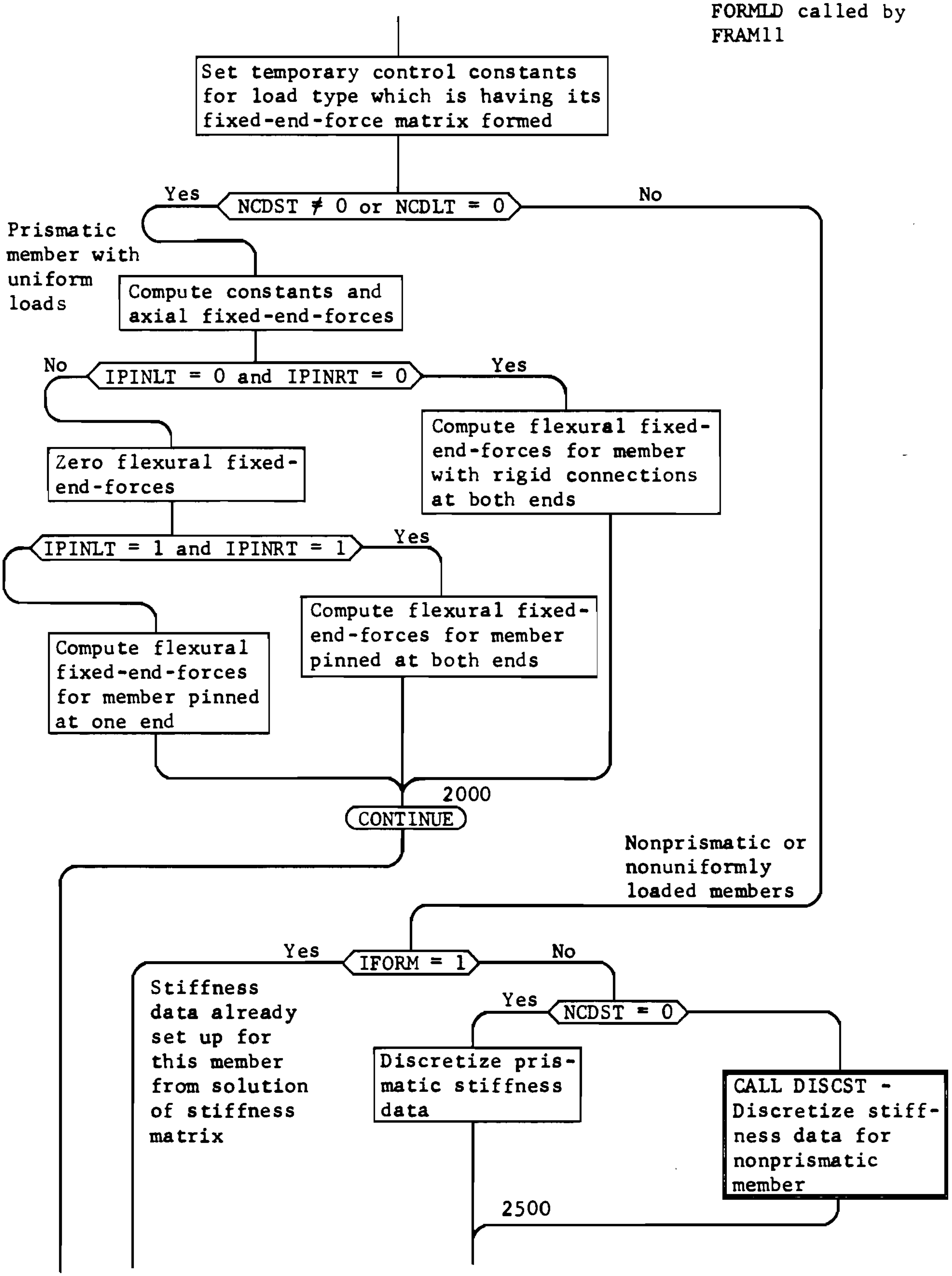
SUBROUTINE FSUB12

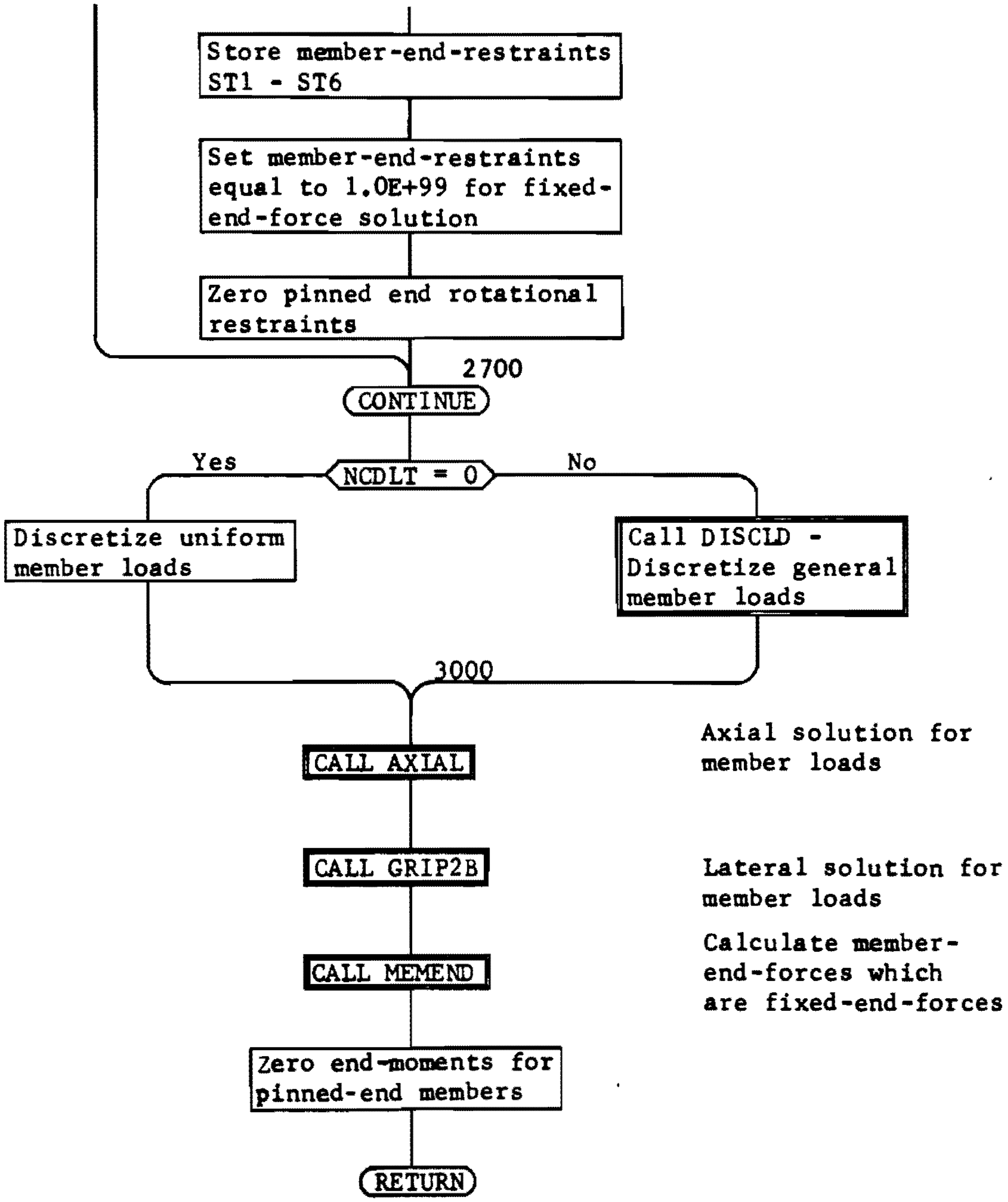
FSUB12 called by
FSUB1



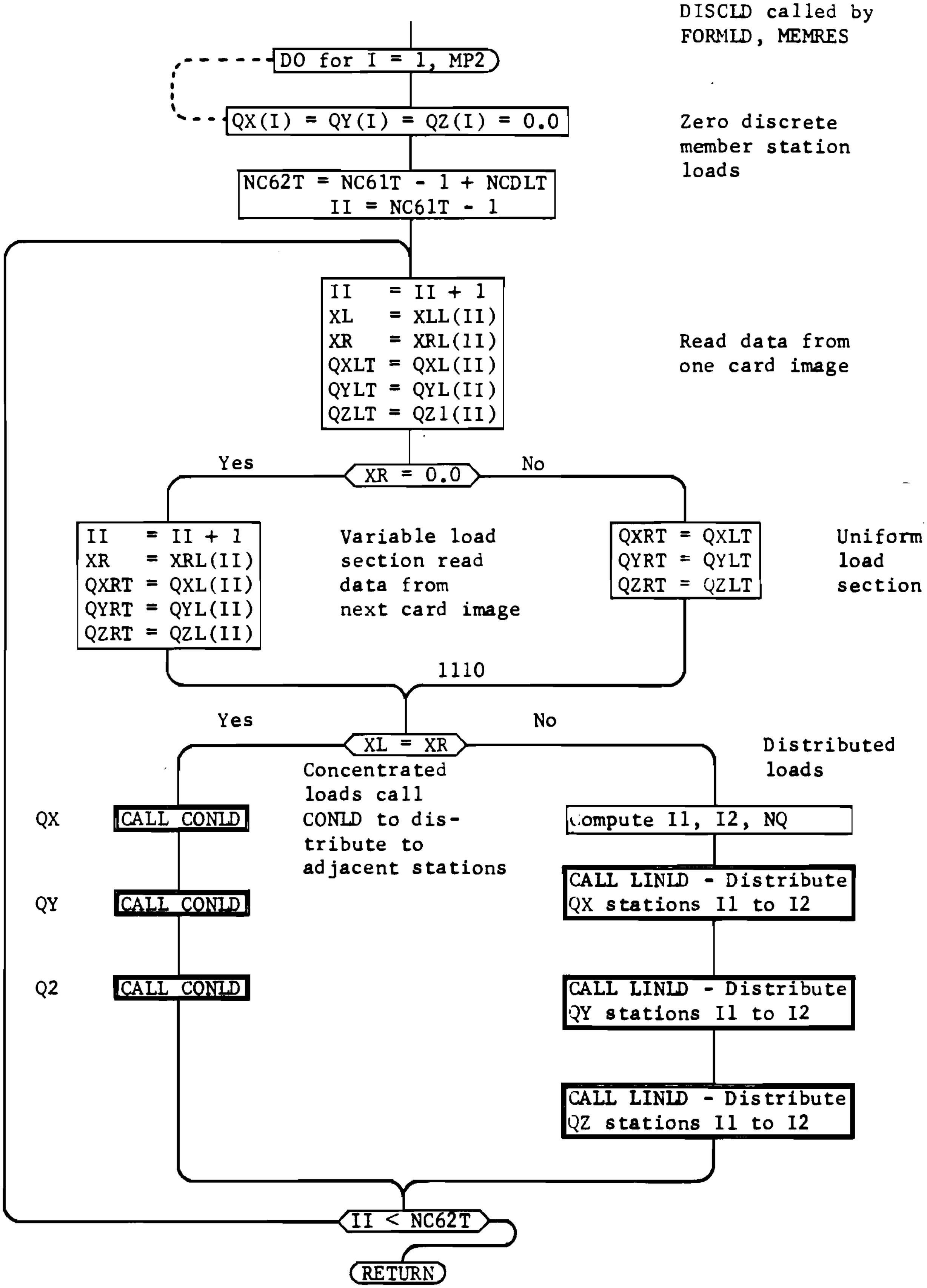
SUBROUTINE FORMLD

FORMLD called by FRAM11




Store member-end-restraints ST1 - ST6
Set member-end-restraints equal to 1.0E+99 for fixed-end-force solution
Zero pinned end rotational restraints
2700
CONTINUE
Yes
NCDLT = 0
No
Discretize uniform member loads
Call DISCLD - Discretize general member loads
3000
CALL AXIAL
Axial solution for member loads
CALL GRIP2B
Lateral solution for member loads
CALL MEMEND
Calculate member-end-forces which are fixed-end-forces
Zero end-moments for pinned-end members
RETURN

SUBROUTINE DISCLD



DISCLD called by FORMLD, MEMRES

Zero discrete member station loads

Read data from one card image

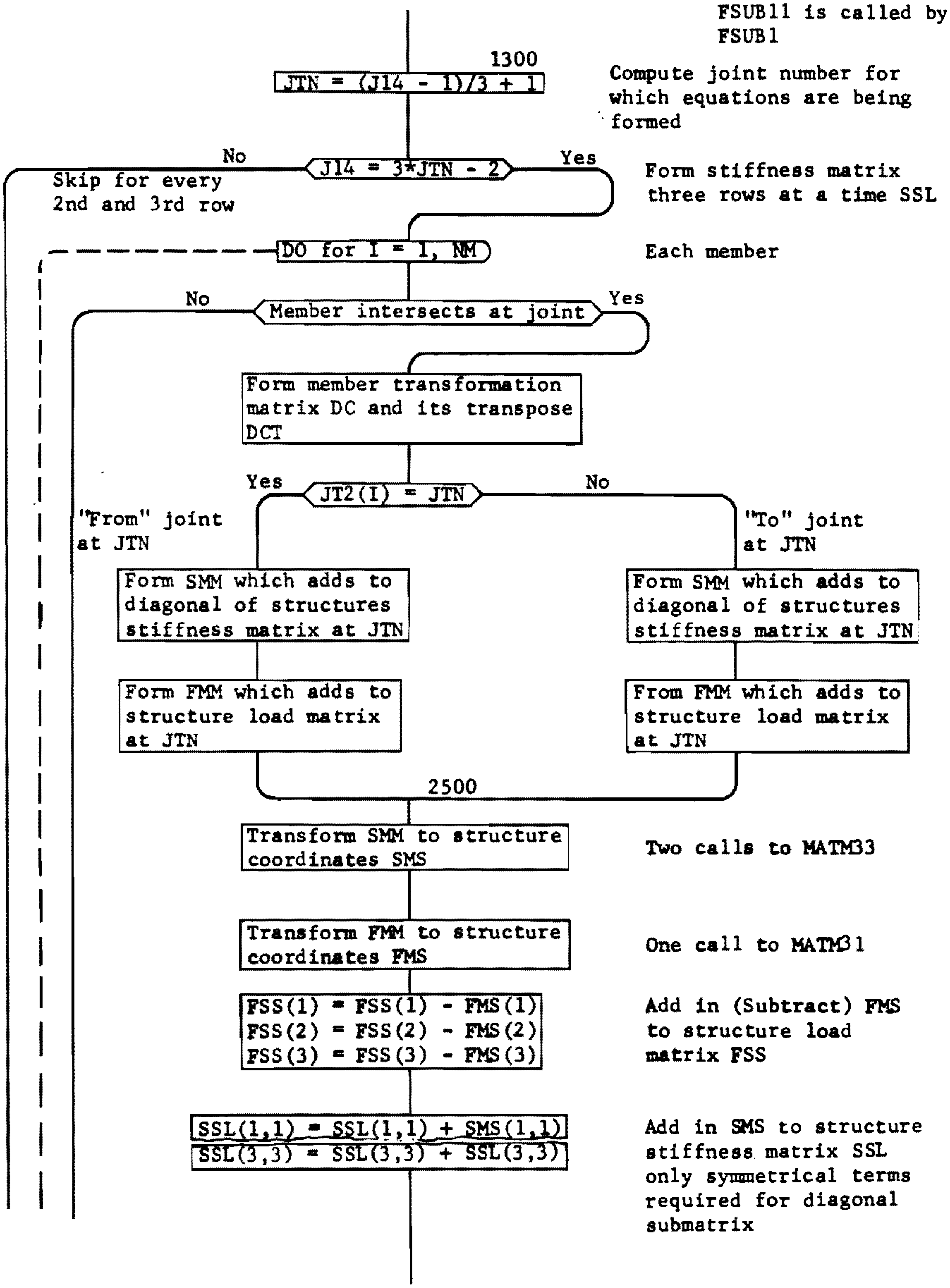
Variable load section read data from next card image

Uniform load section

Concentrated loads call CONLD to distribute to adjacent stations

Distributed loads

SUBROUTINE FSUB11



FSUB11 is called by FSUB1

Compute joint number for which equations are being formed

Form stiffness matrix three rows at a time SSL

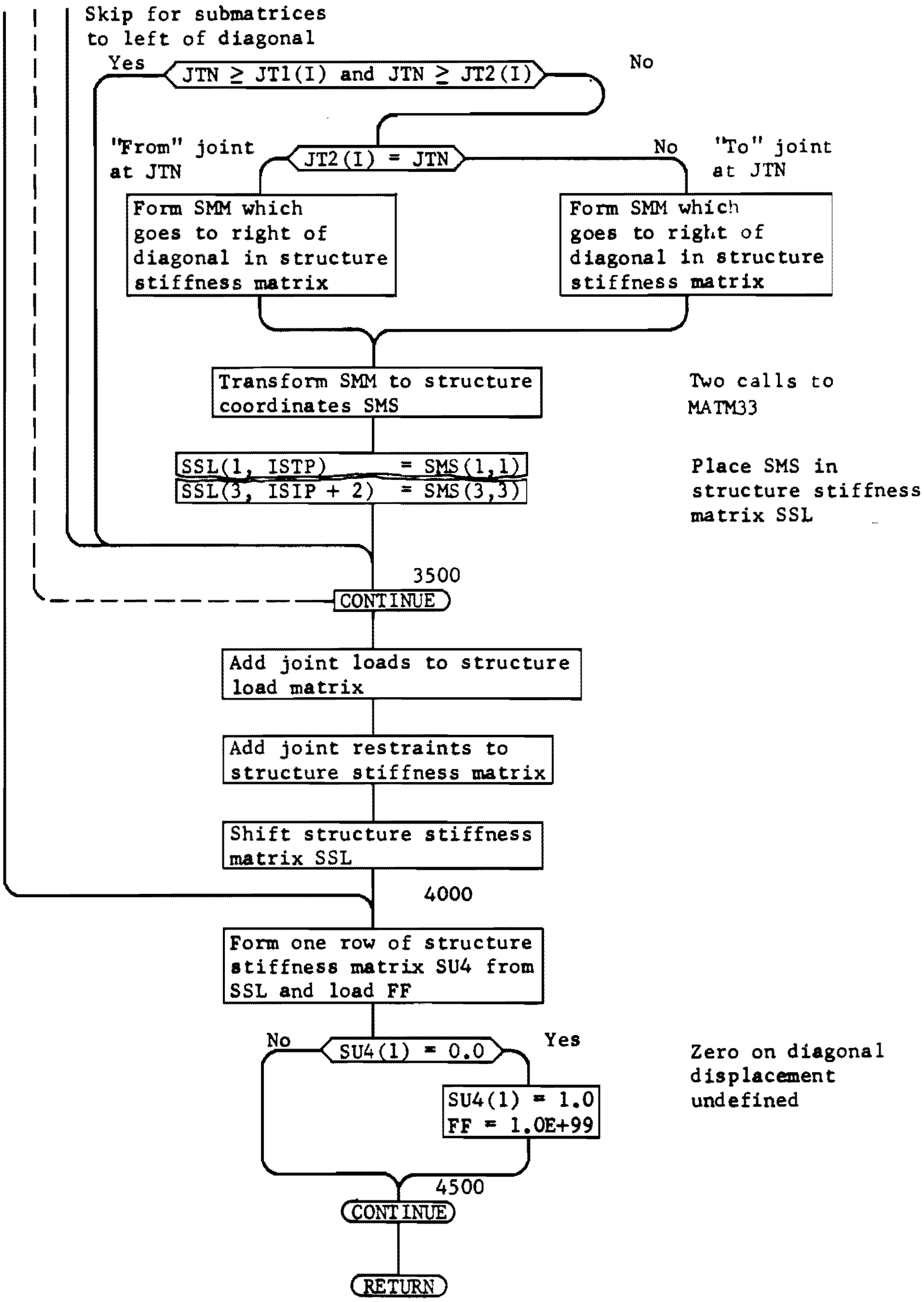
Each member

Two calls to MATM33

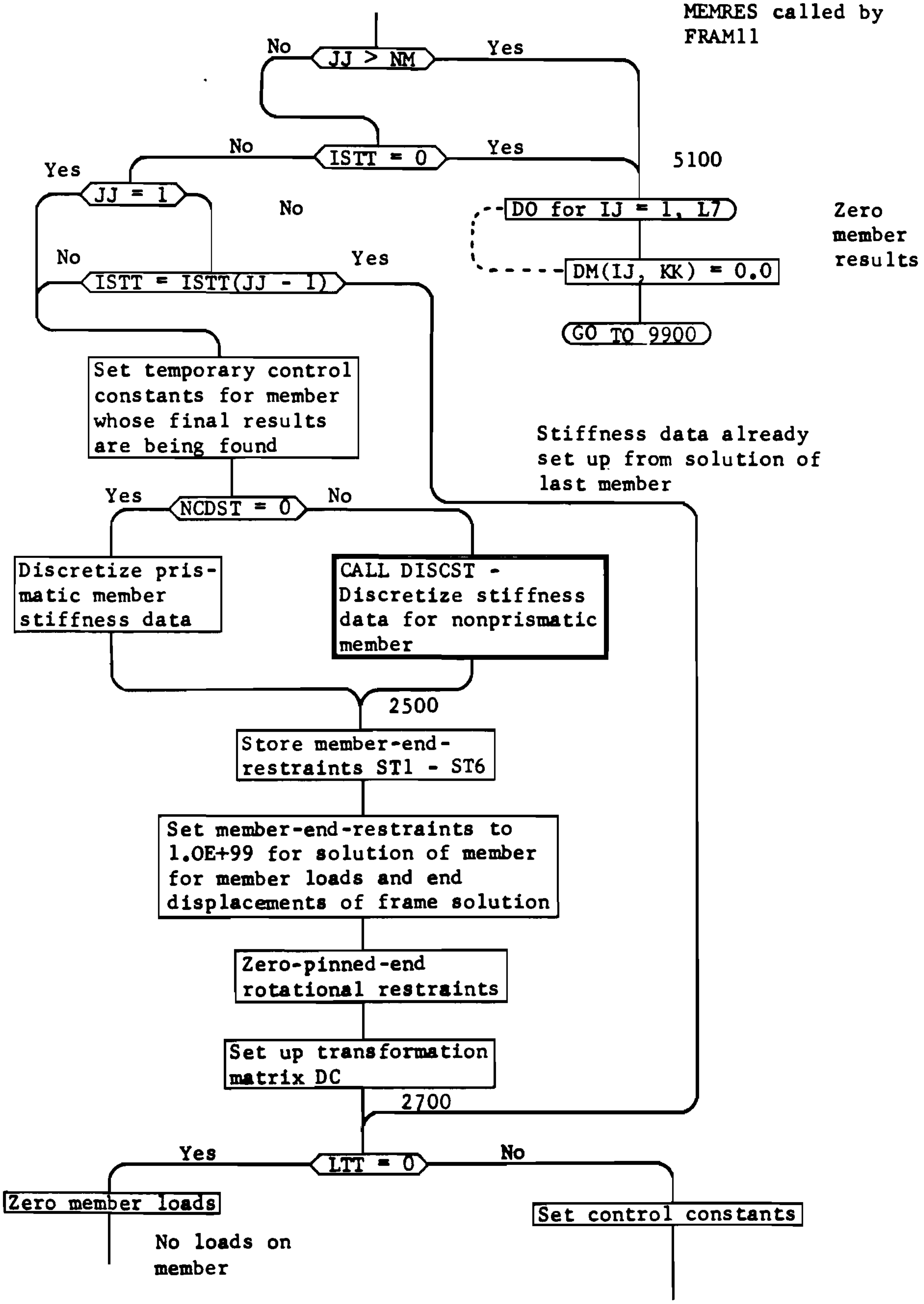
One call to MATM31

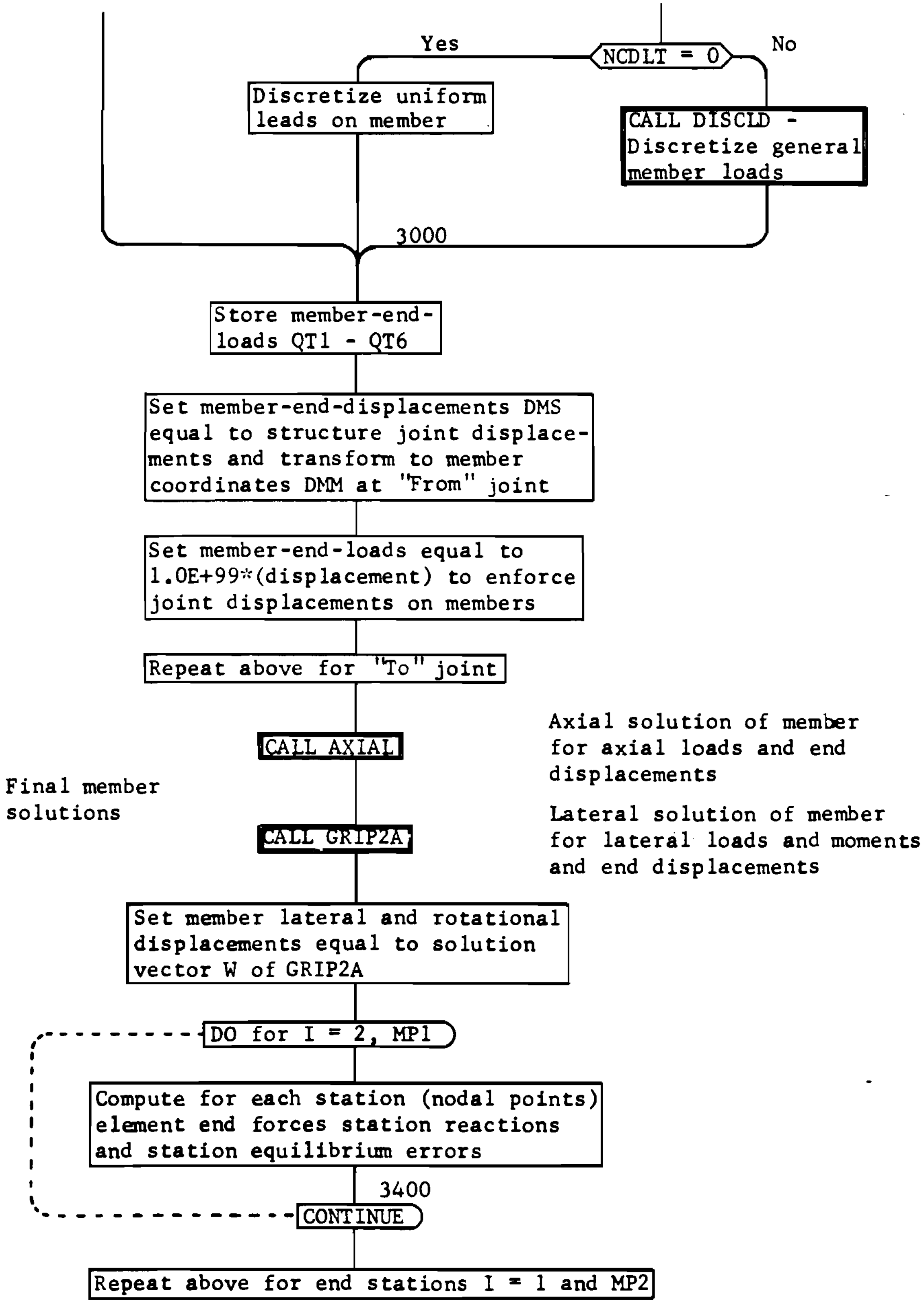
Add in (Subtract) FMS to structure load matrix FSS

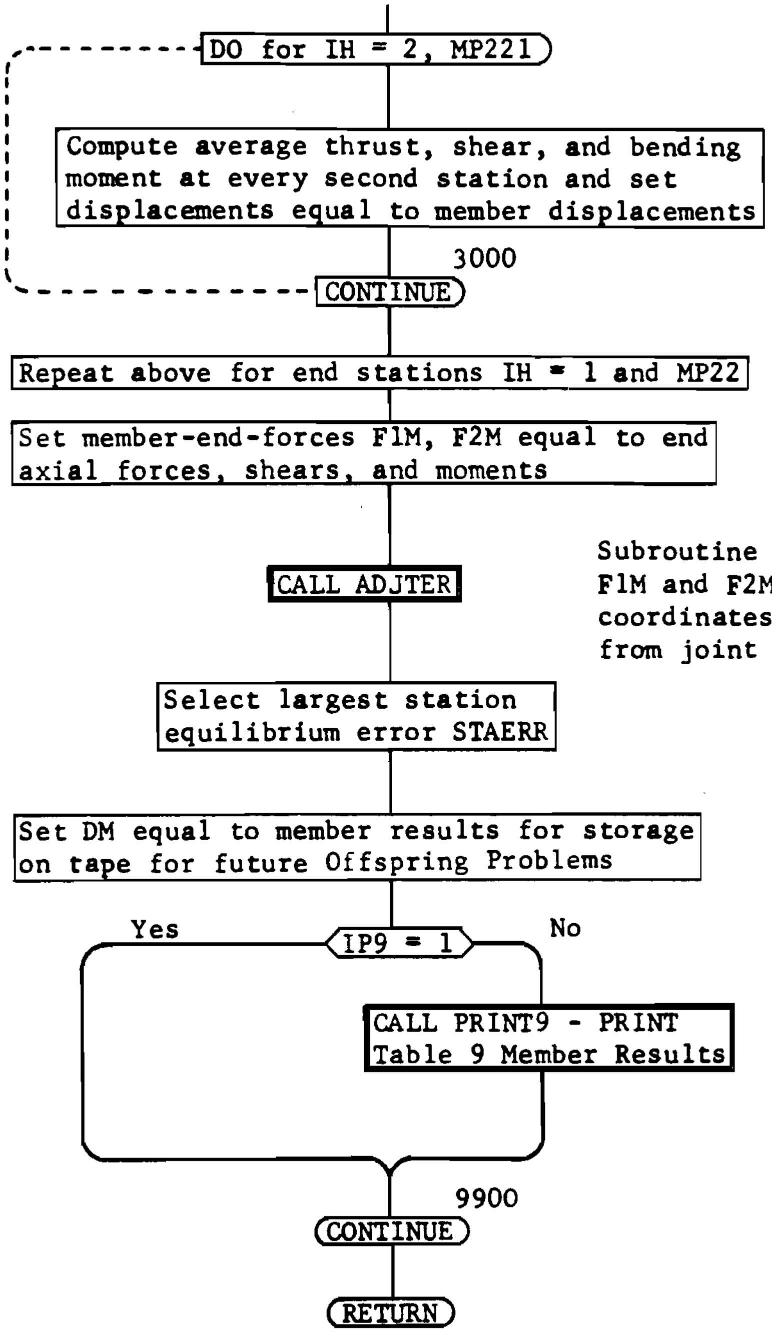
Add in SMS to structure stiffness matrix SSL only symmetrical terms required for diagonal submatrix


Skip for submatrices to left of diagonal
Yes
JTN ≥ JT1(I) and JTN ≥ JT2(I)
No
"From" joint at JTN
JT2(I) = JTN
No
"To" joint at JTN
Form SMM which goes to right of diagonal in structure stiffness matrix
Form SMM which goes to right of diagonal in structure stiffness matrix
Transform SMM to structure coordinates SMS
Two calls to MATM33
SSL(1, ISTP) = SMS(1,1)
SSL(3, ISIP + 2) = SMS(3,3)
Place SMS in structure stiffness matrix SSL
3500
CONTINUE
Add joint loads to structure load matrix
Add joint restraints to structure stiffness matrix
Shift structure stiffness matrix SSL
4000
Form one row of structure stiffness matrix SU4 from SSL and load FF
No
SU4(1) = 0.0
Yes
Zero on diagonal displacement undefined
SU4(1) = 1.0
FF = 1.0E+99
4500
CONTINUE
RETURN

SUBROUTINE MEMRES




Yes
NCDLT = 0
No
Discretize uniform leads on member
CALL DISCLD - Discretize general member loads
3000
Store member-end-loads QT1 - QT6
Set member-end-displacements DMS equal to structure joint displacements and transform to member coordinates DMM at "From" joint
Set member-end-loads equal to 1.0E+99*(displacement) to enforce joint displacements on members
Repeat above for "To" joint
CALL AXIAL
Axial solution of member for axial loads and end displacements
Final member solutions
CALL GRIP2A
Lateral solution of member for lateral loads and moments and end displacements
Set member lateral and rotational displacements equal to solution vector W of GRIP2A
DO for I = 2, MP1
Compute for each station (nodal points) element end forces station reactions and station equilibrium errors
3400
CONTINUE
Repeat above for end stations I = 1 and MP2



Output at every second station

Subroutine ADJTER transform F1M and F2M to structure coordinates and subtracts from joint equilibrium errors

APPENDIX 4

GLOSSARY OF FORTRAN NOTATION

```
C-----NOTATION FOR FRAME 11                                            02JL0
C                                                                       2JL0
C                                                                       2JL0
C          A( )               CONTINUITY COEFFICIENT IN AXIAL SOLUTION  02JL0
C          AE( )              AREA TIMES MODULUS OF ELASTICITY          02JL0
C          AEL( )             VALUES OF AE( ) AT EDGES OF SECTIONS      02JL0
C          AELT               VALUE OF AE( ) AT LEFT (START) OF SECTION 02JL0
C          AERT               VALUE OF AE( ) AT RIGHT (END) OF SECTION  02JL0
C          AETT2              VALUE OF AE( ) AT MIDDLE OF PARTIAL       02JL0
C                             ELEMENT ON RIGHT (END) OF SECTION         02JL0
C          AM( )              DUMMY MATRIX FOR MULTIPLICATION ROUTINES  02JL0
C          AN1( ), AN2( ),    ALPHA-NUMERIC IDENTIFIERS                 02JL0
C          AN3( )                                                       02JL0
C          A1( ), A2          PARTS OF CONTINUITY COEFFICIENT A( ) USED 02JL0
C                             FOR MULTIPLE LOAD OPTIONS                 02JL0
C          B( )               CONTINUITY COEFFICIENT IN AXIAL SOLUTION  02JL0
C          BB                 STIFF COEFF IN AXIAL SOLUTION             02JL0
C          BM( )              BENDING MOMENT OUTPUT VALUE               02JL0
C          BM( , ), BV( )     DUMMY MATRICES IN MULTIPLICATION ROUTINES 02JL0
C          C                  DISTANCE FROM CONCENTRATED LOAD TO        02JL0
C                             STATION ON LEFT                           02JL0
C          CC                 STIFFNESS COEFFICIENT IN AXIAL SOLUTION   02JL0
C          CM( , ), CV( )     DUMMY MATRICES IN MULTIPLICATION ROUTINES 02JL0
C          D( )               RECURSION MULTIPLIER IN AXIAL SOLUTION    02JL0
C          DC( , )            MATRIX OF DIRECTION COSINES               02JL0
C          DCT( , )           TRANSPOSE OF DC MATRIX                    02JL0
C          DC1, DC2           DIRECTION COSINES                         02JL0
C          DC1L( ), DC2L( )   DIRECTION COSINES FOR LOAD TYPES          02JL0
C          DC1S( ), DC2S( )   DIRECTION COSINES FOR STIFFNESS TYPES     02JL0
C          DD                 STIFFNESS COEFFICIENT IN AXIAL SOLUTION   02JL0
C          DDIS               DISTANCES BETWEEN MEMBER OUTPUT STATIONS  02JL0
C          DDX                AXIAL CHANGE IN LENGTH IN ELEMENT         02JL0
C          DEL                LENGTH OF SECTION OF MEMBER LOADING       02JL0
C          DENOM( )           DENOMINATOR IN AXIAL SOLUTION             02JL0
C          DIS                DISTANCE FROM THE FROM JOINT TO OUTPUT    02JL0
C                             STATION                                   02JL0
C          DM( , ), DMT( , )  STORAGE MATRICES FOR SIX MEMBER RESULTS   02JL0
C          DMM( )             MATRIX OF MEMBER END DISPLACEMENTS        02JL0
C                             IN MEMBER COORDINATES                     02JL0
C          DMS( )             MATRIX OF MEMBER END DIOPLACEMENTS        02JL0
C                             IN STRUCTURE COORDINATES                  02JL0
C          DQ                 SLOPE OF LINEAR VARIATION IN LOADING OR   02JL0
C                             ELASTIC RESTRAINTS                        02JL0
C          DS                 SLOPE OF LINEAR STIFFNESS VARIATION       02JL0
C          DX( ), DY( ),DZ( ) MEMBER STATION DISPLACEMENTS              02JL0
C          DX, DY             X AND Y OFFSETS                           02JL0
C          DXL( ), DYL( )     X AND Y OFFSETS FOR LOAD TYPES            02JL0
C          DXS( ), DYS( )     X AND Y OFFSETS FOR STIFFNESS TYPES       02JL0
C          DXT( ), DYT( )     DX( ), DY( ), DZ( ) AT OUTPUT STATIONS    02JL0
C          DZT( )                                                       02JL0
C          DXX( ), DYY( ),    JOINT DISPLACEMENTS                       02JL0
C          DZZ( )                                                       02JL0
C          E                  MODULUS OF ELASTICITY                     02JL0
C          ERR                ABSOLUTE VALUE OF ERX( ), ERY( ), ERZ( )  02JL0
C          ERX( ), ERY( ),    STATION EQUILIBRIUM ERRORS                02JL0
C          ERZ( )                                                       02JL0
C          ERX, ERY           ERROR IN JOINT COORDINATES OR MEMBER      02JL0
C                             OFFSETS                                   02JL0
C          ERRLN              ERROR IN LENGTH OF MEMBER                 02JL0
C          ERXX( ), ERYY( ),  JOINT EQUILIBRIUM ERRORS                  02JL0
C          ERZZ( )                                                      02JL0
C          F( )               MOMENT OF INERTIA TIMES MODULUS OF ELAS   02JL0
C          FF                 COEFFICIENT IN LOAD MATRIX                02JL0
C          FL( )              VALUES OF F( ) AT EDGES OF SECTIONS       02JL0
C          FLT                VALUE OF FL( ) AT LEFT (START) OF SECTION 02JL0
C          FMM( )             MEMBER END FORCES IN MEMBER COORDINATES   02JL0
C          FMS( )             MEMBER END FORCES IN STRUCTURE            02JL0
C                             COORDINATES                               02JL0
C          FUMM( , )          MEMBER FIXED END FORCES                   02JL0
C          FUMMT( )           MEMBER FIXED END FORCES FOR ONE MEMBER    02JL0
C          FRT                VALUE OF F( ) AT RIGHT (END) OF SECTION   02JL0
C          FSS( )             STRUCTURE LOAD MATRIX                     02JL0
C          FTT2               VALUE OF F( ) AT MIDDLE OF PARTIAL        02JL0
C                             ELEMENT ON RIGHT (END) OF SECTION         02JL0
C          F1M( )             MEMBER END FORCES AT FROM JOINT IN        02JL0
C                             MEMBER COORDINATES                        02JL0
C          F2M( )             MEMBER END FORCES AT TO JOINT IN MEMBER   02JL0
C                             COORDINATES                               02JL0
C          F1S( )             MEMBER END FORCES AT FROM JOINT IN        02JL0
C                             STRUCTURE COORDINATES                     02JL0
C          F2S( )             MEMBER END FORCES AT TO JOINT IN          02JL0
C                             STRUCTURE COORDINATES                     02JL0
C          H                  ONE HALF OF ELEMENTS LENGTH               02JL0
C          HCU                H*H*H                                     02JL0
C          HSQ                H*H                                       02JL0
C          I                  INTEGER INDEX                             02JL0
C          IABAN              FATAL ERROR FLAG                          02JL0
C          IAXOPL( )          AXIS OPTIONS FOR LOAD TYPES               02JL0
C          IAXOPS( )          AXIS OPTIONS FOR STIFFNESS TYPES          02JL0
C          IAXOPT             TEMPORARY VALUE OF AXIS OPTION            02JL0
C          IC                 PRINTER CONTROL                           02JL0
C          IB                 DECREMENTING INTEGER                      02JL0
C          ICOUNT             CONTROL CONSTANT                          02JL0
C          IDJ                MAXIMUM DIFFERENCE IN JOINT NUMBERS       02JL0
C                             CONNECTED BY MEMBERS                      02JL0
C          IFORM              CONTROL CONSTANT                          02JL0
C          IM                 INTEGER INDEX FOR OUTPUT STATIONS         02JL0
C          IHB                (BANDWIDTH OF EQ - 1)/2                   02JL0
C          IHBP1              IHB + 1                                   02JL0
C          IHB1               IHB - 1                                   02JL0
C          I1, I11, IJ, IJT,  INTEGER INDICES                           02JL0
C          IJ1, IJ6                                                     02JL0
C          IM1                I - 1                                     02JL0
C          IOPL               PRINTER CONTROL                           02JL0
C          IOPOP( ), IOPOPT   MEMBER OUTPUT OPTION                      02JL0
C          IPINL( ), IPINLT   PIN AT LEFT (FROM) JOINT OPTION           02JL0
C          IPINR( ), INPINRT  PIN AT RIGHT (TO) JOINT OPTION            02JL0
C          IP1                I + 1                                     02JL0
C          IP8, IP9, IP10     PRINT OPTIONS FOR TABLES 8, 9, 10         02JL0
C          IST( ), ISTT       STIFFNESS TYPE                            02JL0
C          ISTP               3*J21 + 1                                 02JL0
C          ITEST( )           ALPHANUMBERIC CONSTANTS                   02JL0
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C          ITYPE              PROBLEM TYPE                              02JL0
C          ITYPEL             PROBLEM TYPE OF PREVIOUS PROBLEM          02JL0
C          I1, I2             FIRST AND LAST STATION INSIDE SFCTION     02JL0
C          I1PNO              I1 + NO                                   02JL0
C          I1P1               I1 + 1                                    02JL0
C          J, JJ, JJJ         INTEGER INDICIES                          02JL0
C          J1J                SWITCH TO ALTERNATE FORCE AND MOMENT      02JL0
C                             EQUATIONS                                 02JL0
C          JM1                J - 1                                     02JL0
C          JNTL               ERROR FLAG FOR JOINT NUMBER TO LARGE      02JL0
C          JTN                JOINT NUMBER                              02JL0
C          JT1( ), JT1T, J1,  FROM JOINT                                02JL0
C          J11                                                           2JL0
C          J21                ABSOLUTE VALUE OF DIFFERENCE IN JOINT     02JL0
C                             NUMBERS OF MEMBERS                        02JL0
C          K                  INTEGER INDEX                             02JL0
C          KEEP2-KEEP7        HOLD OPTIONS FOR TABLES 2-7               02JL0
C          KEKE               CHECK FOR INDEPENDENT PROBLEM             02JL0
C          KK                 INTEGER INDEX                             02JL0
C          L                  INTEGER INDEX                             02JL0
C          LT( ), LTT         LOAD TYPE                                 02JL0
C          L1-L4, L6, L7      DIMENSION LIMITS                          02JL0
C          L7M1               L7 - 1                                    02JL0
C          L7M2               L7 - 2                                    02JL0
C          L7M3               LT - 3                                    02JL0
C          M                  NUMBER OF ELEMENT IN MEMBER               02JL0
C          MDJT               MAXIMUM PERMITTED VALUE OF IDJ            02JL0
C          MMB                MAXIMUM PERMITTED VALUE OF IMB            02JL0
C          MMB1               MMB + 1                                   02JL0
C          ML, MLT, ML4       CONTROL FOR MULTIPLE LOAD OPTION          02JL0
C          MM1                M - 1                                     02JL0
C          MNC5               MAXIMUM VALUE PERMITTED FOR NC5           02JL0
C          MNC6               MAXIMUM VALUE PERMITTED FOR NC6           02JL0
C          MNJT               MAXIMUM VALUE PERMITTED FOR NJT           02JL0
C          MNLC               MAXIMUM VALUE PERMITTED FOR NLC           02JL0
C          MNLT               MAXIMUM VALUE PERMITTED FOR NLT           02JL0
C          MNM                MAXIMUM VALUE PERMITTED FOR NM            02JL0
C          MNST               MAXIMUM VALUE PERMITTED FOR NST           02JL0
C          MP1                M + 1                                     02JL0
C          MP2                M + 2                                     02JL0
C          MP22               (M + 2)/2                                 02JL0
C          MP221              MP22 - 1                                  02JL0
C          NCDL( ), NCDLT     NUMBER OF CARDS THAT FOLLOW FOR LOAD TYPE 02JL0
C          NCDS( ), NCDST     NUMBER OF CARDS THAT FOLLOW FOR STIF TYPE 02JL0
C          NCD2-NCD7          NUMBER OF CARDS IN TABLES 2-7             02JL0
C          NCR5, NCR6         NUMBER OF CARDS READ IN TABLES 5 AND 6    02JL0
C          NC51( ), NC5       NUMBER OF CARDS IN TABLE 5 ABOVF THE      02JL0
C                             NUMBER OF STIFF TYPES (VARIABLE STIFF)    02JL0
C          NC51T, NC52T       FIRST AND LAST CARD NUMBER OF VARIABLF    02JL0
C                             STIFF DATA FOR MEMBER                     02JL0
C          NC61( ), NC6       NUMBER OF CARDS IN TABLE 6 ABOVE THE      02JL0
C                             NUMBER OF LOADS TYPES (VARIABLE LOADS)    02JL0
C          NC61T, NC62T       FIRST AND LAST CARD NUMBER OF VARIABLE    02JL0
C                             LOAD DATA FOR MEMBER                      02JL0
C          NFSUB              SWITCH TO CHOOSE APPROPRIATE FSUM         02JL0
C          NI                 INTEGER INDEX                             02JL0
C          NJNZ               NUMBER OF NON ZERO JOINTS ON DATA CARD IN 02JL0
C                             TABLES 2,3                                02JL0
C          NJT                NUMBER OF FRAME JOINTS                    02JL0
C          NL,NL4             NUMBER OF SIMULTANEOUS EQUATIONS          02JL0
C          NLC                NUMBER OF LOAD CASES                      02JL0
C          NLT                NUMBER OF LOAD TYPES                      02JL0
C          NLTL               NLT FOR LAST PROBLEM                      02JL0
C          NM                 NUMBER OF FRAME MEMBERS                   02JL0
C          NM6                NM/6                                      02JL0
C          NP( , )            LIST OF PROBLEM NUMBERS RESULTS SAVED FOR 02JL0
C          NPROB( ), NPT( )   PROBLEM NUMBER (ALPHA NUMBERIC)           02JL0
C          NQ                 NUMBER OF ELEMENTS REMAINING IN SECTION   02JL0
C          NST                NUMBER OF STIFF TYPES                     02JL0
C          NSTL               NST FOR LAST PROBLEM                      02JL0
C          N2M1               NCD2 - 1                                  02JL0
C          N3M1               NCD3 - 1                                  02JL0
C          N123               CONTROL WHICH CYCLES 1,2,3                02JL0
C          N2, N3             ALTERNATING SWITCHES FOR TAPES 2,3        02JL0
C          PRAE( ), PRAET     PRISMATIC AE( )                           02JL0
C          PRAT               PRISMATIC AREA                            02JL0
C          PRF( ), PRFT       PRISMATIC F( )                            02JL0
C          PRIT               PRISMATIC MOMENT OF INERTIA               02JL0
C          QQ                 CONCENTRATED STATION LOAD OR SPRING       02JL0
C          QI                 CONCENTRATED LOAD OR SPRING BETWEEN       02JL0
C                             STATIONS                                  02JL0
C          QL, QR             INTENSITY OF LOADING OR RESTRAINT AT LEFT 02JL0
C                             (START) AND RIGHT (END) OF SECTION        02JL0
C          QT1-QT6            LOADS ON MEMBER END STATIONS              02JL0
C          QX( ), QY( ), QZ( ) MEMBER STATION LOADS                     02JL0
C          QXL( ), QYL( ),    MEMBER LOADS AT EDGES OF SECTIONS         02JL0
C          QZL( )                                                        2JL0
C          QXLT,QYLT,         VALUES OF QXL( ),QYL( ), AT LEFT (START)  02JL0
C          QZLT               OF SECTION                                02JL0
C          QXRT, QYRT,        VALUES OF QXL( ), QYL( ), QZL( ) AT RIGHT 02JL0
C          QZRT               (END) OF SECTION                          02JL0
C          QXX( ), QYY( ),    JOINT LOADS                               02JL0
C          QZZ( )                                                       *2JL0
C          QXXT, QYYT, QZZT   TEMPORARY VALUES OF QXX( ), QYY( ), QZZ   02JL0
C          Q1, Q2             INTENSITY OF LOADING OR RESTRAINTS AT     02JL0
C                             BEGINNING AND END OF ELEMENT              02JL0
C          RM( , ), RO( )     RECURSION MULTIPLIERS                     02JL0
C          RX( ), RY( ), RZ( ) STATION REACTIONS                        02JL0
C          RXX( ), RYY( ),    JOINT REACTIONS                           02JL0
C          RZZ( )                                                       02JL0
C          SL( )              VECTOR OF STIFFNESS MATRIX                02JL0
C          SMC( , )           MEMBER STIFFNESS MATRICES IN COMPACT FORM 02JL0
C          SMM( , )           MEMBER STIFFNESS MATRIX (3X3) IN MEMBER   02JL0
C                             COORDINATES                               02JL0
C          SMT( )             SINGLE MEMBERS STIFFNESS MATRIX IN        02JL0
C                             COMPACT VECTOR FORM                       02JL0
C          SMS                MEMBER STIFFNESS MATRIX (3X3) IN          02JL0
C                             STRUCTURE COORDINATES                     02JL0
C          SSL                STRUCTURE STIFFNESS MATRIX                02JL0
C          ST                 STATION VALUE OF STIFFNESS                02JL0
C          STAERR             LARGEST STATION EQUILIBRIUM ERROR IN      02JL0
C                             MEMBER                                    02JL0
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C         STL. STR            STIFFNESS AT LEFT (START) AND RIGHT (END) 02JL0
C                             OF SECTION                                02JL0
C         STT1. STT2          STIFFNESS AT MID POINTS OF PARTIAL        02JL0
C                             ELEMENTS AT BEGINNING AND END OF          02JL0
C                             ADAJACENT SECTIONS                        02JL0
C         ST1. ST6            RESTRAINTS AT MEMBER END STATIONS         02JL0
C         SU( ). SU4()        COEFF OF STIFF MATRIX (ONE ROW)           02JL0
C         SX( ). SY( ). SZ( ) MEMBER STATION ELASTIC RESTRAINTS         02JL0
C         SXL( ). SYL( ).     VALUES OF SX( ). SY( ). SZ( ). AT EDGES   02JL0
C         SZL()               OF SECTIONS                               02JL0
C         SXLT. SYLT. SZLT    VALUES OF SXL( ). SYL( ). SZL( ) AT       02JL0
C                             LEFT (START) OF SECTION                   02JL0
C         SXRT. SYRT. SZRT    VALUES OF SXL( ). SYL( ). SZL( ) AT       02JL0
C                             RIGHT (END) OF SECTION                    02JL0
C         SXX( ). SYY( ).     JOINT RESTRAINTS                          02JL0
C         SZZ( )                                                         2JL0
C         SXXT. SYYT. SZZT    TEMPORARY VALUES OF SXX( ). SYY( ).       02JL0
C                             SZZ( )                                    02JL0
C         T( )                AXIAL THRUST OUTPUT VALUE                 02JL0
C         TAU1. TAU2          CONCENTRATED ANGLE CHANGES IN ELEMENT     02JL0
C         TEMP1. TEMP2        TEMPORARY VALUES                          02JL0
C         TH                  ELELMENT LENGTH                           02JL0
C         TOL                 JOINT LOCATION TOLERANCE                  02JL0
C         TTOL                2*TOL                                     02JL0
C         T33                 TEMPORARY MATRIX USED TO OBTAIN TRIPLE    02JL0
C                             PRODUCT                                   02JL0
C         UQX( ). UQY( )      UNIFORM MEMBER LOADS                      02JL0
C         UQXT. UQYT          TEMPORARY VALUES OF UQX( ). UQY( )        02JL0
C         U1( ). U2( )        AXIAL FORCES ON ENDS OF ELEMENT           02JL0
C         V                   SHEAR FORCE OUTPUT VALUE                  02JL0
C         V1( ). V2( )        SHEAR FORCES ON ENDS OF ELEMENT           02JL0
C         W( )                DISPLACEMENT VECTOR FROM GRIP2A           02JL0
C         W1( ). W2( )        MOMENTS ON ENDS OF ELEMENT                02JL0
C         X( ). Y( )          JOINT COORDINATES                         02JL0
C         XL                  DISTANCE TO LEFT (START) OF SECTION       02JL0
C         XLL( )              DISTANCE TO LEFT (START) OF LOAD SECTION  02JL0
C         XLS( )              DISTANCE TO LEFT (START) OF STIFF SECTION 02JL0
C         XR                  DISTANCE TO RIGHT (END) OF SECTION        02JL0
C         XRL                 DISTANCE TO RIGHT (END) OF LOAD SECTION   02JL0
C         XRS( )              DISTANCE TO RIGHT (END) OF STIFF SECTION  02JL0
C         XT. YT              TEMPORARY JOINT COORDINATES               02JL0
C         XX                  DISTANCE TO CONCENTRATED LOAD FROM        02JL0
C                             STATION                                   02JL0
C         X1. X2              LENGTH OF PARTIAL ELEMENTS AT ENDS OF     02JL0
C                             SECTIONS                                  02JL0
C         X2L                 X2 FROM LAST SECTION                      02JL0
C         ZI                  FLOATING POINT I                          02JL0
C         ZI1. ZI2            FLOATING POINT I1 AND I2                  02JL0
C         ZL                  MEMBERS LENGTH                            02JL0
C         ZLL( )              LENGTH OF MEMBERS BY LOAD TYPE            02JL0
C         ZLS( )              LENGTH OF MEMBERS BY STIFF TYPE           02JL0
C         ZL2                 ZL*ZL                                     02JL0
C         ZL3                 ZL2*ZL                                    02JL0
C         ZM( ). ZMT          LOAD MULTIPLIERS                          02JL0
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APPENDIX 5

FORTRAN LISTING OF PROGRAM

```
      PROGRAM FRAME11 (INPUT,OUTPUT,TAPE1,TAPE2,TAPE3,TAPE4)            16JE0
COMMENT - THIS DRIVER ONLY DIMENSIONS PROGRAM                           24AP0
COMMENT - TO CHANGE DIMENSIONS CHANGE ONLY THIS DRIVER AND DIMENSIONED  24AP0
COMMENT - COMMON BLOCKS IN APPROPRIATE SUBROUTINES                      24AP0
COMMENT - VARIABLE NAMES DO NOT CHANGE IN DIMENSIONED COMMON BLOCKS     24AP0
COMMENT - DIMENSION GUIDE  -  DIMENSION GUIDE  -  DIMENSION GUIDE       28AP0
COMMENT - RM(L3, L6)     RO(L6)     W(L6)     SL(L3)    SU(L4)          28AP0
COMMENT - DM(L7, 6)      DMT(L7, 6)                                     28AP0
COMMENT - COMMON /BLOCK1/      (MNJT)    COMMON /BLOCK2/     (MNST)     28AP0
COMMENT - COMMON /BLOCK3/      (MNLT)    COMMON /BLOCK4/     ( MNM)     28AP0
COMMENT - COMMON /BLOCK5/      (MNC5)    COMMON /BLOCK6/     (MNC6)     28AP0
COMMENT - COMMON /BLOCK7/      ( MP2)    COMMON /BLOCK8/     (MNLC)     28AP0
COMMENT - COMMON /BLOCK9/      (MP22)    COMMON /BLOC10/   . (MHB1)     28AP0
      DIMENSION RM(29,225) , RO(225) , W(225) , SL(29) , SU(30)         08AP0
      DIMENSION DM(127,6), DMT(127,6)                                   08AP0
      COMMON /BLOCK1/ X( 75),     Y( 75),     QXX( 75),   QYY( 75),     13FE0
     2    UZZ( 75),   SXX( 75),   SYY( 75),   SZZ( 75),   DXX( 75),     13FE0
     3    DYY( 75),   DZZ( 75),   RXX( 75),   RYY( 75),   RZZ( 75),     13FE0
     4    ERXX( 75),  ERYY( 75),  ERZZ( 75)                             13FE0
      COMMON /BLOCK2/ DXS( 50),   DYS( 50),   ZLS( 50),   DC1S( 50),    26JA0
     2    DC2S( 50),  PRF( 50),   PRAE( 50),  NCDS( 50),  IAXOPS( 50),  26JA0
     3    IOPOP( 50), IPINL( 50), IPINR( 50), NC51( 50),  SMC( 50,13)   20MY0
      COMMON /BLOCK3/ DXL( 50),   DYL( 50),   ZLL( 50),   DC1L( 50),    26JA0
     2    DC2L( 50),  UQX( 50),   UQY( 50),   NCDL( 50),  IAXOPL( 50),  26JA0
     3    NC61( 50)                                                     26JA0
      COMMON /BLOCK4/ JT1(150),   JT2(150),   IST(150),   LT(150),      26JA0
     2    FORM(150,6)                                                   26JA0
      COMMON /BLOCK5/ XLS( 75),   XRS( 75),   FL( 75),    AEL( 75),     26JA0
     2    SXL( 75),   SYL( 75),   SZL( 75)                              26JA0
      COMMON /BLOCK6/ XLL(150),   XRL(150),   QXL(150),   QYL(150),     26JA0
     2    QZL(150)                                                      26JA0
      COMMON /BLOCK7/ F( 42),     AE( 42),    SX( 42),    SY(42),       26JA0
     2    SZ( 42),    QX( 42),    QY( 42),    QZ( 42),    A( 42),       26JA0
     3    B( 42),     A1( 42),    D( 42),     DX( 42),    DY( 42),      26JA0
     4    DZ(42),     U1(42),     V1(42),     W1(42),     U2(42),       13MR0
     5    V2(42),     W2(42),     ERX(42),    ERY(42),    ERZ(42),      13MR0
     6    RX(42),     RY(42),     RZ(42)                                13MR0
      COMMON /BLOCK8/ NP(21,2),   ZM(21)                                09JE0
      COMMON /BLOCK9/ T(21),      V(21),      BM(21),     DXT(21),      13MR0
     2    DYT(21),    DZT(21)                                           13MR0
      COMMON / BLOC10 / SSL (3,30)                                      08AP0
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, XEEP6, KEEP7,          26JA0
     2         ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,          26JA0
     3         IABAN, IFORM, NN,    NJT,   NST,   NLT,   TOL,           26JA0
     4         M,     MP1,   MP2,   IST7,  LTT,   ITYPEL,IDJ,           12FE0
     5         NLC,   IP8,   IP9,   IP10                                13FE0
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,NO,H,TH,HSQ,HCU,X2L               26JA0
      COMMON /BLK3/  MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNLC             07FE0
      COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6                             26JA0
      COMMON /BLK5/ NFSUB                                               08AP0
      COMMON / RI / NL, ML, J1                                          08AP0
    1 FORMAT  (  47H ********** MNM MUST BE GREATER THAN OR EQUAL TO,   08JE0
     2       15H MNJT **********, / ,  25H     REDIMENSION DRIVER  )    08JE0
    2 FORMAT  (  46H ********** M MUST BE AN EVEN INTEGER LESS THAN,    08JE0
     2       20H 3*MNJT/2 - 1 ***** , /,,  25H     REDIMENSION DRIVER  ) 08JE0
COMMENT - SET DIMENSION LIMITS                                          16MY0
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            MNJT =  75                                                  06AP0
COMMENT - MNM MUST BE GREATER THAN OR EQUAL TO MNJT                     16MY0
            MNM  = 150                                                  06AP0
         IF (MNM .LT. MNJT) PRINT 1                                     08JE0
            MNST =  50                                                  06AP0
            MNLT =  50                                                  06AP0
            MNC5 =  75                                                  06AP0
            MNC6 = 150                                                  06AP0
            MDJT =   9                                                  06AP0
            MNLC = 21                                                   26JA0
COMMENT - M MUST BE AN EVEN INTEGER NUMBER LESS THAN 3*MNJT/2 - 1       16MY0
            M = 40                                                      26JA0
         IF (M .GE. (3*MNJT/2 - 1)) PRINT 2                             08JE0
         IF (((M/2)*2) .NE. M) PRINT 2                                  08JE0
COMMENT - COMPUTE CONSTANTS                                             16MY0
            MP1 = M + 1                                                 26JA0
            MP2 = M + 2                                                 26JA0
            MP22 = MP2/2                                                28AP0
            MHB   =  3*MDJT + 2                                         26JA0
            MHB1 = MHB + 1                                              28AP0
            L1   =  MP2                                                 11FE0
            L2   =  2*MP1                                               11FE0
            L3   =  MHB                                                 11FE0
            L4   =  MHB + 1                                             11FE0
            L6 = 3*MNJT                                                 26JA0
            L7 = 3*MP2 + 1                                              20MR0
COMMENT - SUBROUTINE FRAM11 IS THE MAIN SUBROUTINE OF PROGRAM FRAME11   29AP0
      CALL        FRAM11 ( RM, RO, W, SL, SU, DM, DMT, L1, L2, L3, L4,  08AP0
     2    L6, L7 )                                                       8AP0
      END                                                               26JA0
C
C        *****************************************************************
C
C        SUBROUTINE            SUBROUTINE            SUBROUTINE            SUBROUTINE
C
C        *****************************************************************
C
      SUBROUTINE FRAM11 ( RM, RO, W, SL, SU, DM, DMT, L1, L2, L3, L4,   08AP0
     2    L6, L7 )                                                       8AP0
COMMENT - SUBROUTINE FRAM11 IS THE MAIN SUBROUTINE OF PROGRAM FRAME11   29AP0
      DIMENSION RM(L3,L6), RO(L6), W(L6), SL(L3), SU(L4)                08AP0
      DIMENSION  DM(L7,6),DMT(L7,6)                                     16MR0
      DIMENSION SMMT(13),FOMMT(6)                                       26JA0
      DIMENSION AN1(40), AN2(18), AN3(2), NPROB(2), ITEST(4)            09JE0
      COMMON /BLOCK1/ X( 75),     Y( 75),     QXX( 75),   QYY( 75),     13FE0
     2    UZZ( 75),   SXX( 75),   SYY( 75),   SZZ( 75),   DXX( 75),     13FE0
     3    DYY( 75),   DZZ( 75),   RXX( 75),   RYY( 75),   RZZ( 75),     13FE0
     4    ERXX( 75),  ERYY( 75),  ERZZ( 75)                             13FE0
      COMMON /BLOCK2/ DXS( 50),   DYS( 50),   ZLS( 50),   DC1S( 50),    26JA0
     2    DC2S( 50),  PRF( 50),   PRAE( 50),  NCDS( 50),  IAXOPS( 50),  26JA0
     3    IOPOP( 50), IPINL( 50), IPINR( 50), NC51( 50),  SMC( 50,13)   20MY0
      COMMON /BLOCK3/ DXL( 50),   DYL( 50),   ZLL( 50),   DC1L( 50),    26JA0
     2    DC2L( 50),  UQX( 50),   UQY( 50),   NCDL( 50),  IAXOPL( 50),  26JA0
     3    NC61( 50)                                                     26JA0
      COMMON /BLOCK4/ JT1(150),   JT2(150),   IST(150),   L7(150),      26JA0
     2    FORM(150,6)                                                   26JA0
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      COMMON /BLOCK5/ XLS( 75),    XRS( 75),    FL( 75),     AEL( 75),       26JA0
     2     SXL( 75),   SYL( 75),   SZL( 75)                                  26JA0
      COMMON /BLOCK6/ XLL(150),    XRL(150),    QXL(150),    QYL(150),       26JA0
     2     QZL(150)                                                          26JA0
      COMMON /BLOCK7/ F( 42),      AE( 42),     SX( 42),     SY(42),         26JA0
     2     SZ( 42),    QX( 42),    QY( 42),     QZ( 42),     A( 42),         26JA0
     3     B( 42),     A1( 42),    D( 42),      DX( 42),     DY( 42),        26JA0
     4     DZ(42),     U1(42),     V1(42),      W1(42),      U2(42),         13MR0
     5     V2(42),     W2(42),     ERX(42),     ERY(42),     ERZ(42),        13MR0
     6     RX(42),     RY(42),     RZ(42)                                    13MR0
      COMMON /BLOCK9/ T(21),       V(21),       BM(21),      DXT(21),        13MR0
     2     DYT(21),    DZT(21)                                               13MR0
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,               26JA0
     2          ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,              26JA0
     3          IABAN, IFORM, NN,    NJT,   NST,   NLT,   TOL,               26JA0
     4          N,     NP1,   NP2,   ISTT,  LTT,   ITYPEL,IDJ,               12FE0
     5          NLC,   IP8,   IP9,   IP10                                    13FE0
      COMMON /BLK3/  NNJT,NNST,NNLT,NNN,NNC5,NNC6,NDJT,NNLC                  07FE0
      COMMON /BLK5/ NFSUB                                                    08AP0
      COMMON / R1 / NL, ML, J1                                               08AP0
    1 FORMAT  (  50H      PROGRAM  FRAME 11 - DEV DECK - MATLOCK-HAYS   ,  26JA0
     2                26HREVISION DATE = 27 AUG  70)                         27AG0
   10 FORMAT  (  5H       ,BOX    10H1--------TRIM  )                        26JA0
   11 FORMAT  (  5H1      ,BOX    10H1--------TRIM  )                        26JA0
   12 FORMAT (  20A4   )                                                     18MY0
   13 FORMAT (     5X, 20A4 )                                                18MY0
   14 FORMAT ( A1, A4, 5X, 17A4, A2        )                                 18MY0
   15 FORMAT (///10H      PROB , /5X, A1, A4, 5X, 17A4, A2 )                 18MY0
   16 FORMAT (///17H      PROB (CONTD), /5X, A1, A4, 5X, 17A4, A2, // )      18MY0
   17 FORMAT (A1,A4,A1,A4,17A4,A2)                                           08JE0
   50 FORMAT (     51H      SOLUTION ABANDONED IN SEARCH OF AN INDEPENDENT  26JA0
     2             10H PROBLEM  ,///,                                        26JA0
     3             49H      THE FOLLOWING CARDS WERE DISCARDED IN SEARCH,   26JA0
     4             //)                                                       26JA0
   51 FORMAT (//,50H      NO HOLD OPTIONS MAY BE EXERCISED ON FIRST PRO,   07FE0
     2             15HBLEM OF RUN    )                                       07FE0
   52 FORMAT (     40H      PROBLEM MUST BE TYPE 1, 2, 3, OR 4 )             04MY0
   53 FORMAT (     35H      HOLD OPTIONS MUST BE 1 OR 0    )                 04MY0
   54 FORMAT (     35H      PRINT OPTIONS MUST BE 1 OR 0   )                 04MY0
   55 FORMAT (     46H      NUMBER OF CARDS ADDED CAN NOT BE NEGATIVE)       04MY0
  100 FORMAT  (5X,I5,5X, 6I5,5X,3I5,/,15X, 6I5)                              13MR0
  101 FORMAT  (8(/), 35H      TABLE 1 - PROGRAM CONTROL DATA,/,              26JA0
     2             17H      PROBLEM TYPE,I5,///,29X,12HINPUT TABLES,//,      30MR0
     3      10X,   45H TABLE    HOLD DATA FROM       NUMBER OF CARDS,/,     26JA0
     4      10X,   45H NUMBER    LAST PROBLEM        ADDED FOR THIS ,/,      26JA0
     5      10X,   45H           (1 - YES,0 - NO)    PROBLEM         ,//,    26JA0
     6      10X,5H    2,10X,I5,15X,I5,/,  10X,5H    3,10X,I5,15X,I5,/,      26JA0
     7      10X,5H    4,10X,I5,15X,I5,/,  10X,5H    5,10X,I5,15X,I5,/,      26JA0
     8      10X,5H    6,10X,I5,15X,I5,/,  10X,5H    7,10X,I5,15X,I5,//,     13MR0
     9      29X,   13HOUTPUT TABLES,//,                                      30MR0
     1      10X,   29H  TABLE    SUPPRESS OUTPUT,/,                          13MR0
     2      10X,   29H NUMBER  (1 = YES,0 = NO),//,                          13MR0
     3      10X,5H    8,10X,I5,/,10X,5H    9,10X,I5,/,10X,5H   10,10X,I5)   13MR0
  151 FORMAT (     50H      TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS   , 10FE0
     2 ///,20X,   15HDISPLACEMENTS  ,16X,  10H REACTIONS,//,                 10FE0
     3       5X,  39HJOINT  DISP(X)     DISP(Y)  ROTATION(Z) ,               30MR0
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     4                31HREACT(X)    REACT(Y)    REACT(Z) ,// )              10FE0
  152 FORMAT (5X,I5,6E11.3)                                                 10FE0
  162 FORMAT  (  45H      TABLE 10 - JOINT EQUILIBRIUM ERRORS        ,///,  25MR0
     2           40H      JOINT  ERR(X)      ERR(Y)      ERR(Z),/,           24AP0
     3           40H             FORCE       FORCE       MOMENT,//)          24AP0
      DATA  ITEST(1), ITEST(2), ITEST(3), ITEST(4) / 1HC, 4HEASE, 1H ,     10JE0
     2    4H    /                                                            10JE0
               ITYPEL = 0                                                    07FE0
COMMENT - READ RUN ID,PRINT PROGRAM ID AND RUN ID                            24AP0
      READ  12, (AN1(II), II = 1, 40)                                        09JE0
      PRINT 11                                                               26JA0
      PRINT 1                                                                26JA0
      PRINT 12, (AN1(II), II = 1, 40)                                        09JE0
COMMENT - RETURN HERE TO READ NEW PROBLEM                                    24AP0
 1010 READ  14, NPROB, (AN2(II), II = 1, 18)                                 09JE0
COMMENT - IF NPROB = CEASE, TERMINATE RUN                                    24AP0
         IF (NPROB(1) .EQ. ITEST(1) .AND. NPROB(2) .EQ. ITEST(2))            09JE0
     2                                                 GO TO 9900            09JE0
COMMENT - INPUT AND ECHO PRINT PROGRAM CONTROL DATA (TABLE 1)                24AP0
      READ 100, ITYPE,KEEP2,KEEP3,KEEP4,KEEP5,KEEP6,KEEP7,IP8,IP9,IP10,     13MR0
     2    NCD2,NCD3,NCD4,NCD5,NCD6,NCD7                                      26JA0
 1050 PRINT 11                                                               26JA0
      PRINT 12, (AN1(II), II = 1, 40)                                        09JE0
      PRINT 15, NPROB, (AN2(II), II = 1, 18)                                 09JE0
      PRINT 101,  ITYPE,KEEP2,NCD2,KEEP3,NCD3,KEEP4,NCD4,KEEP5,NCD5,        26JA0
     2    KEEP6,NCD6,KEEP7,NCD7,IP8,IP9,IP10                                 13MR0
COMMENT - CHECK FOR ILLEGAL DATA IN TABLE 1                                  22MY0
         IF (ITYPE .LT. 1 .OR. ITYPE .GT. 4) GO TO 1210                      04MY0
         IF (KEEP2 .LT. 0 .OR. KEEP2 .GT. 1)  GO TO 1220                     04MY0
         IF (KEEP3 .LT. 0 .OR. KEEP3 .GT. 1)  GO TO 1220                     04MY0
         IF (KEEP4 .LT. 0 .OR. KEEP4 .GT. 1)  GO TO 1220                     04MY0
         IF (KEEP5 .LT. 0 .OR. KEEP5 .GT. 1)  GO TO 1220                     04MY0
         IF (KEEP6 .LT. 0 .OR. KEEP6 .GT. 1)  GO TO 1220                     04MY0
         IF (KEEP7 .LT. 0 .OR. KEEP7 .GT. 1)  GO TO 1220                     04MY0
         IF (IP8  .LT. 0 .OR. IP8  .GT. 1) GO TO 1230                        04MY0
         IF (IP9  .LT. 0 .OR. IP9  .GT. 1) GO TO 1230                        04MY0
         IF (IP10 .LT. 0 .OR. IP10 .GT. 1) GO TO 1230                        04MY0
         IF (NCD2 .LT. 0) GO TO 1240                                         04MY0
         IF (NCD3 .LT. 0) GO TO 1240                                         04MY0
         IF (NCD4 .LT. 0) GO TO 1240                                         04MY0
         IF (NCD5 .LT. 0) GO TO 1240                                         04MY0
         IF (NCD6 .LT. 0) GO TO 1240                                         04MY0
         IF (NCD7 .LT. 0) GO TO 1240                                         04MY0
            KEKE = KEEP2 + KEEP3 + KEEP4 + KEEP5 + KEEP6 + KEEP7             07FE0
         IF ( ITYPEL .EQ. 0 .AND. KEKE .NE. 0 ) GO TO 1200                   07FE0
         GO TO 1300                                                           7FE0
COMMENT - ABORT PROBLEM,SEARCH FOR INDEPENDENT PROBLEM                       24AP0
 1200 PRINT 51                                                                7FE0
         GO TO 9800                                                          07FE0
 1210 PRINT 52                                                                4MY0
         GO TO 9800                                                           4MY0
 1220 PRINT 53                                                                4MY0
         GO TO 9800                                                          04MY0
 1230 PRINT 54                                                               04MY0
         GO TO 9800                                                          04MY0
 1240 PRINT 55                                                                4MY0
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           GO TO 9800                                                     04MYO
 1300      CONTINUE                                                       09FEO
                IABAN = 0                                                 26JAO
COMMENT - IABAN = 1 INDICATES FATAL ERROR FOUND IN SUBROUTINE             24APO
COMMENT - PROBLEM ABANDONED IN SEARCH OF AN INDEPENDENT PROBLEM           24APO
           IF (KEEP5 .EQ. 0)  NSTL = 0                                    26JAO
COMMENT - MAIN PROGRAM STARTS HERE                                        24APO
COMMENT - SKIP TABLES 2 - 6 FOR FAMILY PROBLEM                            24APO
           IF ( ITYPE .EQ. 4 ) GO TO 4000                                 09FEO
      PRINT 11                                                            26JAO
      PRINT 16, NPROB, (AN2(II), II = 1, 18)                              09JEO
COMMENT - SUBROUTINE JTCORD INPUTS JOINT GEOMETRY DATA (TABLE 2)          24APO
COMMENT - CHECKS FOR BAD DATA, COMPUTES JOINT COORDINATES,ECHO PRINTS     24APO
COMMENT - DATA AND PRINTS COMPUTED JOINT COORDINATES                      24APO
      CALL       JTCORD                                                   26JAO
           IF ( IABAN .EQ. 1 ) GO TO 9800                                 26JAO
      PRINT 11                                                            26JAO
      PRINT 16, NPROB, (AN2(II), II = 1, 18)                              09JEO
COMMENT - SUBROUTINE  MEMLOC  INPUTS LOCATION OF STIFFNESS AND LOAD       24APO
COMMENT - TYPES IN FRAME (TABLE 3),CHECKS FOR BAD DATA,COMPUTES MEMBER    24APO
COMMENT - NUMBERS,LENGTHS OFFSETS AND DIRECTION COSINES,ECHO PRINTS DATA24APO
COMMENT - AND PRINTS COMPUTED MEMBER NUMBERS,LENGTHS AND OFFSETS          24APO
      CALL       MEMLOC                                                   76JAO
           IF ( IABAN .EQ. 1) GO TO 9800                                  26JAO
      PRINT 11                                                            26JAO
      PRINT 16, NPROB, (AN2(II), II = 1, 18)                              09JEO
COMMENT - SUBROUTINE JNTDAT INPUTS JOINT LOADS AND RESTRAINTS             24APO
COMMENT - (TABLE 4),CHECKS FOR BAD DATA,ACCUMULATES JOINT LOADS AND       24APO
COMMENT - RESTRAINTS,ECHO PRINTS DATA AND PRINTS ACCUMULATED DATA         24APO
      CALL       JNTDAT                                                   26JAO
           IF ( IABAN .EQ. 1) GO TO 9800                                  26JAO
      PRINT 11                                                            26JAO
      PRINT 16, NPROB, (AN2(II), II = 1, 18)                              09JEO
COMMENT - SUBROUTINE RDMST  INPUTS MEMBER STIFFNESS DATA (TABLE 5),       24APO
COMMENT - CHECKS FOR BAD DATA,CONVERTS INPUT DISTANCES TO MEMBER          24APO
COMMENT - COORDINATES AND ECHO PRINTS DATA                                24APO
      CALL       RDMST                                                    26JAO
           IF ( IABAN .EQ. 1) GO TO 9800                                  26JAO
      PRINT 11                                                            26JAO
      PRINT 16, NPROB, (AN2(II), II = 1, 18)                              09JEO
COMMENT - FOR BAD DATA, CONVERTS LOADS AND DISTANCES TO MEMBER            24APO
COMMENT - COORDINATES AND ECHO PRINTS DATA                                24APO
      CALL       RDMLD                                                    26JAO
           IF ( IABAN .EQ. 1) GO TO 9800                                  26JAO
 4000      CONTINUE                                                        9FEO
      PRINT 11                                                             9FEO
      PRINT 16, NPROB, (AN2(II), II = 1, 18)                              09JEO
COMMENT - SUBROUTINE  COMP  INPUTS SUPERPOSITION DATA (TABLE 7) FOR       24APO
COMMENT - FAMILY PROBLEMS,CHECKS FOR BAD DATA,SETS UP STORAGE FOR FAMILY24APO
COMMENT - SOLUTIONS, ACCUMULATES PROBLE MULTIPLIERS,ECHO PRINTS DATA      24APO
COMMENT - AND PRINTS ACCUMULATED PROBLEN MULTIPLIERS                      24APO
      CALL       COMP ( NPROB )                                           09FEO
           IF ( IABAN .EQ. 1 ) GO TO 9800                                 09FEO
                ITYPEL = ITYPE                                            09FEO
COMMENT - SKIP FOR FAMILY PROBLEN                                         24APO
           IF ( ITYPE .EQ. 4 ) GO TO 6800                                 09FEO
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COMMENT - FORM MEMBER STIFFNESS MATRICES AND MEMBER FIXED-END-FORCE       24APO
COMMENT - MATRICES                                                        24APO
           DO 5800  JJ = 1,NM                                             26JAO
                ISTT = IST(JJ)                                            26JAO
                LTT = LT(JJ)                                              26JAO
COMMENT - SKIP FOR NULL MEMBER                                            24APO
           IF (ISTT .EQ. 0) GO TO 5750                                    06APO
COMMENT - SKIP FOR OFFSPRING PROBLEMS                                     22MYO
           IF (ITYPE .EQ. 3) GO TO 5550                                   20MYO
COMMENT - SKIP FOR STIFFNESS TYPES HELD FROM LAST PROBLEM - NOTE THAT     24APO
COMMENT - IF TABLE 5 IS NOT KEPT NSTL = 0.                                24APO
           IF (ISTT .LE. NSTL) GO TO 5550                                 24APO
           IF (JJ .EQ. 1) GO TO 5500                                      24APO
COMMENT - SKIP FOR STIFFNESS TYPE REPEATED IN THIS PROBLEM                24APO
           IF (ISTT .EQ. IST(JJ - 1)) GO TO 5700                          26JAO
COMMENT - SUBROUTINE FORMST CALCULATES STIFFNESS MATRIX FOR BOTH          24APO
COMMENT - PRISMATIC AND VARIABLE CROSS SECTION MEMBERS AND STORES IN      24APO
COMMENT - COMPACT VECTOR  SMMT(I = 1,13)                                  24APO
 5500 CALL       FORMST ( RM, RO, W, SL, SU, SMMT, L1, L3, L4, L6 )       08APO
           DO 5510  I = 1,13                                              26JAO
 5510           SMC(ISTT,I) = SMMT(I)                                     21MYO
           GO TO 5700                                                     26JAO
 5550           IFORM = 0                                                 26JAO
 5700      CONTINUE                                                       26JAO
           IF (LTT .EQ. 0) GO TO 5750                                     26JAO
COMMENT - SUBROUTINE FORMLD CALCULATES FIXED-END-FORCE MATRIX FOR         24APO
COMMENT - BOTH PRISMATIC UNIFORMLY LOADED MEMBERS AND ALL OTHERS          24APO
      CALL       FORMLD ( RM, RO, W, SL, SU, FOMMT, L1, L3, L4, L6 )      08APO
           DO 5710  I = 1,6                                               26JAO
 5710           FOMM(JJ,I) = FOMMT(I)                                     11FEO
           GO TO 5800                                                     26JAO
COMMENT - SET FIXED END-FORCE-MATRIX TO NULL MATRIX FOR NULL LOADING      24APO
 5750      DO 5780  I = 1,6                                               26JAO
 5780           FOMM(JJ,I) = 0.0                                          11FEO
 5800      CONTINUE                                                       26JAO
                NSTL = NST                                                26JAO
COMMENT - START SOLUTION OF FRAME JOINT EQUILIBRIUM EQUATIONS             24APO
COMMENT - SET CONTROL CONSTANTS FOR FRAME SOLUTION                        24APO
                IHB = 3*IDJ + 2                                           26JAO
                NL = 3*NJT                                                08APO
           IF (ITYPE .EQ. 1) NL =  0                                      08APO
           IF (ITYPE .EQ. 2) NL =  1                                      08APO
           IF (ITYPE .EQ. 3) NL =  -1                                     08APO
                NFSUB = 11                                                08APO
      REWIND  2                                                            8APO
COMMENT - READ RM AND RO OFF TAPE FOR OFFSPRING PROBLEM                   24APO
           IF (NL .NE. -1) GO TO 6100                                     09JEO
      READ  (2)  (((RM(I,J),I = 1,IHB),RO(J)),J = 1,NL)                   01JLO
 6100      CONTINUE                                                       09JEO
COMMENT - CALL GRIP2A FOR SOLUTION OF FRAME JOINT EQUILIBRIUM EQUATIONS 24APO
COMMENT - GRIP2A SOLVES BOTH FRAME JOINT EQUILIBRIUM EQUATIONS AND        24APO
COMMENT - MEMBER EQUILIBRIUM EQUATIONS - GRIP2A CALLS FSUB1 WHICH CALLS 24APO
COMMENT - FSUB11 TO SET UP FRAME EQUATIONS OR FSUB12 TO SET UP MEMBER     24APO
COMMENT - EQUATIONS                                                       24APO
      CALL       GRIP2A ( RM, RO, W, SL, SU, L3, L4, L6, IHB )            15MYO
COMMENT - WRITE RM AND RO ON TAPE FOR PARENT PROBLEM - THEY WOULD BE      24APO
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COMMENT - DESTROYED BY MEMBER SOLUTIONS IF NOT STORED                    24APO
          IF (NL .EQ. 0) GO TO 6200                                      09JEO
      WRITE (2)  (((RM(I,J),I = 1,IMB),RO(J)),J = 1,NL)                  01JLO
 6200     CONTINUE                                                        9JEO
                J = 0                                                    24APO
COMMENT - TRANSFER JOINT DISPLACEMENTS FROM W TO DXX, DYY, DZZ           24APO
          DO 6500  I = 1, NJT                                            28JAO
                J = J + 1                                                06MRO
                DXX(I) = W(J)                                            08APO
                J = J + 1                                                06MRO
                DYY(I) = W(J)                                            08APO
                J = J + 1                                                06MRO
                DZZ(I) = W(J)                                            08APO
 6500     CONTINUE                                                       06MRO
COMMENT - SOLVE FOR JOINT REACTIONS                                      24APO
          DO 6600  I = 1,NJT                                             10FEO
                RXX(I) = SXX(I)*DXX(I)*(-1.0)                            10FEO
                RYY(I) = SYY(I)*DYY(I)*(-1.0)                            10FEO
 6600           RZZ(I) = SZZ(I)*DZZ(I)*(-1.0)                            11FEO
COMMENT - SKIP FOR REGULAR PROBLEM                                       24APO
          IF (ITYPE .EQ. 1) GO TO 7000                                   12FEO
COMMENT - START NEW SERIES OF SUPERPOSITION SOLUTIONS                    24APO
          IF (ITYPE .EQ. 2) REWIND 1                                     16JEO
COMMENT - STORE JOINT DISPLACEMENTS,REACTIONS,AND LOADS ON TAPE FOR      24APO
COMMENT - PARENT AND OFFSPRING PROBLEMS                                  24APO
      WRITE (1) ( DXX(I),DYY(I),DZZ(I),RXX(I),RYY(I),RZZ(I),QXX(I),      16JEO
     2                QYY(I), QZZ(I),    I = 1,NJT )                     12FEO
          GO TO 7000                                                     10FEO
 6800     CONTINUE                                                        9FEO
COMMENT - SUBROUTINE SUM1      DOES SUPERPOSITION SOLUTION FOR FRAME     24APO
COMMENT - JOINT DISPLACEMENTS AND REACTIONS FOR FAMILY PROBLEMS          24APO
      CALL        SUM1                                                   12FEO
 7000     CONTINUE                                                       10FEO
COMMENT - PRINT TABLE 8 IF REQUESTED                                     24APO
          IF (IP8 .EQ. 1) GO TO 7200                                     13MRO
      PRINT 11                                                           10FEO
      PRINT 16, NPROB, (AN2(II), II = 1, 18)                             09JEO
      PRINT 151                                                          10FEO
          DO 7100  I = 1,NJT                                             10FEO
 7100 PRINT 152, I, DXX(I), DYY(I), DZZ(I), RXX(I), RYY(I), RZZ(I)       10FEO
 7200     CONTINUE                                                       13MRO
COMMENT - COMPUTE FOR EACH JOINT - THE SUM OF APPLIED JOINT LOAD         24APO
COMMENT - AND THE REACTION - WHEN THE APPROPRIATE MEMBER END FORCES ARE  24APO
COMMENT - SUBTRACTED FROM THIS SUM THE RESULT IS THE JOINT EQUILIBRIUM   24APO
COMMENT - ERRORS                                                         24APO
          DO 7250  I = 1,NJT                                             20MRO
                ERXX(I) = QXX(I) + RXX(I)                                20MRO
                ERYY(I) = QYY(I) + RYY(I)                                20MRO
 7250           ERZZ(I) = QZZ(I) + RZZ(I)                                20MRO
COMMENT - START SOLUTION FOR MEMBER RESULTS                              24APO
                JJ = 0                                                   16MRO
COMMENT - MEMBERS ARE PUT IN GROUPS OF SIX SO RESULTS CAN BE WRITTEN ON  24APO
COMMENT - TAPE ON LONG BINARY RECORD                                     24APO
                NM6 = (NM - 1)/6 + 1                                     06APO
COMMENT - START NEW SERIES OF SUPERSITION SOLUTIONS FOR PARENT PROBLEM   24APO
          IF (ITYPE .EQ. 2)     REWIND 4                                 16JEO
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COMMENT - SKIP FOR FAMILY PROBLEM                                        24APO
          IF (ITYPE .EQ. 4) GO TO 7900                                   13MRO
COMMENT - DO IN GROUPS OF SIX                                            24APO
          DO 7500  NI = 1, NM6                                           20MRO
COMMENT - DO FOR EACH MEMBER OF GROUP                                    24APO
          DO 7400  KK = 1,6                                              20MRO
                JJ = JJ + 1                                              16MRO
COMMENT - SUBROUTINE MEMRES COMPUTES MEMBER RESULTS FOR ALL MEMBERS      24APO
COMMENT - IN FRAME, SUBTRACTS APPROPRIATE MEMBER END FORCES TO COMPLETE  24APO
COMMENT - CALCULATION OF JOINT EUULIB ERRORS  AND PRINTS OUT MEMBER      24APO
COMMENT - RESULTS                                                        24APO
      CALL        MEMRES ( DM, JJ, KK, RM, RO, W, SL, SU, NPROB, AN2, L1,08APO
     2    L3, L4, L6, LT )                                               08APO
 7400     CONTINUE                                                       13MRO
COMMENT - SKIP FOR REGULAR PROBLEM                                       24APO
          IF (ITYPE .EQ. 1) GO TO 7500                                   20MRO
COMMENT - STORE RESULTS FOR SIX MEMBERS                                  24APO
      WRITE  (4)     ((DM(IJ,KK) , IJ = 1,L7 ), KK = 1,6 )               16JEO
 7500     CONTINUE                                                       20MRO
          GO TO 8000                                                     20MRO
 7900     CONTINUE                                                       20MRO
COMMENT - SUBROUTINE  SUM2    DOES SUPERPOSITION SOLUTION FOR MEMBERS    24APO
COMMENT - FUR FAMILY PROBLEMS,SUBTHACTS APPROPRIATE MEMBER END FORCES    24APO
COMMENT - TO CUMPLETE CALCULATION OF JOINT EQUILIBRIUM ERROR AND PRINTS 24APO
COMMENT - MEMBER RESULTS                                                 24APO
      CALL        SUM2 (DM,DMT,LT,NM6,AN2,NPROB )                        25MRO
 8000     CONTINUE                                                       13MRO
COMMENT - PRINT TABLE 10 (JOINT EQUILIBRIUM ERRORS)IF REQUESTED          24APO
          IF (IP10 .EQ. 1) GO TO 8500                                    25MRO
      PRINT 11                                                           25MRO
      PRINT 16, NPROB, (AN2(II), II = 1, 18)                             09JEO
      PRINT 162                                                          25MRO
          DO 8100  I = 1,NJT                                             21MRO
 8100 PRINT 152, I, ERXX(I), ERYY(I), ERZZ(I)                            21MRO
 8500     CONTINUE                                                       13MRO
COMMENT - RETURN FOR NEW PROBLEM                                         24APO
 9000     GO TO 1010                                                     26JAO
COMMENT - SULUTIUN ABANDONED - SEARCH FOR INDEPENDENT PROBLEM BEGINS     24APO
COMMENT - HERE                                                           24APO
 9800 PRINT 50                                                           26JAO
 9810 READ  17, NPROB, AN3, (AN2(II), II = 1, 18)                        09JEO
          IF (NPROB(1) .NE. ITEST(3) .OR. NPROB(2) .NE. ITEST(4))        10JEO
     2                                               GO TO 9840          09JEO
      PRINT 17, NPROB, AN3, (AN2(II), II = 1, 18)                        09JEO
          GO TO 9810                                                     26JAO
 9840     IF (NPROB(1) .EQ. ITEST(1) .AND. NPROB(2) .EQ. ITEST(2))       09JEO
     2                                               GO TO 9900          09JEO
      READ 100, ITYPE,KEEP2,KEEP3,KEEP4,KEEP5,KEEP6,KEEP7,IP8,IP9,IP10, 13MRO
     2    NCD2,NCD3,NCD4,NCD5,NCD6,NCD7                                  26JAO
               KEKE = KEEP2 + KEEP3 + KEEP4 + KEEP5 + KEEP6 + KEEP7      26JAO
          IF (KEKE .EQ. 0 .AND. ITYPE .LE. 2) GO TO 1050                 09FEO
      PRINT 17, NPROB, AN3, (AN2(II), II = 1, 18)                        09JEO
      PRINT 100,ITYPE,KEEP2,KEEP3,KEEP4,KEEP5,KEEP6,KEEP7,IP8,IP9,IP10, 22APO
     2    NCD2,NCD3,NCD4,NCD5,NCD6,NCD7                                  22APO
          GO TO 9810                                                     26JAO
 9900     CONTINUE                                                       26JAO
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      RETURN                                                            26JA0
      END                                                               26JA0
C
C         ****************************************************************
C
C         SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C         ****************************************************************
C
      SUBROUTINE JTCORD                                                 26JA0
COMMENT - SUBROUTINE JTCORD INPUTS JOINT GEOMETRY DATA (TABLE 2)        24AP0
COMMENT - CHECKS FOR BAD DATA, COMPUTES JOINT COORDINATES,ECHO PRINTS   24AP0
COMMENT - DATA AND PRINTS COMPUTED JOINT COORDINATES                    24AP0
      DIMENSION J2( 7 )                                                 26JA0
      COMMON /BLOCK1/ X( 75),      Y( 75),     OXX( 75),   OYY( 75),    13FE0
     2    OZZ( 75),   SXX( 75),   SYY( 75),   SZZ( 75),   DXX( 75),     13FE0
     3    DYY( 75),   DZZ( 75),   RXX( 75),   RYY( 75),   RZZ( 75),     13FE0
     4    ERXX( 75),  ERYY( 75),  ERZZ( 75)                             13FE0
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,          26JA0
     2         ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,          26JA0
     3         IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,           26JA0
     4         M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,           12FE0
     5         NLC,   IP8,   IP9,   IP10                                13FE0
      COMMON /BLK3/  MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNLC             07FE0
    9 FORMAT (          35H     TABLE 2 - FRAME GEOMETRY DATA ,///)     26JA0
   10 FORMAT (10X,I5,5X,I5,5X,2E10.3,10X,E10.3)                         26JA0
   11 FORMAT (          32H     NUMBER OF JOINTS IN FRAME =,I5,/,       26JA0
     2              30H     REFERENCE JOINT IS JOINT ,I5,    5H  AT ,   26JA0
     3               5H X  =,E12.3,10H AND Y =  ,E10.3,/ ,3X,           26JA0
     4              25H  JOINT TOLERANCE IS      ,E10.3,//)             26JA0
   12 FORMAT (10X,I5,5X,2E10.3,5X,7I5)                                  26JA0
   13 FORMAT ( 10X,I5,5X,2E11.3,5X,7I5)                                 26JA0
   14 FORMAT ( 25X,  23H INPUT OF JOINT OFFSETS ,//,                    26JA0
     2          10X,   35H FROM         X-OFFSET    Y-OFFSET     ,3X,   26JA0
     3                 35H  TO    TO    TO    TO    TO    TO    TO ,/,  30MR0
     4     10X,    5HJOINT, 32X, 5HJOINT ,/)                            30MR0
   15 FORMAT ( 47X,7I5)                                                 26JA0
   16 FORMAT ( 10X,I5)                                                  26JA0
   17 FORMAT      (48H     HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS,  26JA0
     2              15H THE FOLLOWING , //)                             26JA0
   18 FORMAT    ( 33H     NUMBER OF JOINTS IN FRAME = , I5,///)         26JA0
   19 FORMAT ( 3(/),10X,   26HCOMPUTED JOINT COORDINATES, //, 10X,      30MR0
     2                     25HJOINT      X           Y    ,/)           26JA0
   20 FORMAT (   45H     JOINT NUMBERS MUST BE POSITIVE           )     26JA0
   21 FORMAT ( 10X,I5,2E11.3)                                           26JA0
   22 FORMAT (   19H     JOINT NUMBERS, I5,17H NOT LOCATED )            29AP0
   23 FORMAT (   10H     NONE )                                         26JA0
   30 FORMAT (   40H     NO DATA HELD OR READ IN TABLE 2     )          26JA0
   31 FORMAT (   50H     NUMBER OF CARDS IN TABLE 2 MAY NOT EQUAL 1    ) 09MY0
   40 FORMAT  (  51H     TYPE 3 PROBLEM SHOULD HAVE NO CHANGES IN JOINT,26JA0
     2          13H COORDINATES ,/,                                     26JA0
     3          33H     NO CARDS ALLOWED IN TABLE 2 )                   26JA0
   50 FORMAT (   43H     JOINT NUMBER ABOVE GREATER THAN NUMBER,        26JA0
     2          20H OF JOINTS IN FRAME )                                26JA0
   60 FORMAT (   43H     NUMBER OF JOINTS IN FRAME GREATER THAN,        26JA0
     2          15H STORAGE ALLOWS)                                     26JA0
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   70 FORMAT (   35H            X AND Y OFFSETS FOR JOINT, I7,          26JA0
     2          15H  ARE BOTH ZERO)                                     26JA0
   80 FORMAT (   10H     JOINT, I5,  30H  HAS NOT PREVIOUSLY BEEN SPEC, 26JA0
     2           5HIFIED)                                               26JA0
   90 FORMAT (   32H     ERROR IN LOCATION OF JOINT , I5,               26JA0
     2          40H  EXCEEDS THE TOLERANCE SPECIFIED ABOVE ,/,4X,       26JA0
     3          30H THE ERROR IN X DIRECTION IS    ,E10.3,/,4X,         26JA0
     4          30H THE ERROR IN Y DIRECTION IS  ,E10.3)                26JA0
  100 FORMAT    ( 40H     TOLERANCE MUST BE A POSITIVE NUMBER)          04MY0
      PRINT 9                                                           26JA0
          IF (NCD2 .EQ. 1) GO TO 8100                                   09MY0
          IF ( NCD2 .LE. 0 .AND.   KEEP2 .LE. 0 ) GO TO 8300            26JA0
          IF (ITYPE .EQ. 3 .AND. NCD2 .NE. 0) GO TO 8400                26JA0
          IF(NCD2 .NE. 0) GO TO 1150                                    26JA0
COMMENT - NO NEW DATA                                                   29AP0
      PRINT 17                                                          26JA0
      PRINT 23                                                          26JA0
          GO TO 9800                                                    13FE0
 1150     CONTINUE                                                      26JA0
              JNTL = 0                                                  26JA0
          IF (KEEP2 .EQ. 1) GO TO 1230                                  26JA0
COMMENT - ALL NEW DATA - SET COORDINATES EQUAL TO 1.01E50               29AP0
          DO 1200 I = 1,MNJT                                            26JA0
 1200         X(I) = Y(I) = 1.01E50                                     26JA0
COMMENT - READ FIRST CARD OF TABLE 2                                    29AP0
      READ  10,NJT,J1,DX,DY,TOL                                         26JA0
      PRINT 11,NJT,J1,DX,DY,TOL                                         26JA0
          IF ( TOL .LE. 0.0) GO TO 9000                                 04MY0
          IF (J1 .LE. 0) GO TO 8200                                     26JA0
          IF (J1 .GT. NJT) GO TO 8500                                   26JA0
COMMENT - COMPUTE COORDINATES OF REFERENCE JOINT                        29AP0
              X(J1) = DX                                                26JA0
              Y(J1) = DY                                                26JA0
          GO TO 1240                                                    26JA0
COMMENT - HOLDING DATA                                                  29AP0
COMMENT - READ FIRST CARD OF TABLE 2                                    29AP0
 1230 READ 16,NJT                                                       26JA0
      PRINT 17                                                          26JA0
      PRINT 18,NJT                                                      26JA0
 1240     CONTINUE                                                      26JA0
          IF (NJT .GT. MNJT) GO TO 8600                                 26JA0
      PRINT 14                                                          26JA0
              N2M1 = NCD2 - 1                                           26JA0
COMMENT - DO FOR SECOND AND SUCCEEDING CARDS OF TABLE 2                 29AP0
          DO 4900 JJ = 1,N2M1                                           26JA0
      READ  12,J1,DX ,DY ,(J2(II),II=1,7)                               26JA0
          IF (J1 .GT. NJT)   JNTL = 1                                   26JA0
              NJNZ = 0                                                  26JA0
          DO 1270 II = 1,7                                              26JA0
          IF (J2(II) .GT. NJT) JNTL = 1                                 26JA0
 1270     IF (J2(II) .NE. 0) NJNZ = NJNZ + 1                            26JA0
      PRINT 13,J1,DX ,DY ,(J2(II),II=1,NJNZ)                            26JA0
          IF (J1 .LE. 0  .OR. J2(1) .LE. 0)  GO TO 8200                 26JA0
COMMENT - CHECK IF FROM JOINT HAS BEEN LOCATED                          29AP0
 1300     IF (X(J1) .GT. 1.0E50) GO TO 8800                             26JA0
          IF ( DX  .EQ. 0.0 .AND. DY  .EQ. 0.0 ) GO TO 8700             26JA0
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          IF (JNTL .EQ. 1) GO TO 8900                                    26JA0
COMMENT - DO FOR ALL JOINTS SPECIFIED ON THIS CARD                        29AP0
          DO 4600 II= 1.NJNZ                                             26JA0
COMMENT - COMPUTE TEMPORARY VALUES OF COORDINATES                         29AP0
 5250           XT = X(J1) + DX                                          26JA0
                YT = Y(J1) + DY                                          26JA0
                J2II = J2(II)                                            26JA0
          IF (J2II .LE. 0) GO TO 8200                                    26JA0
          IF (X(J2II)  .GT. 1.00E50) GO TO 4000                          26JA0
COMMENT - JOINT PREVIOUSLY LOCATED COMPUTE DIFFERENCE BETWEEN OLD         29AP0
COMMENT - LOCATION AND NEW LOCATION ERX AND ERY                           29AP0
                ERX = ABS(X(J2II)  - XT)                                 26JA0
                ERY = ABS(Y(J2II)  - YT)                                 26JA0
          IF ( ERX .GT. TOL .OR. ERY .GT. TOL) GO TO 8900                26JA0
COMMENT - AVERAGE OLD AND NEW COORDINATES                                 29AP0
                X(J2II)  = 0.5*(X(J2II)  + XT)                           26JA0
                Y(J2II)  = 0.5*(Y(J2II)  + YT)                           26JA0
          GO TO 4500                                                     26JA0
COMMENT - JOINT NOT PREVIOUSLY LOCATED                                    29AP0
 4000           X(J2II)  = XT                                            26JA0
                Y(J2II)  = YT                                            26JA0
 4500     CONTINUE                                                       26JA0
                J1 = J2II                                                26JA0
 4600     CONTINUE                                                       26JA0
 4900     CONTINUE                                                       26JA0
          GO TO 9800                                                     26JA0
 8100 PRINT 51                                                            9MY0
          GO TO 9700                                                      9MY0
 8200 PRINT 20                                                           26JA0
          GO TO 9700                                                     26JA0
 8300 PRINT 30                                                           26JA0
          GO TO 9700                                                     26JA0
 8400 PRINT 40                                                           26JA0
          GO TO 9700                                                     26JA0
 8500 PRINT 50                                                           26JA0
          GO TO 9700                                                     26JA0
 8600 PRINT 60                                                           26JA0
          GO TO 9700                                                     26JA0
 8700 PRINT 70. J1                                                       26JA0
          GO TO 9700                                                     26JA0
 8800 PRINT 80.J1                                                        26JA0
          GO TO 9700                                                     26JA0
 8900 PRINT 90. J2II.ERX.ERY                                             26JA0
          GO TO 9700                                                      4MY0
 9000 PRINT 100                                                           4MY0
 9700           IABAN = 1                                                26JA0
          GO TO 9900                                                     26JA0
 9800     CONTINUE                                                       26JA0
      PRINT 19                                                           26JA0
COMMENT - PRINT JOINT COORDINATES AND CHECK FOR JOINT NOT SPECIFIED       29AP0
          DO 9850 I = 1.NJT                                              26JA0
          IF (X(I) .GT. 1.0E50 .OR. Y(I) .GT. 1.0E50) GO TO 9840         26JA0
 9830 PRINT 21.I.X(I).Y(I)                                               26JA0
          GO TO 9845                                                     26JA0
 9840 PRINT 22.I                                                         26JA0
                IABAN = 1                                                26JA0
 9845     CONTINUE                                                       26JA0
 9850     CONTINUE                                                       26JA0
 9900     CONTINUE                                                       26JA0
      RETURN                                                             26JA0
      END                                                                26JA0
C
C         ******************************************************************
C
C         SUBROUTINE            SUBROUTINE           SUBROUTINE           SUBROUTINE
C
C         ******************************************************************
C
      SUBROUTINE MEMLOC                                                  26JA0
COMMENT - SUBROUTINE  MEMLOC  INPUTS LOCATION OF STIFFNESS AND LOAD      24AP0
COMMENT - TYPES IN FRAME (TABLE 3).CHECKS FOR BAD DATA.COMPUTES MEMBER   24AP0
COMMENT - NUMBERS.LENGTHS OFFSETS AND DIRECTION COSINES.ECHO PRINTS DATA24AP0
COMMENT - AND PRINTS COMPUTED MEMBER NUMBERS.LENGTHS AND OFFSETS         24AP0
      DIMENSION J2( 10 )                                                 26JA0
      COMMON /BLOCK1/ X( 75).     Y( 75).     QXX( 75).   QYY( 75).      13FE0
     2    WZZ( 75(.   SXX( 75).   SYY( 75).   SZZ( 75).   DXX( 75).      13FE0
     3    DYY( 75).   DZZ( 75).   RXX( 75).   RYY( 75).   RZZ( 75).      13FE0
     4    ERXX( 75).  ERYY( 75).  ERZZ( 75)                              13FE0
      COMMON /BLOCK2/ DXS( 50).   DYS( 50).   ZLS( 50).   DC1S( 50).     26JA0
     2    DC2S( 50(.  PRF( 50).   PRAE( 50).  NCDS( 50).  IAXOPS( 50).   26JA0
     3    IOPOP( 50). IPINL( 50). IPINR( 50). NC51( 50).  SMC( 50.13)    20MY0
      COMMON /BLOCK3/ DXL( 50).   DYL( 50).   ZLL( 50).   DC1L( 50).     26JA0
     2    DC2L( 50).  UOX( 50).   UOY( 50).   NCDL( 50).  IAXOPL( 50).   26JA0
     5    NC61( 50)                                                      26JA0
      COMMON /BLOCK4/ JT1(150).   JT2(150).   IST(150).   LT(150).       26JA0
     2    FORM(150.6)                                                    26JA0
      COMMON /BLK1/  KEEP2. KEEP3. KEEP4. KEEP5. KEEP6. KEEP7.           26JA0
     2         ITYPE. NCD2.  NCD3.  NCD4.  NCD5.  NCD6.  NCD7.           26JA0
     3         IABAN. IFORM. NM.    NJT.   NST.   NLT.   TOL.            26JA0
     4         M.     MP1.   MP2.   ISTT.  LTT.   ITYPEL.IDJ.            12FE0
     5         MLC.   IP8.   IP9.   IP10                                 13FE0
      COMMON /BLK3/  MNJT.MNST.MNLT.MNM.MNC5.MNC6.MDJT.MNLC              07FE0
    6 FORMAT (5X.  3(I5.1X). 2X. 2I5)                                    30MR0
    7 FORMAT (5X.  3(I5.1X). 2X. 2I5. 3E11.3)                            30MR0
    8 FORMAT  ( ///.10X.   40H COMPUTED MEMBER NUMBERS.LENGTHS.AND OFF. 30MR0
     2 4HSETS.//.46H    MEMBER  FROM   TO    STIFF LOAD   LENGTH  .      30MR0
     3           25H  X-OFFSET   Y-OFFSET     ./.                        30MR0
     4           35H     NUMB  JOINT  JOINT   TYPE TYPE.//)              30MR0
    9 FORMAT (    40H     TABLE 3 - MEMBER LOCATION DATA      .////)     26JA0
   10 FORMAT (10X.I5.5X.I5)                                              26JA0
   11 FORMAT  (  40H      NUMBER OF MEMBER STIFFNESS TYPES  =.I5./.      26JA0
     1           40H      NUMBER OF MEMBER LOAD TYPES  =     .I5.///)    26JA0
   12 FORMAT ( 5X.I5.5X.2I5.5X.10I5)                                     26JA0
   13 FORMAT ( 5X.I5.5X.2I5.5X.10I5)                                     26JA0
   14 FORMAT (25X.    26H INPUT OF MEMBER LOCATIONS .//.                 26JA0
     2           50H      FROM      STIFF LOAD        TO   TO   TO   TO .26JA0
     3           30H  TO   TO   TO   TO   TO   TO . /.                   26JA0
     4           35H     JOINT      TYPE TYPE     JOINT.//)              30MR0
   17 FORMAT     (48H     HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS.   26JA0
     2           15H THE FOLLOWING . //)                                 26JA0
   18 FORMAT (//.47H *** COMPUTED MEMBER NUMBERS MAY NOT AGREE WITH .    01MY0
     2           20H LAST PROBLEM ***    )                               01MY0
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   19 FORMAT (//,50H *** COMPUTED MEMBER NUMBERS AGREE WITH LAST PROBL. 01MYO
    2          10HEM ***    )                                          01MYO
   20 FORMAT (    45H      JOINT NUMBERS MUST BE POSITIVE          )     26JAO
   23 FORMAT (    10H      NONE )                                       26JAO
   25 FORMAT (    32H      MEMBER WITH STIFFNESS TYPE ,I5, 9H AND LOAD,   26JAO
    2              5H TYPE,I5,/,32H     WAS SPECIFIED AS GOING FROM,    26JAO
    3              7H JOINT ,I5, 9H TO JOINT,I5,/,17H     PROGRAM DOES,  26JAO
    4             36H NOT ALLOW THIS ORDER TO BE REVERSED)              26JAO
   27 FORMAT (    51H      TYPE 3 PROBLEM DOES NOT ALLOW ANY CHANGE IN ST,26JAO
    2             31HIFFNESS TYPES FROM LAST PROBLEM,/,                 26JAO
    3             38H      LAST PROBLEM DID NOT SPECIFY TYPE,I5,         26JAO
    4             20H STIFF BETWEEN JOINT,I5,10H AND JOINT,I5 )         26JAO
   30 FORMAT (    40H      NO DATA HELD OR READ IN TABLE 3     )        26JAO
   31 FORMAT (    50H      NUMBER OF CARDS IN TABLE 3 MAY NOT EQUAL 1    ) 09MYO
   50 FORMAT (    43H      JOINT NUMBER ABOVE GREATER THAN NUMBER,       26JAO
    2             20H OF JOINTS IN FRAME )                              26JAO
   61 FORMAT (    51H      NUMBER OF STIFFNESS TYPES GREATER THAN STORAGE,26JAO
    2              7H ALLOWS)                                           26JAO
   62 FORMAT (    46H      NUMBER OF LOAD TYPES GREATER THAN STORAGE,    26JAO
    2              7H ALLOWS)                                           26JAO
   71 FORMAT (    46H      STIFFNESS AND LOAD TYPES MUST BE POSITIVE,    26JAO
    2              8 NUMBERS)                                           26JAO
   72 FORMAT (    51H     STIFFNESS OR LOAD TYPE ABOVE GREATER THAN TOTAL,26JAO
    2             50H NUMBER OF STIFFNESS OR LOAD TYPES SPECIFIED ABOVE) 26JAO
   73 FORMAT (    51H      YOU CANNOT HOLD UP THE LOAD WITHOUT SOME STIFF,26JAO
    2             50HNESS - IF STIFF TYPE = 0 - LOAD TYPE MUST = 0      ) 26JAO
   74 FORMAT (     5H   74)                                             26JAO
   91 FORMAT (    50H      ERROR IN OFFSETS FOR MEMBER OF STIFFNESS TYPE, 26JAO
    2        I5,/,47H      THE X AND Y OFFSETS FOR THE MEMBER BETWEEN,   26JAO
    3              7H JOINTS,I5, 5H AND ,I5,/,                          26JAO
    4             49H      DO NOT AGREE WITH PREVIOUSLY DEFINED OFFSETS,  26JAO
    5             46H FOR A MEMBER OF THIS TYPE, WITHIN THE ALLOWED,/,   26JAO
    6             51H      ERROR OF TWO TIMES THE JOINT LOCATION TOLERANC,26JAO
    7              1HE)                                                 26JAO
   92 FORMAT (    45H      ERROR IN OFFSETS FOR MEMBER OF LOAD TYPE,     26JAO
    2        I5,/,47H      THE X AND Y OFFSETS FOR THE MEMBER BETWEEN,   26JAO
    3              7H JOINTS,I5, 5H AND ,I5,/,                          26JAO
    4             49H      DO NOT AGREE WITH PREVIOUSLY DEFINED OFFSETS,  26JAO
    5             46H FOR A MEMBER OF THIS TYPE, WITHIN THE ALLOWED,/,   26JAO
    6             51H      ERROR OF TWO TIMES THE JOINT LOCATION TOLERANC,26JAO
    7              1HE)                                                 26JAO
COMMENT - PRINT TABLE HEADING                                          01MYO
      PRINT 9                                                          26JAO
         IF (NCD3 .EQ. 1) GO TO 8100                                   09MYO
         IF (NCD3 .LE. 0  .AND. KEEP3 .LE. 0 ) GO TO 8900              26JAO
                TTOL = 2.0*TOL                                         26JAO
COMMENT - SET OFFSETS FOR STIFF TYPES                                  01MYO
         DO 1100  I = 1, MNST                                          03APO
 1100           DXS(I) = DYS(I) = 1.01E50                              03APO
COMMENT - SET OFFSETS FOR LOAD TYPES                                   01MYO
         DO 1110  I = 1, MNLT                                          03APO
 1110           DXL(I) = DYL(I) = 1.01E50                              03APO
         IF (KEEP3 .NE. 1) GO TO 1150                                  25APO
      PRINT 17                                                         26JAO
 1150    CONTINUE                                                      26JAO
COMMENT - NM IS NUMBER OF MEMBERS ACCUMULATED AND MUST NOT CHANGE      01MYO
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COMMENT - FROM PREVIOUS PROBLEM FOR OFFSPRING PROBLEMS                 01MYO
         IF (KEEP3 .EQ. 1 .OR. ITYPE .EQ. 3) GO TO 1160                25APO
                NM = 0                                                 25APO
 1160    CONTINUE                                                      25APO
         IF (NCD3 .NE. 0) GO TO 1180                                   03APO
      PRINT 23                                                         26JAO
         GO TO  6000                                                    3APO
 1180           JNTL = 0                                               26JAO
 1250    CONTINUE                                                      26JAO
COMMENT - READ FIRST CARD IN TABLE 3                                   01MYO
      READ 10,NST,NLT                                                  26JAO
      PRINT 11, NST,NLT                                                26JAO
         IF (NST .GT. MNST) GO TO 8610                                 26JAO
         IF (NLT .GT. MNLT) GO TO 8620                                 26JAO
      PRINT 14                                                         26JAO
                N3M1 = NCD3 - 1                                        26JAO
         DO 4900 JJ = 1,N3M1                                           26JAO
COMMENT - READ 2ND AND SUCCEEDING CARDS IN TABLE 3                     01MYO
      READ 12,J1,ISTT,LTT,(J2(II),II = 1,10)                           26JAO
         IF (J1 .GT. NJT) JNTL = 1                                     26JAO
                NJNZ = 0                                               26JAO
         DO 1270 II = 1,10                                             26JAO
         IF (J2(II) .GT. NJT) JNTL = 1                                 26JAO
         IF (J2(II) .NE. 0) NJNZ = NJNZ + 1                            30APO
 1270    CONTINUE                                                      30APO
COMMENT - PRINT 2ND AND SUCCEEDING CARDS IN TABLE 3                    01MYO
      PRINT 13,J1,ISTT,LTT, (J2(II),II = 1,NJNZ )                      26JAO
         IF (J1 .LE. 0) GO TO 8200                                     30APO
         IF (JNTL .EQ. 1)  GO TO 8500                                  26JAO
         IF (ISTT .LT. 0 .OR. LTT .LT. 0) GO TO 8710                   26JAO
         IF (ISTT .GT. NST .OR. LTT .GT. NLT) GO TO 8720               26JAO
         IF (ISTT .EQ. 0 .AND. LTT .NE. 0) GO TO 8730                  26JAO
COMMENT - DO FOR NUMBER OF MEMBERS SPECIFIED ON ONE CARD               01MYO
         DO 4500  II = 1,NJNZ                                          26JAO
                J2II = J2(II)                                          26JAO
         IF (J2II .LE. 0) GO TO 8200                                   30APO
         IF (KEEP3 .NE. 1 .AND. ITYPE .NE. 3) GO TO 4425               25APO
                NML = NM                                               25APO
COMMENT - DO FOR EACH MEMBER                                           01MYO
         DO 4400 K = 1,NM                                              26JAO
         IF (J1 .EQ. JT1(K) .AND. J2II .EQ. JT2(K) ) GO TO 4410        26JAO
         IF (J1 .EQ. JT2(K) .AND. J2II .EQ. JT1(K) ) GO TO 8250        26JAO
 4400    CONTINUE                                                      26JAO
         GO TO 4425                                                    26JAO
COMMENT - OLD MEMBER (PREVIOUSLY GIVEN STIFF AND LOAD TYPE)            01MYO
COMMENT - CAN NOT CHANGE STIFF TYPE FOR OFFSPRING PROBLEM              01MYO
 4410    IF (ITYPE .EQ. 3 .AND. IST(K)  .NE. ISTT) GO TO 8270          26JAO
         IST(K) = ISTT                                                 26JAO
         LT(K) = LTT                                                   26JAO
         GO TO 4450                                                    26JAO
COMMENT - NEW MEMBER INCREASE NM                                       01MYO
 4425           NM = NM + 1                                            26JAO
                JT1(NM) = J1                                           26JAO
                JT2(NM) = J2II                                         26JAO
                IST(NM) = ISTT                                         26JAO
                LT(NM) = LTT                                           26JAO
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          IF (ITYPE .NE. 3) GO TO 4450                                   25APO
COMMENT - NM CAN NOT CHANGE FOR AN OFFSPRING PROBLEM                     01MYO
          IF (NM .NE. NML) GO TO 8270                                    25APO
 4450     CONTINUE                                                       26JAO
               J1 = J2I1                                                 26JAO
 4500     CONTINUE                                                       26JAO
 4900     CONTINUE                                                       26JAO
          IF (KEEP3 .EQ. 1 .OR. ITYPE .EQ. 3) GO TO 6000                 01MYO
               IJT = 1                                                   26JAO
               KK = 0                                                    26JAO
 5100     CONTINUE                                                       26JAO
COMMENT - SORT MEMBERS BY STIFF TYPE IN ASCENDING ORDER                  01MYO
               IJ =  IJT                                                 26JAO
COMMENT - SORT THROUGH THE REST OF THE MEMBER LIST                       01MYO
          DO 5200  JJ =  IJ,NM                                           26JAO
          IF (IST(JJ) .NE. KK) GO TO 5200                                26JAO
          IF (JJ .EQ. IJT) GO TO 5170                                    26JAO
               JT1T = JT1(IJT)                                           26JAO
               JT2T = JT2(IJT)                                           26JAO
               ISTT = IST(IJT)                                           26JAO
               LTT = LT(IJT)                                             26JAO
               JT1(IJT) = JT1(JJ)                                        26JAO
               JT2(IJT) = JT2(JJ)                                        26JAO
               IST(IJT) = IST(JJ)                                        26JAO
               LT(IJT) = LT(JJ)                                          26JAO
               JT1(JJ) = JT1T                                            26JAO
               JT2(JJ) = JT2T                                            26JAO
               IST (JJ) = ISTT                                           26JAO
               LT(JJ) = LTT                                              26JAO
 5170          IJT = IJT + 1                                             26JAO
 5200     CONTINUE                                                       26JAO
               KK = KK + 1                                               26JAO
          IF (KK .LE. NST) GO TO 5100                                    26JAO
 6000     CONTINUE                                                        3APO
          DO 6600  I = 1,NM                                              03APO
               ISTT = IST(I)                                             03APO
               LTT  =  LT(I)                                             03APO
               J2I = JT2(I)                                              03APO
               J1  = JT1(I)                                              03APO
COMMENT - COMPUTE OFFSETS                                                05MYO
               DX  = X(J2I)  - X(J1)                                     03APO
               DY  = Y(J2I)  - Y(J1)                                     03APO
          IF (ISTT .EQ. 0) GO TO 6100                                    03APO
          IF (DXS(ISTT) .GT. 1.0E50) GO TO 6050                          03APO
COMMENT - CHECK FOR TWO MEMBERS WITH SAME STIFFNESS TYPE BUT DIFFERENT   01MYO
COMMENT - ORIENTATIONS                                                   01MYO
               ERX = ABS(DXS(ISTT) - DX )                                26JAO
               ERY = ABS(DYS(ISTT) - DY )                                26JAO
          IF (ERX  .GT. TTOL .OR.  ERY  .GT. TTOL) GO TO 8910            26JAO
               DXS(ISTT)  = 0.5*(DXS(ISTT) + DX)                         26JAO
               DYS(ISTT)  = 0.5*(DYS(ISTT) + DY)                         26JAO
          GO TO 6100                                                      3APO
 6050     CONTINUE                                                       03APO
               DXS(ISTT)  = DX                                           26JAO
               DYS(ISTT)  = DY                                           26JAO
 6100     CONTINUE                                                       03APO
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          IF ( LTT .EQ. 0) GO TO 6300                                    03APO
          IF (DXL(LTT) .GT. 1.0E50) GO TO 6200                           03APO
COMMENT - CHECK FOR TWO MEMBERS WITH SAME LOAD TYPE BUT DIFFERENT        01MYO
COMMENT - ORIENTATIONS                                                   01MYO
               ERX = ABS(DXL(LTT) - DX)                                  26JAO
               ERY = ABS(DYL(LTT) - DY)                                  26JAO
          IF (ERX .GT. TTOL .OR. ERY .GT. TTOL) GO TO 8920               26JAO
               DXL(LTT) = 0.5*(DXL(LTT) + DX)                            26JAO
               DYL(LTT) = 0.5*(DYL(LTT) + DY)                            26JAO
          GO TO 6300                                                      3APO
 6200     CONTINUE                                                        3APO
               DXL(LTT) = DX                                             26JAO
               DYL(LTT) = DY                                             26JAO
 6300     CONTINUE                                                       03APO
 6600     CONTINUE                                                       03APO
          DO 7400 I = 1,NST                                              03APO
COMMENT - COMPUTE LENGTHS AND DIRECTION COSINES FOR STIFFNESS TYPES      01MYO
               ZLS(I) = (DXS(I)*DXS(I) + DYS(I)*DYS(I) ) **0.5           26JAO
               DC1S(I) = DXS(I)/ZLS(I)                                   26JAO
 7400          DC2S(I) = DYS(I)/ZLS(I)                                   03APO
          DO 7500 I = 1,NLT                                              03APO
COMMENT - COMPUTE LENGTHS AND DIRECTION COSINES FOR LOAD TYPES           01MYO
               ZLL(I) = (DXL(I)*DXL(I) + DYL(I)*DYL(I) )**0.5            26JAO
               DC1L(I) = DXL(I)/ZLL(I)                                   26JAO
 7500          DC2L(I) = DYL(I)/ZLL(I)                                   03APO
               IDJT = 0                                                  26JAO
               IDJ  = 0                                                  26JAO
COMMENT - COMPUTE HALF BAND WIDTH OF FRAME                               01MYO
          DO 7700 I = 1,NM                                               03APO
               IDJT = IABS (JT1(I) - JT2(I))                             29JAO
          IF (IDJT .GT. IDJ)   IDJ = IDJT                                26JAO
 7700     CONTINUE                                                       03APO
          IF (IDJ .GT. MDJT)  GO TO 8740                                 26JAO
          GO TO 9800                                                     26JAO
 8100 PRINT 31                                                            9MYO
          GO TO 9700                                                      9MYO
 8200 PRINT 20                                                           26JAO
          GO TO 9700                                                     26JAO
 8250 PRINT 25, ISTT,J2I1,J1                                             26JAO
          GO TO 9700                                                     26JAO
 8270 PRINT 27,ISTT,J1,J2I1                                              26JAO
 8300 PRINT 30                                                           26JAO
          GO TO 9700                                                     26JAO
 8500 PRINT 50                                                           26JAO
          GO TO 9700                                                     26JAO
 8610 PRINT 61                                                           26JAO
          GO TO 9700                                                     26JAO
 8620 PRINT 62                                                           26JAO
          GO TO 9700                                                     26JAO
 8710 PRINT 71                                                           26JAO
          GO TO 9700                                                     26JAO
 8720 PRINT 72                                                           26JAO
          GO TO 9700                                                     26JAO
 8730 PRINT 73                                                           26JAO
          GO TO 9700                                                     26JAO
 8740 PRINT 74                                                           26JAO
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         GO TO 9700                                                      26JA0
 8910 PRINT 91.ISTT.J1.J21                                               06MR0
         GO TO 9700                                                      26JA0
 8920 PRINT 92.LTT, J1, J2)                                              06MR0
         GO TO 9700                                                      26JA0
 9700 IABAN = 1                                                          26JA0
         GO TO 9900                                                      26JA0
 9800    CONTINUE                                                        26JA0
      PRINT 8                                                            26JA0
COMMENT - PRINT MEMBER NUMBERS.FROM AND TO JOINTS.LENGTHS AND OFFSETS   01MY0
         DO 9875 I = 1.MM                                                26JA0
            ISTT = IST(I)                                                26JA0
      IF (ISTT .EQ. 0) GO TO 9860                                        26JA0
      PRINT 7. I. JT1(I). JT2(I). IST(I). LT(I). ZLS(ISTT). DXS(ISTT).   30MR0
     2   DYS(ISTT)                                                       30MR0
         GO TO 9875                                                      26JA0
 9860 PRINT 6. I. JT1(I). JT2(I). IST(I). LT(I)                          30MR0
 9875    CONTINUE                                                        26JA0
         IF (ITYPE .EQ. 3 .OR. KEEP3 .EQ. 1 ) GO TO 9880                 01MY0
      PRINT 10                                                            1MY0
         GO TO 9900                                                       1MY0
 9880 PRINT 19                                                            1MY0
 9900    CONTINUE                                                        26JA0
      RETURN                                                             26JA0
      END                                                                26JA0
C
C        *****************************************************************
C
C        SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C        *****************************************************************
C
      SUBROUTINE JNTDAT                                                  26JA0
COMMENT - SUBROUTINE JNTDAT INPUTS JOINT LOADS AND RESTRAINTS            24AP0
COMMENT - (TABLE 4).CHECKS FOR BAD DATA.ACCUMULATES JOINT LOADS AND      24AP0
COMMENT - RESTRAINTS.ECHO PRINTS DATA AND PRINTS ACCUMULATED DATA        24AP0
      COMMON /BLOCK1/ X( 75).      Y( 75).     QXX( 75).   QYY( 75).     13FE0
     2    QZZ( 75).   SXX( 75).   SYY( 75).   SZZ( 75).   DXX( 75).      13FE0
     3    DYY( 75).   DZZ( 75).   RXX( 75).   RYY( 75).   RZZ( 75).      13FE0
     4    ERXX( 75).  ERYY( 75).  ERZZ( 75)                              13FE0
      COMMON /BLK1/  KEEP2. KEEP3. KEEP4. KEEP5. KEEP6. KEEP7.           26JA0
     2        ITYPE. NCD2.  NCD3.  NCD4.  NCD5.  NCD6.  NCD7.            26JA0
     3        IABAN. IFORM. MM.    MJT.   NST.   NLT.   TOL.             26JA0
     4        M.     MP1.   MP2.   ISTT.  LTT.   ITYPEL.IDJ.              12FE0
     5        MLC.   IP8.   IP9.   IP10                                  13FE0
      COMMON /BLK3/  MNJT,MNST,MNLT,MNM,MNC5.MNC6,MDJT.MNLC              07FE0
    7 FORMAT (    35H      SAME AS INPUT FOR THIS PROBLEM)                06FE0
    9 FORMAT ( 25H     TABLE 4 - JOINT DATA.///)                          26JA0
   12 FORMAT ( 5X.I5.6E10.3)                                             26JA0
   13 FORMAT ( 5X,I5.6E11.3)                                             26JA0
   14 FORMAT  ( 25X.20H INPUT OF JOINT DATA.//)                          26JA0
   15 FORMAT  (5X, 38HJOINT  FORCE(X)   FORCE(Y)  MOMENT(Z) .            26JA0
     2                   33H SPRING(X)  SPRING(Y)  SPRING(Z) .//)        26JA0
   16 FORMAT ( //.25X.23H ACCUMULATED JOINT DATA.//)                     26JA0
   17 FORMAT ( 48H      HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS.     26JA0
     2          15H THE FOLLOWING .//)                                   26JA0
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   20 FORMAT ( 35H     JOINT NUMBERS MUST BE POSITIVE)                   26JA0
   23 FORMAT (    10H     NONE )                                         26JA0
   27 FORMAT ( 50H     TYPE 3 PROBLEM DOES NOT ALLOW ANY CHANGE IN .     26JA0
     2          10H SUPPORTS ./.                                         02MY0
     3          50H     RESTRAINTS MAY NOT CHANGE FROM LAST PROBLEM  ) 02MY0
   30 FORMAT  (  15H     NO DATA    )                                    02MY0
   50 FORMAT ( 43H     JOINT NUMBER ABOVE GREATER THAN NUMBER,           26JA0
     2        20H OF JOINTS IN FRAME )                                   26JA0
      PRINT 9                                                            26JA0
         IF (ITYPE .NE. 3) GO TO 1120                                    02MY0
COMMENT - STORE JOINT RESTRAINTS FOR OFFSPRING PROBLEMS                  04MY0
         DO 1110  I = 1.NJT                                              02MY0
            ERXX(I) = SXX(I)                                             02MY0
            ERYY(I) = SYY(I)                                             02MY0
            ERZZ(I) = SZZ(I)                                             02MY0
 1110    CONTINUE                                                        02MY0
 1120    CONTINUE                                                        02MY0
         IF (KEEP4 .EQ. 1) GO TO  1230                                   26JA0
COMMENT - ZERO JOINT DATA                                                04MY0
         DO 1200 I = 1. MNJT                                             26JA0
            QXX(I) = QYY(I) = QZZ(I) = 0.0                               26JA0
 1200       SXX(I) = SYY(I) = SZZ(I) = 0.0                               26JA0
         IF (NCD4 .NE. 0) GO TO 1240                                     02MY0
      PRINT 30                                                            2MY0
         GO TO 5000                                                       2MY0
COMMENT - HOLDING DATA                                                   04MY0
 1230 PRINT 17                                                           26JA0
         IF (NCD4 .NE. 0) GO TO 1240                                     02MY0
      PRINT 23                                                            2MY0
         GO TO 9800                                                      02MY0
 1240    CONTINUE                                                        26JA0
      PRINT 14                                                           26JA0
      PRINT 15                                                           26JA0
         DO 4900  II = 1. NCD4                                           26JA0
COMMENT - READ AND PRINT ONE DATA CARD                                   04MY0
      READ  12. I.QXXT,QYYT.QZZT.SXXT.SYYT.SZZT                          26JA0
      PRINT 13. I.QXXT,QYYT.QZZT.SXXT.SYYT.SZZT                          26JA0
         IF (I .GT. NJT) GO TO  8500                                     26JA0
         IF (I .LE. 0 ) GO TO  8200                                      26JA0
COMMENT - ACCUMULATE DATA                                                04MY0
            QXX(I) = QXX(I) + QXXT                                       26JA0
            QYY(I) = QYY(I) + QYYT                                       26JA0
            QZZ(I) = QZZ(I) + QZZT                                       26JA0
            SXX(I) = SXX(I) + SXXT                                       26JA0
            SYY(I) = SYY(I) + SYYT                                       26JA0
            SZZ(I) = SZZ(I) + SZZT                                       26JA0
 4900    CONTINUE                                                        26JA0
 5000    CONTINUE                                                         2MY0
         IF (ITYPE .NE. 3) GO TO 6000                                    02MY0
COMMENT - COMPARE JOINT RESTRAINTS WITH LAST PROBLEM FOR OFFSPRING       04MY0
         DO 5900  I = 1.NJT                                              02MY0
         IF (ERXX(I) .NE. SXX(I)) GO TO 8270                             02MY0
         IF (ERYY(I) .NE. SYY(I)) GO TO 8270                             02MY0
         IF (ERZZ(I) .NE. SZZ(I)) GO TO 8270                             02MY0
 5900    CONTINUE                                                        -2MY0
 6000    CONTINUE                                                        02MY0
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          GO TO  9800                                                   26JA0
 8200 PRINT 20                                                          26JA0
          GO TO 9700                                                    26JA0
 8270 PRINT 27                                                          26JA0
          GO TO 9700                                                    26JA0
 8500 PRINT 50                                                          26JA0
 9700               IABAN = 1                                           26JA0
          GO TO  9900                                                   26JA0
 9800     CONTINUE                                                      26JA0
COMMENT - PRINT ACCUMULATED JOINT DATA UNLESS IT IS THE SAME AS INPUT   04MY0
COMMENT - FOR THIS PROBLEM                                              04MY0
      PRINT 16                                                          26JA0
          IF (KEEP4 .EQ. 1) GO TO  9820                                 26JA0
          IF (NCD4 .EQ. 0) GO TO 9900                                   02MY0
      PRINT 7                                                           26JA0
          GO TO 9900                                                    26JA0
 9820     CONTINUE                                                      26JA0
      PRINT 15                                                          23AP0
          DO 9860 I = 1, NJT                                            26JA0
          IF (QXX(I) .NE. 0) GO TO 9850                                 26JA0
          IF (QYY(I) .NE. 0) GO TO 9850                                 26JA0
          IF (QZZ(I) .NE. 3) GO TO 9850                                 26JA0
          IF (SXX(I) .NE. 0) GO TO 9850                                 26JA0
          IF (SYY(I) .NE. 0) GO TO 9850                                 26JA0
          IF (SZZ(I) .NE. 0) GO TO 9850                                 26JA0
          GO TO 9860                                                    26JA0
 9850 PRINT 13, I,QXX(I),QYY(I),QZZ(I),SXX(I),SYY(I),SZZ(I)             26JA0
 9860     CONTINUE                                                      26JA0
 9900     CONTINUE                                                      26JA0
      RETURN                                                            26JA0
      END                                                               26JA0
C
C         ***************************************************************
C
C         SUBROUTINE            SUBROUTINE            SUBROUTINE            SUBROUTINE
C
C         ***************************************************************
C
      SUBROUTINE RDMST                                                  26JA0
COMMENT - SUBROUTINE RDMST  INPUTS MEMBER STIFFNESS DATA (TABLE 5),     24AP0
COMMENT - CHECKS FOR BAD DATA,CONVERTS INPUT DISTANCES TO MEMBER        24AP0
COMMENT - COORDINATES AND ECHO PRINTS DATA                              24AP0
      COMMON /BLOCK2/ DXS( 50),   DYS( 50),   ZLS( 50),   DC1S( 50),    26JA0
     2    DC2S( 50),  PRF( 50),   PRAE( 50),  NCDS( 50),  IAXOPS( 50),  26JA0
     3    IOPOP( 50), IPINL( 50), IPINR( 50), NCS1( 50),  SMC( 50,13)   20MY0
      COMMON /BLOCK5/ XLS( 75),   XRS( 75),   FL( 75),    AEL( 75),     26JA0
     2    SXL( 75),   SYL( 75),   SZL( 75)                              26JA0
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,          26JA0
     2          ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,         26JA0
     3          IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,          26JA0
     4          M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,          12FE0
     5          NLC,   IP8,   IP9,   IP10                               13FE0
      COMMON /BLK3/  MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNLC             07FE0
    9 FORMAT (   40H      TABLE 5 - MEMBER STIFFNESS DATA      ,///)    26JA0
   12 FORMAT ( 5X,I5,E10.3,10X,2E10.3,5X,5I5)                           30MR0
   13 FORMAT ( 5X,I5,    3E10.3,3I5,5X,2I5)                             30MR0
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   14 FORMAT (//,40H      STIFF  MOD OF   PRISMATIC PRISMATIC,          04MY0
     2           30H  NO  AXIS  OUTPUT   PIN  PIN , /,                  30MR0
     3           40H      TYPE  ELAST        I          A      ,        30MR0
     4           30HCARDS  OPT   OPT    FROM   TO ,//)                  30MR0
   15 FORMAT (10X,7E10.3)                                               26JA0
   16 FORMAT ( 5X,7E11.3)                                               26JA0
   17 FORMAT (   48H      HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS,  26JA0
     2           15H THE FOLLOWING ,//)                                 26JA0
   18 FORMAT ( /,20H            STIFF TYPE, I5,6H CONTD,5X,             04MY0
     2           40H RESTRAINTS ARE IN MEMBER PRIMED AXES    ,/,        04MY0
     3        3X, 47H        FROM          TO          I           A      ,  02MY0
     4           30H    SX             SY             SZ,/)             02MY0
   23 FORMAT (   10H      NONE )                                        26JA0
   30 FORMAT (   25H      NO DATA IN TABLE 5   )                        31MR0
   31 FORMAT (   51H      NUMBER OF CARDS TO FOLLOW MUST NOT BE NEGATIVE)04AP0
   32 FORMAT (   35H      OUTPUT OPTION MUST BE 0 OR 1   )              04MY0
   33 FORMAT (   30H      PIN OPTION MUST BE 0 OR 1)                    04MY0
   51 FORMAT (   35H      STIFF DATA MUST START AT 0.0   )              31MR0
   52 FORMAT (   40H      STIFF DATA MUST STOP AT END OF MEMB)          31MR0
   53 FORMAT (   50H      STIFF SEQUENCE MUST BE LONGER THAN 1/40 SPAN ) 31MR0
   54 FORMAT (   50H      STIFF DATA MUST BE SPECIFIED CONTINUOUSLY,IE , 31MR0
     2           35H FROM DIST MUST EQUAL LAST TO DIST )                31MR0
   55 FORMAT (   48H      NO CARDS IN TABLE 5 BUT STIFF TYPES NOT ALL,  29AP0
     2           10H SPECIFIED)                                         29AP0
   56 FORMAT (   49H      ALL CARDS SPECIFIED FOR TABLE 5 READ BUT ALL, 29AP0
     2           26H STIFF TYPES NOT SPECIFIED,/,                       30AP0
     3           47H      CHECK CARD COUNT AND NUMBER OF STIFF TYPES)   30AP0
   57 FORMAT (   48H      ALL STIFF TYPES SPECIFIED BUT ALL CARDS NOT,  30AP0
     2            5H READ,/,                                            30AP0
     3           47H      CHECK CARD COUNT AND NUMBER OF STIFF TYPES)   30AP0
   58 FORMAT (   40H      AXIS OPTION MUST EQUAL 1, 2, OR 3   )         30AP0
   60 FORMAT (   50H      NEGATIVE VALUES OF A       I ARE NOT PERMITTED) 02MY0
   65 FORMAT (   45H      STIFF TYPES MUST BE IN ASCENDING ORDER   )    31MR0
   67 FORMAT (   50H      IF 2ND CARD USED FOR STIFF TYPE, PRISMATIC I , 02MY0
     2           20H AND A  MUST BE 0.0 )                               02MY0
   71 FORMAT (   40H      STIFF TYPES MUST NOT BE NEGATIVE     )        31MR0
   72 FORMAT (   40H      STIFF TYPE GREATER THAN TOTAL NUMBER OF STIFF, 31MR0
     2           20H TYPES SPECIFIED     )                              31MR0
      PRINT 9                                                           26JA0
          IF (KEEP5 .EQ. 0) NSTL = 0                                    24AP0
COMMENT - FRAME MUST HAVE AT LEAST ONE STIFFNESS TYPE                   04MY0
          IF (NCD5 .LE. 0 .AND. KEEP5 .LE. 0) GO TO  8300               26JA0
          IF (NCD5 .NE. 0) GO TO 1150                                   26JA0
          IF (NST .NE. NSTL) GO TO 8550                                 29AP0
      PRINT 17                                                          26JA0
      PRINT 23                                                          26JA0
          GO TO 9900                                                    26JA0
 1150     CONTINUE                                                      26JA0
          IF (KEEP5 .EQ. 1) GO TO 1240                                  26JA0
COMMENT - ALL NEW DATA                                                  04MY0
          DO 1200 I=1,MNST                                              26JA0
               NCS1(I) = -1                                             26JA0
 1200          NCDS(I)= - 1                                             26JA0
               NC5 = 0                                                  26JA0
          GO TO 1250                                                    26JA0
 1240 PRINT 17                                                          26JA0
```

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 1250     CONTINUE                                                     26JA0
      PRINT 14                                                         26JA0
                NCRS = 0                                               29AP0
COMMENT - DO FOR EACH STIFF TYPE                                       04MY0
          DO 4900 JJ =1,NST                                            26JA0
COMMENT - SKIP FOR STIFF TYPE PREVIOUSLY DEFINED                       04MY0
          IF (NCDS(JJ) .NE. -1) GO TO 4900                             06MY0
          IF (JJ .EQ. 1) GO TO 1300                                    26JA0
          IF (JJ .EQ. NSTL + 1) GO TO 1300                             24AP0
COMMENT - PRINT NEW HEADING FOR FIRST STIFF TYPE OF PROBLEM AND AFTER  04MY0
COMMENT - EVERY NON PRISMATIC STIFF TYPE                               04MY0
          IF (NCDS(JJ - 1) .GT. 0) PRINT 14                            26JA0
 1300     CONTINUE                                                      4MY0
          IF (NCRS .EQ. NCDS) GO TO 8560                               29AP0
COMMENT - READ AND PRINT 1ST CARD FOR STIFF TYPE                       04MY0
      READ 12, ISTT,E,PRIT,PRAT,NCDST,IAXOPT,IOPOPT,IPINLT,IPINRT      04MY0
      PRINT 13, ISTT,E,PRIT,PRAT,NCDST,IAXOPT,IOPOPT,IPINLT,IPINRT     30MR0
          IF (IAXOPT .LT. 1  .OR. IAXOPT .GT. 3) GO TO 8580            30AP0
          IF (NCDST .LT. 0) GO TO 8310                                 04MY0
          IF (IOPOPT .LT. 0  .OR. IOPOPT .GT. 1) GO TO 8320            04MY0
          IF (IPINLT .LT. 0  .OR. IPINLT .GT. 1) GO TO 8330            04MY0
          IF (IPINRT .LT. 0 .OR. IPINRT .GT. 1)  GO TO 8330            04MY0
                NCRS = NCRS + 1                                        29AP0
COMMENT - MULTIPLY A AND I BY E                                        04MY0
                PRFT = E*PRIT                                          30MR0
                PRAET = E*PRAT                                         30MR0
          IF (JJ .NE. ISTT) GO TO 8650                                 26JA0
          IF (ISTT .GT. NST) GO TO 8720                                26JA0
          IF (ISTT .LT. 0) GO TO 8710                                  26JA0
          IF (NCDST .GT. 0) GO TO 2400                                 26JA0
COMMENT - PRISMATIC MEMBER - NO CARDS FOLLOW                           04MY0
          IF (PRFT .LE. 0.0  .OR. PRAET .LE. 0.0) GO TO 8660           10AP0
COMMENT - STORE TEMPORARY READ IN VALUES                               04MY0
                PRF(ISTT) = PRFT                                       26JA0
                PRAE(ISTT) = PRAET                                     26JA0
                NCDS(ISTT) = 0                                         26JA0
                IAXOPS(ISTT) = IAXOPT                                  26JA0
                IOPOP(ISTT) = IOPOPT                                   26JA0
                IPINL(ISTT) = IPINLT                                   26JA0
                IPINR(ISTT) = IPINRT                                   26JA0
          GO TO 4900                                                   26JA0
 2400     CONTINUE                                                     26JA0
COMMENT - NON PRISMATIC MEMBER - NCDST CARDS FOLLOW                    04MY0
          IF (PRFT .GT. 0.0  .OR. PRAET .GT. 0.0) GO TO 8670           10AP0
COMMENT - STORE TEMPORARY READ IN VALUES                               04MY0
                NCDS(ISTT) = NCDST                                     26JA0
                IAXOPS(ISTT) = IAXOPT                                  26JA0
                IOPOP(ISTT)  = IOPOPT                                  26JA0
                IPINL(ISTT) = IPINLT                                   26JA0
                IPINR(ISTT) = IPINRT                                   26JA0
      PRINT 18,ISTT                                                    26JA0
COMMENT - DO FOR EACH ADDITIONAL DATA CARD FOR THIS STIFF TYPE         04MY0
          DO 4500  II = 1,NCDST                                        26JA0
                NCS = NCS + 1                                          26JA0
          IF (II .EQ. 1) NCS1(ISTT) = NCS                              26JA0
          IF (NCRS .EQ. NCDS) GO TO 8560                               29AP0
```

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COMMENT - READ AND PRINT NON PRISMATIC STIFFNESS VALUES                04MY0
      READ 15, XLS(NCS),XRS(NCS),FL(NCS),AEL(NCS),SXL(NCS),SYL(NCS),   26JA0
     2    SZL(NCS)                                                     26JA0
      PRINT 16,XLS(NCS),XRS(NCS),FL(NCS),AEL(NCS),SXL(NCS),SYL(NCS),   26JA0
     2    SZL(NCS)                                                     26JA0
                NCRS = NCRS + 1                                        29AP0
          IF (AEL(NCS) .LE. 0.0 .OR. FL(NCS) .LE. 0.0) GO TO 8660      04MY0
COMMENT - MULTIPLY A AND I BY E                                        04MY0
                FL(NCS) = E*FL(NCS)                                    30MR0
                AEL(NCS) = E*AEL(NCS)                                  30MR0
COMMENT - CONVERT DISTANCES TO MEMBER COORDINATES                      04MY0
          GO TO (2800,2700,2600), IAXOPT                               04MY0
 2600           XLS(NCS) = XLS(NCS)/DC2S(ISTT)                         26JA0
                XRS(NCS) = XRS(NCS)/DC2S(ISTT)                         26JA0
          GO TO 2800                                                   26JA0
 2700           XLS(NCS) = XLS(NCS)/DC1S(ISTT)                         26JA0
                XRS(NCS) = XRS(NCS)/DC1S(ISTT)                         26JA0
 2800     CONTINUE                                                     26JA0
COMMENT - CHECK FOR BAD DATA                                           04MY0
                TH = ZLS(ISTT)/M                                       26JA0
          IF  (II .EQ. 1) GO TO 3200                                   14AP0
          IF  (XLS(NCS) .NE. XRS(NCS - 1)) GO TO 8540                  14AP0
          IF  (XLS(NCS) .NE. 0.0) GO TO 3300                           14AP0
          IF (XLS(NCS - 1) + TH .GE. XRS(NCS) ) GO TO 8530             20AP0
          GO TO 4000                                                   14AP0
 3200     IF (XLS(NCS) .NE. 0.0) GO TO 8510                            14AP0
 3300     IF (XRS(NCS) .EQ. 0.0) GO TO 4000                            20AP0
          IF (XLS(NCS) + TH .GE. XRS(NCS)) GO TO 8530                  14AP0
 4000     CONTINUE                                                     14AP0
 4500     CONTINUE                                                     26JA0
COMMENT - CHECK FOR STIFF NOT STOPING AT END OF MEMBER                 04MY0
                ERRLN = ABS (ZLS(ISTT) - XRS(NCS))                     26JA0
          IF (ERRLN .GT. 0.1*TH) GO TO 8520                            23AP0
                XRS(NCS) = ZLS(ISTT)                                   26JA0
 4900     CONTINUE                                                     26JA0
          IF (NCRS .LT. NCDS) GO TO 8570                               30AP0
          GO TO 9900                                                   26JA0
 8300 PRINT 30                                                         26JA0
          GO TO 9700                                                   26JA0
 8310 PRINT 31                                                          4MY0
          GO TO 9700                                                   04MY0
 8320 PRINT 32                                                          4MY0
          GO TO 9700                                                   04MY0
 8330 PRINT 33                                                          4MY0
          GO TO 9700                                                   04MY0
 8510 PRINT 51                                                         26JA0
          GO TO 9700                                                   26JA0
 8520 PRINT 52                                                         26JA0
          GO TO 9700                                                   26JA0
 8530 PRINT 53                                                         26JA0
          GO TO 9700                                                   26JA0
 8540 PRINT 54                                                         26JA0
          GO TO 9700                                                   26JA0
 8550 PRINT 55                                                         29AP0
          GO TO 9700                                                   29AP0
 8560 PRINT 56                                                         29AP0
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            GO TO 9700                                                   29APO
 8570 PRINT 57                                                           30APO
            GO TO 9700                                                   30APO
 8580 PRINT 58                                                           30APO
            GO TO 9700                                                   30APO
 8650 PRINT 65                                                           26JAO
            GO TO 9700                                                   26JAO
 8660 PRINT 60                                                           26JAO
            GO. TO 9700                                                  26JAO
 8670 PRINT 67                                                           26JAO
            GO TO 9700                                                   26JAO
 8710 PRINT 71                                                           26JAO
            GO TO 9700                                                   26JAO
 8720 PRINT 72                                                           26JAO
 9700             IABAN = 1                                              26JAO
 9900       CONTINUE                                                     26JAO
                  NSTL = NST                                             24APO
      RETURN                                                             26JAO
      END                                                                26JAO
C
C           ********************************************************************
C
C           SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C           ********************************************************************
C
      SUBROUTINE RDMLD                                                   26JAO
COMMENT - SUBROUTINE RDMLD  INPUTS MEMBER LOAD DATA (TABLE 6) CHECKS    24APO
COMMENT - FOR BAD DATA, CONVERTS LOADS AND DISTANCES TO MEMBER          24APO
COMMENT - COORDINATES AND ECHO PRINTS DATA                              24APO
      COMMON /BLOCK3/ DXL( 50),   DYL( 50),   ZLL( 50),   DC1L( 50),     26JAO
     2    DC2L( 50), UQX( 50),   UQY( 50),   NCDL( 50),  IAXOPL( 50),    26JAO
     3    NC61( 50)                                                      26JAO
      COMMON /BLOCK6/ XLL(150),   XRL(150),   QXL(150),   QYL(150),      26JAO
     2    QZL(150)                                                       26JAO
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEPT,           26JAO
     2        ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,            26JAO
     3        IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,             26JAO
     4        N,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,             12FEO
     5        NLC,   IP8,   IP9,   IP10                                  13FEO
      COMMON /BLK3/  MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNLC              07FEO
    9 FORMAT (   40H     TABLE 6 - MEMBER LOAD DATA           ,///)      26JAO
   12 FORMAT ( 5X, I5, 20X, 2E10.3,  5X,2I5 )                            08JEO
   13 FORMAT ( 5X, I5,       2E11.3,      2I5 )                          25MRO
   14 FORMAT (//,50H      LOAD  UNIFORM     UNIFORM     NO   AXIS      , 26JAO
     2        /, 50H      TYPE       QX          QY      CARDS  OPT    , 26JAO
     3        //)                                                        26JAO
   15 FORMAT (10X,5E10.3)                                                26JAO
   16 FORMAT ( 5X,5E11.3)                                                26JAO
   17 FORMAT (    48H      HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS,  26JAO
     2            15H THE FOLLOWING ,//)                                 26JAO
   18 FORMAT (//,20H          LOAD TYPE ,I5,6H CONTD,/,2X,               02MYO
     2            49H         FROM        TO          QX          QY   , 26JAO
     3            30H    QZ                       , //)                  26JAO
   23 FORMAT (    10H      NONE )                                        26JAO
   24 FORMAT (    20H      NO DATA         )                             04FEO
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   52 FORMAT  (  50H     LOAD SPECIFIED BEYOND THE END OF MEMBER      ) 31MRO
   53 FORMAT  (  50H     LOAD SEQUENCE MUST BE LONGER THAN 1/40 SPAN  ) 31MRO
   54 FORMAT  (  51H     LOAD SPECIFIED AT NEGATIVE DISTANCE ALONG MEMB)31MRO
   55 FORMAT  (  49H     TO DISTANCE OF ZERO IMPLIES THAT IT IS FIRST,  21APO
     2 55H CARD OF TWO CARD SEQUENCE AND NEXT CARD WILL HAVE FROM,/,     21APO
     3 20H DISTANCE OF ZERO    )                                         21APO
   56 FORMAT  (  50H     ALL CARDS SPECIFIED FOR TABLE 6 READ BUT ALL , 29APO
     2           25HLOAD TYPES NOT SPECIFIED ,/,                         30APO
     3           46H     CHECK CARD COUNT AND NUMBER OF LOAD TYPES)      30APO
   57 FORMAT  (  48H     NO CARDS IN TABLE 6  BUT ALL LOAD TYPES NOT,    29APO
     2           10H SPECIFIED)                                          29APO
   58 FORMAT  (  51H     ALL LOAD TYPES SPECIFIED BUT ALL CADS NOT READ 30APO
     2     ,/,   46H     CHECK CARD COUNT AND NUMBER OF LOAD TYPES)      30APO
   59 FORMAT  (  40H     AXIS OPTION MUST BE 1,2,3, OR 4      )          30APO
   60 FORMAT  (  51H     NUMBER OF CARDS TO FOLLOW MUST NOT BE NEGATIVE)04APO
   61 FORMAT  (  48H     CONCENTRATED LOADS AT 0.0 ARE NOT PERMITTED)    04MYO
   65 FORMAT  (  45H     LOAD TYPES MUST BE IN ASCENDING ORDER    )      31MRO
   67 FORMAT  (  50H     IF 2ND CARD USED FOR LOAD TYPE, UNIFORM LOAD , 31MRO
     2           20HVALUES MUST BE 0.0  )                                31MRO
   71 FORMAT  (  36H     LOAD TYPES MUST NOT BE NEGATIVE)                31MRO
   72 FORMAT  (  48H     LOAD TYPE GREATER THAN TOTAL NUMBER OF LOAD,    31MRO
     2           16H TYPES SPECIFIED)                                    31MRO
COMMENT - PRINT TABLE HEADING                                            05MYO
      PRINT 9                                                            26JAO
            IF (KEEP6 .EQ. 0) NLTL = 0                                   24APO
            IF (NCD6 .EQ. 0 .AND. KEEP6 .EQ. 0) GO TO 1110               04FEO
            GO TO 1120                                                   04FEO
 1110 PRINT 24                                                            4FEO
            IF (NLT .NE. 0) GO TO 8570                                   29APO
            GO TO 9900                                                    4FEO
 1120       IF (NCD6 .NE. 0) GO TO 1150                                  04FEO
            IF (NLT .NE. NLTL) GO TO 8570                                29APO
      PRINT 17                                                           26JAO
      PRINT 23                                                           26JAO
            GO TO 9900                                                   26JAO
 1150       CONTINUE                                                     26JAO
            IF (KEEP6 .EQ. 1) GO TO 1240                                 26JAO
COMMENT - ALL NEW DATA                                                   04MYO
 1160       DO 1200  I = 1,MNLT                                          06MYO
                  NC61(I) = -1                                           26JAO
 1200             NCDL(I)= - 1                                           26JAO
                  NC6 = 0                                                26JAO
            GO TO 1250                                                   26JAO
 1240 PRINT 17                                                           26JAO
            IF (NLTL .EQ. 0) GO TO 1160                                  06MYO
 1250       CONTINUE                                                     26JAO
      PRINT 14                                                           26JAO
                  NCR6 = 0                                               29APO
COMMENT - DO FOR EACH LOAD TYPE                                          05MYO
            DO 4900 JJ =1,NLT                                            26JAO
COMMENT - SKIP FOR LOAD TYPES HELD FROM PREVIOUS PROBLEM              .   5MYO
            IF (NCDL(JJ) .NE. -1) GO TO 4900                             06MYO
            IF (JJ .EQ. 1) GO TO 1300                                    26JAO
            IF (JJ .EQ. NLTL + 1) GO TO 1300                             24APO
            IF (NCDL(JJ - 1) .GT. 0) PRINT 14                            26JAO
 1300       CONTINUE                                                      4MYO
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          IF (NCR6 .EQ. NCD6) GO TO 8560                                  29APO
COMMENT - READ AND PRINT FIRST CARD FOR LOAD TYPE                         05MYO
      READ  12, LTT,UQXT,UQYT,NCDLT,IAXOPT                                04MYO
      PRINT 13, LTT,UQXT,UQYT,NCDLT,IAXOPT                                26JAO
          IF (IAXOPT .LT.1  .OR. IAXOPT .GT. 4) GO TO 8590                30APO
               NCR6 = NCR6 + 1                                            29APO
          IF (LTT .GT. NLT) GO TO 8720                                    26JAO
          IF ( LTT .LT. 0) GO TO 8710                                     26JAO
          IF (JJ .NE.  LTT) GO TO 0650                                    26JA^
          IF (NCDLT .LT. 0) GO TO 8600                                    04MYO
          IF (NCDLT .GT. 0) GO TO 2400                                    26JAO
COMMENT - UNIFORM LOADS ONLY                                              05MYO
          IF (IAXOPT .EQ. 1) GO TO 1500                                   17MRO
          IF (IAXOPT .EQ. 2) GO TO 1400                                   17MRO
COMMENT - AXIS OPTION 3 OR 4 - CONVERT UNIFORM LOADS TO DIRECTIONS        05MYO
COMMENT - AND INTENSITY OF MEMBER AXES                                    05MYO
               TEMP1 = ABS(DC1L(LTT))                                     26JAO
               TEMP2 = ABS(DC2L(LTT))                                     26JAO
               UQX(LTT) =  UQXT*DC1L(LTT)*TEMP2 +                         26JAO
     2                     UQYT*DC2L(LTT)*TEMP1                           26JAO
               UQY(LTT) = -UQXT*DC2L(LTT)*TEMP2 +                         26JAO
     2                     UQYT*DC1L(LTT)*TEMP1                           26JAO
          GO TO 1600                                                      26JAO
COMMENT - AXIS OPTION 2 - CONVERT UNIFORM LOADS TO DIRECTIONS OF          05MYO
COMMENT - MEMBER AXES                                                      5MYO
 1400          UQX(LTT) = UQXT*DC1L(LTT) + UQYT*DC2L(LTT)                 26JAO
               UQY(LTT) = - UQXT*DC2L(LTT) + UQYT*DC1L(LTT)               26JAO
          GO TO 1600                                                      26JAO
COMMENT - AXIS OPTION 1 - LOADS ALLREADY IN MEMBER AXES                   05MYO
 1500          UQX(LTT) = UQXT                                            26JAO
               UQY(LTT) = UQYT                                            26JAO
 1600          NCDL(LTT) = 0                                              26JAO
               IAXOPL(LTT) = IAXOPT                                       26JAO
          GO TO 4900                                                      26JAO
COMMENT - VARIABLE LOADING                                                05MYO
 2400     CONTINUE                                                        26JAO
          IF (UQXT .NE. 0 .OR.  UQYT .NE. 0) GO TO 8670                   26JAO
               NCDL(LTT) = NCDLT                                          26JAO
               IAXOPL(LTT) = IAXOPT                                       26JAO
      PRINT 18, LTT                                                       26JAO
COMMENT - DO FOR EACH ADDITIONAL CARD OF LOAD TYPE                         5MYO
          DO 4500  II = 1,NCDLT                                           26JAO
               NC6 = NC6 + 1                                              26JAO
          IF (II .EQ. 1) NC61(LTT) = NC6                                  26JAO
          IF (NCR6.EQ. NCD6) GO TO 8560                                   29APO
COMMENT - READ AND PRINT NONUNIFORM LOAD DATA                             05MYO
      READ  15, XLL(NC6),XRL(NC6),QXLT,QYLT,QZL(NC6)                      26JAO
      PRINT 16, XLL(NC6),XRL(NC6),QXLT,QYLT,QZL(NC6)                      26JA^
               NCR6 = NCR6 + 1                                            29APO
               TH = ZLL(LTT)/M                                            26JAO
COMMENT - CONVERT DISTANCES TO MEMBER COORDINATES                         05MYO
          GO TO  (2800,2800,2700,2600), IAXOPT                            21APO
 2600          XLL(NC6) = XLL(NC6)/DC2L(LTT)                              26JAO
               XRL(NC6) = XRL(NC6)/DC2L(LTT)                              26JAO
          GO TO 2800                                                      26JAO
 2700          XLL(NC6) = XLL(NC6)/DC1L(LTT)                              26JAO
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               XRL(NC6) = XRL(NC6)/DC1L(LTT)                              26JAO
 2800     CONTINUE                                                        26JAO
COMMENT - CHECK FOR ILLEGAL DATA                                          05MYO
          IF (XLL(NC6) .LT. 0.0) GO TO 8540                               21APO
          IF (XRL(NC6) .GT. ZLL(LTT) + 0.1*TH) GO TO 8520                 21APO
          IF (XRL(NC6) .EQ. 0.0) GO TO 2838                               21APO
          IF (II .EQ. 1) GO TO 2820                                       04MYO
          IF (XRL(NC6 - 1) .NE. 0.0) GO TO 2820                           71APO
          IF (XLL(NC6) .NE. 0.0) GO TO 8550                               21APO
               DEL = XRL(NC6) - XLL(NC6 - 1)                              21APO
          GO TO 2830                                                      21APO
 2820          DEL = XRL(NC6) - XLL(NC6)                                  21APO
          IF (DEL .EQ. 0.0) GO TO 2840                                    21APO
 2830     IF (DEL .LE. TH) GO TO 8530                                     21APO
          GO TO 2840                                                      21APO
 2838          DEL = 1.0                                                  21APO
          IF (II .EQ. 1) GO TO 2840                                       04MYO
          IF (XLL(NC6) .EQ. 0.0 .AND. XRL(NC6 - 1) .EQ. 0.0) GO TO 8610 04MYO
 2840     CONTINUE                                                        21APO
          IF (IAXOPT .EQ. 1) GO TO 2900                                   21APO
          IF (IAXOPT .EQ. 2 .OR. DEL .EQ. 0.0) GO TO 2850                 21AP^
COMMENT - AXIS APTIONS 3 OR 4 - CONVERT DISTRIBUTED LOADS TO DIRECTIONS 05MYO
COMMENT - AND INTENSITY OF MEMBER AXES                                    05MYO
               TEMP1 = ABS(DC1L(LTT))                                     26JAO
               TEMP2 = ABS(DC2L(LTT))                                     26JAO
               QXL(NC6) =  QXLT*DC1L(LTT)*TEMP2 +                         26JAO
     2                     QYLT*DC2L(LTT)*TEMP1                           26JAO
               QYL(NC6) = -QXLT*DC2L(LTT)*TEMP2 +                         26JAO
     2                     QYLT*DC1L(LTT)*TEMP1                           26JAO
          GO TO 2950                                                      26JAO
 2850     CONTINUE                                                        26JAO
COMMENT - AXIS OPTION 2 OR CONCENTRATED LOADS - CONVERT DISTRIBUTED       05MYO
COMMENT - AND CONCENTRATED LOADS TO DIRECTIONS OF MEMBER AXES             05MYO
               QXL(NC6) = QXLT*DC1L(LTT) + QYLT*DC2L(LTT)                 26JAO
               QYL(NC6) = -QXLT*DC2L(LTT) + QYLT*DC1L(LTT)                26JAO
          GO TO 2950                                                      26JAO
 2900     CONTINUE                                                        26JAO
COMMENT - AXIS OPTION 1 - LOADS ALLREADY IN MEMBER AXES                   05MYO
               QXL(NC6) = QXLT                                            26JAO
               QYL(NC6) + QYLT                                            26JAO
 2950     CONTINUE                                                        21APO
 4500     CONTINUE                                                        26JAO
 4900     CONTINUE                                                        26JAO
          IF (NCR6 .LT. NCD6) GO TO 8580                                  01MYO
          GO TO 9900                                                      26JAO
 8520 PRINT 52                                                            76JAO
          GO TO 9700                                                       9FEO
 8530 PRINT 53                                                            26JAO
          GO TO 9700                                                      26JAO
 8540 PRINT 54                                                             9FEO
          GO TO 9700                                                      26JAO
 8550 PRINT 55                                                            21APO
          GO TO 9700                                                      21APO
 8560 PRINT 56                                                            29APO
          GO TO 9700                                                      29APO
 8570 PRINT 57                                                            29APO
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         GO TO 9700                                                      29APO
 8580 PRINT 58                                                           30APO
         GO TO 9700                                                      30APO
 8590 PRINT 59                                                           30APO
         GO TO 9700                                                      30APO
 8600 PRINT 60                                                            4MYO
         GO TO 9700                                                       4MYO
 8610 PRINT 61                                                            4MYO
         GO TO 9700                                                      04MYO
 8650 PRINT 65                                                           26JAO
         GO TO 9700                                                      26JAO
 8670 PRINT 67                                                           26JAO
         GO TO 9700                                                      26JAO
 8710 PRINT 71                                                           26JAO
         GO TO 9700                                                      26JAO
 8720 PRINT 72                                                           26JAO
 9700            IABAN = 1                                               26JAO
 9900       CONTINUE                                                     26JAO
                 NLTL = NLT                                              24APO
      RETURN                                                             26JAO
      END                                                                26JAO
C
C        ************************************************************************
C
C        SUBROUTINE           SUBROUTINE           SUBROUTINE           SUBROUTINE
C
C        ************************************************************************
C
      SUBROUTINE COMP ( NPROB )                                          07FEO
COMMENT - SUBROUTINE  COMP  INPUTS SUPERPOSITION DATA (TABLE 7) FOR      24APO
COMMENT - FAMILY PROBLEMS,CHECKS FOR BAD DATA,SETS UP STORAGE FOR FAMILY24APO
COMMENT - SULUTIONS, ACCUMULATES PROBLE MULTIPLIERS,ECHO PRINTS DATA     24APO
COMMENT - AND PRINTS ACCUMULATED PROBLEM MULTIPLIERS                     24APC
      DIMENSION NPROB(2),NPT(2)                                          09JEO
      COMMUN /BLOCK0/ NP(21,2),    ZM(21)                                09JEO
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,           07FEO
     2         ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,           07FEO
     3         IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,            07FEO
     4         N,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,            12FFO
     5         NLC,   IP8,   IP9,   IP10                                 13FEO
      COMMUN /BLK3/  MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNLC              07FEO
    9 FORMAT  (  35H      TABLE 7 - COMPILATION TABLE    ,////)          07FEO
   10 FORMAT  (  15H      NO DATA    )                                   07FEO
   11 FORMAT  (  30H      TABLES (2 - 6) OMITTED    ,////)               10FEO
   12 FORMAT  (  48H      HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS,   07FEO
     2           15H THE FOLLOWING , /// )                               07FEO
   13 FORMAT  (  50H            INPUT OF PROBLEM NUMBERS AND MULTIPLIERS, 07FEO
     2    //,5X, 20HNPROB      MULTIPLIER,// )                           07FEO
   14 FORMAT (5X,A1,A4,10X,E10.3)                                        10JEO
   15 FORMAT (5X,A1,A4,E10.3)                                            09JEO
   16 FORMAT ( ////, 5X,                                                 10FEO
     2           50H      PROBLEM NUMBERS AND MULTIPLIERS USED FOR THIS, 10FEO
     3           10H PROBLEM  ,/,5X,                                     10FEO
     4           50H      PROBLEM NUMBERS IN ORDER PROBLEMS WERE INPUT , 10FEO
     5     //,   25H      NPROB     MULTIPLIER,// )                      10FEO
   36 FORMAT  (  50H      NO CARDS IN TABLE 7 - UNLESS PROBLEM TYPE 4  ) 07FEO
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   30 FORMAT  (  50H      PROBLEM TYPE 3 MUST FOLLOW A TYPE 2 OR TYPE 3) 07FEO
   40 FORMAT  (  45H      PROBLEM TYPE 4 MUST HAVE DATA IN TABLE 7)      07FEO
   50 FORMAT  (  50H      PROBLEM TYPE 4 MUST FOLLOW A TYPE 2, TYPE 3, , 07FEO
     2           10HOR TYPE 4 )                                          07FEO
   60 FORMAT  (  46H      A PROBLEM NUMBER MAY NOT BE REPEATED IN A,     07FEO
     2           50H SERIES OF RELATED PROBLEMS    )                     07FE^
   70 FORMAT  (  50H      STORAGE LIMITATION ON NUMBER OF CONSECTUTIVE , 07FEO
     2           25H TYPE 3 PROBLEMS EXCEEDED)                           07FEO
   80 FORMAT  (  50H      LAST PROBLEM WAS NOT TYPE 4 - HENCE DATA CAN , 07FEO
     2           15H NOT BE HELD    )                                    07FEO
   90 FORMAT  (  20H      PROBLEM NUMBER ,A5,   20H HAS NOT BEEN WORKED, 09FEO
     2           35H IN THIS SERIES OF RELATED PROBLEMS)                 07FEO
      PRINT 9                                                             7FEO
         IF ((ITYPE .LT. 4 .AND. NCD7 .NE. 0) GO TO 8360                 07FEO
         GO TO ( 1200, 1050, 1060, 1250 ) ITYPE                          07FEO
COMMENT - ITYPE = 2 - PARENT PROBLEM - FIRST PROBLEM OF SERIES IN WHICH 05MYO
COMMENT - THE STIFFNESS OF THE STRUCTURE DOES NOT CHANGE - THE RESULTS  05MYO
COMMENT - UF THE PARENT AND ITS OFFSPRING ARE STORED SO SUPPERPOSITION  05MYO
COMMENT - SOLUTIONS CAN BE MADE FOR FAMILY PROBLEMS                     05MYO
 1050            NLC = 1                                                 07FEO
                 NP(1,1) = NPROB(1)                                      09JEO
                 NP(1,2) = NPROB(2)                                      09JEO
         GO TO 1200                                                       7FEO
COMMENT - ITYPE = 3 - OFFSPRING PROBLEM - SOLUTION OF PARENT FOR ANOTHER05MYO
COMMENT - LUAD CONDITION                                                 05MYD
 1060    IF ((ITYPEL .EQ. 2 .OR. ITYPEL .EQ. 3) GO TO 1070               07FEO
         GO TO 8300                                                       7FEO
 1070    DO 1100  I = 1,NLC                                              07FEO
         IF (NPROB(1) .EQ. NP(I,1) .AND. NPROB(2) .EQ. NP(I,2))          09JEO
     2                                                 GO TO 8600        09JEO
 1100    CONTINUE                                                         7FEO
                 NLC = NLC + 1                                           07FEO
         IF (NLC .GT. MNLC) GO TO 8700                                   07FEO
                 NP(NLC,1) = NPROB(1)                                    09JEO
                 NP(NLC,2) = NPROB(2)                                    09JEO
COMMENT - ITYPE = 1 - REGULAR PROBLEM                                    05MYO
 1200    CONTINUE                                                        07FEO
      PRINT 10                                                            7FEO
         GO TO 9900                                                      07FEO
COMMENT - ITYPE = 4 - FAMILY PROBLEM - SUPERPOSITION SOLUTION OF         05MYO
COMMENT - A GROUP OF RELATED OFFSPRING PROBLEMS AND POSSIBLY THEIR       05MYO
COMMENT - PARENT                                                          5MYO
 1250    CONTINUE                                                        07FEO
         IF (NCD7 .EQ. 0) GO TO 8400                                     07FEO
         IF ((ITYPEL .EQ. 1 .OR. ITYPEL .EQ. 0) GO TO 8500               07FEO
         IF ((ITYPEL .LT. 4 .AND. KEEP7 .EQ. 1) GO TO 8800               07FEO
      PRINT 11                                                            7FEO
      IF (KEEP7 .EQ. 1) GO TO 1350                                       07FEO
COMMENT - ZERU MULTIPLIERS                                               05MYB
         DO 1320  I = 1,NLC                                              07FEO
 1320            ZM(I) = 0.0                                             07FEO
         GO TO 1400                                                      07FEO
 1350 PRINT 12                                                            7FEO
 1400    CONTINUE                                                        07FEO
      PRINT 13                                                            7FEO
COMMENT - READ AND PRINT PROBLEM NUMBERS AND MULTIPLIERS                 05MYO
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          DO 3000  J = 1,NCD7                                               07FE0
      READ 14, NPT,ZMT                                                      07FE0
      PRINT 15, NPT,ZMT                                                     07FE0
COMMENT - SEARCH FOR PROBLEM NUMBER IN LIST OF PROBLEM NUMBERS STORED      05MY0
          DO 2600  I = 1,NLC                                                07FE0
          IF (NPT(1) .EQ. NP(I,1) .AND. NPT(2) .EQ. NP(I,2))                09JE0
     2                                                  GO TO 2700          09JE0
 2600     CONTINUE                                                          07FE0
          GO TO 8900                                                        07FE0
COMMENT - ACCUMULATE MULTIPLIERS                                            05MY0
 2700           ZM(I) = ZM(I) + ZMT                                         07FE0
 3000     CONTINUE                                                          07FE0
      PRINT 16                                                              07FE0
COMMENT - PRINT ACCUMULATED MULTIPLIERS                                     05MY0
          DO 3100  I = 1,NLC                                                07FE0
 3100 PRINT 15, NP(I,1), NP(I,2), ZM(I)                                     07FE0
          GO TO 9900                                                        07FE0
 8300 PRINT 30                                                               7FE0
          GO TO 9700                                                        07FE0
 8360 PRINT 36                                                               7FE0
          GO TO 9700                                                        07FE0
 8400 PRINT 40                                                               7FE0
          GO TO 9700                                                        07FE0
 8500 PRINT 50                                                               7FE0
          GO TO 9700                                                        07FE0
 8600 PRINT 60                                                               7FE0
          GO TO 9700                                                        07FE0
 8700 PRINT 70                                                               7FE0
          GO TO 9700                                                        07FE0
 8800 PRINT 80                                                               7FE0
          GO TO 9700                                                        07FE0
 8900 PRINT 90,NPT                                                          07FE0
 9700           IABAN = 1                                                   07FE0
 9900 RETURN                                                                 7FE0
      END                                                                   07FE0
C
C         ************************************************************************
C
C         SUBROUTINE           SUBROUTINE           SUBROUTINE           SUBROUTINE
C
C         ************************************************************************
C
      SUBROUTINE FORMST ( RM, RO, W, SL, SU, SMMT, L1, L3, L4, L6 )        08AP0
COMMENT - SUBROUTINE FORMST CALCULATES STIFFNESS MATRIX FOR BOTH           24AP0
COMMENT - PRISMATIC AND VARIABLE CROSS SECTION MEMBERS AND STORES IN       24AP0
COMMENT - COMPACT VECTOR  SMMT(I = 1,13)                                   24AP0
      DIMENSION FMM(6), SMMT(13)                                           08AP0
      DIMENSION RM(L3,L6), RO(L6), W(L6), SL(L3), SU(L4)                   08AP0
      COMMON /BLOCK2/ DXS( 50),   DYS( 50),   ZLS( 50),   DC1S( 50),       26JA0
     2    DC2S( 50),  PRF( 50),   PRAE( 50),  NCDS( 50),  IAXOPS( 50),     26JA0
     3    IOPOP( 50), IPINL( 50), IPINR( 50), NC51( 50),  SMC( 50,13)      11FE0
      COMMON /BLOCK5/ XLS( 75),   XRS( 75),   FL( 75),    AEL( 75),        26JA0
     2    SXL( 75),   SYL( 75),   SZL( 75)                                 26JA0
      COMMON /BLOCK7/ F( 42),     AE( 42),    SX( 42),    SY(42),          26JA0
     2    SZ( 42),    QX( 42),    QY( 42),    QZ( 42),    A( 42),          26JA0
     3    B( 42),     A1( 42),    D( 42),     DX( 42),    DY( 42),         26JA0
     4    DZ(42),     U1(42),     V1(42),     W1(42),     U2(42),          13MR0
     5    V2(42),     W2(42),     ERX(42),    ERY(42),    ERZ(42),         13MR0
     6    RX(42),     RY(42),     RZ(42)                                   13MR0
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,             26JA0
     2        ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,              26JA0
     3        IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,               26JA0
     4        M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,               12FE0
     5        NLC,   IP8,   IP9,   IP10                                    13FE0
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,NO,M,TM,MSO,MCU,X2L                  26JA0
      COMMON /BLK3/  MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNLC                07FE0
      COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6                                26JA0
      COMMON /BLK5/ NFSUB                                                  08AP0
      COMMON / RI / NL, ML, J1                                             08AP0
COMMENT - SET TEMPORARY CONTROL CONSTANTS FOR STIFF TYPE ISTT              13MY0
                IPINLT = IPINL(ISTT)                                       26JA0
                IPINRT = IPINR(ISTT)                                       26JA0
                ZL = ZLS(ISTT)                                             26JA0
                PRFT = PRF(ISTT)                                           26JA0
                PRAET = PRAE(ISTT)                                         26JA0
                NCDST = NCDS(ISTT)                                         26JA0
                NC51T = NC51(ISTT)                                         26JA0
          IF (NCDST .NE. 0) GO TO 2100                                     26JA0
COMMENT - PRISMATIC MEMBERS                                                13MY0
COMMENT - COMPUTE CONSTANTS AND AXIAL STIFFNESSES                           13MY0
                ZL2 = ZL*ZL                                                26JA0
                ZL3 = ZL2*ZL                                               26JA0
                SMMT(1) = PRAET/ZL                                         26JA0
                SMMT(2) = -SMMT(1)                                         26JA0
                SMMT(10) = SMMT(1)                                         26JA0
          IF (IPINLT .EQ. 0 .AND. IPINRT .EQ. 0) GO TO 1800                26JA0
COMMENT - ZERO FLEXURAL STIFFNESS VALUES                                   13MY0
                SMMT(3) = SMMT(4) = SMMT(5) = SMMT(6) = 0.0                26JA0
                SMMT(7) = SMMT(8) = SMMT(9) = SMMT(11) = 0.0               26JA0
                SMMT(12) = SMMT(13) = 0.0                                  26JA0
          IF (IPINLT .EQ. 1 .AND. IPINRT .EQ. 1) GO TO 2000                26JA0
COMMENT - COMPUTE FLEXURAL STIFFNESSES FOR MEMBER PINNED AT ONE END        13MY0
                SMMT(3) = 3.0*PRFT/ZL3                                     26JA0
                SMMT(11) = SMMT(3)                                         26JA0
                SMMT(5) = -SMMT(3)                                         26JA0
          IF (IPINRT .EQ. 1) GO TO 1700                                    26JA0
                SMMT(6) = 3.0*PRFT/ZL2                                     26JA0
                SMMT(12) = -SMMT(6)                                        26JA0
                SMMT(13) = 3.0*PRFT/ZL                                     26JA0
          GO TO 2000                                                       26JA0
 1700           SMMT(4) = 3.0*PRFT/ZL2                                     26JA0
                SMMT(7) = 3.0*PRFT/ZL                                      26JA0
                SMMT(8) = -SMMT(4)                                         26JA0
          GO TO 2000                                                       26JA0
COMMENT - COMPUTE FLEXURAL STIFFNESSES FOR MEMBER WITH RIGID               13MY0
COMMENT - CONNECTIONS AT BOTH JOINTS                                       13MY0
 1800           SMMT(3) = 12.0*PRFT/ZL3                                    26JA0
                SMMT(4) = 6.0*PRFT/ZL2                                     26JA0
                SMMT(5) = -SMMT(3)                                         26JA0
                SMMT(6) = SMMT(4)                                          26JA0
                SMMT(7) = 4.0*PRFT/ZL                                      26JA0
                SMMT(8) = -SMMT(4)                                         26JA0
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                SMMT(9) = 0.5*SMMT(7)                                      26JAO
                SMMT(11) = SMMT(3)                                         26JAO
                SMMT(12) = -SMMT(6)                                        26JAO
                SMMT(13) = SMMT(7)                                         26JAO
 2000           IFORM = 0                                                  26JAO
          GO TO 9900                                                       26JAO
 2100     CONTINUE                                                         26JAO
COMMENT - NONPRISMATIC MEMBERS                                             22MYO
COMMENT - COMPUTE CONSTANTS FOR MEMBER SOLUTIONS FOR STIFFNESS VALUES      13MYO
                TH = ZL/M                                                  26JAO
                H = 0.5*TH                                                 26JAO
                HSQ = H*H                                                  26JAO
                HCU = HSQ*H                                                26JAO
                NL = 2*MP1                                                 26JAO
                IFORM = 1                                                  26JAO
COMMENT - SUBROUTINE DISCST  DISCRETIZES MEMBER STIFFNESS DATA  F, AE,     13MYO
COMMENT - SX, SY, AND SZ                                                   13MYO
     CALL         DISCST ( NCSIT, NCDST, ZL, L1 )                          11FEO
COMMENT - STORE MEMBER END RESTRAINTS ST1 -  ST6                           13MYO
                ST1 = SX(1)                                                26JAO
                ST2 = SY(1)                                                26JAO
                ST3 = SZ(1)                                                26JAO
                ST4 = SX(MP1)                                              26JAO
                ST5 = SY(MP1)                                              26JAO
                ST6 = SZ(MP1)                                              26JAO
COMMENT - SET MEMBER END RESTRAINTS TO 1.0E+99 FOR SIX MEMBER SOLUTIONS 13MYO
                SX(1) = SX(MP1) = 1.0E99                                   26JAO
                SY(1) = SY(MP1) = 1.0E99                                   26JAO
                SZ(1) = SZ(MP1) = 1.0E99                                   26JAO
COMMENT - ZERO PINNED END ROTATION RESTRAINTS                              13MYO
          IF ( IPINLT .EQ. 1) SZ(1) = 0.0                                  26JAO
          IF ( IPINRT .EQ. 1) SZ(MP1) = 0.0                                26JAO
                MLT = 1                                                    26JAO
                NL = 1                                                     26JAO
COMMENT - ZERO MEMBER LOADS QX, QY, QZ                                     13MYO
          DO 3100  I = 1,MP2                                               26JAO
 3100           QX(I) = QY(I) = QZ(I) = 0.0                                26JAO
COMMENT - AXIAL SOLUTION FOR UNIT AXIAL DISPLACEMENT AT  FROM  JOINT       13MYO
                QX(1) = 1.0 E99                                            26JAO
COMMENT - SUBROUTINE AXIAL SOLVES FOR AXIAL DISPLACEMENTS OF MEMBER        13MYO
     CALL          AXIAL ( MLT )                                           26JAO
                QX(1) = 0.0                                                26JAO
                QY(1) = 1.00E99                                            26JAO
COMMENT - LATERAL SOLUTION FOR UNIT LATERAL DISPLACEMENT AT  FROM  JNT     13MYO
                NFSUB = 12                                                 08APO
COMMENT - SUBROUTINE GRIP2A SOLVES FOR LATERAL DISPLACEMENTS AND           13MYO
COMMENT - ROTATIONS OF MEMBERS                                             13MYO
     CALL        GRIP2A ( RM, RO, W, SL, SU, L3, L4, L6, 3    )            15MYO
                QY(1) = 0.0                                                26JAO
COMMENT - SUBROUTINE MEMEND SOLVES FOR END FORCES ON MEMBER                13MYO
     CALL        MEMEND ( W, FMM, L6 )                                     08APO
COMMENT - SET STIFFNESS VALUES EQUAL TO MEMBER-END-FORCES                  13MYO
                SMMT(1) = FMM(1)                                           26JAO
                SMMT(2) = FMM(4)                                           26JAO
                SMMT(3) = FMM(2)                                           26JAO
                SMMT(4) = FMM(3)                                           26JAO
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                SMMT(5) = FMM(5)                                           26JAO
                SMMT(6) = FMM(6)                                           26JAO
                NL = -1                                                    26JAO
          IF (IPINLT .EQ. 0) GO TO 3500                                    26JAO
COMMENT - ZERO STIFFNESS TERMS FOR PINNED CONNECTIONS                      13MYO
                SMMT(4) = 0.0                                              27AGO
                SMMT(7) = 0.0                                              26JAO
                SMMT(8) = 0.0                                              26JAO
                SMMT(9) = 0.0                                              26JAO
          GO TO 3600                                                       26JAO
COMMENT - LATERAL SOLUTION FOR UNIT ROTATION AT  FROM  JOINT               13MYO
 3500           QZ(1) = 1.0E99                                             26JAO
COMMENT - SUBROUTINE GRIP2A SOLVES FOR LATERAL DISPLACEMENTS AND           13MYO
COMMENT - ROTATIONS OF MEMBERS                                             13MYO
     CALL        GRIP2A ( RM, RO, W, SL, SU, L3, L4, L6, 3    )            15MYO
                QZ(1) = 0.0                                                26JAO
COMMENT - SUBROUTINE MEMEND SOLVES FOR END FORCES ON MEMBER                13MYO
     CALL        MEMEND ( W, FMM, L6 )                                     08APO
COMMENT - SET STIFFNESS VALUES EQUAL TO MEMBER-END-FORCES                  13MYO
                SMMT(7) = FMM(3)                                           26JAO
                SMMT(8) = FMM(5)                                           26JAO
                SMMT(9) = FMM(6)                                           26JAO
 3600           MLT = -1                                                   26JAO
COMMENT - AXIAL SOLUTION FOR UNIT AXIAL DISPLACEMENT AT  TO   JOINT        13MYO
                QX(MP1) = 1.0E99                                           26JAO
COMMENT - SUBROUTINE AXIAL SOLVES FOR AXIAL DISPLACEMENTS OF MEMBER        13MYO
     CALL          AXIAL ( MLT )                                           26JAO
                QX(MP1) = 0.0                                              26JAO
COMMENT - LATERAL SOLUTION FOR UNIT LATERAL DISPLACEMENT AT   TO   JNT     13MYO
                QY(MP1) = 1.0E99                                           26JAO
COMMENT - SUBROUTINE GRIP2A SOLVES FOR LATERAL DISPLACEMENTS AND           13MYO
COMMENT - ROTATIONS OF MEMBERS                                             13MYO
     CALL        GRIP2A ( RM, RO, W, SL, SU, L3, L4, L6, 3    )            15MYO
                QY(MP1) = 0.0                                              26JAO
COMMENT - SUBROUTINE MEMEND SOLVES FOR END FORCES ON MEMBER                13MYO
     CALL        MEMEND ( W, FMM, L6 )                                     08APO
COMMENT - SET STIFFNESS VALUES EQUAL TO MEMBER-END-FORCES                  13MYO
                SMMT(10) = FMM(4)                                          26JAO
                SMMT(11) = FMM(5)                                          26JAO
                SMMT(12) = FMM(6)                                          26JAO
          IF (IPINRT .EQ. 0) GO TO 3700                                    26JAO
COMMENT - ZERO STIFFNESS TERMS FOR PINNED CONNECTIONS                      13MYO
                SMMT(6) = 0.0                                              27AGO
                SMMT(9) = 0.0                                              27AGO
                SMMT(12) = 0.0                                             27AGO
                SMMT(13) = 0.0                                             26JAO
          GO TO 9900                                                       27AGO
COMMENT - LATERAL SOLUTION FOR UNIT ROTATION AT   TO   JOINT               13MYO
 3700           QZ(MP1) = 1.0E99                                           26JAO
COMMENT - SUBROUTINE GRIP2A SOLVES FOR LATERAL DISPLACEMENTS AND           13MYO
COMMENT - ROTATIONS OF MEMBERS                                             13MYO
     CALL        GRIP2A ( RM, RO, W, SL, SU, L3, L4, L6, 3    )            15MYO
                QZ(MP1) = 0.0                                              26JAO
COMMENT - SUBROUTINE MEMEND SOLVES FOR END FORCES ON MEMBER                13MYO
     CALL        MEMEND ( W, FMM, L6 )                                     08APO
COMMENT - SET STIFFNESS VALUES EQUAL TO MEMBER-END-FORCES                  13MYO
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              SMMT(13) = FNM(6)                                            26JA0
 9900     CONTINUE                                                         26JA0
      RETURN                                                               26JA0
      END                                                                  26JA0
C
C         ******************************************************************
C
C         SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C         ******************************************************************
C
      SUBROUTINE DISCST ( NC51T, NCDST, ZL, L1)                            11FE0
COMMENT - SUBROUTINE DISCST DISCRETIZES MEMBER STIFFNESS DATA F, AE,       22MY0
COMMENT - SX, SY,  AND SZ                                                  22MY0
      COMMON /BLOCK5/ XLS( 75),   XRS( 75),   FL( 75),    AEL( 75),        26JA0
     2    SXL( 75),   SYL( 75),   SZL( 75)                                 26JA0
      COMMON /BLOCK7/ F( 42),     AE( 42),    SX( 42),    SY(42),          26JA0
     2    SZ( 42),    QX( 42),    QY( 42),    QZ( 42),    A( 42),          26JA0
     3    B( 42),     A1( 42),    D( 42),     DX( 42),    DY( 42),         26JA0
     4    DZ(42),     U1(42),     V1(42),     W1(42),     U2(42),          13MR0
     5    V2(42),     W2(42),     ERX(42),    ERY(42),    ERZ(42),         13MR0
     6    RX(42),     RY(42),     RZ(42)                                   13MR0
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,             26JA0
     2        ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,              26JA0
     3        IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,               26JA0
     4        M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,               12FE0
     5        NLC,   IP8,   IP9,   IP10                                    13FE0
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,NQ,H,TH,HSQ,HCU,X2L                  26JA0
COMMENT - ZERO MEMBER STIFFNESS DATA                                       13MY0
       DO 102D I = 1,MP2                                                   26JA0
              SX(I) = 0.0                                                  26JA0
              SY(I) = 0.0                                                  26JA0
              SZ(I) = 0.0                                                  26JA0
              F(I) = 0.0                                                   26JA0
              AE(I) = 0.0                                                  26JA0
 1020     CONTINUE                                                         26JA0
              ICOUNT = 0                                                   26JA0
              NC52T = NC51T - 1 + NCDST                                    26JA0
COMMENT - II GOES FROM NC51T TO NC52T                                      13MY0
              II = NC51T - 1                                               26JA0
 1050         II = II + 1                                                  26JA0
COMMENT - READ DATA FROM ONE CARD IMAGE  (STIFFNESS AT LEFT OF SECTION)    13MY0
              XL = XLS(II)                                                 26JA0
              XR = XRS(II)                                                 26JA0
              FLT = FL(II)                                                 26JA0
              AELT = AEL(II)                                               26JA0
              SXLT = SXL(II)                                               26JA0
              SYLT = SYL(II)                                               26JA0
              SZLT = SZL(II)                                               26JA0
          IF (XR .NE. 0.0) GO TO 1100                                      26JA0
COMMENT - VARIABLE STIFFNESS SECTION READ ONE CARD IMAGE (STIFFNESS AT     13MY0
COMMENT - RIGHT OF SECTION)                                                13MY0
              II = II + 1                                                  26JA0
              XR = XRS(II)                                                 26JA0
              FRT = FL(II)                                                 26JA0
              AERT = AEL(II)                                               26JA0
              SXRT = SXL(II)                                               26JA0
              SYRT = SYL(II)                                               26JA0
              SZRT = SZL(II)                                               26JA0
          GO TO 1110                                                       26JA0
COMMENT - UNIFORM STIFFNESS SECTION SET STIFFNESS ON RIGHT EQUAL TO        13MY0
COMMENT - STIFFNESS ON LEFT                                                13MY0
 1100         FRT = FLT                                                    26JA0
              AERT = AELT                                                  26JA0
              SXRT = SXLT                                                  26JA0
              SYRT = SYLT                                                  26JA0
              SZRT = SZLT                                                  26JA0
 1110     CONTINUE                                                         26JA0
          IF  (ICOUNT .NE. 0 ) GO TO 1210                                  26JA0
COMMENT - FIRST SECTION OF MEMBERS STIFFNESS DATA                          13MY0
              ICOUNT = 1                                                   26JA0
              I1 = 2                                                       26JA0
              X1 = TH                                                      26JA0
          GO TO 1250                                                       26JA0
 1210     CONTINUE                                                         11MY0
              I1 = I2 + 1                                                  26JA0
              X1 = TH - X2                                                 26JA0
 1250     CONTINUE                                                         26JA0
          IF (XR .NE. ZL) GO TO 1260                                       26JA0
COMMENT - LAST SECTION OF MEMBERS STIFFNESS DATA                           13MY0
              I2 = MP1                                                     26JA0
              X2 = 0.0                                                     26JA0
          GO TO 1270                                                       26JA0
 1260         ZI2 = XR/TH + 1.0                                            26JA0
              I2 = ZI2                                                     26JA0
              X2 = XR - I2*TH + TH                                         26JA0
 1270         NQ = I2 - I1                                                 26JA0
COMMENT - SUBROUTINE LINSTF DISTRIBUTES F AND AE                           13MY0
      CALL        LINSTF ( FLT, FRT, F, FTT2, L1 )                         11FE0
      CALL        LINSTF (AELT, AERT, AE, AETT2, L1 )                      11FE0
COMMENT - SUBROUTINE LINLD DISTRIBUTES SX,SY,SZ, QX,QY, AND QZ             13MY0
          IF (SXLT .EQ. 0.0 .AND. SXRT .EQ. 0.0) GO TO 1280                11MY0
      CALL        LINLD ( SXLT, SXRT, SX, L1 )                             11FE0
 1280     IF (SYLT .EQ. 0.0 .AND. SYRT .EQ. 0.0) GO TO 1290                11MY0
      CALL        LINLD ( SYLT, SYRT, SY, L1 )                             11FE0
 1290     IF (SZLT .EQ. 0.0 .AND. SZRT .EQ. 0.0) GO TO 1330                11MY0
      CALL        LINLD ( SZLT, SZRT, SZ, L1 )                             11FE0
 1330     CONTINUE                                                         26JA0
              X2L = X2                                                     26JA0
COMMENT - RETURN FOR IMAGE OF NEXT DATA CARD IF II LESS THAN NC52T         13MY0
 9000     IF (II .LT. NC52T) GO TO 1050                                    26JA0
 9900     CONTINUE                                                         26JA0
      RETURN                                                               26JA0
      END                                                                  26JA0
C
C         ******************************************************************
C
C         SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C         ******************************************************************
C
      SUBROUTINE LINSTF (STL,STR,ST,STT2,L1)                               11FE0
```

```
COMMENT - SUBROUTINE LINSTF DISTRIBUTES F AND AE                       22MYO
      DIMENSION ST(L1)                                                 11FEO
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,NO,H,TH,HSO,HCU,X2L              26JA0
          IF ( XL .NE. 0.0 ) GO TO 1150                                26JA0
COMMENT - FIRST SECTION OF MEMBER                                      13MYO
              X2L = 0.0                                                26JA0
              STT2 = 1.0                                               26JA0
 1150     CONTINUE                                                     26JA0
          IF ( STR .EQ. STL ) GO TO 1310                               26JA0
COMMENT - LINEAR STIFFNESS SECTION                                     13MYO
COMMENT - CALCULATE SLOPE OF LINEAR STIFFNESS VARIATION                13MYO
              DS = (STR - STL)/(XR-XL)                                 26JA0
COMMENT - FIRST ELEMENT (TH LONG) OF SECTION                           13MYO
COMMENT - COMPUTE EFFECTIVE STIFFNESS OF ELEMENT CONSIDERING JUMP AT   15MYO
COMMENT - START OF SECTION                                             15MYO
              ST1 = STL                                                26JA0
              ST2 = STL + DS*X1                                        26JA0
              STT1 = 0.5*(ST1 + ST2)                                   26JA0
              ST(I1) = (TH*STT1*STT2)/(X2L*STT1 + X1*STT2)             26JA0
          IF (NO .EQ. 0 ) GO TO 1250                                   26JA0
              I1P1 = I1 + 1                                            26JA0
              I1PNO = I1 + NO                                          26JA0
COMMENT - REMAINING NO ELEMENTS                                        13MYO
COMMENT - COMPUTE STIFFNESS AT MID POINT OF ELEMENT                    15MYO
          DO 1210 I  = I1P1, I1PNO                                     26JA0
              ST1 = ST2                                                26JA0
              ST2 = ST1 + DS*TH                                        26JA0
 1210         ST(I) = 0.5*(ST1 + ST2)                                  26JA0
 1250     CONTINUE                                                     26JA0
              ST1 = ST2                                                26JA0
              ST2 = STR                                                26JA0
              STT2 = 0.5*(ST1 + ST2)                                   26JA0
 1290     GO TO 1000                                                   26JA0
COMMENT - UNIFORM STIFFNESS SECTION                                    13MYO
COMMENT - FIRST ELEMENT (TH LONG) OF SECTION                           13MYO
COMMENT - COMPUTE EFFECTIVE STIFFNESS OF ELEMENT CONSIDERING JUMP AT   15MYO
COMMENT - START OF SECTION                                             15MYO
 1310         STT1 = STL                                               26JA0
              ST(I1) = (TH*STT1*STT2)/(X2L*STT1 + X1*STT2)             26JA0
          IF (NO .EQ. 0 ) GO TO 1360                                   26JA0
              I1P1 = I1 + 1                                            26JA0
              I1PNO = I1 + NO                                          26JA0
COMMENT - REMAINING NO ELEMENTS HAVE CONSTANT STIFFNESS                15MYO
          DO 1350 I  = I1P1, I1PNO                                     26JA0
 1350         ST(I)  = STL                                             26JA0
 1360         STT2 = STL                                               26JA0
 1000     CONTINUE                                                     26JA0
      RETURN                                                           26JA0
      END                                                              26JA0
C
C         ********************************************************************
C
C         SUBROUTINE           SUBROUTINE           SUBROUTINE           SUBROUTINF
C
C         ********************************************************************
C
```

```
      SUBROUTINE LINLD  ( QL, QR, Q,L1)                                  11FEO
COMMENT - SUBROUTINE LINLD DISTRIBUTES SX, SY, SZ, QX, QY, AND QZ        15MYO
      DIMENSION Q(L1)                                                    11FEO
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,NO,H,TH,HSO,HCU,X2L                26JA0
COMMENT -COMPUTE SLOPE OF LINEAR VARIATION                               15MYO
              DQ = (QR - QL)/(XR - XL)                                   26JA0
COMMENT - COMPUTE CONCENTRATED LOAD OR RESTRAINT FOR ELEMENT AT RIGHT    15MYO
COMMENT - END OF SECTION Q1, DISTANCE TO LINE OF ACTION Z AND CALL       15MYO
COMMENT - CONLD TO DISTRIBUTE TO ADJACENT STATIONS                       15MYO
              Q2 = QR                                                    26JA0
              Q1 = QR - DQ*X2                                            26JA0
          IF ( ABS (Q1 + Q2) .LE. 1.0E-10 ) GO TO 1005                   26JA0
              Z = XR - X2 + (X2/3.0)*(2.0*Q2 + Q1)/(Q1 + Q2)             26JA0
              Q1 = 0.5*X2*(Q1 + Q2)                                      26JA0
          IF ( ABS(Q1) .LE. 1.0E-10 ) GO TO 1005                         26JA0
      CALL        CONLD  ( Q1, Z,  Q, L1 )                               11FEO
COMMENT - SAME AS ABOVE FOR ELEMENT AT LEFT END OF SECTION               15MYO
 1005         Q1 = QL                                                    26JA0
              Q2 = QL + DQ*X1                                            26JA0
          IF ( ABS (Q1 + Q2) .LE. 1.0E-10 ) GO TO 1009                   26JA0
              Z = XL + (X1/3.0)*(2.0*Q2 + Q1)/(Q1 + Q2)                  26JA0
              Q1 = 0.5*X1*(Q1 + Q2)                                      26JA0
          IF ( ABS(Q1) .LE. 1.0E-10 ) GO TO 1009                         26JA0
      CALL   .    CONLD  ( Q1, Z,  Q, L1 )                               11FEO
 1009     IF ( NO .EQ. 0 ) GO TO 2000                                    26JA0
 1020         XX = XL + X1                                               26JA0
COMMENT - SAME AS ABOVE FOR REMAINING NO ELEMENTS                        15MYO
          DO 1990 II = 1,NO                                              26JA0
              Q1 = Q2                                                    26JA0
              Q2 = Q1 + DQ*TH                                            26JA0
          IF ( ABS(Q1 + Q2) .LE. 1.0E-10) GO TO 1990                     11MYO
              Z = XX + (TH/3.C)*(2.0*Q2 + Q1)/(Q1 + Q2)                  26JA0
              XX = XX + TH                                               26JA0
              Q1 = 0.5*TH*(Q1 + Q2)                                      26JA0
      CALL        CONLD  ( Q1, Z,  Q, L1 )                               11FEO
 1990     CONTINUE                                                       26JA0
 2000     CONTINUE                                                       26JA0
      RETURN                                                             26JA0
      END                                                                26JA0
C
C         ********************************************************************
C
C         SUBROUTINE           SUBROUTINE           SUBROUTINE           SUBROUTINE
C
C         ********************************************************************
C
      SUBROUTINE CONLD  ( Q1, Z, QO, L1)                                 11FEO
COMMENT - SUBROUTINE CONLD DISTRIBUTES CONCENTRATED LOAD OR ELASTIC      15MYO
COMMENT - SPRING RESTRAINT TO ADJACENT STATIONS I AND IP1                15MYO
      DIMENSION QO(L1)                                                   11FEO
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,NO,H,TH,HSO,HCU,X2L                26JA0
              Z1 = Z/TH  + 1.0                                           26JA0
              I = Z1                                                     26JA0
              C = Z - I*TH + TH                                          01JLO
              IP1 = I + 1                                                01JLO
              QO(I) = QO(I) + Q1*(TH - C)/TH                             01JLO
```

```
            QO(IP1) = QO(IP1) + QI*C/TH                                 01JL0
      RETURN                                                            26JA0
      END                                                               26JA0
C
C         *****************************************************************
C
C         SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C         *****************************************************************
C
      SUBROUTINE  AXIAL ( NLT )                                         26JA0
COMMENT - SUBROUTINE AXIAL SOLVES FOR AXIAL DISPLACEMENTS OF MEMBER DX  15MY0
COMMENT - SUBROUTINE AXIAL SETS UP STIFFNESS COEFF (BB, CC, DD) AND     15MY0
COMMENT - LOAD FF AND SOLVES FOR DX USING RECURSIVE SOLUTION OF         15MY0
COMMENT - PREVIOUS BEAM COLUMN SOLUTIONS NOTING THAT AA = EE = 0        15MY0
      COMMON /BLOCK7/ F( 42),     AE( 42),    SX( 42),    SY(42),       26JA0
     2    SZ( 42),    QX( 42),    QY( 42),    QZ( 42),    A( 42),       26JA0
     3    B( 42),     A1( 42),    D( 42),     DX( 42),    DY( 42),      26JA0
     4    DZ(42),     U1(42),     V1(42),     W1(42),     U2(42),       13MR0
     5    V2(42),     W2(42),     ERX(42),    ERY(42),    ERZ(42),      13MR0
     6    RX(42),     RY(42),     RZ(42)                                13MR0
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,          26JA0
     2        ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,           26JA0
     3        IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,            26JA0
     4        M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,            12FE0
     5        NLC,   IP8,   IP9,   IP10                                 13FE0
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,NQ,H,TH,HSQ,HCU,X2L               26JA0
            D(1) = -1.0/ (AE(2) + SX(1)*TH)                             26JA0
            B(1) = -D(1)*AE(2)                                          26JA0
            A(1) = - D(1)*QX(1)*TH                                      26JA0
         DO 2000 I = 2,MP1                                              26JA0
            IP1 = I + 1                                                 26JA0
            IM1 = I - 1                                                 26JA0
         IF (NL .EQ. -1) GO TO 1500                                     26JA0
            BB = - AE(I)                                                26JA0
            CC = AE(I) + AE(IP1) + SX(I)*TH                             26JA^
            DD = - AE(IP1)                                              26JA0
            DENOM = BB*B(IM1) + CC                                      26JA0
            D(I) = -1.0/DENOM                                           26JA0
            B(I) = D(I)*DD                                              26JA0
            A1(I) = D(I)*BB                                             26JA0
 1500       FF = QX(I)*TH                                               26JA0
            A2 = D(I)*FF                                                26JA0
            A(I) = A1(I)*A(IM1) - A2                                    26JA0
 2000    CONTINUE                                                       26JA0
            DX(MP2 ) = 0.0                                              26JA0
         DO 2800 L = 1, MP1                                             26JA0
            I = MP2 - L                                                 26JA0
            IP1 = I + 1                                                 26JA0
 2800    DX(I) = A(I) + B(I)*DX(IP1)                                    26JA0
      RETURN                                                            26JA0
      END                                                               26JA0
C
C         *****************************************************************
C
C         SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
```

```
C
C         *****************************************************************
C
      SUBROUTINE GRIP2A ( RM, RO, W, SL, SU, L3, L4, L6, M    )         15MY0
COMMENT - GRIP2A SOLVES BOTH FRAME JOINT EQUILIBRIUM EQUATIONS AND      24AP0
COMMENT - MEMBER EQUILIBRIUM EQUATIONS - GRIP2B CALLS FSUB1 WHICH CALLS 24AP0
COMMENT - FSUB11 TO SET UP FRAME EQUATIONS OR FSUB12 TO SET UP MEMBER   24AP0
COMMENT - EQUATIONS                                                     24AP0
C  $  $  $  $  $  $  $  $  $  $  $  $  REVISION DATE =    07 APR 70     DATF
C---------RM(M,NL) , RO(NL)    , W(NL) , SL(M) , SU(M+1)  -**-  DIMENSION GUIDE
C         NL IS ORDER                                                    6AP0
C    ***   NL MUST BE GREATER THAN 2                                    06AP0
C         M  IS HALF-WIDTH  ( J = 2*M + 1 ), WHERE J IS THE BAND WIDTH  06AP0
C    ***   M MUST BE GREATER THAN 1                                     06AP0
C         RM(  )      RECURSION MULTIPLIERS                             06AP0
C         F           CONSTANT TERM FOR THE 1-TH ROW                    06AP0
C         W (  )      SOLUTION VECTOR                                   06AP0
      DIMENSION RM(L3,L6), RO(L6), W(L6), SL(L3), SU(L4)                08AP0
      COMMON /R1/ NL, ML, J1                                            20JA9
                J1 = 1                                                  11JL8
                M1 = M - 1                                              11JL8
                MP = M + 1                                              11JL8
                NLM1 = NL - 1                                           11JL8
                NLMM = NL - M                                           11JL8
                IZ = 0                                                  25JL8
                I2 = 1                                                  25JL8
                I3 = 1                                                  25JL8
C*********************************************************************
C                                    CALCULATE RECURSION MULTIPLIERS      *
C*********************************************************************
                SL(1) = 0.0                                             07AP0
      CALL         FSUB1 ( SU, F , M, L4 )                              08AP0
         IF ( NL ) 210, 100, 100                                        11JL8
  100           RM(M,1) = -1.0 / SU(MP)                                 25JL8
         DO 150  I = 1 , M1                                             25JL8
                IB = MP - I                                             25JL8
                RM(I,IB) = SU(I+1)                                      25JL8
  150    CONTINUE                                                       25JL8
                RO(1) = SU(1)                                           06AP0
  210           W(1) = RM(M,1) * ( -F )                                 11JL8
         DO 100u  J = 2 , NL                                            11JL8
                J1 = J - 1                                              07AP0
         IF ( J.GT.M )  J1 = M1                                         06AP0
         DO 250  I = 1, J1                                              07AP0
                IB = J1 + 2 - I                                         07AP0
                SL(IB) = SL(IB-1)                                       07AP0
  250    CONTINUE                                                       07AP0
                SL(1) = SU(1)                                           07AP^
                J1 = J                                                  11JL8
      CALL         FSUB1 ( SU, F , M, L4 )                              08AP0
                J1 = J - 1                                              07AP0
         IF ( J.GT.M )  J1 = M1                                         06AP0
         IF ( NL ) 750, 290, 290                                        11JL8
  290           IX = J + M1                                             25JL8
         IF ( IX - NL - 1 ) 299 , 295 , 292                             25JL8
  292           I3 = I3 + 1                                             25JL8
```

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  295         I2 = I2 - 1                                               25JL8
              I2 = I2 + 1                                               25JL8
  299         I1 = IX + I2                                              25JL8
              IE = I3                                                   07APO
        DO 300  I = I2 , M                                              25JL8
              RM(I,I1) = SU(I+1)                                        25JL8
              I1 = I1 - 1                                               25JL8
  300   CONTINUE                                                        11JL8
              RO(J) = SU(1)                                             06APO
        DO 400  L = 1 , J1                                              06APO
              TEMP = RM(M,J-L) * RM(M-L,J)                              06APO
        IF((J+M-L).LE.NL)   RM(L,M+J-L) = RM(L,M+J-L) + SL(L) * TEMP    06APO
              LXX = 1                                                   07APO
        IF ( IE.GT.1 )       LXX = IE                                   07APO
        IF ( IE.GT.1 )       IE = IE - 1                                07APO
              LXX = LXX + L                                             07APO
        DO 350  I = LXX, M                                              06APO
              RM(I,J+M-I) = RM(I,J+M-I) + RM(I-L,J+M-I) * TEMP          06APO
  350   CONTINUE                                                        06APO
  400   CONTINUE                                                        11JL8
        IF ( J.GT.M )  RM(M,J) = RM(M,J) + SL(M) * RM(M,J-M) * SL(M)    06AP"
              RM(M,J) = -1.0 / RM(M,J)                                  11JL8
C      COMPUTE PRELIMINARY VALUE FOR W(J)                               25JL8
  750         W(J) = 0.0                                                11JL8
        DO 800  I = 1 , J1                                              11JL8
              W(J) = W(J) + RM(M-I,J) * W(J-I)                          11JL8
  800   CONTINUE                                                        11JL8
        IF ( J.GT.M )  W(J) = W(J) + RO(J-M) * W(J-M)                   07APO
              W(J) = RM(M,J) * ( W(J) - F )                             11JL8
 1000   CONTINUE                                                        11JL8
C***********************************************************************
C                                  CALCULATE RECURSION EQUATION        *
C***********************************************************************
              K = 0                                                     11JL8
        DO 3000  L = 1, NLM1                                            06APO
              J = NL - L                                                06APO
              TEMP = W(J)                                               06APO
              W(J) = 0                                                  C6APO
              K = K + 1                                                 11JL8
        DO 2100  I = 1, M1                                              06APO
              W(J) = W(J) + RM(M-I,J+I) * W(J+I)                        06APO
        IF ( I.EQ.K )      GO TO 2200                                   06APO
 2100   CONTINUE                                                        11JL8
 2200   IF ( J.LE.NLMM )     W(J) = W(J) + RO(J) * W(J+M)               06APO
              W(J) = RM(M,J) * W(J) + TEMP                              06APO
 3000   CONTINUE                                                        11JL8
      RETURN                                                            11JL8
      END                                                               11JL8
C
C       ****************************************************************
C
C       SUBROUTINE         SUBROUTINE         SUBROUTINE         SUBROUTINE
C
C       ****************************************************************
C
      SUBROUTINE FSUB1 ( SU, FF, M, L4 )                                08APO
```

```
COMMENT - SUBROUTINE FSUB1 CALLS FSUB11 FOR FRAME SOLUTION AND FSUB12   15MYO
COMMENT - FOR MEMBER SOLUTIONS                                          15MYO
      DIMENSION  SU(L4)                                                 08APO
      COMMON /BLK5/ NFSUB                                               08APO
           IF  (NFSUB .EQ. 11) CALL FSUB11 (SU, FF, L4, M)              08APO
           IF  (NFSUB .EQ. 12) CALL FSUB12 (SU, FF, L4)                 08APO
      RETURN                                                             8APO
      END                                                                8APO
C
C       ****************************************************************
C
C       SUBROUTINE         SUBROUTINE         SUBROUTINE         SUBROUTINE
C
C       ****************************************************************
C
      SUBROUTINE FSUB12  ( SU, FF, L4 )                                 08APO
COMMENT - SUBROUTINE FSUB12 FURNISHES RIGHT SIDE OF SYMMETRIC STIFFNESS 19MYO
COMMENT - MATRIX SU AND LOAD TERM F TO GRIP2A FOR MEMBER SOLUTION       19MYO
      DIMENSION  SU (L4 )                                               08APO
COMMENT - JJ IS EQUATION NUMBER - SU(1) IS LAST TERM IN BAND ON RIGHT   19MYO
      COMMON /BLOCK7/ F( 42),      AE( 42),     SX( 42),     SY(42),    26JAO
     2    SZ( 42),     QX( 42),     QY( 42),     QZ( 42),     A( 42),   26JAO
     3    B( 42),      A1( 42),     D( 42),      DX( 42),     DY( 42),  26JAO
     4    UZ(42),      U1(42),      V1(42),      W1(42),      U2(42),   13MRO
     5    V2(42),      W2(42),      ERX(42),     ERY(42),     ERZ(42),  13MRO
     6    RX(42),      RY(42),      RZ(42)                              13MRO
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,NQ,H,TH,HSQ,HCU,X2L               26JAO
      COMMON / RI / NL, ML, J1                                          08APO
              JJ = J1                                                   09APO
              JJJ = JJ/2                                                08APO
              JIJ = 2 *JJJ                                              26JAO
           IF (JJ .EQ. JIJ) GO TO 600                                   26JAO
COMMENT - ODD NUMBERED EQUATION FOR LATERAL FORCE EQUILIBRIUM           19MY"
              I = JJ/2 + 1                                              26JAO
              IP1 = I + 1                                               26JAO
COMMENT - SU NOT REQUIRED FOR OFFSPRING                                 19MYO
      IF (ML .EQ. - 1)  GO TO  50                                       26JAO
              SU(1) =      TH*F(IP1)                                    26JAO
              SU(2) = -2.0*F(IP1)                                       26JAO
              SU(3) =      -TH*(F(I) - F(IP1))                          26JAO
              SU(4) = 2.0*(F(I) + F(IP1)) + SY(I)*HCU                   26JAO
   50         FF = QY(I)*HCU                                            26JAO
           GO TO 800                                                    26JAO
  600      CONTINUE                                                     26JAO
COMMENT - EVEN NUMBERED EQUATION FOR MOMENT EQUILIBRIUM                 19MYO
              I = JJ/2                                                  26JAO
              IP1 = I + 1                                               26JAO
COMMENT - SU NOT REQUIRED FOR OFFSPRING                                 19MYO
      IF (ML .EQ. - 1)  GO TO 650                                       26JAO
              SU(1) = 0.0                                               26JAO
              SU(2) = 1.5*F(IP1)*HSQ                                    26JAO
              SU(3) =    - TH*F(IP1)                                    26JAO
              SU(4) = 2.5*(F(I) + F(IP1))*HSQ +SZ(I) *HCU               26JAO
  650         FF =  QZ(I)*HCU                                           26JAO
  800      CONTINUE                                                     26JAO
      RETURN                                                            26JAO
```

```
      END                                                               26JA0
C
C     ******************************************************************
C
C     SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C     ******************************************************************
C
      SUBROUTINE FORMLD ( RM, RO, W, SL, SU, FOMM , L1, L3, L4, L6 )    08APO
COMMENT - SUBROUTINE FORMLD CALCULATES FIXED-END-FORCE MATRIX FOR       24APO
COMMENT - BOTH PRISMATIC UNIFORMLY LOADED MEMBERS AND ALL OTHERS        24APO
      DIMENSION RM(L3,L6), RO(L6), W(L6), SL(L3), SU(L4)                08APO
      DIMENSION  FOMM(6)                                                08APO
      COMMON /BLOCK2/ DXS( 50),   DYS( 50),   ZLS( 50),   DC1S( 50),    26JA0
     2    DC2S( 50),  PRF( 50),   PRAE( 50),  NCDS( 50),  IAXOPS( 50),  26JA0
     3    IOPOP( 50), IPINL( 50), IPINR( 50), NC51( 50),  SMC( 50,13)   20MY0
      COMMON /BLOCK3/ DXL( 50),   DYL( 50),   ZLL( 50),   DC1L( 50),    26JA0
     2    DC2L( 50),  UQX( 50),   UQY( 50),   NCDL( 50),  IAXOPL( 50),  26JA0
     3    NC61( 50)                                                     26JA0
      COMMON /BLOCK5/ XLS( 75),   XRS( 75),   FL( 75),    AEL( 75),     26JA0
     2    SXL( 75),   SYL( 75),   SZL( 75)                              26JA0
      COMMON /BLOCK6/ XLL(150),   XRL(150),   QXL(150),   QYL(150),     26JA0
     2    QZL(150)                                                      26JA0
      COMMON /BLOCK7/ F( 42),     AE( 42),    SX( 42),    SY(42),       26JA0
     2    SZ( 42),    QX( 42),    QY( 42),    QZ( 42),    A( 42),       26JA0
     3    B( 42),     A1( 42),    D( 42),     DX( 42),    DY( 42),      26JA0
     4    DZ(42),     U1(42),     V1(42),     W1(42),     U2(42),       13MR0
     5    V2(42),     W2(42),     ERX(42),    ERY(42),    ERZ(42),      13MR0
     6    RX(42),     RY(42),     RZ(42)                                13MR0
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,          26JA0
     2        ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,           26JA0
     3        IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,            26JA0
     4        M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,            12FE0
     5        NLC,   IP8,   IP9,   IP10                                 13FE0
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,MQ,H,TH,HSQ,HCU,X2L               26JA0
      COMMON /BLK3/  MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNLC             07FE0
      COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6                             26JA0
      COMMON /BLK5/ NFSUB                                               08APO
      COMMON / RI / NL, ML, J1                                          08APO
COMMENT - SET TEMPORARY CONTROL CONSTANTS FOR LOAD TYPE WHICH IS        16MY0
COMMENT - HAVING ITS FIXED-END-FORCE MATRIX FORMED                      16MY0
            IPINLT = IPINL(ISTT)                                        26JA0
            IPINRT = IPINR(ISTT)                                        26JA0
            ZL = ZLS(ISTT)                                              26JA0
            PRFT = PRF(ISTT)                                            26JA0
            PRAET = PRAE(ISTT)                                          26JA0
            NCDST = NCDS(ISTT)                                          26JA0
            NC51T = NC51(ISTT)                                          26JA0
            UQXT = UQX(LTT)                                             26JA0
            UQYT = UQY(LTT)                                             26JA0
            NCDLT = NCDL(LTT)                                           26JA0
            NC61T = NC61(LTT)                                           26JA0
         IF (NCDST .NE. 0 .OR. NCDLT .NE. 0) GO TO 2100                 26JA0
COMMENT - PRISMATIC MEMBER WITH UNIFORM LOADS                           16MY0
COMMENT - COMPUTE CONSTANTS AND AXIAL FIXED-END-FORCES                  16MY0
            ZL2 = ZL*ZL                                                 26JA0
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            FOMM(1) = - 0.5*UQXT*ZL                                     26JA0
            FOMM(4) = FOMM(1)                                           26JA0
         IF (IPINLT .EQ. 0 .AND. IPINRT .EQ. 0) GO TO 1800              26JA0
COMMENT - ZERO FLEXURAL FIXED END FORCES                                16MY0
            FOMM(3) = FOMM(6) = 0.0                                     26FE0
         IF (IPINLT .EQ. 1 .AND. IPINRT .EQ. 1) GO TO 1600              26FE0
         IF (IPINRT .EQ. 1) GO TO 1700                                  26JA0
COMMENT - COMPUTE FLEXURAL FIXED-END-FORCES FOR MEMBER PINNED AT        16MY0
COMMENT - FROM JOINT                                                    16MY0
            FOMM(2) = -0.375*UQYT*ZL                                    26JA0
            FOMM(5) = -0.625*UQYT*ZL                                    26JA0
            FOMM(6) = UQYT*ZL2/8.0                                      26JA0
         GO TO 2000                                                     16MY0
COMMENT - COMPUTE FLEXURAL FIXED-END-FORCES FOR MEMBER PINNED AT        16MY0
COMMENT - BOTH JOINTS                                                   16MY0
 1600       FOMM(2) = -0.5*UQYT*ZL                                      26FE0
            FOMM(5) = FOMM(2)                                           26FE0
         GO TO 2000                                                     16MY0
COMMENT - COMPUTE FLEXURAL FIXED-END-FORCES FOR MEMBER PINNED AT        16MY0
COMMENT - TO JOINT                                                      16MY0
 1700       FOMM(2) = -0.625*UQYT*ZL                                    26JA0
            FOMM(3) = -UQYT*ZL2/8.0                                     26JA0
            FOMM(5) = -0.375*UQYT*ZL                                    26JA0
         GO TO 2000                                                     16MY0
COMMENT - COMPUTE FLEXURAL FIXED-END-FORCES FOR MEMBER WITH RIGID       16MY0
COMMENT - CONNECTIONS AT BOTH JOINTS                                    16MY0
 1800       FOMM(2) = - 0.5*UQYT*ZL                                     26JA0
            FOMM(3) = -UQYT*ZL2/12.0                                    26JA0
            FOMM(5) = FOMM(2)                                           26JA0
            FOMM(6) = - FOMM(3)                                         26JA0
 2000    CONTINUE                                                       26JA0
         GO TO 9900                                                     26JA0
 2100    CONTINUE                                                       26JA0
COMMENT - NONPRISMATIC OR NONUNIFORMLY LOADED MEMBER                    16MY0
         IF (IFORM .EQ. 1) GO TO 2700                                   26JA0
            TH = ZL/M                                                   26JA0
            H = 0.5*TH                                                  26JA0
            HSQ = H*H                                                   26JA0
            HCU = HSQ*H                                                 26JA0
            NL = 2*MP1                                                  26JA0
         IF (NCDST .NE. 0) GO TO 2400                                   26JA0
COMMENT - DISCRETIZE PRISMATIC STIFFNESS DATA                           16MY0
         DO 2300  I = 1,MP2                                             26JA0
            SX(I) = SY(I) = SZ(I) = 0.0                                 26JA0
            AE(I) = PRAET                                               26JA0
 2300       F(I) = PRFT                                                 26JA0
            AE(1) = F(1) = AE(MP2) = F(MP2) = 0.0                       26JA0
         GO TO 2500                                                     26JA0
COMMENT - NONPRISMATIC MEMBER                                           16MY0
COMMENT - SUBROUTINE DISCST DISCRETIZES MEMBER STIFFNESS DATA F, AE,    16MY0
COMMENT - SX, SY, AND SZ                                                16MY0
 2400 CALL       DISCST ( NC51T, NCDST, ZL, L1)                         11FE0
 2500    CONTINUE                                                       26JA0
COMMENT - STORE MEMBER END RESTRAINTS ST1-ST6                           16MY0
            ST1 = SX(1)                                                 26JA0
            ST2 = SY(1)                                                 26JA0
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              ST3 = SZ(1)                                                26JA0
              ST4 = SX(MP1)                                              26JA0
              ST5 = SY(MP1)                                              76JA0
              ST6 = SZ(MP1)                                              26JA0
              ML = 1                                                     26JA0
              MLT = 1                                                    26JA0
COMMENT - SET MEMBER-END-RESTRAINTS EQUAL TO 1.0E+99 FOR FIXED-END-FORCE16MY0
COMMENT - SOLUTION                                                       16MY0
              SX(1) = SX(MP1) = 1.0E99                                   26JA0
              SY(1) = SY(MP1) = 1.0E99                                   26JA0
              SZ(1) = SZ(MP1) = 1.0E99                                   26JA0
COMMENT - ZERO PINNED END ROTATIONAL RESTRAINTS                          16MY0
          IF (IPINLT .EQ. 1) SZ(1) = 0.0                                 26JA0
          IF (IPINRT .EQ. 1) SZ(MP1) = 0.0                               26JA0
 2700     CONTINUE                                                       26JA0
          IF (NCDLT .NE. 0) GO TO 2900                                   26JA0
COMMENT - DISCRETIZE UNIFORM MEMBER LOADS                                16MY0
          DO 2800  I = 2,M                                               26JA0
              QX(I) = UQXT*TH                                            16MY0
              QY(I) = UQYT*TH                                            26JA0
 2800         QZ(I) = 0.0                                                26JA0
              QX(MP2) = QY(MP2) = QZ(MP2) = 0.0                          26JA0
              QX(1) = QX(MP1) = 0.5*UQXT*TH                              26JA0
              QY(1) = QY(MP1) = 0.5*UQYT*TH                              26JA0
              QZ(1) = QZ(MP1) = 0.0                                      26JA0
          GO TO 3000                                                     26JA0
COMMENT - NONUNIFORM LOADS                                               16MY0
COMMENT - SUBROUTINE DISCLD DISCRETIZES GENERAL MEMBER LOADS QX, QY, QZ 16MY0
 2900 CALL       DISCLD ( NC61T, NCDLT, ZL, LI )                         11FE0
 3000     CONTINUE                                                       26JA0
COMMENT - AXIAL SOLUTION FOR MEMBER LOADS                                16MY0
      CALL        AXIAL ( MLT )                                          26JA0
              NFSUB = 12                                                 08AP0
COMMENT - LATERAL SOLUTION FOR MEMBER LOADS                              16MY0
      CALL       GRIP2A ( RM, RO, W, SL, SU, L3, L4, L6, 9   )           15MY0
COMMENT - CALCULATE MEMBER-END-FORCES WHICH ARE EQUAL TO FIXED-END-      16MY0
COMMENT - FORCES                                                         16MY0
      CALL       MEMEND ( W, FOMM, L6 )                                  08AP0
COMMENT - ZERO END-MOMENTS FOR PINNED END MEMBERS                        16MY0
          IF (IPINLT .EQ. 1) FOMM(3) = 0.0                               29JA0
          IF (IPINRT .EQ. 1) FOMM(6) = 0.0                               29JA0
 9900     CONTINUE                                                       26JA0
      RETURN                                                             26JA0
      END                                                                26JA0
C
C         ****************************************************************
C
C         SUBROUTINE            SUBROUTINE            SUBROUTINE         SUBROUTINE
C
C         ****************************************************************
C
      SUBROUTINE DISCLD ( NC61T, NCDLT, ZL, L1 )                         11FE8
COMMENT - SUBROUTINE DISCLD DISCRETIZES GENERAL MEMBER LOADS QX, QY, QZ 22MY0
      COMMON /BLOCK6/ XLL(150),   XRL(150),   QXL(150),   QYL(150),      26JA0
     2    QZL(150)                                                       26JA0
      COMMON /BLOCK7/ F( 42),     AE( 42),    SX( 42),    SY(42),        26JA0
     2    SZ( 42),    QX( 42),    QY( 42),    QZ( 42),    A( 42),        26JA0
     3    B( 42),     A1( 42),    D( 42),     DX( 42),    DY( 42),       26JA0
     4    DZ(42),     U1(42),     V1(42),     W1(42),     U2(42),        13MR0
     5    V2(42),     W2(42),     ERX(42),    ERY(42),    ERZ(42),       13MR0
     6    RX(42),     RY(42),     RZ(42)                                 13MR0
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,           26JA0
     2         ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,           26JA0
     3         IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,            26JA0
     4         M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,            12FE0
     5         NLC,   IP8,   IP9,   IP10                                 13FE0
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,NQ,H,TH,HSQ,HCU,X2L                26JA0
COMMENT - ZERO MEMBER LOAD DATA                                          15MY0
          DO 1020  I = 1,MP2                                             26JA0
 1020         QX(I) = QY(I) = QZ(I) = 0.0                                26JA0
              NC62T = NC61T - 1 + NCDLT                                  26JA0
              II = NC61T - 1                                             26JA0
COMMENT - II GOES FROM NC61T TO NC62T                                    15MY0
 1050         II = II + 1                                                26JA0
COMMENT - READ DATA FROM ONE CARD IMAGE (LOADS AT LEFT OF SECTION)       15MY0
              XL = XLL(II)                                               26JA0
              XR = XRL(II)                                               26JA0
              QXLT = QXL(II)                                             26JA0
              QYLT = QYL(II)                                             26JA0
              QZLT = QZL(II)                                             26JA0
          IF (XR .NE. 0.0) GO TO 1100                                    26JA0
COMMENT - VARIABLE LOADING SECTION READ ONE CARD IMAGE (LOADS AT         15MY0
COMMENT - RIGHT OF SECTION)                                              15MY0
              II = II + 1                                                26JA0
              XR = XRL(II)                                               26JA0
              QXRT = QXL(II)                                             26JA0
              QYRT = QYL(II)                                             26JA0
              QZRT = QZL(II)                                             26JA0
          GO TO 1110                                                     26JA0
 1100         QXRT = QXLT                                                26JA0
              QYRT = QYLT                                                26JA0
              QZRT = QZLT                                                26JA0
 1110     CONTINUE                                                       26JA0
          IF ( XL .NE. XR) GO TO 2100                                    26JA0
COMMENT - CONCENTRATED LOADS CALL CONLD TO DISTRIBUTE CONCENTRATED       15MY0
COMMENT - LOADS TO ADJACENT STATIONS                                     15MY0
      CALL        CONLD ( QXLT, XL, QX, L1 )                             11FE0
      CALL        CONLD ( QYLT, XL, QY, L1 )                             11FE0
      CALL        CONLD ( QZLT, XL, QZ, L1 )                             11FE0
          GO TO 2200                                                     26JA0
 2100     CONTINUE                                                       26JA0
              ZI1 = XL/TH + 2.0                                          26JA0
              I1 = ZI1                                                   26JA0
              X1 = I1*TH - XL - TH                                       26JA0
              ZI2 = XR/TH + 1.0                                          26JA0
              I2 = ZI2                                                   26JA0
              X2 = XR - I2*TH + TH                                       26JA0
              NQ = I2 - I1                                               26JA0
COMMENT - DISTRIBUTION LOADS CALL LINLD TO DISTRIBUTE LOADS STATIONS     15MY0
COMMENT - I1 TO I2                                                       15MY0
          IF (QXLT .EQ. 0.0 .AND. QXRT .EQ. 0.0) GO TO 2150              11MY0
      CALL        LINLD ( QXLT, QXRT, QX, L1 )                           11FE0
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 2150      IF (QYLT .EQ. 0.0 .AND. QYRT .EQ. 0.0) GO TO 2160                11MYO
      CALL       LINLD ( QYLT, QYRT, QY, L1 )                               11FEO
 2160      IF (QZLT .EQ. 0.0 .AND. QZRT .EQ. 0.0) GO TO 2200                11MYO
      CALL       LINLD ( QZLT, QZRT, QZ, L1 )                               11FEO
 2200      CONTINUE                                                         26JAO
 9000      IF (II .LT. NC62T) GO TO 1050                                    26JAO
 9900      CONTINUE                                                         26JAO
      RETURN                                                                26JAO
      END                                                                   26JAO
C
C          ****************************************************************
C
C          SUBROUTINE           SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C          ****************************************************************
C
      SUBROUTINE MEMEND ( W, FMM, L6 )                                      08APO
COMMENT - SUBROUTINE MEMEND CALCULATES FORCES ON END OF MEMBER USING        15MYO
COMMENT - DISPLACEMENTS FOUND FROM MEMBER SOLUTION                          15MYO
      DIMENSION FMM(6), W(L6)                                               08APO
      COMMON /BLOCK7/ F( 42),    AE( 42),    SX( 42),    SY(42),            26JAO
     2    SZ( 42),    QX( 42),    QY( 42),    QZ( 42),    A( 42),           26JAO
     3    B( 42),     A1( 42),    D( 42),     DX( 42),    DY( 42),          26JAO
     4    DZ(42),     U1(42),     V1(42),     W1(42),     U2(42),           13MRO
     5    V2(42),     W2(42),     ERX(42),    ERY(42),    ERZ(42),          13MRO
     6    RX(42),     RY(42),     RZ(42)                                    13MRO
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,              26JAO
     2        ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,               26JAO
     3        IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,                26JAO
     4        M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,                12FEO
     5        NLC,   IP8,   IP9,   IP10                                     13FEO
      COMMON /BLK2/ XL,XR,X1,X2,I1,I2,HQ,H,TH,HSQ,HCU,X2L                   26JAO
      COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6                                 26JAO
COMMENT - COMPUTE AXIAL END FORCES                                          15MYO
              DDX = DX(2) - DX(1)                                           26JAO
              FMM (1) = -AE(2)*DDX/TH + ST1*DX(1) - QX(1)                   26JAO
              DDX = DX(MP1) - DX(M)                                         26JAO
              FMM (4) = AE(MP1)*DDX/TH + ST4*DX(MP1) - QX(MP1)              26JAO
COMMENT - CONVERT DISPLACEMENTS FROM GRIP2B (W) TO LATERAL AND              15MYO
COMMENT - ROTATIONAL DISPLACEMENTS DY AND DZ                                15MYO
              DY(1) = W(1)                                                  26JAO
              DZ(1) = W(2)                                                  26JAO
              DY(2) = W(3)                                                  26JAO
              DZ(2) = W(4)                                                  26JAO
              DY(M) = W(2*M - 1)                                            26JAO
              DZ(M) = W(2*M)                                                26JAO
              DY(MP1) = W(2*M + 1)                                          26JAO
              DZ(MP1) = W(2*M + 2)                                          26JAO
COMMENT - COMPUTE CURVATURES                                                15MYO
              TAU1 =  (DY(2) - DY(1))/H - (1.5*DZ(1) + 0.5*DZ(2))           26JAO
              TAU2 = -(DY(2) - DY(1))/H + (0.5*DZ(1) + 1.5*DZ(2))           26JAO
COMMENT - COMPUTE LATERAL AND ROTATIONAL END FORCES                         15MYO
              FMM (2) = F(2)*(TAU2 - TAU1)/HSQ + ST2*DY(1) - QY(1)          26JAO
              FMM (3) = F(2)*( -1.5*TAU1 + 0.5*TAU2)/H + ST3*DZ(1) -        26JAO
     2                  QZ(1)                                               26JAO
              TAU1 =  (DY(MP1) - DY(M))/H - (1.5*DZ(M) + 0.5*DZ(MP1))       26JAO
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              TAU2 = -(DY(MP1) - DY(M))/H + (0.5*DZ(M) + 1.5*DZ(MP1))       26JAO
              FMM (5) = F(MP1)*(TAU1 - TAU2)/HSQ + ST5*DY(MP1) -            26JAO
     2                  QY(MP1)                                             26JAO
              FMM (6) = F(MP1)*( - 0.5*TAU1 + 1.5*TAU2)/H  +                26JAO
     2                  ST6*DZ(MP1) - QZ(MP1)                               26JAO
      RETURN                                                                26JAO
      END                                                                   26JAO
C
C          ****************************************************************
C
C          SUBROUTINE           SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C          ****************************************************************
C
      SUBROUTINE FSUB11 ( SU4, FF, L4, IHB )                                25JLO
COMMENT - SUBROUTINE FSUB11 FURNISHES RIGHT SIDE OF SYMMETRIC STIFFNESS 21MYO
COMMENT - MATRIX SU AND LOAD TERM F TO GRIP2A FOR FRAME SOLUTION            21MYO
COMMENT - SU IS ONE ROW OF STIFFNESS MATRIX AND F IS CORRESPONDING LOAD 21MYO
COMMENT - FSUB11 FORMS SSL (3 ROWS OF SU) AND FSS (3 LOADS) EVERY THIRD 21MYO
COMMENT - CALL FROM GRIP2A AND FURNISHES SU AND F FOR EACH CALL             21MYO
      DIMENSION SU4(L4)                                                     21MYO
      DIMENSION SMM(3,3),SMS(3,3),DC(3,3),DCT(3,3),T33(3,3),                21MYO
     2 FMM(3),FSS(3),FMS(3)                                                 21MYO
      COMMON /BLOCK1/ X( 75),    Y( 75),     QXX( 75),   QYY( 75),          13FEO
     2    QZZ( 75),   SXX( 75),   SYY( 75),   SZZ( 75),   DXX( 75),         13FEO
     3    DYY( 75),   DZZ( 75),   RXX( 75),   RYY( 75),   RZZ( 75),         13FEO
     4    ERXX( 75),  ERYY( 75),  ERZZ( 75)                                 13FEO
      COMMON /BLOCK2/ DXS( 50),   DYS( 50),   ZLS( 50),   DC1S( 50),        26JAO
     2    DC2S( 50),  PRF( 50),   PRAE( 50),  NCDS( 50),  IAXOPS( 50),      26JAO
     3    IOPOP( 50), IPINL( 50), IPINR( 50), NC51( 50),  SMC( 50,13)       20MYO
      COMMON /BLOCK3/ DXL( 50),   DYL( 50),   ZLL( 50),   DC1L( 50),        26JAO
     2    DC2L( 50),  UQX( 50),   UQY( 50),   NCDL( 50),  IAXOPL( 50),      26JAO
     3    NC61( 50)                                                         26JAO
      COMMON /BLOCK4/ JT1(150),   JT2(150),   IST(150),   LT(150),          26JAO
     2    FOMM(150,6)                                                       26JAO
      COMMON / BLOC10 / SSL (3,30)                                          08APO
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,              26JAO
     2        ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,               26JAO
     3        IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,                26JAO
     4        M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,                12FEO
     5        NLC,   IP8,   IP9,   IP10                                     13FEO
      COMMON / R1 / NL, ML, J1                                              08APO
              NL4 = NL                                                      08APO
              ML4 = ML                                                      08APO
              J14 = J1                                                      08APO
         IF (J14 .NE. 1 )  GO TO 1300                                       26JAO
COMMENT - SET CONSTANTS ON FIRST CALL FROM GRIP2A                           21MYO
              IHBP1 = IHB + 1                                               26JAO
              IHB1 = IHB - 1                                                26JAO
              SMM(1,2) = SMM(1,3) = SMM(2,1) = SMM(3,1) = 0.0               20MYO
              DC(1,3)  = DC(2,3)  = DC(3,1)  = DC(3,2)  = 0.0               26JAO
              DCT(1,3) = DCT(2,3) = DCT(3,1) = DCT(3,2) = 0.0               26JAO
              DC(3,3)  = DCT(3,3) = 1.0                                     26JAO
COMMENT - COMPUTE JOINT NUMBER FOR WHICH EQUATIONS ARE BEING FORMED         21MYO
 1300         JTN = (J14 - 1)/3 + 1                                         26JAO
COMMENT - SKIP FOR EVERY SECOND AND THIRD EQUATION (CALL FROM GRIP2A)       21MYO
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          IF (J14 .NE. 3*JTN - 2)  GO TO 4000                          26JA0
COMMENT - ZERO SSL AND FSS                                             21MY0
          DO 1400 I = 1, 3                                             26JA0
          DO 1400 J = 1,IMBP1                                          26JA0
 1400          SSL(I,J) = 0.0                                          26JA0
               FSS(1) = FSS(2) = FSS(3) = 0.0                          31JA0
COMMENT - DO FOR EACH MEMBER - ADD ITS STIFFNESS MATRIX AND LOAD MATRIX 21MY0
COMMENT - INTO STRUCTURE STIFFNESS MATRIX SSL AND LOAD MATRIX FSS      21MY0
          DO 3500  I = 1,NM                                            26JA0
          IF ( JT1(I) .NE. JTN .AND. JT2(I) .NE. JTN ) GO TO 3500      26JA0
               ISTT = IST(I)                                           26JA0
COMMENT - SKIP FOR NULL MEMBER                                         21MY0
          IF ( ISTT .EQ. 0 ) GO TO 3500                                29JA0
COMMENT - FORM TRANSFORMATION MATRIX AND ITS TRANSPOSE                 21MY0
               DC(1,1) = DC1S(ISTT)                                    26JA0
               DC(1,2) = DC2S(ISTT)                                    26JA0
               DC(2,1) = - DC(1,2)                                     26JA0
               DC(2,2) = DC(1,1)                                       26JA0
               DCT(1,1) = DC(1,1)                                      26JA0
               DCT(1,2) = DC(2,1)                                      26JA0
               DCT(2,1) = DC(1,2)                                      26JA0
               DCT(2,2) = DC(2,2)                                      26JA0
          IF ( JT2(I) .EQ. JTN) GO TO 2300                             26JA0
COMMENT - SKIP FOR OFFSPRING                                           21MY0
          IF ( ML4 .EQ. -1 ) GO TO 2250                                05MR0
COMMENT - FORM SMM FOR MEMBER WITH FROM JOINT AT JOINT JTN             21MY0
               SMM(1,1) =  SMC(ISTT,1)                                 20MY0
               SMM(2,2) =  SMC(ISTT,3)                                 20MY0
               SMM(2,3) =  SMC(ISTT,4)                                 20MY0
               SMM(3,2) =  SMC(ISTT,4)                                 20MY0
               SMM(3,3) =  SMC(ISTT,7)                                 20MY0
COMMENT - FORM FMM FOR MEMBER WITH FROM JOINT AT JOINT JTN             21MY0
 2250          FMM(1) =  FOMM(I,1)                                     20MY0
               FMM(2) =  FOMM(I,2)                                     20MY0
               FMM(3) =  FOMM(I,3)                                     20MY0
          GO TO 2500                                                   26JA0
 2300     CONTINUE                                                     27JA0
COMMENT - SKIP FOR OFFSPRING                                           21MY0
          IF ( ML4 .EQ. -1 ) GO TO 2350                                05MR0
COMMENT - FORM SMM FOR MEMBER WITH  TO  JOINT AT JOINT JTN             21MY0
               SMM(1,1) = SMC(ISTT,10)                                 20MY0
               SMM(2,2) = SMC(ISTT,11)                                 20MY0
               SMM(2,3) = SMC(ISTT,12)                                 20MY0
               SMM(3,2) = SMC(ISTT,12)                                 20MY0
               SMM(3,3) = SMC(ISTT,13)                                 20MY0
COMMENT - FORM FMM FOR MEMBER WITH  TO  JOINT AT JOINT JTN             21MY0
 2350          FMM(1) =  FOMM(I,4)                                     21MY0
               FMM(2) =  FOMM(I,5)                                     21MY0
               FMM(3) =  FOMM(I,6)                                     21MY0
 2500     CONTINUE                                                     26JA0
          IF ( ML4 .EQ. -1 ) GO TO 2550                                05MR0
COMMENT - TRANSFORM SMM AND FMM TO STRUCTURE COORDINATES SMS AND FMS   21MY0
      CALL MATM33 ( DCT, SMM, T33)                                     20MY0
      CALL MATM33 ( T33, DC,  SMS)                                     20MY0
 2550 CALL MATM31 ( DCT, FMM, FMS)                                     20MY0
COMMENT - ADD (SUBTRACT) IN FMS TO STRUCTURE LOAD MATRIX FSS           21MY0
               FSS(1) = FSS(1) - FMS(1)                                20MY0
               FSS(2) = FSS(2) - FMS(2)                                20MY0
               FSS(3) = FSS(3) - FMS(3)                                20MY0
COMMENT - SKIP FOR OFFSPRING                                           21MY0
          IF ( ML4 .EQ. -1 ) GO TO 3500                                05MR0
COMMENT - ADD IN SMS TO DIAGONAL SUBMATRIX OF SSL - SYMMETRICAL TERMS  21MY0
               SSL(1,1) = SSL(1,1)  +  SMS(1,1)                        20MY0
               SSL(1,2) = SSL(1,2)  +  SMS(1,2)                        20MY0
               SSL(1,3) = SSL(1,3)  +  SMS(1,3)                        20MY0
               SSL(2,2) = SSL(2,2)  +  SMS(2,2)                        20MY0
               SSL(2,3) = SSL(2,3)  +  SMS(2,3)                        20MY0
               SSL(3,3) = SSL(3,3)  +  SMS(3,3)                        20MY0
COMMENT - SKIP FOR SMM WHICH ARE TO LEFT OF DIAGONAL                   21MY0
          IF (JTN .GE. JT1(I) .AND. JTN .GE. JT2(I)) GO TO 3500        01FE0
          IF (JT2(I) .EQ. JTN) GO TO 2700                              26JA0
COMMENT - FORM SMM FOR MEMBER WITH FROM JOINT AT JOINT JTN             21MY0
               SMM(1,1) = SMC(ISTT, 2)                                 20MY0
               SMM(2,2) = SMC(ISTT, 5)                                 20MY0
               SMM(2,3) = SMC(ISTT,6)                                  20MY0
               SMM(3,2) = SMC(ISTT,8)                                  20MY0
               SMM(3,3) = SMC(ISTT,9)                                  20MY0
               GO TO 3000                                              26JA0
COMMENT - FORM SMM FOR MEMBER WITH  TO  JOINT AT JOINT JTN             21MY0
 2700          SMM(1,1) = SMC(ISTT,2)                                  20MY0
               SMM(2,2) = SMC(ISTT,5)                                  20MY0
               SMM(2,3) = SMC(ISTT,8)                                  20MY0
               SMM(3,2) = SMC(ISTT,6)                                  20MY0
               SMM(3,3) = SMC(ISTT,9)                                  20MY0
 3000     CONTINUE                                                     26JA0
COMMENT - TRANSFORM SMM TO STRUCTURE COORDINATES SMS                   21MY0
      CALL        MATM33 ( DCT, SMM, T33 )                             20MY0
      CALL        MATM33 ( T33, DC, SMS )                              20MY0
COMMENT - PLACE SMS IN SSL                                             21MY0
               J21 = IABS (JT2(I) - JT1(I))                            29JA0
               ISTP = 3*J21 + 1                                        26JA0
               SSL(1,ISTP)        =  SMS(1,1)                          20MY0
               SSL(1,ISTP + 1)    =  SMS(1,2)                          20MY0
               SSL(1,ISTP + 2)    =  SMS(1,3)                          20MY0
               SSL(2,ISTP)        =  SMS(2,1)                          20MY0
               SSL(2,ISTP + 1)    =  SMS(2,2)                          20MY0
               SSL(2,ISTP + 2)    =  SMS(2,3)                          20MY0
               SSL(3,ISTP)        =  SMS(3,1)                          20MY0
               SSL(3,ISTP + 1)    =  SMS(3,2)                          20MY0
               SSL(3,ISTP + 2)    =  SMS(3,3)                          20MY0
 3500     CONTINUE                                                     26JA0
COMMENT - ADD IN JOINT LOADS                                           21MY0
               FSS(1) = FSS(1) + QXX(JTN)                              27JA0
               FSS(2) = FSS(2) + QYY(JTN)                              27JA0
               FSS(3) = FSS(3) + QZZ(JTN)                              27JA0
COMMENT - SKIP FOR OFFSPRING                                           21MY0
          IF ( ML4 .EQ. -1 ) GO TO 4000                                05MR0
COMMENT - ADD IN JOINT RESTRAINTS                                      21MY0
               SSL(1,1) = SSL(1,1) + SXX(JTN)                          27JA0
               SSL(2,2) = SSL(2,2) + SYY(JTN)                          27JA0
               SSL(3,3) = SSL(3,3) + SZZ(JTN)                          27JA0
COMMENT - SHIFT SSL TO FACILITATE OBTAINING SU FROM 2ND AND 3RD ROW    21MY0
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COMMENT - OF SSL                                                     21MYO
          DO 3600  I = 1,IHB                                         27JAO
 3600         SSL(2,I) = SSL(2, I + 1)                               27JAO
          DO 3700  I = 1,IHB1                                        27JAO
 3700         SSL(3,I) = SSL(3,I + 2)                                27JAO
              SSL(2,IHBP1) = SSL(3,IHBP1) = SSL(3,IHB) = 0.0         28JAO
 4000     CONTINUE                                                   26JAO
              N123 =  J14 - 3*JTN = 3                                05MRO
          IF ( ML4 .EQ. -1 ) GO TO 4400                              05MRO
COMMENT - SKIP FOR OFFSPRING                                         21MYO
              IB = IHBP1                                             01JLO
COMMENT - FORM SU FROM ROW(N123) OF SSL                              21MYO
          DO 4300  I = 1,IHBP1                                       27JAO
              SU4(I) = SSL(N123,IB)                                  01JEO
 4300         IB = IB - 1                                            01JLO
 4400         FF = FSS(N123)                                         27JAO
COMMENT - SKIP FOR ALL BUT OFFSPRING                                 21MYO
          IF (ML4 .GT. -1 ) GO TO 4450                               05MRO
COMMENT - CHECK FOR UNDEFINED DISPLACEMENT IN PARENT OF THIS OFFSPRING 21MYO
          IF ( N123 .EQ. 1 .AND. DXX(JTN) .EQ. 1.0E99 ) GO TO 4480   08APO
          IF ( N123 .EQ. 2 .AND. DYY(JTN) .EQ. 1.0E99 ) GO TO 4480   08APO
          IF ( N123 .EQ. 3 .AND. DZZ(JTN) .EQ. 1.0E99 ) GO TO 4480   08APO
          GO TO 4500                                                 05MRO
 4450         K = IHBP1                                              05MRO
          IF (SU4(K) .NE. 0.0) GO TO 4500                            05MRO
COMMENT - ZERO ON DIAGONAL OF MATRIX - DISPLACEMENT UNDEFINED - SET  21MYO
COMMENT - DISPLACEMENT EQUAL TO 1.0E-99                              21MYO
              SU4(K)  = 1.0                                          05MRO
 4480         FF = 1.0E99                                            05MRO
 4500     CONTINUE                                                   05MRO
      RETURN                                                         26JAO
      END                                                            26JAO
C
C         ****************************************************************
C
C         SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C         ****************************************************************
C
      SUBROUTINE MATM33 ( AM, BM, CM )                               26JAO
COMMENT - THIS SUBROUTINE MULTIPLIES A 3X3 MATRIX ,AM, TIMES A       26JAO
COMMENT - 3X3 MATRIX ,BM, TO PRODUCE A 3X3 MATRIX ,CM                26JAO
      DIMENSION AM(3,3),BM(3,3),CM(3,3)                              26JAO
          DO 25  I = 1,3                                             26JAO
          DO 25  J = 1,3                                             26JAO
              CM(I,J) = 0.0                                          26JAO
          DO 25  K = 1,3                                             26JAO
              CM(I,J) = AM(I,K)*BM(K,J) + CM(I,J)                    26JAO
   25     CONTINUE                                                   26JAO
      RETURN                                                         26JAO
      END                                                            26JAO
C
C         ****************************************************************
C
C         SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
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C         ****************************************************************
C
      SUBROUTINE MATM31 ( AM, BV, CV )                               26JAO
COMMENT - THIS SUBROUTINE MULTIPLIES A 3X3 MATRIX ,AM, TIMES A       26JAO
COMMENT - 3X1 MATRIX ,BV TO PRODUCE A 3X1 MATRIX ,CV                 26JAO
      DIMENSION AM(3,3),BV(3),CV(3)                                  26JEO
          DO 25  I = 1,3                                             26JAO
              CV(I) = 0.0                                            26JAO
          DO 25  K = 1,3                                             26JAO
              CV(I) = AM(I,K)*BV(K) + CV(I)                          01JLO
   25     CONTINUE                                                   26JAO
      RETURN                                                         26JAO
      END                                                            26JAO
C
C         ****************************************************************
C
C         SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C         ****************************************************************
C
      SUBROUTINE SUM1                                                12FEO
COMMENT - SUBROUTINE SUM1      DOES SUPERPOSITION SOLUTION FOR FRAME 24APO
COMMENT - JOINT DISPLACEMENTS AND REACTIONS FOR FAMILY PROBLEMS      24APO
      COMMON /BLOCK1/ X( 75),     Y( 75),     DXX( 75),   DYY( 75),  13FEO
     2    DZZ( 75),   SXX( 75),   SYY( 75),   SZZ( 75),   OXX( 75),  13FEO
     3    DYY( 75),   OZZ( 75),   RXX( 75),   RYY( 75),   RZZ( 75),  13FEO
     4    ERXX( 75),  ERYY( 75),  ERZZ( 75)                          13FEO
      COMMON /BLOCK4/ JT1(150),   JT2(150),   IST(150),   LT(150),   26JAO
     2    FOMM(150,6)                                                26JAO
      COMMON /BLOCK8/ MP(21,2),   ZM(21)                             09JEO
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,       12FEO
     2        ITYPE, NCD2, NCD3, NCD4, NCD5, NCD6, NCD7,             12FEO
     3        IABAN, IFORM, NM,   NJT,  NST,  NLT,  TOL,             12FEO
     4        M,     MP1,   MP2,  ISTT, LTT,  ITYPEL,IDJ,            12FEO
     5        NLC,   IP8,   IP9,  IP10                               13FEO
      REWIND 1                                                       16JFO
COMMENT - ZERO JOINT DISPLACEMENTS,REACTIONS,AND LOADS               20MYO
          DO 1100  I = 1, NJT                                        12FEO
              DXX(I) = DYY(I) = DZZ(I) = 0.0                         12FEO
              RXX(I) = RYY(I) = RZZ(I) = 0.0                         12FEO
 1100         OXX(I) = OYY(I) = OZZ(I) = 0.0                         12FEO
COMMENT - DO FOR EACH PROBLEM RESULTS ARE STORED FOR                 20MYO
          DO 2400  J = 1, NLC                                        17FEO
COMMENT - ERXX,ERYY,ERZZ,AND FOMM ARE NOT NEEDED FOR TYPE 4 PROBLEM AND 20MYO
COMMENT - ARE USED AS DUMMIES TO READ IN VALUES OF DISPLACEMENTS,    20MYO
COMMENT - REACTIONS AND LOADS FROM TAPE                              20MYO
      READ  (1)  ( ERXX(I), ERYY(I), ERZZ(I), FOMM(I,1), FOMM(I,2),  16JEO
     2    FOMM(I,3), FOMM(I,4), FOMM(I,5), FOMM(I,6) , I = 1,NJT )   19FEO
COMMENT - SKIP FOR ZERO MULTIPLIER                                   20MYO
          IF ( ZM(J) .EQ. 0.0) GO TO 2400                            12FFO
COMMENT - MULTIPLY AND SUM                                           20MYO
          DO 2100  I = 1, NJT                                        13FEO
              DXX(I) = DXX(I) + ZM(J)*ERXX(I)                        13FEO
              DYY(I) = DYY(I) + ZM(J)*ERYY(I)                        13FEO
              DZZ(I) = DZZ(I) + ZM(J)*ERZZ(I)                        13FEO
              RXX(I) = RXX(I) + ZM(J)*FOMM(I,1)                      12FEO
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                RYY(I) = RYY(I) + ZM(J)*FOMM(T,2)                  12FEO
                RZZ(I) = RZZ(I) + ZM(J)*FOMM(I,3)                  12FEO
                QXX(I) = QXX(I) + ZM(J)*FOMM(T,4)                  12FEO
                QYY(I) = QYY(I) + ZM(J)*FOMM(T,5)                  12FEO
                QZZ(I) = QZZ(I) + ZM(J)*FOMM(I,6)                  12FEO
 2100     CONTINUE                                                 12FEO
 2400     CONTINUE                                                 12FEO
      RETURN                                                       12FEO
      END                                                          12FEO
C
C         ****************************************************************
C
C         SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C         ****************************************************************
C
      SUBROUTINE MEMRES ( DM, JJ, KK, RM, RO, W, SL, SU, NPROB, ANZ, L1,08APO
     2    L3, L4, L6, L7 )                                         08APO
COMMENT - SUBROUTINE MEMRES COMPUTES MEMBER RESULTS FOR ALL MEMBERS      24APO
COMMENT - IN FRAME, SUBTRACTS APPROPRTATE MEMBER END FORCES TO COMPLETE 24APO
COMMENT - CALCULATION OF JOINT EQUIL1B ERRORS  AND PRINTS OUT MEMBER    24APO
COMMENT - RESULTS                                                  24APO
      DIMENSION RM(L3,L6), RO(L6), W(L6), SL(L3), SU(L4)           08APO
      DIMENSION  DC(3,3), DMM(3), DMS(3), DM(L7,6)                 08APO
      DIMENSION F1M(3), F2M(3)                                     21MRO
      DIMENSION ANZ(18), NPROB(2)                                  11JEO
      COMMON /BLOCK1/ X( 75),     Y( 75),     QXX( 75),   QYY( 75),   13FEO
     2    UZZ( 75),   SXX( 75),   SYY( 75),   SZZ( 75),   DXX( 75),   13FEO
     3    DYY( 75),   DZZ( 75),   RXX( 75),   RYY( 75),   RZZ( 75),   13FEO
     4    ERXX( 75),  ERYY( 75),  ERZZ( 75)                          13FEO
      COMMON /BLOCK2/ DXS( 50),   DYS( 50),   ZLS( 50),   DC1S( 50),  26JAO
     2    DC2S( 50),  PRF( 50),   PRAE( 50),  NCDS( 50),  I6XOPS( 50), 26JAO
     3    IOPOP( 50), IPINL( 50), IPINR( 50), NC51( 50),  SMC( 50,13) 20MYO
      COMMON /BLOCK3/ DXL( 50),   DYL( 50),   ZLL( 50),   DC1L( 50),  26JAO
     2    DC2L( 50),  UOX( 50),   UOY( 50),   NCDL( 50),  IAXOPL( 50), 26JAO
     3    NC61( 50)                                                26JAO
      COMMON /BLOCK4/ JT1(150),   JT2(150),   IST(150),   LT(150),    26JAO
     2    FOMM(150,6)                                              26JAO
      COMMON /BLOCK5/ XLS( 75),   XRS( 75),   FL( 75),    AEL( 75),   26JAO
     2    SXL( 75),   SYL( 75),   SZL( 75)                         26JAO
      COMMON /BLOCK6/ XLL(150),   XRL(150),   QXL(150),   QYL(150),   26JAO
     2    QZL(150)                                                 26JAO
      COMMON /BLOCK7/ F( 42),     AE( 42),    SX( 42),    SY(42),     13MRO
     2    SZ( 42),    QX( 42),    QY( 42),    QZ( 42),    A( 42),     13MRO
     3    B( 42),     A1( 42),    D( 42),     DX( 42),    DY( 42),    13MRO
     4    DZ(42),     U1(42),     V1(42),     W1(42),     U2(42),     13MRO
     5    V2(42),     W2(42),     ERX(42),    ERY(42),    ERZ(42),    13MRO
     6    RX(42),     RY(42),     RZ(42)                           13MRO
      COMMON /BLOCK9/ T(21),      V(21),      BM(21),     DXT(21),    16MRO
     2    DYT(21),    DZT(21)                                      16MRO
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,     13MRO
     2          ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,    13MRO
     3          IABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,     13MRO
     4          M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IOJ,     13MRO
     5          NLC,   IP8,   IP9,   IP10                          13MRO
      COMMON /BLK2/ XL,XR,X1,X2,T1,T2,HO,H,TH,HSQ,HCU,X2L          13MRO
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      COMMON /BLK3/  MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNLC        13MRO
      COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6                        13MRO
      COMMON /BLK5/ NFSUB                                          08APO
      COMMON / RI / NL, ML, J1                                     08APO
            MP22 = MP2/2                                           16MPO
            MP221 = MP22 - 1                                       20MRO
            MM1 = M - 1                                            17MRO
         IF (JJ .GT. NM) GO TO 5100                                16MRO
            ISTT = IST(JJ)                                         16MRO
            LTT = LT(JJ)                                           16MRO
         IF ( ISTT .EQ. 0 ) GO TO 5100                             13MRO
         IF (JJ .EQ. 1)  GO TO 1300                                16MRO
         IF (ISTT .NE. IST(JJ - 1) ) GO TO 1300                    16MRO
COMMENT - SKIP FOR MEMBER WHICH HAS SAME STIFFNESS TYPE AS LAST MEMBER  16MYO
            NL = -1                                                17MRO
            NLT = -1                                               17MRO
         GO TO 2700                                                17MRO
 1300    CONTINUE                                                  13MRO
COMMENT - SET TEMPORARY CONTROL CONSTANTS                          16MYO
            IPINLT = IPINL(ISTT)                                   13MRO
            IPINRT = IPINR(ISTT)                                   13MRO
            ZL = ZLS(ISTT)                                         13MRO
            PRFT = PRF(ISTT)                                       13MRO
            PRAET = PRAE(ISTT)                                     13MRO
            NCDST = NCDS(ISTT)                                     13MRO
            NC51T = NC51(ISTT)                                     13MRO
            TH = ZL/M                                              13MRO
            H = 0.5*TH                                             13MRO
            HSQ = H*H                                              13MRO
            HCU = HSQ*H                                            13MRO
            NL = 2*MP1                                             13MRO
         IF (NCDST .NE. 0) GO TO 2400                              13MRO
COMMENT - PRISMATIC MEMBER DISCRETIZE MEMBER STIFFNESS DATA        16MYO
         DO 2300  I = 1,MP2                                        13MRO
            SX(I) = SY(I) = SZ(I) = 0.0                            13MRO
            AE(I) = PRAET                                          13MRO
 2300       F(I) = PRFT                                            13MRO
            AE(1) = F(1) = AE(MP2) = F(MP2) = 0.0                  13MRO
         GO TO 2500                                                13MRO
COMMENT - NONPRISMATIC MEMBER DISCRETIZE MEMBER STIFFNESS DATA     16MYO
 2400 CALL      DISCST ( NC51T, NCDST, ZL , L1 )                   13MRO
 2500    CONTINUE                                                  13MRO
COMMENT - STORE MEMBER-END-RESTRAINTS ST1 - ST6                    16MYO
            ST1 = SX(1)                                            13MRO
            ST2 = SY(1)                                            13MRO
            ST3 = SZ(1)                                            13MRO
            ST4 = SX(MP1)                                          13MRO
            ST5 = SY(MP1)                                          13MRO
            ST6 = SZ(MP1)                                          13MRO
            NL = 1                                                 13MRD
            NLT = 1                                                13MRO
COMMENT - SET MEMBER-END-RESTRAINTS EQUAL TO 1.0E+99 FOR FINAL MEMBER  16MYO
COMMENT - SOLUTION                                                 16MYD
            SX(1) = SX(MP1) = 1.0E99                               13MRO
            SY(1) = SY(MP1) = 1.0E99                               13MRO
            SZ(1) = SZ(MP1) = 1.0E99                               13MRO
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COMMENT - ZERO PINNED END ROTATIONAL RESTRAINTS                             16MY0
          IF (IPINLT .EQ. 1) SZ(1) = 0.0                                    13MR0
          IF (IPINRT .EQ. 1) SZ(MP1) = 0.0                                  13MR0
COMMENT - SET UP MEMBERS TRANSFORMATION MATRIX DC                           16MY0
                DC(1,3) = DC(2,3) = DC(3,1) = DC(3,2) = 0.0                 13MR0
                DC(3,3) = 1.0                                               13MR0
                DC(1,1) = DC1S(ISTT)                                        13MR0
                DC(1,2) = DC2S(ISTT)                                        13MR0
                DC(2,1) = -DC(1,2)                                          13MR0
                DC(2,2) = DC(1,1)                                           13MR0
 2700     CONTINUE                                                          13MR0
          IF (LTT .NE. 0 ) GO TO 2750                                       13MR0
COMMENT - ZERO MEMBER LOADS FOR LOAD TYPE ZERO                              16MY0
          DO 2720  I = 1,MP2                                                17MR0
 2720           QX(I) = QY(I) = QZ(I) = 0.0                                 13MR0
          GO TO 3000                                                        13MR0
COMMENT - SET CONTROL CONSTANTS                                             16MY0
 2750           UQXT = UQX(LTT)                                             13MR0
                UQYT = UQY(LTT)                                             13MR0
                NCDLT = NCDL(LTT)                                           13MR0
                NC61T = NC61(LTT)                                           13MR0
          IF (NCDLT .NE. 0) GO TO 2900                                      13MR0
COMMENT - UNIFORMLY LOADED MEMBER DISCRETIZE MEMBER LOADS                   16MY0
          DO 2800  I = 2,M                                                  13MR0
                QX(I) = UQXT*TH                                             13MR0
                QY(I) = UQYT*TH                                             13MR0
 2800           QZ(I) = 0.0                                                 13MR0
                QX(MP2) = QY(MP2) = QZ(MP2) = 0.0                           13MR0
                QX(1) = QX(MP1) = 0.5*UQXT*TH                               13MR0
                QY(1) = QY(MP1) = 0.5*UQYT*TH                               13MR0
                QZ(1) = QZ(MP1) = 0.0                                       13MR0
          GO TO 3000                                                        13MR0
COMMENT - DISCRETIZE GENERAL MEMBER LOADS                                   16MY0
 2900 CALL        DISCLD ( NC61T, NCDLT, ZL , L1 )                          13MR0
 3000     CONTINUE                                                          13MR0
COMMENT - STORE MEMBER-END-LOADS QT1 -QT6                                   16MY0
                QT1 = QX(1)                                                 13MR0
                QT2 = QY(1)                                                 13MR0
                QT3 = QZ(1)                                                 13MR0
                QT4 = QX(MP1)                                               13MR0
                QT5 = QY(MP1)                                               13MR0
                QT6 = QZ(MP1)                                               13MR0
                J1I = JT1(JJ)                                               08AP0
COMMENT - SET MEMBER-END-DISPLACEMENTS IN STRUCTURE COORDINATES DMS         16MY0
COMMENT - EQUAL TO STRUCTURE JOINT DISPLACEMENTS AT FROM JOINT              16MY0
                DMS(1) = DXX(J1I)                                           08AP0
                DMS(2) = DYY(J1I)                                           08AP0
                DMS(3) = DZZ(J1I)                                           08AP0
COMMENT - TRANSFORM DMS TO DMM AT FROM JOINT                                16MY0
      CALL        MATM31 (DC,DMS,DMM)                                       13MR0
COMMENT - SET MEMBER END-LOADS TO 1.0E+99 TIMES DMM AT FROM JOINT           16MY0
                QX(1) = DMM(1)*1.0E99                                       13MR0
                QY(1) = DMM(2)*1.0E99                                       13MR0
          IF (IPINLT .EQ. 1) GO TO 3120                                     16MR0
                QZ(1) = DMM(3)*1.0E99                                       13MR0
          GO TO 3150                                                        16MR0
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 3120           QZ(1) = 0.0                                                 16MR0
 3150     CONTINUE                                                          16MR0
COMMENT - REPEAT ABOVE FOR TO JOINT                                         16MY0
                J2I = JT2(JJ)                                               08AP0
                DMS(1) = DXX(J2I)                                           08AP0
                DMS(2) = DYY(J2I)                                           08AP0
                DMS(3) = DZZ(J2I)                                           08AP0
      CALL        MATM31 (DC,DMS,DMM)                                       13MR0
                QX(MP1) = DMM(1)*1.0E99                                     13MR0
                QY(MP1) = DMM(2)*1.0E99                                     13MR0
          IF (IPINRT .EQ. 1) GO TO 3220                                     16MR0
                QZ(MP1) = DMM(3)*1.0E99                                     13MR0
          GO TO 3250                                                        16MR0
 3220           QZ(MP1) = 0.0                                               16MR0
 3250     CONTINUE                                                          16MR0
COMMENT - FINAL AXIAL SOLUTION OF MEMBER                                    16MY0
      CALL        AXIAL ( MLT )                                             13MR0
                NFSUB = 12                                                  08AP0
COMMENT - FINAL LATERAL SOLUTION OF MEMBER                                  16MY0
      CALL        GRIP2A ( RM, RO, W, SL, SU, L3, L4, L6, 3   )             15MY0
COMMENT - SET MEMBER LATERAL AND ROTATIONAL DISPLACEMENTS EQUAL TO          16MY0
COMMENT - SOLUTION VECTOR W FROM GRIP2B                                     16MY0
          DO 3300  I = 1, MP1                                               16MR0
                J = 2*I                                                     16MR0
                JM1 = J - 1                                                 16MR0
                DY(I) = W(JM1)                                              16MR0
 3300           DZ(I) = W(J)                                                16MR0
                U1(1) = U1(MP2) = U2(1) = U2(MP2) = 0.0                     13MR0
                V1(1) = V1(MP2) = V2(1)  = V2(MP2) = 0.0                    13MR0
                W1(1) = W1(MP2) = W2(1)  = W2(MP2) = 0.0                    13MR0
COMMENT - DO FOR EACH INTERIOR STATION                                      16MY0
          DO  3400  I = 2,MP1                                               13MR0
                IP1 = I + 1                                                 13MR0
                IM1 = I - 1                                                 13MR0
COMMENT - COMPUTE AXIAL SHORTENING                                          16MY0
                DDX = DX(I) - DX(IM1)                                       01JL0
COMMENT - COMPUTE AXIAL FORCES ON ENDS OF ELEMENTS                          16MY0
                U2(I) = AE(I)*DDX/TH                                        01JL0
                U1(I) = - U2(I)                                             13MR0
COMMENT - COMPUTE CURVATURES                                                16MY0
                TAU1    =   (DY(I) - DY(IM1))/H    - (1.5*DZ(IM1) +         13MR0
     2               0.5*DZ(I))                                             13MR0
                TAU2    =  -(DY(I) - DY(IM1))/H    + (0.5*DZ(IM1) +         13MR0
     2               1.5*DZ(I))                                             13MR0
COMMENT - COMPUTE SHEARS AND MOMENTS ON ENDS OF ELEMENTS                    16MY0
                W1(I) = F(I)*(-1.5*TAU1    + 0.5*TAU2    )/H                13MR0
                W2(I) = F(I)*(-0.5*TAU1    + 1.5*TAU2    )/H                13MR0
                V2(I) =  F(I)*(TAU1    - TAU2    )/HSQ                      13MR0
                V1(I) =   - V2(I)                                           13MR0
COMMENT - COMPUTE STATION REACTIONS                                         16MY0
                RX(IM1) = -SX(IM1)*DX(IM1)                                  13MR0
                RY(IM1) = -SY(IM1)*DY(IM1)                                  13MR0
                RZ(IM1) = -SZ(IM1)*DZ(IM1)                                  13MR0
COMMENT - COMPUTE STATION EQUILIBRIUM ERRORS                                16MY0
                ERX(IM1)  = QX(IM1)  +RX(IM1) - U2(IM1) - U1(I)             13MR0
                ERY(IM1)  = QY(IM1)  +RY(IM1) - V2(IM1) - V1(I)             13MR0
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            ERZ(IM1)  = QZ(IM1)  +RZ(IM1) - W2(IM1) - W1(I)                 13MRO
 3400     CONTINUE                                                          13MRO
COMMENT - REPEAT ABOVE FOR END STATIONS                                     16MYO
            U1(2) = U1(2) + ST1*DX(1) - QT1                                 23MRO
            V1(2) = V1(2) + ST2*DY(1) - QT2                                 23MRO
            W1(2) = W1(2) + ST3*DZ(1) - QT3                                 23MRO
            U2(MP1) = U2(MP1) + ST4*DX(MP1) - QT4                           23MRO
            V2(MP1) = V2(MP1) + ST5*DY(MP1) - QT5                           23MRO
            W2(MP1) = W2(MP1) + ST6*DZ(MP1) - QT6                           23MRO
            I = 1                                                           17MRO
COMMENT - DO FOR EVERY SECOND INTERIOR STATION                              16MYO
          DO 3600  IM = 2,MP221                                             20MRO
            I = I + 2                                                       17MRO
            IP1 = I + 1                                                     17MRO
COMMENT - COMPUTE AVERAGE AXIAL FORCE,SHEAR,AND BENDING MOMENT              16MYO
            T(IM)  =  0.5*(U2(I) - U1(IP1))                                 17MRO
            V(IM)  = -0.5*(V2(I) - V1(IP1))                                 17MRO
            BM(IM) =  0.5*(W2(I) - W1(IP1))                                 17MRO
COMMENT - OUTPUT DISPLACEMENTS                                              16MYO
            DXT(IM) = DX(I)                                                 17MRO
            DYT(IM) = DY(I)                                                 17MRO
            DZT(IM) = DZ(I)                                                 17MRO
 3600     CONTINUE                                                          17MRO
COMMENT - REPEAT ABOVE FOR END STATIONS                                     16MYO
            T(1) = -U1(2)                                                   23MRO
            V(1) =  V1(2)                                                   23MRO
            BM(1) = -W1(2)                                                  23MRO
            DXT(1) = DX(1)                                                  17MRO
            DYT(1) = DY(1)                                                  17MRO
            DZT(1) = DZ(1)                                                  17MRO
            T(MP22)   =  U2(MP1)                                            23MRO
            V(MP22)   = -V2(MP1)                                            23MRO
            BM(MP22) =  W2(MP1)                                             23MRO
            DXT(MP22) = DX(MP1)                                             17MRO
            DYT(MP22) = DY(MP1)                                             17MRO
            DZT(MP22) = DZ(MP1)                                             17MRO
COMMENT - COMPUTE MEMBER END FORCES                                         16MYO
            F1M(1) = -T(1)                                                  23MRO
            F1M(2) =  V(1)                                                  23MRO
            F1M(3) = -BM(1)                                                 23MRO
            F2M(1) =  T(MP22)                                               23MRO
            F2M(2) = -V(MP22)                                               23MRO
            F2M(3) =  BM(MP22)                                              23MRO
COMMENT - SUBROUTINE ADJTER TRANSFORMS MEMBER END FORCES AND SUBTRACTS  16MYO
COMMENT - FROM JOINT EQUILIBRIUM ERRORS TO ACCUMULATE JOINT EQUILIBRIUM 16MYO
COMMENT - ERRORS FOR FRAME                                                  16MYO
      CALL        ADJTER ( F1M, F2M, JT1(JJ), JT2(JJ),  DC1S(ISTT),         23MRO
     2    DC2S(ISTT) )                                                      23MRO
COMMENT - COMPUTE MAXIMUM EQULIBRIUM ERROR IN MEMBER                        16MYO
            STAERR = 0.0                                                    17MRO
          DO 3800  I = 2,M                                                  17MRO
            ERR = ABS(ERX(I))                                               17MRO
          IF (ERR .LE. STAERR) GO TO 3740                                   17MRO
            STAERR = ERR                                                    17MRO
 3740       ERR = ABS(ERY(I))                                               17MRO
          IF (ERR .LE. STAERR) GO TO 3760                                   17MRO
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```
            STAERR = ERR                                                    17MRO
 3760       ERR = ABS(ERZ(I))                                               17MRO
          IF (ERR .LE. STAERR) GO TO 3780                                   17MRO
            STAERR = ERR                                                    17MRO
 3780     CONTINUE                                                          17MRO
 3800     CONTINUE                                                          17MRO
            IJ = 0                                                          17MRO
COMMENT - DM IS STORAGE VARIABLE FOR SIX MEMBER RESULTS                     16MYO
          DO 4100  IM = 1,MP22                                              17MRO
            IJ = IJ + 1                                                     17MRO
            DM(IJ,KK) = DXT(IM)                                             17MRO
            IJ = IJ + 1                                                     17MRO
            DM(IJ,KK) = DYT(IM)                                             17MRO
            IJ = IJ + 1                                                     17MRO
            DM(IJ,KK) = DZT(IM)                                             17MRO
            IJ = IJ + 1                                                     17MRO
            DM(IJ,KK) = T(IM)                                               17MRO
            IJ = IJ + 1                                                     17MRO
            DM(IJ,KK) = V(IM)                                               17MRO
            IJ = IJ + 1                                                     17MRO
 4100       DM(IJ,KK) = BM(IM)                                              17MRO
            IJ = IJ + 1                                                     17MRO
            DM(IJ,KK) = STAERR                                              17MRO
COMMENT - PRINT TABLE 9 MEMBEX RESULTS IF REQUESTED                         16MYO
          IF (IP9 .EQ. 1) GO TO 9900                                        25MRO
      CALL        PRINT9 ( DM, L7, AR2, JJ, KK , NPROB )                    25MRO
          GO TO 9900                                                        17MRO
 5100     CONTINUE                                                          17MRO
COMMENT - ZERO MEMBER RESULTS FOR ZERO STIFFNESS TYPE AND DUMMY MEMBERS 16MYO
COMMENT - USED TO FILL OUT GROUPS OF SIX                                    16MYO
          DO 5200  IJ = 1,L7                                                17MRO
 5200       DM(IJ,KK) = 0.0                                                 17MRO
 9900     CONTINUE                                                          17MRO
      RETURN                                                                13MRO
      END                                                                   13MRO
C
C         ***************************************************************
C
C         SUBROUTINE         SUBROUTINE         SUBROUTINE         SUBROUTINE
C
C         ***************************************************************
C
      SUBROUTINE ADJTER (F1M, F2M, J1, J2, DC1, DC2)                        23MRO
COMMENT - SUBROUTINE ADJTER TRANSFORMS MEMBER-END-FORCES TO STRUCTURE       20MYO
COMMENT - COORDINATES AND SUBTRACTS FROM APPROPRIATE JOINT EQUILIBRIUM      20MYO
COMMENT - ERROR FOR FRAME                                                   20MYO
      DIMENSION  F1M(3), F2M(3), F1S(3), F2S(3)                             21MRO
      DIMENSION  DCT(3,3)                                                   21MRO
      COMMON /BLOCK1/ X( 75),     Y( 75),     QXX( 75),   QYY( 75),         13FEO
     2    QZZ( 75),   SXX( 75),   SYY( 75),   SZZ( 75),   DXX( 75),         13FEO
     3    DYY( 75),   DZZ( 75),   RXX( 75),   RYY( 75),   RZZ( 75),         13FEO
     4    ERXX( 75),  ERYY( 75),  ERZZ( 75)                                 13FEO
COMMENT - FORM TRANSPOSE OF MEMBER TRANSFORMATION MATRIX                    20MYO
            DCT(1,3) = DCT(2,3) = DCT(3,1) = DCT(3,2) = 0.0                 21MRO
            DCT(3,3) = 1.0                                                  21MRO
            DCT(1,1) = DC1                                                  21MRO
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            DCT(1,2) = -DC2                                               21MRO
            DCT(2,1) = DC2                                                21MRO
            DCT(2,2) = DC1                                                21MRO
COMMENT - TRANSFORM MEMBER-END-FORCES AT FROM JOINT TO STRUCTURE COORD   20MYO
      CALL       MATM31 (DCT,F1M,F1S)                                    21MRO
COMMENT - ACCUMULATE JOINT EQUILIBRIUM ERROR AT MEMBERS FROM JOINT       20MYO
            ERXX(J1) = ERXX(J1) - F1S(1)                                  23MRO
            ERYY(J1) = ERYY(J1) - F1S(2)                                  23MRO
            ERZZ(J1) = ERZZ(J1) - F1S(3)                                  23MRO
COMMENT - TRANSFORM MEMBER-END-FORCES AT TO JOINT TO STRUCTURE COORD     20MYO
      CALL       MATM31 (DCT,F2M,F2S)                                    23MRO
COMMENT - ACCUMULATE JOINT EQUILIBRIUM ERROR AT MEMBERS TO JOINT         20MYO
            ERXX(J2) = ERXX(J2) - F2S(1)                                  23MRO
            ERYY(J2) = ERYY(J2) - F2S(2)                                  23MRO
            ERZZ(J2) = ERZZ(J2) - F2S(3)                                  23MRO
      RETURN                                                             21MRO
      END                                                                21MRO
C
C        ****************************************************************
C
C        SUBROUTINE          SUBROUTINE          SUBROUTINE          SUBROUTINE
C
C        ****************************************************************
C
      SUBROUTINE SUM2 (DM,DMT,L7,NM6,AN2,NPROB )                         25MRO
COMMENT - SUBROUTINE  SUM2    DOES SUPERPOSITION SOLUTION FOR MEMBERS    24APO
COMMENT - FOR FAMILY PROBLEMS,SUBTRACTS APPROPRIATE MEMBER END FORCES    24APO
COMMENT - TO COMPLETE CALCULATION OF JOINT EQUILIBRIUM ERROR AND PRINTS  24APO
COMMENT - MEMBER RESULTS                                                 24APO
COMMENT - RESULTS OF PREVIOUS PROBLEMS ARE STORED ON TAPE 4              16JEO
COMMENT - TAPES 2 AND 3 ARE USED TO INCREASE EFFICIENCY OF TAPE          16JEO
COMMENT - OPERATIONS                                                     20MYO
      DIMENSION  DM(L7,6), DMT(L7,6)                                     20MRO
      DIMENSION  F1M(3), F2M(3)                                          21MRO
      DIMENSION AN2(18), NPROB(2)                                        11JEO
      COMMON /BLOCK2/ DXS( 50),    DYS( 50),   ZLS( 50),   DC1S( 50),    26JAO
     2   DC2S( 50),  PRF( 50),   PRAE( 50),  NCOS( 50),  IAXOPS( 50),    26JAO
     3   IOPOP( 50), IPINL( 50), IPINR( 50), NC51( 50),  SMM( 50,13)     11FEO
      COMMON /BLOCK4/ JT1(150),    JT2(150),    IST(150),   LT(150),     26JAO
     2   FORM(150,6)                                                     26JAO
      COMMON /BLOCK8/ NP(21,2),    ZM(21)                                09JEO
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEPT,           20MRO
     2        ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,            20MRO
     3        IABAR, IFORM, NM,    NJT,   NST,   NLT,   TOL,             20MRO
     4        N,     NP1,   NP2,   ISTT,  LTT,   ITYPEL,IOJ,             20MRO
     5        NLC,   IP8,   IP9,   IP10                                  20MRO
            L7M1 = L7 - 1                                                21MRO
            L7M2 = L7 - 2                                                21MRO
            L7M3 = L7 - 3                                                21MRO
      REWIND  2                                                          20MRO
      REWIND  3                                                          20MRO
      REWIND 4                                                           16JEO
COMMENT - CLEAR TAPE 3                                                   20MYO
        DO 220  IJ = 1,L7                                                20MRO
        DO 220  KK = 1,6                                                 20MRO
  220          DM(IJ,KK) = 0.0                                           20MRO
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          DO 225  II = 1,NM6                                                 20MRO
  225 WRITE  (3) ((DM(IJ,KK), IJ = 1,L7), KK = 1,6)                          20MRO
      REWIND  3                                                              20MRO
                N2 = 3                                                       20MRO
                N3 = 2                                                       20MRO
COMMENT - DO FOR EACH PROBLEM WITH RESULTS STORED                            20MYO
          DO 310  J = 1,NLC                                                  20MRO
COMMENT - SET SWITCHES TO OPTIMIZE HANDLING OF TAPES 2 AND 3                 20MYO
          IF (N2 .EQ. 2) GO TO 230                                           20MRO
                N3 = 3                                                       20MRO
                N2 = 2                                                       20MRO
          GO TO 235                                                          20MRO
  230           N2 = 3                                                       20MRO
                N3 = 2                                                       20MRO
  235     CONTINUE                                                           20MRO
          DO 280  II = 1,NM6                                                 23MRO
COMMENT - READ RESULTS FROM TAPE 4 FOR SIX MEMBERS                           16JEO
      READ   (4)    ((DM(IJ,KK), IJ = 1,LT), KK = 1,6)                       16JEO
          DO 240  KK = 1,6                                                   20MRO
          DO 240  IJ = 1,LT                                                  20MRO
COMMENT - MULTIPLY RESULTS FOR SIX MEMBERS BY MULTIPLIERS                    20MYO
  240           DMT(IJ,KK) = ZM(J)*DM(IJ,KK)                                 20MRO
COMMENT - READ SUM OF OFF TAPE 2 OR 3 FOR SIX MEMBERS                        19MYO
      READ  (N3)  ((DM(IJ,KK), IJ = 1,LT), KK = 1,6)                         20MRO
          DO 260  KK = 1,6                                                   23MRO
          DO 245  IJ = 1,LT                                                  20MRO
COMMENT - ADD TO SUM                                                         19MYO
                DM(IJ,KK) = DM(IJ,KK) + DMT(IJ,KK)                           21MRO
  245     CONTINUE                                                           21MRO
COMMENT - SKIP UNTIL LAST LOAD CASE                                          19MYO
          IF  (J .LT. NLC) GO TO 260                                         21MRO
          IF  (II .EQ. 1 .AND.  KK .EQ. 1 )  JJ = 0                          23MRO
                JJ = JJ + 1                                                  21MRO
          IF (JJ .GT. NM) GO TO 260                                          25MRO
                ISTT = IST(JJ)                                               21MRO
          IF (ISTT .EQ. 0) GO TO 260                                         25MRO
                J1 = JT1(JJ)                                                 21MRO
                J2 = JT2(JJ)                                                 21MRO
                DC1 = DC1S(ISTT)                                             21MRO
                DC2 = DC2S(ISTT)                                             21MRO
                F1M(1) = -DM(4,KK)                                           23MRO
                F1M(2) =  DM(5,KK)                                           23MRO
                F1M(3) = -DM(6,KK)                                           23MRO
                F2M(1) =  DM(L7M3,KK)                                        23MRO
                F2M(2) = -DM(L7M2,KK)                                        23MRO
                F2M(3) =  DM(L7M1,KK)                                        23MRO
COMMENT - ACCUMULATE JOINT EQUILIBRIUM ERRORS                                19MYO
      CALL       ADJTER ( F1M, F2M, J1, J2, DC1, DC2 )                       23MRO
COMMENT - PRINT TABLE 9 MEMBER RESULTS IF REQUESTED                          19MYO
          IF (IP9 .EQ. 1) GO TO 260                                          19MYO
      CALL       PRINT9 ( DM, L7, AN2, JJ, KK , NPROB )                      25MRO
  260     CONTINUE                                                           23MRO
          IF (J .EQ. NLC) GO TO 280                                          25MRO
COMMENT - WRITE SUM ON TAPE 2 OR 3 FOR ALL BUT LAST LOAD CASE                19MYO
      WRITE (N2)  ((DM(IJ,KK), IJ = 1,L7), KK = 1,6)                         23MRO
  280     CONTINUE                                                           23MRO
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      REWIND  2                                                         20MRO
      REWIND  3                                                         20MRO
  310     CONTINUE                                                      20MRO
      RETURN                                                            20MRO
      END                                                               20MRO
C
C         ****************************************************************
C
C         SUBROUTINE            SUBROUTINE            SUBROUTINE            SUBROUTINE
C
C         ****************************************************************
C
      SUBROUTINE PRINT9 ( DM, LT, AM2, JJ, KK , NPROB )                 25MRO
COMMENT - SUBROUTINE PRINT9 PRINTS MEMBER RESULTS FOR ALL MEMBERS       19MYO
COMMENT - PRINT9 IS CALLED FOR EACH INDIVIDUAL MEMBER (NUMBER JJ)       19MYO
      DIMENSION  DM(LT,6)                                               02MYO
      DIMENSION AN2(18), NPROB(2)                                       11JEO
      COMMON /BLOCK2/ DXS( 50),    DYS( 50),    ZLS( 50),    DC1S( 50), 26JAO
     2    DC2S( 50),  PRF( 50),    PRAE( 50),   NCDS( 50),   IAXOPS( 50), 26JAO
     3    IOPOP( 50), IPTRL( 50), IPINR( 50), NCS1( 50),   SMM( 50,13)  11FEO
      COMMON /BLOCK4/ JT1(150),    JT2(150),    IST(150),    LT(150),   26JAO
     2    FORM(150,6)                                                   26JAO
      COMMON /BLK1/  KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, KEEP7,          23MRO
     2          ITYPE, NCD2,  NCD3,  NCD4,  NCD5,  NCD6,  NCD7,         23MRO
     3          TABAN, IFORM, NM,    NJT,   NST,   NLT,   TOL,          23MRO
     4          M,     MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,          23MRO
     5          NLC,   IP8,   IP9,   IP10                               23MRO
   11 FORMAT  (  5H1       ,80X    10H1-----TRIN  )                     25MRO
   16 FORMAT (///17H       PROB (CONTD), /5X, A1, A4, 5X, 17A4, A2, // ) 18MYO
   51 FORMAT  (  30H       TABLE 9 - MEMBER RESULTS ,///)               25MRO
   52 FORMAT  (  40H       TABLE 9 - MEMBER RESULTS (CONTD)    ,///)    30MRO
   61 FORMAT  (  18H       MEMBER NUMBER,I5,15H     STIFF TYPE,I5,      30MRO
     2           15H       LOAD TYPE , I5 )                             30MRO
   62 FORMAT  (  18H       MEMBER NUMBER,I5,15H     STIFF TYPE,I5)      30MRO
   71 FORMAT  (  14H       LENGTH = ,E11.3, 13H     ALPHA = ,E11.3,     30MRO
     2           13H        BETA = ,E11.3 )                             30MRO
   81 FORMAT  (  20H       GOES FROM JOINT, I5 ,  9H TO JOINT,I5)       25MRO
   91 FORMAT  (  34H       OUTPUT DISTANCES ARE FROM JOINT, I5,         25MRO
     2           25H ALONG THE MEMBER AXIS    )                         25MRO
   92 FORMAT  (  34H       OUTDUT DISTANCES ARE FROM JOINT, I5,         30MRO
     2           27H ALONG THE STRUCTURE X-AXIS)                        25MRO
   93 FORMAT  (  34H       OUTPUT DISTANCES ARE FROM JOINT, I5,         30MRO
     2           27H ALONG THE STRUCTURE Y-AXIS)                        25MRO
  101 FORMAT  (  49H       ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH,  25MRO
     2           30H RESPECT TO THE MEMBER AXES    ,////,               25MRO
     3      26X, 15H DISPLACEMENTS , 21X,  7H FORCES,//,                25MRO
     4           50H        DISTANCE      AXIAL     LATERAL   ROTATIONAL , 25MRO
     5           30H  AXIAL        SHEAR        MOMENT ,/)              25MRO
  111 FORMAT  ( 5X,7E11.3)                                              25MRO
  201 FORMAT  (  46H       ALL OUTPUT FORCES ARE WITH RESPECT TO THE,   25MRO
     2           15H MEMBER AXES    , // , 15X,                         25MRO
     3           10H AT JOINT , I5,  12X, 10H AT JOINT , I5,//,5X,      25MRO
     4           15H AXIAL FORCE = ,E11.3,5X,  15H AXIAL FORCE = ,E11.3,25MRO
     5     /, 5X, 15H SHEAR        = ,E11.3,5X,  15H SHEAR        = ,E11.3,30MRO
     6     /, 5X, 15H MOMENT       = ,E11.3,5X,  15H MOMENT       = ,E11.3)24APO
  301 FORMAT  (/,50H       THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE, 25MRO
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     2           10H MEMBER I5, E11.3, ///)                             25MRO
              MP22 = MP2/2                                              25MRO
              L7M1 = LT - 1                                             25MRO
              L7M2 = LT - 2                                             25MRO
              L7M3 = LT - 3                                             25MRO
COMMENT - SKIP FOR COMPLETE OUTPUT                                      19MYO
          IF ( IOPOP(ISTT) .EQ. 0 ) GO TO 1600                          25MRO
          IF ( JJ .EQ. 1 )  GO TO 1500                                  25MRO
COMMENT - PRINT PARTIAL RESULTS FOR 3 MEMBERS ON 1 SHEET                19MYO
          IF ( IOPL .NE. 1 ) GO TO 1500                                 25MRO
              IC = IC + 1                                               25MRO
          IF ( IC .EQ. 4 ) GO TO 1500                                   25MRO
          GO TO 2100                                                    25MRO
 1500         IC = 1                                                    25MRO
 1600     CONTINUE                                                      25MRO
COMMENT - PRINT HEADINGS                                                19MYO
      PRINT 11                                                          25MRO
      PRINT 16, NPROB, (AN2(II), II = 1, 18)                            09JEO
          IF ( JJ .EQ. 1 )  GO TO 1700                                  25MRO
      PRINT  52                                                         25MRO
          GO TO 2100                                                    25MRO
 1700 PRINT  51                                                         25MRO
 2100     CONTINUE                                                      25MRO
          IF ( ITYPE .NE. 4 ) GO TO 2500                                25MRO
      PRINT  62, JJ, ISTT                                               30MRO
          GO TO 2600                                                    25MRO
 2500 PRINT 61, JJ, ISTT, LTT                                           30MRO
 2600     CONTINUE                                                      25MRO
      PRINT 71, ZLS(ISTT), DC1S(ISTT), DC2S(ISTT)                       30MRO
      PRINT  81, JT1( JJ ), JT2( JJ )                                   25MRO
          IF ( IOPOP(ISTT) .EQ. 1 )  GO TO 5100                         25MRO
              IAXOPT = IAXOPS(ISTT)                                     25MRO
          GO TO  ( 2800, 2900, 3000 ) , IAXOPT                          25MRO
 2800 PRINT 91, JT1( JJ )                                               25MRO
          GO TO 3100                                                    25MRO
 2900 PRINT  92, JT1( JJ )                                              25MRO
          GO TO 3100                                                    25MRO
 3000 PRINT  93, JT1( JJ )                                              25MRO
 3100 PRINT 101                                                         25MRO
              DDIS = 2.0*ZLS(ISTT)/M                                    25MRO
          IF (IAXOPS(ISTT) .EQ. 2) DDIS = DC1S(ISTT)*DDIS               24APO
COMMENT - CONVERT OUTPUT DISTANCES TO BE COMPATIBLE WITH STIFFNESS INPUT19MYO
          IF (IAXOPS(ISTT) .EQ. 3) DDIS = DC2S(ISTT)*DDIS               24APO
              DIS = - DDIS                                              25MRO
              IJ6 = 0                                                   25MRO
          DO 3600  I = 1, MP22                                          25MRO
              DIS = DIS + DDIS                                          25MRO
              IJ1 = IJ6 + 1                                             25MRO
              IJ2 = IJ1 + 1                                             25MRO
              IJ3 = IJ2 + 1                                             25MRO
              IJ4 = IJ3 + 1                                             25MRO
              IJ5 = IJ4 + 1                                             25MRO
              IJ6 = IJ5 + 1                                             25MRO
COMMENT - PRINT COMPLETE MEMBER RESULTS                                 19MYO
      PRINT 111,DIS, DM(IJ1,KK), DM(IJ2,KK), DM(IJ3,KK), DM(IJ4,KK),    25MRO
     2                  DM(IJ5,KK), DM(IJ6,KK)                          25MRO
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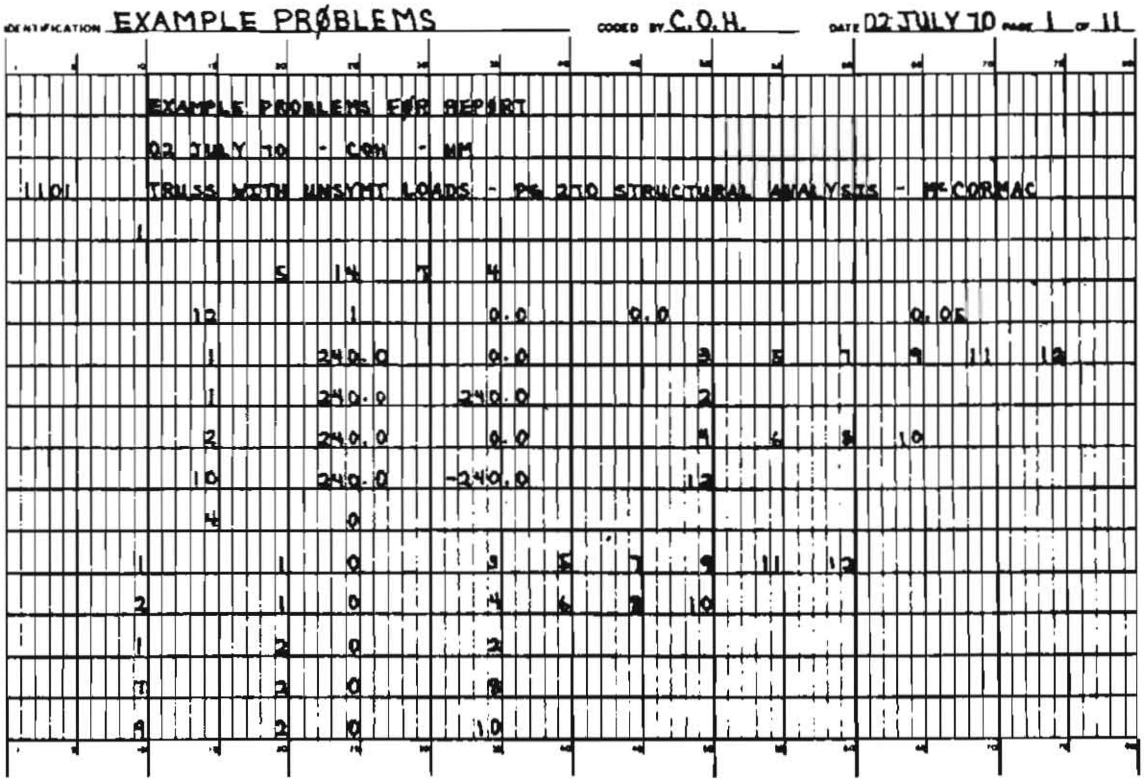
 3600      CONTINUE                                                        25MRO
           GO TO 7100                                                      25MRO
 5100      CONTINUE                                                        25MRO
COMMENT - PRINT PARTIAL  MEMBER RESULTS                                    19MYO
      PRINT 201, JT1( JJ ), JT2( JJ ), DM(4,KK), DM(L7M3,KK), DM(5,KK), 25MRO
     2     DM(L7M2,KK), DM(6,KK), DM(L7M1,KK)                              25MRO
 7100      CONTINUE                                                        25MRO
      PRINT  301, DM(L7,KK)                                                25MRO
                IOPL = IOPOP(ISTT)                                         25MRO
      RETURN                                                               25MRO
      END                                                                  25MRO
```

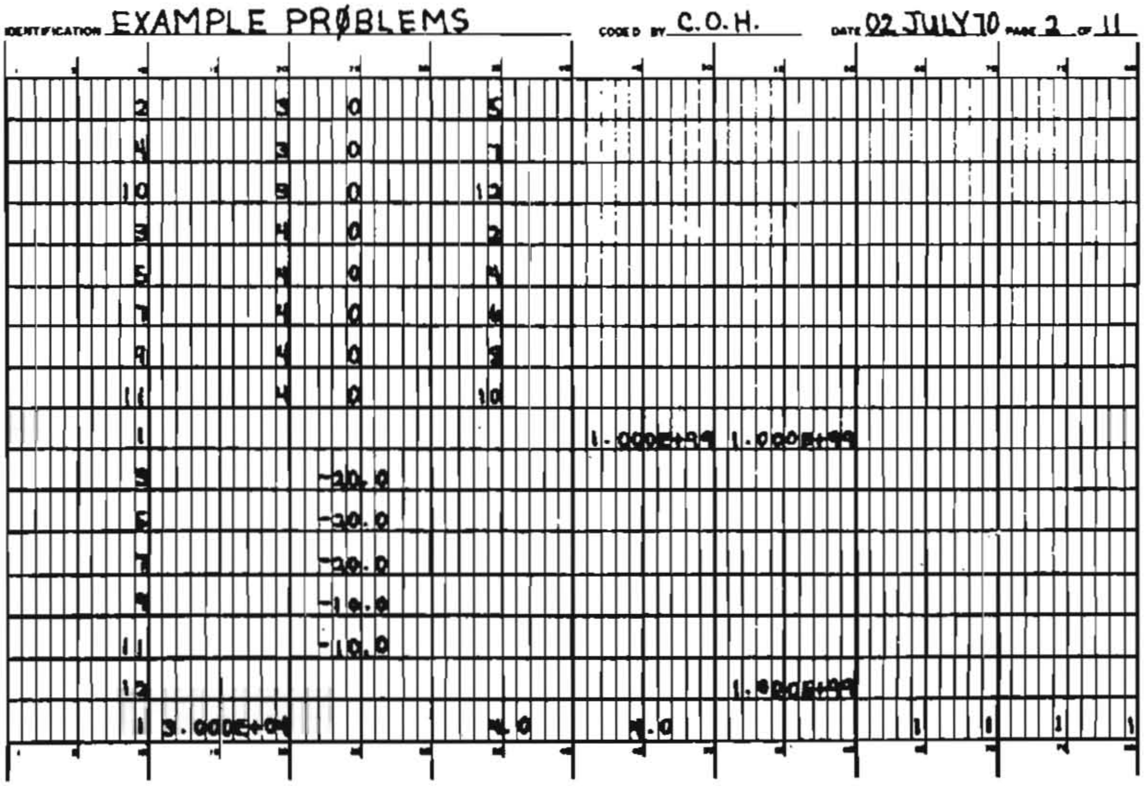
APPENDIX 6

INPUT FOR EXAMPLE PROBLEMS



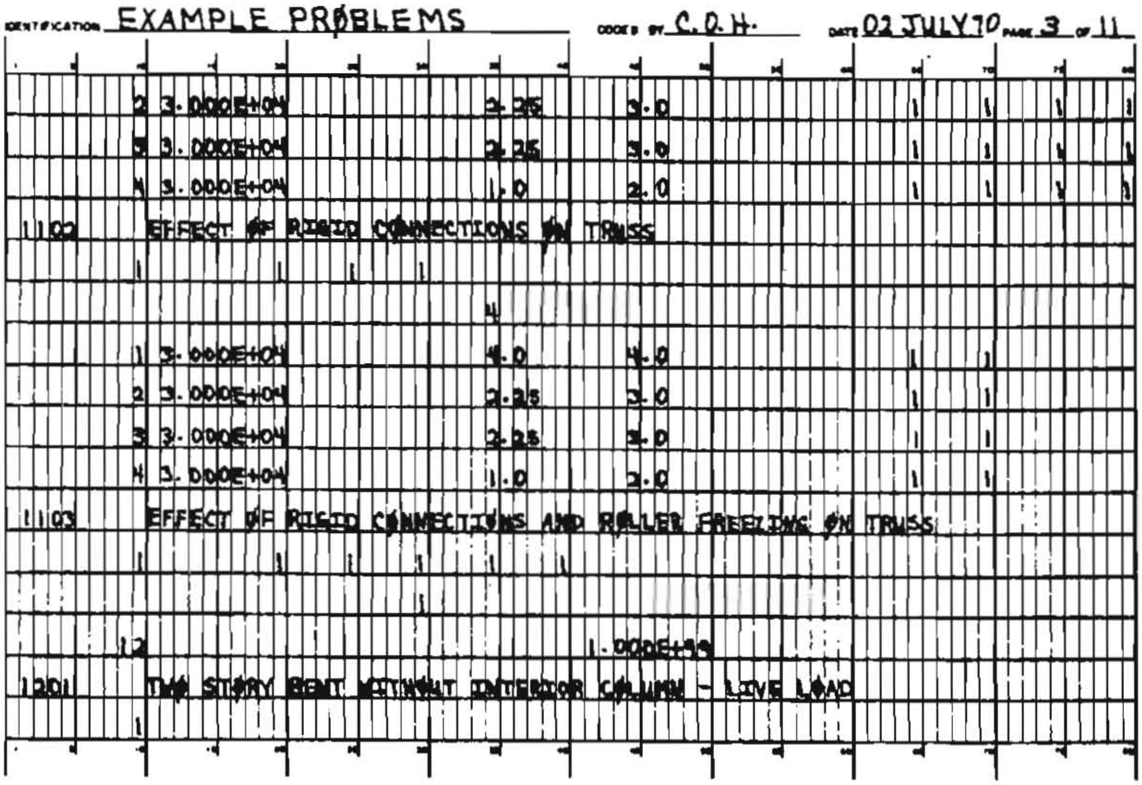
IDENTIFICATION EXAMPLE PROBLEMS CODED BY C.O.H. DATE 02 JULY 70 PAGE 1 OF 11

```
          EXAMPLE PROBLEMS FOR REPORT
          02 JULY 70  - COH  - NM
1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - McCORMAC
         1
                   5   14    3    4
             12         1         0.0       0.0                 0.05
              1       240.0       0.0            3    5    7    9   11   12
              1       240.0     240.0            2
              2       240.0       0.0            4    6    8   10
             10       240.0    -240.0           12
              4         0
         1         1    0         3    5    7    9   11   12
         2         1    0         4    6    8   10
         1         2    0         2
         7         2    0         8
         9         2    0        10
```



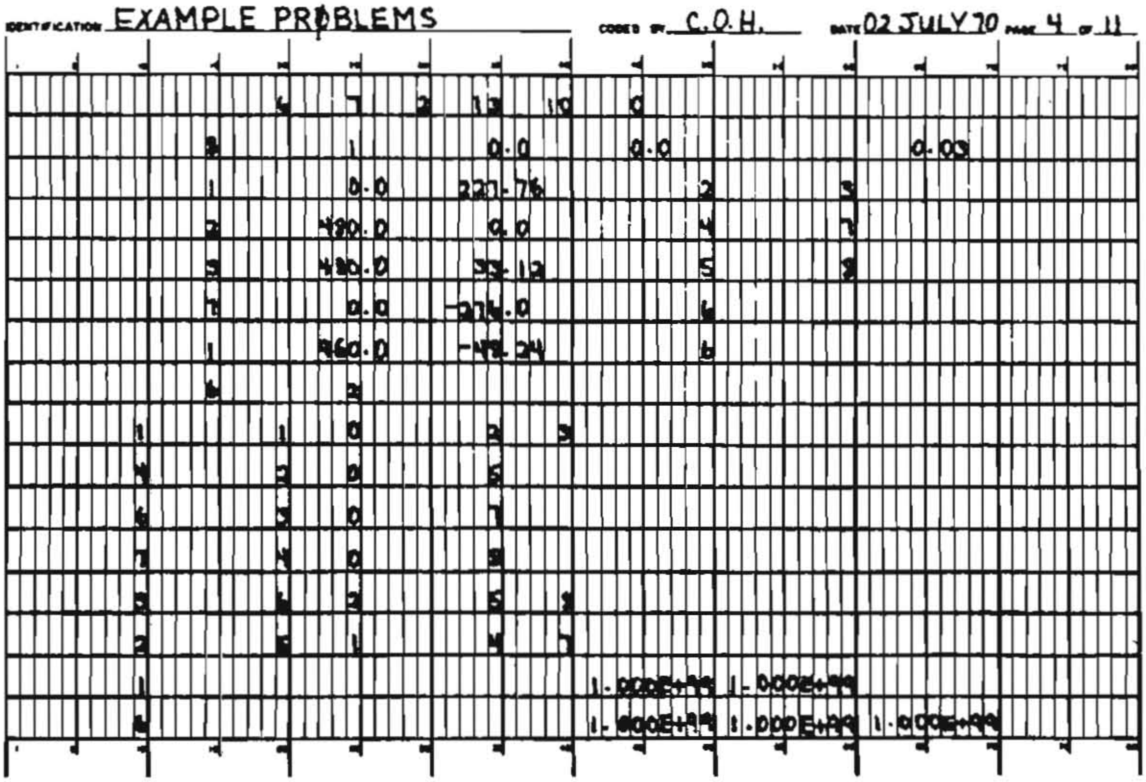
IDENTIFICATION EXAMPLE PROBLEMS CODED BY C.O.H. DATE 02 JULY 70 PAGE 2 OF 11

```
         2         3    0         5
         4         3    0         7
        10         3    0        12
         3         4    0         2
         5         4    0         4
         7         4    0         6
         9         4    0         8
        11         4    0        10
         1                               1.000E+99 1.000E+99
         3            -20.0
         5            -20.0
         7            -20.0
         9            -10.0
        11            -10.0
        12                                         1.000E+99
         1 3.000E+04              4.0       4.0                 1    1    1    1
```



IDENTIFICATION EXAMPLE PRØBLEMS CODED BY C.O.H. DATE 02 JULY 70 PAGE 3 OF 11

```
         2 3.000E+04              2.25      3.0                 1    1    1    1
         3 3.000E+04              2.25      3.0                 1    1    1    1
         4 3.000E+04               1.0      2.0                 1    1    1    1
 1102     EFFECT ØF RIGID CØNNECTIØNS ØN TRUSS
         1         1    1    1
                                  4
         1 3.000E+04               4.0      4.0                 1    1
         2 3.000E+04              2.25      3.0                 1    1
         3 3.000E+04              2.25      3.0                 1    1
         4 3.000E+04               1.0      2.0                 1    1
 1103     EFFECT ØF RIGID CØNNECTIØNS AND RØLLER FREEZING ØN TRUSS
         1         1    1    1    1    1
                             1
        12                               1.000E+99
 1201     TWØ STØRY BENT WITHØUT INTERIØR CØLUMN - LIVE LØAD
         1
```



IDENTIFICATION EXAMPLE PRØBLEMS CODED BY C.O.H. DATE 02 JULY 70 PAGE 4 OF 11

```
                   6    7    2   13   10    0
              8         1         0.0       0.0                 0.03
              1         0.0     220.76          2         3
              2       480.0       0.0           4         7
              3       480.0      53.12          5         8
              7         0.0    -274.0           6
              1       960.0     -49.24          6
              6         2
         1         1    0         2    3
         4         2    0         5
         6         3    0         7
         7         4    0         8
         5         6    2         5    3
         2         6    1         4    7
         1                               1.000E+99 1.000E+99
         6                               1.000E+99 1.000E+99 1.000E+99
```

IDENTIFICATION EXAMPLE PROBLEMS   CODED BY C.O.H.   DATE 02 JULY 70   PAGE 5 OF 11

```
         1 2.960E+04           1050.0      28.0                 1    1
         2 2.960E+04            800.0      20.0                 1    1         1
         3 2.960E+04           1050.0      28.0                 1    1
         4 2.960E+04           1050.0      22.0                 1    1
         5 2.960E+04           1200.0      24.0                 1
         6 2.960E+04                                       7    2
              0.0              9000.0      70.0
                       63.6    3400.0      42.0
             63.6     186.0    3400.0      42.0
            186.0     294.0    5000.0      60.0
            294.0     416.4    3400.0      42.0
            416.4              3400.0      42.0
                      480.0    9000.0      70.0
         1                                                 4    3
             96.0      96.0               -10.0
            192.0     192.0               -10.0
```

IDENTIFICATION EXAMPLE PROBLEMS   CODED BY C.O.H.   DATE 02 JULY 70   PAGE 6 OF 11

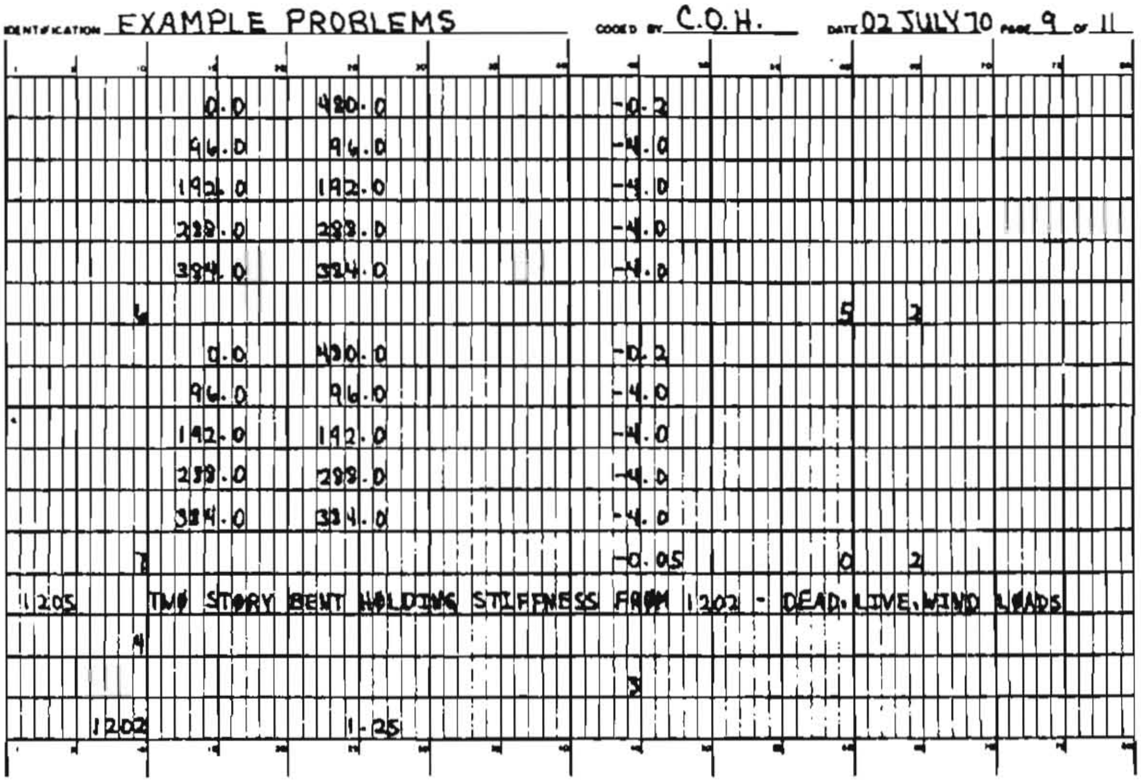
```
            288.0     288.0               -10.0
            384.0     384.0               -10.0
         2                                                 4    3
             96.0      96.0               -20.0
            192.0     192.0               -20.0
            288.0     288.0               -20.0
            384.0     384.0               -20.0
 1202     TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD
         2         1    1    1    1    1
                   2    2    1    4    0
              9
         4              0.0    -396.0            9
              7         2
         9         7    0         4
         9                                      20.0
         7 2.960E+04                                       3    1
```

IDENTIFICATION EXAMPLE PRØBLEMS CODED BY C.O.H. DATE 02 JULY 70 PAGE 7 OF 11

```
              0.0              1050.0      28.0       2.0       3.0
                      192.0    1050.0      28.0       2.0       1.5
            192.0     396.0    1050.0      28.0
 1203     TWØ STØRY BENT HØLDING STIFFNESS FRØM 1202 - WIND LØAD
         3         1    1    1    1    0
                   0    6    0    0    4
              7         4
         1         1    1         2    3
         6         3    2         7
         7         4    3         8
         2         5    0         4    7
         3         6    4         5    8
         1                                 -0.025               1
         2                              -4.333E-03              1
         3                              -4.333E-03              1
         4                              -4.333E-03              1
```

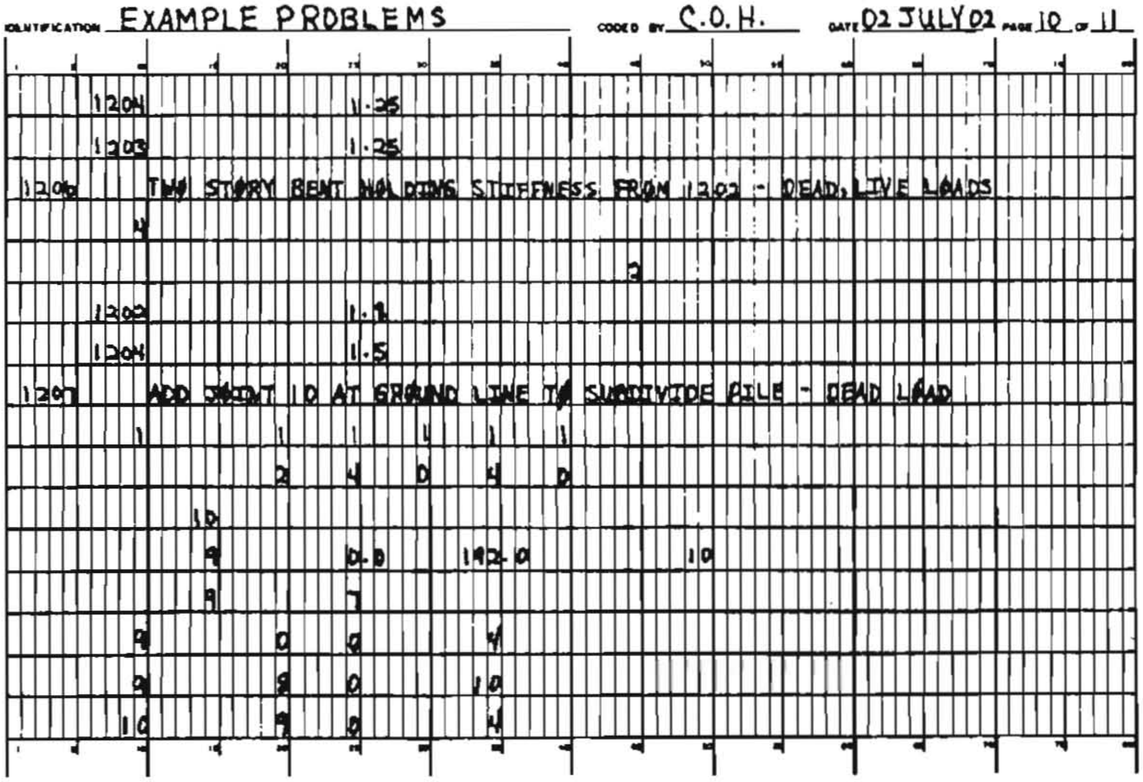
IDENTIFICATION EXAMPLE PROBLEMS CODED BY C.O.H. DATE 02 JULY 70 PAGE 8 OF 11

```
 1204     TWØ STØRY BENT HØLDING STIFFNESS FRØM 1202 - DEAD LØAD
         3         1    0    1    1    0
                   0    8    0    0   17
              7         7
         1         1    1         2    3
         9         7    7         4
         4         2    2         5
         6         3    3         7
         7         4    4         8
         2         5    5         4    7
         3         6    6         5    8
         1                                 -0.05           0    2
         2                                 -0.05           0    2
         3                                 -0.05           0    2
         4                                 -0.05           0    2
         5                                                 5    2
```



IDENTIFICATION EXAMPLE PROBLEMS CODED BY C.O.H. DATE 02 JULY 70 PAGE 9 OF 11

```
              0.0     480.0                -0.2
             96.0      96.0                -4.0
            192.0     192.0                -4.0
            288.0     288.0                -4.0
            384.0     384.0                -4.0
         6                                                 5    2
              0.0     480.0                -0.2
             96.0      96.0                -4.0
            192.0     192.0                -4.0
            288.0     288.0                -4.0
            384.0     384.0                -4.0
         7                                 -0.05           0    2
1205      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD,LIVE,WIND LOADS
         4
                                            3
      1202              1.25
```



IDENTIFICATION EXAMPLE PROBLEMS CODED BY C.O.H. DATE 02 JULY 02 PAGE 10 OF 11

```
      1204              1.25
      1203              1.25
1206      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD,LIVE LOADS
         4
                                            2
      1202              1.1
      1204              1.5
1207      ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD
         1         1    1    4    1    1
                   2    4    0    4    0
             10
              9         0.0     192.0           10
              9         7
         9         0    0         4
         9         8    0        10
        10         9    0         4
```

IDENTIFICATION EXAMPLE PROBLEMS CODED BY C.O.H. DATE 02 JULY 70 PAGE 11 OF 11

```
         8 2.960E+04                                       2    1
              0.0              1050.0      28.0       2.0       3.0
                      192.0    1050.0      28.0       2.0       1.5
         9 2.960E+04           1050.0      28.0                 1
```

APPENDIX 7

SELECTED OUTPUT FOR EXAMPLE PROBLEMS

```
     02 JULY 78  - COM - MM
     EXAMPLE PROBLEMS FOR REPORT


PROB
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC




TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE     1


                    INPUT TABLES

      TABLE     HOLD DATA FROM.        NUMBER OF CARDS
      NUMBER    LAST PROBLEM           ADDED FOR THIS
               (1 = YES,0 = NO)        PROBLEM

        2             -0                     5
        3             -0                    14
        4             -0                     7
        5             -0                     4
        6             -0                    -0
        7             -0                    -0

                    OUTPUT TABLES

      TABLE    SUPPRESS OUTPUT
      NUMBER  (1 = YES,0 = NO)

        8             -0
        9             -0
       10             -0
```

```
PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 2 - FRAME GEOMETRY DATA


NUMBER OF JOINTS IN FRAME =    12
REFERENCE JOINT IS JOINT      1  AT  X  =   0.         AND Y =   0.
JOINT TOLERANCE IS        5.000E-02

                         INPUT OF JOINT OFFSETS

      FROM        X-OFFSET   Y-OFFSET          TO   TO   TO   TO   TO   TO   TO
     JOINT                                  JOINT

         1        2.400E+02  0.                 3    5    7    9   11   12
         1        2.400E+02  2.400E+02          2
         2        2.400E+02  0.                 4    6    8   10
        10        2.400E+02 -2.400E+02         12


     COMPUTED JOINT COORDINATES

     JOINT      X           Y

         1  0.          0.
         2  2.400E+02   2.400E+02
         3  2.400E+02   0.
         4  4.800E+02   2.400E+02
         5  4.800E+02   0.
         6  7.200E+02   2.400E+02
         7  7.200E+02   0.
         8  9.600E+02   2.400E+02
         9  9.600E+02   0.
        10  1.200E+03   2.400E+02
        11  1.200E+03   0.
        12  1.440E+03   0.
```

```
PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC


TABLE 3 - MEMBER LOCATION DATA


NUMBER OF MEMBER STIFFNESS TYPES  =     4
NUMBER OF MEMBER LOAD TYPES  =          0


                         INPUT OF MEMBER LOCATIONS

 FROM      STIFF LOAD        TO   TO   TO   TO   TO   TO   TO   TO   TO   TO
JOINT       TYPE TYPE     JOINT

    1          1    0         3    5    7    9   11   12
    2          1    0         4    6    8   10
    1          2    0         2
    7          2    0         8
    9          2    0        10
    2          3    0         5
    4          3    0         7
   10          3    0        12
    3          4    0         2
    5          4    0         4
    7          4    0         6
    9          4    0         8
   11          4    0        10


      COMPUTED MEMBER NUMBERS,LENGTHS,AND OFFSETS

MEMBER  FROM    TO    STIFF LOAD   LENGTH     X-OFFSET   Y-OFFSET
 NUMB  JOINT  JOINT    TYPE TYPE

    1     1      3        1    0  2.400E+02  2.400E+02  0.
    2     3      5        1    0  2.400E+02  2.400E+02  0.
    3     5      7        1    0  2.400E+02  2.400E+02  0.
    4     7      9        1    0  2.400E+02  2.400E+02  0.
    5     9     11        1    0  2.400E+02  2.400E+02  0.
    6    11     12        1    0  2.400E+02  2.400E+02  0.
    7     2      4        1    0  2.400E+02  2.400E+02  0.
    8     4      6        1    0  2.400E+02  2.400E+02  0.
    9     6      8        1    0  2.400E+02  2.400E+02  0.
   10     8     10        1    0  2.400E+02  2.400E+02  0.
   11     1      2        2    0  3.394E+02  2.400E+02  2.400E+02
   12     7      8        2    0  3.394E+02  2.400E+02  2.400E+02
   13     9     10        2    0  3.394E+02  2.400E+02  2.400E+02
   14     2      5        3    0  3.394E+02  2.400E+02 -2.400E+02
   15     4      7        3    0  3.394E+02  2.400E+02 -2.400E+02
   16    10     12        3    0  3.394E+02  2.400E+02 -2.400E+02
   17     3      2        4    0  2.400E+02  0.         2.400E+02
   18     5      4        4    0  2.400E+02  0.         2.400E+02
   19     7      6        4    0  2.400E+02  0.         2.400E+02
   20     9      8        4    0  2.400E+02  0.         2.400E+02
   21    11     10        4    0  2.400E+02  0.         2.400E+02

*** COMPUTED MEMBER NUMBERS MAY NOT AGREE WITH LAST PROBLEM ***

  PROB (CONTD)
   1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

  TABLE 4 - JOINT DATA


                         INPUT OF JOINY DATA


  JOINT  FORCE(X)    FORCE(Y)   MOMENT(Z)  SPRING(X)  SPRING(Y)  SPRING(Z)


      1 -0.          -0.         -0.          1.000E+99  1.000E.99 -0.
      3 -0.          -2.000E+01  -0.        -0.         -0.        -0.
      5 -0.          -2.000E+01  -0.        -0.         -0.        -0.
      7 -0.          -2.000E+01  -0.        -0.         -0.        -0.
      9 -0.          -1.000E+01  -0.        -0.         -0.        -0.
     11 -0.          -1.000E+01  -0.        -0.         -0.        -0.
     12 -0.          -0.         -0.        -0.          1.000E.99 -0.

                         ACCUMULATED JOINT DATA

  SAME AS INPUT FOR THIS PROBLEM


  PROB (CONTD)
   1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

  TABLE 5 - MEMBER STIFFNESS DATA


  STIFF   MOD OF    PRISMATIC PRISMATIC  NO  AXIS  OUTPUT   PIN  PIN
  TYPE    ELAST         I         A    CARDS  OPT   OPT    FROM   TO

      1 3.000E+04 4.000E+00 4.000E+00   -0     1     1        1    1
      2 3.000E+04 2.250E+00 3.000E+00   -0     1     1        1    1
      3 3.000E+04 2.250E+09 3.000E+00   -0     1     1        1    1
      4 3.000E+04 1.000E+00 2.000E+00   -0     1     1        1    1
```

```
PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 6 - MEMBER LOAD DATA


NO DATA



PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 7 - COMPILATION TABLE



NO DATA



PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS

                 DISPLACEMENTS                          REACTIONS

JOINT  DISP(X)      DISP(Y)  ROTATION(Z) REACT(X)     REACT(Y)     REACT(Z)



    1  1.592-110 -4.500E-08  1.000E+99 -1.592E-11  4.500E+01  0.
    2  5.967E-01 -9.361E-01  1.000E+99  0.          0.         0.
    3  0.000E-02 -1.016E+00  1.000E+99  0.          0.         0.
    4  4.567E-01 -1.561E+00  1.000E+98  0.          0.         0.
    5  1.000E-01 -1.541E+00  1.000E+99  0.          0.         0.
    6  3.067E-01 -1.736E+00  1.000E+99  0.          0.         0.
    7  3.200E-01 -1.730E+00  1.000E+99  0.          0.         0.
    8  1.567E-01 -1.459E+00  1.000E+99  0.          0.         0.
    9  4.400E-01 -1.399E+00  1.000E+99  0.          0.         0.
   10  3.667E-02 -8.073E-01  1.000E+99  0.          0.         0.
   11  5.190E-01 -8.473E-01  1.000E+99  0.          0.         0.
   12  5.800E-01 -3.500E-08  1.000E+99  0.          3.500E+01  0.
```

```
PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 9 - MEMBER RESULTS


MEMBER NUMBER     1      STIFF TYPE     1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00       BETA =   0.
GOES FROM JOINT     1 TO JOINT     3
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT      1                  AT JOINT      3

 AXIAL FORCE =    4.500E+01       AXIAL FORCE =   4.500E+01
 SHEAR        =  -1.036E-10       SHEAR        =   1.865E-10
 MOMENT       =  -4.441E-12       MOMENT       =   4.441E-11

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  4.641E-10



MEMBER NUMBER     2      STIFF TYPE     1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00       BETA =   0.
GOES FROM JOINT     3 TO JOINT     5
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT      3                  AT JOINT      5

 AXIAL FORCE =    4.500E+01       AXIAL FORCE =   4.500E+01
 SHEAR        =  -5.240E-10       SHEAR        =   4.130E-10
 MOMENT       =  -5.329E-11       MOMENT       =   1.465E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.066E-09



MEMBER NUMBER     3      STIFF TYPE     1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00       BETA =   0.
GOES FROM JOINT     5 TO JOINT     7
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT      5                  AT JOINT      7

 AXIAL FORCE =    7.000E+01       AXIAL FORCE =   7.000E+01
 SHEAR        =  -8.200E-10       SHEAR        =   5.715E-10
 MOMENT       =  -2.442E-11       MOMENT       =   3.610E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.255E-09
```

```
PROB (CONTD)
 1101     TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER     4      STIFF TYPE     1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00        BETA =   0.
GOES FROM JOINT    7 TO JOINT    9
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT      7               AT JOINT      9

 AXIAL FORCE =   6.000E+01      AXIAL FORCE =   6.000E+01
 SHEAR       =  -7.268E-10      SHEAR       =   4.024E-10
 MOMENT      =  -4.485E-10      MOMENT      =   2.034E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.033E-09


MEMBER NUMBER     5      STIFF TYPE     1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00        BETA =   0.
GOES FROM JOINT    9 TO JOINT   11
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT      9               AT JOINT     11

 AXIAL FORCE =   3.500E+01      AXIAL FORCE =   3.500E+01
 SHEAR       =  -5.773E-10      SHEAR       =   3.271E-10
 MOMENT      =  -2.398E-10      MOMENT      =   1.221E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.008E-09


MEMBER NUMBER     6      STIFF TYPE     1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00        BETA =   0.
GOES FROM JOINT   11 TO JOINT   12
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT     11               AT JOINT     12

 AXIAL FORCE =   3.500E+01      AXIAL FORCE =   3.500E+01
 SHEAR       =  -3.249E-10      SHEAR       =   8.845E-11
 MOMENT      =  -7.327E-11      MOMENT      =   4.106E-12

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  4.563E-10
```

```
PROB (CONTD)
 1101     TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER     7      STIFF TYPE     1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00        BETA =   0.
GOES FROM JOINT    2 TO JOINT    4
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT      2               AT JOINT      4

 AXIAL FORCE =  -7.000E+01      AXIAL FORCE =  -7.000E+01
 SHEAR       =  -5.003E-10      SHEAR       =   4.989E-10
 MOMENT      =  -1.066E-10      MOMENT      =   4.186E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.004E-09


MEMBER NUMBER     8      STIFF TYPE     1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00        BETA =   0.
GOES FROM JOINT    4 TO JOINT    6
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT      4               AT JOINT      6

 AXIAL FORCE =  -7.500E+01      AXIAL FORCE =  -7.500E+01
 SHEAR       =  -8.051E-10      SHEAR       =   5.647E-10
 MOMENT      =   3.497E-11      MOMENT      =   3.370E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.062E-09


MEMBER NUMBER     9      STIFF TYPE     1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00        BETA =   0.
GOES FROM JOINT    6 TO JOINT    8
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT                      AT JOINT      8

 AXIAL FORCE =  -7.500E+01      AXIAL FORCE =  -7.500E+01
 SHEAR       =  -8.293E-10      SHEAR       =   5.642E-10
 MOMENT      =   1.887E-11      MOMENT      =   4.211E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.010E-09
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PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER   10      STIFF TYPE    1      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   1.000E+00        BETA =   0.
GOES FROM JOINT    8 TO JOINT   10
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

             AT JOINT      8                 AT JOINT     10

 AXIAL FORCE =  -6.000E+01       AXIAL FORCE =  -6.000E+01
 SHEAR       =  -6.565E-10       SHEAR       =   3.664E-10
 MOMENT      =  -1.088E-10       MOMENT      =   2.420E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  6.016E-10


MEMBER NUMBER   11      STIFF TYPE    2      LOAD TYPE      0
LENGTH =   3.394E+02      ALPHA =   7.071E-01        BETA =   7.071E-01
GOES FROM JOINT    1 TO JOINT    2
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

             AT JOINT      1                 AT JOINT      2

 AXIAL FORCE =  -6.364E+01       AXIAL FORCE =  -6.364E+01
 SHEAR       =   5.329E-11       SHEAR       =  -7.223E-11
 MOMENT      =  -1.766E-12       MOMENT      =   1.457E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.839E-10


MEMBER NUMBER   12      STIFF TYPE    2      LOAD TYPE      0
LENGTH =   3.394E+02      ALPHA =   7.071E-01        BETA =   7.071E-01
GOES FROM JOINT    7 TO JOINT    8
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

             AT JOINT      7                 AT JOINT      8

 AXIAL FORCE =   2.121E+01       AXIAL FORCE =   2.121E+01
 SHEAR       =   1.839E-10       SHEAR       =  -1.655E-10
 MOMENT      =  -4.800E-11       MOMENT      =   7.604E-11

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.300E-10
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PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER   13      STIFF TYPE    2      LOAD TYPE      0
LENGTH =   3.394E+02      ALPHA =   7.071E-01        BETA =   7.071E-01
GOES FROM JOINT    9 TO JOINT   10
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

             AT JOINT      9                 AT JOINT     10

 AXIAL FORCE =   3.536E+01       AXIAL FORCE =   3.536E+01
 SHEAR       =   1.374E-10       SHEAR       =  -1.039E-10
 MOMENT      =  -7.065E-12       MOMENT      =   7.728E-11

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.343E-10


MEMBER NUMBER   14      STIFF TYPE    3      LOAD TYPE      0
LENGTH =   3.394E+02      ALPHA =   7.071E-01        BETA =  -7.071E-01
GOES FROM JOINT    2 TO JOINT    5
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

             AT JOINT      2                 AT JOINT      5

 AXIAL FORCE =   3.536E+01       AXIAL FORCE =   3.536E+01
 SHEAR       =   6.287E-11       SHEAR       =  -9.263E-11
 MOMENT      =   7.065E-12       MOMENT      =   5.785E-11

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.262E-10


MEMBER NUMBER   15      STIFF TYPE    3      LOAD TYPE      0
LENGTH =   3.394E+02      ALPHA =   7.071E-01        BETA =  -7.071E-01
GOES FROM JOINT    4 TO JOINT    7
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

             AT JOINT      4                 AT JOINT      7

 AXIAL FORCE =   7.071E+00       AXIAL FORCE =   7.071E+00
 SHEAR       =   1.062E-10       SHEAR       =  -1.090E-10
 MOMENT      =  -1.082E-11       MOMENT      =   1.156E-10

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.261E-10
```

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PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC


TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER   16      STIFF TYPE     3      LOAD TYPE      0
LENGTH =   3.394E+02      ALPHA =    7.071E-01        BETA =  -7.071E-01
GOES FROM JOINT   10 TO JOINT   12
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT     10                 AT JOINT     12

 AXIAL FORCE =  -4.950E+01       AXIAL FORCE =  -4.950E+01
 SHEAR       =   2.248E-11       SHEAR       =   8.431E-12
 MOMENT      =  -1.413E-11       MOMENT      =  -2.318E-11

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.132E-10


MEMBER NUMBER   17      STIFF TYPE     4      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   0.                   BETA =   1.000E+00
GOES FROM JOINT    3 TO JOINT    2
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      3                 AT JOINT      2

 AXIAL FORCE =   2.000E+01       AXIAL FORCE =   2.000E+01
 SHEAR       =  -2.442E-11       SHEAR       =   3.095E-11
 MOMENT      =  -0.              MOMENT      =   3.428E-11

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.842E-10


MEMBER NUMBER   18      STIFF TYPE     4      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   0.                   BETA =   1.000E+00
GOES FROM JOINT    5 TO JOINT    4
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      5                 AT JOINT      4

 AXIAL FORCE =  -5.000E+00       AXIAL FORCE =  -5.000E+00
 SHEAR       =  -2.877E-11       SHEAR       =   3.247E-11
 MOMENT      =  -8.604E-12       MOMENT      =   2.567E-11

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  3.553E-10
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PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC


TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER   19      STIFF TYPE     4      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   0.                   BETA =   1.000E+00
GOES FROM JOINT    7 TO JOINT    6
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      7                 AT JOINT      6

 AXIAL FORCE =   2.132E-09       AXIAL FORCE =  -1.492E-09
 SHEAR       =  -4.441E-11       SHEAR       =   3.101E-11
 MOMENT      =   1.112E-11       MOMENT      =   2.944E-11

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  3.553E-10


MEMBER NUMBER   20      STIFF TYPE     4      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   0.                   BETA =   1.000E+00
GOES FROM JOINT    9 TO JOINT    8
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES


            AT JOINT      9                 AT JOINT      8


 AXIAL FORCE =  -1.500E+01       AXIAL FORCE =  -1.500E+01
 SHEAR       =  -4.746E-11       SHEAR       =   2.239E-11
 MOMENT      =   2.776E-13       MOMENT      =   1.360E-11

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.842E-10


MEMBER NUMBER   21      STIFF TYPE     4      LOAD TYPE      0
LENGTH =   2.400E+02      ALPHA =   0.                   BETA =   1.000E+00
GOES FROM JOINT   11 TO JOINT   10
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT     11                 AT JOINT     10

 AXIAL FORCE =   1.000E+01       AXIAL FORCE =   1.000E+01
 SHEAR       =  -4.959E-11       SHEAR       =   1.527E-11
 MOMENT      =  -1.554E-11       MOMENT      =   2.982E-12

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.421E-10
```

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PROB (CONTD)
 1101      TRUSS WITH UNSYMT LOADS - PG 270 STRUCTURAL ANALYSIS - MCCORMAC

TABLE 10 - JOINT EQUILIBRIUM ERRORS

JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT

    1  4.229E-11   1.344E-10 -6.207E-12
    2 -2.517E-09   2.538E-09 -2.795E-10
    3 -4.064E-10   2.014E-09 -9.770E-11
    4 -3.447E-09   4.036E-09 -4.201E-10
    5 -1.906E-09   4.124E-09 -2.374E-10
    6 -1.417E-09   2.886E-09 -3.475E-10
    7 -1.608E-09   5.326E-09 -9.628E-10
    8  1.924E-10   3.191E-09 -6.195E-10
    9 -1.132E-09   3.382E-09 -4.500E-10
   10 -1.526E-10   2.063E-09 -3.355E-10
   11 -2.394E-09   1.695E-09 -2.109E-10
   12 -1.397E-09   4.818E-10  1.708E-11
```

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02 JULY 70  - COM - MM
EXAMPLE PROBLEMS FOR REPORT


PROB
 1102     EFFECT OF RIGID CONNECTIONS ON TRUSS




TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE    1


                   INPUT TABLES

     TABLE    HOLD DATA FROM       NUMBER OF CARDS
     NUMBER   LAST PROBLEM         ADDED FOR THIS
              (1 = YES,0 = NO)     PROBLEM

       2             1                  -0
       3             1                  -0
       4             1                  -0
       5            -0                   4
       6            -0                  -0
       7            -0                  -0
                  OUTPUT TABLES

     TABLE   SUPPRESS OUTPUT
     NUMBER  (1 = YES,0 = NO)

       8            -0
       9            -0
      10            -0
```

```
PROB (CONTD)
 1102     EFFECT OF RIGID CONNECTIONS ON TRUSS


TABLE 2 - FRAME GEOMETRY DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE


     COMPUTED JOINT COORDINATES

     JOINT      X           Y


        1  0.         0.
        2  2.400E+02  2.400E+02
        3  2.400E+02  0.
        4  4.800E+02  2.400E+02
        5  4.800E+02  0.
        6  7.200E+02  2.400E+02
        7  7.200E+02  0.
        8  9.600E+02  2.400E+02
        9  9.600E+02  0.
       10  1.200E+03  2.400E+02
       11  1.200E+03  0.
       12  1.440E+03  0.
```

```
PROB (CONTD)
 1102      EFFECT OF RIGID CONNECTIONS ON TRUSS


TABLE 3 - MEMBER LOCATION DATA



HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE


       COMPUTED MEMBER NUMBERS,LENGTHS,AND OFFSETS

MEMBER  FROM    TO    STIFF LOAD   LENGTH     X-OFFSET    Y-OFFSET
 NUMB  JOINT  JOINT    TYPE TYPE


     1      1      3      1    0  2.400E+02  2.400E+02  0.
     2      3      5      1    0  2.400E+02  2.400E+02  0.
     3      5      7      1    0  2.400E+02  2.400E+02  0.
     4      7      9      1    0  2.400E+02  2.400E+02  0.
     5      9     11      1    0  2.400E+02  2.400E+02  0.
     6     11     12      1    0  2.400E+02  2.400E+02  0.
     7      2      4      1    0  2.400E+02  2.400E+02  0.
     8      4      6      1    0  2.400E+02  2.400E+02  0.
     9      6      8      1    0  2.400E+02  2.400E+02  0.
    10      8     10      1    0  2.400E+02  2.400E+02  0.
    11      1      2      2    0  3.394E+02  2.400E+02  2.400E+02
    12      7      8      2    0  3.394E+02  2.400E+02  2.400E+02
    13      9     10      2    0  3.394E+02  2.400E+02  2.400E+02
    14      2      5      3    0  3.394E+02  2.400E+02 -2.400E+02
    15      4      7      3    0  3.394E+02  2.400E+02 -2.400E+02
    16     10     12      3    0  3.394E+02  2.400E+02 -2.400E+02
    17      3      2      4    0  2.400E+02  0.         2.400E+02
    18      5      4      4    0  2.400E+02  0.         2.400E+02
    19      7      6      4    0  2.400E+02  0.         2.400E+02
    20      9      8      4    0  2.400E+02  0.         2.400E+02
    21     11     10      4    0  2.400E+02  0.         2.400E+02

*** COMPUTED MEMBER NUMBERS AGREE WITH LAST PROBLEM ***
```

```
PROB (CONTD)
 1102      EFFECT OF RIGID CONNECTIONS ON TRUSS


TABLE 4 - JOINT DATA



HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE


                         ACCUMULATED JOINT DATA


JOINT  FORCE(X)    FORCE(Y)   MOMENT(Z)   SPRING(X)   SPRING(Y)   SPRING(Z)


    1  0.           0.          0.          1.000E+99   1.000E+99   0.
    3  0.          -2.000E+01   0.          0.          0.          0.
    5  0.          -2.000E+01   0.          0.          0.          0.
    7  0.          -2.000E+01   0.          0.          0.          0.
    9  0.          -1.000E+01   0.          0.          0.          0.
   11  0.          -1.000E+01   0.          0.          0.          0.
   12  0.           0.          0.          0.          1.000E+99   0.
```

```
PROB (CONTD)
 1102      EFFECT OF RIGID CONNECTIONS ON TRUSS


TABLE 5 - MEMBER STIFFNESS DATA




STIFF   MOD OF    PRISMATIC PRISMATIC  NO  AXIS   OUTPUT    PIN   PIN
 TYPE   ELAST         I         A    CARDS  OPT     OPT    FROM    TO


    1 3.000E+04 4.000E+00 4.000E+00   -0     1      1       -0    -0
    2 3.000E+04 2.250E+00 3.000E+00   -0     1      1       -0    -0
    3 3.000E+04 2.250E+00 3.000E+00   -0     1      1       -0    -0
    4 3.000E+04 1.000E+00 2.000E+00   -0     1      1       -0    -0
```

```
PROB (CONTD)
 1102      EFFECT OF RIGID CONNECTIONS ON TRUSS


TABLE 6 - MEMBER LOAD DATA


NO DATA



PROB (CONTD)
 1102      EFFECT OF RIGID CONNECTIONS ON TRUSS

TABLE 7 - COMPILATION TABLE


NO DATA



PROB (CONTD)
 1102      EFFECT OF RIGID CONNECTIONS ON TRUSS

TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS

             DISPLACEMENTS                         REACTIONS

JOINT  DISP(X)     DISP(Y)   ROTATION(Z) REACT(X)     REACT(Y)     REACT(Z)


    1  4.343-110 -4.500E-98 -4.391E-03 -4.343E-11  4.500E+01  0.
    2  5.966E-01 -9.359E-01 -2.670E-03  0.          0.         0.
    3  8.998E-02 -1.016E+00 -3.172E-03  0.          0.         0.
    4  4.566E-01 -1.561E+00 -1.683E-03  0.          0.         0.
    5  1.800E-01 -1.541E+00 -1.513E-03  0.          0.         0.
    6  3.066E-01 -1.735E+00  2.246E-04  0.          0.         0.
    7  3.200E-01 -1.735E+00  2.702E-04  0.          0.         0.
    8  1.567E-01 -1.459E+00  1.922E-03  0.          0.         0.
    9  4.400E-01 -1.399E+00  1.853E-03  0.          0.         0.
   10  3.667E-02 -8.072E-01  2.604E-03  0.          0.         0.
   11  5.100E-01 -8.472E-01  2.859E-03  0.          0.         0.
   12  5.799E-01 -3.500E-98  3.596E-03  0.          3.500E+01  0.
```

```
PROB (CONTD)
 1102      EFFECT OF RIGID CONNECTIONS ON TRUSS


TABLE 9 - MEMBER RESULTS


MEMBER NUMBER    1      STIFF TYPE    1      LOAD TYPE    0
LENGTH =   2.400E+02      ALPHA =   1.000E+00       BETA =   0.
GOES FROM JOINT     1 TO JOINT     3
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      1                AT JOINT      3

 AXIAL FORCE =    4.499E+01       AXIAL FORCE =   4.499E+01
 SHEAR       =    1.129E-02       SHEAR       =   1.129E-02
 MOMENT      =   -7.451E- 1       MOMENT      =   1.963E+00


THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  3.775E-10



MEMBER NUMBER    2      STIFF TYPE    1      LOAD TYPE    0
LENGTH =   2.400E+02      ALPHA =   1.000E+00       BETA =   0.
GOES FROM JOINT     3 TO JOINT     5
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      3                AT

 AXIAL FORCE =    4.500E+01
 SHEAR       =   -3.861
 MOMENT      =                                LOAD TYPE    0
                                                              BETA =   1.000E+00
                                   8
THE                      TH RESPECT TO THE MEMBER AXES

              JOINT      4                AT JOINT      8

 AXIAL FORCE =   -1.498E+01       AXIAL FORCE =  -1.498E+01
 SHEAR       =    4.423E-03       SHEAR       =   4.423E-03
 MOMENT      =   -5.221E- 1       MOMENT      =   5.394E-01

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.842E-10



MEMBER NUMBER   21      STIFF TYPE    4      LOAD TYPE    0
LENGTH =   2.400E+02      ALPHA =   0.                      BETA =   1.000E+00
GOES FROM JOINT    11 TO JOINT    10
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES


            AT JOINT     11                AT JOINT     10

 AXIAL FORCE =    9.991E+00       AXIAL FORCE =   9.991E+00
 SHEAR       =    4.747E-03       SHEAR       =   4.747E-03
 MOMENT      =   -6.016E-01       MOMENT      =   5.377E-01


THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.776E-10
```

```
PROB (CONTD)
 1102     EFFECT OF RIGID CONNECTIONS ON TRUSS

TABLE 10 - JOINT EQUILIBRIUM ERRORS


JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT


    1 -2.621E-07 -1.501E-06 -1.487E-04
    2  1.022E-06 -1.960E-06 -4.970E-05
    3 -7.916E-07  2.369E-06 -4.425E-05
    4  4.775E-07  1.733E-06 -1.360E-04
    5 -4.082E-07 -1.305E-06  2.958E-05
    6 -1.887E-07  2.957E-07  1.552E-05
    7  2.801E-07  1.880E-06  2.587E-05
    8 -8.309E-07  1.606E-06  1.321E-04
    9  8.106E-07 -1.667E-06  2.046E-05
   10 -1.085E-06 -1.867E-06  4.071E-05
   11  7.394E-07  1.406E-06  2.601E-05
   12  2.210E-07 -9.586E-07  8.840E-05
```

```
     02 JULY 70  - COM - MM
     EXAMPLE PROBLEMS FOR REPORT


PROB
 1103      EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS


TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE     1


                         INPUT TABLES

       TABLE     HOLD DATA FROM       NUMBER OF CARDS
      NUMBER     LAST PROBLEM         ADDED FOR THIS
                 (1 = YES,0 = NO)     PROBLEM

         2              1                    -0
         3              1                    -0
         4              1                     1
         5              1                    -0
         6              1                    -0
         7             -0                    -0
                         OUTPUT TABLES

       TABLE   SUPPRESS OUTPUT
      NUMBER  (1 = YES,0 = NO)


         8             -0
         9             -0
        10             -0
```

```
PROB (CONTD)
 1103      EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS

TABLE 2 - FRAME GEOMETRY DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE


     COMPUTED JOINT COORDINATES


     JOINT      X           Y

         1  0.          0.
         2  2.400E+02  2.400E+02
         3  2.400E+02  0.
         4  4.800E+02  2.400E+02
         5  4.800E+02  0.
         6  7.200E+02  2.400E+02
         7  7.200E+02  0.
         8  9.600E+02  2.400E+02
         9  9.600E+02  0.
        10  1.200E+03  2.400E+02
        11  1.200E+03  0.
        12  1.440E+03  0.
```

```
PROB (CONTD)
 1103      EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS


TABLE 3 - MEMBER LOCATION DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE


        COMPUTED MEMBER NUMBERS,LENGTHS,AND OFFSETS

MEMBER  FROM    TO    STIFF LOAD   LENGTH     X-OFFSET   Y-OFFSET
 NUMB   JOINT  JOINT   TYPE TYPE


    1      1     3      1    0  2.400E+02  2.400E+02  0.
    2      3     5      1    0  2.400E+02  2.400E+02  0.
    3      5     7      1    0  2.400E+02  2.400E+02  0.
    4      7     9      1    0  2.400E+02  2.400E+02  0.
    5      9    11      1    0  2.400E+02  2.400E+02  0.
    6     11    12      1    0  2.400E+02  2.400E+02  0.
    7      2     4      1    0  2.400E+02  2.400E+02  0.
    8      4     6      1    0  2.400E+02  2.400E+02  0.
    9      6     8      1    0  2.400E+02  2.400E+02  0.
   10      8    10      1    0  2.400E+02  2.400E+02  0.
   11      1     2      2    0  3.394E+02  2.400E+02  2.400E+02
   12      7     8      2    0  3.394E+02  2.400E+02  2.400E+02
   13      9    10      2    0  3.394E+02  2.400E+02  2.400E+02
   14      2     5      3    0  3.394E+02  2.400E+02 -2.400E+02
   15      4     7      3    0  3.394E+02  2.400E+02 -2.400E+02
   16     10    12      3    0  3.394E+02  2.400E+02 -2.400E+02
   17      3     2      4    0  2.400E+02  0.         2.400E+02
   18      5     4      4    0  2.400E+02  0.         2.400E+02
   19      7     6      4    0  2.400E+02  0.         2.400E+02
   20      9     8      4    0  2.400E+02  0.         2.400E+02
   21     11    10      4    0  2.400E+02  0.         2.400E+02

*** COMPUTED MEMBER NUMBERS AGREE WITH LAST PROBLEM ***
```

```
PROB (CONTD)
 1103      EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS

TABLE 4 - JOINT DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

                          INPUT OF JOINT DATA

JOINT  FORCE(X)   FORCE(Y)  MOMENT(Z)  SPRING(X)  SPRING(Y)  SPRING(Z)


  12 -0.         -0.        -0.         1.000E+99 -0.         -0.

                          ACCUMULATED JOINT DATA


JOINT  FORCE(X)   FORCE(Y)  MOMENT(Z)  SPRING(X)  SPRING(Y)  SPRING(Z)


   1  0.          0.         0.         1.000E+99  1.000E+99  0.
   3  0.         -2.000E+01  0.         0.         0.         0.
   5  0.         -2.000E+01  0.         0.         0.         0.
   7  0.         -2.000E+01  0.         0.         0.         0.
   9  0.         -1.000E+01  0.         0.         0.         0.
  11  0.         -1.000E+01  0.         0.         0.         0.
  12  0.          0.         0.         1.000E+99  1.000E+99  0.
```

```
PROB (CONTD)
 1103      EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS

TABLE 5 - MEMBER STIFFNESS DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE
```

```
PROB (CONTD)
 1103     EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS

TABLE 6 - MEMBER LOAD DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE
```

```
PROB (CONTD)
 1103     EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS

TABLE 7 - COMPILATION TABLE


NO DATA
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PROB (CONTD)
 1103     EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS

TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS


              DISPLACEMENTS                        REACTIONS


JOINT  DISP(X)     DISP(Y)   ROTATION(Z) REACT(X)     REACT(Y)    REACT(Z)


    1 -4.833E-98 -4.500E-98 -2.967E-03  4.833E+01  4.500E+01  0.
    2  3.066E-01 -6.460E-01 -1.998E-03  0.         0.         0.
    3 -6.673E-03 -7.259E-01 -2.354E-03  0.         0.         0.
    4  1.666E-01 -1.174E+00 -1.532E-03  0.         0.         0.
    5 -1.334E-02 -1.154E+00 -1.349E-03  0.         0.         0.
    6  1.065E-02 -1.349E+00  2.246E-04  0.         0.         0.
    7  2.999E-02 -1.349E+00  2.702E-04  0.         0.         0.
    8 -1.333E-01 -1.072E+00  1.772E-03  0.         0.         0.
    9  5.332E-02 -1.012E+00  1.689E-03  0.         0.         0.
   10 -2.533E-01 -5.173E-01  1.932E-03  0.         0.         0.
   11  2.667E-02 -5.572E-01  2.041E-03  0.         0.         0.
   12  4.833E-98 -3.500E-98  2.172E-03 -4.833E+01  3.500E+01  0.
```

```
PROB (CONTD)
 1103     EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS

TABLE 9 - MEMBER RESULTS


MEMBER NUMBER     1      STIFF TYPE     1      LOAD TYPE     0
LENGTH =   2.400E+02      ALPHA =   1.000E+00       BETA =   0.
GOES FROM JOINT    1 TO JOINT    3
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT      1                AT JOINT      3


 AXIAL FORCE =  -3.337E+00       AXIAL FORCE =  -3.337E+00
 SHEAR       =   9.108E-03       SHEAR       =   9.108E-03
 MOMENT      =  -7.867E-01       MOMENT      =   1.399E+00

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  3.220E-10


MEMBER NUMBER     2      STIFF TYPE     1      LOAD TYPE     0
LENGTH =   2.400E+02      ALPHA =   1.000E+00       BETA =   0.
GOES FROM JOINT    3 TO JOINT    5
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES
           AT JOINT      3                AT

 AXIAL FORCE =  -3.331E+00
 SHEAR       =  -1.65
 MOMENT      =                             OAD TYPE      0
                                                  BETA =   1.000E+00
                           ESPECT TO THE MEMBER AXES

           AT JOINT      9                AT JOINT      8

 AXIAL FORCE =  -1.498E+01       AXIAL FORCE =  -1.498E+01
 SHEAR       =   5.956E-03       SHEAR       =   5.956E-03
 MOMENT      =  -7.[illegible]44E-01       MOMENT      =   7.25[illegible]E-01

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  3.553E-10


MEMBER NUMBER    21      STIFF TYPE     4      LOAD TYPE     0
LENGTH =   2.400E+02      ALPHA =   0.                  BETA =   1.000E+00
GOES FROM JOINT   11 TO JOINT   10
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT     11                AT JOINT     10

 AXIAL FORCE =   9.995E+00       AXIAL FORCE =   9.995E+00
 SHEAR       =   5.126E-03       SHEAR       =   5.126E-03
 MOMENT      =  -6.288E-01       MOMENT      =   6.014E-01


THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.776E-10
```

```
PROB (CONTD)
 1103     EFFECT OF RIGID CONNECTIONS AND ROLLER FREEZING ON TRUSS

TABLE 10 - JOINT EQUILIBRIUM ERRORS


JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT


    1 -3.866E-07 -1.036E-06 -7.796E-05
    2  1.195E-06 -2.130E-06 -1.946E-05
    3 -8.504E-07  1.683E-06 -3.765E-05
    4  6.602E-07  1.413E-06 -1.605E-04
    5 -6.348E-07 -1.269E-06 -2.421E-05
    6 -1.874E-07  8.829E-07  1.552E-05
    7  2.817E-07  2.636E-06  2.588E-05
    8 -1.011E-06  1.286E-06  1.566E-04
    9  1.040E-06 -1.631E-06  7.424E-05
   10 -1.256E-06 -2.037E-06  1.047E-05
   11  8.008E-07  7.210E-07  1.941E-05
   12  3.469E-07 -4.942E-07  1.767E-05
```

```
02 JULY 70  - COM - MM
EXAMPLE PROBLEMS FOR REPORT


PROB
 1201      TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD


TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE     1


                   INPUT TABLES

  TABLE     HOLD DATA FROM        NUMBER OF CARDS
 NUMBER     LAST PROBLEM          ADDED FOR THIS
            (1 = YES,0 = NO)      PROBLEM

    2              -0                    6
    3              -0                    7
    4              -0                    2
    5              -0                   13
    6              -0                   10
    7              -0                    0

                   OUTPUT TABLES

  TABLE    SUPPRESS OUTPUT
 NUMBER   (1 = YES,0 = NO)

    8              -0
    9              -0
   10              -0
```

```
PROB (CONTD)
 1201      TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 2 - FRAME GEOMETRY DATA


NUMBER OF JOINTS IN FRAME =     8
REFERENCE JOINT IS JOINT      1  AT  X  =   0.          AND Y =   0.
JOINT TOLERANCE IS       1.000E-02


                   INPUT OF JOINT OFFSETS

    FROM       X-OFFSET   Y-OFFSET         TO    TO    TO    TO    TO    TO    TO
   JOINT                                JOINT

      1       0.          2.278E+02        2     3
      2       4.800E+02  -0.               4     7
      3       4.800E+02   3.312E+01        5     8
      7       0.         -2.760E+02        6
      1       9.600E+02  -4.824E+01        6


   COMPUTED JOINT COORDINATES

   JOINT      X           Y

      1  0.          0.
      2  0.          2.278E+02
      3  0.          4.555E+02
      4  4.800E+02   2.278E+02
      5  4.800E+02   4.886E+02
      6  9.600E+02  -4.824E+01
      7  9.600E+02   2.278E+02
      8  9.600E+02   5.218E+02
```

```
PROB (CONTD)
 1201      TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD


TABLE 3 - MEMBER LOCATION DATA


NUMBER OF MEMBER STIFFNESS TYPES  =    6
NUMBER OF MEMBER LOAD TYPES  =         2


                    INPUT OF MEMBER LOCATIONS

 FROM       STIFF LOAD         TO   TO   TO   TO  TO   TO   TO   TO   TO   TO
JOINT        TYPE TYPE      JOINT


    1          1    0          2    3
    4          2    0          5
    6          3    0          7
    7          4    0          8
    3          6    2          5    8
    2          5    1          4    7


         COMPUTED MEMBER NUMBERS,LENGTHS,AND OFFSETS

MEMBER  FROM   TO    STIFF LOAD  LENGTH    X-OFFSET   Y-OFFSET
 NUMB  JOINT  JOINT   TYPE TYPE


     1     1     2       1    0  2.278E+02  0.         2.278E+02
     2     2     3       1    0  2.278E+02  0.         2.278E+02
     3     4     5       2    0  2.609E+02  0.         2.609E+02
     4     6     7       3    0  2.760E+02  0.         2.740E+02
     5     7     8       4    0  2.940E+02  0.         2.940E+02
     6     2     4       5    1  4.800E+02  4.800E+02  0.
     7     4     7       5    1  4.800E+02  4.800E+02  0.
     8     3     5       6    2  4.811E+02  4.800E+02  3.312E+01
     9     5     8       6    2  4.811E+02  4.800E+02  3.312E+01

*** COMPUTED MEMBER NUMBERS MAY NOT AGREE WITH LAST PROBLEM ***
```

```
PROB (CONTD)
 1201      TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 4 - JOINT DATA


                    INPUT OF JOINT DATA


JOINT  FORCE(X)   FORCE(Y)  MOMENT(Z)  SPRING(X)  SPRING(Y)  SPRING(Z)


    1 -0.         -0.        -0.        1.000E+99  1.000E+99 -0.
    6 -0.         -0.        -0.        1.000E+99  1.000E+99  1.000E+99

                    ACCUMULATED JOINT DATA

SAME AS INPUT FOR THIS PROBLEM




PROB (CONTD)
 1201      TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 5 - MEMBER STIFFNESS DATA




STIFF  MOD OF    PRISMATIC PRISMATIC  NO   AXIS  OUTPUT   PIN   PIN
 TYPE  ELAST         I         A     CARDS  OPT   OPT    FROM   TO


   1 2.960E+04 1.050E+03 2.800E+01   -0     1     1       -0    -0
   2 2.960E+04 8.000E+02 2.000E+01   -0     1     1       -0     1
   3 2.960E+04 1.050E+03 2.800E+01   -0     1     1       -0    -0
   4 2.960E+04 1.050E+03 2.800E+01   -0     1     1       -0    -0
   5 2.960E+04 1.800E+03 2.400E+01   -0     1    -0       -0    -0
   6 2.960E+04-0.         -0.         7     2    -0       -0    -0
     STIFF TYPE    6 CONTD       RESTRAINTS ARE IN MEMBER PRIMED AXES
     FROM         TO          I           A          SX             SY             SZ

  0.          -0.         9.000E+03  7.000E+01 -0.          -0.          -0.
 -0.           6.300E+01  3.400E+03  4.200E+01 -0.          -0.          -0.
  6.300E+01   1.860E+02  3.400E+03  4.200E+01 -0.          -0.          -0.
  1.860E+02   2.940E+02  5.000E+03  5.000E+01 -0.          -0.          -0.
  2.940E+02   4.164E+02  3.400E+03  4.200E+01 -0.          -0.          -0.
  4.164E+02  -0.          3.400E+03  4.200E+01 -0.          -0.          -0.
 -0.           4.800E+02  9.000E+03  7.000E+01 -0.          -0.          -0.
```

```
PROB (CONTD)
 1201     TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 6 - MEMBER LOAD DATA


 LOAD  UNIFORM      UNIFORM     NO   AXIS
 TYPE      QX          QY      CARDS  OPT

    1 -0.          -0.            4    3

     LOAD TYPE      1 CONTD
     FROM         TO          QX          QY            QZ

  9.600E+01  9.600E+01 -0.          -1.000E+01 -0.
  1.920E+02  1.920E+02 -0.          -1.000E+01 -0.
  2.880E+02  2.880E+02 -0.          -1.000E+01 -0.
  3.840E+02  3.840E+02 -0.          -1.000E+01 -0.

 LOAD  UNIFORM      UNIFORM     NO   AXIS
 TYPE      QX          QY      CARDS  OPT

    2 -0.          -0.            4    3

     LOAD TYPE      2 CONTD
     FROM         TO          QX          QY            QZ

  9.600E+01  9.600E+01 -0.          -2.000E+01 -0.
  1.920E+02  1.920E+02 -0.          -2.000E+01 -0.
  2.880E+02  2.880E+02 -0.          -2.000E+01 -0.
  3.840E+02  3.840E+02 -0.           2.000E+01 -0.
```

```
PROB (CONTD)
 1201     TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD


TABLE 7 - COMPILATION TABLE


NO DATA
```

```
PROB (CONTD)
 1201     TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD


TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS

               DISPLACEMENTS                        REACTIONS

JOINT  DISP(X)     DISP(Y)  ROTATION(Z) REACT(X)    REACT(Y)    REACT(Z)


    1 -1.090E-98 -1.205E-97  3.181E-03  1.090E+01  1.205E+02  0.
    2 -3.377E-02 -3.312E-02 -5.918E-03  0.         0.         0.
    3  7.278E-01 -5.390E-02 -1.590E-02  0.         0.         0.
    4 -4.391E-03 -5.928E+00 -7.025E-04  0.         0.         0.
    5  1.114E+00 -5.934E+00  3.291E-04  0.         0.         0.
    6  1.090E-98 -1.195E-97 -1.021E-96 -1.090E+01  1.195E+02  1.021E+03
    7  2.246E-02 -3.979E-02  4.291E-03  0.         0.         0.
    8  6.917E-01 -6.477E-02  1.463E-02  0.         0.         0.
```

```
PROB (CONTD)
 1201      TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 4 - MEMBER RESULTS


MEMBER NUMBER     1      STIFF TYPE    1      LOAD TYPE      0
LENGTH =   2.278E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     1 TO JOINT     2
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      1                 AT JOINT      2

 AXIAL FORCE =  -1.205E+02       AXIAL FORCE =  -1.205E+02
 SHEAR       =  -1.091E+01       SHEAR       =  -1.091E+01
 MOMENT      =   1.940E-01       MOMENT      =  -2.484E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  5.787E-08


MEMBER NUMBER     2      STIFF TYPE    1      LOAD TYPE      0
LENGTH =   2.278E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     2 TO JOINT     3
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      2                 AT JOINT      3

 AXIAL FORCE =  -7.562E+01       AXIAL FORCE =  -7.562E+01
 SHEAR       =  -5.440E+01       SHEAR       =  -5.440E+01
 MOMENT      =   4.833E+03       MOMENT      =  -7.557E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  6.820E-08


MEMBER NUMBER     3      STIFF TYPE    2      LOAD TYPE      0
LENGTH =   2.609E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     4 TO JOINT     5
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      4                 AT JOINT      5

 AXIAL FORCE =  -1.395E+01       AXIAL FORCE =  -1.395E+01
 SHEAR       =   3.740E+00       SHEAR       =   3.740E+00
 MOMENT      =  -9.757E+02       MOMENT      =   3.95 E-08

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  6.392E-08
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PROB (CONTD)
 1201      TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 4 - MEMBER RESULTS (CONTD)


MEMBER NUMBER     4      STIFF TYPE    3      LOAD TYPE      0
LENGTH =   2.760E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     6 TO JOINT     7
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      6                 AT JOINT      7

 AXIAL FORCE =  -1.195E+02       AXIAL FORCE =  -1.195E+02
 SHEAR       =   1.091E+01       SHEAR       =   1.091E+01
 MOMENT      =  -1.022E+03       MOMENT      =   1.988E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.969E-08


MEMBER NUMBER     5      STIFF TYPE    4      LOAD TYPE      0
LENGTH =   2.946E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     7 TO JOINT     8
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      7                 AT JOINT      8

 AXIAL FORCE =  -7.042E+01       AXIAL FORCE =  -7.042E+01
 SHEAR       =   5.066E+01       SHEAR       =   5.066E+01
 MOMENT      =  -6.353E+03       MOMENT      =   8.54 E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.556E-07
```

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PROB (CONTD)
 1201     TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER     6      STIFF TYPE     5      LOAD TYPE      1
LENGTH =   4.800E+02      ALPHA =   1.000E+00      BETA =   0.
GOES FROM JOINT     2 TO JOINT     4
OUTPUT DISTANCES ARE FROM JOINT     2 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                     DISPLACEMENTS                            FORCES

  DISTANCE      AXIAL      LATERAL    ROTATIONAL    AXIAL       SHEAR       MOMENT


  0.          -3.377E-02 -3.312E-02 -5.918E-03   4.349E+01   4.490E+01  -7.316E+03
  2.400E+01   -3.230E-02 -2.127E-01 -8.971E-03   4.349E+01   4.490E+01  -6.239E+03
  4.800E+01   -3.084E-02 -4.597E-01 -1.154E-02   4.349E+01   4.490E+01  -5.161E+03
  7.200E+01   -2.937E-02 -7.625E-01 -1.302E-02   4.349E+01   4.490E+01  -4.084E+03
  9.600E+01   -2.790E-02 -1.109E+00 -1.522E-02   4.349E+01   3.990E+01  -3.006E+03
  1.200E+02   -2.643E-02 -1.489E+00 -1.638E-02   4.349E+01   3.490E+01  -2.169E+03
  1.440E+02   -2.496E-02 -1.893E+00 -1.717E-02   4.349E+01   3.490E+01  -1.331E+03
  1.680E+02   -2.349E-02 -2.311E+00 -1.758E-02   4.349E+01   3.490E+01  -4.936E+02
  1.920E+02   -2.202E-02 -2.734E+00 -1.762E-02   4.349E+01   2.990E+01   3.439E+02
  2.160E+02   -2.055E-02 -3.153E+00 -1.733E-02   4.349E+01   2.490E+01   9.414E+02
  2.400E+02   -1.908E-02 -3.563E+00 -1.677E-02   4.349E+01   2.490E+01   1.539E+03
  2.640E+02   -1.761E-02 -3.956E+00 -1.594E-02   4.349E+01   2.490E+01   2.136E+03
  2.880E+02   -1.614E-02 -4.326E+00 -1.484E-02   4.349E+01   1.990E+01   2.734E+03
  3.120E+02   -1.468E-02 -4.667E+00 -1.353E-02   4.349E+01   1.490E+01   3.091E+03
  3.360E+02   -1.321E-02 -4.974E+00 -1.206E-02   4.349E+01   1.490E+01   3.449E+03
  3.600E+02   -1.174E-02 -5.244E+00 -1.042E-02   4.349E+01   1.490E+01   3.806E+03
  3.840E+02   -1.027E-02 -5.473E+00 -8.629E-03   4.349E+01   9.896E+00   4.164E+03
  4.080E+02   -8.799E-03 -5.657E+00 -6.726E-03   4.349E+01   4.896E+00   4.281E+03
  4.320E+02   -7.329E-03 -5.796E+00 -4.771E-03   4.349E+01   4.896E+00   4.399E+03
  4.560E+02   -5.860E-03 -5.886E+00 -2.763E-03   4.349E+01   4.896E+00   4.516E+03
  4.800E+02   -4.391E-03 -5.920E+00 -7.025E-04   4.349E+01   4.896E+00   4.634E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  3.209E-07
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PROB (CONTD)
 1201     TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER     7      STIFF TYPE     5      LOAD TYPE      1
LENGTH =   4.800E+02      ALPHA =   1.000E+00      BETA =   0.
GOES FROM JOINT     4 TO JOINT     7
OUTPUT DISTANCES ARE FROM JOINT     4 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                     DISPLACEMENTS                            FORCES

  DISTANCE      AXIAL      LATERAL    ROTATIONAL    AXIAL       SHEAR       MOMENT

  0.          -4.391E-03 -5.920E+00 -7.025E-04   3.975E+01  -9.065E+00   5.610E+03
  2.400E+01   -3.048E-03 -5.915E+00  1.775E-03   3.975E+01  -9.065E+00   5.392E+03
  4.800E+01   -1.706E-03 -5.843E+00  4.155E-03   3.975E+01  -9.065E+00   5.175E+03
  7.200E+01   -3.629E-04 -5.716E+00  6.437E-03   3.975E+01  -9.065E+00   4.957E+03
  9.600E+01    9.799E-04 -5.535E+00  8.621E-03   3.975E+01  -1.406E+01   4.740E+03
  1.200E+02    2.323E-03 -5.303E+00  1.065E-02   3.975E+01  -1.906E+01   4.282E+03
  1.440E+02    3.665E-03 -5.025E+00  1.248E-02   3.975E+01  -1.906E+01   3.825E+03
  1.680E+02    5.008E-03 -4.706E+00  1.410E-02   3.975E+01  -1.906E+01   3.367E+03
  1.920E+02    6.351E-03 -4.350E+00  1.551E-02   3.975E+01  -2.406E+01   2.909E+03
  2.160E+02    7.694E-03 -3.964E+00  1.667E-02   3.975E+01  -2.906E+01   2.212E+03
  2.400E+02    9.037E-03 -3.553E+00  1.751E-02   3.975E+01  -2.906E+01   1.514E+03
  2.640E+02    1.038E-02 -3.126E+00  1.803E-02   3.975E+01  -2.906E+01   8.167E+02
  2.880E+02    1.172E-02 -2.690E+00  1.824E-02   3.975E+01  -3.406E+01   1.192E+02
  3.120E+02    1.306E-02 -2.254E+00  1.808E-02   3.975E+01  -3.906E+01  -8.184E+02
  3.360E+02    1.441E-02 -1.826E+00  1.750E-02   3.975E+01  -3.906E+01  -1.756E+03
  3.600E+02    1.575E-02 -1.417E+00  1.650E-02   3.975E+01  -3.906E+01  -2.693E+03
  3.840E+02    1.709E-02 -1.037E+00  1.508E-02   3.975E+01  -4.406E+01  -3.631E+03
  4.080E+02    1.844E-02 -6.971E-01  1.318E-02   3.975E+01  -4.906E+01  -4.809E+03
  4.320E+02    1.978E-02 -4.090E-01  1.075E-02   3.975E+01  -4.906E+01  -5.986E+03
  4.560E+02    2.112E-02 -1.857E-01  7.783E-03   3.975E+01  -4.906E+01  -7.164E+03
  4.800E+02    2.246E-02 -3.979E-02  4.291E-03   3.975E+01  -4.906E+01  -8.341E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  3.845E-07
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PROB (CONTD)
 1201      TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER     8      STIFF TYPE     6     LOAD TYPE      2
LENGTH =   4.811E+02      ALPHA =   9.976E-01       BETA =   6.884E-02
GOES FROM JOINT    3 TO JOINT    5
OUTOUT DISTANCES ARE FROM JOINT     3 ALONG THE STRUCTURE X-AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                        DISPLACEMENTS                           FORCES

  DISTANCE       AXIAL      LATERAL   ROTATIONAL    AXIAL        SHEAR       MOMENT

  0.           7.223E-01 -1.039E-01 -1.590E-02 -5.947E+01   7.170E+01 -7.556E+03
  2.400E+01    7.216E-01 -4.947E-01 -1.658E-02 -5.947E+01   7.170E+01 -5.831E+03
  4.800E+01    7.207E-01 -9.020E-01 -1.728E-02 -5.947E+01   7.170E+01 -4.106E+03
  7.200E+01    7.196E-01 -1.326E+00 -1.796E-02 -5.947E+01   7.170E+01 -2.381E+03
  9.600E+01    7.184E-01 -1.763E+00 -1.832E-02 -5.878E+01   6.172E+01 -6.564E+02
  1.200E+02    7.173E-01 -2.205E+00 -1.833E-02 -5.809E+01   5.175E+01  5.885E+02
  1.440E+02    7.162E-01 -2.643E+00 -1.804E-02 -5.809E+01   5.175E+01  1.833E+03
  1.680E+02    7.151E-01 -3.070E+00 -1.746E-02 -5.809E+01   5.175E+01  3.078E+03
  1.920E+02    7.140E-01 -3.481E+00 -1.665E-02 -5.740E+01   4.177E+01  4.323E+03
  2.160E+02    7.131E-01 -3.872E+00 -1.588E-02 -5.671E+01   3.180E+01  5.088E+03
  2.400E+02    7.121E-01 -4.244E+00 -1.499E-02 -5.671E+01   3.180E+01  5.853E+03
  2.640E+02    7.112E-01 -4.593E+00 -1.398E-02 -5.671E+01   3.180E+01  6.618E+03
  2.880E+02    7.103E-01 -4.915E+00 -1.284E-02 -5.602E+01   2.182E+01  7.383E+03
  3.120E+02    7.093E-01 -5.205E+00 -1.119E-02 -5.534E+01   1.184E+01  7.668E+03
  3.360E+02    7.082E-01 -5.452E+00 -9.318E-03 -5.534E+01   1.184E+01  7.953E+03
  3.600E+02    7.071E-01 -5.653E+00 -7.383E-03 -5.534E+01   1.184E+01  8.238E+03
  3.840E+02    7.061E-01 -5.807E+00 -5.380E-03 -5.465E+01   1.866E+00  8.522E+03
  4.080E+02    7.050E-01 -5.912E+00 -3.366E-03 -5.396E+01  -8.110E+00  8.327E+03
  4.320E+02    7.040E-01 -5.971E+00 -1.607E-03 -5.396E+01  -8.110E+00  8.132E+03
  4.560E+02    7.032E-01 -5.995E+00 -4.769E-04 -5.396E+01  -8.110E+00  7.937E+03
  4.800E+02    7.025E-01 -5.996E+00  3.291E-04 -5.396E+01  -8.110E+00  7.742E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.283E-06
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PROB (CONTD)
 1201      TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER     9      STIFF TYPE     6     LOAD TYPE      2
LENGTH =   4.811E+02      ALPHA =   9.976E-01       BETA =   6.884E-02
GOES FROM JOINT    5 TO JOINT    8
OUTOUT DISTANCES ARE FROM JOINT     5 ALONG THE STRUCTURE X-AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                        DISPLACEMENTS                           FORCES

  DISTANCE       AXIAL      LATERAL   ROTATIONAL    AXIAL        SHEAR       MOMENT

  0.           7.025E-01 -5.996E+00  3.291E-04 -5.119E+01   6.067E+00  7.742E+03
  2.400E+01    7.019E-01 -5.979E+00  1.133E-03 -5.119E+01   6.067E+00  7.888E+03
  4.800E+01    7.011E-01 -5.939E+00  2.252E-03 -5.119E+01   6.067E+00  8.034E+03
  7.200E+01    7.002E-01 -5.865E+00  3.985E-03 -5.119E+01   6.067E+00  8.180E+03
  9.600E+01    6.992E-01 -5.746E+00  5.958E-03 -5.050E+01  -3.909E+00  8.326E+03
  1.200E+02    6.982E-01 -5.579E+00  7.908E-03 -4.981E+01  -1.389E+01  7.992E+03
  1.440E+02    6.972E-01 -5.366E+00  9.778E-03 -4.981E+01  -1.389E+01  7.658E+03
  1.680E+02    6.963E-01 -5.109E+00  1.157E-02 -4.981E+01  -1.389E+01  7.324E+03
  1.920E+02    6.954E-01 -4.811E+00  1.314E-02 -4.912E+01  -2.386E+01  6.990E+03
  2.160E+02    6.946E-01 -4.481E+00  1.421E-02 -4.844E+01  -3.384E+01  6.176E+03
  2.400E+02    6.938E-01 -4.128E+00  1.515E-02 -4.844E+01  -3.384E+01  5.362E+03
  2.640E+02    6.930E-01 -3.754E+00  1.596E-02 -4.844E+01  -3.384E+01  4.548E+03
  2.880E+02    6.922E-01 -3.361E+00  1.663E-02 -4.775E+01  -4.381E+01  3.734E+03
  3.120E+02    6.913E-01 -2.953E+00  1.730E-02 -4.706E+01  -5.379E+01  2.440E+03
  3.360E+02    6.904E-01 -2.531E+00  1.773E-02 -4.706E+01  -5.379E+01  1.145E+03
  3.600E+02    6.895E-01 -2.102E+00  1.785E-02 -4.706E+01  -5.379E+01 -1.486E+02
  3.840E+02    6.886E-01 -1.675E+00  1.766E-02 -4.637E+01  -6.377E+01 -1.443E+03
  4.080E+02    6.877E-01 -1.250E+00  1.710E-02 -4.568E+01  -7.374E+01 -3.217E+03
  4.320E+02    6.869E-01 -8.545E-01  1.624E-02 -4.568E+01  -7.374E+01 -4.991E+03
  4.560E+02    6.862E-01 -4.737E-01  1.542E-02 -4.568E+01  -7.374E+01 -6.765E+03
  4.800E+02    6.856E-01 -1.122E-01  1.463E-02 -4.568E+01  -7.374E+01 -8.539E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.175E-06
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PROB (CONTD)
 1201     TWO STORY BENT WITHOUT INTERIOR COLUMN - LIVE LOAD


TABLE 10 - JOINT EQUILIBRIUM ERRORS


JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT


    1 -1.704E-03  1.801E-10  1.940E-01
    2 -6.796E-03 -3.890E-03  2.284E-01
    3  8.500E-03  1.546E-09  9.680E-01
    4  1.461E-04  8.432E-03  1.182E-01
    5 -1.461E-04  1.691E-07 -1.221E-06
    6  1.704E-03  1.764E-10 -2.351E-01
    7  6.211E-03 -4.541E-03 -3.088E-01
    8 -7.915E-03  1.055E-08 -1.164E+00
```

```
     02 JULY 70  - CON - HM
     EXAMPLE PROBLEMS FOR REPORT


PROB
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD



TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE     2

                     INPUT TABLES

      TABLE    HOLD DATA FROM     NUMBER OF CARDS
      NUMBER   LAST PROBLEM       ADDED FOR THIS
                (1 = YES,0 = NO)   PROBLEM

        2             1                 2
        3             1                 2
        4             1                 1
        5             1                 4
        6             1                 0
        7            -0                -0

                     OUTPUT TABLES

      TABLE   SUPPRESS OUTPUT
      NUMBER  (1 = YES,0 = NO)

        8            -0
        9            -0
       10            -0
```

```
PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD

TABLE 2 - FRAME GEOMETRY DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NUMBER OF JOINTS IN FRAME =      9


                      INPUT OF JOINT OFFSETS


    FROM        X-OFFSET   Y-OFFSET          TO    TO    TO    TO    TO    TO    TO
   JOINT                                   JOINT

     4           0.        -3.960E+02         9


   COMPUTED JOINT COORDINATES

   JOINT      X           Y


      1  0.          0.
      2  0.          2.278E+02
      3  0.          4.555E+02
      4  4.800E+02   2.278E+02
      5  4.800E+02   4.886E+02
      6  9.600E+02  -4.824E+01
      7  9.600E+02   2.278E+02
      8  9.600E+02   5.218E+02
      9  4.800E+02  -1.682E+02
```

```
PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD

TABLE 3 - MEMBER LOCATION DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NUMBER OF MEMBER STIFFNESS TYPES  =    7
NUMBER OF MEMBER LOAD TYPES  =         2


                        INPUT OF MEMBER LOCATIONS


 FROM      STIFF LOAD        TO    TO    TO    TO  TO    TO    TO    TO    TO    TO
JOINT       TYPE TYPE     JOINT

    9          7    0          4


       COMPUTED MEMBER NUMBERS,LENGTHS,AND OFFSETS
MEMBER  FROM    TO    STIFF LOAD   LENGTH    X-OFFSET    Y-OFFSET
 NUMB  JOINT  JOINT    TYPE TYPE

     1     1      2      1    0 2.270E+02  0.          2.270E+02
     2     2      3      1    0 2.270E+02  0.          2.270E+02
     3     4      5      2    0 2.609E+02  0.          2.609E+02
     4     6      7      3    0 2.760E+02  0.          2.760E+02
     5     7      8      4    0 2.940E+02  0.          2.940E+02
     6     2      4      5    1 4.800E+02  4.800E+02  0.
     7     4      7      5    1 4.800E+02  4.800E+02  0.
     8     3      5      6    2 4.811E+02  4.800E+02  3.312E+01
     9     5      8      6    2 4.811E+02  4.800E+02  3.312E+01
    10     9      4      7    0 3.960E+02  0.          3.960E+02

*** COMPUTED MEMBER NUMBERS AGREE WITH LAST PROBLEM ***
```

```
PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD


TABLE 4 - JOINT DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

                        INPUT OF JOINT DATA

JOINT  FORCE(X)   FORCE(Y)  MOMENT(Z)  SPRING(X)  SPRING(Y)  SPRING(Z)

    9 -0.        -0.        -0.        -0.         2.000E+01 -0.


                        ACCUMULATED JOINT DATA

JOINT  FORCE(X)   FORCE(Y)  MOMENT(Z)  SPRING(X)  SPRING(Y)  SPRING(Z)

    1  0.         0.         0.         1.000E+99  1.000E+99  0.
    6  0.         0.         0.         1.000E+99  1.000E+99  1.000E+99
    9  0.         0.         0.         0.         2.000E+01  0.
```

```
PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD


TABLE 5 - MEMBER STIFFNESS DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


STIFF  MOD OF    PRISMATIC PRISMATIC  NO  AXIS  OUTPUT   PIN  PIN
 TYPE  ELAST         I          A    CARDS  OPT   OPT    FROM   TO

   7 2.960E+04-0.        -0.          3    1   -0         -0   -0
     STIFF TYPE     7 CONTD       RESTRAINTS ARE IN MEMBER PRIMED AXES
     FROM          TO           I          A          SX          SY          SZ

  0.         -0.         1.050E+03  2.800E+01  2.000E+00  3.000E+00 -0.
 -0.          1.920E+02  1.050E+03  2.800E+01  2.000E+00  1.500E+00 -0.
  1.920E+02  3.960E+02  1.050E+03  2.800E+01 -0.         -0.        -0.
```

```
PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD

TABLE 6 - MEMBER LOAD DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE
```

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PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD

TABLE 7 - COMPILATION TABLE


NO DATA
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PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD

TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS


              DISPLACEMENTS                          REACTIONS

JOINT  DISP(X)     DISP(Y)   ROTATION(Z) REACT(X)   REACT(Y)    REACT(Z)


    1 -2.706E-99 -5.439E-98  7.556E-04  2.706E+00  5.439E+01  0.
    2 -6.516E-04 -1.495E-02 -1.503E-03  0.         0.         0.
    3  1.803E-01 -2.444E-02 -3.445E-03  0.         0.         0.
    4  5.677E-03 -3.685E-01 -7.806E-05  0.         0.         0.
    5  2.028E-01 -4.090E-01  8.050E-05  0.         0.         0.
    6  2.785E-99 -5.411E-98 -2.655E-97 -2.785E+00  5.411E+01  2.055E+02
    7  1.147E-02 -1.802E-02  1.054E-03  0.         0.         0.
    8  1.725E-01 -2.988E-02  3.118E-03  0.         0.         0.
    9  1.167E-04 -3.202E-01  3.337E-06  0.         6.405E+00  0.
```

```
PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD


TABLE 9 - MEMBER RESULTS



MEMBER NUMBER     1      STIFF TYPE     1      LOAD TYPE      0
LENGTH =    2.278E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     1 TO JOINT     2
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      1                  AT JOINT      2

 AXIAL FORCE =  -5.439E+01       AXIAL FORCE =  -5.439E+01
 SHEAR       =  -2.706E+00       SHEAR       =  -2.706E+00
 MOMENT      =   4.816E-02       MOMENT      =  -6.164E+02

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.191E-08



MEMBER NUMBER     2      STIFF TYPE     1      LOAD TYPE      0
LENGTH =    2.278E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     2 TO JOINT     3
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

            AT JOINT      2                  AT JOINT      3

                                                              SHEAR      MOMENT
 AXIAL FORCE =  -3.454E+01       AXIAL
 SHEAR       =  -1.207E+01                     -03 -1.454E+01  4.567E+01 -4.662E+03
 MOMENT      =   1.110E                   3.402E-04 -1.454E+01  4.567E+01 -3.563E+03
THE MAXIMUM                        E-01 -7.603E-04 -1.454E+01  4.567E+01 -2.464E+03
                             -4.618E-01 -1.163E-03 -1.454E+01  4.567E+01 -1.366E+03
                      E-01   -4.926E-01 -1.358E-03 -1.385E+01  3.569E+01 -2.670E+02
               1.729E-01     -5.255E-01 -1.348E-03 -1.317E+01  2.572E+01  3.516E+02
    0E+02      1.727E-01     -5.563E-01 -1.190E-03 -1.317E+01  2.572E+01  9.703E+02
  1.680E+02    1.724E-01     -5.815E-01 -8.845E-04 -1.317E+01  2.572E+01  1.589E+03
  1.920E+02    1.722E-01     -5.978E-01 -4.700E-04 -1.248E+01  1.574E+01  2.208E+03
  2.160E+02    1.720E-01     -6.047E-01 -9.988E-05 -1.179E+01  5.763E+00  2.346E+03
  2.400E+02    1.718E-01     -6.025E-01  2.928E-04 -1.179E+01  5.763E+00  2.485E+03
  2.640E+02    1.716E-01     -5.905E-01  7.079E-04 -1.179E+01  5.763E+00  2.623E+03
  2.880E+02    1.714E-01     -5.682E-01  1.146E-03 -1.110E+01 -4.213E+00  2.762E+03
  3.120E+02    1.712E-01     -5.340E-01  1.714E-03 -1.041E+01 -1.419E+01  2.421E+03
  3.360E+02    1.710E-01     -4.861E-01  2.252E-03 -1.041E+01 -1.419E+01  2.079E+03
  3.600E+02    1.708E-01     -4.263E-01  2.708E-03 -1.041E+01 -1.419E+01  1.738E+03
  3.840E+02    1.706E-01     -3.565E-01  3.083E-03 -9.794E+00 -2.417E+01  1.397E+03
  4.080E+02    1.704E-01     -2.791E-01  3.318E-03 -9.036E+00 -3.414E+01  5.753E+02
  4.320E+02    1.703E-01     -1.985E-01  3.358E-03 -9.036E+00 -3.414E+01 -2.460E+02
  4.560E+02    1.701E-01     -1.186E-01  3.268E-03 -9.036E+00 -3.414E+01 -1.067E+03
  4.800E+02    1.700E-01     -4.108E-02  3.118E-03 -9.036E+00 -3.414E+01 -1.889E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.234E-07
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PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER   10      STIFF TYPE     7      LOAD TYPE      0
LENGTH =   3.960E+02       ALPHA =   0.                BETA =   1.000E+00
GOES FROM JOINT     9 TO JOINT     4
OUTPUT DISTANCES ARE FROM JOINT     9 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                      DISPLACEMENTS                              FORCES

 DISTANCE       AXIAL      LATERAL    ROTATIONAL    AXIAL        SHEAR       MONENT

 0.           -3.202E-01 -1.167E-04  3.337E-06 -6.405E+00  4.475E-14 -1.532E-12
 1.980E+01 -3.206E-01 -5.055E-05  3.351E-06 -1.909E+01  4.851E-03  5.798E-02
 3.960E+01 -3.212E-01  1.642E-05  3.424E-06 -3.180E+01  5.817E-03  1.728E-01
 5.940E+01 -3.221E-01  8.554E-05  3.567E-06 -4.453E+01  3.215E-03  2.707E-01
 7.920E+01 -3.233E-01  1.580E-04  3.749E-06 -5.731E+01 -2.673E-03  2.838E-01
 9.900E+01 -3.248E-01  2.338E-04  3.894E-06 -7.014E+01 -1.157E-02  1.499E-01
 1.188E+02 -3.266E-01  3.112E-04  3.891E-06 -8.304E+01 -2.313E-02 -1.876E-01
 1.386E+02 -3.288E-01  3.858E-04  3.595E-06 -9.602E+01 -3.688E-02 -7.771E-01
 1.584E+02 -3.312E-01  4.503E-04  2.832E-06 -1.091E+02 -5.212E-02 -1.656E+00
 1.782E+02 -3.340E-01  4.935E-04  1.411E-06 -1.233E+02 -4.791E-02 -2.844E+00
 1.980E+02 -3.371E-01  5.004E-04 -8.638E-07 -1.312E+02 -7.839E-02 -4.328E+00
 2.178E+02 -3.402E-01  4.526E-04 -4.117E-06 -1.315E+02 -7.868E-02 -5.886E+00
 2.376E+02 -3.433E-01  3.306E-04 -8.364E-06 -1.315E+02 -7.868E-02 -7.444E+00
 2.574E+02 -3.465E-01  1.147E-04 -1.360E-05 -1.315E+02 -7.868E-02 -9.002E+00
 2.772E+02 -3.496E-01 -2.148E-04 -1.903E-05 -1.315E+02 -7.868E-02 -1.056E+01
 2.970E+02 -3.528E-01 -6.775E-04 -2.706E-05 -1.315E+02 -7.868E-02 -1.212E+01
 3.168E+02 -3.559E-01 -1.293E-03 -3.527E-05 -1.315E+02 -7.868E-02 -1.368E+01
 3.366E+02 -3.590E-01 -2.081E-03 -4.448E-05 -1.315E+02 -7.868E-02 -1.523E+01
 3.564E+02 -3.622E-01 -3.061E-03 -5.468E-05 -1.315E+02 -7.868E-02 -1.679E+01
 3.762E+02 -3.653E-01 -4.253E-03 -6.587E-05 -1.315E+02 -7.868E-02 -1.835E+01
 3.960E+02 -3.685E-01 -5.677E-03 -7.806E-05 -1.315E+02 -7.868E-02 -1.991E+01
THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.983E-10


PROB (CONTD)
 1202      TWO STORY BENT - ADD INTERIOR COLUMN - LIVE LOAD


TABLE 10 - JOINT EQUILIBRIUM ERRORS


JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT


    1 -4.229E-04  7.981E-11  4.816E-02
    2 -1.464E-03  2.334E-05  2.686E-01
    3  1.886E-03  1.920E-09  2.148E-01
    4  2.762E-05  8.160E-05  2.358E-02
    5 -2.762E-05  1.482E-08 -9.907E-08
    6  4.352E-04  8.072E-11 -6.005E-02
    7  1.341E-03 -1.049E-04 -2.959E-01
    8 -1.776E-03  1.877E-09 -2.611E-01
    9  4.475E-14  2.729E-10 -1.532E-12
```

```
02 JULY 70  - COM - MM
EXAMPLE PROBLEMS FOR REPORT


PROB
 1203      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD


TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE     3


                    INPUT TABLES

  TABLE     HOLD DATA FROM      NUMBER OF CARDS
  NUMBER    LAST PROBLEM        ADDED FOR THIS
            (1 = YES,0 = NO)    PROBLEM

    2             1                    0
    3             1                    6
    4             1                    0
    5             1                    0
    6             0                    4
    7            -0                   -0

                    OUTPUT TABLES

  TABLE    SUPPRESS OUTPUT
  NUMBER   (1 = YES,0 = NO)


    8            -0
    9            -0
   10            -0
```

```
PROB (CONTD)
 1203     TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD

TABLE 2 - FRAME GEOMETRY DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE



     COMPUTED JOINT COORDINATES


     JOINT      X            Y


         1  0.           0.
         2  0.           2.278E+02
         3  0.           4.555E+02
         4  4.800E+02    2.278E+02
         5  4.800E+02    4.886E+02
         6  9.600E+02   -4.824E+01
         7  9.600E+02    2.278E+02
         8  9.600E+02    5.218E+02
         9  4.800E+02   -1.682E+02
```

```
PROB (CONTD)
 1203     TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD


TABLE 4 - MEMBER LOCATION DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NUMBER OF MEMBER STIFFNESS TYPES  =     7
NUMBER OF MEMBER LOAD TYPES  =          4


                        INPUT OF MEMBER LOCATIONS

 FROM     STIFF LOAD        TO   TO   TO   TO  TO   TO   TO   TO   TO   TO
JOINT      TYPE TYPE      JOINT


    1        1    1         2    3
    6        3    2         7
    7        4    3         8
    2        5    0         4    7
    3        6    4         5    8


       COMPUTED MEMBER NUMBERS,LENGTHS,AND OFFSETS

MEMBER  FROM   TO   STIFF LOAD   LENGTH    X-OFFSET   Y-OFFSET
 NUMB  JOINT  JOINT  TYPE TYPE


    1     1     2      1    1  2.278E+02  0.         2.278E+02
    2     2     3      1    1  2.278E+02  0.         2.278E+02
    3     4     5      2    0  2.609E+02  0.         2.609E+02
    4     6     7      3    2  2.760E+02  0.         2.760E+02
    5     7     8      4    3  2.940E+02  0.         2.940E+02
    6     2     4      5    0  4.800E+02  4.800E+02  0.
    7     4     7      5    0  4.800E+02  4.800E+02  0.
    8     3     5      6    4  4.811E+02  4.800E+02  3.312E+01
    9     5     8      6    4  4.811E+02  4.800E+02  3.312E+01
   10     9     4      7    0  3.960E+02  0.         3.960E+02

*** COMPUTED MEMBER NUMBERS AGREE WITH LAST PROBLEM ***
```

```
PROB (CONTD)
 1203      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD

TABLE 4 - JOINT DATA

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE

                      ACCUMULATED JOINT DATA

JOINT  FORCE(X)    FORCE(Y)   MOMENT(Z)  SPRING(X)  SPRING(Y)  SPRING(Z)

    1  0.          0.          0.         1.000E+99  1.000E+99  0.
    6  0.          0.          0.         1.000E+99  1.000E+99  1.000E+99
    9  0.          0.          0.         0.         2.000E+01  0.
```

```
PROB (CONTD)
 1203      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD

TABLE 5 - MEMBER STIFFNESS DATA

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE
```

```
PROB (CONTD)
 1203      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD

TABLE 6 - MEMBER LOAD DATA


 LOAD  UNIFORM     UNIFORM     NO    AXIS
 TYPE     QX          QY      CARDS   OPT

    1 -0.         -2.580E-02   -0     1
    2 -0.         -4.333E-03   -0     1
    3 -0.         -4.333E-03   -0     1
    4 -0.         -4.333E-03   -0     1
```

```
PROB (CONTD)
 1203      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD

TABLE 7 - COMPILATION TABLE

NO DATA
```

```
PROB (CONTD)
 1203      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD

TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS

                DISPLACEMENTS                       REACTIONS

JOINT  DISP(X)     DISP(Y)   ROTATION(Z) REACT(X)    REACT(Y)    REACT(Z)

    1  3.794E-99  1.603E-99 -2.567E-03 -3.794E+00 -1.603E+00  0.
    2  4.344E-01  4.405E-04 -9.644E-04  0.          0.         0.
    3  6.684E-01  3.623E-04 -4.053E-04  0.          0.         0.
    4  4.296E-01 -7.009E-03 -4.069E-04  0.          0.         0.
    5  6.688E-01 -8.211E-03  1.479E-04  0.          0.         0.
    6  5.510E-99 -3.261E-99 -8.283E-97 -5.510E+00  3.261E+00  8.283E+02
    7  4.276E-01 -1.086E-03 -1.092E-03  0.          0.         0.
    8  6.683E-01 -1.493E-03 -1.525E-04  0.          0.         0.
    9 -2.863E-02 -6.091E-03 -2.862E-04  0.          1.218E-01  0.
```

```
PROB (CONTD)
 1203     TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD

TABLE 9 - MEMBER RESULTS


MEMBER NUMBER    1      STIFF TYPE    1      LOAD TYPE     1
LENGTH =   2.278E+02     ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     1 TO JOINT     2
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES


           AT JOINT      1                 AT JOINT      2


 AXIAL FORCE =    1.603E+00       AXIAL FORCE =   1.603E+00
 SHEAR       =    3.794E+00       SHEAR       =  -1.900E+00
 MOMENT      =    5.070E-02       MOMENT      =   2.157E+02

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  5.916E-08


MEMBER NUMBER    2      STIFF TYPE    1      LOAD TYPE     1
LENGTH =   2.278E+02     ALPHA =   0.                 BETA =   1.0
GOES FROM JOINT     2 TO JOINT     3
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER

           AT JOINT      2                                     SHEAR      MOMENT


 AXIAL FORCE =  -2.                        1.479E-04 -1.301E-01  9.263E-01 -1.360E+02
 SHEAR                          3E-02      1.350E-04 -1.301E-01  8.221E-01 -1.157E+02
 MOMENT                01 -4.776E-02      1.201E-04 -1.301E-01  7.179E-01 -9.720E+01
               667E-01 -4.509E-02      1.012E-04 -1.301E-01  6.136E-01 -8.118E+01
          01  6.667E-01 -4.287E-02      8.342E-05 -1.301E-01  5.094E-01 -6.768E+01
  1.200E+02  6.667E-01 -4.109E-02      6.859E-05 -1.301E-01  4.051E-01 -5.668E+01
  1.440E+02  6.667E-01 -3.956E-02      5.610E-05 -1.301E-01  3.009E-01 -4.818E+01
  1.680E+02  6.667E-01 -3.834E-02      4.533E-05 -1.301E-01  1.967E-01 -4.220E+01
  1.920E+02  6.667E-01 -3.736E-02      3.645E-05 -1.301E-01  9.242E-02 -3.872E+0
  2.160E+02  6.667E-01 -3.656E-02      3.026E-05 -1.301E-01 -1.182E-02 -3.775E+01
  2.400E+02  6.667E-01 -3.590E-02      2.403E-05 -1.301E-01 -1.161E-01 -3.929E+01
  2.640E+02  6.667E-01 -3.541E-02      1.734E-05 -1.301E-01 -2.203E-01 -4.334E+01
  2.880E+02  6.667E-01 -3.508E-02      9.765E-06 -1.301E-01 -3.245E-01 -4.909E+01
  3.120E+02  6.667E-01 -3.498E-02     -2.191E-06 -1.301E-01 -4.288E-01 -5.895E+01
  3.360E+02  6.667E-01 -3.521E-02     -1.763E-05 -1.301E-01 -5.330E-01 -7.052E+01
  3.600E+02  6.666E-01 -3.585E-02     -3.613E-05 -1.301E-01 -6.373E-01 -8.460E+01
  3.840E+02  6.666E-01 -3.698E-02     -5.830E-05 -1.301E-01 -7.415E-01 -1.012E+02
  4.080E+02  6.666E-01 -3.869E-02     -8.473E-05 -1.301E-01 -8.457E-01 -1.203E+02
  4.320E+02  6.666E-01 -4.107E-02     -1.126E-04 -1.301E-01 -9.500E-01 -1.419E+02
  4.560E+02  6.666E-01 -4.404E-02     -1.341E-04 -1.301E-01 -1.054E+00 -1.660E+02
  4.800E+02  6.666E-01 -4.749E-02     -1.525E-04 -1.301E-01 -1.158E+00 -1.926E+02

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.037E-08
```

```
PROB (CONTD)
 1203     TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD


TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER   10      STIFF TYPE    7      LOAD TYPE     0
LENGTH =   3.960E+02     ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     9 TO JOINT     4
OUTPUT DISTANCES ARE FROM JOINT     9 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                          DISPLACEMENTS                          FORCES

  DISTANCE      AXIAL      LATERAL   ROTATIONAL     AXIAL       SHEAR      MOMENT

  0.          -6.091E-03  2.863E-02 -2.862E-04 -1.218E-01  8.228E-11 -5.664E-10
  1.980E+01  -6.097E-03  2.294E-02 -2.900E-04 -3.632E-01 -1.491E+00 -1.573E+01
  3.960E+01  -6.109E-03  1.702E-02 -3.123E-04 -6.048E-01 -2.590E+00 -5.709E+01
  5.940E+01  -6.126E-03  1.035E-02 -3.670E-04 -8.471E-01 -3.304E+00 -1.164E+02
  7.920E+01  -6.149E-03  2.202E-03 -4.631E-04 -1.090E+00 -3.618E+00 -1.859E+02
  9.900E+01  -6.178E-03 -8.296E-03 -6.044E-04 -1.334E+00 -3.491E+00 -2.575E+02
  1.188E+02  -6.213E-03 -2.203E-02 -7.894E-04 -1.580E+00 -2.861E+00 -3.217E+02
  1.386E+02  -6.254E-03 -3.980E-02 -1.010E-03 -1.826E+00 -1.650E+00 -3.680E+02
  1.584E+02  -6.300E-03 -6.217E-02 -1.251E-03 -2.075E+00  1.802E-01 -3.862E+02
  1.782E+02  -6.353E-03 -8.933E-02 -1.489E-03 -2.325E+00  2.687E+00 -3.575E+02
  1.980E+02  -6.411E-03 -1.209E-01 -1.694E-03 -2.496E+00  4.771E+00 -2.773E+02
  2.178E+02  -6.471E-03 -1.560E-01 -1.840E-03 -2.501E+00  4.841E+00 -1.815E+02
  2.376E+02  -6.531E-03 -1.934E-01 -1.925E-03 -2.501E+00  4.841E+00 -8.560E+01
  2.574E+02  -6.590E-03 -2.318E-01 -1.969E-03 -2.501E+00  4.841E+00  1.026E+01
  2.772E+02  -6.650E-03 -2.701E-01 -1.912E-03 -2.501E+00  4.841E+00  1.061E+02
  2.970E+02  -6.710E-03 -3.071E-01 -1.814E-03 -2.501E+00  4.841E+00  2.020E+02
  3.168E+02  -6.770E-03 -3.415E-01 -1.654E-03 -2.501E+00  4.841E+00  2.978E+02
  3.366E+02  -6.829E-03 -3.722E-01 -1.434E-03 -2.501E+00  4.841E+00  3.937E+02
  3.564E+02  -6.889E-03 -3.979E-01 -1.153E-03 -2.501E+00  4.841E+00  4.895E+02
  3.762E+02  -6.949E-03 -4.174E-01 -8.103E-04 -2.501E+00  4.841E+00  5.854E+02
  3.960E+02  -7.009E-03 -4.296E-01 -4.069E-04 -2.501E+00  4.841E+00  6.813E+02

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.712E-08
```

```
PROB (CONTD)
 1203      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - WIND LOAD

TABLE 10 - JOINT EQUILIBRIUM ERRORS


JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT


    1  1.480E-04 -2.352E-12  5.070E-02
    2  2.257E-04  2.949E-04  1.137E-02
    3 -3.738E-04  1.152E-10 -1.101E-01
    4  2.079E-05  3.550E-05  1.447E-01
    5 -2.081E-05  1.759E-09 -5.263E-08
    6  7.676E-04  4.846E-12 -8.874E-02
    7 -6.353E-04 -3.304E-04 -4.375E-02
    8 -1.323E-04  1.248E-09 -3.895E-02
    9  8.228E-11  2.588E-12 -5.664E-10
```

```
PROB (CONTD)
 1204      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD LOAD


TABLE 3 - MEMBER LOCATION DATA


NUMBER OF MEMBER STIFFNESS TYPES  =     7
NUMBER OF MEMBER LOAD TYPES  =          7


                    INPUT OF MEMBER LOCATIONS

 FROM      STIFF LOAD        TO   TO   TO   TO  TO   TO   TO   TO   TO   TO
JOINT       TYPE TYPE     JOINT

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


       COMPUTED MEMBER NUMBERS,LENGTHS,AND OFFSETS

MEMBER  FROM   TO    STIFF LOAD   LENGTH    X-OFFSET    Y-OFFSET
 NUMB  JOINT  JOINT   TYPE TYPE

    1     1     2       1    1  2.278E+02  0.          2.278E+02
    2     2     3       1    1  2.278E+02  0.          2.278E+02
    3     4     5       2    2  2.609E+02  0.          2.609E+02
    4     6     7       3    3  2.760E+02  0.          2.760E+02
    5     7     8       4    4  2.940E+02  0.          2.940E+02
    6     2     4       5    5  4.800E+02  4.800E+02  0.
    7     4     7       5    5  4.800E+02  4.800E+02  0.
    8     3     5       6    6  4.811E+02  4.800E+02  3.312E+01
    9     5     8       6    6  4.811E+02  4.800E+02  3.312E+01
   10     9     4       7    7  3.960E+02  0.          3.960E+02


*** COMPUTED MEMBER NUMBERS AGREE WITH LAST PROBLEM ***
```

```
PROB (CONTD)
 1204      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD LOAD

TABLE 4 - JOINT DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE

                    ACCUMULATED JOINT DATA

JOINT  FORCE(X)   FORCE(Y)  MOMENT(Z)  SPRING(X)  SPRING(Y)  SPRING(Z)


    1  0.         0.        0.         1.000E+99  1.000E+99  0.
    6  0.         0.        0.         1.000E+99  1.000E+99  1.000E+99
    9  0.         0.        0.         0.         2.000E+01  0.
```

```
PROB (CONTD)
 1204      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD LOAD

TABLE 5 - MEMBER STIFFNESS DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE
```

```
02 JULY 70  - COM - MM
EXAMPLE PROBLEMS FOR REPORT


PROB
 1204      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD LOAD


TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE     3


                  INPUT TABLES

      TABLE    HOLD DATA FROM      NUMBER OF CARDS
      NUMBER   LAST PROBLEM        ADDED FOR THIS
               (1 = YES,0 = NO)    PROBLEM

        2             1                  0
        3             0                  0
        4             1                  0
        5             1                  0
        6             0                 17
        7            -0                 -0

                  OUTPUT TABLES

      TABLE   SUPPRESS OUTPUT
      NUMBER  (1 = YES,0 = NO)


        8            -0
        9            -0
       10            -0
```

```
PROB (CONTD)
 1204      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD LOAD

TABLE 2 - FRAME GEOMETRY DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING


NONE


     COMPUTED JOINT COORDINATES


     JOINT      X             Y

         1  0.           0.
         2  0.           2.278E+02
         3  0.           4.555E+02
         4  4.800E+02    2.278E+02
         5  4.800E+02    4.886E+02
         6  9.600E+02   -4.824E+01
         7  9.600E+02    2.278E+02
         8  9.600E+02    5.218E+02
         9  4.800E+02   -1.062E+02
```

```
PROB (CONTD)
 1204     TWO STORY BENT HOLDING STIFFNESS FROM 1902 - DEAD LOAD

TABLE 6 - MEMBER LOAD DATA



 LOAD  UNIFORM      UNIFORM     NO    AXIS
 TYPE     QX           QY     CARDS   OPT


    1 -0.         -5.000E-02   -0     2
    2 -0.         -5.000E-02   -0     2
    3 -0.         -5.000E-02   -0     2
    4 -0.         -5.000E-02   -0     2
    5 -0.         -0.           5     2


      LOAD TYPE       5 CONTD
      FROM           TO          QX          QY            QZ


  0.          4.800E+02 -0.          -2.000E-01 -0.
  9.600E+01   9.600E+01 -0.          -4.000E+00 -0.
  1.920E+02   1.920E+02 -0.          -4.000E+00 -0.
  2.880E+02   2.880E+02 -0.          -4.000E+00 -0.
  3.840E+02   3.840E+02 -0.          -4.000E+00 -0.

 LOAD  UNIFORM      UNIFORM     NO    AXIS
 TYPE     QX           QY     CARDS   OPT

    6 -0.         -0.           5     2

      LOAD TYPE       6 CONTD
      FROM           TO          QX          QY            QZ


  0.          4.800E+02 -0.          -2.000E-01 -0.
  9.600E+01   9.600E+01 -0.          -4.000E+00 -0.
  1.920E+02   1.920E+02 -0.          -4.000E+00 -0.
  2.880E+02   2.880E+02 -0.          -4.000E+00 -0.
  3.840E+02   3.840E+02 -0.          -4.000E+00 -0.

 LOAD  UNIFORM      UNIFORM     NO    AXIS
 TYPE     QX           QY     CARDS   OPT


    7 -0.         -5.000E-02   -0     2
```

```
PROB (CONTD)
 1204     TWO STORY BENT HOLDING STIFFNESS FROM 1902 - DEAD LOAD


TABLE 7 - COMPILATION TABLE


NO DATA




PROB (CONTD)
 1204     TWO STORY BENT HOLDING STIFFNESS FROM 1902 - DEAD LOAD

TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS


                  DISPLACEMENTS                       REACTIONS


JOINT  DISP(X)     DISP(Y)   ROTATION(Z) REACT(X)    REACT(Y)    REACT(Z)


    1 -7.093E-99 -1.301E-97  2.101E-03  7.093E+00  1.301E+02  0.
    2 -2.913E-02 -3.419E-02 -3.818E-03  0.         0.         0.
    3  2.757E-01 -5.025E-02 -4.634E-03  0.         0.         0.
    4 -1.989E-02 -7.438E-01 -1.203E-04  0.         0.         0.
    5  3.203E-01 -7.999E-01  1.519E-04  0.         0.         0.
    6  7.590E-99 -1.350E-97 -6.886E-97 -7.590E+00  1.350E+02  6.806E+02
    7 -1.183E-02 -4.265E-02  3.186E-03  0.         0.         0.
    8  2.625E-01 -6.323E-02  3.997E-03  0.         0.         0.
    9  2.274E-03 -6.506E-01  2.688E-05  0.         1.301E+01  0.
```

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PROB (CONTD)
 1204      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD LOAD


TABLE 9 - MEMBER RESULTS


MEMBER NUMBER     1      STIFF TYPE     1      LOAD TYPE      1
LENGTH =   2.278E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     1 TO JOINT     2
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES


          AT JOINT      1                  AT JOINT      2


 AXIAL FORCE =  -1.301E+02       AXIAL FORCE =  -1.107E+02
 SHEAR       =  -7.094E+00       SHEAR       =  -7.094E+00
 MOMENT      =   1.262E-01       MOMENT      =  -1.616E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  3.356E-08


MEMBER NUMBER     2      STIFF TYPE     1      LOAD TYPE      1
LENGTH =   2.270E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     2 TO JOINT     3
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

          AT JOINT      2                  AT JOINT                 E+01  -4.805E+03
                                                          5.504E+01  -3.423E+03
 AXIAL FORCE =  -6.410E+01       AX              E+01     5.024E+01  -2.156E+03
 SHEAR       =  -2.076E+01                   -2.271E+01   4.544E+01  -1.005E+03
 MOMENT      =   2.2                 E-03    -2.223E+01   3.061E+01   2.922E+01
                            E-01 -9.923E-04  -2.177E+01   3.185E+01   8.532E+02
                      .245E-01   -7.020E-04  -2.144E+01   2.705E+01   1.562E+03
 I             E-01  -9.363E-01  -2.560E-04  -2.111E+01   2.225E+01   2.155E+03
              2.613E-01  -9.360E-01   2.696E-04  -2.063E+01   1.538E+01   2.631E+03
       E+02   2.610E-01  -9.242E-01   7.200E-04  -2.017E+01   8.662E+00   2.897E+03
  2.400E+02   2.607E-01  -9.011E-01   1.204E-03  -1.984E+01   3.862E+00   3.047E+03
  2.640E+02   2.604E-01  -8.661E-01   1.704E-03  -1.951E+01  -9.303E-01   3.082E+03
  2.880E+02   2.600E-01  -8.192E-01   2.199E-03  -1.903E+01  -7.847E+00   2.999E+03
  3.120E+02   2.597E-01  -7.589E-01   2.827E-03  -1.857E+01  -1.453E+01   2.708E+03
  3.360E+02   2.593E-01  -6.835E-01   3.427E-03  -1.824E+01  -1.933E+01   2.300E+03
  3.600E+02   2.590E-01  -5.949E-01   3.916E-03  -1.790E+01  -2.413E+01   1.770E+03
  3.840E+02   2.586E-01  -4.962E-01   4.267E-03  -1.743E+01  -3.108E+01   1.136E+03
  4.080E+02   2.583E-01  -3.911E-01   4.438E-03  -1.697E+01  -3.772E+01   2.861E+02
  4.320E+02   2.580E-01  -2.844E-01   4.403E-03  -1.644E+01  -4.252E+01  -6.790E+02
  4.560E+02   2.578E-01  -1.803E-01   4.236E-03  -1.630E+01  -4.732E+01  -1.760E+03
  4.800E+02   2.576E-01  -8.115E-02   3.997E-03  -1.599E+01  -5.189E+01  -2.956E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.701E-07
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PROB (CONTD)
 1204      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD LOAD


TABLE 9 - MEMBER RESULTS (CONTD)



MEMBER NUMBER    10      STIFF TYPE     7      LOAD TYPE      7
LENGTH =   3.960E+02      ALPHA =   0.                 BETA =   1.000E+00
GOES FROM JOINT     9 TO JOINT     4
OUTPUT DISTANCES ARE FROM JOINT     9 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                        DISPLACEMENTS                         FORCES

 DISTANCE       AXIAL      LATERAL    ROTATIONAL     AXIAL       SHEAR      MOMENT

 0.          -6.506E-01 -2.274E-03  2.608E-05 -1.301E+01 -1.067E-11  1.191E-10
 1.980E+01   -6.513E-01 -1.740E-03  2.719E-05 -3.780E+01  1.161E-01  1.238E+00
 3.960E+01   -6.525E-01 -1.187E-03  2.892E-05 -6.262E+01  1.966E-01  4.419E+00
 5.940E+01   -6.542E-01 -5.776E-04  3.312E-05 -8.750E+01  2.428E-01  8.854E+00
 7.920E+01   -6.566E-01  1.447E-04  4.034E-05 -1.125E+02  2.540E-01  1.386E+01
 9.900E+01   -6.596E-01  1.042E-03  5.074E-05 -1.375E+02  2.279E-01  1.873E+01
 1.188E+02   -6.632E-01  2.174E-03  6.399E-05 -1.627E+02  1.606E-01  2.268E+01
 1.386E+02   -6.674E-01  3.589E-03  7.922E-05 -1.881E+02  4.810E-02  2.486E+01
 1.584E+02   -6.722E-01  5.315E-03  9.502E-05 -2.136E+02 -1.127E-01  2.435E+01
 1.782E+02   -6.776E-01  7.342E-03  1.094E-04 -2.394E+02 -3.225E-01  2.016E+01
 1.980E+02   -6.836E-01  9.618E-03  1.196E-04 -2.546E+02 -4.918E-01  1.157E+01
 2.178E+02   -6.897E-01  1.204E-02  1.239E-04 -2.541E+02 -4.974E-01  1.724E+00
 2.376E+02   -6.958E-01  1.448E-02  1.218E-04 -2.551E+02 -4.974E-01 -8.124E+00
 2.574E+02   -7.019E-01  1.682E-02  1.135E-04 -2.542E+02 -4.974E-01 -1.797E+01
 2.772E+02   -7.080E-01  1.893E-02  9.894E-05 -2.532E+02 -4.974E-01 -2.782E+01
 2.970E+02   -7.140E-01  2.070E-02  7.808E-05 -2.522E+02 -4.974E-01 -3.767E+01
 3.168E+02   -7.200E-01  2.198E-02  5.094E-05 -2.512E+02 -4.974E-01 -4.752E+01
 3.366E+02   -7.260E-01  2.267E-02  1.753E-05 -2.502E+02 -4.974E-01 -5.736E+01
 3.564E+02   -7.320E-01  2.263E-02 -2.215E-05 -2.492E+02 -4.974E-01 -6.721E+01
 3.762E+02   -7.379E-01  2.175E-02 -6.810E-05 -2.482E+02 -4.974E-01 -7.706E+01
 3.960E+02   -7.438E-01  1.989E-02 -1.203E-04 -2.472E+02 -4.974E-01 -8.691E+01

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.285E-09
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PROB (CONTD)
 1204      TWO STORY BENT HOLDING STIFFNESS FROM 1902 - DEAD LOAD

TABLE 10 - JOINT EQUILIBRIUM ERRORS

JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT


    1 -1.108E-03  2.001E-10  1.262E-01
    2 -2.136E-03  2.129E-04  5.468E-01
    3  3.244E-03  3.720E-09  3.694E-01
    4  4.827E-05 -2.441E-04  3.099E-02
    5 -4.827E-05  2.593E-08 -2.195E-07
    6  1.186E-03  2.046E-10 -1.637E-01
    7  1.865E-03  3.129E-05 -6.197E-01
    8 -3.051E-03  6.947E-09 -4.485E-01
    9 -1.067E-11  7.595E-10  1.191E-10
```

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     02 JULY 70  - COM - HM
     EXAMPLE PROBLEMS FOR REPORT


PROB
 1205      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD,LIVE,WIND LOADS


TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE     4

                     INPUT TABLES

     TABLE     HOLD DATA FROM      NUMBER OF CARDS
     NUMBER    LAST PROBLEM        ADDED FOR THIS
               (1 = YES,0 = NO)    PROBLEM

        2            -0                  -0
        3            -0                  -0
        4            -0                  -0
        5            -0                  -0
        6            -0                  -0
        7            -0                   3
                     OUTPUT TABLES

     TABLE   SUPPRESS OUTPUT
     NUMBER  (1 = YES,0 = NO)


        8            -0
        9            -0
       10            -0
```

```
PROB (CONTD)
 1205      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD,LIVE,WIND LOADS


TABLE 7 - COMPILATION TABLE


TABLES (2 - 6) OMITTED


     INPUT OF PROBLEM NUMBERS AND MULTIPLIERS

NPROB      MULTIPLIER


 1202 1.250E+00
 1204 1.250E+00
 1203 1.250E+00




     PROBLEM NUMBERS AND MULTIPLIERS USED FOR THIS PROBLEM
     PROBLEM NUMBERS IN ORDER PROBLEMS WERE INPUT

NPROB      MULTIPLIER


 1202 1.250E+00
 1203 1.250E+00
 1204 1.250E+00
```

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PROB (CONTD)
 1205      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD,LIVE,WIND LOADS


TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS


             DISPLACEMENTS                       REACTIONS


JOINT  DISP(X)     DISP(Y)   ROTATION(Z) REACT(X)    REACT(Y)    REACT(Z)


    1 -7.506E-09 -2.286E-07  3.625E-04  7.506E+00  2.286E+02  0.
    2  5.058E-01 -6.086E-02 -7.882E-03  0.         0.         0.
    3  1.406E+00 -9.290E-02 -1.060E-02  0.         0.         0.
    4  5.192E-01 -1.399E+00 -7.566E-04  0.         0.         0.
    5  1.490E+00 -1.521E+00  4.753E-04  0.         0.         0.
    6  1.986E-08 -2.404E-07 -2.228E-06 -1.986E+01  2.404E+02  2.228E+03
    7  5.341E-01 -7.719E-02  3.935E-03  0.         0.         0.
    8  1.379E+00 -1.183E-01  8.703E-03  0.         0.         0.
    9 -3.280E-02 -1.221E+00 -3.199E-04  0.         2.442E+01  0.
```

```
PROB (CONTD)
 1205      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD,LIVE,WIND LOADS

TABLE 9 - MEMBER RESULTS


MEMBER NUMBER     1      STIFF TYPE     1
LENGTH =   2.270E+02      ALPHA =   0.                BETA =   1.000E+00
GOES FROM JOINT     1 TO JOINT     2
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

           AT JOINT     1                 AT JOINT     2


 AXIAL FORCE =  -2.286E+02       AXIAL FORCE =  -2.144E+02
 SHEAR       =  -7.508E+00       SHEAR       =  -1.463E+01
 MOMENT      =   2.813E-01       MOMENT      =  -2.520E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.308E-07


MEMBER NUMBER     2      STIFF TYPE     1
LENGTH =   2.278E+02      ALPHA =   0.                BETA =   1.000E+0
GOES FROM JOINT     2 TO JOINT     3
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES
                                                          SHEAR      MOMENT
           AT JOINT     2
                                       -04 -4.796E+01  1.330E+02 -1.200E+04
 AXIAL FORCE =  -1.237E+0       8.913E-04 -4.755E+01  1.269E+02 -8.877E+03
 SHEAR       =  -          E+00 -1.619E-03 -4.714E+01  1.208E+02 -5.897E+03
 MOMENT               1.699E+00 -2.559E-03 -4.672E+01  1.147E+02 -3.065E+03
                 E+00 -1.767E+00 -2.960E-03 -4.527E+01  9.351E+01 -3.810E+02
            1.378E+00 -1.838E+00 -2.840E-03 -4.383E+01  7.247E+01  1.435E+03
      0E+02  1.377E+00 -1.900E+00 -2.295E-03 -4.342E+01  6.634E+01  3.105E+03
  1.680E+02  1.376E+00 -1.945E+00 -1.369E-03 -4.300E+01  6.021E+01  4.627E+03
  1.920E+02  1.375E+00 -1.964E+00 -2.050E-04 -4.155E+01  3.902E+01  5.999E+03
  2.160E+02  1.375E+00 -1.957E+00  8.129E-04 -4.011E+01  1.802E+01  6.506E+03
  2.400E+02  1.374E+00 -1.924E+00  1.981E-03 -3.969E+01  1.109E+01  6.866E+03
  2.640E+02  1.373E+00 -1.865E+00  3.036E-03 -3.970E+01  5.755E+00  7.070E+03
  2.880E+02  1.373E+00 -1.770E+00  4.193E-03 -3.782E+01 -1.548E+01  7.140E+03
  3.120E+02  1.372E+00 -1.660E+00  5.673E-03 -3.639E+01 -3.643E+01  6.337E+03
  3.360E+02  1.371E+00 -1.506E+00  7.077E-03 -3.497E+01 -4.256E+01  5.307E+03
  3.600E+02  1.371E+00 -1.321E+00  8.235E-03 -3.596E+01 -4.869E+01  4.209E+03
  3.840E+02  1.370E+00 -1.112E+00  9.114E-03 -3.410E+01 -6.998E+01  3.039E+03
  4.080E+02  1.369E+00 -8.862E-01  9.590E-03 -3.267E+01 -9.008E+01  9.268E+02
  4.320E+02  1.369E+00 -6.550E-01  9.561E-03 -3.225E+01 -9.701E+01 -1.334E+03
  4.560E+02  1.368E+00 -4.287E-01  9.213E-03 -3.104E+01 -1.031E+02 -3.741E+03
  4.800E+02  1.368E+00 -2.129E-01  8.703E-03 -3.144E+01 -1.090E+02 -6.296E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  3.173E-07
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PROB (CONTD)
 1205      TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD,LIVE,WIND LOADS

TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER    10      STIFF TYPE     7
LENGTH =   3.960E+02      ALPHA =   0.                BETA =   1.000E+00
GOES FROM JOINT     9 TO JOINT     4
OUTPUT DISTANCES ARE FROM JOINT     9 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                       DISPLACEMENTS                              FORCES

 DISTANCE       AXIAL      LATERAL   ROTATIONAL    AXIAL         SHEAR      MOMENT

 0.          -1.221E+00  3.280E-02 -3.199E-04 -2.442E+01  8.957E-11 -5.610E-10
 1.980E+01   -1.222E+00  2.644E-02 -3.243E-04 -7.157E+01 -1.713E+00 -1.805E+01
 3.960E+01   -1.225E+00  1.981E-02 -3.580E-04 -1.188E+02 -2.984E+00 -6.562E+01
 5.940E+01   -1.228E+00  1.232E-02 -4.129E-04 -1.641E+02 -3.822E+00 -1.341E+02
 7.920E+01   -1.233E+00  3.131E-03 -5.237E-04 -2.136E+02 -4.209E+00 -2.148E+02
 9.900E+01   -1.238E+00 -8.775E-03 -6.872E-04 -2.613E+02 -4.094E+00 -2.983E+02
 1.188E+02   -1.245E+00 -2.643E-02 -9.019E-04 -3.092E+02 -3.404E+00 -3.740E+02
 1.386E+02   -1.253E+00 -4.478E-02 -1.159E-03 -3.574E+02 -2.058E+00 -4.290E+02
 1.584E+02   -1.262E+00 -7.051E-02 -1.442E-03 -4.060E+02  1.919E-02 -4.519E+02
 1.782E+02   -1.272E+00 -1.019E-01 -1.723E-03 -4.549E+02  2.871E+00 -4.252E+02
 1.980E+02   -1.284E+00 -1.385E-01 -1.969E-03 -4.879E+02  5.251E+00 -3.376E+02
 2.178E+02   -1.296E+00 -1.794E-01 -2.150E-03 -4.877E+02  5.332E+00 -2.320E+02
 2.376E+02   -1.307E+00 -2.232E-01 -2.264E-03 -4.864E+02  5.332E+00 -1.265E+02
 2.574E+02   -1.319E+00 -2.686E-01 -2.311E-03 -4.852E+02  5.332E+00 -2.089E+01
 2.772E+02   -1.330E+00 -3.142E-01 -2.291E-03 -4.840E+02  5.332E+00  8.467E+01
 2.970E+02   -1.342E+00 -3.580E-01 -2.203E-03 -4.827E+02  5.332E+00  1.902E+02
 3.168E+02   -1.353E+00 -4.010E-01 -2.048E-03 -4.815E+02  5.332E+00  2.958E+02
 3.366E+02   -1.365E+00 -4.395E-01 -1.826E-03 -4.802E+02  5.332E+00  4.014E+02
 3.564E+02   -1.376E+00 -4.729E-01 -1.537E-03 -4.790E+02  5.332E+00  5.069E+02
 3.762E+02   -1.388E+00 -4.999E-01 -1.180E-03 -4.778E+02  5.332E+00  6.125E+02
 3.960E+02   -1.399E+00 -5.192E-01 -7.566E-04 -4.765E+02  5.332E+00  7.181E+02

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.338E-08
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PROB (CONTD)
 1205     TWO STORY BENT HOLDING STIFFNESS FROM 1202 - DEAD,LIVE,WIND LOADS

TABLE 10 - JOINT EQUILIBRIUM ERRORS

JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT


    1 -1.729E-03  3.465E-10  2.813E-01
    2 -4.217E-03  6.639E-04  1.033E+00
    3  5.946E-03  7.195E-09  5.927E-01
    4  1.208E-04 -1.588E-04  2.490E-01
    5 -1.209E-04  5.313E-08 -4.640E-07
    6  2.986E-03  3.620E-10 -3.906E-01
    7  3.213E-03 -5.051E-04 -1.199E+00
    8 -6.199E-03  1.259E-08 -9.357E-01
    9  8.957E-11  1.294E-09 -5.610E-10
```

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02 JULY 70  - COH - HM
EXAMPLE PROBLEMS FOR REPORT


PROB
 1206      TWO STORY BENT HOLDING STIFFNESS FROM 1202 -  DEAD+LIVE LOADS

TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE     4

                        INPUT TABLES

     TABLE     HOLD DATA FROM       NUMBER OF CARDS
     NUMBER    LAST PROBLEM         ADDED FOR THIS
              (1 = YES,0 = NO)      PROBLEM


       2             -0                  -0
       3             -0                  -0
       4             -0                  -0
       5             -0                  -0
       6             -0                  -0
       7             -0                   2
                        OUTPUT TABLES

     TABLE    SUPPRESS OUTPUT
     NUMBER   (1 = YES,0 = NO)

       8             -0
       9             -0
      10             -0
```

```
PROB (CONTD)
 1206      TWO STORY BENT HOLDING STIFFNESS FROM 1202 -  DEAD+LIVE LOADS


TABLE 7 - COMPILATION TABLE


TABLES (2 - 6) OMITTED


     INPUT OF PROBLEM NUMBERS AND MULTIPLIERS

NPROB     MULTIPLIER


 1202 1.800E+00
 1204 1.500E+00



     PROBLEM NUMBERS AND MULTIPLIERS USED FOR THIS PROBLEM
     PROBLEM NUMBERS IN ORDER PROBLEMS WERE INPUT

NPROB     MULTIPLIER


 1202 1.800E+00
 1203 0.
 1204 1.500E+00



PROB (CONTD)
 1206      TWO STORY BENT HOLDING STIFFNESS FROM 1202 -  DEAD+LIVE LOADS

TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS


                 DISPLACEMENTS                        REACTIONS

JOINT  DISP(X)     DISP(Y)  ROTATION(Z) REACT(X)    REACT(Y)    REACT(Z)


    1 -1.551E-08 -2.931E-07  4.511E-03  1.551E+01  2.931E+02  0.
    2 -4.487E-02 -7.820E-02 -8.432E-03  0.         0.         0.
    3  7.382E-01 -1.194E-01 -1.315E-02  0.         0.         0.
    4 -1.962E-02 -1.779E+00 -3.210E-04  0.         0.         0.
    5  8.454E-01 -1.936E+00  3.727E-04  0.         0.         0.
    6  1.640E-08 -2.999E-07 -1.511E-06 -1.640E+01  2.999E+02  1.511E+03
    7  2.906E-03 -9.641E-02  6.677E-03  0.         0.         0.
    8  7.043E-01 -1.486E-01  1.161E-02  0.         0.         0.
    9  3.621E-03 -1.552E+00  4.633E-05  0.         3.105E+01  0.
```

```
PROB (CONTD)
 1206     TWO STORY BENT HOLDING STIFFNESS FROM 1202 -  DEAD+LIVE LOADS


TABLE 9 - MEMBER RESULTS


MEMBER NUMBER     1      STIFF TYPE     1
LENGTH =   2.278E+02     ALPHA =   0.                BETA =   1.000E+00
GOES FROM JOINT    1 TO JOINT    2
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

          AT JOINT     1                  AT JOINT     2


 AXIAL FORCE =  -2.931E+02        AXIAL FORCE =  -2.760E+02
 SHEAR       =  -1.551E+01        SHEAR       =  -1.551E+01
 MOMENT      =   2.760E-01        MOMENT      =  -3.533E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  7.178E-08


MEMBER NUMBER     2      STIFF TYPE     1
LENGTH =   2.278E+02     ALPHA =   0.                BETA =   1.000E
GOES FROM JOINT    2 TO JOINT    3
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES

          AT JOINT     2                AT                      SHEAR       MOMENT

 AXIAL FORCE =  -1.583E+02
 SHEAR       =  -5.200                 6727E-04 -6.173E+01   1.720E+02 -1.560E+04
 MOMENT      =                  E+00 -1.014E-03 -6.123E+01   1.648E+02 -1.155E+04
                          -2.038E+00 -2.351E-03 -6.073E+01   1.576E+02 -7.670E+03
THE                 4E-01 -2.110E+00 -3.571E-03 -6.023E+01   1.504E+02 -3.966E+03
                 7.062E-01 -2.204E+00 -4.095E-03 -5.829E+01   1.222E+02 -4.368E+02
    200E+02      7.051E-01 -2.302E+00 -3.916E-03 -5.635E+01   9.407E+01  1.913E+03
   1.440E+02     7.040E-01 -2.388E+00 -3.196E-03 -5.505E+01   8.687E+01  4.089E+03
   1.680E+02     7.029E-01 -2.451E+00 -1.976E-03 -5.536E+01   7.967E+01  6.092E+03
   1.920E+02     7.019E-01 -2.400E+00 -4.416E-04 -5.341E+01   5.140E+01  7.919E+03
   2.160E+02     7.011E-01 -2.475E+00  9.002E-04 -5.147E+01   2.337E+01  8.568E+03
   2.400E+02     7.002E-01 -2.436E+00  2.333E-03 -5.098E+01   1.417E+01  9.044E+03
   2.640E+02     6.994E-01 -2.362E+00  3.830E-03 -5.048E+01   8.966E+00  9.346E+03
   2.880E+02     6.986E-01 -2.252E+00  5.361E-03 -4.852E+01  -1.935E+01  9.471E+03
   3.120E+02     6.977E-01 -2.100E+00  7.325E-03 -4.659E+01  -4.733E+01  8.419E+03
   3.360E+02     6.968E-01 -1.908E+00  9.194E-03 -4.610E+01  -5.453E+01  7.194E+03
   3.600E+02     6.959E-01 -1.660E+00  1.075E-02 -4.560E+01  -4.173E+01  5.795E+03
   3.840E+02     6.951E-01 -1.386E+00  1.195E-02 -4.364E+01  -9.011E+01  4.218E+03
   4.080E+02     6.943E-01 -1.089E+00  1.263E-02 -4.172E+01  -1.180E+02  1.465E+03
   4.320E+02     6.935E-01 -7.839E-01  1.265E-02 -4.122E+01  -1.252E+02 -1.461E+03
   4.560E+02     6.929E-01 -4.840E-01  1.224E-02 -4.072E+01  -1.324E+02 -4.561E+03
   4.800E+02     6.924E-01 -1.968E-01  1.161E-02 -4.075E+01  -1.393E+02 -7.833E+03


 THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  4.022E-07
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PROB (CONTD)
 1206     TWO STORY BENT HOLDING STIFFNESS FROM 1202 -  DEAD+LIVE LOADS


TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER   10      STIFF TYPE     7
LENGTH =    3.960E+02      ALPHA =   0.                BETA =   1.000E+00
GOES FROM JOINT    9 TO JOINT    4
OUTPUT DISTANCES ARE FROM JOINT     9 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                    DISPLACEMENTS                          FORCES

  DISTANCE      AXIAL      LATERAL    ROTATIONAL   AXIAL       SHEAR      MOMENT

  0.          -1.552E+00 -3.621E-03  4.633E-05 -3.105E+01 -1.592E-11  1.759E-10
  1.980E+01   -1.554E+00 -2.701E-03  4.681E-05 -9.106E+01  1.828E-01  1.961E+00
  3.960E+01   -1.557E+00 -1.752E-03  4.955E-05 -1.512E+02  3.054E-01  6.940E+00
  5.940E+01   -1.561E+00 -7.124E-04  5.610E-05 -2.114E+02  3.699E-01  1.377E+01
  7.920E+01   -1.567E+00  5.014E-04  6.726E-05 -2.719E+02  3.762E-01  2.130E+01
  9.900E+01   -1.574E+00  1.983E-03  8.313E-05 -3.326E+02  3.210E-01  2.836E+01
  1.188E+02   -1.583E+00  3.821E-03  1.030E-04 -3.936E+02  1.993E-01  3.368E+01
  1.386E+02   -1.593E+00  6.078E-03  1.253E-04 -4.550E+02  5.756E-03  3.590E+01
  1.584E+02   -1.605E+00  8.783E-03  1.476E-04 -5.168E+02 -2.629E-01  3.354E+01
  1.782E+02   -1.618E+00  1.190E-02  1.666E-04 -5.791E+02 -6.060E-01  2.512E+01
  1.980E+02   -1.632E+00  1.533E-02  1.779E-04 -6.211E+02 -8.788E-01  9.568E+00
  2.178E+02   -1.647E+00  1.887E-02  1.784E-04 -6.209E+02 -8.877E-01 -8.009E+00
  2.376E+02   -1.662E+00  2.232E-02  1.677E-04 -6.194E+02 -8.877E-01 -2.558E+01
  2.574E+02   -1.677E+00  2.544E-02  1.458E-04 -6.179E+02 -8.877E-01 -4.316E+01
  2.772E+02   -1.691E+00  2.801E-02  1.127E-04 -6.145E+02 -8.877E-01 -6.074E+01
  2.970E+02   -1.706E+00  2.982E-02  6.841E-05 -6.150E+02 -8.877E-01 -7.831E+01
  3.168E+02   -1.721E+00  3.065E-02  1.292E-05 -6.135E+02 -8.877E-01 -9.589E+01
  3.366E+02   -1.735E+00  3.026E-02 -5.376E-05 -6.120E+02 -8.877E-01 -1.135E+02
  3.564E+02   -1.750E+00  2.844E-02 -1.316E-04 -6.105E+02 -8.877E-01 -1.310E+02
  3.762E+02   -1.764E+00  2.497E-02 -2.207E-04 -6.090E+02 -8.877E-01 -1.486E+02
  3.960E+02   -1.779E+00  1.962E-02 -3.210E-04 -6.075E+02 -8.877E-01 -1.662E+02

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.465E-09


PROB (CONTD)
 1206     TWO STORY BENT HOLDING STIFFNESS FROM 1202 -  DEAD+LIVE LOADS


TABLE 10 - JOINT EQUILIBRIUM ERRORS


JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT



    1 -2.424E-03  4.438E-10  2.760E-01
    2 -5.838E-03  3.613E-04  1.304E+00
    3  8.262E-03  9.036E-09  9.409E-01
    4  1.221E-04 -2.193E-04  8.892E-02
    5 -1.221E-04  6.557E-08 -5.076E-07
    6  2.563E-03  4.529E-10 -3.536E-01
    7  5.211E-03 -1.419E-04 -1.462E+00
    8 -7.773E-03  1.380E-08 -1.143E+00
    9 -1.592E-11  1.630E-09  1.759E-10
```

```
02 JULY 70  - COM - MM
EXAMPLE PROBLEMS FOR REPORT


PROB
 1207     ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD




TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE     1

                    INPUT TABLES

      TABLE     HOLD DATA FROM      NUMBER OF CARDS
      NUMBER    LAST PROBLEM        ADDED FOR THIS
                (1 = YES,0 = NO)    PROBLEM

        2              1                 2
        3              1                 4
        4              1                 8
        5              1                 4
        6              1                 8
        7             -0                -0

                    OUTPUT TABLES

      TABLE   SUPPRESS OUTPUT
      NUMBER  (1 = YES,0 = NO)

        8             -0
        9             -0
       10             -0
```

```
PROB (CONTD)
 1207     ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD

TABLE 2 - FRAME GEOMETRY DATA

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NUMBER OF JOINTS IN FRAME =    10


                      INPUT OF JOINT OFFSETS

     FROM        X-OFFSET   Y-OFFSET         TO    TO    TO    TO    TO    TO    TO
    JOINT                                  JOINT

       9         0.         1.920E+02        10


    COMPUTED JOINT COORDINATES

    JOINT       X            Y

        1  0.           0.
        2  0.           2.278E+02
        3  0.           4.555E+02
        4  4.800E+02    2.278E+02
        5  4.800E+02    4.806E+02
        6  9.600E+02   -4.824E+01
        7  9.600E+02    2.278E+02
        8  9.600E+02    5.218E+02
        9  4.800E+02   -1.682E+02
       10  4.800E+02    2.376E+01
```

```
PROB (CONTD)
 1207     ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD

TABLE 3 - MEMBER LOCATION DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NUMBER OF MEMBER STIFFNESS TYPES  =     9
NUMBER OF MEMBER LOAD TYPES  =          7


                    INPUT OF MEMBER LOCATIONS

 FROM      STIFF LOAD        TO   TO   TO   TO  TO   TO   TO   TO   TO   TO
JOINT       TYPE TYPE     JOINT


     9         8    0         4
     9         8    0        10
    10         9    0         4


      COMPUTED MEMBER NUMBERS,LENGTHS,AND OFFSETS

MEMBER  FROM   TO    STIFF LOAD   LENGTH    X-OFFSET    Y-OFFSET
 NUMB  JOINT  JOINT   TYPE TYPE


     1     1     2       1    1  2.278E+02  0.          2.278E+02
     2     2     3       1    1  2.278E+02  0.          2.278E+02
     3     4     5       2    2  2.609E+02  0.          2.609E+02
     4     6     7       3    3  2.760E+02  0.          2.760E+02
     5     7     8       4    4  2.940E+02  0.          2.940E+02
     6     2     4       5    5  4.800E+02  4.800E+02  0.
     7     4     7       5    5  4.800E+02  4.800E+02  0.
     8     3     5       6    6  4.811E+02  4.800E+02  3.312E+01
     9     5     8       6    6  4.811E+02  4.800E+02  3.312E+01
    10     9     4       0    0
    11     9    10       8    0  1.920E+02  0.          1.920E+02
    12    10     4       9    0  2.040E+02  0.          2.040E+02

*** COMPUTED MEMBER NUMBERS AGREE WITH LAST PROBLEM ***
```

```
PROB (CONTD)
 1207     ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD

TABLE 4 - JOINT DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE

                     ACCUMULATED JOINT DATA

JOINT  FORCE(X)    FORCE(Y)  MOMENT(Z)  SPRING(X)  SPRING(Y)  SPRING(Z)


    1  0.          0.          0.         1.000E+99  1.000E+99  0.
    6  0.          0.          0.         1.000E+99  1.000E+99  1.000E+99
    9  0.          0.          0.         0.         2.000E+01  0.
```

```
PROB (CONTD)
 1207     ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD

TABLE 5 - MEMBER STIFFNESS DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING



STIFF  MOD OF    PRISMATIC PRISMATIC  NO  AXIS  OUTPUT   PIN  PIN
 TYPE  ELAST         I          A     CARDS  OPT   OPT    FROM   TO


    8 2.960E+04-0.       -0.          2    1   -0        -0   -0
      STIFF TYPE    8 CONTD       RESTRAINTS ARE IN MEMBER PRIMED AXES
      FROM         TO         I          A          RX          SY           SZ

  0.        -0.         1.050E+03  2.800E+01  2.000E+00  9.000E+00 -0.
 -0.          1.920E+02  1.050E+03  2.800E+01  2.000E+00  1.500E+00 -0.

STIFF  MOD OF    PRISMATIC PRISMATIC  NO  AXIS  OUTPUT   PIN  PIN
 TYPE  ELAST         I          A     CARDS  OPT   OPT    FROM   TO

    9 2.960E+04 1.050E+03 2.800E+01    0 ,  1   -0        -0   -0
```

```
PROB (CONTD)
 1207     ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD

TABLE 6 - MEMBER LOAD DATA


HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE


PROB (CONTD)
 1207     ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD


TABLE 7 - COMPILATION TABLE


NO DATA


PROB (CONTD)
 1207     ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD


TABLE 8 - JOINT DISPLACEMENTS AND REACTIONS

                 DISPLACEMENTS                          REACTIONS

JOINT  DISP(X)     DISP(Y)   ROTATION(Z) REACT(X)    REACT(Y)    REACT(Z)

    1 -7.024E-99 -1.296E-97  2.082E-03  7.024E+00  1.296E+02  0.
    2 -2.923E-02 -3.404E-02 -3.779E-03  0.         0.         0.
    3  2.705E-01 -4.999E-02 -4.526E-03  0.         0.         0.
    4 -2.019E-02 -6.959E-01 -1.163E-04  0.         0.         0.
    5  3.120E-01 -7.522E-01  1.497E-04  0.         0.         0.
    6  7.516E-99 -1.344E-97 -6.814E-97 -7.516E+00  1.344E+02  6.814E+02
    7 -1.231E-02 -4.246E-02  3.159E-03  0.         0.         0.
    8  2.576E-01 -6.293E-02  3.897E-03  0.         0.         0.
    9  2.278E-03 -6.048E-01  2.692E-05  0.         1.210E+01  0.
   10 -8.894E-03 -6.348E-01  1.172E-04  0.         0.         0.
```

```
PROB (CONTD)
 1207     ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD

TABLE 9 - MEMBER RESULTS


MEMBER NUMBER    1     STIFF TYPE    1     LOAD TYPE     1
LENGTH =   2.278E+02     ALPHA =    0.                BETA =   1.000E+00
GOES FROM JOINT    1 TO JOINT    2
ALL OUTPUT FORCES ARE WITH RESPECT TO THE MEMBER AXES


           AT JOINT     1                AT JOINT     2


 AXIAL FORCE =  -1.296E+02       AXIAL FORCE =  -1.182E+02
 SHEAR       =  -7.025E+00       SHEAR       =  -7.025E+00
 MOMENT      =   1.250E-01       MOMENT      =  -1.600E+03

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  2.901E-08


MEMBER NUMBER    2     STIFF TYPE    1     LOAD TYPE     1
LENGTH =   2.278E+02     ALPHA =    0.               BETA
GOES FROM JOINT    2 TO JOINT    3                                   MOMENT
ALL OUTPUT FORCES ARE WITH RESPECT TO THE

           AT JOINT     2                  -04 -2.338E+01  4.018E+01 -4.912E+03
                                    .805E-04 -2.305E+01  5.538E+01 -3.521E+03
 AXIAL FORCE =                  -01 -6.808E-04 -2.272E+01  5.058E+01 -2.247E+03
 SHEAR                 .061E-01 -1.029E-03 -2.239E+01  4.578E+01 -1.088E+03
 MOM                E-01 -8.329E-01 -1.163E-03 -2.192E+01  3.895E+01 -4.485E+01
              2.576E-01 -8.602E-01 -1.072E-03 -2.145E+01  3.219E+01  7.874E+02
      E+02    2.571E-01 -8.830E-01 -7.965E-04 -2.112E+01  2.739E+01  1.504E+03
 1.680E+02    2.567E-01 -8.972E-01 -3.634E-04 -2.079E+01  2.259E+01  2.105E+03
 1.920E+02    2.564E-01 -8.997E-01  1.522E-04 -2.032E+01  1.572E+01  2.589E+03
 2.160E+02    2.560E-01 -8.907E-01  5.966E-04 -1.985E+01  9.003E+00  2.864E+03
 2.400E+02    2.557E-01 -8.707E-01  1.076E-03 -1.952E+01  4.203E+00  3.023E+03
 2.640E+02    2.554E-01 -8.388E-01  1.572E-03 -1.919E+01 -5.971E-01  3.066E+03
 2.880E+02    2.551E-01 -7.951E-01  2.066E-03 -1.871E+01 -7.506E+00  2.991E+03
 3.120E+02    2.547E-01  7.380E-01  2.693E-03 -1.825E+01 -1.419E+01  2.707E+03
 3.360E+02    2.544E-01 -6.658E-01  3.294E-03 -1.792E+01 -1.899E+01  2.308E+03
 3.600E+02    2.540E-01 -5.805E-01  3.786E-03 -1.759E+01 -2.379E+01  1.794E+03
 3.840E+02    2.537E-01 -4.848E-01  4.141E-03 -1.711E+01 -3.073E+01  1.160E+03
 4.080E+02    2.534E-01 -3.827E-01  4.319E-03 -1.665E+01 -3.738E+01  3.188E+02
 4.320E+02    2.531E-01 -2.787E-01  4.292E-03 -1.632E+01 -4.218E+01 -6.381E+02
 4.560E+02    2.528E-01 -1.772E-01  4.131E-03 -1.599E+01 -4.698E+01 -1.711E+03
 4.800E+02    2.526E-01 -8.051E-02  3.897E-03 -1.547E+01 -5.155E+01 -2.898E+03


THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.333E-07
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PROB (CONTD)
 1207      ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD


TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER   11      STIFF TYPE    8      LOAD TYPE     0
LENGTH =   1.920E+02      ALPHA =   0.                  BETA =   1.000E+00
GOES FROM JOINT    9 TO JOINT   10
OUTPUT DISTANCES ARE FROM JOINT     9 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                        DISPLACEMENTS                         FORCES

 DISTANCE      AXIAL     LATERAL   ROTATIONAL    AXIAL        SHEAR       MOMENT

 0.          -6.048E-01 -2.278E-03  2.692E-05 -1.210E+01 -1.745E-11  1.741E-10
 9.600E+00   -6.051E-01 -2.020E-03  2.695E-05 -2.371E+01  6.108E-02  3.035E-01
 1.920E+01   -6.054E-01 -1.760E-03  2.717E-05 -3.533E+01  1.135E-01  1.152E+00
 2.880E+01   -6.059E-01 -1.497E-03  2.772E-05 -4.696E+01  1.575E-01  2.463E+00
 3.840E+01   -6.065E-01 -1.227E-03  2.873E-05 -5.860E+01  1.933E-01  4.156E+00
 4.800E+01   -6.072E-01 -9.436E-04  3.032E-05 -7.025E+01  2.211E-01  6.155E+00
 5.760E+01   -6.081E-01 -6.423E-04  3.256E-05 -8.192E+01  2.409E-01  8.383E+00
 6.720E+01   -6.091E-01 -3.160E-04  3.552E-05 -9.360E+01  2.525E-01  1.076E+01
 7.680E+01   -6.103E-01  4.214E-05  3.922E-05 -1.053E+02  2.558E-01  1.321E+01
 8.640E+01   -6.116E-01  4.395E-04  4.368E-05 -1.170E+02  2.504E-01  1.565E+01
 9.600E+01   -6.130E-01  8.832E-04  4.888E-05 -1.288E+02  2.360E-01  1.800E+01
 1.056E+02   -6.146E-01  1.380E-03  5.477E-05 -1.406E+02  2.121E-01  2.016E+01
 1.152E+02   -6.162E-01  1.937E-03  6.130E-05 -1.524E+02  1.782E-01  2.205E+01
 1.248E+02   -6.181E-01  2.559E-03  6.835E-05 -1.642E+02  1.338E-01  2.356E+01
 1.344E+02   -6.201E-01  3.251E-03  7.579E-05 -1.761E+02  7.855E-02  2.459E+01
 1.440E+02   -6.222E-01  4.015E-03  8.347E-05 -1.881E+02  1.201E-02  2.504E+01
 1.536E+02   -6.244E-01  4.853E-03  9.118E-05 -2.000E+02 -6.605E-02  2.479E+01
 1.632E+02   -6.268E-01  5.765E-03  9.869E-05 -2.120E+02 -1.557E-01  2.374E+01
 1.728E+02   -6.293E-01  6.747E-03  1.057E-04 -2.241E+02 -2.569E-01  2.177E+01
 1.824E+02   -6.320E-01  7.793E-03  1.120E-04 -2.362E+02 -3.693E-01  1.878E+01
 1.920E+02   -6.348E-01  8.894E-03  1.172E-04 -2.484E+02 -4.926E-01  1.466E+01

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  1.445E-09
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PROB (CONTD)
 1207      ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD


TABLE 9 - MEMBER RESULTS (CONTD)


MEMBER NUMBER   12      STIFF TYPE    9      LOAD TYPE     0
LENGTH =   2.040E+02      ALPHA =   0.                  BETA =   1.000E+00
GOES FROM JOINT   10 TO JOINT    4
OUTPUT DISTANCES ARE FROM JOINT    10 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES


                        DISPLACEMENTS                         FORCES

 DISTANCE      AXIAL     LATERAL   ROTATIONAL    AXIAL        SHEAR       MOMENT

 0.          -6.348E-01  8.894E-03  1.172E-04 -2.484E+02 -4.926E-01  1.467E+01
 1.020E+01   -6.378E-01  1.011E-02  1.212E-04 -2.484E+02 -4.926E-01  9.641E+00
 2.040E+01   -6.409E-01  1.136E-02  1.235E-04 -2.484E+02 -4.926E-01  4.616E+00
 3.060E+01   -6.440E-01  1.263E-02  1.242E-04 -2.484E+02 -4.926E-01 -4.087E-01
 4.080E+01   -6.470E-01  1.389E-02  1.233E-04 -2.484E+02 -4.926E-01 -5.434E+00
 5.100E+01   -6.501E-01  1.513E-02  1.207E-04 -2.484E+02 -4.926E-01 -1.046E+01
 6.120E+01   -6.531E-01  1.634E-02  1.164E-04 -2.484E+02 -4.926E-01 -1.548E+01
 7.140E+01   -6.562E-01  1.750E-02  1.105E-04 -2.484E+02 -4.926E-01 -2.051E+01
 8.160E+01   -6.592E-01  1.859E-02  1.029E-04 -2.484E+02 -4.926E-01 -2.553E+01
 9.180E+01   -6.623E-01  1.960E-02  9.374E-05 -2.484E+02 -4.926E-01 -3.056E+01
 1.020E+02   -6.654E-01  2.050E-02  8.289E-05 -2.484E+02 -4.926E-01 -3.558E+01
 1.122E+02   -6.684E-01  2.128E-02  7.039E-05 -2.484E+02 -4.926E-01 -4.061E+01
 1.224E+02   -6.715E-01  2.193E-02  5.624E-05 -2.484E+02 -4.926E-01 -4.563E+01
 1.326E+02   -6.745E-01  2.242E-02  4.044E-05 -2.484E+02 -4.926E-01 -5.066E+01
 1.428E+02   -6.776E-01  2.275E-02  2.299E-05 -2.484E+02 -4.926E-01 -5.568E+01
 1.530E+02   -6.806E-01  2.289E-02  3.887E-06 -2.484E+02 -4.926E-01 -6.071E+01
 1.632E+02   -6.837E-01  2.282E-02 -1.686E-05 -2.484E+02 -4.926E-01 -6.573E+01
 1.734E+02   -6.868E-01  2.254E-02 -3.926E-05 -2.484E+02 -4.926E-01 -7.076E+01
 1.836E+02   -6.898E-01  2.202E-02 -6.330E-05 -2.484E+02 -4.926E-01 -7.578E+01
 1.938E+02   -6.929E-01  2.124E-02 -8.900E-05 -2.484E+02 -4.926E-01 -8.081E+01
 2.040E+02   -6.959E-01  2.019E-02 -1.163E-04 -2.484E+02 -4.926E-01 -8.583E+01

THE MAXIMUM EQUILIBRIUM ERROR INTERNAL TO THE MEMBER IS  4.081E-09
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PROB (CONTD)
 1207      ADD JOINT 10 AT GROUND LINE TO SUBDIVIDE PILE - DEAD LOAD


TABLE 10 - JOINT EQUILIBRIUM ERRORS


JOINT  ERR(X)      ERR(Y)      ERR(Z)
       FORCE       FORCE       MOMENT


   1 -1.098E-03  1.992E-10  1.250E-01
   2 -2.089E-03  2.467E-04  5.471E-01
   3  3.187E-03  2.511E-09  3.629E-01
   4  1.242E-04 -3.161E-04  3.808E-02
   5 -4.717E-05  2.161E-08 -8.149E-08
   6  1.175E-03  2.037E-10 -1.621E-01
   7  1.824E-03  6.947E-05 -6.195E-01
   8 -2.996E-03  3.809E-09 -4.407E-01
   9 -1.745E-11  1.414E-09  1.741E-10
  10 -7.697E-05  1.664E-08  7.851E-03
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