A FINITE-ELEMENT METHOD OF SOLUTION FOR STRUCTURAL FRAMES

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 a method of frame analysis which is useful in solving a variety of structural problems. The method is a new approach to frame problems, although much of it is based on previously developed finite-element concepts.

This is the third in a series of reports that describe the work in Research Project No. 3-5-63-56, entitled "Development of Methods for Computer Simulation of Beam-Columns and Grid-Beam and Slab Systems." The reader will find it necessary to review Report No. 56-1 (See List of Reports) which provides background for this report.

Although the computer program presented here is written for the CDC 1604 computer, it is in FORTRAN language and only minor changes are required to make it compatible with IBM 7090 systems. 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.

This report is a product of the combined efforts of many people. The assistance of the Texas Highway Department contact representative, L. G. Walker, is greatly appreciated. The support of the U. S. Bureau of Public Roads is gratefully acknowledged.

The excellent facilities of the Computation Center of The University of Texas and the cooperation of its staff have contributed significantly to this report. Thanks are due to Evangeline Emory, Sam Jones, and all others who assisted with the manuscript.

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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.

ABSTRACT

An efficient numerical method of solution to structural frame problems is presented. The method is shown to be applicable to no-sway, plane-frame structures that may derive part or all of their support from soils.

A finite-element model composed of bars and springs is used to represent groups of orthogonal frame members. Finite-difference equations written for this model are solved by a previously developed recursive method. Individual beams are solved alternately in the two orthogonal directions and at each joint a relaxation technique is used to adjust the two solutions and achieve rotational compatibility.

A complete listing of the FORTRAN computer program is included, plus two example problems illustrating the applicability of the method.

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NOMENCLATURE

Symbol	Typical Units	Definition
a	-	Coefficient in stiffness matrix
A_i	-	Continuity Coefficient computed in recursive solution of equations
b	-	Coefficient in stiffness matrix
B_i	-	Continuity Coefficient computed in recursive solution of equations
c	-	Coefficient in stiffness matrix
C_i	-	Continuity Coefficient computed in recursive solution of equations
d	-	Coefficient in stiffness matrix
D_i	-	Multiplier used in computing Continuity Coefficients
e	-	Coefficient in stiffness matrix
E	lb/in^2	Modulus of elasticity
E_i	-	Multiplier used in computing Continuity Coefficients
f	-	Coefficient in load matrix
$\{f\}$	-	Column load matrix
F	$lb\text{-}in^2$	Flexural stiffness = EI
h	in.	Increment length
i	-	Station number
I	in^4	Moment of inertia of the cross section
k	lb/in	Differential spring
m	-	Total number of increments in beam-column
M	in-lb	Bending moment

Symbol	Typical Units	Definition
q	lb/in	Applied transverse load per unit length
Q	lb	Concentrated applied transverse load
Q_x	lb	Load resisted by beam in x-direction
Q_y	lb	Load resisted by beam in y-direction
r	in-lb/rad/in	Rotational restraint per unit length
R	in-lb/rad	Concentrated rotational restraint
R^F	in-lb/rad	Differential retational spring
s	lb/in^2	Transverse spring restraint per unit length
S	lb/in	Concentrated transverse spring restraint
$[S]$	-	Square stiffness matrix
t	in-lb/in	Applied torque per unit length
T	in-lb	Concentrated applied torque
T^A	in-lb	Torque absorbed by beam intersecting one being solved
T^x	in-lb	Torque resisted by the x-beam
T^y	in-lb	Torque resisted by the y-beam
V	lb	Shear
w	in.	Transverse deflection
$\{w\}$	-	Column deflection matrix
x	in.	Distance along axis of beam-column
θ	radians	Slope

CHAPTER 1. INTRODUCTION

Analysis of structural frame problems by conventional methods usually involves a large amount of arithmetic work. In most cases, a frame that has complex loading, flexural stiffness, or boundary conditions must be reduced to a simpler problem by making simplifying assumptions. The analysis of structural frames may also be complicated by the variable loads that soils impose on them. Outstanding examples of soil-structure interaction problems are offshore structures, highway bridge bents, culverts, and some of the structural members in buildings. Analysis of such systems, in order to be rational, must achieve compatibility in the force-deformation behavior of all parts of the system (Ref 9).

A finite-element technique (Refs 10, 12) has been applied to a wide variety of beam and beam-on-foundation problems (Ref 7) that have variable loading, flexural stiffness, and boundary conditions. Extension of this finite-element approach has broadened its applicability to include nonlinear beams on nonlinear foundations (Refs 3, 11). However, interaction problems involving more complex structural systems, such as frames, have not been analyzed.

A general method of frame analysis must allow complete flexibility in loading, flexural stiffness, and boundary conditions. It is therefore the purpose of this presentation to extend finite-element concepts to the solution of plane-frame structures that may derive part or all of their support from soils.

This method of analysis is accomplished by application of the following concepts:

(1) An orthogonal plane-frame system is represented by a finite-element model composed of bars and springs. This is analogous to a technique used to solve grid-beam systems (orthogonal sets of beams).

(2) Equations developed for the finite-element frame model are based on finite-difference concepts which allow random variation of input data at each increment point.

(3) Frame members are solved alternately in the two orthogonal directions as individual beams. A relaxation technique is used at each joint to coordinate the two solutions.

(4) A rapid and direct method is used to solve the individual beam equations.

Since much of this method is based on previous solutions of beams and grid-beam systems, the basic finite-element equations for these two systems are briefly discussed in Chapter 2. Chapter 3 shows the development of equations for a finite-element model of a plane frame. Solution of individual beam equations and specified boundary conditions are explained in Chapter 4. Chapter 5 contains information pertinent to the best choice of closure springs, closure tolerances, and increment lengths. The capabilities and limitations of the computer program are explained in Chapter 6. Finally, the versatility and generality of the method are illustrated by the solution of two example problems in Chapter 7.

CHAPTER 2. PREVIOUSLY DEVELOPED EQUATIONS FOR BEAMS AND GRID-BEAM SYSTEMS

A considerable amount of work has been done at The University of Texas on numerical methods of analyzing beam-element and grid-beam systems. The extension and application of these methods have progressed rapidly. Certainly, it is not within the scope of this presentation to describe these developments in any detail, but, since the method of frame analysis presented herein is based on fundamental concepts of beam and grid-beam analyses, it seems appropriate to briefly describe these systems and their corresponding finite-element models.

Beam Equations

The curvature of a deformed element of a beam, from conventional beam mechanics, is approximately

$$\frac{d^2w}{dx^2} = \frac{M}{EI} = \frac{M}{F} \tag{2.1}$$

where d^2w/dx^2 , the second derivative of beam deflection w with respect to distance x along the beam, is related to the bending moment M by the beam's flexural stiffness EI or F . Flexural stiffness will hereafter be represented by the symbol F .

Load q in conventional beam mechanics is equal to the second derivative of bending moment M with respect to distance along the beam:

$$\frac{d^2M}{dx^2} = q \tag{2.2}$$

The two differential equations stated above were derived with the following assumptions:

(1) Shearing and axial deformations are neglected.

(2) Beams are straight and of symmetrical cross-section.

(3) Lateral deflections are small compared to original dimensions.

(4) Beam material is linearly elastic.

(5) Plane sections remain plane after bending.

(6) Torsion effects are neglected.

With the foregoing equations and assumptions in mind, consider the deformed beam elements shown in Figs 1a and 1b.

Figure 1a shows a deformed element of a beam for which Eq 2.1, the relation between approximate beam curvature and bending moment, is applicable and is shown as Eq 1.

Figure 1b shows a beam element which, in this case, is much more generalized in loading and restraint than the element in Fig 1a. The various terms shown on the figure are all acting in a positive sense. The transverse loads which act normal to the axis of the beam segment are composed of the loads q and spring reactions s . Couples t and elastic rotational springs r act in an angular sense. In addition, it is possible to have an axial load acting on the element (Ref 12), but this term will be omitted in this presentation. Summing moments about the right end of the beam element shown in Fig 1b which has been deflected an amount w and rotated through an angle dw/dx , one obtains

$$dM = Vdx + q\frac{dx^2}{2} - sw\frac{dx^2}{2} + tdx + rdw \tag{2.3}$$

Neglecting the higher order terms and dividing through by dx produces

$$\frac{dM}{dx} = V + t + r\frac{dw}{dx} \tag{2.4}$$

Summing forces in the vertical direction yields

$$-dV + qdx - swdx = 0 \tag{2.5}$$

or

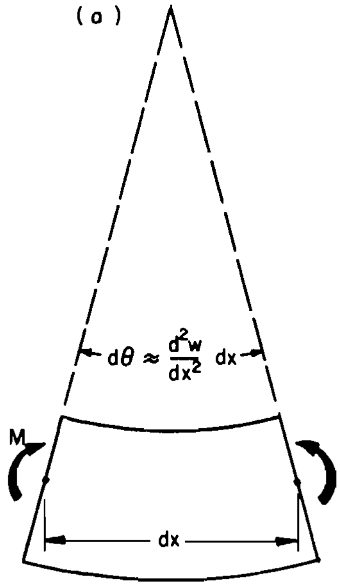
$$\frac{dV}{dx} = q - sw \tag{2.6}$$

Substituting for $\frac{dV}{dx}$

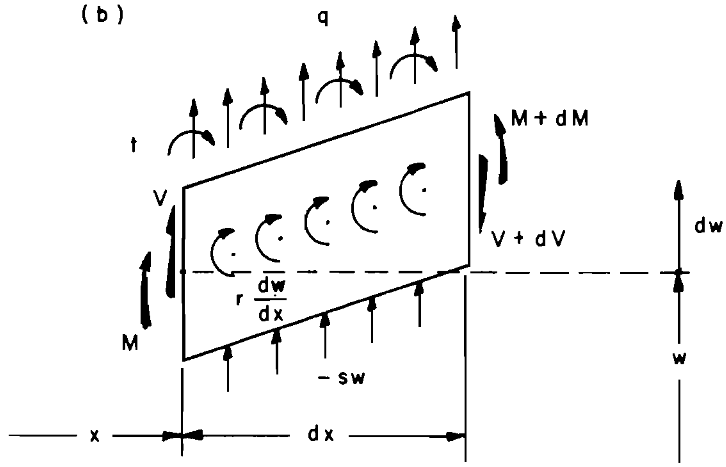
$$\frac{d^2M}{dx^2} = q - sw + \frac{d}{dx}\left[t + r\frac{dw}{dx}\right] \tag{2.7}$$

Let $q - sw = q_{ni}$ and $u = t + r\frac{dw}{dx}$.

(a)



(b)



$$F \frac{d^2 w}{dx^2} = M \quad \text{...(1)}$$

$$\frac{d^2 M}{dx^2} = q_{n_i} + \frac{du}{dx} \quad \text{...(2)}$$

where $q_{n_i} = q - sw$

$u = t + r \frac{dw}{dx}$

(c)

$$F_{i-1} \left(\frac{w_{i-2} - 2w_{i-1} + w_i}{h^2} \right) = M_{i-1}$$

$$F_i \left(\frac{w_{i-1} - 2w_i + w_{i+1}}{h^2} \right) = M_i$$

$$F_{i+1} \left(\frac{w_i - 2w_{i+1} + w_{i+2}}{h^2} \right) = M_{i+1} \quad \text{...(3)}$$

$$\frac{M_{i-1} - 2M_i + M_{i+1}}{h^2} = q_{n_i} + \frac{-u_{i-1} + u_{i+1}}{2h} \quad \text{...(4)}$$

where $q_{n_i} = q_i - s_i w_i$

$u_i = t_i + r_i \left(\frac{-w_{i-1} + w_{i+1}}{2h} \right)$

$$a_i w_{i-2} + b_i w_{i-1} + c_i w_i + d_i w_{i+1} + e_i w_{i+2} = f_i \quad \text{...(5)}$$

where

$a_i = F_{i-1} - 0.25h^2 r_{i-1}$

$b_i = -2 (F_{i-1} + F_i)$

$c_i = F_{i-1} + 4F_i + F_{i+1} + h^4 s_i + 0.25h^2 \; (r_{i-1} + r_{i+1})$

$d_i = -2 (F_i + F_{i+1})$

$e_i = F_{i+1} - 0.25h^2 r_{i+1}$

$f_i = h^4 q_i - 0.5h^3 (t_{i-1} - t_{i+1})$

Fig 1. Development of fourth-order difference equation from the two second-order differential equations for a beam (after Matlock and Ingram, Ref 12, p 376).

Therefore

$$\frac{d^2M}{dx^2} = q_{ni} + \frac{du}{dx} \qquad (2.8)$$

shown as Eq 2 in Fig 1b. This equation is very similar to Eq 2.2 of conventional beam mechanics except that the total transverse load q includes both forces and spring reactions and an additional term du/dx is included to express the rotational effects t and r.

By dividing the beam into m number of increments of equal length h Eqs 1 and 2 of Fig 1 may be expressed in finite-difference form as Eqs 3 and 4 (Refs 5, 8, 12). The fourth-order difference expression given as Eq 5 results from the combination of Eqs 3 and 4. The coefficients a_i through e_i on the left side of Eq 5 comprise one row of a five-member diagonal stiffness matrix centered about some Station i on the beam. On the right side, f_i is one term of a column-load matrix also centered about Station i. This fourth-order difference equation may then be written repetitively at each station (increment point) along the beam, resulting in a set of $m + 3$ simultaneous equations where the deflections w_i at each station are the unknowns.

The combination of equations in Fig 1 which resulted in Eq 5, as explained above, has been shown (Ref 12) to permit input data for beam stiffness, applied loads, and elastic restraints to vary in a freely discontinuous manner from station to station. Input quantities, which are used in all subsequent expressions, are designated by capital letters. As such they are "lumped" quantities which may represent either concentrated effects or approximations of distributed effects per increment length h.

Resulting Finite-Element Beam Model

If all input quantities are concentrated at the increment points, there results a mechanical model, Fig 2, which is an aid in visualizing the relation between the finite-difference equation and the physical system. Figure 2 is an exact representation of some Station i whose behavior is described by Eq 5. The bending stiffness F_i is represented as a spring-restrained hinge concentrated at an increment point between two rigid bars. All reactions from elastic restraints and loads are represented as transverse loads applied at the increment points. The couple T_i centered about Station i is ultimately expressed as two equal and opposite forces $T_i/2h$. Similarly,

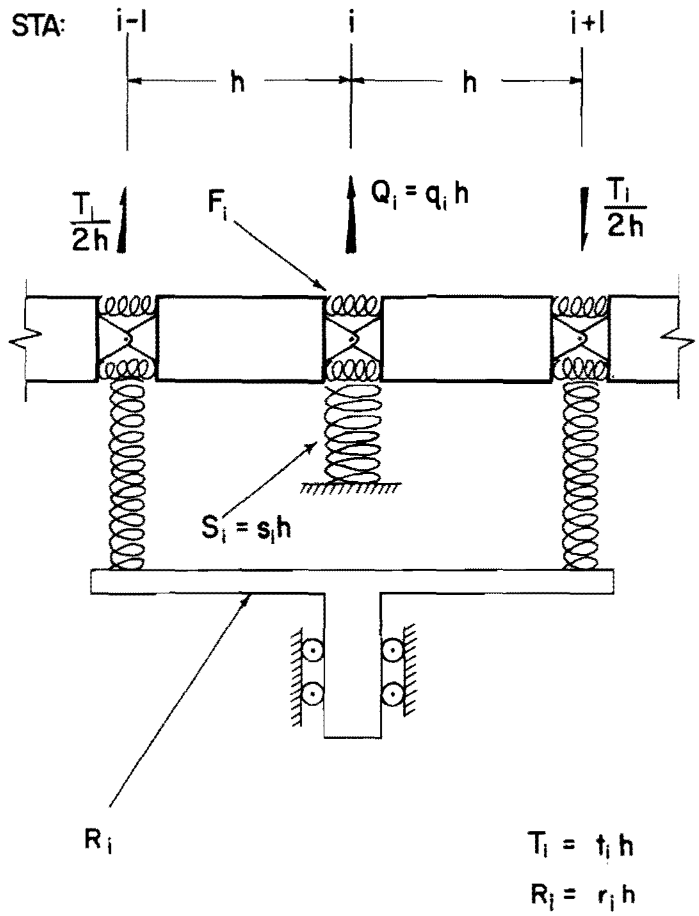


Fig 2. Finite-element beam model corresponding exactly to fourth-order difference equation (after Matlock and Ingram, Ref 12, p 377).

the rotational spring R_i , which will assume a large degree of importance in the frame analysis method, causes two equal but opposite forces.

The finite-element mechanical model as presented in the preceding paragraph represents a powerful concept in the analysis of structural systems. This finite-element-model approach was used by Tucker (Ref 13) to obtain solutions to a wide variety of grid-beam problems.

Just as some of the methods used in the solution of grid-beam systems were based on beam methods, the frame analysis method presented in this study is similarly based on both beam and grid-beam techniques. Therefore, a brief discussion of grid-beam solutions will follow.

Development of Grid-Beam Equations

A grid-beam system is composed of two orthogonal sets of beams. The following differential equation represents the behavior of an idealized grid-beam system:

$$\frac{\partial^4 w}{\partial x^4} + \frac{\partial^4 w}{\partial y^4} = \frac{q}{F} \tag{2.9}$$

where w represents deflection transverse to the plane of the system, q , a uniform load over the system, and F , constant flexural stiffness.

If the two orthogonal sets of beams are connected at their intersections by ball and socket connections, then they transfer transverse loads but otherwise act independently. Thus, at any intersection the total applied transverse load Q must be reacted by the load in the beams, or

$$Q = Q_x + Q_y \tag{2.10}$$

where Q_x is the load resisted by the beam in the x-direction and Q_y is the load resisted by the beam in the y-direction. The above equation indicates that the solution of Eq 2.9 could be obtained by solving the beams individually, i.e.,

$$Q_x = Q - Q_y \tag{2.11a}$$

$$Q_y = Q - Q_x \tag{2.11b}$$

One method of solution which has been applied to Eqs 2.11a and 2.11b is an iterative process termed an alternating-direction method. The method consists of alternately solving the x and y-beams of the grid-beam system. Equation 2.11a is alternately applied to the x-beams and, solving for their deflected shapes, the loads Q_x resisted by the x-beams are determined by numerical differentiation. Substituting Q_x into Eq 2.11b, it is then applied to the y-beams and their deflected shapes are determined. For each cycle of the iterative process the right side of the equation being solved is temporarily held constant while the terms on the left side are treated as unknowns. However, to achieve convergence of the iterative process described above, it has been shown (Ref 13) that the solution of the individual beams must be coordinated by a method other than just the simple transfer of loads Q_x and Q_y .

The method of coordinating the individual beam solutions is accomplished by employing a differential spring at each intersection. This differential spring concept is based on a rigorous interpretation of the finite-element grid-beam model illustrated in Fig 3.

The basic feature of this method (Ref 13) is that the loads and differential springs act alternately on the x and y-beams. A typical x-beam segment at an intersection is shown in Fig 4. It has been shown (Ref 13) that the following equations can be derived from consideration of the beam segment in Fig 4:

$$Q_x + K(w_x - w_y) = Q - Q_y \tag{2.12a}$$

$$Q_y + K(w_y - w_x) = Q - Q_x \tag{2.12b}$$

Note that these expressions are the same as Eqs 2.11a and 2.11b except for adding the differential spring K , which drops out of the equation when the solution is obtained, i.e., when $w_x = w_y$.

Due to the success of this alternating-direction and relaxation technique on grid-beam systems, it appeared that this method could be applied to other types of structural systems. This study represents an extension of finite-element-model and alternating-direction methods to the solution of two-dimensional structural frames. These concepts applied to frames will be described in the next chapter.

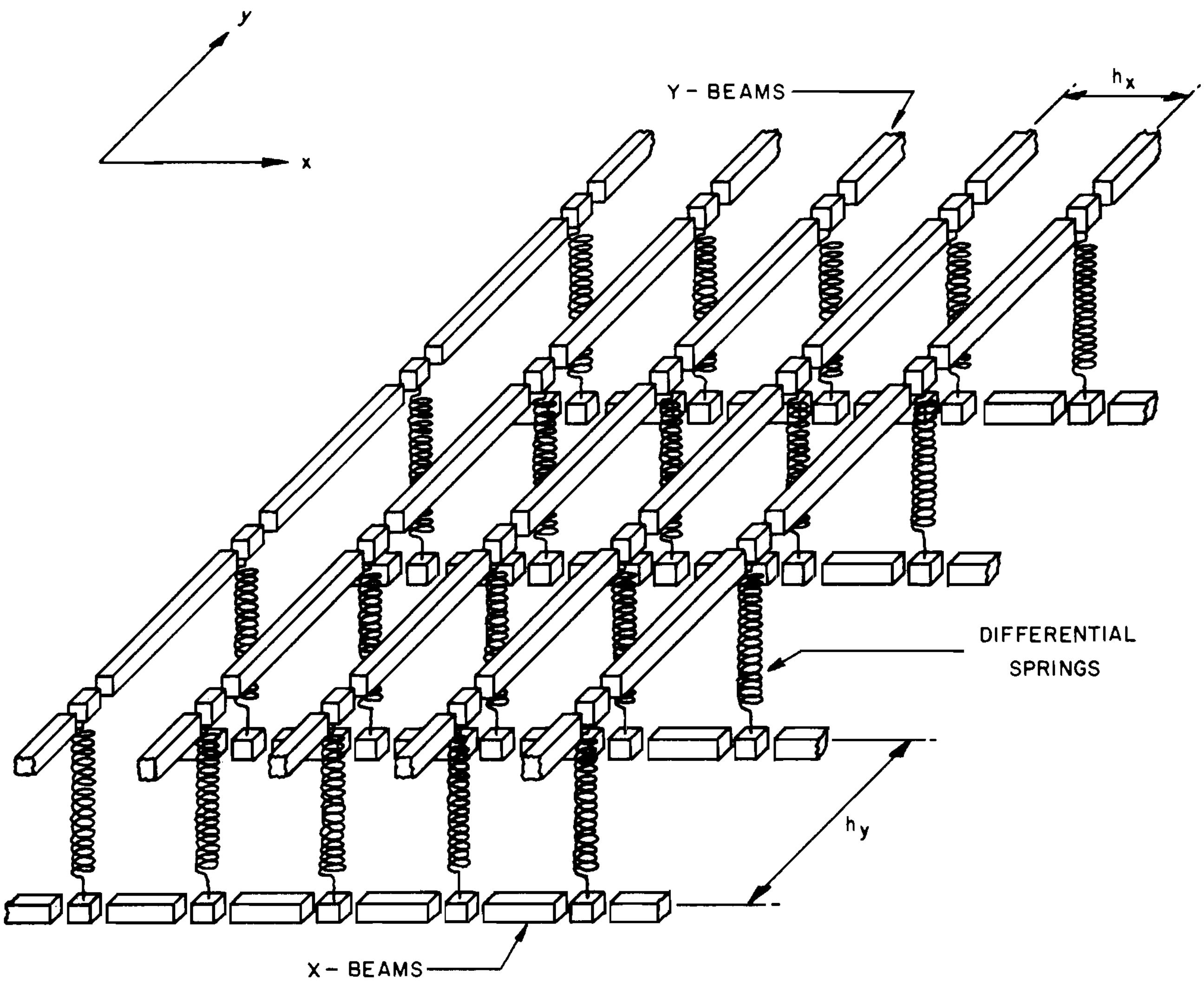


Fig 3. Grid-beam system represented as two orthogonal systems joined by springs (after Tucker, Ref 13, p 17).

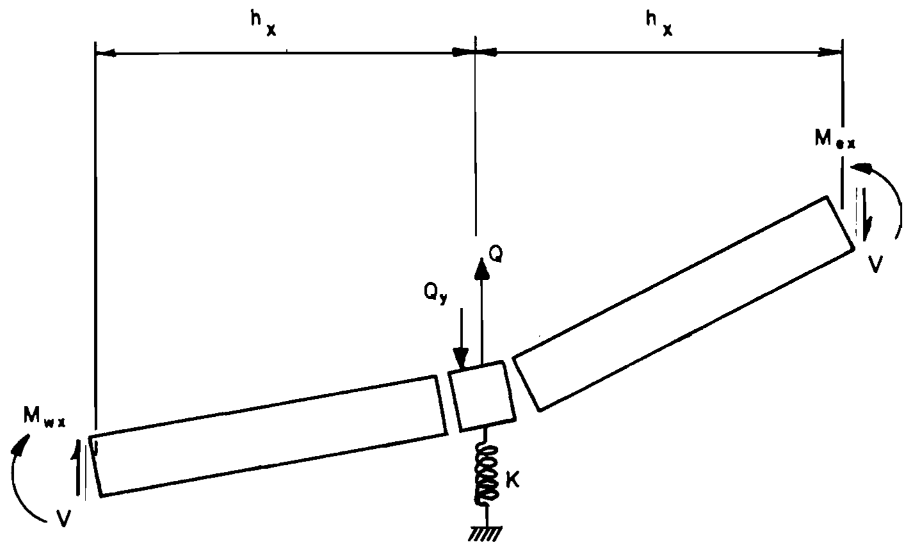


Fig 4. Free-body of a general segment of an x-beam (adapted after Tucker, p 63).

CHAPTER 3. DEVELOPMENT OF EQUATIONS FOR A FINITE-ELEMENT MODEL OF A STRUCTURAL FRAME

The development of iterative methods for solving a finite-element frame model will be prefaced by a review of conventional rigid joint frames. Joints in both systems must satisfy the same compatibility and equilibrium conditions. However, much greater generality is achieved by the use of finite-element frame models which are discussed later in this chapter.

Conventional Frame Systems

A typical rigid-frame joint is shown in Fig 5. Because of the rigid connection, the joint must satisfy the following equilibrium and compatibility conditions:

(1) All members meeting at the joint must rotate through the same angle,

$$\theta_x = \theta_y \tag{3.1}$$

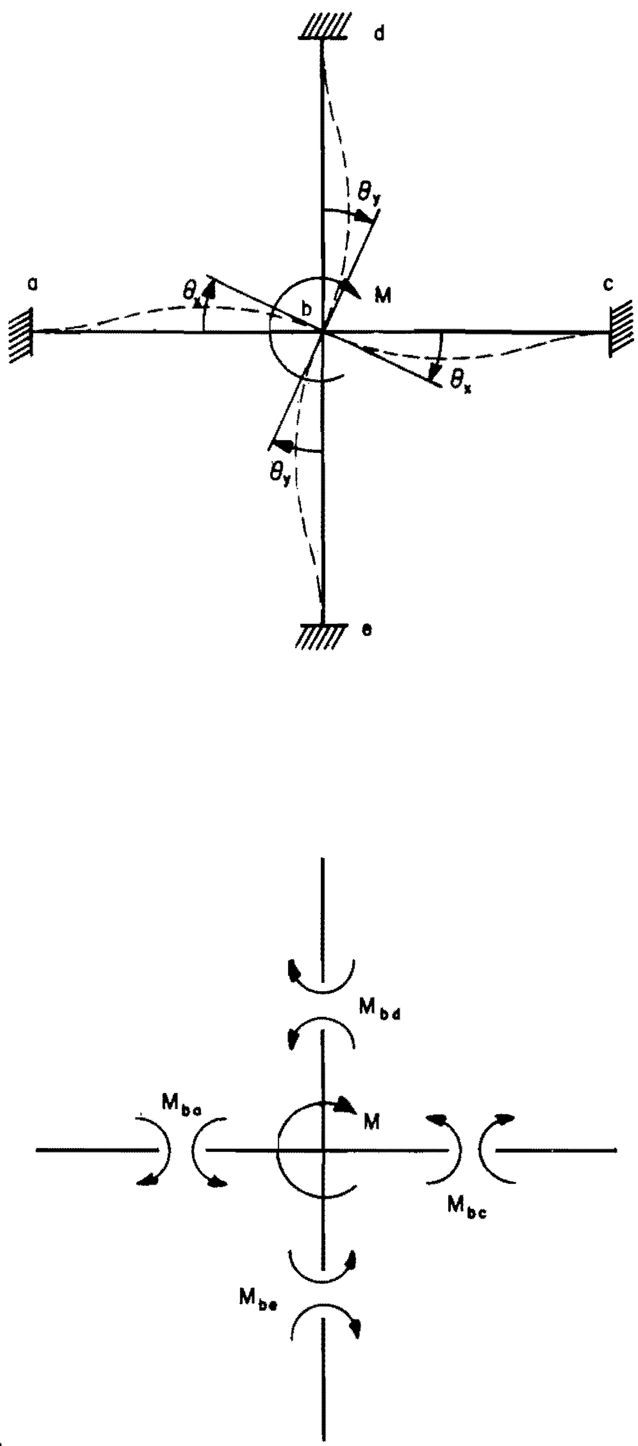
(2) and,

$$M_{ba} + M_{bd} + M_{bc} + M_{be} + M = 0 \tag{3.2}$$

Conventional methods of analysis such as slope-deflection, moment distribution, unit-load, and others (Refs 1, 4, 6) use these conditions of compatibility and equilibrium to formulate equations to solve for moments and loads in the frame members. These methods of analysis can become quite complicated and time consuming, especially when discontinuous patterns of loading, support, and flexural stiffness are encountered. Flexibility or stiffness matrix methods (Ref 4) are inefficient because of the time required to manipulate matrices for even small problems, but application of finite-element concepts permits rapid solution of very complex systems.

Finite-Element Model of a Frame

In order to apply finite-element concepts, the conventional frame system is represented by a finite-element model. The resulting equations derived in finite-difference form exactly describe the model's behavior and



(a)

(b)

Fig 5. Typical rigid-frame joint.

allow discontinuity of any of the input functions. In other words, all of the approximations lie in the substitution of the finite-element model for the original system since the derived difference expressions are exact for the model.

The finite-element model for a frame is composed of a system of bars and springs such as that shown in Fig 6. The bars are infinitely rigid and the springs located between bars represent the bending stiffness F of the frame member. Note that frame members are essentially finite-element models corresponding to the beam-element model shown in Fig 2.

At intersections, the beams are connected by a ball and socket connection but with a closure spring included to enforce rotational compatibility and equilibrium. This closure spring is in the form of a differential rotational spring and will be discussed in greater detail in subsequent developments. A typical intersection i,j is shown in Fig 7. The forces and restraints that effect its behavior are shown in the figure and include a differential rotational spring $R^F_{i,j}$, a transverse load $Q_{i-1,j}$, a transverse spring $S_{i+1,j}$, and a torque $T_{i,j}$.

Conditions and assumptions relevant to the finite-element systems shown in Figs 6 and 7, excluding those already listed in Chapter 2, page 3, are listed below.

(1) Axial loads on frame members are not considered.

(2) Frame joints do not translate.

(3) The bars are weightless and infinitely stiff.

(4) For nonprismatic members, the neutral axis is at the same level for all elements.

(5) The increment length h must be the same in both x and y-directions. This requirement could be eliminated by a more general derivation.

(6) The flexural stiffness of the beams in the x and y-directions may be different and may vary from point to point along any frame member.

(7) Only effects of bending deformations are considered.

(8) All bending deformations occur at the spring hinges between the infinitely stiff bars.

(9) Frame members are orthogonal.

(10) Rotational springs act to resist a change in slope which is approximated by the central-difference form for the first derivative of deflection

$$\theta_{i,j} = \frac{-w_{i-1,j} + w_{i+1,j}}{2h} \tag{3.3}$$

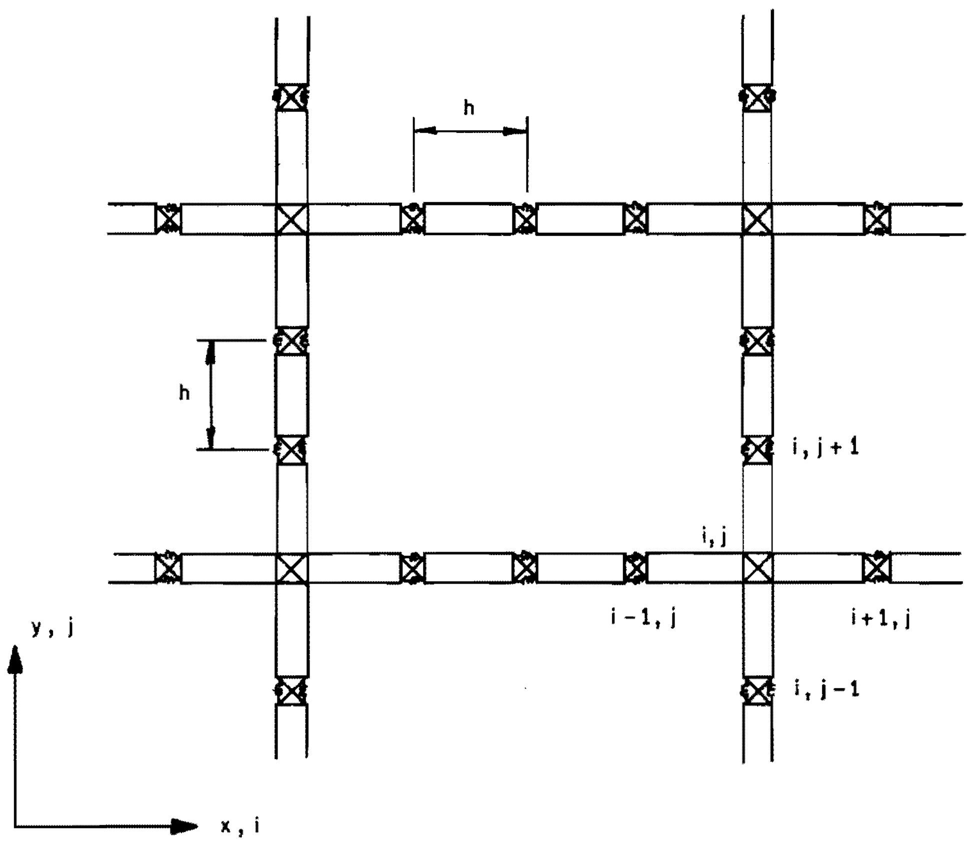


Fig 6. Frame represented as two orthogonal systems composed of bars and springs.

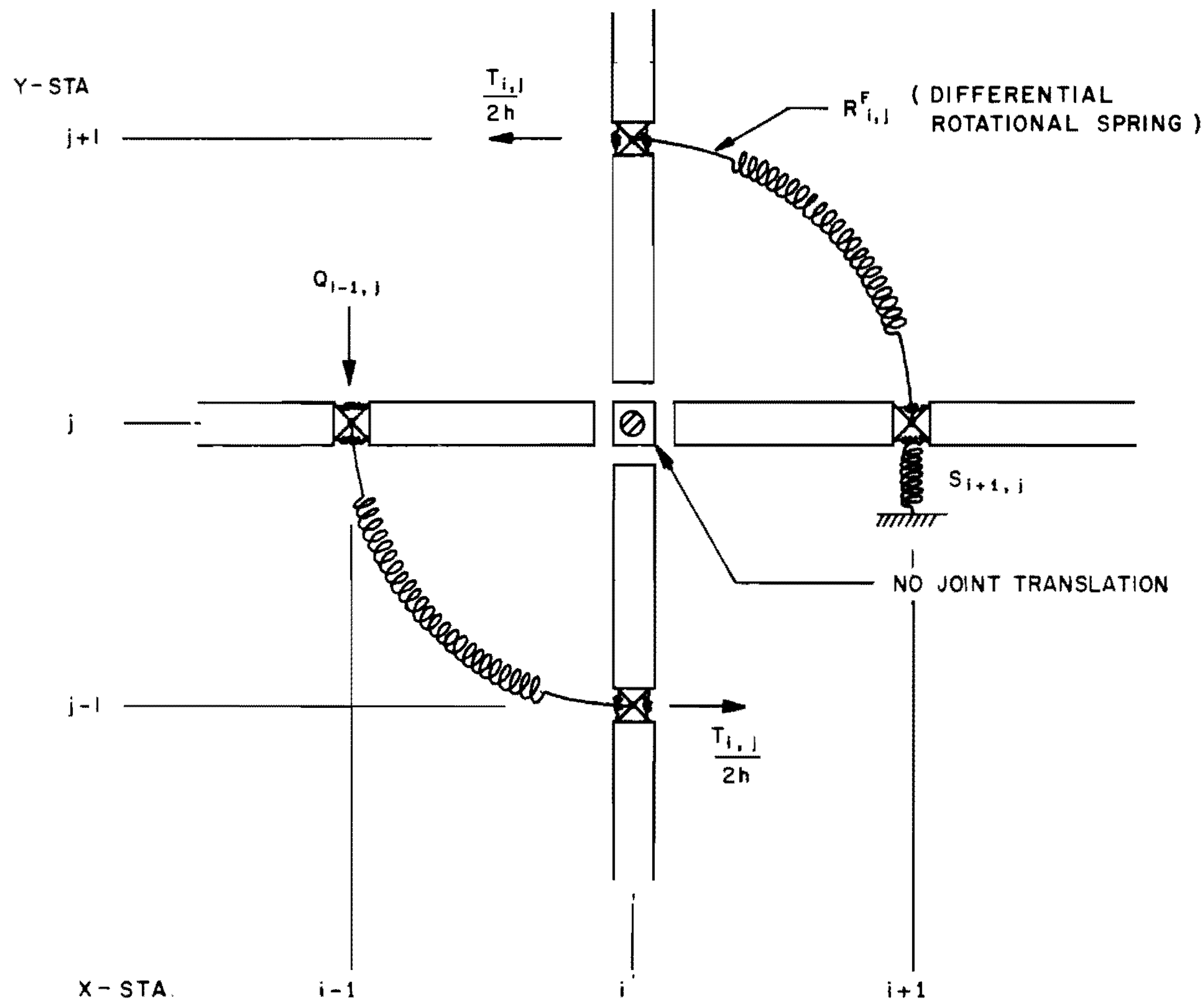


Fig 7. General system of loading at stations pertinent to the behavior of a typical finite-element joint i,j .

Iteration Concepts

In the discussion that follows, iterative methods are introduced in a non-mathematical fashion making them rather easy to visualize.

These iterative methods are based on alternating-direction concepts in which each beam in the two orthogonal sets of beams is solved one time during each iteration. In subsequent developments, this method will be shown to be analogous to the iterative method used to solve grid-beam systems.

Consider a rigid-frame joint to which an external torque T has been applied as shown in Fig 8. The total torque T applied in the plane of the frame must be resisted by the torque in the beams, or,

$$T = T^x + T^y \tag{3.4}$$

where T^x is the torque resisted by the x-beam and T^y is the torque resisted by the y-beam. From Eq 3.4, the torque applied to the x-beams and y-beams could also be expressed as

$$T^x = T - T^y \tag{3.5a}$$

$$T^y = T - T^x \tag{3.5b}$$

In this form Eqs 3.5a and 3.5b suggest an alternating-direction iterative method of solution where each x and y-beam is solved independently. However, to coordinate the two alternate solutions there must be a method of transferring torque between the orthogonal sets of beams.

The method of coordinating the two alternate solutions is achieved by a differential rotational spring such as that shown in Fig 7. Physically, this spring may be thought of as transferring rotational effects between the two beams. It can be seen that as the x-beam undergoes some rotation the y-beam would be physically pulled in the same direction by the rotational spring $R^F_{i,j}$. While it is necessary to have this spring to coordinate the alternate solutions, it is also necessary that it drop out of the solution when compatibility and equilibrium conditions have been satisfied. With these conditions in mind, the differential rotational spring may be included in the iterative Eqs 3.5a and 3.5b as follows:

$$T^x + R^F (\theta^x - \theta^y) = T - T^y \tag{3.6a}$$

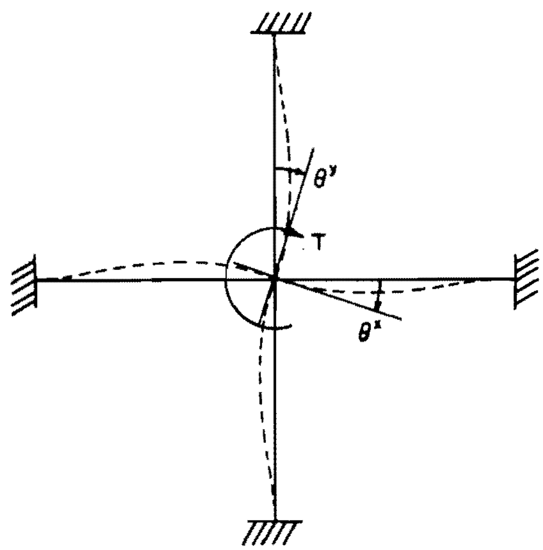


Fig 8. External torque applied to rigid-frame joint.

$$T^y - R^F (\theta^y - \theta^x) = T - T^x \tag{3.6b}$$

where θ^x and θ^y are the slopes of the x and y-beams, respectively. Once the solution has been achieved, i.e., when $\theta^x = \theta^y$, the differential rotational spring drops out and Eqs 3.6a and 3.6b reduce to Eq 3.4.

Although the terms in Eqs 3.6a and 3.6b express only rotational effects, it should be kept in mind that in finite-element concepts these effects are ultimately expressed as transverse loads. The finite-difference expressions for Eqs 3.6a and 3.6b will be derived in the following paragraphs.

Equations Derived for a Finite-Element Frame Model

Consider the forces and restraints on an x-beam at an intersection i,j, as shown in Fig 9a. Forces $T_{i,j}/2h$ result from an externally applied torque, while $T^y_{i,j}/2h$ and $R^F_{i,j}$ temporarily represent the y-beam. The magnitude of $T^y_{i,j}$ represents the amount of externally applied torque absorbed by the y-beam and is known from the previous cycle in which the y-beam system was solved. $T^y_{i,j}$ is determined by taking the fourth derivative of y-beam deflection at one station either side of the joint and subtracting all load effects, except $T_{i,j}/2h$, at that station. Then the resulting load term is multiplied by the distance (2h) between the two stations. Similarly, $T^x_{i,j}$ in Fig 9b is determined by the same numerical differentiation process.

Finite-difference equations for the x-beam model in Fig 9a are derived by including the additional load and restraint terms in the beam-element equation (Eq 5, Fig 1). The resulting finite-difference equation is of the form

$$a_{i,j}\, w^x_{i-2,j} + b_{i,j}\, w^x_{i-1,j} + c_{i,j}\, w^x_{i,j} + d_{i,j}\, w^x_{i+1,j} + e_{i,j}\, w^x_{i+2,j} = f_{i,j} \tag{3.7}$$

where

$$a_{i,j} = F^x_{i-1,j} - 0.25h\,(R^F_{i-1,j})$$

$$b_{i,j} = -2\,(F^x_{i-1,j} + F^x_{i,j})$$

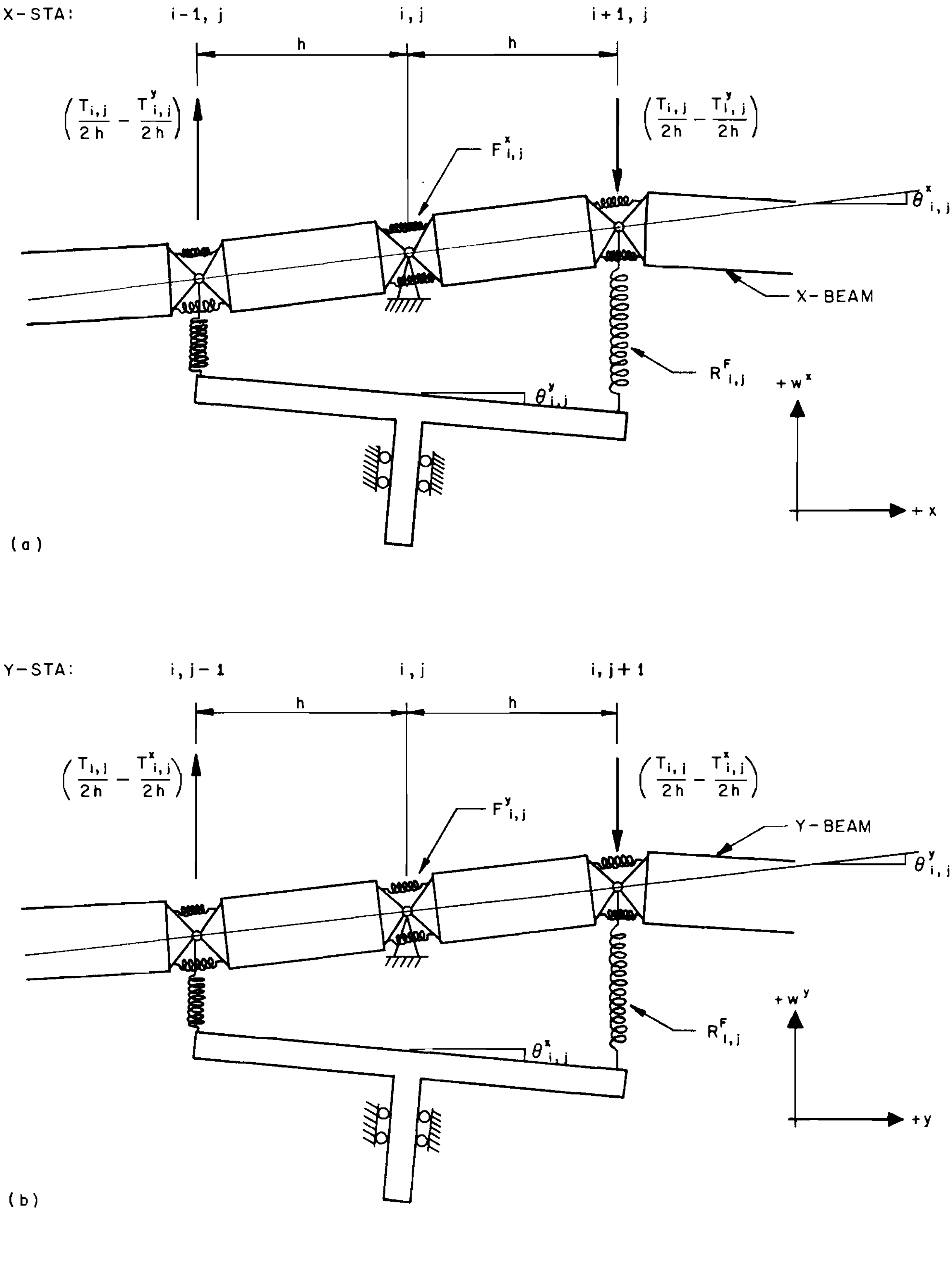


Fig 9. Individual orthogonal beams at a typical finite-element model frame joint i,j . Note that the y-beam has been placed in a horizontal position.

$$c_{i,j} = F^x_{i-1,j} + 4\ F^x_{i,j} + F^x_{i+1,j} + 0.25h\ (R^F_{i-1,j} + R^F_{i+1,j})$$

$$d_{i,j} = -2\ (F^x_{i,j} + F^x_{i+1,j})$$

$$e_{i,j} = F^x_{i+1,j} - 0.25h\ (R^F_{i+1,j})$$

$$f_{i,j} = Q^x_{i,j}\ h^3 - 0.5h^2\ (T_{i-1,j} - T_{i+1,j} - T^y_{i-1,j} + T^y_{i+1,j} + R^F_{i+1,j}\ \Theta^y_{i,j} - R^F_{i-1,j}\ \Theta^y_{i,j})$$

Referring to the y-beam segment in Fig 9b, the resulting finite-difference equation is of the form

$$a_{i,j}\ w^y_{i,j-2} + b_{i,j}\ w^y_{i,j-1} + c_{i,j}\ w^y_{i,j} + d_{i,j}\ w^y_{i,j+1} + e_{i,j}\ w^y_{i,j+2} = f_{i,j} \tag{3.8}$$

where

$$a_{i,j} = F^y_{i,j-1} - 0.25h\ (R^F_{i,j-1})$$

$$b_{i,j} = -2\ (F^y_{i,j-1} + F^y_{i,j})$$

$$c_{i,j} = F^y_{i,j-1} + 4\ F^y_{i,j} + F^y_{i,j+1} + 0.25h\ (R^F_{i,j-1} + R^F_{i,j+1})$$

$$d_{i,j} = -2\ (F^y_{i,j} + F^y_{i,j+1})$$

$$e_{i,j} = F^y_{i,j+1} - 0.25h\ (R^F_{i,j+1})$$

$$f_{i,j} = Q^y_{i,j}\ h^3 - 0.5h^2\ (T_{i,j-1} - T_{i,j+1} - T^x_{i,j-1} + T^x_{i,j+1} + R^F_{i,j+1}\ \Theta^x_{i,j} - R^F_{i,j-1}\ \Theta^x_{i,j})$$

Using Eqs 3.6a and 3.6b, the procedure for solving the entire system of orthogonal frame members is summarized below.

(1) Select initial values of the closure spring R^F which are cycled after each complete x and y-beam solution. Chapter 5 is devoted to suggestions for selecting these spring values.

(2) Assume initial deflection values for the y-beams equal to zero. Thus, the initial value of the absorbed torque T^y is equal to zero.

(3) Solve the x-beams individually using Eq 3.7, the finite-difference form of Eq 3.6a. The results of this solution will yield values of deflection at each increment point from which values of $T^x/2h$ may be determined by numerical differentiation.

(4) Solve the y-beams similarly using the finite-difference Eq 3.8.

(5) Repeat Steps 3 and 4 using the next spring value.

(6) Repeat Steps 3, 4, and 5 until values of $\theta^x_{i,j}$ and $\theta^y_{i,j}$ are in agreement with each other within prescribed tolerances.

(7) Final deflected shapes are numerically differentiated as follows:

$$\left(\frac{dw}{dx}\right)_i = \left(\frac{-w_{i-1} + w_{i+1}}{2h}\right) \tag{3.9}$$

$$F_i \left(\frac{d^2w}{dx^2}\right)_i = M_i = F_i \left(\frac{+w_{i-1} - 2w_i + w_{i+1}}{h^2}\right) \tag{3.10}$$

$$\left(\frac{dM}{dx}\right)_i = \left(\frac{-M_{i-1} + M_{i+1}}{2h}\right) \tag{3.11}$$

where $(dw/dx)_i$, $F_i(d^2w/dx^2)_i$, and $(dM/dx)_i$ are respectively slope, moment, and dM/dx from which conventional shear can be obtained by applying Eq 2.4.

Compatibility and Equilibrium of the Finite-Element Frame Joint

The method that has been presented in this chapter represents a new approach to rigid joint frame problems. However, the finite-element model joints, like the conventional rigid joints, must satisfy the conditions expressed in Eqs 3.1 and 3.2.

In finite-difference concepts the slope at any station (Eq 3.3) involves the deflection one station behind and one station ahead. Referring to the finite-element model joint in Fig 7 the x and y-beam slopes must be equal for rotational compatibility:

$$\frac{-w^x_{i-1,j} + w^x_{i+1,j}}{2h} = \frac{-w^y_{i,j-1} + w^y_{i,j+1}}{2h} \tag{3.12}$$

Thus, by the method presented herein, rotational compatibility is satisfied for a joint that is two increments wide in each orthogonal direction. Moment equilibrium of a finite-element frame joint is also based on a joint two increments wide. Referring to Fig 7 joint equilibrium may be verified by summing the moments about i,j of all forces and couples that act within one increment from Station i,j in both orthogonal directions.

Due to these finite-difference approximations, increment length is a significant factor in this method. Suggestions are made in Chapter 5 for selecting the increment length.

The equations that have been presented in this chapter can be rapidly solved by a recursive technique. The solution of these finite-difference equations is explained in the following chapter.

CHAPTER 4. SOLUTION OF INDIVIDUAL BEAM EQUATIONS AND METHODS OF ESTABLISHING SPECIFIED CONDITIONS

A rapid method of solving fourth-order difference equations has been developed previously (Ref 10). This recursive method is used to solve the individual beam equations derived in the preceding chapter; therefore, a brief discussion of the method will follow. Also included in this chapter is an explanation of the technique for establishing specified conditions of deflection, slope, or both along any frame member.

Solution of Individual Beam Equations

Independent equations in the form of Eq 3.6 may be written at each y-beam intersection on the x-beams. For simplicity, only a solution of x-beam equations will be referred to, but this discussion also applies to y-beams. At stations along the x-beam that are between intersections, Eq 3.6 reduces exactly to Eq 5 of Fig 1. The resulting system of equations written repeatedly along a beam can be arranged into matrix form such that the matrix expression is

$$\left[S \right] \left\{ w \right\} = \left\{ f \right\} \tag{4.1}$$

where $\left[S \right]$ is a square matrix containing the stiffness coefficients a_i, b_i, c_i, etc.; $\left\{ w \right\}$ is a column matrix of unknown deflection values; and $\left\{ f \right\}$, a column load matrix. Matrix $\left[S \right]$ is a five-diagonal banded matrix referred to as a quidiagonal system.

The recursive method is used to solve the quidiagonal system by proceeding from left to right (increasing i) along the beam and eliminating unknown deflections (w_{i-2} and w_{i-1}). This results in another diagonally banded system of equations of the form

$$w_i - B_i w_{i+1} - C_i w_{i+2} = A_i \tag{4.2}$$

where

$$A_i = D_i (E_i A_{i-1} + a_i A_{i-2} - f_i) \tag{4.3}$$

$$B_i = D_i (E_i C_{i-1} + d_i) \quad (4.4)$$

$$C_i = D_i (e_i) \quad (4.5)$$

and

$$D_i = -1/(E_i B_{i-1} + a_i C_{i-2} + c_i) \quad (4.6)$$

$$E_i = a_i B_{i-2} + b_i \quad (4.7)$$

Unknown deflections w_i at each station are then computed from right to left (decreasing i) along the beam by applying the following version of Eq 4.2:

$$w_i = A_i + B_i w_{i+1} + C_i w_{i+2} \quad (4.8)$$

The forward pass (Eq 4.2) and the reverse pass (Eq 4.8) must have some known values to get started in the process. This is done by starting the recursive process and turning it around on a fictitious station (one station beyond each end of the real beam) for which the flexural stiffness is zero. This entire process of generating the required system of $m + 3$ simultaneous equations for a finite-element model of a frame member is illustrated in Figs 10a through 10c.

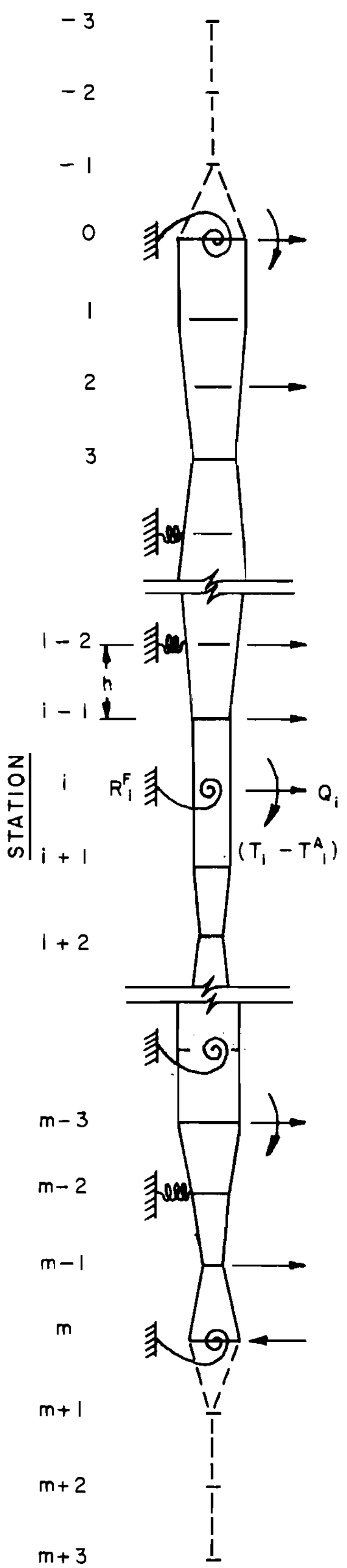
Specified Deflections

The continuity coefficients A_i , B_i , and C_i in Eq 4.8 can be manipulated as they are calculated to enforce specified conditions. To set deflection at any station along the beam the computation of these coefficients is interrupted at that particular station. Coefficients B_i and C_i are set equal to zero and the coefficient A_i is set equal to the desired deflection. This method in effect causes a reaction (transverse force) at Station i of sufficient magnitude to create the desired deflection.

Specified Slopes

The slope at any Station i is set by manipulating the continuity coefficients at Stations $i - 1$ and $i + 1$. In finite-difference form

(a) FINITE - ELEMENT MODEL



(b) STIFFNESS MATRIX — (c) LOAD MATRIX

$$
\begin{array}{cc|cccccccc|c}
0 & 0 & c_{-1} & d_{-1} & e_{-1} & & & & & & f_{-1} \\
 & 0 & b_0 & c_0 & d_0 & e_0 & & & & & f_0 \\
 & & a_1 & b_1 & c_1 & d_1 & e_1 & & & & f_1 \\
 & & & a_2 & b_2 & c_2 & d_2 & e_2 & & & f_2 \\
 & & & & a_3 & b_3 & c_3 & d_3 & e_3 & & f_3
\end{array}
$$

* * *

GENERAL DIFFERENCE EQUATION AT A FRAME JOINT, STATION i

$$a_i w_{i-2} + b_i w_{i-1} + c_i w_i + d_i w_{i+1} + e_i w_{i+2} = f_i$$

where *

$$a_i = F_{i-1} - 0.25h(R^F_{i-1})$$
$$b_i = -2(F_{i-1} + F_i)$$
$$c_i = F_{i-1} + 4F_i + F_{i+1} + 0.25h(R^F_{i-1} + R^F_{i+1})$$
$$d_i = -2(F_i + F_{i+1})$$
$$e_i = F_{i+1} - 0.25h(R^F_{i+1})$$
$$f_i = Q_i h^3 - 0.5h^2(T_{i-1} - T_{i+1} - T^A_{i-1} + T^A_{i+1} + R^F_{i+1}\theta_j - R^F_{i-1}\theta_j)$$

* * *

$$
\begin{array}{ccccccc|cc|c}
a_{m-3} & b_{m-3} & c_{m-3} & d_{m-3} & e_{m-3} & & & & & f_{m-3} \\
 & a_{m-2} & b_{m-2} & c_{m-2} & d_{m-2} & e_{m-2} & & & & f_{m-2} \\
 & & a_{m-1} & b_{m-1} & c_{m-1} & d_{m-1} & e_{m-1} & & & f_{m-1} \\
 & & & a_m & b_m & c_m & d_m & 0 & & f_m \\
 & & & & a_{m+1} & b_{m+1} & c_{m+1} & 0 & 0 & f_{m+1}
\end{array}
$$

F = BENDING STIFFNESS EI

T^A_i = TORQUE ABSORBED BY BEAM INTERSECTING ONE BEING SOLVED

R^F = CLOSURE SPRING

θ_j = SLOPE OF BEAM INTERSECTING ONE BEING SOLVED

Fig 10. System of m + 3 simultaneous equations for a finite-element model of a frame member.

the slope at Station i is

$$\theta_i = \frac{-w_{i-1} + w_{i+1}}{2h} \tag{4.9}$$

For this condition, manipulation of the continuity coefficients at Stations i - 1 and i + 1 causes a transverse couple about Station i of sufficient magnitude to rotate the beam through the desired slope.

The necessary reactions to create specified conditions of deflection and slope act at different stations. Therefore, it is possible to specify both conditions at the same station (Ref 10).

The solutions to the equations developed in this chapter are obtained rather rapidly. But, the rapidity and the accuracy of the final solution is dependent on several factors, namely: (1) choice of rotational closure springs, (2) closure tolerance, and (3) increment length. While the choice of values for these factors is somewhat empirical, there are certain ranges of values which can be suggested. These suggestions are made in the next chapter.

CHAPTER 5. CLOSURE SPRING VALUES, INCREMENT LENGTHS, AND CLOSURE TOLERANCES FOR FINITE-ELEMENT FRAME MODELS

Selection of Closure Spring Values

Although the selection of the differential rotational spring or closure spring values may be entirely arbitrary, some judgment should be used in order to select springs that will produce rapid closure. Springs that are too soft or too stiff may produce slow convergence, or possibly divergence. A rigorous method of determining spring values would involve consideration of the flexural properties of the system, increment length, boundary conditions, and loading. Therefore, exact selection of springs that will produce the most rapid convergence is very difficult. However, empirical methods of spring selection based only on flexural stiffnesses have been successful in most cases.

The empirical method of selecting closure springs is based on an interpretation of the significance of the differential rotational spring in the alternating-direction method. In Figs 9a and 9b each orthogonal beam was represented on the other as a load and a differential rotational spring. Based on this interpretation, the closure spring should represent the rotational stiffness of the intersecting beams. This rotational stiffness in structural analysis is referred to as a stiffness factor. The stiffness factor is defined as the moment applied at the end of a beam that produces a unit rotation at that end. For a prismatic member fixed at the far end the stiffness factor is $4EI/L$ and with hinged end is $3EI/L$. In most frames these stiffness factors will vary considerably due to various boundary conditions, member lengths, and flexural stiffnesses. However, two or three spring values ranging from the smallest value of $4EI/L$ to the largest value of $4EI/L$ of the frame system will in most cases produce rapid closure. This empirical method predicts an efficient set of spring values, but it should be emphasized that only rate of closure is affected by these values and not the final results.

Based on mathematical literature concerning alternating-direction implicit solutions, it appears that spring values selected by the preceding suggestions should be arranged in the input data according to increasing stiffness. The computer program automatically uses the springs in repeated cyclic order (one spring per iteration).

Using spring values based on the preceding recommendations and procedures, convergence of x and y-beam slopes at an intersection is shown in Fig 11. Figure 11 was plotted from the results of Example Problem 1, Chapter 7, at the intersection of Beams 1 and 3.

Increment Lengths

In numerical methods of solution, errors may be expected from truncation and loss of significant figures in arithmetic operations. Truncation errors are to be expected when using finite-difference expressions of continuous functions, but were shown (Ref 10) to be almost insignificant in solving beam problems by finite-difference methods. However, the elastic curve of framed members undergoes more reversals of curvature than beams. Therefore, framed members must be divided into more increments in order to accurately describe their deflected shapes.

The rigid-frame bent in Fig 12 was solved using various increment lengths to illustrate their effects on the accuracy of the solution. The slope values at Joints B and C are tabulated below Fig 12. This problem is an extreme example but indicates that the effect of increment length on the accuracy of solutions should be checked for new types of problems.

Closure Tolerances

The iterative procedure given in Eqs 3.6a and 3.6b gives only an approximate solution to Eq 3.4. For example, in Eq 3.6a the term $R^F(\theta^x - \theta^y)$ represents the amount of torque with which the iterative equation differs from the equation that must be satisfied (Eq 3.4). If θ^x were equal to θ^y it is evident that the term $R^F(\theta^x - \theta^y)$ would drop out of Eq 3.6a and it would reduce to Eq 3.4. Thus, the most logical tolerance test should be based on the allowable difference between the x and y-beam slopes. To arrive at a specific value for the closure tolerance the approximate magnitude of slopes for the system being solved should be considered. In addition, consideration should be given to errors in truncation and loss of significant figures.

In general, the user of this iterative method will have to exercise engineering judgment in determining spring values, increment lengths, and closure tolerances.

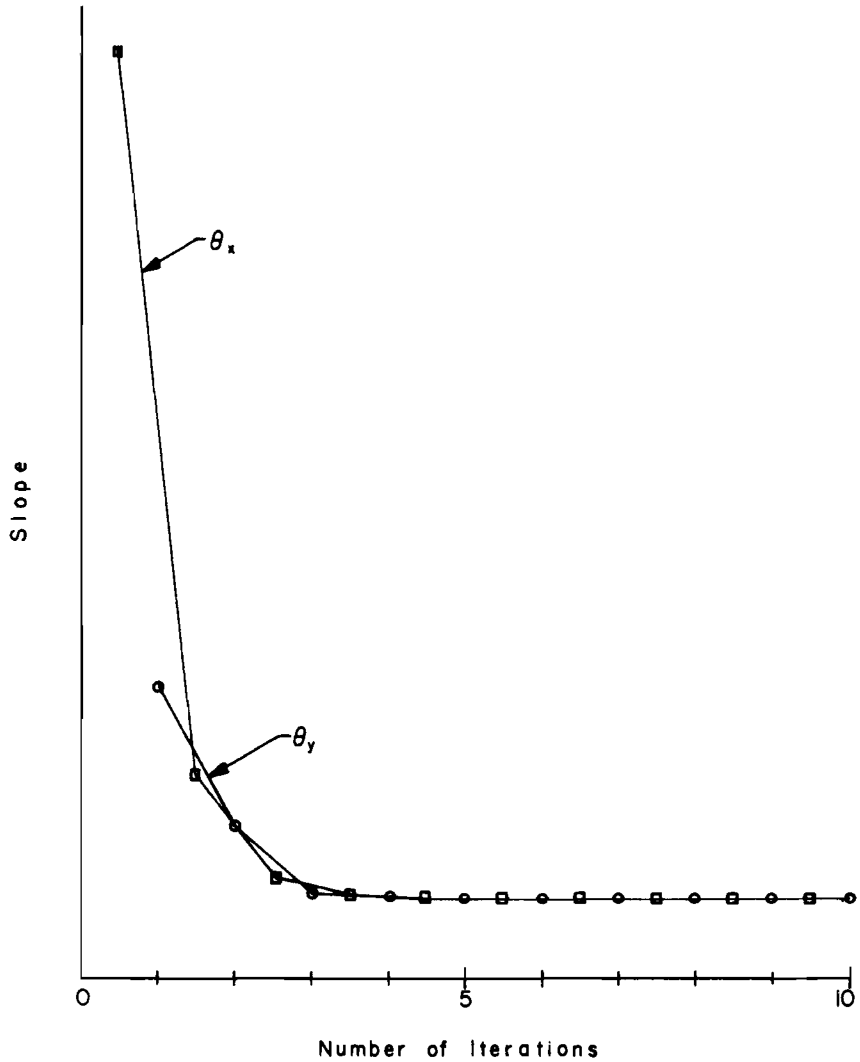
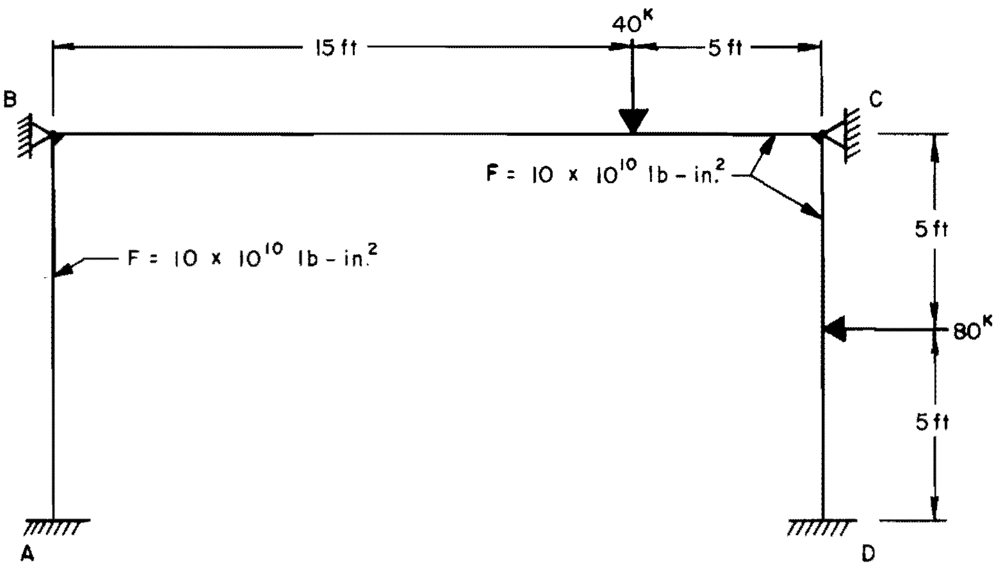


Fig 11. Convergence of slope values at a joint using suggested spring values and procedures.



VALUES OF SLOPE

SLOPE AT	METHOD OF CALCULATION			
	MOMENT DISTRIBUTION	FRAME 4		
		h = 12 in.	h = 3 in.	h = 2 in.
B	-9.740×10^{-5}	-9.923×10^{-5}	-9.781×10^{-5}	-9.776×10^{-5}
C	4.610×10^{-5}	4.684×10^{-5}	4.630×10^{-5}	4.629×10^{-5}

Fig 12. Rigid-frame bent solved by Program FRAME 4 using various increment lengths h .

CHAPTER 6. PROGRAM FRAME 4

FRAME 4 is a computer program written to solve elastic frames having rigidly connected joints that are not allowed to translate. No provision is made for including axial loads in the frame members and only deformations due to bending are considered. However, frames that have freely discontinuous loadings, flexural stiffnesses, elastic supports, and rotational restraints may be solved. It is the purpose of this chapter to explain Program FRAME 4 in such a manner that it can be immediately applied to practical problems.

The FORTRAN Program

A general flow diagram of FRAME 4 is contained in App 1. A list of notations used within the program is given in App 2 and a listing of the program is in App 3. Comment cards are used within the program to indicate various operations. These comments should be helpful in relating the flow diagram to the listing.

The program is written in FORTRAN-63 language for a Control Data Corporation (CDC) 1604 digital computer having a 48-bit word length and operated with a FORTRAN-63 monitor system. Storage capacity of the CDC 1604, without using tape units, is approximately 32,600 words. FRAME 4 uses about 23,000 words with the remaining storage being reserved for library functions. This storage capacity limits the size of the frame system that presently can be solved to nine beams, each divided into 150 increments. Minor program revisions would probably allow solution of approximately nine additional beams.

The time required to solve a problem depends on its complexity. The solution time for each example problem is included in the next chapter. Compile time for FRAME 4 is about 1 minute and 30 seconds.

A guide for preparing input data is given in App 4. Detailed instructions are included. Data input for the example problems in Chapter 7 is given in App 5.

Program Results

The computer results for all the example problems in Chapter 7 are shown in App 6. The output listings show the deflection w , slope dw/dx , bending moment Fd^2w/dx^2 , dM/dx , and an error term corresponding to distance x along the frame member.

For both moment and shear no attempt should be made to extract conventional values from the output listings within the zone influenced by torques or rotational restraints. Usually structures are idealized as line members, and rotational effects T and R are assumed to act at a point. However, in actual structural frames, an abrupt discontinuity does not occur in moment or shear and, depending on the increment length, it is possible for the finite-element frame model to provide more realistic values than the corresponding line-member idealization.

In the finite-element beam, any concentrated torque applied as a T-value or developed as the result of a specified slope or rotational restraint must be ultimately felt by the beam as two equal but opposite forces acting one increment each way from the station considered. The change in moment at a joint in the finite-element frame model results from the forces created by the torques T , T^x , and T^y centered about the joint. Therefore, as a general rule, no attempt should be made to extract conventional values of moment closer than one increment to a joint or shear values closer than two increments. However, it should be possible to correct the moment and shear obtained by conventional line-member idealization to give values more consistent with the distributed joint forces of real frames and with the finite-element reactions. This is frequently done in design to get values nearer the faces of supports.

The error term in the output listings refers to the error in torque equilibrium of the finite-element frame joint. The error term represents the amount of torque with which the iterative procedure given in Eqs 3.6a and 3.6b differs from the equation that must be satisfied, Eq 3.4. This difference is equal to $R^F(\theta^x - \theta^y)$ which has units of in-lb. Prior to final stabilization, error terms based on this concept are somewhat dependent on the selected closure spring value; however, if terms are very small, they do serve as a good indication that the system has been solved. If necessary, a precise check on a solution may be obtained by making a joint equilibrium check as explained in Chapter 3.

CHAPTER 7. EXAMPLE PROBLEMS

Several example problems have been selected to illustrate the applicability of this method and the use of the computer program. Data input for both of the example problems are in App 5. Computer results are in App 6.

Three-Barrel Box Culvert

Figure 13a illustrates one of the box culverts analyzed for the Texas Highway Department during the development of FRAME 4. The three-barrel box culvert is covered by 10.5 ft of fill material. For design purposes it is desired to determine the bending moment in the vertical walls and top and bottom slabs.

The culvert, as modeled for the FRAME 4 solution, is shown in Fig 13b. A one-foot-wide slice of the culvert is analyzed as a two-dimensional frame. A support has been placed at each joint along the bottom slab and also at one end of the top slab to prevent joint translation. Top and bottom slabs have been divided into 78 increments, each 3 inches in length. The culvert walls are divided into 18 increments, which must also be 3 inches in length. The flexural stiffness values for slabs and walls are as shown in the figure. Beams are numbered according to the input data instructions in App 4.

The resulting bending-moment diagram plotted from the computer solution is shown in Fig 13c. Ordinates of the bending-moment diagram in this example problem and in the remaining problems are plotted on the side of the member that is in compression. Stresses checked at the point of maximum moment indicated that the wall and slab sections were adequate. For actual design problems, the wall and slab sections could be varied with a minimum of additional input data by using options to hold data from problem to problem. In a similar manner, other design parameters could also be investigated in order to find the most efficient design.

The accuracy of the FRAME 4 solution of this problem was checked by moment distribution. The difference in maximum bending moment by the two methods differed by only 2 percent.

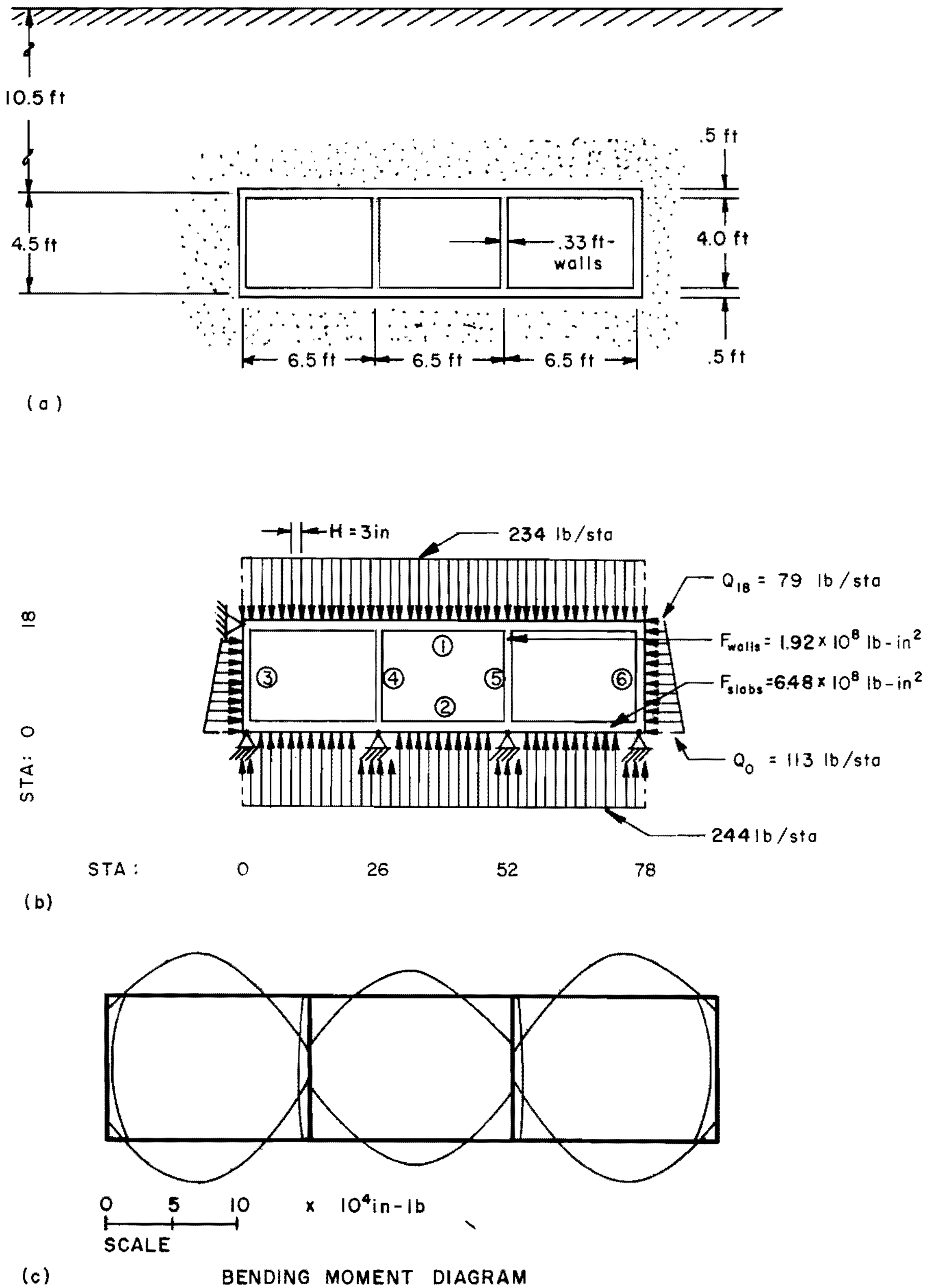


Fig 13. Example Problem 1: three-barrel box culvert.

Multi-Story Framed Structure Supported by Elastic Foundation

Figure 14 illustrates a framed structure with only vertical loads. It is assumed that no sidesway occurs at the joints. The effects of axial loads on bending are not considered in this frame analysis method. This is consistent with the usual methods of bending analysis. However, stresses due to axial loads would still have to be included for final design stresses.

The frame is modeled for the FRAME 4 solution as shown in Fig 15. The columns are fixed against rotation at ground level. Uniform loads are input as pounds per station or increment length. Bending stiffness variation is shown in Fig 16 for a one-foot slice. The bending stiffnesses of the straight-line haunches are represented by linear variations from one end to the other; however, this is not precisely correct for the intermediate stations. The neutral axis of these non-prismatic members is assumed to lie at the same level.

This example problem is intended to represent some of the complex loading patterns, flexural stiffnesses, and elastic foundation conditions that can be handled by this method. The problem required very little time to code and prepare for solution by FRAME 4. Actual solution time was 1 minute.

The resulting moment diagram is shown in Fig 17. Note that the moment at joints changes across a width of two increments in accordance with the explanation in Chapter 6.

The frame member deflections are also of interest in problems of this type. These deflections are included in the computer results in App 6.

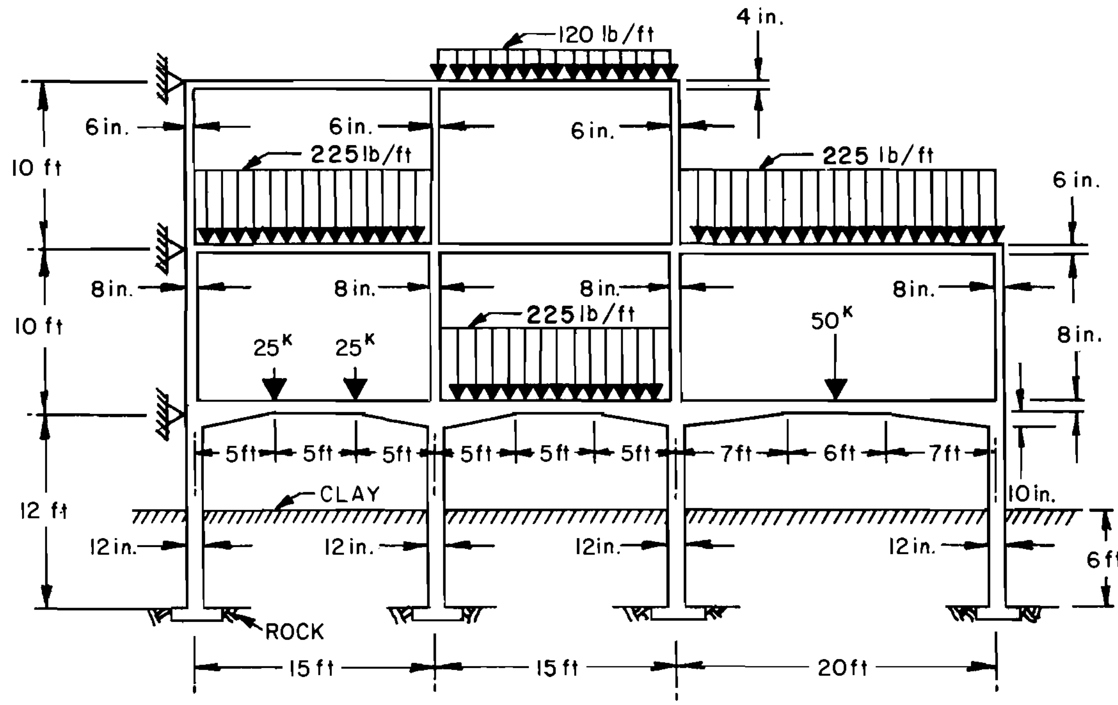


Fig 14. Example Problem 2 : multi-story framed structure (without sidesway).

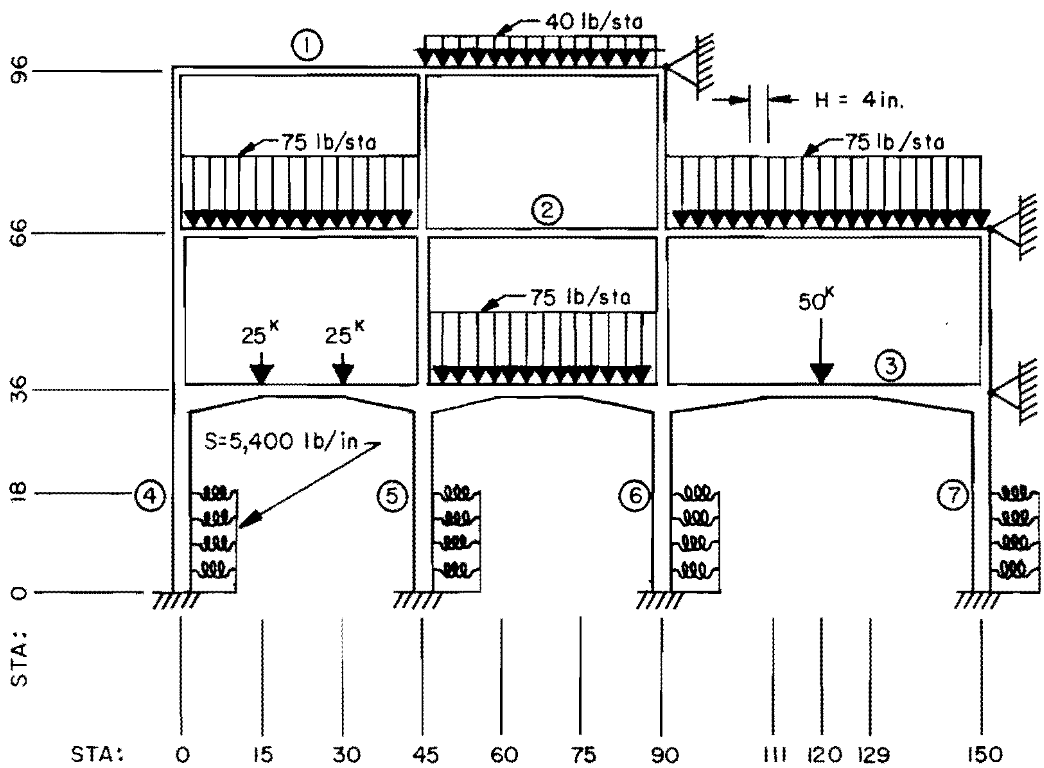


Fig 15. Example Problem 2: frame modeled for solution.

TABLE OF FLEXURAL STIFFNESS VALUES: EXAMPLE PROBLEM 2

	AT STA
BEAM (1)	
F = 192 x 10^6 lb - in.^{2}	0
F = 192 x 10^6 lb - in.^{2}	90
BEAM (2)	
F = 648 x 10^6 lb - in.^{2}	0
F = 648 x 10^6 lb - in.^{2}	150
BEAM (3)	
F = 17,496 x 10^6 lb - in.^{2}	0
F = 1,536 x 10^6 lb - in.^{2}	15
F = 1,536 x 10^6 lb - in.^{2}	30
F = 17,496 x 10^6 lb - in.^{2}	45
F = 1,536 x 10^6 lb - in.^{2}	60
F = 1,536 x 10^6 lb - in.^{2}	75
F = 17,496 x 10^6 lb - in.^{2}	90
F = 1,536 x 10^6 lb - in.^{2}	111
F = 1,536 x 10^6 lb - in.^{2}	129
F = 17,496 x 10^6 lb - in.^{2}	150
BEAMS (4) (5) (6)	
F = 5,184 x 10^6 lb - in.^{2}	0
F = 5,184 x 10^6 lb - in.^{2}	36
F = 1,536 x 10^6 lb - in.^{2}	36
F = 1,536 x 10^6 lb - in.^{2}	66
F = 648 x 10^6 lb - in.^{2}	66
F = 648 x 10^6 lb - in.^{2}	96
BEAM (7)	
F = 5,184 x 10^6 lb - in.^{2}	0
F = 5,184 x 10^6 lb - in.^{2}	36
F = 1,536 x 10^6 lb - in.^{2}	36
F = 1,536 x 10^6 lb - in.^{2}	66

Fig 16. Example Problem 2: bending stiffness variation.

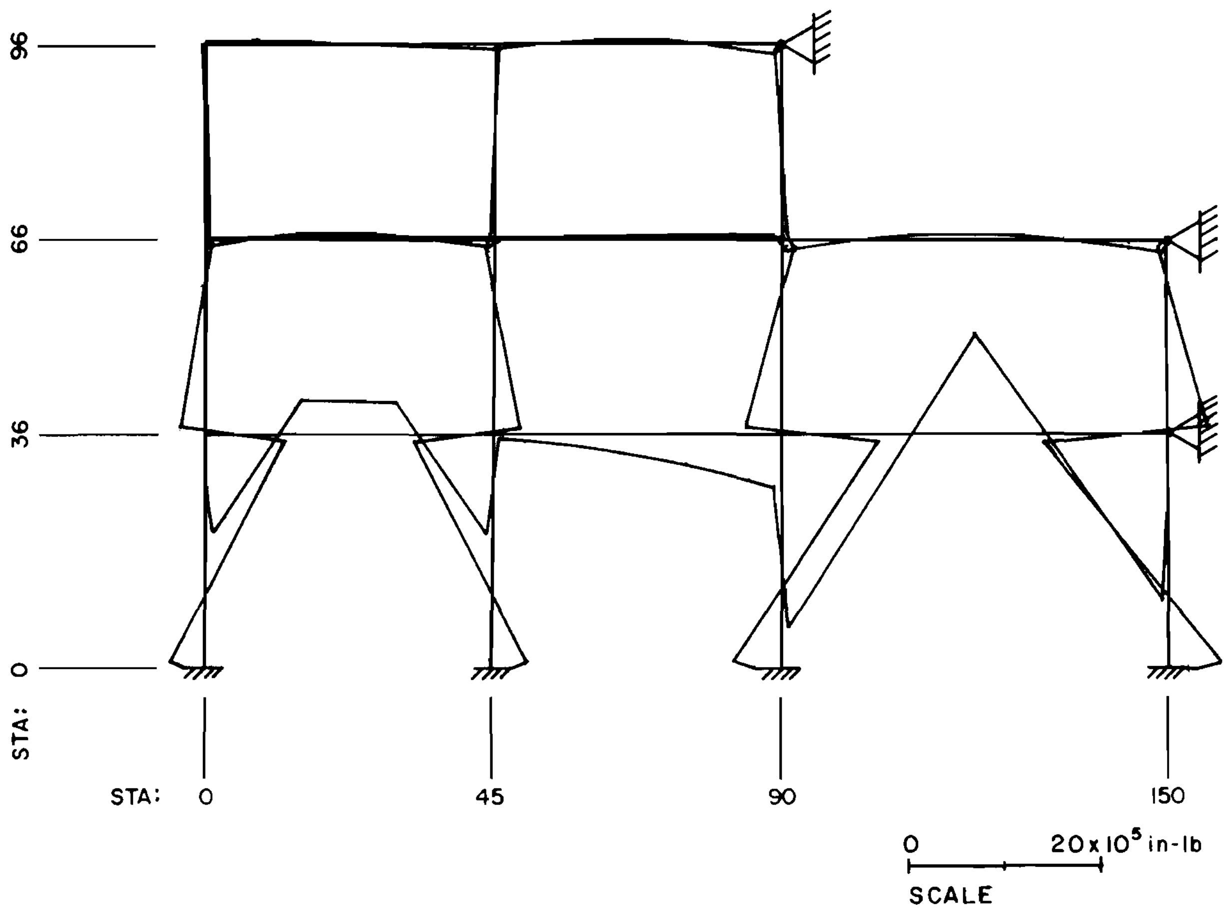


Fig 17. Example Problem 2: bending moment diagram.

CHAPTER 8. SUMMARY AND CONCLUSIONS

The frame analysis approach which has been described provides a rapid method for solving a wide variety of frame problems. Principal features of the method are summarized as follows:

(1) A conventional frame system is represented by a finite-element model composed of bars and springs.

(2) Equations derived for the frame model are based on finite-element concepts which permit beam stiffnesses, applied loads, and elastic restraints to vary in a freely discontinuous manner from station to station.

(3) A rapid and direct method is used to solve the individual beam equations.

(4) Frame members are solved alternately in the two orthogonal directions as individual beams. A relaxation technique is used at each joint to adjust the two solutions, thereby obtaining rotational compatibility.

Significance of the Method

This method, subject to the previously described assumptions, is applicable to a wide range of structural problems. Specifically, this includes orthogonal rigid-joint frames where joints do not translate and only deformations due to bending are considered. While restricted to problems in this category, it should be noted that solutions to problems which are virtually impossible by other methods are quickly and easily solved by this approach. Frames that derive support from an elastic foundation can be solved rapidly as well as frames with discontinuous loading, stiffness, and restraint conditions.

This method is also a useful design tool. Design conditions may be varied on any problem without greatly increasing the time required to code the problem data or time required to solve the problem. Of course, solution time is somewhat dependent on the proper choice of the closure springs. However, with experience in solving problems by this method, one should be able to select an efficient set of springs.

Further Refinements and Developments

There are numerous refinements of this method that could improve its accuracy and applicability. These refinements, along with suggested future extensions, are listed below:

(1) Allow for different increment lengths in the x and y-directions.

(2) Derive difference equations for the finite-element model to allow for varying increment lengths along a beam. This would permit small increment lengths in the vicinity of a joint and larger ones near the middle of the beams, thereby increasing the accuracy of the final solution and removing some of the computer storage problems.

(3) Studies should be made on the closure spring to determine if there is a better method for selecting the most efficient set of spring values.

(4) Allow for translation of joints and axial shortening of members.

(5) Include axial-load effects on bending.

(6) Equations for the frame should be extended to allow for non-linear characteristics in both flexural stiffness and supports.

(7) Efforts should be made to apply this finite-element-model technique to three-dimensional space frames.

REFERENCES

1. Borg, Sidney F. and Joseph J. Jennaro, Advanced Structural Analysis, 1st Edition. New Jersey: D. Van Nostrand Company, Inc., 1959.

2. Ferguson, Phil M., Reinforced Concrete Fundamentals, 1st Edition. New York and London: John Wiley and Sons, Inc., 1958.

3. Haliburton, T. Allan, "A Numerical Method of Nonlinear Beam-Column Solution," Unpublished Master's thesis, Austin: The University of Texas, June 1963.

4. Hall, Arthur S. and Ronald W. Woodhead, Frame Analysis, 1st Edition. New York and London: John Wiley and Sons, Inc., 1961.

5. Ingram, Wayne B., "Solution of Generalized Beam-Columns on Nonlinear Foundations," Unpublished Master's thesis, Austin: The University of Texas, August 1962.

6. Norris, C. H. and J. B. Wilbur, Elementary Structural Analysis, 2nd Edition. New York: McGraw-Hill Book Co., Inc., 1958.

7. Matlock, Hudson, "Applications of Numerical Methods to Some Problems in Offshore Operations," Proceedings, First Conference on Drilling and Rock Mechanics, Austin: The University of Texas, January 23-24, 1963.

8. Matlock, Hudson, "Interaction of Soils and Structures," C.E. 394.2 Class Notes, Austin: The University of Texas, Spring 1964.

9. Matlock, Hudson and Berry R. Grubbs, Discussion of Proc. Paper 3825, "Lateral Resistance of Piles in Cohesive Soils," Journal of the Soil Mechanics and Foundation Division, American Society of Civil Engineers, Vol 91, No. SM1, Part 1, January 1965, pp 183-188.

10. Matlock, Hudson and T. Allan Haliburton, "A Finite-Element Method of Solution for Linearly Elastic Beam-Columns," Research Report No. 56-1, Center for Highway Research, Austin: The University of Texas, September 1, 1966.

11. Matlock, Hudson and T. Allan Haliburton, "Inelastic Bending and Buckling of Piles," a paper presented at the Conference on Deep Foundations, Mexican Society of Soil Mechanics, Mexico City, December 1964.

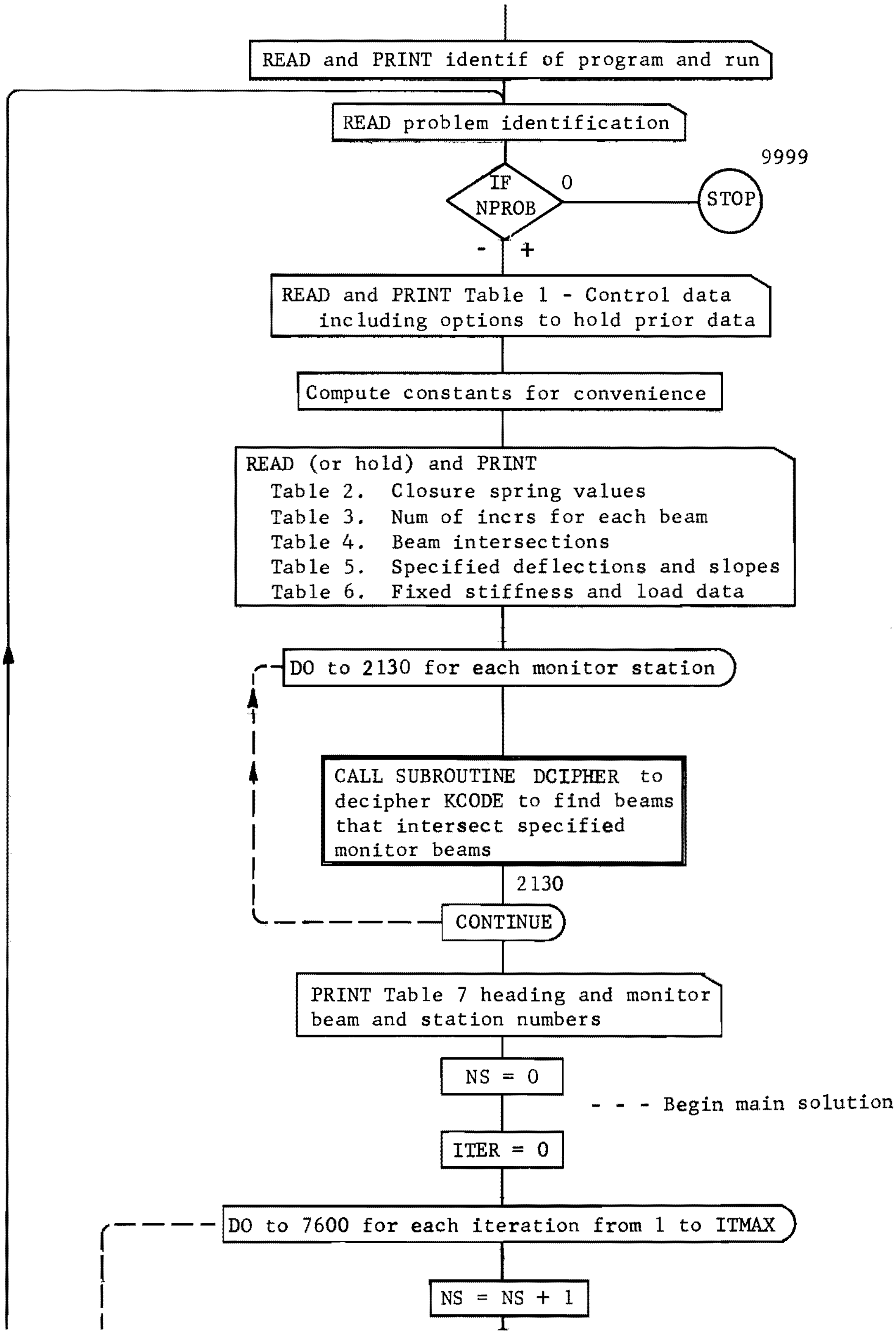
12. Matlock, Hudson and Wayne B. Ingram, "Bending and Buckling of Soil-Supported Structural Elements," Paper No. 32, Proceedings, Second Pan-American Conference on Soil Mechanics and Foundation Engineering, Brazil, June 1963.

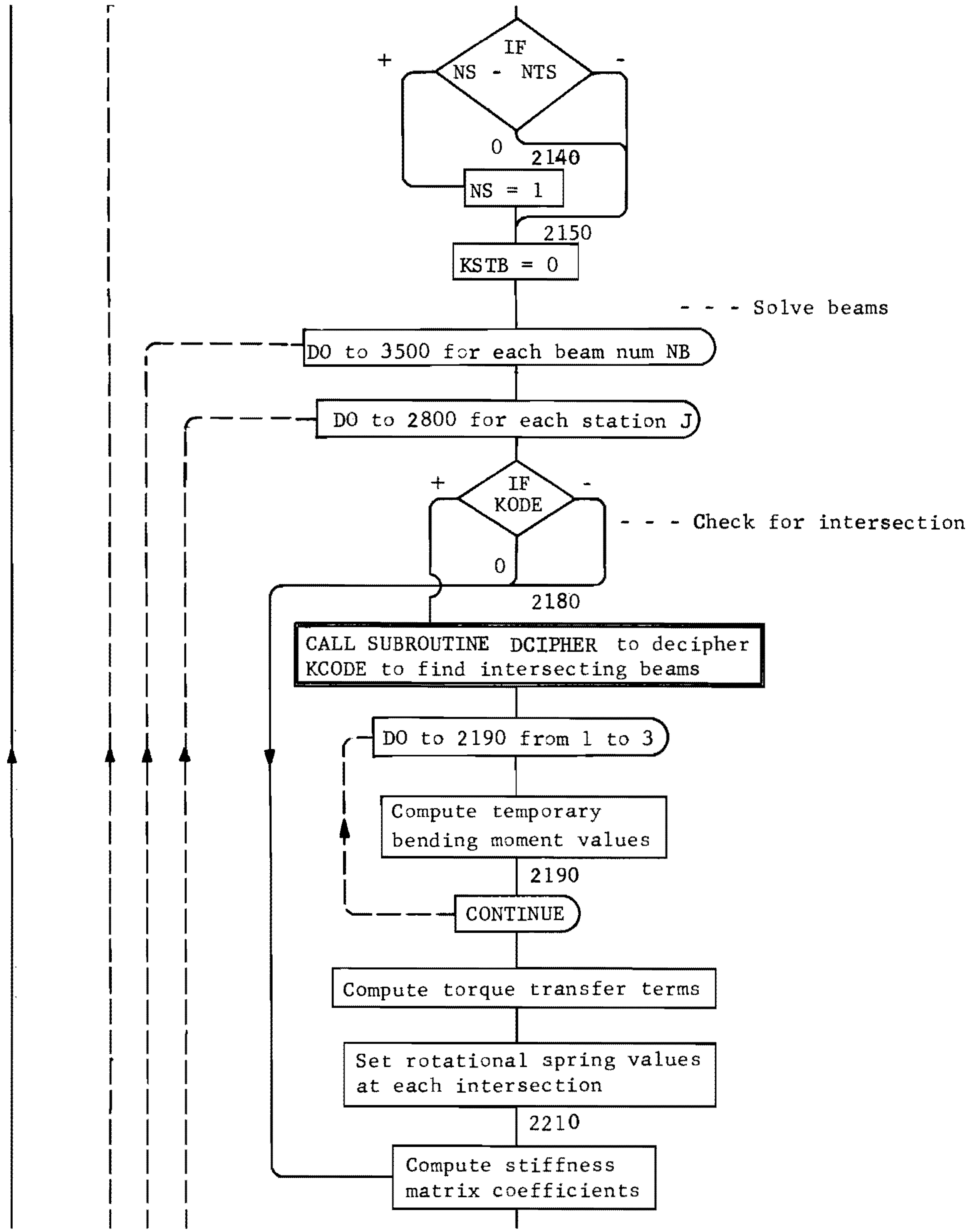
13. Tucker, Richard L., "A General Method for Solving Grid-Beam and Plate Problems," Unpublished Ph.D dissertation, Austin: The University of Texas, May 1963.

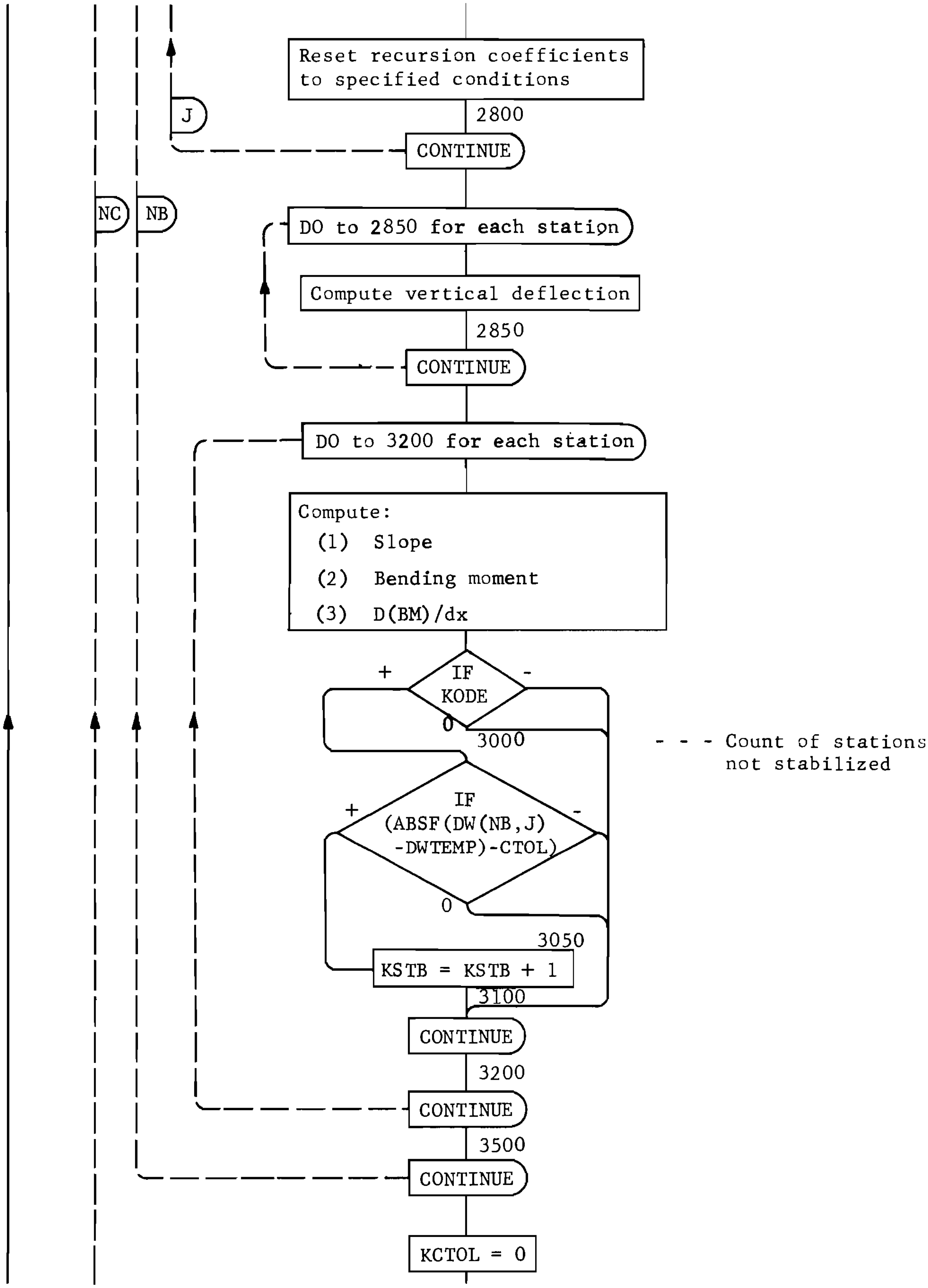
APPENDIX 1

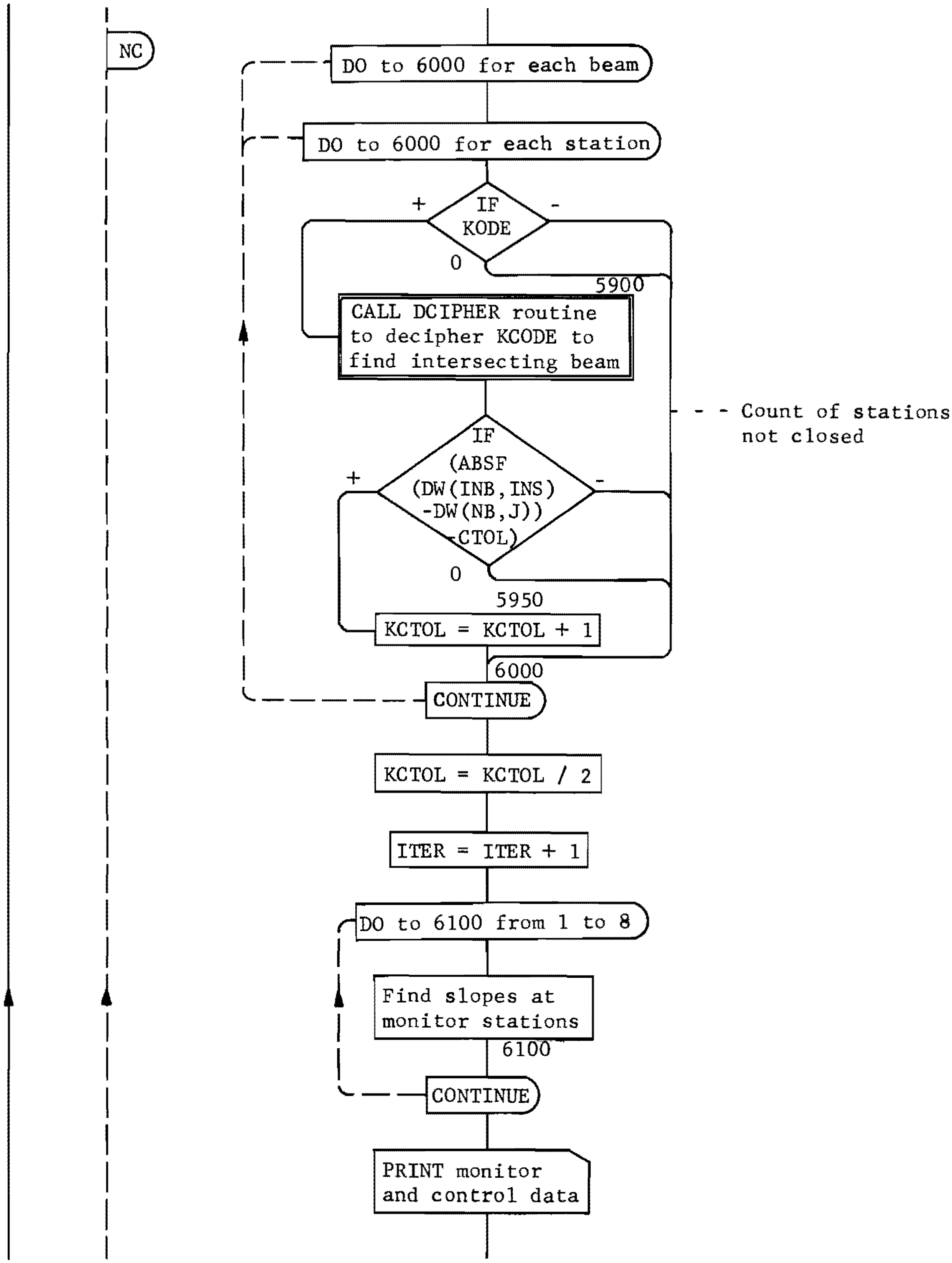
GENERAL FLOW DIAGRAM FOR PROGRAM FRAME 4

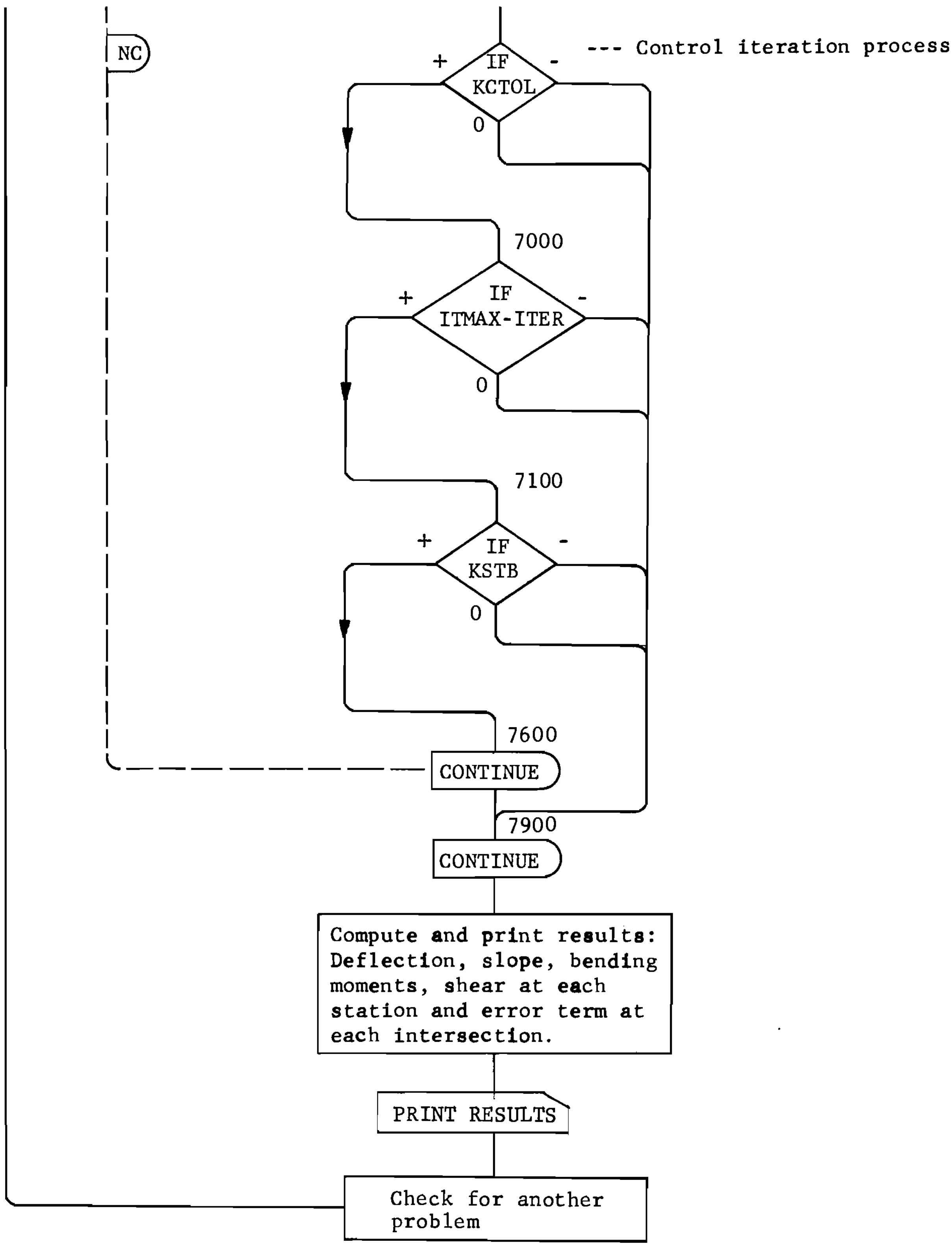
APPENDIX 1. GENERAL FLOW DIAGRAM FOR PROGRAM FRAME 4




IF
NS - NTS
+
-
0
2140
NS = 1
2150
KSTB = 0
- - - Solve beams
DO to 3500 for each beam num NB
DO to 2800 for each station J
IF
KODE
+
-
0
- - - Check for intersection
2180
CALL SUBROUTINE DCIPHER to decipher KCODE to find intersecting beams
DO to 2190 from 1 to 3
Compute temporary bending moment values
2190
CONTINUE
Compute torque transfer terms
Set rotational spring values at each intersection
2210
Compute stiffness matrix coefficients


Reset recursion coefficients to specified conditions
J
2800
CONTINUE
NC
NB
DO to 2850 for each station
Compute vertical deflection
2850
CONTINUE
DO to 3200 for each station
Compute:
(1) Slope
(2) Bending moment
(3) D(BM)/dx
+
IF KODE
-
0
3000
- - - Count of stations not stabilized
IF (ABSF(DW(NB,J) -DWTEMP)-CTOL)
+
-
0
3050
KSTB = KSTB + 1
3100
CONTINUE
3200
CONTINUE
3500
CONTINUE
KCTOL = 0


NC
DO to 6000 for each beam
DO to 6000 for each station
IF KODE
+
-
0
5900
CALL DCIPHER routine to decipher KCODE to find intersecting beam
Count of stations not closed
IF (ABSF (DW(INB,INS) -DW(NB,J)) -CTOL)
+
-
0
5950
KCTOL = KCTOL + 1
6000
CONTINUE
KCTOL = KCTOL / 2
ITER = ITER + 1
DO to 6100 from 1 to 8
Find slopes at monitor stations
6100
CONTINUE
PRINT monitor and control data


NC
IF
KCTOL
+
-
0
--- Control iteration process
7000
IF
ITMAX-ITER
+
-
0
7100
IF
KSTB
+
-
0
7600
CONTINUE
7900
CONTINUE
Compute and print results: Deflection, slope, bending moments, shear at each station and error term at each intersection.
PRINT RESULTS
Check for another problem

APPENDIX 2

GLOSSARY OF NOTATION FOR FRAME 4

```
C-----NOTATION FOR FRAME 4                                                 27MR5
C          AA                  COEFF IN STIFFNESS MATRIX                   27MR5
C          A( ), B( ), C( )    CONTINUITY OR RECURSION COEFFICIENTS        29MR5
C          A(J), ATEMP, AREV   CONTINUITY COEFFICIENT                      12JE3
C          AN1(N), ETC.        ALPHANUMERIC REMARKS, INFORMATION ONLY      29MR5
C          BB                  COEFF IN STIFFNESS MATRIX                   27MR5
C          B(J), BTEMP, BREV   CONTINUITY COEFFICIENT                      12JE3
C          BM                  BENDING MOMENT                              29MR5
C          BMT(N)              TEMPORARY BENDING MOMENT VALUES             29MR5
C          CC                  COEFF IN STIFFNESS MATRIX                   27MR5
C          C(J), CTEMP, CREV   CONTINUITY COEFFICIENT                      12JE3
C          CTOL                CLOSURE TOLERANCE, X VS Y SLOPES            21JA5
C          DD                  COEFF IN STIFFNESS MATRIX                   27MR5
C          D, DTEMP, DREV      MULTIPLIER IN CONTINUITY COEFF EQS          12JE3
C          DBM                 SHEAR ( FIRST DERIV OF BENDING MOMENT )     27MR5
C          DENOM               DENOMINATOR                                 07JE3
C          DIFF                DIFFERENCE                                  27MR5
C          DW                  SLOPE ( FIRST DERIV OF DEFLECTION )         27MR5
C          DWM(  )             SLOPE AT A SPECIFIED MONITOR STATION        27MR5
C          DWS(  )             SPECIFIED VALUE OF SLOPE                    27MR5
C          DWTEMP              TEMPORARY VALUES OF SLOPE                   29MR5
C          EE                  COEFF IN STIFFNESS MATRIX                   27MR5
C          E                   TERM IN CONTINUITY COEFF EQS                12JE3
C          ESM                 MULTIPLIER FOR HALF VALUES AT END STAS      27MR5
C          FF                  COEFF IN LOAD MATRIX                        27MR5
C          FN1, FN2, F(NB,J)   FLEXURAL STIFFNESS (EI), ( INPUT, TOTAL )  29MR5
C          H                   INCREMENT LENGTH                            29MR5
C          HE2                 H SQUARED                                   27MR5
C          HE3                 H CUBED                                     27MR5
C          HT2                 H TIMES 2                                   27MR5
C          INS, IS             STA ON INTERSECTING BEAM                    29MR5
C          INB, IB             NUM OF INTERSECTING BEAM                    29MR5
C          ISW                 ROUTING SWITCH FOR TABLE 6                  27MR5
C          ITER                COUNT OF NUM OF ITERATIONS                  29MR5
C          ITMAX               MAXIMUM NUMBER OF ITERATIONS ALLOWED        29MR5
C          J                   INTERNAL STA NUM = EXT STA NUM + 4          29MR5
C          JC1, JC2            EXTERNAL STA NUMBER AT BEAM INTERSECTIONS  29MR5
C          JINCR               INCREMENTATION INDEX                        27MR5
C          JN1,JN2             EXTERNAL STATION NUMBER                     29MR5
C          JS                  INTERNAL STA NUM FOR SPECIFIED CONDITIONS  29MR5
C          JSTA                TEMP STA NUMBER ( EXTERNAL )                29MR5
C          J1, J2              INITIAL AND FINAL STAS IN DISTRIBUTE SEQ    29MR5
C          KASE                CASE NUM FOR SPECIFIED CONDITIONS           21JA5
C          KCODE               TEMP VALUE OF KODE                          29MR5
C          KCTOL               NUM OF INTERSECTIONS NOT CLOSED             29MR5
C          KEEP2 THRU KEEP6    IF = 1, KEEP PRIOR DATA, TABLE 2 - 6        27MR5
C          KEY(NB,JS), KEYJ    ROUTING SWITCH FOR SPECIFIED CONDITIONS     27MR5
C          KK                  MISC INDEX                                  29MR5
C          KODE                CODE TO DETERMINE INTERSECTION LOCATION     29MR5
C          KR1                 PRIOR VALUE OF KR2                          27MR5
C          KR2                 IF = 1, REFER TO NEXT CARD                  27MR5
C          KSW                 ROUTING SWITCH FOR INPUTTING TABLE 6        27MR5
C          KSTB                NUM OF STAS NOT STABILIZED                  29MR5
C          L                   MISC INDEX                                  27MR5
C          M(  )               NUM OF INCREMENTS                           29MR5
```

```
C          MONB(    )            BEAM NUMBER FOR MONITOR DATA                 29MR5
C          MONS(    )            STATION NUMBER FOR MONITOR DATA              29MR5
C          MP4, MP5, MP7         M+4, M+5, M+7, ETC                           27MR5
C          N                     MISC INDEX                                   27MR5
C          NB                    BEAM NUMBER                                  29MR5
C          NB1, NB2              BEAM NUMBERS OF INTERSECTING BEAMS           29MR5
C          NC                    COUNT OF NUMBER OF ITERATIONS                25AG4
C          NCD2, NCD3, ETC.      NUM CARDS IN TABLES 2, 3, ETC., THIS PROB 27MR5
C          NINT                  NUM OF INTERSECTIONS                         29MR5
C          NPROB                 NUMBER OF PROBLEM, PROG STOPS IF ZERO        29MR5
C          NS                    SPRING OR CYCLE NUM (COUNTER)                27MR5
C          NTS                   TOTAL NUMBER OF CLOSURE SPRINGS              29AP5
C          NTB                   NUM OF X AND Y-BEAMS                         29MR5
C          NXB                   NUM OF X-BEAMS                               29MR5
C          NYB                   NUM OF Y-BEAMS                               29MR5
C          PART                  INTERPOLATION FRACTION                       27MR5
C          QN1, QN2, Q(NB,J)     TRANSVERSE FORCE ( INPUT, TOTAL )            29MR5
C          RF(    )              CLOSURE SPRING VALUE AT EACH INTERSECTION 29MR5
C          RN1, RN2, R(NB,J)     ROTATIONAL RESTRAINT ( INPUT, TOTAL )        29MR5
C          RR(    )              TEMP INPUT VALUE OF CLOSURE SPRING, RF       29MR5
C          SN1, SN2, S(NB,J)     SPRING SUPPORT STIFFNESS ( INPUT, TOTAL ) 29MR5
C          TA(   )               TORQUE ABSORBED BY INTERSECTING BEAM         04MY5
C                                ON PREVIOUS HALF CYCLE                       04MY5
C          TN1, TN2, T(NB,J)     TRANSVERSE TORQUE ( INPUT, TOTAL )           29MR5
C          W(NB,J)               DEFLECTION ON BEAM NB AT STA J               27MR5
C          WS(   )               SPECIFIED VALUE OF DEFLECTION                27MR5
C          X                     DISTANCE ALONG BEAM                          29MR5
C          ZI                    DECIMAL VALUE FOR JSTA                       29MR5
```

APPENDIX 3

LISTING OF PROGRAM DECK OF FRAME 4

```
      PROGRAM FRAME 4                                                    25MR5
    1 FORMAT (    52H     PROGRAM FRAME 4 - MATLOCK - DECK 5             18MR5 ID
     1                                  28H  REVISION DATE = 30 AP 65  ) -------*
      DIMENSION      AN1(32), AN2(14),                                   18FE5 ID
     1F(9,157), Q(9,157), S(9,157), T(9,157), DBM(9,157), FF(157),       29MR5
     2TA(157), DW(9,157), W(9,157), WS(9,157), DWS(9,157),               29MR5
     3KEY(9,157), KODE(9,157), BM(9,157), A(157), B(157), C(157),        03MR5
     4M(9), RR(20), FMT(6), DWM(99,8), MONB(8), MONS(8), R(9,157)        18MR5
   10 FORMAT (     5H      , 80X, 10HI-----TRIM )                        27FE4 ID
   11 FORMAT (     5H1     , 80X, 10HI-----TRIM )                        27FE4 ID
   12 FORMAT (  16A5   )                                                 04MY3 ID
   13 FORMAT (          5X, 16A5 )                                       27FE4 ID
   14 FORMAT ( A5, 5X, 14A5 )                                            18FE5 ID
   15 FORMAT (///10H      PROB  , /5X, A5, 5X, 14A5 )                    18FE5 ID
   16 FORMAT (///17H      PROB (CONTD), /5X, A5, 5X, 14A5 )              18FE5 ID
   19 FORMAT (///48H      RETURN THIS PAGE TO TIME RECORD FILE -- FM )   12MR5 ID
  100 FORMAT ( 5X, 5 ( 4X, I1 ), 10X, 5 ( 3X, I2 ) )                     10MR5
  101 FORMAT ( 5X, 3 ( 3X, I2 ), 10X, 2E10.3 )                           10MR5
  102 FORMAT ( //30H      TABLE 1.  CONTROL DATA              , / ,      10MR5
     1      45X, 30H              TABLE NUMBER                 , / ,     10MR5
     2      45X, 30H         2    3    4    5    6             , //,     10MR5
     3            39H          PRIOR-DATA OPTIONS ( 1=HOLD ),11X,5(4X,I1)10MR5
     4           /39H          NUM CARDS INPUT THIS PROBLEM ,11X,5(3X,I2)10MR5
     5          //40H          MAX NUM ITERATIONS                , 32X, I3, /10MR5
     6            40H          NUM OF X-BEAMS                    , 32X, I3, /10MR5
     7            40H          NUM OF Y-BEAMS                    , 32X, I3, /10MR5
     8            40H          X AND Y-BEAM INCR LENGTH      ,25X,E10.3,/19MR5
     9            40H          CLOSURE TOLERANCE             ,25X,E10.3 )10MR5
  112 FORMAT ( 5X, 4 ( 3X, I2, 2X, I3 ) )                                12MR5
  113 FORMAT (  /28H           MONITOR STAS NB,J   , 5X, 4 ( I6, I4 ), / )09AP5
  120 FORMAT ( //36H      TABLE 2.  CLOSURE SPRING VALUES     , // ,     9MR5
     1            40H         SPRING NUM     CLOSURE SPRING  , / ,  )    9MR5
  124 FORMAT ( 20X, E10.3 )                                              19MR5
  125 FORMAT ( 13X, I2, 10X, E10.3 )                                     9MR5
  130 FORMAT (///46H      TABLE 3.  NUM OF INCREMENTS FOR EACH BEAM ,//, 9MR5
     1            36H         BEAM NUM        NUM OF INCRS     , / ,  )  9MR5
  135 FORMAT ( 5X, 15I5 )                                                03AP5
  136 FORMAT ( 12X, I2, 14X, I3 )                                        03AP5
  140 FORMAT (///35H      TABLE 4.  BEAM INTERSECTIONS         , // ,    9MR5
     1            52H                INT     BEAM       STA        BEAM  9MR5
     2             5H STA , / , )                                        9MR5
  143 FORMAT ( 5X, 5 ( 2X, I3 ) )                                        9MR5
  144 FORMAT ( 16X, I3, 4X, I3, 3 ( 7X, I3 ) )                           9MR5
  150 FORMAT ( //46H      TABLE 5. SPECIFIED DEFLECTIONS AND SLOPES,/    12MR5
     1            17H       BEAM     STA,/                               28JA5
     2            52H       NUM      NUM            CASE         DEFLECTION  28JA5
     3             6H SLOPE ,/ )                                         28JA5
  154 FORMAT ( 5X, 2 ( 2X, I3 ), 8X, I2, 5X, 2E10.3 )                    10MR5
  155 FORMAT ( 6X, I3, 5X, I3, 11X, I3, 9X, E10.3, 6X, 4HNONE )          109MR5
  156 FORMAT ( 6X, I3, 5X, I3, 11X, I3, 9X, 6X, 4HNONE, E10.3 )          09MR5
  157 FORMAT ( 6X, I3, 5X, I3, 11X, I3, 9X, 2E10.3 )                     12MR5
  162 FORMAT (///45H      TABLE 6.  FIXED STIFFNESS AND LOAD DATA , // , 9MR5
     1            10H       BEAM      , / ,                              9MR5
     2            52H        NUM    FROM    TO  CONTD        F          Q  9MR5
     3            28H    S          T           R        , / , )        9MR5
  177 FORMAT ( 5X, 4 ( 2X, I3 ), 5X, 5E10.3 )                            23MR5
```

```
  178 FORMAT ( 7X, I2, 1X, 2 ( 3X, I3), 4X, I1, 3X, 5E11.3 )              23MR5
  179 FORMAT ( 7X, I2, 4X, I3, 10X, I1, 3X, 5E11.3 )                       13MR5
  180 FORMAT ( 19X, I3, 4X, I1, 3X, 5E11.3 )                               23MR5
  205 FORMAT (///52H      TABLE 7.  ITERATION MONITOR DATA AND SLOPES AT   12MR5
     1            23HFOUR SELECTED STATIONS    , / ,                        10MR5
     2      //35X, 47H    BEAM STA     BEAM STA     BEAM STA     BEAM STA   10MR5
     3            / 38H          ITR      CLOSURE      NOT  NOT    , 4( 2I4, 4X )10MR5
     4            / 38H          NLM      SPRING       STAB CLOS   , 4( 2I4, 4X))10MR5
  206 FORMAT ( / 8X, I3, E12.3, 2X, I5, I5, 4E12.3, / 35X, 4E12.3 )        12MR5
  208 FORMAT (   /35H      TABLE 8.  RESULTS -- ITERATION, I3 )            12MR5
  209 FORMAT   ( /51H      SOLUTION NOT CLOSED WITHIN SPECIFIED TOLERANCE)12MR5
  210 FORMAT (   /52H      NB JSTA      X           DEFL          SLOPE    29MR5
     1           30HMOMENT        SHEAR        ERROR ,// )                 29MR5
  212 FORMAT ( 5X, I2, 1X, I3, 2X, 6E12.3 )                                29MR5
  211 FORMAT ( / )                                                         12MR5
  907 FORMAT (    25H                         NONE )                       9MR5
  908 FORMAT (5X,42H     USING DATA FROM PREVIOUS PROBLEM PLUS / )         09AP5
  909 FORMAT (5X,41H     USING DATA FROM THE PREVIOUS PROBLEM )            9MR5
          ITEST = 5H                                                       18FE5 ID
 1000 PRINT 10                                                             12JL3 ID
      CALL TIME                                                            18FE5
C-----PROGRAM AND PROBLEM IDENTIFICATION                                    04MY3 ID
      READ  12, ( AN1(N), N = 1, 32 )                                      18FE5 ID
 1010 READ  14,  NPROB, ( AN2(N), N = 1, 14 )                              28AG3 ID
          IF ( NPROB - ITEST ) 1020, 9990, 1020                            26FE5 ID
 1020 PRINT 11                                                             26AG3 ID
      PRINT 1                                                              18FE5 ID
      PRINT 13, ( AN1(N), N = 1, 32 )                                      18FE5 ID
      PRINT 15, NPROB, ( AN2(N), N = 1, 14 )                               26AG3 ID
C-----INPUT TABLE 1 - CONTROL DATA                                         28JA5
      READ 100, KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, NCD2, NCD3, NCD4,      10MR5
     1           NCD5, NCD6                                                10MR5
      READ 101, ITMAX, NXB, NYB, H, CTOL                                   10MR5
      PRINT  102, KEEP2, KEEP3, KEEP4, KEEP5, KEEP6, NCD2, NCD3, NCD4,    16MR5
     1            NCD5, NCD6, ITMAX, NXB, NYB, H, CTOL                     10MR5
      READ  112, ( MONB(N), MONS(N), N = 1, 4 )                            10MR5
      PRINT 113, ( MONB(N), MONS(N), N = 1, 4 )                            10MR5
C-----COMPUTE CONSTANTS FOR CONVENIENCE                                    28JA5
               HE2 = H ** 2                                                28JA5
               HE3 = HE2 * H                                               28JA5
               HT2 = 2. * H                                                28JA5
               NTB = NXB + NYB                                             28JA5
C-----CLEAR VALUES FROM PREVIOUS PROBLEMS AND SET KEYS                     28JA5
          DO 1160  NB = 1, NTB                                             22AP5
          DO 1150   J = 1, 157                                             22AP5
               W(NB,J) = 0.0                                               9MR5
               DW(NB,J) = 0.0                                              9MR5
               BM(NB,J) = 0.0                                              9MR5
               DBM(NB,J) = 0.0                                             16AP5
               TA(J) = 0.0                                                 03AP5
               RF(J) = 0.0                                                 03AP5
               A(J) = 0.0                                                  9MR5
               B(J) = 0.0                                                  9MR5
               C(J) = 0.0                                                  9MR5
 1150     CONTINUE                                                         22AP5
 1160     CONTINUE                                                         22AP5
```

```
          DO 1170  N = 1, 6                                              22AP5
                BMT(N) = 0.0                                             26MR5
 1170     CONTINUE                                                       22AP5
C-----INPUT TABLE 2 - CLOSURE SPRING DATA                                9MR5
      PRINT 120                                                          9MR5
          IF ( KEEP2 ) 1220, 1220, 1210                                  22AP5
 1210 PRINT 909                                                          22AP5
          GO TO 1260                                                     22AP5
 1220     DO 1230  N = 1, NCD2                                           22AP5
      READ  124, RR(N)                                                   9MR5
      PRINT 125, N, RR(N)                                                9MR5
 1230     CONTINUE                                                       22AP5
                NTS = NCD2                                               29AP5
C-----INPUT TABLE 3 - NUM OF INCREMENTS FOR EACH BEAM                     9MR5
 1260 PRINT 130                                                          22AP5
          IF (KEEP3 ) 1320, 1320, 1310                                   22AP5
 1310 PRINT 909                                                          22AP5
          GO TO 1390                                                     22AP5
 1320 READ 135, (M(L), L = 1, NTB )                                      22AP5
      PRINT 136, ( L, M(L), L = 1, NTB )                                 05AP5
C-----INPUT TABLE 4 - BEAM INTERSECTIONS                                 9MR5
 1390 PRINT 140                                                          22AP5
          IF (KEEP4 ) 1420, 1420, 1410                                   22AP5
 1410 PRINT 909                                                          22AP5
          GO TO 1480                                                     22AP5
 1420     DO 1460  NB = 1, NTB                                           22AP5
          DO 1460   J = 1, 157                                           22AP5
               KODE(NB,J) = 0.0                                          11MR5
               WS(NB,J) = 0.0                                            10MR5
               DWS(NB,J) = 0.0                                           10MR5
               KEY(NB,J) = 1                                             10MR5
 1460     CONTINUE                                                       22AP5
          DO 1470  N = 1, NCD4                                           22AP5
      READ  143, NINT, NB1, JC1, NB2, JC2                                9MR5
      PRINT 144, NINT, NB1, JC1, NB2, JC2                                9MR5
C-----SET REFERENCE CODE TO DEFINE ORTHOGONAL BEAM INTERSECTIONS AND      01MR5
C-----SET KEY FOR ZERO DEFL AT EVERY INTERSECTION                         01MR5
               KEY(NB1,JC1+4) = 2                                        04MR5
               KEY(NB2,JC2+4) = 2                                        04MR5
               KODE(NB1,JC1+4) = NB2 * 1000 + ( JC2 + 4 )                10MR5
               KODE(NB2,JC2+4) = NB1 * 1000 + ( JC1 + 4 )                10MR5
 1470     CONTINUE                                                       22AP5
C-----INPUT TABLE 5 - SPECIFIED DEFLECTIONS AND SLOPES                    9MR5
 1480 PRINT 150                                                          22AP5
          IF (KEEP5 ) 1510, 1510, 1490                                   22AP5
 1490 PRINT 909                                                          22AP5
          GO TO 1630                                                     22AP5
 1510     IF ( NCD5 ) 1520, 1520, 1530                                   22AP5
 1520 PRINT 907                                                          22AP5
          GO TO 1630                                                     22AP5
 1530     DO 1610  N = 1, NCD5                                           22AP5
      READ  154, NB, JN1, KASE, WS(NB,JN1+4), DWS(NB,JN1+4)              09AP5
               JS = JN1 + 4                                              28JA5
          GO TO ( 1580, 1590, 1600 ), KASE                               22AP5
 1580          KEY(NB,JS) = 2                                            22AP5
      PRINT 155, NB, JN1, KASE, WS(NB,JS)                                09AP5
```

```
      GO TO 1610                                                        22AP5
 1590         KEY(NB,JS-1) = 3                                          22AP5
              KEY(NB,JS+1) = 5                                          28JA5
      PRINT 156, NB, JN1, KASE, DWS(NB,JS)                              09AP5
      GO TO 1610                                                        22AP5
 1600         KEY(NB,JS-1) = 3                                          22AP5
              KEY(NB,JS) = 4                                            28JA5
              KEY(NB,JS+1) = 5                                          28JA5
      PRINT 157, NB, JN1, KASE, WS(NB,JS), DWS(NB,JS)                   09AP5
 1610     CONTINUE                                                      22AP5
C-----INPUT TABLE 6 - FIXED STIFFNESS AND LOAD DATA                      9MR5
 1630 PRINT 162                                                         22AP5
      IF ( KEEP6 ) 1640, 1640, 1660                                     22AP5
 1640     DO 1650  NB = 1, NTE                                          22AP5
          DO 1650   J = 1, 157                                          22AP5
              F(NB,J) = 0.0                                             9MR5
              Q(NB,J) = 0.0                                             9MR5
              S(NB,J) = 0.0                                             9MR5
              T(NB,J) = 0.0                                             9MR5
              R(NB,J) = 0.0                                             9MR5
 1650     CONTINUE                                                      22AP5
      GO TO 1700                                                        22AP5
 1660 PRINT 908                                                         22AP5
 1700     IF ( NCD6 ) 1710, 1710, 1720                                  22AP5
 1710 PRINT 907                                                         22AP5
      GO TO 2020                                                        22AP5
 1720         KR2 = 0                                                   22AP5
      DO 2010   N = 1, NCD6                                             22AP5
              KR1 = KR2                                                 9MR5
      READ  177, NB, JN1, JN2, KR2, FN2, QN2, SN2, TN2, RN2             23MR5
              JN = JN1 + 4                                              9MR5
              J2 = JN2 + 4                                              9MR5
              KSW = 1 + KR2 + 2 * KR1                                   12MR5
      GO TO ( 1830, 1860, 1880, 1880 ), KSW                             22AP5
 1830 PRINT 178, NB, JN1, JN2, KR2, FN2, QN2, SN2, TN2, RN2             22AP5
      GO TO 1890                                                        22AP5
 1860 PRINT 179, NB, JN1, KR2, FN2, QN2, SN2, TN2, RN2                  22AP5
      GO TO 1890                                                        22AP5
 1880 PRINT 180, JN2, KR2, FN2, QN2, SN2, TN2, RN2                      22AP5
      GO TO 1920                                                        22AP5
 1890         J1 = JN                                                   22AP5
 1900         FN1 = FN2                                                 22AP5
              QN1 = QN2                                                 9MR5
              SN1 = SN2                                                 9MR5
              TN1 = TN2                                                 9MR5
              RN1 = RN2                                                 9MR5
      GO TO ( 1920, 2010, 1910, 2010 ), KSW                             22AP5
 1910     GO TO 9999                                                    22AP5
 1920         JINCR = 1                                                 22AP5
              ESM = 1.0                                                 9MR5
      IF ( J2 - J1) 1940, 1940, 1930                                    22AP5
 1930         DENOM = J2 - J1                                           22AP5
              ISW = 1                                                   9MR5
      GO TO 1950                                                        22AP5
 1940         DENOM = 1.0                                               22AP5
              ISW = 0                                                   12MR5
```

```
 1950      DO 1960  J = J1, J2, JINCR                                   22AP5
                DIFF = J - J1                                           9MR5
                PART = DIFF / DENOM                                     18MR5
                F(NB,J) = F(NB,J) + ( FN1 + PART * ( FN2 - FN1 ) ) * ESM 9MR5
                Q(NB,J) = Q(NB,J) + ( QN1 + PART * ( QN2 - QN1 ) ) * ESM 10MR5
                S(NB,J) = S(NB,J) + ( SN1 + PART * ( SN2 - SN1 ) ) * ESM 10MR5
                T(NB,J) = T(NB,J) + ( TN1 + PART * ( TN2 - TN1 ) ) * ESM 10MR5
                R(NB,J) = R(NB,J) + ( RN1 + PART * ( RN2 - RN1 ) ) * ESM 10MR5
 1960      CONTINUE                                                     22AP5
           IF ( ISW ) 1980, 1980, 1970                                  22AP5
 1970           JINCR = J2 - J1                                         22AP5
                ESM = - 0.5                                             10MR5
                ISW = 0                                                 10MR5
           GO TO 1950                                                   22AP5
 1980      GO TO ( 2010, 1910, 2010, 1990 ), KSW                        22AP5
 1990           J1 = J2                                                 22AP5
           GO TO 1900                                                   22AP5
 2010      CONTINUE                                                     22AP5
 2020      CONTINUE                                                     22AP5
C-----FIND BEAMS THAT INTERSECT THE 4 SPECIFIED MONITOR BEAMS            27MR5
           DO 2130  N = 5, 8                                            22AP5
                MB = MONB(N-4)                                          10MR5
                MS = MONS(N-4) + 4                                      10MR5
      CALL DCIPHER ( KODE(MB,MS), MONB(N), MS )                         10MR5
                MONS(N) = MS - 4                                        10MR5
 2130      CONTINUE                                                     22AP5
      PRINT 205, ( MONB(N), MONS(N), N = 1, 8 )                         12MR5
C-----BEGIN MAIN SOLUTION                                               28JA5
                NS = 0                                                  9MR5
                ITER = 0                                                28JA5
           DO 7600  NC = 1, ITMAX                                       22AP5
                NS = NS + 1                                             9MR5
           IF ( NS - NTS ) 2150, 2150, 2140                             29AP5
 2140           NS = 1                                                  22AP5
 2150           KSTB = 0                                                22AP5
C-----SOLVE BEAMS                                                       28JA5
           DO 3500  NB = 1, NTB                                         22AP5
                MP5 = M(NB) + 5                                         02FE5
           DO 2800  J = 3, MP5                                          22AP5
                RF(J+1) = 0.0                                           29MR5
                TA(J+1) = 0.0                                           29MR5
C-----FIND BEAM INTERSECTIONS                                           28JA5
           IF ( KODE(NB,J+1) ) 2170, 2170, 2180                         22AP5
 2170      GO TO 2210                                                   22AP5
 2180           KODE = KODE(NB,J+1)                                     22AP5
      CALL DCIPHER ( KODE, INB, INS )                                   28JA5
           DO 2190  N = 1, 3                                            22AP5
                L = INS + N - 3                                         28JA5
                BMT(N)= F(INB,L) * ( W(INB,L-1) - 2.0 * W(INB,L) +      28JA5
     1                        W(INB,L+1) ) / HE2                        28JA5
 2190      CONTINUE                                                     22AP5
C-----COMPUTE TORQUE ABSORBED BY INTERSECTING BEAMS ON THE PREVIOUS      04MY5
C     CYCLE                                                             04MY5
                TA(INS) = 2. * H * ( ( BMT(1) - 2. * BMT(2) + BMT(3) ) /H28AP5
     1                    - Q(INB,INS-1) + S(INB,INS-1) * W(INB,INS-1) ) 28AP5
                TA(J+1) = TA(INS)                                       29MR5
```

```
C-----SET ROTATIONAL SPRING AT INTERSECTIONS                            28JA5
              RF(J+1) = RR(NS)                                          29MR5
C-----COMPUTE MATRIX COEFFICIENTS                                       28JA5
 2210         AA = F(NB,J-1) -0.25 * H * ( R(NB,J-1) + RF(J-1) )        22AP5
              BB = - 2.0 * ( F(NB,J-1) + F(NB,J) )                      28JA5
              CC = F(NB,J-1) + 4.0 * F(NB,J) + F(NB,J+1) + 0.25 * H *   29MR5
     1             ( R(NB,J-1) + R(NB,J+1) + RF(J-1) + RF(J+1) ) +      29MR5
     2             S(NB,J)                                              29MR5
              DD = - 2.0 * ( F(NB,J) + F(NB,J+1) )                      28JA5
              EE = F(NB,J+1) - 0.25 * H * ( R(NB,J+1) + RF(J+1) )       29MR5
              FF = Q(NB,J) * HE3 - 0.5 * HE2 * ( T(NB,J-1) - T(NB,J+1)  29MR5
     1             - TA(J-1) + TA(J+1) - RF(J-1) * DW(INB,INS) +        29MR5
     2             RF(J+1) * DW(INB,INS) )                              29MR5
C-----COMPUTE RECURSION COEFFICIENTS                                    28JA5
              E = AA * B(J-2) + BB                                      25AG4
              DENOM = E * B(J-1) + AA * C(J-2) + CC                     20JL4
          IF ( DENOM ) 2240, 2230, 2240                                 22AP5
 2230         D = 0.0                                                   22AP5
          GO TO 2250                                                    22AP5
 2240         D = - 1.0 / DENOM                                         22AP5
 2250         C(J) = D * EE                                             22AP5
              B(J) = D * ( E * C(J-1) + DD )                            20JL4
              A(J) = D * ( E * A(J-1) + AA * A(J-2) - FF )              20JL4
              KEYJ = KEY(NB,J)                                          28JA5
C-----RESET RECURSION COEFFICIENTS TO SPECIFIED CONDITIONS              28JA5
          GO TO ( 2700, 2300, 2400, 2500, 2600 ), KEYJ                  22AP5
 2300         C(J) = 0.0                                                22AP5
              B(J) = 0.0                                                28JA5
              A(J) = WS(NB,J)                                           07MY5
          GO TO 2700                                                    22AP5
 2400         DTEMP = D                                                 22AP5
              CTEMP = C(J)                                              20JL4
              BTEMP = B(J)                                              27AG4
              ATEMP = A(J)                                              20JL4
              C(J) = 1.0                                                20JL4
              B(J) = 0.0                                                28JA5
              A(J) = - HT2 * DWS(NB,J)                                  07MY5
          GO TO 2700                                                    22AP5
 2500         C(J) = 0.0                                                22AP5
              B(J) = 0.0                                                20JL4
              A(J) = WS(NB,J)                                           07MY5
          GO TO 2700                                                    22AP5
 2600         DREV = 1.0 / ( 1.0 - ( BTEMP * B(J-1) + CTEMP - 1.0 ) *   22AP5
     1              D / DTEMP )                                         28JA5
              CREV = DREV * C(J)                                        20JL4
              BREV = DREV * ( B(J) + ( BTEMP * C(J-1) ) * D / DTEMP )   25AG4
              AREV = DREV * ( A(J) + ( HT2 * DWS(NB,J) + ATEMP          07MY5
     1              + BTEMP * A(J-1) ) * D / DTEMP )                    28JA5
              C(J) = CREV                                               20JL4
              B(J) = BREV                                               20JL4
              A(J) = AREV                                               20JL4
 2700     CONTINUE                                                      22AP5
 2800     CONTINUE                                                      22AP5
              MP5 = M(NB) + 5                                           02FE5
          DO 2850 KK = 3, MP5                                           22AP5
              J = M(NB) + 8 - KK                                        16FE5
```

```
            W(NB,J) = A(J) + B(J) * W(NB,J+1) + C(J) * W(NB,J+2)      16FE5
 2850     CONTINUE                                                     22AP5
            MP4 = M(NB) + 4                                            02FE5
            MP5 = M(NB) + 5                                            07MY5
            MP6 = M(NB) + 6                                            07MY5
            MP7 = M(NB) + 7                                            07MY5
            W(NB,MP6) = 2.0 * W(NB,MP5) - W(NB,MP4)                    07MY5
            W(NB,MP7) = 2.0 * W(NB,MP6) - W(NB,MP5)                    07MY5
            W(NB,2) = 2.0 * W(NB,3) - W(NB,4)                          07MY5
            W(NB,1) = 2.0 * W(NB,2) - W(NB,3)                          07MY5
          DO 3200  J = 3, MP5                                          07MY5
            DWTEMP = DW(NB,J)                                          28JA5
            DW(NB,J) = ( - W(NB,J-1) + W(NB,J+1) ) / ( 2. * H )        28JA5
            BM(NB,J) = F(NB,J) * (W(NB,J-1) - 2. * W(NB,J) +           28JA5
     1                   W(NB,J+1) ) / HE2                             28JA5
            DBM(NB,J) = ( - BM(NB,J-1) + BM(NB,J+1) ) / HT2            29MR5
C-----COUNT OF BEAMS NOT STABILIZED                                     28JA5
          IF ( KODE(NB,J) ) 3100, 3100, 3000                           22AP5
 3000     IF ( ABSF ( DW(NB,J) - DWTEMP ) - CTOL ) 3100, 3100, 3050    22AP5
 3050       KSTB = KSTB + 1                                            22AP5
 3100     CONTINUE                                                     22AP5
 3200     CONTINUE                                                     22AP5
 3500     CONTINUE                                                     22AP5
C-----COUNT OF INTERSECTIONS NOT CLOSED                                 29JA5
            KCTCL = 0                                                  29JA5
          DO 6000   NB = 1, NTB                                        22AP5
            MP4 = M(NB) + 4                                            02FE5
          DO 6000   J = 4, MP4                                         22AP5
          IF ( KODE(NB,J) ) 6000, 6000, 5900                           22AP5
 5900       KCODE = KODE(NB,J)                                         22AP5
      CALL DCIPHER ( KCODE, INB, INS )                                 29JA5
          IF ( ABSF ( DW(INB,INS) - DW(NB,J) ) - CTOL ) 6000, 6000, 595022AP5
 5950       KCTCL = KCTCL + 1                                          22AP5
 6000     CONTINUE                                                     22AP5
            KCTCL = KCTCL / 2                                          28JA5
            ITER = ITER + 1                                            29JA5
          DO 6100  N = 1, 8                                            22AP5
            IB = MONB(N)                                               10MR5
            IS = MONS(N) + 4                                           10MR5
            DWM(NC,N) = DW(IB,IS)                                      10MR5
 6100     CONTINUE                                                     22AP5
C-----PRINT TABLE 7 HEADING AND 4 MONITOR BEAM AND STATION NUMBERS      27MR5
      PRINT 206, ITER, RR(NS), KSTB, KCTCL, ( DWM(NC,N), N = 1, 8 )    12MR5
C-----CONTROL ITERATION PROCESS                                         29JA5
          IF ( KCTCL ) 7900, 7900, 7000                                22AP5
 7000     IF (ITMAX - ITER ) 7900, 7900, 7100                          22AP5
 7100     IF ( KSTB ) 7900, 7900, 7600                                 22AP5
 7600     CONTINUE                                                     22AP5
 7900     CONTINUE                                                     22AP5
C-----COMPUTE AND PRINT RESULTS                                         29JA5
      PRINT 11                                                         08MY3 ID
      PRINT 1                                                          18FE5 ID
      PRINT 13, ( AN1(N), N = 1, 32 )                                  18FE5 ID
      PRINT 16, NPROB, ( AN2(N), N = 1, 14 )                           28AG3 ID
      PRINT 208, ITER                                                  12MR5
          IF ( KCTCL ) 8120, 8120, 8110                                22AP5
```

```
8110 PRINT 209                                                           22AP5
8120 PRINT 210                                                           22AP5
         DO 8600  NB = 1, NTB                                            22AP5
              MP5 = M(NB) + 5                                            02FE5
     PRINT 211                                                           12MR5
         DO 8500   J = 3, MP5                                            22AP5
              JSTA = J - 4                                               29JA5
              ZI = JSTA                                                  29MR5
              X = JSTA * H                                               29MR5
         IF ( KODE(NB,J) ) 8200, 8200, 8300                              22AP5
8200          ERROR = 0.0                                                22AP5
         GO TO 8400                                                      22AP5
8300          KCODE = KODE(NB,J)                                         22AP5
     CALL DCIPHER ( KCODE, INB, INS )                                    03AP5
              ERROR = RR(NS) * ( DW(INB,INS) - DW(NB,J) )                03AP5
8400 PRINT 212, NB, JSTA, X, W(NB,J), DW(NB,J), BM(NB,J), DBM(NB,J),     22AP5
    1          ERROR                                                     03AP5
8500     CONTINUE                                                        22AP5
8600     CONTINUE                                                        22AP5
     CALL TIME                                                           18FE5
         GO TO 1010                                                      26AG3 ID
9990 CONTINUE                                                            12MR5 ID
9999 CONTINUE                                                            04MY3 ID
     PRINT 11                                                            08MY3 ID
     PRINT 1                                                             18FE5 ID
     PRINT 13, ( AN1(N), N = 1, 32 )                                     18FE5 ID
     PRINT 19                                                            26AG3 ID
     END                                                                 04MY3 ID
```

APPENDIX 4

GUIDE FOR DATA INPUT FOR FRAME 4

FRAME 4 GUIDE FOR DATA INPUT --- Card forms

IDENTIFICATION OF PROGRAM AND RUN (2 alphanumeric cards per run)

Card 1: columns 1–80

Card 2: columns 1–80

IDENTIFICATION OF PROBLEM (one card each problem)

PROB NUM: columns 1–5

DESCRIPTION OF PROBLEM (alphanumeric): columns 11–80

TABLE 1. PROGRAM CONTROL DATA (three cards each problem)

ENTER "1" TO HOLD PRECEDING TABLE

TABLE	2	3	4	5	6
Column	10	15	20	25	30

NUM OF CARDS ADDED FOR TABLE

TABLE	2	3	4	5	6
Column	45	50	55	60	65

Field	Columns (ending)
MAX NUM OF ITRS	10
NUM OF X-BEAMS	15
NUM OF Y-BEAMS	20
INCREMENT LENGTH	31–40
CLOSURE TOLERANCE	40–50

MONITOR INTERSECTIONS

BEAM NUM	STA	BEAM NUM	STA	BEAM NUM	STA	BEAM NUM	STA
10	15	20	25	30	35	40	45

TABLE 2. CLOSURE SPRING VALUES (number of cards according to Table 1; none if preceding Table 2 is held)

SPRING NUM	SPRING VALUE
10	21–30

TABLE 3. NUM OF INCREMENTS FOR EACH BEAM (number of cards according to Table 1 ; none if preceding Table 3 is held)

NUM OF INCRS FOR

BEAM 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
10	15	20	25	30	35	40	45	50	55	60	65	70	75	80

TABLE 4. BEAM INTERSECTIONS (number of cards according to Table 1; none if preceding Table 4 is held)

INTER NUM	BEAM NUM	STA	BEAM NUM	STA
10	15	20	25	30

TABLE 5. SPECIFIED DEFLECTIONS AND SLOPES (number of cards according to Table 1; none if preceding Table 5 is held)

BEAM NUM	STA	CASE	DEFLECTION	SLOPE
10	15	25	31–40	50

CASE= I for deflection only, 2 for slope only, 3 for both

TABLE 6. FIXED STIFFNESS AND LOAD DATA (number of cards according to Table 1). Data <u>added</u> to storage as lumped quantities per increment length, linearly interpolated between values input at indicated end stations, with 1/2-values at each end station. Concentrated effects are established as full values at single stations by setting final station = initial station.

BEAM NUM	STA	TO STA	ENTER 1 IF CONT'D ON NEXT CARD	F BENDING STIFFNESS	Q TRANSVERSE FORCE	S SPRING SUPPORT	T TRANSVERSE COUPLE	R ROTATIONAL RESTRAINT
10	15	20	25	31–40	50	60	70	80

STOP CARD (one blank at end of each run)

GENERAL PROGRAM NOTES

A consistent system of units must be used for all input data, for example: pounds and inches.

All 5-space words are understood to be whole numbers . . . . -4321

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

TABLE 1. PROGRAM CONTROL DATA

For each of Tables 2, 3, 4 and 5, a choice must be made between holding all of the data from the preceding problem or entering entirely new data. If the hold-option for any of these tables is set equal to 1, the number of cards input for that table must be zero.

For Table 6, the data are accumulated in storage by adding to previously stored data. The number of cards input is therefore independent of the hold-option.

Card counts in Table 1 should be rechecked carefully after coding of each problem is completed.

The maximum number of iterations that may be specified is 99. Usually 20 are sufficient.

A certain beam numbering system must be followed. Number all the x-beams, starting with the top beam as 1. Then number all the y-beams, starting with the left-most beam having the number of x-beams plus 1. Beams are solved in numerical order.

The maximum number of x and y-beams is 9 in this program. This number may be adjusted with minor program revisions. It is dependent on the computer's storage capacity.

Typical units for the value of the increment length are inches.

Increment lengths must be the same in both the x and y-direction.

The maximum number of increments into which a beam may be divided is 150.

Closure tolerance is equal to the allowable difference between x and y-beam slopes at intersections.

Four sets of beam and station numbers are required to designate intersections where values of slope are monitored after each iteration. Only one beam and station number are required to identify an intersection, i.e., the program automatically finds the beam and station number of the intersecting beam.

All four monitor stations must be specified; therefore beam and station numbers may be repeated for problems with fewer than four intersections.

There is no hold option on this table, i.e., 3 new data cards must be entered for each problem.

TABLE 2. CLOSURE SPRING VALUES

The rotational closure springs input in this table are used in repeated cyclic order. Springs should be input in the order they are to be cycled. Maximum number of springs is 5.

TABLE 3. NUMBER OF INCREMENTS FOR EACH BEAM

Number of increments for each beam must be entered according to numerical beam order.

TABLE 4. BEAM INTERSECTIONS

The total number of intersections input in this table should be rechecked carefully after coding of each problem is completed.

Both pairs of beam and station numbers corresponding to an intersection must be designated.

TABLE 5. SPECIFIED DEFLECTIONS AND SLOPES

Deflections are automatically set equal to zero at each beam intersection in Table 4, so it is not necessary to specify zero deflections at intersections.

No conditions other than zero deflections may be specified at a joint. However, conditions may be specified along a frame member if the following rules are followed.

Specified conditions on frame members should not cause axial shortening in any frame members.

A slope may not be specified closer than 3 increments from another specified slope on two stations within either side of a joint.

A deflection may not be specified closer than 2 increments from a specified slope, except that both a deflection and a slope may be specified at the same station.

TABLE 6. STIFFNESS AND LOAD DATA

Typical units,

Variables:	F	Q	S	T	R
Values per station:	lb $\times$ in^2	lb	lb/in	in $\times$ lb	in $\times$ lb/radian

R may be specified at any station except at a station where an intersection occurs or at stations away from an intersection.

T may be specified at any station except two stations away from an intersection.

Data in this table which would express effects at fictitious stations beyond the ends of the real beam should not be entered (nor held from the preceding problem).

For the interpolation and distribution process, there are four variations in the station numbering and in referencing for continuation to succeeding cards. These variations are explained and illustrated on the following page.

There are no restrictions on the order of cards in Table 6 except that within a distribution sequence the stations must be in regular order.

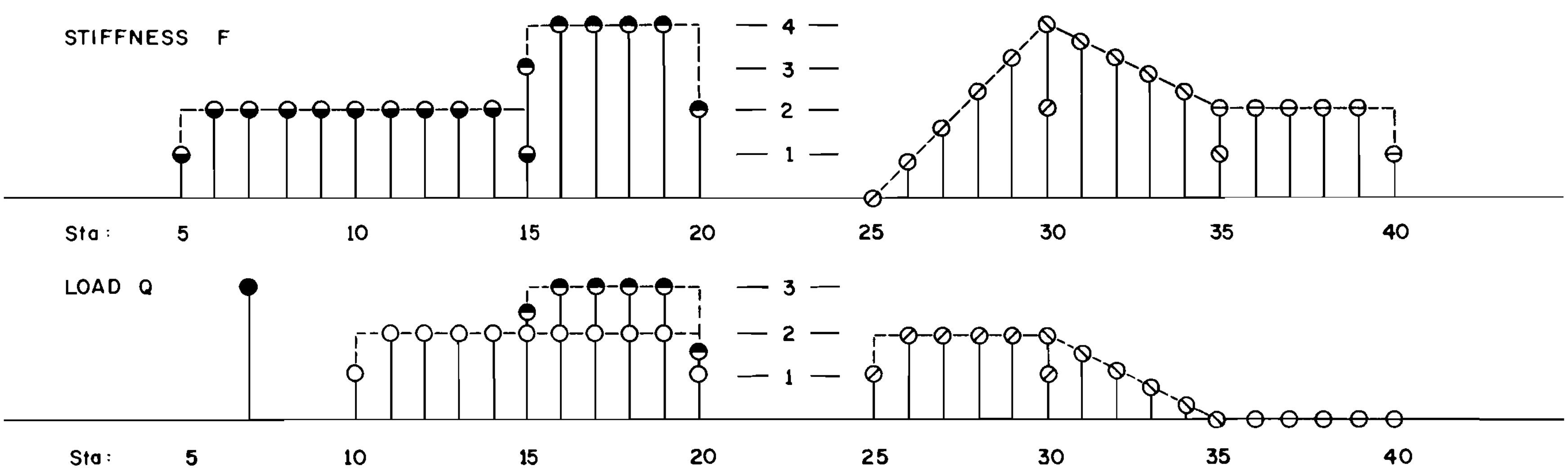
Individual – card Input

	BEAM NUM	FROM STA	TO STA	CONT'D TO NEXT CARD ?	F	Q	etc...
Case a.1. Data concentrated at one sta	9	7 →	7	0 = NO		3.0	
Case a.2. Data uniformly distributed	9	5 →	15	0 = NO	2.0		
	9	15 →	20	0 = NO	4.0	1.0	
	9	10 →	20.	0 = NO		2.0	

Multiple – card Sequence

	BEAM NUM	FROM STA	TO STA	CONT'D TO NEXT CARD ?	F	Q	etc...
Case b. First – of – sequence	9	25		1 = YES	0.0	2.0	
Case c. Interior – of – sequence	9		→ 30	1 = YES	4.0	2.0	
	9		→ 35	1 = YES	2.0	0.0	
Case d. End – of – sequence	9		→ 40	0 = NO	2.0		

Resulting Distribution of Data



APPENDIX 5

LISTING OF INPUT DATA FOR EXAMPLE PROBLEMS

```
CE051118  --  CODED BY BRG,DMP  --  RUN DATE  26 OC 66
EXAMPLE PROBLEMS  --  FINAL REPORT
    1     THD 3-BARREL BOX CULVERT, 10 FT FILL, UNIFORM LOADS
         0                                  2    1    8    0    8
        20    2    4             3.0E+00   1.0E-09
         1    0    2   26    1   52    2   78
         1             1.6E+07
         2             1.0E+08
        78   78   18   18   18   18
         1    1    0    3   18
         2    1   26    4   18
         3    1   52    5   18
         4    1   78    6   18
         5    2    0    3    0
         6    2   26    4    0
         7    2   52    5    0
         8    2   78    6    0
         1    0   78    0       6.48E+08-234.0E+00
         2    0   78    0       6.48E+08 244.0E+00
         3    0         1       1.92E+08-113.0E+00
         3        18    0       1.92E+08 -79.0E+00
         6    0         1       1.92E+08 113.0E+00
         6        18    0       1.92E+08  79.0E+00
         4    0   18    0       1.92E+08
         5    0   18    0       1.92E+08
    2     MULTI-STORY FRAMED STRUCTURE  -  VERTICAL LOADS ONLY
         0                                  2    1   11    4   34
        20    3    4             4.0E+00   1.0E-09
         4   96    7   66    2   45    3   90
         1            4.27E+06
         2            2.00E+08
        90  150  150   96   96   96   66
         1    1    0    4   96
         2    1   45    5   96
         3    1   90    6   96
         4    2    0    4   66
         5    2   45    5   66
         6    2   90    6   66
         7    2  150    7   66
         8    3    0    4   36
         9    3   45    5   36
        10    3   90    6   36
        11    3  150    7   36
         4    0         3              0.0       0.0
         5    0         3              0.0       0.0
         6    0         3              0.0       0.0
         7    0         3              0.0       0.0
         1    0   90    0      1.920E+08
         1   45   90    0                -40.0E+00
         2    0  150    0      6.480E+08
         2    0   45    0                -75.0E+00
         2   90  150    0                -75.0E+00
         3    0         1     1.7496E+10
         3        15    1     1.5360E+09
         3        30    1     1.5360E+09
```

3		45	1	1.7496E+10		
3		60	1	1.5360E+09		
3		75	1	1.5360E+09		
3		90	1	1.7496E+10		
3		111	1	1.5360E+09		
3		129	1	1.5360E+09		
3		150	0	1.7496E+10		
3	15	15	0		-25.0E+03	
3	30	30	0		-25.0E+03	
3	45	90	0		-75.0E+00	
3	120	120	0		-50.0E+03	
4	0	36	0	5.1840E+09		
4	36	66	0	1.5360E+09		
4	66	96	0	6.4800E+08		
5	0	36	0	5.1840E+09		
5	36	66	0	1.5360E+09		
5	66	96	0	6.4800E+08		
6	0	36	0	5.1840E+09		
6	36	66	0	1.5360E+09		
6	66	96	0	6.4800E+08		
7	0	36	0	5.1840E+09		
7	36	66	0	1.5360E+09		
4	0	18	0			5.40E+04
5	0	18	0			5.40E+04
6	0	18	0			5.40E+04
7	0	18	0			5.40E+04

APPENDIX 6

COMPUTED RESULTS FOR EXAMPLE PROBLEMS

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PROGRAM FRAME 4 - MATLOCK - DECK 5                    REVISION DATE = 30 AP 65
CE051118  --  CODED BY BRG,CMP  --  RUN DATE  26 OC 66
EXAMPLE PROBLEMS  --  FINAL REPORT
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PROB
1 TFC 3-BARREL BOX CULVERT, 10 FT FILL, UNIFORM LOADS

TABLE 1. CONTROL DATA

	TABLE NUMBER 2	3	4	5	6
PRIOR-DATA OPTIONS (1=HOLD)	0	0	0	0	0
NUM CARDS INPUT THIS PROBLEM	2	1	8	0	8

MAX NUM ITERATIONS	20
NUM OF X-BEAMS	2
NUM OF Y-BEAMS	4
X AND Y-BEAM INCR LENGTH	3.000E 00
CLOSURE TOLERANCE	1.000E-09

MONITOR STAS NB,J 1 0 2 26 1 52 2 78

TABLE 2. CLOSURE SPRING VALUES

SPRING NUM	CLOSURE SPRING
1	1.600E 07
2	1.000E 08

TABLE 3. NUM OF INCREMENTS FOR EACH BEAM

BEAM NUM	NUM OF INCRS
1	78
2	78
3	18
4	18
5	18
6	18

TABLE 4. BEAM INTERSECTIONS

INT	BEAM	STA	BEAM	STA
1	1	0	3	18
2	1	26	4	18
3	1	52	5	18
4	1	78	6	18
5	2	0	3	0
6	2	26	4	0
7	2	52	5	0
8	2	78	6	0

TABLE 5. SPECIFIED DEFLECTIONS AND SLOPES

BEAM NUM	STA NUM	CASE	DEFLECTION	SLOPE
	NONE			

TABLE 6. FIXED STIFFNESS AND LOAD DATA

BEAM NUM	FROM	TO	CONTD	F	Q	S	T	R
1	0	78	0	6.480E 08	-2.340E 02	0	0	0
2	0	78	0	6.480E 08	2.440E 02	0	0	0
3	0		1	1.920E 08	-1.130E 02	0	0	0
		18	0	1.920E 08	-7.900E 01	0	0	0
6	0		1	1.920E 08	1.130E 02	0	0	0
		18	0	1.920E 08	7.900E 01	0	0	0
4	0	18	0	1.920E 08	0	0	0	0
5	0	18	0	1.920E 08	0	0	0	0

TABLE 7. ITERATION MONITOR DATA AND SLOPES AT FOUR SELECTED STATIONS

ITR NUM	CLOSURE SPRING	NOT STAB	NOT CLOS	BEAM STA 1 0 / 3 18	BEAM STA 2 26 / 4 0	BEAM STA 1 52 / 5 18	BEAM STA 2 78 / 6 0
1	1.600E 07	16	8	-8.664E-04	-2.333E-04	-2.210E-04	-9.147E-04
				-9.011E-04	-3.198E-04	-3.092E-04	-9.151E-04
2	1.000E 08	16	8	-9.060E-04	-3.000E-04	-2.925E-04	-9.238E-04
				-9.106E-04	-2.832E-04	-2.777E-04	-9.310E-04
3	1.600E 07	16	8	-9.082E-04	-2.735E-04	-2.681E-04	-9.312E-04
				-9.079E-04	-2.698E-04	-2.644E-04	-9.306E-04
4	1.000E 08	16	8	-9.076E-04	-2.706E-04	-2.652E-04	-9.303E-04
				-9.073E-04	-2.713E-04	-2.659E-04	-9.300E-04
5	1.600E 07	16	8	-9.073E-04	-2.717E-04	-2.663E-04	-9.300E-04
				-9.073E-04	-2.719E-04	-2.665E-04	-9.300E-04
6	1.000E 08	16	8	-9.073E-04	-2.718E-04	-2.664E-04	-9.300E-04
				-9.073E-04	-2.718E-04	-2.664E-04	-9.300E-04
7	1.600E 07	14	4	-9.073E-04	-2.718E-04	-2.664E-04	-9.300E-04
				-9.073E-04	-2.718E-04	-2.664E-04	-9.300E-04
8	1.000E 08	12	4	-9.073E-04	-2.718E-04	-2.664E-04	-9.300E-04
				-9.073E-04	-2.718E-04	-2.664E-04	-9.300E-04
9	1.600E 07	8	0	-9.073E-04	-2.718E-04	-2.664E-04	-9.300E-04
				-9.073E-04	-2.718E-04	-2.664E-04	-9.300E-04

PROGRAM FRAME 4 - MATLOCK - DECK 5 REVISION DATE = 30 AP 65
CE051118 -- CODED BY BRG,DMP -- RUN DATE 26 OC 66
EXAMPLE PROBLEMS -- FINAL REPORT

PROB (CONTD)
1 THD 3-BARREL BOX CULVERT, 10 FT FILL, UNIFORM LOADS

TABLE 6. RESULTS -- ITERATION 9

NB	JSTA	X	DEFL	SLOPE	MOMENT	SHEAR	ERROR
1	-1	-3.000E 00	2.626E-03	-8.754E-04	0	-1.148E 03	0
1	0	0	0	-9.073E-04	-6.887E 03	-1.038E 03	4.363E-04
1	1	3.000E 00	-2.818E-03	-9.536E-04	-6.229E 03	1.250E 03	0
1	2	6.000E 00	-5.722E-03	-9.666E-04	6.151E 02	2.164E 03	0
1	3	9.000E 00	-8.617E-03	-9.496E-04	6.757E 03	1.930E 03	0
1	4	1.200E 01	-1.142E-02	-9.057E-04	1.220E 04	1.696E 03	0
1	5	1.500E 01	-1.405E-02	-8.382E-04	1.693E 04	1.462E 03	0
1	6	1.800E 01	-1.645E-02	-7.505E-04	2.097E 04	1.228E 03	0
1	7	2.100E 01	-1.855E-02	-6.457E-04	2.430E 04	9.943E 02	0
1	8	2.400E 01	-2.032E-02	-5.271E-04	2.694E 04	7.603E 02	0
1	9	2.700E 01	-2.172E-02	-3.979E-04	2.887E 04	5.263E 02	0
1	10	3.000E 01	-2.271E-02	-2.614E-04	3.009E 04	2.923E 02	0
1	11	3.300E 01	-2.329E-02	-1.209E-04	3.062E 04	5.825E 01	0
1	12	3.600E 01	-2.344E-02	2.044E-05	3.044E 04	-1.757E 02	0
1	13	3.900E 01	-2.316E-02	1.593E-04	2.956E 04	-4.097E 02	0
1	14	4.200E 01	-2.248E-02	2.926E-04	2.798E 04	-6.437E 02	0
1	15	4.500E 01	-2.141E-02	4.168E-04	2.570E 04	-8.777E 02	0
1	16	4.800E 01	-1.998E-02	5.289E-04	2.272E 04	-1.112E 03	0
1	17	5.100E 01	-1.823E-02	6.256E-04	1.903E 04	-1.346E 03	0
1	18	5.400E 01	-1.623E-02	7.035E-04	1.464E 04	-1.580E 03	0
1	19	5.700E 01	-1.401E-02	7.595E-04	9.553E 03	-1.814E 03	0
1	20	6.000E 01	-1.167E-02	7.903E-04	3.761E 03	-2.048E 03	0
1	21	6.300E 01	-9.271E-03	7.927E-04	-2.733E 03	-2.282E 03	0
1	22	6.600E 01	-6.912E-03	7.634E-04	-9.930E 03	-2.516E 03	0
1	23	6.900E 01	-4.691E-03	6.992E-04	-1.783E 04	-2.750E 03	0
1	24	7.200E 01	-2.717E-03	5.967E-04	-2.643E 04	-2.984E 03	0
1	25	7.500E 01	-1.110E-03	4.528E-04	-3.573E 04	-3.063E 03	0
1	26	7.800E 01	0	2.664E-04	-4.481E 04	1.045E 02	4.678E-03
1	27	8.100E 01	4.880E-04	8.142E-05	-3.510E 04	2.963E 03	0
1	28	8.400E 01	4.885E-04	-6.240E-05	-2.703E 04	2.574E 03	0
1	29	8.700E 01	1.136E-04	-1.705E-04	-1.966E 04	2.340E 03	0
1	30	9.000E 01	-5.344E-04	-2.461E-04	-1.299E 04	2.106E 03	0
1	31	9.300E 01	-1.363E-03	-2.924E-04	-7.023E 03	1.872E 03	0
1	32	9.600E 01	-2.289E-03	-3.127E-04	-1.758E 03	1.638E 03	0
1	33	9.900E 01	-3.239E-03	-3.103E-04	2.805E 03	1.404E 03	0
1	34	1.020E 02	-4.150E-03	-2.884E-04	6.666E 03	1.170E 03	0
1	35	1.050E 02	-4.969E-03	-2.502E-04	9.825E 03	9.360E 02	0
1	36	1.080E 02	-5.652E-03	-1.990E-04	1.228E 04	7.020E 02	0
1	37	1.110E 02	-6.163E-03	-1.381E-04	1.404E 04	4.680E 02	0
1	38	1.140E 02	-6.480E-03	-7.067E-05	1.509E 04	2.340E 02	0
1	39	1.170E 02	-6.587E-03	2.956E-12	1.544E 04	6.273E-03	0
1	40	1.200E 02	-6.480E-03	7.067E-05	1.509E 04	-2.340E 02	0
1	41	1.230E 02	-6.163E-03	1.381E-04	1.404E 04	-4.680E 02	0

1	42	1.260E 02	-5.652E-03	1.990E-04	1.228E 04	-7.020E 02	0
1	43	1.290E 02	-4.969E-03	2.502E-04	9.825E 03	-9.360E 02	0
1	44	1.320E 02	-4.150E-03	2.884E-04	6.666E 03	-1.170E 03	0
1	45	1.350E 02	-3.239E-03	3.103E-04	2.805E 03	-1.404E 03	0
1	46	1.380E 02	-2.289E-03	3.127E-04	-1.758E 03	-1.638E 03	0
1	47	1.410E 02	-1.363E-03	2.924E-04	-7.023E 03	-1.872E 03	0
1	48	1.440E 02	-5.344E-04	2.461E-04	-1.299E 04	-2.106E 03	0
1	49	1.470E 02	1.136E-04	1.705E-04	-1.966E 04	-2.340E 03	0
1	50	1.500E 02	4.885E-04	6.240E-05	-2.703E 04	-2.574E 03	0
1	51	1.530E 02	4.880E-04	-8.142E-05	-3.510E 04	-2.963E 03	0
1	52	1.560E 02	0	-2.664E-04	-4.481E 04	-1.045E 02	-4.762E-03
1	53	1.590E 02	-1.110E-03	-4.528E-04	-3.573E 04	3.063E 03	0
1	54	1.620E 02	-2.717E-03	-5.967E-04	-2.643E 04	2.984E 03	0
1	55	1.650E 02	-4.691E-03	-6.992E-04	-1.783E 04	2.750E 03	0
1	56	1.680E 02	-6.912E-03	-7.634E-04	-9.930E 03	2.516E 03	0
1	57	1.710E 02	-9.271E-03	-7.927E-04	-2.733E 03	2.282E 03	0
1	58	1.740E 02	-1.167E-02	-7.903E-04	3.761E 03	2.048E 03	0
1	59	1.770E 02	-1.401E-02	-7.595E-04	9.553E 03	1.814E 03	0
1	60	1.800E 02	-1.623E-02	-7.035E-04	1.464E 04	1.580E 03	0
1	61	1.830E 02	-1.823E-02	-6.256E-04	1.903E 04	1.346E 03	0
1	62	1.860E 02	-1.998E-02	-5.289E-04	2.272E 04	1.112E 03	0
1	63	1.890E 02	-2.141E-02	-4.168E-04	2.570E 04	8.777E 02	0
1	64	1.920E 02	-2.248E-02	-2.926E-04	2.798E 04	6.437E 02	0
1	65	1.950E 02	-2.316E-02	-1.593E-04	2.956E 04	4.097E 02	0
1	66	1.980E 02	-2.344E-02	-2.044E-05	3.044E 04	1.757E 02	0
1	67	2.010E 02	-2.329E-02	1.209E-04	3.062E 04	-5.825E 01	0
1	68	2.040E 02	-2.271E-02	2.614E-04	3.009E 04	-2.923E 02	0
1	69	2.070E 02	-2.172E-02	3.979E-04	2.887E 04	-5.263E 02	0
1	70	2.100E 02	-2.032E-02	5.271E-04	2.694E 04	-7.603E 02	0
1	71	2.130E 02	-1.855E-02	6.457E-04	2.430E 04	-9.943E 02	0
1	72	2.160E 02	-1.645E-02	7.505E-04	2.097E 04	-1.228E 03	0
1	73	2.190E 02	-1.405E-02	8.382E-04	1.693E 04	-1.462E 03	0
1	74	2.220E 02	-1.142E-02	9.057E-04	1.220E 04	-1.696E 03	0
1	75	2.250E 02	-8.617E-03	9.496E-04	6.757E 03	-1.930E 03	0
1	76	2.280E 02	-5.722E-03	9.666E-04	6.151E 02	-2.164E 03	0
1	77	2.310E 02	-2.818E-03	9.536E-04	-6.229E 03	-1.250E 03	0
1	78	2.340E 02	0	9.073E-04	-6.887E 03	1.038E 03	-2.908E-04
1	79	2.370E 02	2.626E-03	8.754E-04	0	1.148E 03	0
2	-1	-3.000E 00	-2.687E-03	8.958E-04	0	1.233E 03	0
2	0	0	0	9.300E-04	7.398E 03	1.151E 03	-4.247E-04
2	1	3.000E 00	2.893E-03	9.803E-04	6.908E 03	-1.274E 03	0
2	2	6.000E 00	5.882E-03	9.957E-04	-2.474E 02	-2.263E 03	0
2	3	9.000E 00	8.867E-03	9.797E-04	-6.671E 03	-2.019E 03	0
2	4	1.200E 01	1.176E-02	9.356E-04	-1.236E 04	-1.775E 03	0
2	5	1.500E 01	1.448E-02	8.669E-04	-1.732E 04	-1.531E 03	0
2	6	1.800E 01	1.696E-02	7.769E-04	-2.155E 04	-1.287E 03	0
2	7	2.100E 01	1.914E-02	6.691E-04	-2.504E 04	-1.043E 03	0
2	8	2.400E 01	2.098E-02	5.467E-04	-2.781E 04	-7.991E 02	0
2	9	2.700E 01	2.242E-02	4.133E-04	-2.984E 04	-5.551E 02	0
2	10	3.000E 01	2.346E-02	2.722E-04	-3.114E 04	-3.111E 02	0
2	11	3.300E 01	2.406E-02	1.267E-04	-3.171E 04	-6.712E 01	0
2	12	3.600E 01	2.422E-02	-1.973E-05	-3.154E 04	1.769E 02	0
2	13	3.900E 01	2.394E-02	-1.637E-04	-3.064E 04	4.209E 02	0
2	14	4.200E 01	2.323E-02	-3.018E-04	-2.902E 04	6.649E 02	0
2	15	4.500E 01	2.213E-02	-4.306E-04	-2.666E 04	9.089E 02	0
2	16	4.800E 01	2.065E-02	-5.469E-04	-2.356E 04	1.153E 03	0
2	17	5.100E 01	1.885E-02	-6.471E-04	-1.974E 04	1.397E 03	0
2	18	5.400E 01	1.677E-02	-7.280E-04	-1.518E 04	1.641E 03	0

2	19	5.700E 01	1.448E-02	-7.860E-04	-9.893E 03	1.885E 03	0
2	20	6.000E 01	1.205E-02	-8.179E-04	-3.872E 03	2.129E 03	0
2	21	6.300E 01	9.571E-03	-8.202E-04	2.880E 03	2.373E 03	0
2	22	6.600E 01	7.130E-03	-7.895E-04	1.037E 04	2.617E 03	0
2	23	6.900E 01	4.834E-03	-7.225E-04	1.858E 04	2.861E 03	0
2	24	7.200E 01	2.795E-03	-6.157E-04	2.753E 04	3.105E 03	0
2	25	7.500E 01	1.139E-03	-4.659E-04	3.721E 04	3.185E 03	0
2	26	7.800E 01	0	-2.718E-04	4.664E 04	-1.180E 02	-4.673E-03
2	27	8.100E 01	-4.915E-04	-7.933E-05	3.650E 04	-3.092E 03	0
2	28	8.400E 01	-4.760E-04	7.018E-05	2.808E 04	-2.684E 03	0
2	29	8.700E 01	-7.041E-05	1.824E-04	2.040E 04	-2.440E 03	0
2	30	9.000E 01	6.185E-04	2.608E-04	1.344E 04	-2.196E 03	0
2	31	9.300E 01	1.494E-03	3.086E-04	7.223E 03	-1.952E 03	0
2	32	9.600E 01	2.470E-03	3.293E-04	1.733E 03	-1.708E 03	0
2	33	9.900E 01	3.470E-03	3.263E-04	-3.025E 03	-1.464E 03	0
2	34	1.020E 02	4.428E-03	3.030E-04	-7.051E 03	-1.220E 03	0
2	35	1.050E 02	5.288E-03	2.627E-04	-1.035E 04	-9.760E 02	0
2	36	1.080E 02	6.005E-03	2.089E-04	-1.291E 04	-7.320E 02	0
2	37	1.110E 02	6.542E-03	1.449E-04	-1.474E 04	-4.880E 02	0
2	38	1.140E 02	6.874E-03	7.416E-05	-1.584E 04	-2.440E 02	0
2	39	1.170E 02	6.987E-03	-2.956E-12	-1.620E 04	-6.262E-03	0
2	40	1.200E 02	6.874E-03	-7.416E-05	-1.584E 04	2.440E 02	0
2	41	1.230E 02	6.542E-03	-1.449E-04	-1.474E 04	4.880E 02	0
2	42	1.260E 02	6.005E-03	-2.089E-04	-1.291E 04	7.320E 02	0
2	43	1.290E 02	5.288E-03	-2.627E-04	-1.035E 04	9.760E 02	0
2	44	1.320E 02	4.428E-03	-3.030E-04	-7.051E 03	1.220E 03	0
2	45	1.350E 02	3.470E-03	-3.263E-04	-3.025E 03	1.464E 03	0
2	46	1.380E 02	2.470E-03	-3.293E-04	1.733E 03	1.708E 03	0
2	47	1.410E 02	1.494E-03	-3.086E-04	7.223E 03	1.952E 03	0
2	48	1.440E 02	6.185E-04	-2.608E-04	1.344E 04	2.196E 03	0
2	49	1.470E 02	-7.041E-05	-1.824E-04	2.040E 04	2.440E 03	0
2	50	1.500E 02	-4.760E-04	-7.018E-05	2.808E 04	2.684E 03	0
2	51	1.530E 02	-4.915E-04	7.933E-05	3.650E 04	3.092E 03	0
2	52	1.560E 02	0	2.718E-04	4.664E 04	1.180E 02	4.773E-03
2	53	1.590E 02	1.139E-03	4.659E-04	3.721E 04	-3.185E 03	0
2	54	1.620E 02	2.795E-03	6.157E-04	2.753E 04	-3.105E 03	0
2	55	1.650E 02	4.834E-03	7.225E-04	1.858E 04	-2.861E 03	0
2	56	1.680E 02	7.130E-03	7.895E-04	1.037E 04	-2.617E 03	0
2	57	1.710E 02	9.571E-03	8.202E-04	2.880E 03	-2.373E 03	0
2	58	1.740E 02	1.205E-02	8.179E-04	-3.872E 03	-2.129E 03	0
2	59	1.770E 02	1.448E-02	7.860E-04	-9.893E 03	-1.885E 03	0
2	60	1.800E 02	1.677E-02	7.280E-04	-1.518E 04	-1.641E 03	0
2	61	1.830E 02	1.885E-02	6.471E-04	-1.974E 04	-1.397E 03	0
2	62	1.860E 02	2.065E-02	5.469E-04	-2.356E 04	-1.153E 03	0
2	63	1.890E 02	2.213E-02	4.306E-04	-2.666E 04	-9.089E 02	0
2	64	1.920E 02	2.323E-02	3.018E-04	-2.902E 04	-6.649E 02	0
2	65	1.950E 02	2.394E-02	1.637E-04	-3.064E 04	-4.209E 02	0
2	66	1.980E 02	2.422E-02	1.973E-05	-3.154E 04	-1.769E 02	0
2	67	2.010E 02	2.406E-02	-1.267E-04	-3.171E 04	6.712E 01	0
2	68	2.040E 02	2.346E-02	-2.722E-04	-3.114E 04	3.111E 02	0
2	69	2.070E 02	2.242E-02	-4.133E-04	-2.984E 04	5.551E 02	0
2	70	2.100E 02	2.098E-02	-5.467E-04	-2.781E 04	7.991E 02	0
2	71	2.130E 02	1.914E-02	-6.691E-04	-2.504E 04	1.043E 03	0
2	72	2.160E 02	1.696E-02	-7.769E-04	-2.155E 04	1.287E 03	0
2	73	2.190E 02	1.448E-02	-8.669E-04	-1.732E 04	1.531E 03	0
2	74	2.220E 02	1.176E-02	-9.356E-04	-1.236E 04	1.775E 03	0
2	75	2.250E 02	8.867E-03	-9.797E-04	-6.671E 03	2.019E 03	0
2	76	2.280E 02	5.882E-03	-9.957E-04	-2.474E 02	2.263E 03	0
2	77	2.310E 02	2.893E-03	-9.803E-04	6.908E 03	1.274E 03	0
2	78	2.340E 02	0	-9.300E-04	7.398E 03	-1.151E 03	2.387E-04
2	79	2.370E 02	-2.687E-03	-8.958E-04	0	-1.233E 03	0

3	-1	-3.000E 00	-3.137E-03	1.046E-03	0	-1.233E 03	0
3	0	0	0	9.300E-04	-7.398E 03	-2.027E 03	4.247E-04
3	1	3.000E 00	2.443E-03	7.194E-04	-1.216E 04	-4.108E 02	0
3	2	6.000E 00	4.317E-03	5.474E-04	-9.862E 03	7.120E 02	0
3	3	9.000E 00	5.728E-03	4.087E-04	-7.890E 03	6.037E 02	0
3	4	1.200E 01	6.769E-03	2.983E-04	-6.240E 03	4.973E 02	0
3	5	1.500E 01	7.517E-03	2.112E-04	-4.906E 03	3.928E 02	0
3	6	1.800E 01	8.036E-03	1.425E-04	-3.883E 03	2.902E 02	0
3	7	2.100E 01	8.373E-03	8.749E-05	-3.165E 03	1.895E 02	0
3	8	2.400E 01	8.561E-03	4.131E-05	-2.746E 03	9.066E 01	0
3	9	2.700E 01	8.621E-03	-6.201E-07	-2.621E 03	-6.280E 00	0
3	10	3.000E 01	8.557E-03	-4.284E-05	-2.784E 03	-1.013E 02	0
3	11	3.300E 01	8.363E-03	-8.982E-05	-3.229E 03	-1.945E 02	0
3	12	3.600E 01	8.018E-03	-1.459E-04	-3.951E 03	-2.858E 02	0
3	13	3.900E 01	7.488E-03	-2.154E-04	-4.944E 03	-3.752E 02	0
3	14	4.200E 01	6.726E-03	-3.025E-04	-6.202E 03	-4.627E 02	0
3	15	4.500E 01	5.673E-03	-4.112E-04	-7.720E 03	-5.483E 02	0
3	16	4.800E 01	4.259E-03	-5.457E-04	-9.491E 03	-6.320E 02	0
3	17	5.100E 01	2.399E-03	-7.098E-04	-1.151E 04	4.340E 02	0
3	18	5.400E 01	0	-9.073E-04	-6.887E 03	1.919E 03	-4.363E-04
3	19	5.700E 01	-3.045E-03	-1.015E-03	0	1.148E 03	0
4	-1	-3.000E 00	8.616E-04	-2.872E-04	0	1.642E 02	0
4	0	0	0	-2.718E-04	9.853E 02	3.274E 02	4.673E-03
4	1	3.000E 00	-7.692E-04	-2.410E-04	1.964E 03	1.621E 02	0
4	2	6.000E 00	-1.446E-03	-2.104E-04	1.958E 03	-2.117E 00	0
4	3	9.000E 00	-2.032E-03	-1.799E-04	1.952E 03	-2.117E 00	0
4	4	1.200E 01	-2.525E-03	-1.494E-04	1.945E 03	-2.117E 00	0
4	5	1.500E 01	-2.928E-03	-1.191E-04	1.939E 03	-2.117E 00	0
4	6	1.800E 01	-3.240E-03	-8.882E-05	1.933E 03	-2.117E 00	0
4	7	2.100E 01	-3.461E-03	-5.867E-05	1.926E 03	-2.117E 00	0
4	8	2.400E 01	-3.592E-03	-2.863E-05	1.920E 03	-2.117E 00	0
4	9	2.700E 01	-3.633E-03	1.323E-06	1.914E 03	-2.117E 00	0
4	10	3.000E 01	-3.584E-03	3.117E-05	1.907E 03	-2.117E 00	0
4	11	3.300E 01	-3.446E-03	6.092E-05	1.901E 03	-2.117E 00	0
4	12	3.600E 01	-3.218E-03	9.057E-05	1.895E 03	-2.117E 00	0
4	13	3.900E 01	-2.902E-03	1.201E-04	1.888E 03	-2.117E 00	0
4	14	4.200E 01	-2.498E-03	1.496E-04	1.882E 03	-2.117E 00	0
4	15	4.500E 01	-2.005E-03	1.789E-04	1.875E 03	-2.117E 00	0
4	16	4.800E 01	-1.424E-03	2.082E-04	1.869E 03	-2.117E 00	0
4	17	5.100E 01	-7.557E-04	2.373E-04	1.863E 03	-1.568E 02	0
4	18	5.400E 01	0	2.664E-04	9.282E 02	-3.105E 02	-4.678E-03
4	19	5.700E 01	8.427E-04	2.809E-04	0	-1.547E 02	0
5	-1	-3.000E 00	-8.616E-04	2.872E-04	0	-1.642E 02	0
5	0	0	0	2.718E-04	-9.853E 02	-3.274E 02	-4.773E-03
5	1	3.000E 00	7.692E-04	2.410E-04	-1.964E 03	-1.621E 02	0
5	2	6.000E 00	1.446E-03	2.104E-04	-1.958E 03	2.118E 00	0
5	3	9.000E 00	2.032E-03	1.799E-04	-1.952E 03	2.118E 00	0
5	4	1.200E 01	2.525E-03	1.494E-04	-1.945E 03	2.118E 00	0
5	5	1.500E 01	2.928E-03	1.191E-04	-1.939E 03	2.118E 00	0
5	6	1.800E 01	3.240E-03	8.882E-05	-1.933E 03	2.118E 00	0
5	7	2.100E 01	3.461E-03	5.867E-05	-1.926E 03	2.118E 00	0
5	8	2.400E 01	3.592E-03	2.863E-05	-1.920E 03	2.118E 00	0
5	9	2.700E 01	3.633E-03	-1.323E-06	-1.914E 03	2.118E 00	0

5	10	3.000E 01	3.584E-03	-3.117E-05	-1.907E 03	2.118E 00	0
5	11	3.300E 01	3.446E-03	-6.092E-05	-1.901E 03	2.118E 00	0
5	12	3.600E 01	3.218E-03	-9.057E-05	-1.895E 03	2.118E 00	0
5	13	3.900E 01	2.902E-03	-1.201E-04	-1.888E 03	2.118E 00	0
5	14	4.200E 01	2.498E-03	-1.496E-04	-1.882E 03	2.118E 00	0
5	15	4.500E 01	2.005E-03	-1.789E-04	-1.875E 03	2.118E 00	0
5	16	4.800E 01	1.424E-03	-2.082E-04	-1.869E 03	2.118E 00	0
5	17	5.100E 01	7.557E-04	-2.373E-04	-1.863E 03	1.568E 02	0
5	18	5.400E 01	0	-2.664E-04	-9.282E 02	3.105E 02	4.762E-03
5	19	5.700E 01	-8.427E-04	-2.809E-04	0	1.547E 02	0
6	-1	-3.000E 00	3.137E-03	-1.046E-03	0	1.233E 03	0
6	0	0	0	-9.300E-04	7.398E 03	2.027E 03	-2.387E-04
6	1	3.000E 00	-2.443E-03	-7.194E-04	1.216E 04	4.108E 02	0
6	2	6.000E 00	-4.317E-03	-5.474E-04	9.862E 03	-7.120E 02	0
6	3	9.000E 00	-5.728E-03	-4.087E-04	7.890E 03	-6.037E 02	0
6	4	1.200E 01	-6.769E-03	-2.983E-04	6.240E 03	-4.973E 02	0
6	5	1.500E 01	-7.517E-03	-2.112E-04	4.906E 03	-3.928E 02	0
6	6	1.800E 01	-8.036E-03	-1.425E-04	3.883E 03	-2.902E 02	0
6	7	2.100E 01	-8.373E-03	-8.749E-05	3.165E 03	-1.895E 02	0
6	8	2.400E 01	-8.561E-03	-4.131E-05	2.746E 03	-9.066E 01	0
6	9	2.700E 01	-8.621E-03	6.201E-07	2.621E 03	6.280E 00	0
6	10	3.000E 01	-8.557E-03	4.284E-05	2.784E 03	1.013E 02	0
6	11	3.300E 01	-8.363E-03	8.982E-05	3.229E 03	1.945E 02	0
6	12	3.600E 01	-8.018E-03	1.459E-04	3.951E 03	2.858E 02	0
6	13	3.900E 01	-7.488E-03	2.154E-04	4.944E 03	3.752E 02	0
6	14	4.200E 01	-6.726E-03	3.025E-04	6.202E 03	4.627E 02	0
6	15	4.500E 01	-5.673E-03	4.112E-04	7.720E 03	5.483E 02	0
6	16	4.800E 01	-4.259E-03	5.457E-04	9.491E 03	6.320E 02	0
6	17	5.100E 01	-2.399E-03	7.098E-04	1.151E 04	-4.340E 02	0
6	18	5.400E 01	0	9.073E-04	6.887E 03	-1.919E 03	2.908E-04
6	19	5.700E 01	3.045E-03	1.015E-03	0	-1.148E 03	0

TIME = 1 MINUTES, 50 AND 1/60 SECONDS

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PROGRAM FRAME 4 - MATLOCK - DECK 5              REVISION DATE = 30 AP 65
CE051118  --  CODED BY BRG,CMP  --  RUN DATE  26 OC 66
EXAMPLE PROBLEMS  --  FINAL REPORT


PROB
   2     MULTI-STORY FRAMED STRUCTURE  -  VERTICAL LOADS ONLY
```

TABLE 1. CONTROL DATA

	TABLE NUMBER 2	3	4	5	6
PRIOR-DATA OPTIONS (1=HOLD)	0	0	0	0	0
NUM CARDS INPUT THIS PROBLEM	2	1	11	4	34

MAX NUM ITERATIONS	20
NUM OF X-BEAMS	3
NUM OF Y-BEAMS	4
X AND Y-BEAM INCR LENGTH	4.000E 00
CLOSURE TOLERANCE	1.000E-09

MONITOR STAS NB,J   4 96   7 66   2 45   3 90

TABLE 2. CLOSURE SPRING VALUES

SPRING NUM	CLOSURE SPRING
1	4.270E 06
2	2.000E 08

TABLE 3. NUM OF INCREMENTS FOR EACH BEAM

BEAM NUM	NUM OF INCRS
1	90
2	150
3	150
4	96
5	96
6	96
7	66

TABLE 4. BEAM INTERSECTIONS

INT	BEAM	STA	BEAM	STA
1	1	0	4	96
2	1	45	5	96
3	1	90	6	96
4	2	0	4	66
5	2	45	5	66

6	2	90	6	66
7	2	150	7	66
8	3	0	4	36
9	3	45	5	36
10	3	90	6	36
11	3	150	7	36

TABLE 5. SPECIFIED DEFLECTIONS AND SLOPES

BEAM NUM	STA NUM	CASE	DEFLECTION	SLOPE
4	0	3	0	0
5	0	3	0	0
6	0	3	0	0
7	0	3	0	0

TABLE 6. FIXED STIFFNESS AND LOAD DATA

BEAM NUM	FROM	TO	CONTD	F	Q	S	T	R
1	0	90	0	1.920E 08	0	0	0	0
1	45	90	0	0	-4.000E 01	0	0	0
2	0	150	0	6.480E 08	0	0	0	0
2	0	45	0	0	-7.500E 01	0	0	0
2	90	150	0	0	-7.500E 01	0	0	0
3	0		1	1.750E 10	0	0	0	0
		15	1	1.536E 09	0	0	0	0
		30	1	1.536E 09	0	0	0	0
		45	1	1.750E 10	0	0	0	0
		60	1	1.536E 09	0	0	0	0
		75	1	1.536E 09	0	0	0	0
		90	1	1.750E 10	0	0	0	0
		111	1	1.536E 09	0	0	0	0
		129	1	1.536E 09	0	0	0	0
		150	0	1.750E 10	0	0	0	0
3	15	15	0	0	-2.500E 04	0	0	0
3	30	30	0	0	-2.500E 04	0	0	0
3	45	90	0	0	-7.500E 01	0	0	0
3	120	120	0	0	-5.000E 04	0	0	0
4	0	36	0	5.184E 09	0	0	0	0
4	36	66	0	1.536E 09	0	0	0	0
4	66	96	0	6.480E 08	0	0	0	0
5	0	36	0	5.184E 09	0	0	0	0
5	36	66	0	1.536E 09	0	0	0	0
5	66	96	0	6.480E 08	0	0	0	0
6	0	36	0	5.184E 09	0	0	0	0
6	36	66	0	1.536E 09	0	0	0	0
6	66	96	0	6.480E 08	0	0	0	0
7	0	36	0	5.184E 09	0	0	0	0
7	36	66	0	1.536E 09	0	0	0	0
4	0	18	0	0	0	5.400E 04	0	0
5	0	18	0	0	0	5.400E 04	0	0
6	0	18	0	0	0	5.400E 04	0	0
7	0	18	0	0	0	5.400E 04	0	0

TABLE 7. ITERATION MONITOR DATA AND SLOPES AT FOUR SELECTED STATIONS

ITR NUM	CLOSURE SPRING	NOT STAB	NOT CLOS	BEAM STA 4 96 / 1 0	BEAM STA 7 66 / 2 150	BEAM STA 2 45 / 5 66	BEAM STA 3 90 / 6 36
1	4.270E 06	22	11	2.600E-04	3.592E-04	3.611E-03	-3.400E-02
				7.116E-04	7.896E-03	1.150E-04	-1.342E-03
2	2.000E 08	22	11	2.103E-04	-2.659E-04	2.132E-04	-7.570E-03
				2.397E-04	4.641E-04	-2.110E-04	-7.502E-03
3	4.270E 06	22	11	-4.009E-04	-2.206E-03	-5.515E-03	-7.357E-03
				-5.393E-04	-1.218E-02	-8.484E-04	-7.614E-03
4	2.000E 08	22	11	-4.114E-04	-2.443E-03	-9.914E-04	-7.585E-03
				-4.018E-04	-2.361E-03	-1.053E-03	-7.606E-03
5	4.270E 06	22	11	-5.530E-04	-2.676E-03	-1.777E-03	-7.652E-03
				-6.933E-04	-3.860E-03	-1.151E-03	-7.627E-03
6	2.000E 08	22	11	-5.518E-04	-2.701E-03	-1.173E-03	-7.631E-03
				-5.518E-04	-2.691E-03	-1.183E-03	-7.634E-03
7	4.270E 06	22	11	-5.586E-04	-2.732E-03	-1.295E-03	-7.640E-03
				-5.549E-04	-2.886E-03	-1.197E-03	-7.637E-03
8	2.000E 08	22	11	-5.586E-04	-2.734E-03	-1.201E-03	-7.637E-03
				-5.585E-04	-2.733E-03	-1.203E-03	-7.638E-03
9	4.270E 06	22	11	-5.604E-04	-2.738E-03	-1.221E-03	-7.639E-03
				-5.616E-04	-2.756E-03	-1.205E-03	-7.638E-03
10	2.000E 08	22	11	-5.604E-04	-2.738E-03	-1.206E-03	-7.638E-03
				-5.604E-04	-2.738E-03	-1.206E-03	-7.639E-03
11	4.270E 06	22	11	-5.604E-04	-2.738E-03	-1.209E-03	-7.639E-03
				-5.601E-04	-2.740E-03	-1.207E-03	-7.639E-03
12	2.000E 08	22	11	-5.604E-04	-2.738E-03	-1.207E-03	-7.639E-03
				-5.604E-04	-2.738E-03	-1.207E-03	-7.639E-03
13	4.270E 06	22	11	-5.604E-04	-2.738E-03	-1.208E-03	-7.639E-03
				-5.603E-04	-2.738E-03	-1.207E-03	-7.639E-03
14	2.000E 08	20	10	-5.604E-04	-2.738E-03	-1.207E-03	-7.639E-03
				-5.604E-04	-2.738E-03	-1.207E-03	-7.639E-03
15	4.270E 06	20	11	-5.603E-04	-2.738E-03	-1.207E-03	-7.639E-03
				-5.603E-04	-2.738E-03	-1.207E-03	-7.639E-03
16	2.000E 08	16	3	-5.603E-04	-2.738E-03	-1.207E-03	-7.639E-03
				-5.603E-04	-2.738E-03	-1.207E-03	-7.639E-03
17	4.270E 06	16	10	-5.603E-04	-2.738E-03	-1.207E-03	-7.639E-03
				-5.603E-04	-2.738E-03	-1.207E-03	-7.639E-03
18	2.000E 08	13	0	-5.603E-04	-2.738E-03	-1.207E-03	-7.639E-03
				-5.603E-04	-2.738E-03	-1.207E-03	-7.639E-03

PROGRAM FRAME 4 - MATLCCK - DECK 5 REVISION DATE = 30 AP 65
CE051118 -- CCDED BY BRG,CMP -- RUN CATE 26 OC 66
EXAMPLE PRCBLEMS -- FINAL REPCRT

PROB (CONTD)
2 MULTI-STORY FRAMED STRUCTURE - VERTICAL LOADS ONLY

TABLE 8. RESLLTS -- ITERATICN 18

NB	JSTA	X	DEFL	SLOPE	MOMENT	SHEAR	ERROR
1	-1	-4.000E 00	2.375E-03	-5.937E-04	0	2.000E 02	0
1	0	0	0	-5.603E-04	1.600E 03	3.832E 02	1.738E-02
1	1	4.000E 00	-2.108E-03	-4.951E-04	3.066E 03	1.665E 02	0
1	2	8.000E 00	-3.961E-03	-4.326E-04	2.932E 03	-3.342E 01	0
1	3	1.200E 01	-5.569E-03	-3.729E-04	2.798E 03	-3.342E 01	0
1	4	1.600E 01	-6.944E-03	-3.160E-04	2.665E 03	-3.342E 01	0
1	5	2.000E 01	-8.097E-03	-2.619E-04	2.531E 03	-3.342E 01	0
1	6	2.400E 01	-9.039E-03	-2.105E-04	2.397E 03	-3.342E 01	0
1	7	2.800E 01	-9.781E-03	-1.620E-04	2.264E 03	-3.342E 01	0
1	8	3.200E 01	-1.033E-02	-1.162E-04	2.130E 03	-3.342E 01	0
1	9	3.600E 01	-1.071E-02	-7.324E-05	1.996E 03	-3.342E 01	0
1	10	4.000E 01	-1.092E-02	-3.304E-05	1.863E 03	-3.342E 01	0
1	11	4.400E 01	-1.098E-02	4.377E-06	1.729E 03	-3.342E 01	0
1	12	4.800E 01	-1.089E-02	3.901E-05	1.595E 03	-3.342E 01	0
1	13	5.200E 01	-1.066E-02	7.085E-05	1.462E 03	-3.342E 01	0
1	14	5.600E 01	-1.032E-02	9.991E-05	1.328E 03	-3.342E 01	0
1	15	6.000E 01	-9.864E-03	1.262E-04	1.194E 03	-3.342E 01	0
1	16	6.400E 01	-9.309E-03	1.497E-04	1.061E 03	-3.342E 01	0
1	17	6.800E 01	-8.667E-03	1.704E-04	9.271E 02	-3.342E 01	0
1	18	7.200E 01	-7.946E-03	1.883E-04	7.934E 02	-3.342E 01	0
1	19	7.600E 01	-7.160E-03	2.034E-04	6.597E 02	-3.342E 01	0
1	20	8.000E 01	-6.319E-03	2.158E-04	5.261E 02	-3.342E 01	0
1	21	8.400E 01	-5.434E-03	2.254E-04	3.924E 02	-3.342E 01	0
1	22	8.800E 01	-4.516E-03	2.321E-04	2.587E 02	-3.342E 01	0
1	23	9.200E 01	-3.577E-03	2.361E-04	1.251E 02	-3.342E 01	0
1	24	9.600E 01	-2.627E-03	2.374E-04	-8.585E 00	-3.342E 01	0
1	25	1.000E 02	-1.678E-03	2.358E-04	-1.423E 02	-3.342E 01	0
1	26	1.040E 02	-7.404E-04	2.314E-04	-2.759E 02	-3.342E 01	0
1	27	1.080E 02	1.738E-04	2.243E-04	-4.096E 02	-3.341E 01	0
1	28	1.120E 02	1.054E-03	2.144E-04	-5.432E 02	-3.341E 01	0
1	29	1.160E 02	1.889E-03	2.017E-04	-6.769E 02	-3.341E 01	0
1	30	1.200E 02	2.667E-03	1.862E-04	-8.106E 02	-3.341E 01	0
1	31	1.240E 02	3.378E-03	1.679E-04	-9.442E 02	-3.341E 01	0
1	32	1.280E 02	4.010E-03	1.468E-04	-1.078E 03	-3.341E 01	0
1	33	1.320E 02	4.553E-03	1.230E-04	-1.212E 03	-3.341E 01	0
1	34	1.360E 02	4.994E-03	9.634E-05	-1.345E 03	-3.341E 01	0
1	35	1.400E 02	5.323E-03	6.692E-05	-1.479E 03	-3.341E 01	0
1	36	1.440E 02	5.529E-03	3.472E-05	-1.613E 03	-3.341E 01	0
1	37	1.480E 02	5.601E-03	-2.727E-07	-1.746E 03	-3.341E 01	0
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1	39	1.560E 02	5.297E-03	-7.860E-05	-2.014E 03	-3.341E 01	0
1	40	1.600E 02	4.898E-03	-1.219E-04	-2.147E 03	-3.341E 01	0
1	41	1.640E 02	4.321E-03	-1.681E-04	-2.281E 03	-3.341E 01	0

1	42	1.680E 02	3.554E-03	-2.170E-04	-2.415E 03	-3.341E 01	0
1	43	1.720E 02	2.585E-03	-2.687E-04	-2.548E 03	-3.341E 01	0
1	44	1.760E 02	1.404E-03	-3.232E-04	-2.682E 03	-1.509E 03	0
1	45	1.800E 02	0	-5.034E-04	-1.462E 04	-2.526E 03	3.753E-02
1	46	1.840E 02	-2.623E-03	-8.942E-04	-2.289E 04	-6.116E 02	0
1	47	1.880E 02	-7.153E-03	-1.336E-03	-1.952E 04	8.242E 02	0
1	48	1.920E 02	-1.331E-02	-1.709E-03	-1.630E 04	7.842E 02	0
1	49	1.960E 02	-2.083E-02	-2.017E-03	-1.324E 04	7.442E 02	0
1	50	2.000E 02	-2.944E-02	-2.262E-03	-1.034E 04	7.042E 02	0
1	51	2.040E 02	-3.892E-02	-2.449E-03	-7.607E 03	6.642E 02	0
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1	57	2.280E 02	-1.021E-01	-2.526E-03	5.454E 03	4.242E 02	0
1	58	2.320E 02	-1.119E-01	-2.395E-03	7.071E 03	3.842E 02	0
1	59	2.360E 02	-1.212E-01	-2.233E-03	8.528E 03	3.442E 02	0
1	60	2.400E 02	-1.298E-01	-2.041E-03	9.825E 03	3.042E 02	0
1	61	2.440E 02	-1.376E-01	-1.825E-03	1.096E 04	2.642E 02	0
1	62	2.480E 02	-1.444E-01	-1.586E-03	1.194E 04	2.242E 02	0
1	63	2.520E 02	-1.503E-01	-1.329E-03	1.276E 04	1.842E 02	0
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1	66	2.640E 02	-1.612E-01	-4.786E-04	1.425E 04	6.423E 01	0
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1	68	2.720E 02	-1.627E-01	1.207E-04	1.444E 04	-1.577E 01	0
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1	70	2.800E 02	-1.593E-01	7.147E-04	1.399E 04	-9.577E 01	0
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1	76	3.040E 02	-1.230E-01	2.199E-03	8.816E 03	-3.358E 02	0
1	77	3.080E 02	-1.138E-01	2.368E-03	7.393E 03	-3.758E 02	0
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1	79	3.160E 02	-9.376E-02	2.608E-03	4.067E 03	-4.558E 02	0
1	80	3.200E 02	-8.316E-02	2.673E-03	2.164E 03	-4.958E 02	0
1	81	3.240E 02	-7.238E-02	2.696E-03	1.005E 02	-5.358E 02	0
1	82	3.280E 02	-6.159E-02	2.675E-03	-2.123E 03	-5.758E 02	0
1	83	3.320E 02	-5.098E-02	2.606E-03	-4.506E 03	-6.158E 02	0
1	84	3.360E 02	-4.074E-02	2.486E-03	-7.049E 03	-6.558E 02	0
1	85	3.400E 02	-3.109E-02	2.311E-03	-9.752E 03	-6.958E 02	0
1	86	3.440E 02	-2.225E-02	2.078E-03	-1.261E 04	-7.358E 02	0
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1	89	3.560E 02	-3.068E-03	9.978E-04	-2.216E 04	7.484E 02	0
1	90	3.600E 02	0	4.996E-04	-1.283E 04	2.771E 03	-1.129E-02
1	91	3.640E 02	9.288E-04	2.322E-04	0	1.604E 03	0
2	-1	-4.000E 00	-6.548E-03	1.637E-03	0	-3.874E 03	0
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2	1	4.000E 00	5.018E-03	1.084E-03	-5.532E 04	-2.245E 03	0
2	2	8.000E 00	8.669E-03	7.618E-04	-4.896E 04	1.554E 03	0
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2	4	1.600E 01	1.250E-02	2.313E-04	-3.713E 04	1.404E 03	0
2	5	2.000E 01	1.296E-02	1.902E-05	-3.166E 04	1.329E 03	0
2	6	2.400E 01	1.265E-02	-1.605E-04	-2.650E 04	1.254E 03	0

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2	8	3.200E 01	1.018E-02	-4.284E-04	-1.707E 04	1.104E 03	0
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2	18	7.200E 01	-1.310E-02	-4.293E-04	1.209E 04	3.538E 02	0
2	19	7.600E 01	-1.467E-02	-3.508E-04	1.335E 04	2.788E 02	0
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2	22	8.800E 01	-1.730E-02	-8.135E-05	1.535E 04	5.381E 01	0
2	23	9.200E 01	-1.744E-02	1.360E-05	1.541E 04	-2.119E 01	0
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2	25	1.000E 02	-1.658E-02	2.001E-04	1.464E 04	-1.712E 02	0
2	26	1.040E 02	-1.560E-02	2.879E-04	1.381E 04	-2.462E 02	0
2	27	1.080E 02	-1.427E-02	3.696E-04	1.267E 04	-3.212E 02	0
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2	31	1.240E 02	-6.247E-03	5.988E-04	5.136E 03	-6.212E 02	0
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2	36	1.440E 02	5.901E-03	5.262E-04	-1.104E 04	-9.962E 02	0
2	37	1.480E 02	7.870E-03	4.453E-04	-1.517E 04	-1.071E 03	0
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2	41	1.640E 02	1.087E-02	-1.613E-04	-3.471E 04	-1.371E 03	0
2	42	1.680E 02	9.792E-03	-3.930E-04	-4.035E 04	-1.446E 03	0
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2	44	1.760E 02	4.509E-03	-9.653E-04	-5.252E 04	2.553E 03	0
2	45	1.800E 02	0	-1.207E-03	-2.586E 04	7.499E 03	-9.866E-02
2	46	1.840E 02	-5.148E-03	-1.264E-03	7.478E 03	4.184E 03	0
2	47	1.880E 02	-1.011E-02	-1.217E-03	7.617E 03	3.487E 01	0
2	48	1.920E 02	-1.489E-02	-1.170E-03	7.757E 03	3.487E 01	0
2	49	1.960E 02	-1.947E-02	-1.122E-03	7.896E 03	3.487E 01	0
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2	58	2.320E 02	-5.153E-02	-6.480E-04	9.151E 03	3.487E 01	0
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2	63	2.520E 02	-6.160E-02	-3.548E-04	9.848E 03	3.488E 01	0
2	64	2.560E 02	-6.290E-02	-2.935E-04	9.988E 03	3.488E 01	0
2	65	2.600E 02	-6.395E-02	-2.315E-04	1.013E 04	3.488E 01	0
2	66	2.640E 02	-6.475E-02	-1.685E-04	1.027E 04	3.488E 01	0

2	67	2.680E 02	-6.530E-02	-1.047E-04	1.041E 04	3.488E 01	0
2	68	2.720E 02	-6.559E-02	-4.005E-05	1.055E 04	3.488E 01	0
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2	75	3.000E 02	-6.014E-02	4.367E-04	1.152E 04	3.488E 01	0
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2	77	3.080E 02	-5.607E-02	5.807E-04	1.180E 04	3.488E 01	0
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2	80	3.200E 02	-4.778E-02	8.031E-04	1.222E 04	3.488E 01	0
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2	90	3.600E 02	0	1.437E-03	-3.943E 04	-1.218E 04	1.375E-01
2	91	3.640E 02	5.260E-03	1.056E-03	-8.393E 04	-4.532E 03	0
2	92	3.680E 02	8.447E-03	5.632E-04	-7.569E 04	2.023E 03	0
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2	103	4.120E 02	-4.036E-02	-1.966E-03	-4.819E 03	1.198E 03	0
2	104	4.160E 02	-4.829E-02	-1.982E-03	-1.765E 02	1.123E 03	0
2	105	4.200E 02	-5.622E-02	-1.970E-03	4.166E 03	1.048E 03	0
2	106	4.240E 02	-6.404E-02	-1.931E-03	8.209E 03	9.732E 02	0
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2	110	4.400E 02	-9.244E-02	-1.557E-03	2.138E 04	6.732E 02	0
2	111	4.440E 02	-9.840E-02	-1.417E-03	2.392E 04	5.982E 02	0
2	112	4.480E 02	-1.038E-01	-1.262E-03	2.617E 04	5.232E 02	0
2	113	4.520E 02	-1.085E-01	-1.095E-03	2.811E 04	4.482E 02	0
2	114	4.560E 02	-1.125E-01	-9.163E-04	2.975E 04	3.732E 02	0
2	115	4.600E 02	-1.158E-01	-7.284E-04	3.110E 04	2.982E 02	0
2	116	4.640E 02	-1.184E-01	-5.333E-04	3.214E 04	2.232E 02	0
2	117	4.680E 02	-1.201E-01	-3.326E-04	3.288E 04	1.482E 02	0
2	118	4.720E 02	-1.210E-01	-1.283E-04	3.332E 04	7.323E 01	0
2	119	4.760E 02	-1.211E-01	7.789E-05	3.347E 04	-1.766E 00	0
2	120	4.800E 02	-1.204E-01	2.840E-04	3.331E 04	-7.676E 01	0
2	121	4.840E 02	-1.188E-01	4.882E-04	3.285E 04	-1.518E 02	0
2	122	4.880E 02	-1.165E-01	6.887E-04	3.210E 04	-2.268E 02	0
2	123	4.920E 02	-1.133E-01	8.835E-04	3.104E 04	-3.018E 02	0
2	124	4.960E 02	-1.094E-01	1.071E-03	2.968E 04	-3.768E 02	0
2	125	5.000E 02	-1.048E-01	1.249E-03	2.803E 04	-4.518E 02	0
2	126	5.040E 02	-9.943E-02	1.416E-03	2.607E 04	-5.268E 02	0

2	127	5.080E 02	-9.344E-02	1.570E-03	2.381E 04	-6.018E 02	0
2	128	5.120E 02	-8.687E-02	1.709E-03	2.125E 04	-6.768E 02	0
2	129	5.160E 02	-7.977E-02	1.831E-03	1.840E 04	-7.518E 02	0
2	130	5.200E 02	-7.222E-02	1.935E-03	1.524E 04	-8.268E 02	0
2	131	5.240E 02	-6.429E-02	2.019E-03	1.178E 04	-9.018E 02	0
2	132	5.280E 02	-5.607E-02	2.080E-03	8.026E 03	-9.768E 02	0
2	133	5.320E 02	-4.765E-02	2.117E-03	3.969E 03	-1.052E 03	0
2	134	5.360E 02	-3.913E-02	2.128E-03	-3.883E 02	-1.127E 03	0
2	135	5.400E 02	-3.063E-02	2.111E-03	-5.045E 03	-1.202E 03	0
2	136	5.440E 02	-2.224E-02	2.065E-03	-1.000E 04	-1.277E 03	0
2	137	5.480E 02	-1.411E-02	1.987E-03	-1.526E 04	-1.352E 03	0
2	138	5.520E 02	-6.352E-03	1.875E-03	-2.082E 04	-1.427E 03	0
2	139	5.560E 02	8.928E-04	1.729E-03	-2.667E 04	-1.502E 03	0
2	140	5.600E 02	7.478E-03	1.545E-03	-3.283E 04	-1.577E 03	0
2	141	5.640E 02	1.325E-02	1.323E-03	-3.929E 04	-1.652E 03	0
2	142	5.680E 02	1.806E-02	1.059E-03	-4.604E 04	-1.727E 03	0
2	143	5.720E 02	2.173E-02	7.531E-04	-5.310E 04	-1.802E 03	0
2	144	5.760E 02	2.408E-02	4.026E-04	-6.046E 04	-1.877E 03	0
2	145	5.800E 02	2.495E-02	5.805E-06	-6.812E 04	-1.952E 03	0
2	146	5.840E 02	2.413E-02	-4.392E-04	-7.607E 04	-2.027E 03	0
2	147	5.880E 02	2.143E-02	-9.343E-04	-8.433E 04	-2.102E 03	0
2	148	5.920E 02	1.666E-02	-1.481E-03	-9.289E 04	-2.177E 03	0
2	149	5.960E 02	9.584E-03	-2.082E-03	-1.017E 05	4.680E 03	0
2	150	6.000E 02	0	-2.738E-03	-5.545E 04	1.272E 04	8.258E-02
2	151	6.040E 02	-1.232E-02	-3.081E-03	0	6.931E 03	0

3	-1	-4.000E 00	2.239E-02	-5.598E-03	0	-7.116E 04	0
3	0	0	0	-5.728E-03	-5.692E 05	-1.299E 05	9.550E-03
3	1	4.000E 00	-2.343E-02	-5.985E-03	-1.039E 06	-4.633E 04	0
3	2	8.000E 00	-4.788E-02	-6.233E-03	-9.399E 05	2.483E 04	0
3	3	1.200E 01	-7.330E-02	-6.473E-03	-8.406E 05	2.483E 04	0
3	4	1.600E 01	-9.966E-02	-6.703E-03	-7.413E 05	2.483E 04	0
3	5	2.000E 01	-1.269E-01	-6.920E-03	-6.420E 05	2.483E 04	0
3	6	2.400E 01	-1.550E-01	-7.123E-03	-5.427E 05	2.483E 04	0
3	7	2.800E 01	-1.839E-01	-7.309E-03	-4.434E 05	2.483E 04	0
3	8	3.200E 01	-2.135E-01	-7.474E-03	-3.441E 05	2.483E 04	0
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3	10	4.000E 01	-2.744E-01	-7.717E-03	-1.454E 05	2.483E 04	0
3	11	4.400E 01	-3.054E-01	-7.775E-03	-4.614E 04	2.483E 04	0
3	12	4.800E 01	-3.366E-01	-7.768E-03	5.316E 04	2.483E 04	0
3	13	5.200E 01	-3.676E-01	-7.663E-03	1.525E 05	2.483E 04	0
3	14	5.600E 01	-3.979E-01	-7.386E-03	2.518E 05	2.483E 04	0
3	15	6.000E 01	-4.267E-01	-6.735E-03	3.511E 05	1.233E 04	0
3	16	6.400E 01	-4.518E-01	-5.822E-03	3.504E 05	-1.742E 02	0
3	17	6.800E 01	-4.732E-01	-4.910E-03	3.497E 05	-1.742E 02	0
3	18	7.200E 01	-4.911E-01	-4.000E-03	3.490E 05	-1.742E 02	0
3	19	7.600E 01	-5.052E-01	-3.093E-03	3.483E 05	-1.742E 02	0
3	20	8.000E 01	-5.158E-01	-2.187E-03	3.476E 05	-1.742E 02	0
3	21	8.400E 01	-5.227E-01	-1.282E-03	3.469E 05	-1.742E 02	0
3	22	8.800E 01	-5.261E-01	-3.798E-04	3.462E 05	-1.742E 02	0
3	23	9.200E 01	-5.258E-01	5.208E-04	3.455E 05	-1.741E 02	0
3	24	9.600E 01	-5.219E-01	1.420E-03	3.448E 05	-1.741E 02	0
3	25	1.000E 02	-5.144E-01	2.317E-03	3.441E 05	-1.741E 02	0
3	26	1.040E 02	-5.034E-01	3.212E-03	3.434E 05	-1.741E 02	0
3	27	1.080E 02	-4.887E-01	4.105E-03	3.427E 05	-1.741E 02	0
3	28	1.120E 02	-4.705E-01	4.997E-03	3.420E 05	-1.741E 02	0
3	29	1.160E 02	-4.487E-01	5.887E-03	3.413E 05	-1.741E 02	0
3	30	1.200E 02	-4.234E-01	6.775E-03	3.406E 05	-1.267E 04	0
3	31	1.240E 02	-3.946E-01	7.403E-03	2.399E 05	-2.517E 04	0

3	32	1.280E 02	-3.642E-01	7.663E-03	1.392E 05	-2.517E 04	0
3	33	1.320E 02	-3.332E-01	7.755E-03	3.853E 04	-2.517E 04	0
3	34	1.360E 02	-3.022E-01	7.750E-03	-6.217E 04	-2.517E 04	0
3	35	1.400E 02	-2.712E-01	7.681E-03	-1.629E 05	-2.517E 04	0
3	36	1.440E 02	-2.407E-01	7.567E-03	-2.636E 05	-2.517E 04	0
3	37	1.480E 02	-2.107E-01	7.420E-03	-3.643E 05	-2.517E 04	0
3	38	1.520E 02	-1.814E-01	7.246E-03	-4.650E 05	-2.517E 04	0
3	39	1.560E 02	-1.527E-01	7.052E-03	-5.656E 05	-2.517E 04	0
3	40	1.600E 02	-1.249E-01	6.840E-03	-6.663E 05	-2.517E 04	0
3	41	1.640E 02	-9.802E-02	6.615E-03	-7.670E 05	-2.517E 04	0
3	42	1.680E 02	-7.202E-02	6.378E-03	-8.677E 05	-2.517E 04	0
3	43	1.720E 02	-4.699E-02	6.130E-03	-9.684E 05	-2.517E 04	0
3	44	1.760E 02	-2.298E-02	5.874E-03	-1.069E 06	4.572E 04	0
3	45	1.800E 02	0	5.675E-03	-6.027E 05	1.286E 05	2.026E-02
3	46	1.840E 02	2.243E-02	5.601E-03	-4.044E 04	6.963E 04	0
3	47	1.880E 02	4.481E-02	5.591E-03	-4.564E 04	-1.339E 03	0
3	48	1.920E 02	6.715E-02	5.578E-03	-5.115E 04	-1.414E 03	0
3	49	1.960E 02	8.943E-02	5.562E-03	-5.695E 04	-1.489E 03	0
3	50	2.000E 02	1.116E-01	5.543E-03	-6.306E 04	-1.564E 03	0
3	51	2.040E 02	1.338E-01	5.520E-03	-6.946E 04	-1.639E 03	0
3	52	2.080E 02	1.558E-01	5.492E-03	-7.617E 04	-1.714E 03	0
3	53	2.120E 02	1.777E-01	5.459E-03	-8.317E 04	-1.789E 03	0
3	54	2.160E 02	1.995E-01	5.417E-03	-9.048E 04	-1.864E 03	0
3	55	2.200E 02	2.210E-01	5.366E-03	-9.808E 04	-1.939E 03	0
3	56	2.240E 02	2.424E-01	5.301E-03	-1.060E 05	-2.014E 03	0
3	57	2.280E 02	2.635E-01	5.216E-03	-1.142E 05	-2.089E 03	0
3	58	2.320E 02	2.841E-01	5.100E-03	-1.227E 05	-2.164E 03	0
3	59	2.360E 02	3.043E-01	4.932E-03	-1.315E 05	-2.239E 03	0
3	60	2.400E 02	3.236E-01	4.648E-03	-1.406E 05	-2.314E 03	0
3	61	2.440E 02	3.414E-01	4.270E-03	-1.500E 05	-2.389E 03	0
3	62	2.480E 02	3.577E-01	3.866E-03	-1.597E 05	-2.464E 03	0
3	63	2.520E 02	3.724E-01	3.437E-03	-1.697E 05	-2.539E 03	0
3	64	2.560E 02	3.852E-01	2.982E-03	-1.800E 05	-2.614E 03	0
3	65	2.600E 02	3.962E-01	2.499E-03	-1.906E 05	-2.689E 03	0
3	66	2.640E 02	4.052E-01	1.989E-03	-2.015E 05	-2.764E 03	0
3	67	2.680E 02	4.121E-01	1.449E-03	-2.127E 05	-2.839E 03	0
3	68	2.720E 02	4.168E-01	8.802E-04	-2.243E 05	-2.914E 03	0
3	69	2.760E 02	4.192E-01	2.808E-04	-2.361E 05	-2.989E 03	0
3	70	2.800E 02	4.191E-01	-3.497E-04	-2.482E 05	-3.064E 03	0
3	71	2.840E 02	4.164E-01	-1.012E-03	-2.606E 05	-3.139E 03	0
3	72	2.880E 02	4.110E-01	-1.707E-03	-2.733E 05	-3.214E 03	0
3	73	2.920E 02	4.027E-01	-2.436E-03	-2.863E 05	-3.289E 03	0
3	74	2.960E 02	3.915E-01	-3.199E-03	-2.996E 05	-3.364E 03	0
3	75	3.000E 02	3.771E-01	-3.997E-03	-3.132E 05	-3.439E 03	0
3	76	3.040E 02	3.595E-01	-4.656E-03	-3.271E 05	-3.514E 03	0
3	77	3.080E 02	3.399E-01	-5.094E-03	-3.413E 05	-3.589E 03	0
3	78	3.120E 02	3.188E-01	-5.431E-03	-3.558E 05	-3.664E 03	0
3	79	3.160E 02	2.964E-01	-5.709E-03	-3.706E 05	-3.739E 03	0
3	80	3.200E 02	2.731E-01	-5.950E-03	-3.857E 05	-3.814E 03	0
3	81	3.240E 02	2.488E-01	-6.163E-03	-4.011E 05	-3.889E 03	0
3	82	3.280E 02	2.238E-01	-6.358E-03	-4.168E 05	-3.964E 03	0
3	83	3.320E 02	1.980E-01	-6.536E-03	-4.328E 05	-4.039E 03	0
3	84	3.360E 02	1.715E-01	-6.703E-03	-4.491E 05	-4.114E 03	0
3	85	3.400E 02	1.444E-01	-6.861E-03	-4.657E 05	-4.189E 03	0
3	86	3.440E 02	1.166E-01	-7.010E-03	-4.826E 05	-4.264E 03	0
3	87	3.480E 02	8.827E-02	-7.153E-03	-4.999E 05	-4.339E 03	0
3	88	3.520E 02	5.938E-02	-7.290E-03	-5.174E 05	-4.414E 03	0
3	89	3.560E 02	2.995E-02	-7.423E-03	-5.352E 05	-1.003E 05	0
3	90	3.600E 02	0	-7.639E-03	-1.319E 06	-1.806E 05	-3.542E-02
3	91	3.640E 02	-3.116E-02	-8.026E-03	-1.980E 06	-6.947E 04	0

3	92	3.680E 02	-6.421E-02	-8.498E-03	-1.875E 06	2.629E 04	0
3	93	3.720E 02	-9.914E-02	-8.965E-03	-1.770E 06	2.629E 04	0
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3	105	4.200E 02	-6.560E-01	-1.399E-02	-5.079E 05	2.629E 04	0
3	106	4.240E 02	-7.126E-01	-1.431E-02	-4.027E 05	2.629E 04	0
3	107	4.280E 02	-7.704E-01	-1.459E-02	-2.975E 05	2.629E 04	0
3	108	4.320E 02	-8.293E-01	-1.482E-02	-1.923E 05	2.629E 04	0
3	109	4.360E 02	-8.890E-01	-1.498E-02	-8.716E 04	2.629E 04	0
3	110	4.400E 02	-9.491E-01	-1.502E-02	1.802E 04	2.629E 04	0
3	111	4.440E 02	-1.009E 00	-1.484E-02	1.232E 05	2.629E 04	0
3	112	4.480E 02	-1.068E 00	-1.438E-02	2.284E 05	2.629E 04	0
3	113	4.520E 02	-1.124E 00	-1.365E-02	3.336E 05	2.629E 04	0
3	114	4.560E 02	-1.177E 00	-1.265E-02	4.387E 05	2.629E 04	0
3	115	4.600E 02	-1.225E 00	-1.137E-02	5.439E 05	2.629E 04	0
3	116	4.640E 02	-1.268E 00	-9.814E-03	6.491E 05	2.629E 04	0
3	117	4.680E 02	-1.304E 00	-7.987E-03	7.543E 05	2.629E 04	0
3	118	4.720E 02	-1.332E 00	-5.885E-03	8.594E 05	2.629E 04	0
3	119	4.760E 02	-1.351E 00	-3.510E-03	9.646E 05	2.629E 04	0
3	120	4.800E 02	-1.360E 00	-8.613E-04	1.070E 06	1.295E 03	0
3	121	4.840E 02	-1.358E 00	1.801E-03	9.750E 05	-2.371E 04	0
3	122	4.880E 02	-1.346E 00	4.217E-03	8.802E 05	-2.371E 04	0
3	123	4.920E 02	-1.324E 00	6.385E-03	7.853E 05	-2.371E 04	0
3	124	4.960E 02	-1.294E 00	8.307E-03	6.905E 05	-2.371E 04	0
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3	126	5.040E 02	-1.215E 00	1.141E-02	5.009E 05	-2.371E 04	0
3	127	5.080E 02	-1.166E 00	1.259E-02	4.060E 05	-2.371E 04	0
3	128	5.120E 02	-1.114E 00	1.352E-02	3.112E 05	-2.371E 04	0
3	129	5.160E 02	-1.058E 00	1.421E-02	2.164E 05	-2.371E 04	0
3	130	5.200E 02	-1.000E 00	1.460E-02	1.216E 05	-2.371E 04	0
3	131	5.240E 02	-9.414E-01	1.472E-02	2.676E 04	-2.371E 04	0
3	132	5.280E 02	-8.824E-01	1.470E-02	-6.806E 04	-2.371E 04	0
3	133	5.320E 02	-8.238E-01	1.460E-02	-1.629E 05	-2.371E 04	0
3	134	5.360E 02	-7.657E-01	1.443E-02	-2.577E 05	-2.371E 04	0
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3	140	5.600E 02	-4.376E-01	1.276E-02	-8.266E 05	-2.371E 04	0
3	141	5.640E 02	-3.872E-01	1.242E-02	-9.215E 05	-2.371E 04	0
3	142	5.680E 02	-3.382E-01	1.207E-02	-1.016E 06	-2.371E 04	0
3	143	5.720E 02	-2.906E-01	1.171E-02	-1.111E 06	-2.371E 04	0
3	144	5.760E 02	-2.445E-01	1.134E-02	-1.206E 06	-2.371E 04	0
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3	147	5.880E 02	-1.152E-01	1.020E-02	-1.490E 06	-2.371E 04	0
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3	149	5.960E 02	-3.680E-02	9.402E-03	-1.680E 06	8.722E 04	0
3	150	6.000E 02	0	8.998E-03	-8.874E 05	2.100E 05	-1.746E-02
3	151	6.040E 02	3.518E-02	8.795E-03	0	1.109E 05	0

4	-1	-4.000E 00	6.326E-04	-1.582E-04	0	2.562E 04	0
4	0	0	0	0	2.050E 05	4.706E 04	0
4	1	4.000E 00	6.326E-04	3.034E-04	3.765E 05	1.726E 04	0
4	2	8.000E 00	2.427E-03	5.810E-04	3.431E 05	-8.363E 03	0
4	3	1.200E 01	5.281E-03	8.328E-04	3.096E 05	-8.366E 03	0
4	4	1.600E 01	9.090E-03	1.059E-03	2.761E 05	-8.372E 03	0
4	5	2.000E 01	1.375E-02	1.259E-03	2.426E 05	-8.382E 03	0
4	6	2.400E 01	1.916E-02	1.433E-03	2.091E 05	-8.396E 03	0
4	7	2.800E 01	2.522E-02	1.582E-03	1.754E 05	-8.415E 03	0
4	8	3.200E 01	3.181E-02	1.704E-03	1.417E 05	-8.439E 03	0
4	9	3.600E 01	3.885E-02	1.800E-03	1.079E 05	-8.469E 03	0
4	10	4.000E 01	4.622E-02	1.870E-03	7.400E 04	-8.504E 03	0
4	11	4.400E 01	5.381E-02	1.914E-03	3.990E 04	-8.547E 03	0
4	12	4.800E 01	6.153E-02	1.932E-03	5.626E 03	-8.595E 03	0
4	13	5.200E 01	6.927E-02	1.923E-03	-2.886E 04	-8.651E 03	0
4	14	5.600E 01	7.691E-02	1.887E-03	-6.358E 04	-8.712E 03	0
4	15	6.000E 01	8.436E-02	1.825E-03	-9.856E 04	-8.780E 03	0
4	16	6.400E 01	9.151E-02	1.735E-03	-1.338E 05	-8.854E 03	0
4	17	6.800E 01	9.825E-02	1.618E-03	-1.694E 05	-8.934E 03	0
4	18	7.200E 01	1.045E-01	1.474E-03	-2.053E 05	-8.998E 03	0
4	19	7.600E 01	1.100E-01	1.301E-03	-2.414E 05	-9.020E 03	0
4	20	8.000E 01	1.149E-01	1.101E-03	-2.775E 05	-9.020E 03	0
4	21	8.400E 01	1.188E-01	8.731E-04	-3.135E 05	-9.020E 03	0
4	22	8.800E 01	1.219E-01	6.172E-04	-3.496E 05	-9.020E 03	0
4	23	9.200E 01	1.238E-01	3.335E-04	-3.857E 05	-9.020E 03	0
4	24	9.600E 01	1.245E-01	2.201E-05	-4.218E 05	-9.020E 03	0
4	25	1.000E 02	1.240E-01	-3.174E-04	-4.579E 05	-9.020E 03	0
4	26	1.040E 02	1.220E-01	-6.846E-04	-4.939E 05	-9.020E 03	0
4	27	1.080E 02	1.185E-01	-1.080E-03	-5.300E 05	-9.020E 03	0
4	28	1.120E 02	1.133E-01	-1.502E-03	-5.661E 05	-9.020E 03	0
4	29	1.160E 02	1.065E-01	-1.953E-03	-6.022E 05	-9.020E 03	0
4	30	1.200E 02	9.772E-02	-2.432E-03	-6.383E 05	-9.020E 03	0
4	31	1.240E 02	8.701E-02	-2.938E-03	-6.743E 05	-9.020E 03	0
4	32	1.280E 02	7.421E-02	-3.472E-03	-7.104E 05	-9.020E 03	0
4	33	1.320E 02	5.923E-02	-4.034E-03	-7.465E 05	-9.020E 03	0
4	34	1.360E 02	4.194E-02	-4.624E-03	-7.826E 05	-9.020E 03	0
4	35	1.400E 02	2.223E-02	-5.242E-03	-8.187E 05	6.214E 04	0
4	36	1.440E 02	0	-5.728E-03	-2.855E 05	1.363E 05	-9.550E-03
4	37	1.480E 02	-2.359E-02	-5.544E-03	2.714E 05	6.807E 04	0
4	38	1.520E 02	-4.436E-02	-4.854E-03	2.591E 05	-3.086E 03	0
4	39	1.560E 02	-6.242E-02	-4.195E-03	2.467E 05	-3.086E 03	0
4	40	1.600E 02	-7.792E-02	-3.569E-03	2.344E 05	-3.086E 03	0
4	41	1.640E 02	-9.097E-02	-2.975E-03	2.220E 05	-3.086E 03	0
4	42	1.680E 02	-1.017E-01	-2.412E-03	2.097E 05	-3.086E 03	0
4	43	1.720E 02	-1.103E-01	-1.882E-03	1.973E 05	-3.086E 03	0
4	44	1.760E 02	-1.168E-01	-1.385E-03	1.850E 05	-3.086E 03	0
4	45	1.800E 02	-1.213E-01	-9.189E-04	1.727E 05	-3.086E 03	0
4	46	1.840E 02	-1.241E-01	-4.854E-04	1.603E 05	-3.086E 03	0
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4	49	1.960E 02	-1.229E-01	6.223E-04	1.233E 05	-3.086E 03	0
4	50	2.000E 02	-1.198E-01	9.273E-04	1.109E 05	-3.086E 03	0
4	51	2.040E 02	-1.155E-01	1.200E-03	9.859E 04	-3.086E 03	0
4	52	2.080E 02	-1.102E-01	1.441E-03	8.624E 04	-3.086E 03	0
4	53	2.120E 02	-1.040E-01	1.649E-03	7.390E 04	-3.086E 03	0
4	54	2.160E 02	-9.702E-02	1.826E-03	6.156E 04	-3.086E 03	0
4	55	2.200E 02	-8.940E-02	1.970E-03	4.921E 04	-3.086E 03	0
4	56	2.240E 02	-8.126E-02	2.082E-03	3.687E 04	-3.086E 03	0

4	57	2.280E 02	-7.274E-02	2.162E-03	2.452E 04	-3.086E 03	0
4	58	2.320E 02	-6.397E-02	2.210E-03	1.218E 04	-3.086E 03	0
4	59	2.360E 02	-5.507E-02	2.225E-03	-1.647E 02	-3.086E 03	0
4	60	2.400E 02	-4.617E-02	2.209E-03	-1.251E 04	-3.086E 03	0
4	61	2.440E 02	-3.740E-02	2.160E-03	-2.485E 04	-3.086E 03	0
4	62	2.480E 02	-2.888E-02	2.079E-03	-3.720E 04	-3.086E 03	0
4	63	2.520E 02	-2.076E-02	1.966E-03	-4.954E 04	-3.086E 03	0
4	64	2.560E 02	-1.315E-02	1.821E-03	-6.188E 04	-3.086E 03	0
4	65	2.600E 02	-6.190E-03	1.644E-03	-7.423E 04	7.882E 02	0
4	66	2.640E 02	0	1.446E-03	-5.558E 04	6.321E 03	2.271E-02
4	67	2.680E 02	5.376E-03	1.271E-03	-2.366E 04	4.106E 03	0
4	68	2.720E 02	1.017E-02	1.128E-03	-2.273E 04	2.315E 02	0
4	69	2.760E 02	1.440E-02	9.902E-04	-2.181E 04	2.315E 02	0
4	70	2.800E 02	1.809E-02	8.585E-04	-2.088E 04	2.315E 02	0
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4	72	2.880E 02	2.395E-02	6.121E-04	-1.903E 04	2.315E 02	0
4	73	2.920E 02	2.616E-02	4.975E-04	-1.810E 04	2.315E 02	0
4	74	2.960E 02	2.793E-02	3.887E-04	-1.718E 04	2.315E 02	0
4	75	3.000E 02	2.927E-02	2.855E-04	-1.625E 04	2.315E 02	0
4	76	3.040E 02	3.021E-02	1.881E-04	-1.532E 04	2.315E 02	0
4	77	3.080E 02	3.078E-02	9.632E-05	-1.440E 04	2.315E 02	0
4	78	3.120E 02	3.098E-02	1.031E-05	-1.347E 04	2.315E 02	0
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4	80	3.200E 02	3.042E-02	-1.446E-04	-1.162E 04	2.315E 02	0
4	81	3.240E 02	2.970E-02	-2.134E-04	-1.069E 04	2.315E 02	0
4	82	3.280E 02	2.872E-02	-2.766E-04	-9.767E 03	2.315E 02	0
4	83	3.320E 02	2.749E-02	-3.340E-04	-8.840E 03	2.315E 02	0
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4	85	3.400E 02	2.440E-02	-4.317E-04	-6.988E 03	2.315E 02	0
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4	91	3.640E 02	1.174E-02	-5.876E-04	-1.431E 03	2.315E 02	0
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4	94	3.760E 02	4.618E-03	-5.884E-04	1.347E 03	2.315E 02	0
4	95	3.800E 02	2.281E-03	-5.772E-04	2.273E 03	3.157E 01	0
4	96	3.840E 02	0	-5.603E-04	1.600E 03	-2.842E 02	-1.738E-02
4	97	3.880E 02	-2.202E-03	-5.505E-04	0	-2.000E 02	0
5	-1	-4.000E 00	-6.270E-04	1.568E-04	0	-2.539E 04	0
5	0	0	0	0	-2.032E 05	-4.664E 04	0
5	1	4.000E 00	-6.270E-04	-3.007E-04	-3.732E 05	-1.711E 04	0
5	2	8.000E 00	-2.406E-03	-5.759E-04	-3.400E 05	8.289E 03	0
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5	8	3.200E 01	-3.153E-02	-1.689E-03	-1.405E 05	8.364E 03	0
5	9	3.600E 01	-3.850E-02	-1.784E-03	-1.070E 05	8.393E 03	0
5	10	4.000E 01	-4.580E-02	-1.854E-03	-7.334E 04	8.429E 03	0
5	11	4.400E 01	-5.333E-02	-1.897E-03	-3.955E 04	8.471E 03	0
5	12	4.800E 01	-6.098E-02	-1.915E-03	-5.576E 03	8.519E 03	0
5	13	5.200E 01	-6.865E-02	-1.906E-03	2.860E 04	8.574E 03	0
5	14	5.600E 01	-7.623E-02	-1.871E-03	6.301E 04	8.635E 03	0
5	15	6.000E 01	-8.362E-02	-1.809E-03	9.768E 04	8.702E 03	0

5	16	6.400E 01	-9.070E-02	-1.720E-03	1.326E 05	8.776E 03	0
5	17	6.800E 01	-9.737E-02	-1.604E-03	1.679E 05	8.855E 03	0
5	18	7.200E 01	-1.035E-01	-1.460E-03	2.035E 05	8.918E 03	0
5	19	7.600E 01	-1.091E-01	-1.290E-03	2.392E 05	8.940E 03	0
5	20	8.000E 01	-1.138E-01	-1.091E-03	2.750E 05	8.940E 03	0
5	21	8.400E 01	-1.178E-01	-8.653E-04	3.107E 05	8.940E 03	0
5	22	8.800E 01	-1.208E-01	-6.117E-04	3.465E 05	8.940E 03	0
5	23	9.200E 01	-1.227E-01	-3.306E-04	3.823E 05	8.940E 03	0
5	24	9.600E 01	-1.234E-01	-2.182E-05	4.180E 05	8.940E 03	0
5	25	1.000E 02	-1.229E-01	3.145E-04	4.538E 05	8.940E 03	0
5	26	1.040E 02	-1.209E-01	6.785E-04	4.895E 05	8.940E 03	0
5	27	1.080E 02	-1.174E-01	1.070E-03	5.253E 05	8.940E 03	0
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5	31	1.240E 02	-8.623E-02	2.912E-03	6.683E 05	8.940E 03	0
5	32	1.280E 02	-7.355E-02	3.442E-03	7.041E 05	8.940E 03	0
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5	35	1.400E 02	-2.203E-02	5.196E-03	8.114E 05	-6.195E 04	0
5	36	1.440E 02	0	5.675E-03	2.800E 05	-1.357E 05	-2.026E-02
5	37	1.480E 02	2.337E-02	5.485E-03	-2.743E 05	-6.769E 04	0
5	38	1.520E 02	4.388E-02	4.787E-03	-2.615E 05	3.204E 03	0
5	39	1.560E 02	6.166E-02	4.123E-03	-2.487E 05	3.204E 03	0
5	40	1.600E 02	7.686E-02	3.492E-03	-2.359E 05	3.204E 03	0
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5	56	2.240E 02	7.660E-02	-2.065E-03	-3.081E 04	3.204E 03	0
5	57	2.280E 02	6.818E-02	-2.128E-03	-1.799E 04	3.204E 03	0
5	58	2.320E 02	5.957E-02	-2.158E-03	-5.174E 03	3.204E 03	0
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5	66	2.640E 02	0	-1.207E-03	6.417E 04	-6.924E 03	9.866E-02
5	67	2.680E 02	-4.358E-03	-9.996E-04	2.916E 04	-4.604E 03	0
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5	75	3.000E 02	-1.708E-02	8.080E-05	1.460E 04	-4.549E 02	0

5	76	3.040E 02	-1.658E-02	1.653E-04	1.278E 04	-4.549E 02	0
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5	79	3.160E 02	-1.336E-02	3.514E-04	7.321E 03	-4.549E 02	0
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5	83	3.320E 02	-6.735E-03	4.423E-04	4.242E 01	-4.549E 02	0
5	84	3.360E 02	-4.966E-03	4.370E-04	-1.777E 03	-4.549E 02	0
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5	86	3.440E 02	-1.602E-03	3.926E-04	-5.417E 03	-4.549E 02	0
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5	93	3.720E 02	3.597E-03	-1.167E-04	-1.815E 04	-4.549E 02	0
5	94	3.760E 02	2.906E-03	-2.344E-04	-1.997E 04	-4.549E 02	0
5	95	3.800E 02	1.722E-03	-3.633E-04	-2.179E 04	1.021E 03	0
5	96	3.840E 02	0	-5.034E-04	-1.181E 04	2.724E 03	-3.753E-02
5	97	3.880E 02	-2.305E-03	-5.763E-04	0	1.476E 03	0

6	-1	-4.000E 00	8.441E-04	-2.110E-04	0	3.419E 04	0
6	0	0	0	0	2.735E 05	6.279E 04	0
6	1	4.000E 00	8.441E-04	4.048E-04	5.024E 05	2.303E 04	0
6	2	8.000E 00	3.239E-03	7.752E-04	4.577E 05	-1.116E 04	0
6	3	1.200E 01	7.046E-03	1.111E-03	4.131E 05	-1.116E 04	0
6	4	1.600E 01	1.213E-02	1.413E-03	3.684E 05	-1.117E 04	0
6	5	2.000E 01	1.835E-02	1.680E-03	3.237E 05	-1.118E 04	0
6	6	2.400E 01	2.557E-02	1.912E-03	2.789E 05	-1.120E 04	0
6	7	2.800E 01	3.365E-02	2.110E-03	2.341E 05	-1.123E 04	0
6	8	3.200E 01	4.245E-02	2.273E-03	1.891E 05	-1.126E 04	0
6	9	3.600E 01	5.183E-02	2.402E-03	1.440E 05	-1.130E 04	0
6	10	4.000E 01	6.166E-02	2.496E-03	9.873E 04	-1.135E 04	0
6	11	4.400E 01	7.180E-02	2.554E-03	5.324E 04	-1.140E 04	0
6	12	4.800E 01	8.210E-02	2.578E-03	7.506E 03	-1.147E 04	0
6	13	5.200E 01	9.242E-02	2.566E-03	-3.851E 04	-1.154E 04	0
6	14	5.600E 01	1.026E-01	2.518E-03	-8.483E 04	-1.162E 04	0
6	15	6.000E 01	1.126E-01	2.435E-03	-1.315E 05	-1.172E 04	0
6	16	6.400E 01	1.221E-01	2.315E-03	-1.786E 05	-1.181E 04	0
6	17	6.800E 01	1.311E-01	2.159E-03	-2.260E 05	-1.192E 04	0
6	18	7.200E 01	1.394E-01	1.966E-03	-2.739E 05	-1.201E 04	0
6	19	7.600E 01	1.468E-01	1.736E-03	-3.221E 05	-1.204E 04	0
6	20	8.000E 01	1.533E-01	1.469E-03	-3.702E 05	-1.204E 04	0
6	21	8.400E 01	1.586E-01	1.165E-03	-4.183E 05	-1.204E 04	0
6	22	8.800E 01	1.626E-01	8.235E-04	-4.665E 05	-1.204E 04	0
6	23	9.200E 01	1.652E-01	4.450E-04	-5.146E 05	-1.204E 04	0
6	24	9.600E 01	1.661E-01	2.937E-05	-5.628E 05	-1.204E 04	0
6	25	1.000E 02	1.654E-01	-4.234E-04	-6.109E 05	-1.204E 04	0
6	26	1.040E 02	1.628E-01	-9.134E-04	-6.590E 05	-1.204E 04	0
6	27	1.080E 02	1.581E-01	-1.440E-03	-7.072E 05	-1.204E 04	0
6	28	1.120E 02	1.512E-01	-2.005E-03	-7.553E 05	-1.204E 04	0
6	29	1.160E 02	1.420E-01	-2.606E-03	-8.035E 05	-1.204E 04	0
6	30	1.200E 02	1.304E-01	-3.245E-03	-8.516E 05	-1.204E 04	0
6	31	1.240E 02	1.161E-01	-3.920E-03	-8.997E 05	-1.204E 04	0
6	32	1.280E 02	9.902E-02	-4.633E-03	-9.479E 05	-1.204E 04	0
6	33	1.320E 02	7.902E-02	-5.383E-03	-9.960E 05	-1.204E 04	0
6	34	1.360E 02	5.596E-02	-6.170E-03	-1.044E 06	-1.204E 04	0

6	35	1.400E 02	2.966E-02	-6.994E-03	-1.092E 06	8.373E 04	0
6	36	1.440E 02	0	-7.639E-03	-3.743E 05	1.833E 05	3.542E-02
6	37	1.480E 02	-3.145E-02	-7.374E-03	3.741E 05	9.132E 04	0
6	38	1.520E 02	-5.900E-02	-6.423E-03	3.563E 05	-4.443E 03	0
6	39	1.560E 02	-8.283E-02	-5.519E-03	3.385E 05	-4.443E 03	0
6	40	1.600E 02	-1.031E-01	-4.660E-03	3.207E 05	-4.443E 03	0
6	41	1.640E 02	-1.201E-01	-3.848E-03	3.030E 05	-4.443E 03	0
6	42	1.680E 02	-1.339E-01	-3.082E-03	2.852E 05	-4.443E 03	0
6	43	1.720E 02	-1.448E-01	-2.363E-03	2.674E 05	-4.443E 03	0
6	44	1.760E 02	-1.528E-01	-1.689E-03	2.497E 05	-4.443E 03	0
6	45	1.800E 02	-1.583E-01	-1.062E-03	2.319E 05	-4.443E 03	0
6	46	1.840E 02	-1.613E-01	-4.817E-04	2.141E 05	-4.443E 03	0
6	47	1.880E 02	-1.621E-01	5.273E-05	1.963E 05	-4.443E 03	0
6	48	1.920E 02	-1.609E-01	5.409E-04	1.786E 05	-4.443E 03	0
6	49	1.960E 02	-1.578E-01	9.828E-04	1.608E 05	-4.443E 03	0
6	50	2.000E 02	-1.530E-01	1.378E-03	1.430E 05	-4.443E 03	0
6	51	2.040E 02	-1.468E-01	1.728E-03	1.253E 05	-4.443E 03	0
6	52	2.080E 02	-1.392E-01	2.031E-03	1.075E 05	-4.443E 03	0
6	53	2.120E 02	-1.305E-01	2.288E-03	8.972E 04	-4.443E 03	0
6	54	2.160E 02	-1.209E-01	2.498E-03	7.195E 04	-4.443E 03	0
6	55	2.200E 02	-1.106E-01	2.662E-03	5.418E 04	-4.443E 03	0
6	56	2.240E 02	-9.963E-02	2.780E-03	3.640E 04	-4.443E 03	0
6	57	2.280E 02	-8.832E-02	2.852E-03	1.863E 04	-4.443E 03	0
6	58	2.320E 02	-7.681E-02	2.877E-03	8.621E 02	-4.443E 03	0
6	59	2.360E 02	-6.530E-02	2.856E-03	-1.691E 04	-4.443E 03	0
6	60	2.400E 02	-5.396E-02	2.789E-03	-3.468E 04	-4.443E 03	0
6	61	2.440E 02	-4.298E-02	2.676E-03	-5.245E 04	-4.443E 03	0
6	62	2.480E 02	-3.255E-02	2.516E-03	-7.022E 04	-4.443E 03	0
6	63	2.520E 02	-2.286E-02	2.310E-03	-8.799E 04	-4.443E 03	0
6	64	2.560E 02	-1.407E-02	2.058E-03	-1.058E 05	-4.443E 03	0
6	65	2.600E 02	-6.393E-03	1.759E-03	-1.235E 05	2.188E 03	0
6	66	2.640E 02	0	1.437E-03	-8.826E 04	1.129E 04	-1.375E-01
6	67	2.680E 02	5.100E-03	1.173E-03	-3.319E 04	7.138E 03	0
6	68	2.720E 02	9.381E-03	9.740E-04	-3.116E 04	5.074E 02	0
6	69	2.760E 02	1.289E-02	7.879E-04	-2.913E 04	5.074E 02	0
6	70	2.800E 02	1.568E-02	6.144E-04	-2.710E 04	5.074E 02	0
6	71	2.840E 02	1.781E-02	4.534E-04	-2.507E 04	5.074E 02	0
6	72	2.880E 02	1.931E-02	3.049E-04	-2.304E 04	5.074E 02	0
6	73	2.920E 02	2.025E-02	1.690E-04	-2.101E 04	5.074E 02	0
6	74	2.960E 02	2.066E-02	4.553E-05	-1.898E 04	5.074E 02	0
6	75	3.000E 02	2.061E-02	-6.537E-05	-1.695E 04	5.074E 02	0
6	76	3.040E 02	2.014E-02	-1.637E-04	-1.492E 04	5.074E 02	0
6	77	3.080E 02	1.930E-02	-2.496E-04	-1.289E 04	5.074E 02	0
6	78	3.120E 02	1.814E-02	-3.229E-04	-1.086E 04	5.074E 02	0
6	79	3.160E 02	1.672E-02	-3.837E-04	-8.833E 03	5.074E 02	0
6	80	3.200E 02	1.507E-02	-4.320E-04	-6.804E 03	5.074E 02	0
6	81	3.240E 02	1.326E-02	-4.677E-04	-4.774E 03	5.074E 02	0
6	82	3.280E 02	1.133E-02	-4.909E-04	-2.745E 03	5.074E 02	0
6	83	3.320E 02	9.335E-03	-5.016E-04	-7.156E 02	5.074E 02	0
6	84	3.360E 02	7.320E-03	-4.997E-04	1.314E 03	5.074E 02	0
6	85	3.400E 02	5.337E-03	-4.854E-04	3.343E 03	5.074E 02	0
6	86	3.440E 02	3.437E-03	-4.585E-04	5.373E 03	5.074E 02	0
6	87	3.480E 02	1.670E-03	-4.190E-04	7.402E 03	5.074E 02	0
6	88	3.520E 02	8.490E-05	-3.671E-04	9.432E 03	5.074E 02	0
6	89	3.560E 02	-1.267E-03	-3.026E-04	1.146E 04	5.074E 02	0
6	90	3.600E 02	-2.336E-03	-2.256E-04	1.349E 04	5.074E 02	0
6	91	3.640E 02	-3.[illegible]72E-03	-1.360E-04	1.552E 04	5.074E 02	0
6	92	3.680E 02	-3.424E-03	-3.397E-05	1.755E 04	5.074E 02	0
6	93	3.720E 02	-3.343E-03	8.062E-05	1.958E 04	5.074E 02	0
6	94	3.760E 02	-2.779E-03	2.077E-04	2.161E 04	5.074E 02	0

6	95	3.800E 02	-1.681E-03	3.474E-04	2.364E 04	-1.097E 03	0
6	96	3.840E 02	0	4.996E-04	1.283E 04	-2.955E 03	1.129E-02
6	97	3.880E 02	2.315E-03	5.788E-04	0	-1.604E 03	0
7	-1	-4.000E 00	-9.934E-04	2.484E-04	0	-4.023E 04	0
7	0	0	0	0	-3.219E 05	-7.390E 04	0
7	1	4.000E 00	-9.934E-04	-4.764E-04	-5.912E 05	-2.710E 04	0
7	2	8.000E 00	-3.812E-03	-9.124E-04	-5.387E 05	1.313E 04	0
7	3	1.200E 01	-8.292E-03	-1.308E-03	-4.861E 05	1.314E 04	0
7	4	1.600E 01	-1.427E-02	-1.663E-03	-4.336E 05	1.315E 04	0
7	5	2.000E 01	-2.159E-02	-1.977E-03	-3.810E 05	1.316E 04	0
7	6	2.400E 01	-3.009E-02	-2.250E-03	-3.283E 05	1.318E 04	0
7	7	2.800E 01	-3.960E-02	-2.483E-03	-2.755E 05	1.321E 04	0
7	8	3.200E 01	-4.996E-02	-2.676E-03	-2.226E 05	1.325E 04	0
7	9	3.600E 01	-6.100E-02	-2.827E-03	-1.695E 05	1.330E 04	0
7	10	4.000E 01	-7.257E-02	-2.937E-03	-1.162E 05	1.335E 04	0
7	11	4.400E 01	-8.450E-02	-3.006E-03	-6.266E 04	1.342E 04	0
7	12	4.800E 01	-9.662E-02	-3.034E-03	-8.834E 03	1.350E 04	0
7	13	5.200E 01	-1.088E-01	-3.020E-03	4.532E 04	1.358E 04	0
7	14	5.600E 01	-1.208E-01	-2.964E-03	9.983E 04	1.368E 04	0
7	15	6.000E 01	-1.325E-01	-2.865E-03	1.548E 05	1.379E 04	0
7	16	6.400E 01	-1.437E-01	-2.725E-03	2.101E 05	1.390E 04	0
7	17	6.800E 01	-1.543E-01	-2.541E-03	2.660E 05	1.403E 04	0
7	18	7.200E 01	-1.640E-01	-2.314E-03	3.224E 05	1.413E 04	0
7	19	7.600E 01	-1.728E-01	-2.043E-03	3.790E 05	1.416E 04	0
7	20	8.000E 01	-1.804E-01	-1.729E-03	4.357E 05	1.416E 04	0
7	21	8.400E 01	-1.866E-01	-1.371E-03	4.923E 05	1.416E 04	0
7	22	8.800E 01	-1.913E-01	-9.692E-04	5.490E 05	1.416E 04	0
7	23	9.200E 01	-1.944E-01	-5.237E-04	6.056E 05	1.416E 04	0
7	24	9.600E 01	-1.955E-01	-3.457E-05	6.623E 05	1.416E 04	0
7	25	1.000E 02	-1.946E-01	4.983E-04	7.190E 05	1.416E 04	0
7	26	1.040E 02	-1.915E-01	1.075E-03	7.756E 05	1.416E 04	0
7	27	1.080E 02	-1.860E-01	1.695E-03	8.323E 05	1.416E 04	0
7	28	1.120E 02	-1.780E-01	2.359E-03	8.889E 05	1.416E 04	0
7	29	1.160E 02	-1.672E-01	3.067E-03	9.456E 05	1.416E 04	0
7	30	1.200E 02	-1.534E-01	3.818E-03	1.002E 06	1.416E 04	0
7	31	1.240E 02	-1.366E-01	4.614E-03	1.059E 06	1.416E 04	0
7	32	1.280E 02	-1.165E-01	5.453E-03	1.116E 06	1.416E 04	0
7	33	1.320E 02	-9.300E-02	6.335E-03	1.172E 06	1.416E 04	0
7	34	1.360E 02	-6.585E-02	7.261E-03	1.229E 06	1.416E 04	0
7	35	1.400E 02	-3.491E-02	8.232E-03	1.285E 06	-9.676E 04	0
7	36	1.440E 02	0	8.998E-03	4.547E 05	-2.125E 05	1.746E-02
7	37	1.480E 02	3.708E-02	8.729E-03	-4.146E 05	-1.064E 05	0
7	38	1.520E 02	6.983E-02	7.673E-03	-3.965E 05	4.530E 03	0
7	39	1.560E 02	9.846E-02	6.664E-03	-3.783E 05	4.530E 03	0
7	40	1.600E 02	1.231E-01	5.702E-03	-3.602E 05	4.530E 03	0
7	41	1.640E 02	1.441E-01	4.788E-03	-3.421E 05	4.530E 03	0
7	42	1.680E 02	1.614E-01	3.921E-03	-3.240E 05	4.530E 03	0
7	43	1.720E 02	1.754E-01	3.100E-03	-3.059E 05	4.530E 03	0
7	44	1.760E 02	1.863E-01	2.328E-03	-2.877E 05	4.530E 03	0
7	45	1.800E 02	1.941E-01	1.602E-03	-2.696E 05	4.530E 03	0
7	46	1.840E 02	1.991E-01	9.232E-04	-2.515E 05	4.530E 03	0
7	47	1.880E 02	2.014E-01	2.919E-04	-2.334E 05	4.530E 03	0
7	48	1.920E 02	2.014E-01	-2.923E-04	-2.153E 05	4.530E 03	0
7	49	1.960E 02	1.991E-01	-8.293E-04	-1.971E 05	4.530E 03	0
7	50	2.000E 02	1.948E-01	-1.319E-03	-1.790E 05	4.530E 03	0
7	51	2.040E 02	1.886E-01	-1.762E-03	-1.609E 05	4.530E 03	0
7	52	2.080E 02	1.807E-01	-2.157E-03	-1.428E 05	4.530E 03	0
7	53	2.120E 02	1.713E-01	-2.505E-03	-1.247E 05	4.530E 03	0

7	54	2.160E 02	1.606E-01	-2.806E-03	-1.065E 05	4.530E 03	0
7	55	2.200E 02	1.488E-01	-3.060E-03	-8.842E 04	4.530E 03	0
7	56	2.240E 02	1.361E-01	-3.267E-03	-7.030E 04	4.530E 03	0
7	57	2.280E 02	1.227E-01	-3.426E-03	-5.218E 04	4.530E 03	0
7	58	2.320E 02	1.087E-01	-3.539E-03	-3.406E 04	4.530E 03	0
7	59	2.360E 02	9.440E-02	-3.604E-03	-1.594E 04	4.530E 03	0
7	60	2.400E 02	7.991E-02	-3.622E-03	2.180E 03	4.530E 03	0
7	61	2.440E 02	6.543E-02	-3.592E-03	2.030E 04	4.530E 03	0
7	62	2.480E 02	5.117E-02	-3.516E-03	3.842E 04	4.530E 03	0
7	63	2.520E 02	3.730E-02	-3.392E-03	5.654E 04	4.530E 03	0
7	64	2.560E 02	2.403E-02	-3.222E-03	7.466E 04	4.530E 03	0
7	65	2.600E 02	1.153E-02	-3.003E-03	9.278E 04	-2.401E 03	0
7	66	2.640E 02	0	-2.738E-03	5.545E 04	-1.160E 04	-8.258E-02
7	67	2.680E 02	-1.038E-02	-2.594E-03	0	-6.931E 03	0

TIME = 2 MINUTES, 45 AND 8/60 SECONDS