A FINITE-ELEMENT METHOD OF SOLUTION FOR LINEARLY ELASTIC BEAM-COLUMNS

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

There is a strange but very real mental hurdle that stands between those who have actually used a computer program to solve problems and those who have only thought about it. Anyone who has any interest in the present subject, whether he will use the method himself or intends to let subordinates do it for him, is urged to code and solve at least a few simple example problems. Actual trial use is an important step toward understanding the potential range of application.

It is expected that the beam-column (BMCOL) method described will be found useful in solving a wide variety of both simple and complex beam-column problems. Complete instructions for immediate application to practical problems are therefore given. However, the BMCOL method is also the key to consideration of many other problems, and the present report is therefore intended to give a complete development of background theory. The theory itself is quite simple; any difficulties in understanding that may develop are likely to be those involved in making a transition from usual concepts of structural analysis to an approach in which finite-element approximations are used.

This report is the first in a series describing methods by which finite-element representations and computer solutions are used for solving structural and foundation problems.

Although the BMCOL program described in this report is written for the CDC 1604 computer, it is in FORTRAN language and only very minor changes would be required for it to be 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 at The University of Texas.

The continued assistance and advice of the contact representative, Mr. Larry G. Walker of the Texas Highway Department, has been very much appreciated. The very excellent facilities of the Computation Center of The University of Texas and the fine cooperation from its staff have contributed significantly to the results.

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.

ABSTRACT

A wide spectrum of beam and beam-column problems can be described and solved by a single computer method. A finite mechanical analog is employed to allow very general loading and elastic restraint conditions to be considered. The resulting system of equations is solved by a rapid and efficient direct elimination process.

Program BMCOL 34 and associated input forms and instructions are applied to the solution of a series of highway-type example problems. Complete listing of the FORTRAN program is given, plus input and output data for the examples.

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NOMENCLATURE

Symbol	Typical Units	Definition
a	-	Coefficient in stiffness matrix
A	-	Temporary bar numbering used in derivations
A_i	-	Continuity Coefficient computed in recursive solution of equations
b	-	Coefficient in stiffness matrix
B	-	Temporary bar numbering used in derivations
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	$lb\text{-}in^2$	Flexural stiffness = EI
h	in.	Increment length
i	-	Station number
I	in^4	Moment of inertia of the cross section
m	-	Total number of increments in beam-column
M	in-lb	Bending moment
P	lb	Axial tension (+) or compression (-)

Symbol	Typical Units	Definition
q	lb/in	Applied transverse load per unit length
Q	lb	Concentrated applied transverse load
Q_i^s	lb	Reaction at Station i from specified conditions
r	in-lb/rad/in	Rotational restraint per unit length
R	in-lb/rad	Concentrated rotational restraint
s	lb/in^2	Transverse spring restraint per unit length
S	lb/in	Concentrated transverse spring restraint
t	in-lb/in	Applied torque per unit length
T	in-lb	Concentrated applied torque
V	lb	Shear
w	in.	Transverse deflection
x	in.	Distance along axis of beam-column
Z	lb	Transverse load used in developing specified slope equations
ψ	radians	Angle change between bars
θ	radians	Slope

CHAPTER 1. INTRODUCTION

Bending and buckling are encountered in a wide variety of problems in the design of highways and bridges. This report presents a numerical-analysis generalization of bending of straight structural members. A computer program written in FORTRAN language is included and its use is explained with example problems.

It will be shown that one very simple but general mechanical model can be used to represent a broad range of problems in bending. Many of these problems are not susceptible to solution by other presently available methods.

To apply the method, the design engineer expresses the actual physical dimensions and properties of his real problem in numerical terms in the coding forms. By using only one general program and a natural physical interpretation of problems, the effort of learning methods and procedures is reduced.

With such an approach, the primary attention of the designer is directed toward the proper formulation of an engineering description of the problem and toward evaluation of the computed response of the structure. A minimum of time is spent in the tedious manual arithmetic of structural analysis.

History of Development of the Beam-Column Solution

Much work has been done in the field of numerical analysis of linearly elastic beams and beam-columns. Newmark (Ref 1) utilized iterative methods to achieve rational beam-column solutions. Malter (Ref 2) applied the finite-difference technique to the solution of the second-order differential equations of beam behavior. Gleser (Ref 3) suggested a recurring difference-equation form in the analysis of laterally loaded piles that was utilized and developed further by Matlock and Reese (Refs 4 and 5).

Murphy (Ref 6) presented a technique of using a variable spring support and a sustained load to represent nonlinear foundation response.

Matlock and Lytton (Refs 7 and 8) developed a more general recursive solution for beam-columns. This recursive solution was extended and numerical examples were developed by Matlock and Ingram (Refs 9, 10 and 11).

The Scope of This Report

The purpose of this report is fourfold: (1) to review conventional beam theory and corresponding numerical techniques, (2) to present the development of a more general method for the solution of complex beam and beam-column problems based on a finite-element model, (3) to describe the associated FORTRAN computer program and its use, and (4) to demonstrate the versatility of the method by the solution of example problems that are reasonably typical of those encountered in highway engineering.

The review of conventional methods as developed in Chapter 2 will not be used directly in the derivation of the final general method nor in the computer program. However, key concepts are developed which support basic understanding of subsequent developments.

CHAPTER 2. CONVENTIONAL AND FINITE-ELEMENT THEORIES FOR BENDING

The usual relations describing the behavior of beams consist of relatively simple ordinary differential equations. In addition to using conventional methods of solution, such differential equations may be solved by numerical techniques.

In this chapter the pertinent differential equations of the conventional mechanics of beams are stated and finite central-difference methods are used to convert these conventional differential equations to difference forms. These are compared with the results of an alternate physical-model approximation.

Conventional Beam Equations

The conventional second-order differential equation that relates curvature to bending moment M and flexural stiffness EI or F is

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

The second derivative of beam deflection w with respect to distance x along the beam is an approximation of beam curvature that is valid only for small deformations.

The other second-order differential equation of the conventional mechanics of beams is obtained from the requirement for static equilibrium and relates the second derivative of bending moment M , with respect to distance x along the beam, to the load q distributed along the beam:

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

It should be noted that these relations are limited to the usual assumptions for pure bending:

(1) Axial and shear deformations are neglected.

(2) Beams are assumed to be of symmetrical cross section loaded only in the plane of the vertical axis.

(3) Plane sections are assumed to remain plane both during and after bending.

(4) Deflections are assumed to be small compared to original dimensions.

(5) The material of the beam is assumed to behave in a linearly elastic manner.

If the flexural stiffness F is a constant, Eqs 2.1 and 2.2 may be combined into the following fourth-order differential equation:

$$F \frac{d^4 w}{dx^4} = q \tag{2.3}$$

If instead of maintaining F as a constant it is considered to vary along the length of the beam, the resulting differentiations and combination of Eqs 2.1 and 2.2 give:

$$F \frac{d^4 w}{dx^4} + 2 \frac{dF}{dx} \frac{d^3 w}{dx^3} + \frac{d^2 F}{dx^2} \frac{d^2 w}{dx^2} = q \tag{2.4}$$

To solve a problem with either Eq 2.3 or 2.4, four boundary conditions must be known in order to evaluate the four unknown constants that will appear during integration. Even with very simple variations of F , Eq 2.4 may be troublesome to integrate. All terms, including the load q , must vary continuously within the length of the beam considered. Thus, direct application of Eqs 2.3 and 2.4 to real structural problems is seldom attempted. Instead, many different interpretations of the basic equations and a wide variety of analytical techniques are in common use by structural engineers to solve problems of bending.

Some relief may be obtained by resorting to finite-difference approximations and integrating the equations numerically, usually with the aid of a digital computer.

Conventional Difference Equations for Beams

In App 1, conventional central-difference expressions are developed for all derivatives through the fourth. Applying the second-derivative form to Eqs 2.1 and 2.2 gives the following difference equations:

$$+ w_{i-1} - 2w_i + w_{i+1} = h^2 M_i / F_i \tag{2.5}$$

$$+ M_{i-1} - 2M_i + M_{i+1} = h^2 q_i \qquad (2.6)$$

In these equations, the increment length chosen between stations along the beam is h and the stations are designated in order by the subscripts.

For the condition that F is a constant, the algebraic combination of Eqs 2.5 and 2.6 will yield the same fourth-order difference expression as would be obtained by writing directly the finite-difference version of Eq 2.3.

$$+ w_{i-2} - 4w_{i-1} + 6w_i - 4w_{i+1} + w_{i+2} = h^4 q_i / F \qquad (2.7)$$

If F is not constant, but continuously variable with x , Eq 2.4 must be used as a basis instead of Eq 2.3. Writing each of the derivatives in difference form and collecting the many terms that result yields the following expression:

$$(F_{i-1}/2 + F_i - F_{i+1}/2)w_{i-2} + (-6F_i + 2F_{i+1})w_{i-1}$$
$$+ (-2F_{i-1} + 10F_i - 2F_{i+1})w_i + (2F_{i-1} - 6F_i)w_{i+1}$$
$$+ (-F_{i-1}/2 + F_i + F_{i+1}/2)w_{i+2} = h^4 q_i \qquad (2.8)$$

It is important to understand that in developing Eq 2.4, derivatives of certain products were taken that are subject to the limitation of the covering assumption that the functions were smoothly continuous in the interval considered along the beam. If, instead of using Eq 2.4, the two second-order difference versions (Eqs 2.5 and 2.6) are combined algebraically, a fourth-order form is developed that is different from Eq 2.8.

$$(F_{i-1})w_{i-2} - 2(F_{i-1} + F_i)w_{i-1} + (F_{i-1} + 4F_i + F_{i+1})w_i$$
$$- 2(F_i + F_{i+1})w_{i+1} + (F_{i+1})w_{i+2} = h^4 q_i \qquad (2.9)$$

Equation 2.9 is a somewhat cruder approximation for a beam with varying flexural stiffness than Eq 2.8 but it has a distinct advantage in that it is not restricted against abrupt station-by-station changes in any of the input functions, including flexural stiffness F_i . This point is of key importance in the subsequent development of the general beam-column method. It will be demonstrated also by a physical-model or finite-element development for the conventional beam. If F is a constant, both Eqs 2.8 and 2.9 reduce to the form of Eq 2.7.

Finite Mechanical Representation of a Conventional Beam

Figure 1a shows a beam element deformed under the action of pure bending and subject to the assumptions of conventional beam mechanics as stated earlier. Assuming linearly elastic stress-strain behavior, the stresses acting on the beam element are as shown in Fig 1b. These distributed stresses may be replaced by concentrated compressive and tensile forces, as in Fig 1c. A mechanical analog of Fig 1c is shown in Fig 1d, where the deformed beam element is replaced by a pair of plates hinged together at the center and restrained at the top and bottom by linear springs containing the elastic flexural stiffness of the beam element. Thus, a beam could be represented by a series of such beam element models, as shown in Fig 1e.

A cruder beam model could be constructed by using wider plates between hinged joints or replacing the plates by a series of rigid bars hinged at the ends and having the beam flexural stiffness of each finite beam element concentrated in the springs at these hinges. Such a finite-element beam model is shown in Fig 1f. With some temporary reservations about accuracy, this model can be accepted intuitively as a satisfactory approximation for a real beam.

Equations Based on the Finite-Element Beam Model

Figure 2 shows a deformed segment of a finite-element beam model similar to that of Fig 1; i.e., constructed of a series of rigid bars separated by deformable joints where the beam flexibility is concentrated.

Any distributed load q is lumped for one increment length at the increment point as a concentrated load

$$Q_i = hq_i \tag{2.10}$$

The change in slope between Bars A and B is

$$\psi_i = \frac{w_{i-1} - 2w_i + w_{i+1}}{h} \tag{2.11}$$

The equation may be written in the following form:

$$\psi_i = h\left(\frac{w_{i-1} - 2w_i + w_{i+1}}{h^2}\right) \tag{2.12}$$

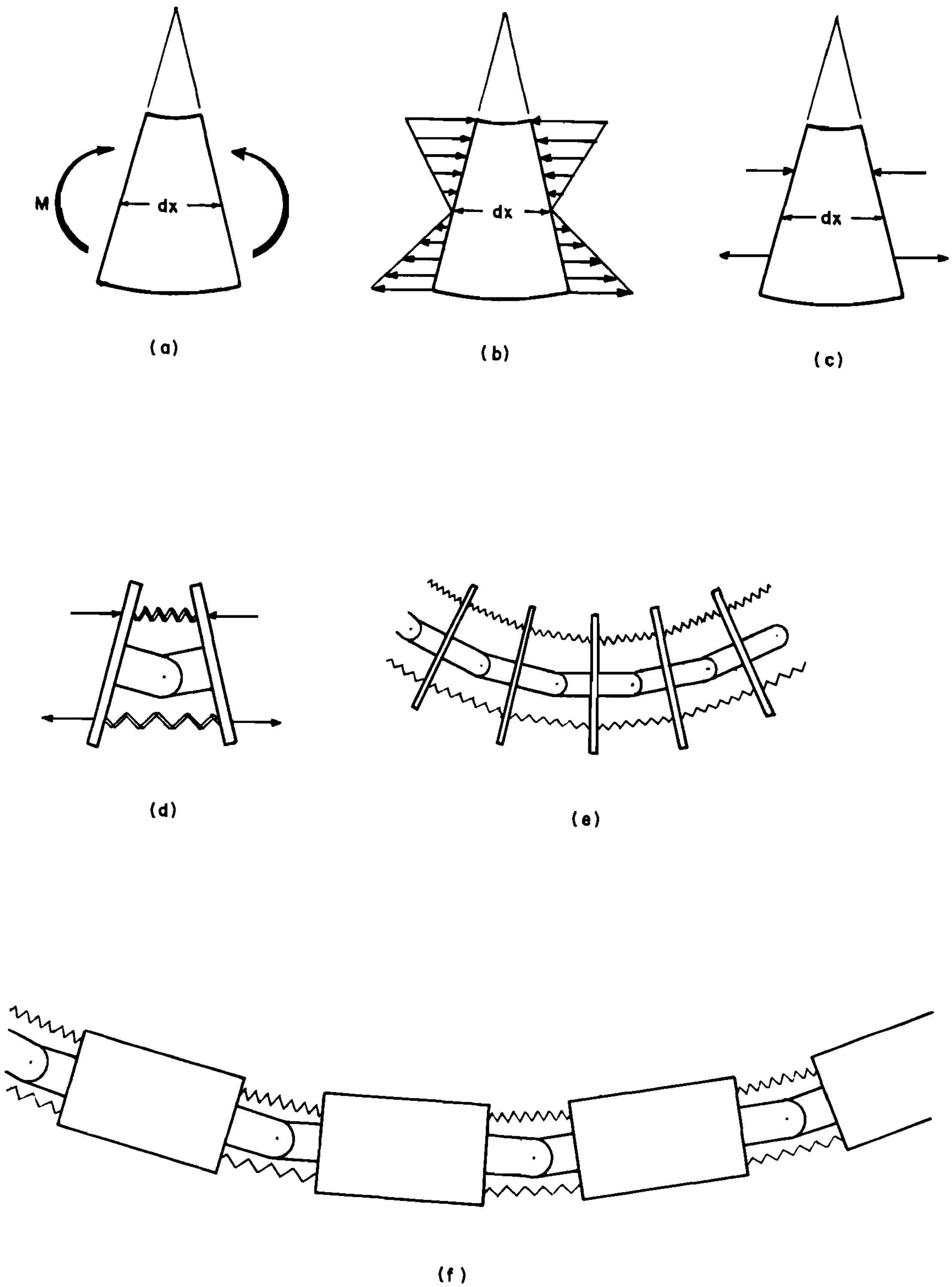


Fig 1. Finite mechanical representation of a conventional beam.

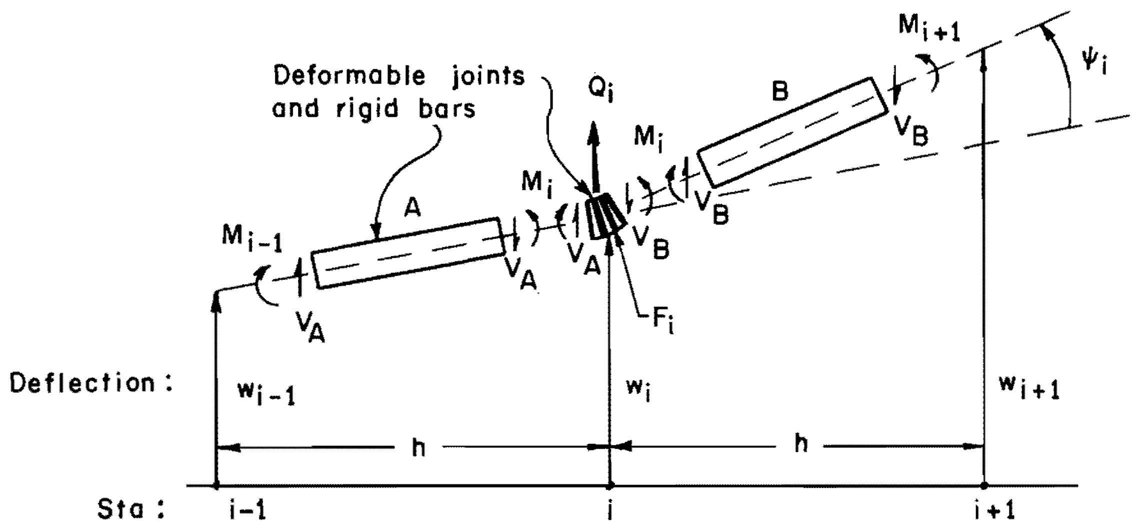


Fig 2. Deformed segment of a finite-element beam model.

Since the term in parentheses is the finite-difference expression for the second derivative of deflection w, Eq 2.12 may be interpreted as expressing the angle ψ_i as the concentration of the beam curvature from one increment length. Thus the moment-stiffness-curvature relation of Eq 2.1 becomes

$$M_i = F_i \psi_i / h \qquad (2.13)$$

The shears and moments required to keep the segment in equilibrium are also shown in Fig 2. Summation of the vertical forces acting on the joint gives

$$Q_i + V_A - V_B = 0 \qquad (2.14)$$

while summing the moments about Bar A gives

$$M_{i-1} - M_i + V_A h = 0 \qquad (2.15)$$

and summing the moments about Bar B gives

$$M_i - M_{i+1} + V_B h = 0 \qquad (2.16)$$

Then Eqs 2.15 and 2.16 may be substituted into Eq 2.14 to eliminate V_A and V_B with the following result:

$$M_{i-1} - 2M_i + M_{i+1} = hQ_i \qquad (2.17)$$

Eq 2.13 written for Stations i-1, i, and i+1 may be substituted into Eq 2.17 to eliminate bending moments.

$$F_{i-1}\psi_{i-1} - 2F_i\psi_i + F_{i+1}\psi_{i+1} = h^2 Q_i \qquad (2.18)$$

Then, substituting Eq 2.12 into Eq 2.18 three times and combining terms results in:

$$(F_{i-1})w_{i-2} - 2(F_{i-1} + F_i)w_{i-1} + (F_{i-1} + 4F_i + F_{i+1})w_i$$

$$-2(F_i + F_{i+1})w_{i+1} + (F_{i+1})w_{i+2} = h^3 Q_i \qquad (2.19)$$

It should be noted that, except for the concentration of the load as Q_i, Eq 2.19 is exactly the same as Eq 2.9. In the derivation of Eq 2.9 and in the development of Eq 2.19 from a finite-element beam model, no assumptions were made about continuity of beam flexural stiffness between increment points;

therefore, large and abrupt discontinuities of flexural stiffness may be introduced in actual beam representations. Such discontinuities in flexural stiffness may include beam hinges formed by setting the flexural stiffness at a station or increment point to zero. In effect, setting the beam flexural stiffness to zero at a station removes the springs from the hinged joint and the resulting simple hinge has no resistance to bending.

CHAPTER 3. SOLUTION OF EQUATIONS

Many different mathematical techniques have been used to solve systems of simultaneous equations. However, for the large number of equations of the general form applicable to beam-column solutions, the most efficient approach appears to be the direct two-pass method described in this chapter and illustrated by a simple example problem.

General Fourth-Order Equation for Beams

Any one of the fourth-order difference equations developed in the preceding chapter may be written in the following form:

$$a_i w_{i-2} + b_i w_{i-1} + c_i w_i + d_i w_{i+1} + e_i w_{i+2} = f_i \tag{3.1}$$

If the unknown deflections w are in inches and if the equation is arranged so that f_i has the units of pounds, the coefficients a_i through e_i will be stiffness constants with units of pounds per inch.

A given beam may be divided into any reasonable number of increments and one unknown deflection w_i may be determined for each station. In the interior of the beam, the arrangement of equations is as shown in Fig 3. If the unknown deflections were omitted and all the coefficients in the equations were written in the same general pattern, the result would be a diagonally banded coefficient matrix, termed the "stiffness matrix," plus a single-column "load" matrix composed of the f-terms. The development of the equations used in solving for the unknown deflections is given in App 2.

Elimination of Unknowns

Solution of the system of equations in Fig 3 is done most easily by a back-and-forth recursion-equation process. Proceeding from top to bottom on the first pass, two unknown deflections (w_{i-2} and w_{i-1} in Eq 3.1) are eliminated from each equation, resulting in another diagonally banded system of equations of the form

$$w_i - B_i w_{i+1} - C_i w_{i+2} = A_i \tag{3.2}$$

$$
\begin{array}{ccccccccccc}
 & * & * & * & & & & & & & \\
+a_{i-2}w_{i-4} & +b_{i-2}w_{i-3} & +c_{i-2}w_{i-2} & +d_{i-2}w_{i-1} & +e_{i-2}w_{i} & & & & & = & f_{i-2} \\
 & +a_{i-1}w_{i-3} & +b_{i-1}w_{i-2} & +c_{i-1}w_{i-1} & +d_{i-1}w_{i} & +e_{i-1}w_{i+1} & & & & = & f_{i-1} \\
 & & +a_{i}w_{i-2} & +b_{i}w_{i-1} & +c_{i}w_{i} & +d_{i}w_{i+1} & +e_{i}w_{i+2} & & & = & f_{i} \\
 & & & +a_{i+1}w_{i-1} & +b_{i+1}w_{i} & +c_{i+1}w_{i+1} & +d_{i+1}w_{i+2} & +e_{i+1}w_{i+3} & & = & f_{i+1} \\
 & & & & +a_{i+2}w_{i} & +b_{i+2}w_{i+1} & +c_{i+2}w_{i+2} & +d_{i+2}w_{i+3} & +e_{i+2}w_{i+4} & = & f_{i+2} \\
 & & & & & & * & * & * & &
\end{array}
$$

Fig 3. Arrangement of equations for solution for the deflections along the beam.

where

$$A_i = D_i(E_iA_{i-1} + a_iA_{i-2} - f_i) \tag{3.3}$$

$$B_i = D_i(E_iC_{i-1} + d_i) \tag{3.4}$$

$$C_i = D_i(e_i) \tag{3.5}$$

and

$$D_i = -1/(E_iB_{i-1} + a_iC_{i-2} + c_i) \tag{3.6}$$

$$E_i = a_iB_{i-2} + b_i \tag{3.7}$$

To complete the solution for all of the unknown deflections w_i , a reverse pass is made by applying the following version of Eq 3.2 at each station:

$$w_i = A_i + B_iw_{i+1} + C_iw_{i+2} \tag{3.8}$$

By the time the reverse pass is made, the deflections w_{i+1} and w_{i+2} will be known. As explained in App 2, for beam and beam-column problems the coefficients A_i , B_i , and C_i are called "Continuity Coefficients."

The above summary intentionally avoids discussing what is required at each end of the diagonally banded system to allow the elimination process to start and then to turn around for the reverse pass. For this purpose, auxiliary fictitious stations are employed at the ends, and the prescribed boundary conditions for the beam provide the necessary equations at those stations.

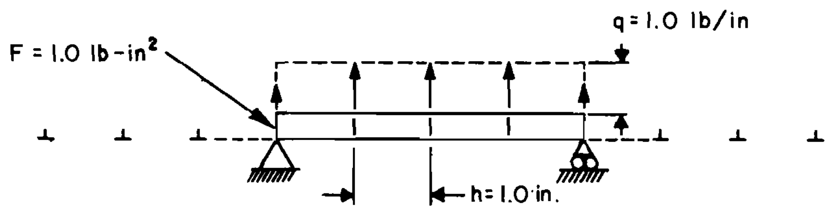
Once the deflections have been determined, any other desired quantities (slope, moment, shear, or reaction) may be obtained very easily by numerical differentiation.

Numerical Example of Basic Method

A very simple example has been chosen to illustrate the process of formulating the necessary equations and reaching a solution. As shown at the top of Fig 4, the beam is simply supported at the ends and is uniformly loaded.

Since the bending stiffness is constant throughout the length, all of the fourth-order equations developed in Chapter 2 would yield identical results. The general form is used to produce the third, fourth and fifth equations in the figure.

The end conditions provide four additional equations that are needed. The



STATION	-3	-2	-1	0	1	2	3	4	5	6	7

EQUATIONS

1	$0 + 0 + w_{-1} - 2w_0 + w_1$	=	0.0
2	$0 + 0 + w_0 + 0 + 0$	=	0.0
3	$w_{-1} - 4w_0 + 6w_1 - 4w_2 + w_3$	=	1.0
4	$w_0 - 4w_1 + 6w_2 - 4w_3 + w_4$	=	1.0
5	$w_1 - 4w_2 + 6w_3 - 4w_4 + w_5$	=	1.0
6	$0 + 0 + w_4 + 0 + 0$	=	0.0
7	$w_3 - 2w_4 + w_5 + 0 + 0$	=	0.0

RECURSION - EQUATION SOLUTION

A_i	0.0	0.0	0.2	.643	1.33	0.0	-2.5
B_i	2.0	0.0	0.8	1.143	1.33	0.0	0.0
C_i	-1.0	0.0	-0.2	-.357	-.467	0.0	0.0
w_i	-2.5	0.0	2.5	3.5	2.5	0.0	-2.5

COMPUTED DEFLECTIONS w_i

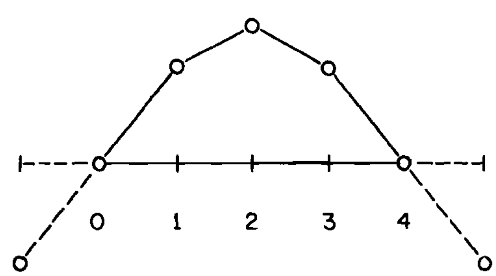


Fig 4. Simple numerical example of basic method of beam solution.

second and sixth equations are simply statements that the deflections are zero at the ends of the beam and consideration of any loads applied at those points is overridden. Referring to Eq 2.5, it can be seen that the first and seventh equations in the figure are statements that the bending moments are zero at the ends of the beam. These equations may be thought of as special forms in the diagonally banded fourth-order system, in which certain terms are reduced to zero. The zero terms that are separated by the dashed lines in Fig 4 allow the recursion-equation process to get started and then get turned around at the far end of the beam.

The forward pass of the recursion-equation solution is made by applying Eqs 3.3 through 3.7 to solve for the Continuity Coefficients A_i , B_i and C_i . Then Eq 3.8 yields the completed solution for deflections w_i on the reverse pass.

To keep the example very simple the beam is divided into only four increments. Nevertheless, the computed maximum deflection of 3.5 inches compares remarkably well with the precise value of 3.33 inches that may be computed from conventional theory for a uniformly loaded simple beam. Later in this report the results from a 40-increment solution of the same problem will be seen to give practically perfect results.

CHAPTER 4. THE GENERALIZED FINITE-ELEMENT BEAM-COLUMN

The solution of realistic engineering problems often may involve externally applied effects not easily represented by simple loads. In this chapter, a variety of external loading and restraint conditions will be considered and applied to a finite-element beam-column model.

The system of equations has the general form of Eq 3.1 and may be solved by the same recursive technique discussed in Chapter 3.

Loads and Restraints

Figure 5 shows an interior segment of a beam-column loaded and elastically restrained in a variety of ways. All forces and restraints are shown acting in the positive sense, including the bending moment M and the shear V .

Lower-case letters represent loads and restraints distributed in some manner along the beam-column, while the corresponding capital letters are used to represent concentrated loads and restraints. The loads Q and q act normal to the axis of the beam-column, as do the linear springs S and s . Couples T and t , as well as rotational springs R and r , act on the beam-column in an angular sense. In addition, a constant or variable axial tension or compression force P acts parallel to the axis of the beam-column. The flexural stiffness of the beam, as previously noted, is represented by F .

Considering these desired loading and restraint conditions, numerical techniques may be applied to produce an approximate mathematical model of the beam-column.

Development of General Beam-Column Equation

Figure 6 shows a deformed element of some beam that is subject to the assumptions of conventional beam theory. Only bending deformations are considered; therefore, the relation between approximate curvature of the element and the bending moment on the element is that previously given by Eq 2.1:

$$M = F \frac{d^2w}{dx^2} \qquad (4.1)$$

Writing Eq 4.1 in finite central-difference form about some Station i gives the relation previously noted as Eq 2.5:

$$M_i = F_i \frac{w_{i-1} - 2w_i + w_{i+1}}{h^2} \tag{4.2}$$

Figure 7 shows a generalized beam-column element deflected a distance w and tilted through some angle dw/dx. The various reactions from distributed loads and elastic restraints similar to those of Fig 5 are shown acting on the element. Although the distributed rotational effects r and t are introduced for the development of equations, it will be seen that in solving actual problems only the concentrated versions of these terms are used. Summing moments about the right end of the element gives the relation

$$dM - Vdx - tdx - q\frac{(dx)^2}{2} + sw\frac{(dx)^2}{2} - rdw - Pdw - dP\frac{dw}{2} = 0 \tag{4.3}$$

Neglecting the higher order terms,

$$\frac{dM}{dx} = V + t + (r + P)\frac{dw}{dx} \tag{4.4}$$

From summation of vertical forces on the element in Fig 7,

$$\frac{dV}{dx} = q - sw \tag{4.5}$$

Differentiating Eq 4.4 and eliminating the shear V by means of Eq 4.5 gives

$$\frac{d^2M}{dx^2} = q - sw + \frac{d}{dx}\left[t + (r + P)\frac{dw}{dx}\right] \tag{4.6}$$

According to Eq 4.6, the second derivative of the bending moment is no longer simply equal to the applied load q as previously expressed by Eq 2.2 but now is also influenced by all of the other effects that were added to generalize the beam-column element. Also, it should be noted from Eq 4.4 that to compute the shear V from the first derivative of the bending moment it is now necessary to account for the applied couples t and the restraint couples developed by the r and P terms.

To avoid the limitations that were noted in developing Eq 2.8, all of the terms in Eq 4.6 must be converted directly to finite-difference form, without first performing in a conventional manner any of the indicated differentiations

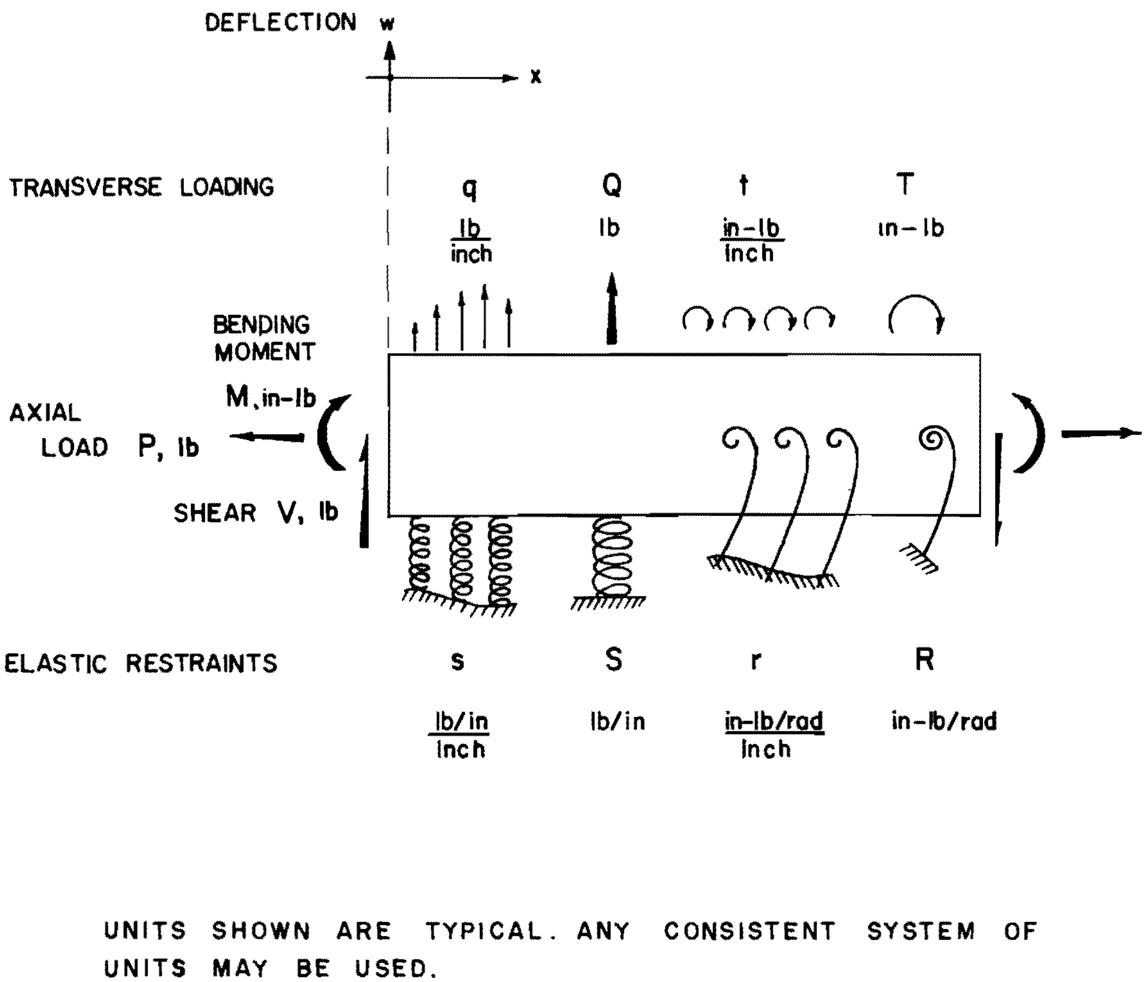


Fig 5. Loads and restraints considered in the generalized beam-column solution. All effects are shown acting in a positive sense in relation to the x-direction.

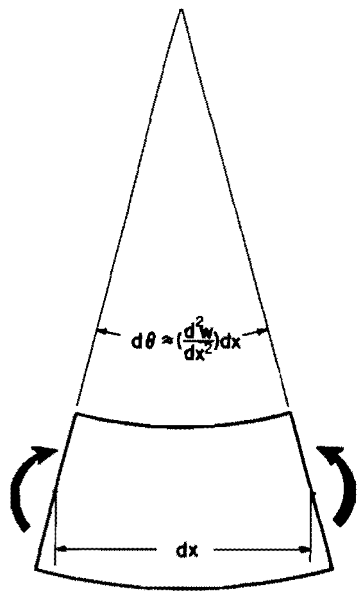


Fig 6. Deformed element corresponding to conventional beam theory.

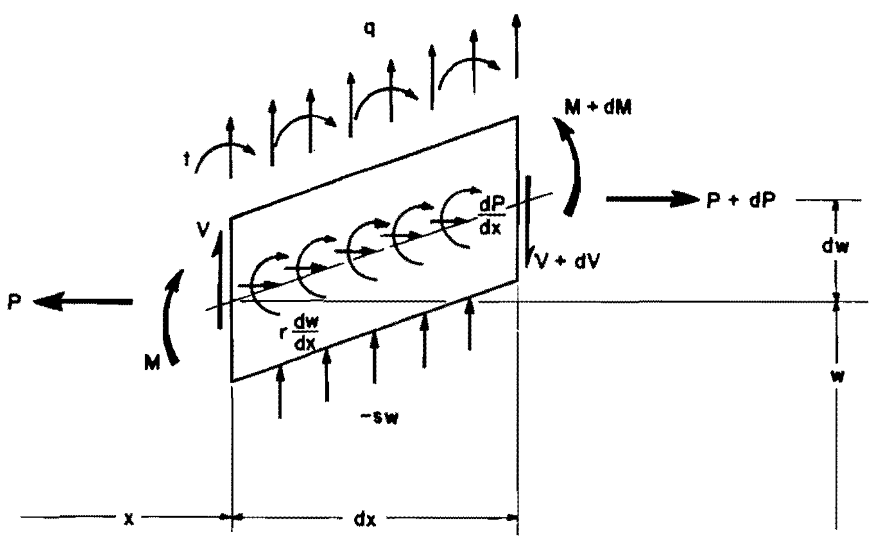


Fig 7. Generalized beam-column element deflected a distance w and tilted through some angle dw/dx .

of products. Because of the unwieldy nature of the expressions, each side of the equation will be developed separately.

Written in central-difference form, the left side of Eq 4.6 is

$$\frac{d^2M}{dx^2} \approx \frac{M_{i-1} - 2M_i + M_{i+1}}{h^2} \tag{4.7}$$

Eliminating the bending moments M by applying Eq 4.2 three times results in:

$$\frac{d^2M}{dx^2} \approx \frac{1}{h^4}\Big[F_{i-1}w_{i-2} - 2(F_{i-1} + F_i)w_{i-1} + (F_{i-1} + 4F_i + F_{i+1})w_i - 2(F_i + F_{i+1})w_{i+1} + F_{i+1}w_{i+2}\Big] \tag{4.8}$$

Next the right side of Eq 4.6 is converted to central-difference form exactly as it stands:

$$\frac{d^2M}{dx^2} \approx q_i - s_iw_i + \frac{1}{2h}\left\{ - \left[t_{i-1} + (r_{i-1} + P_{i-1})\left(\frac{-w_{i-2} + w_i}{2h}\right)\right] + \left[t_{i+1} + (r_{i+1} + P_{i+1})\left(\frac{-w_i + w_{i+2}}{2h}\right)\right] \right\} \tag{4.9}$$

The final equation is obtained by combining Eqs 4.8 and 4.9 and collecting terms. The following conversions to lumped quantities at each increment point are also made.

$$Q_i = hq_i \tag{4.10}$$

$$S_i = hs_i \tag{4.11}$$

$$T_i = ht_i \tag{4.12}$$

$$R_i = hr_i \tag{4.13}$$

It is convenient to write the final general beam-column equation in the form of Eq 3.1, as follows:

$$a_iw_{i-2} + b_iw_{i-1} + c_iw_i + d_iw_{i+1} + e_iw_{i+2} = f_i \tag{4.14}$$

where, in the present case,

$$a_i = F_{i-1} - 0.25h(R_{i-1} + hP_{i-1}) \quad (4.15)$$

$$b_i = -2(F_{i-1} + F_i) \quad (4.16)$$

$$c_i = F_{i-1} + 4F_i + F_{i+1} + h^3S_i + 0.25h(R_{i-1} + hP_{i-1})$$

$$+ 0.25h(R_{i+1} + hP_{i+1}) \quad (4.17)$$

$$d_i = -2(F_i + F_{i+1}) \quad (4.18)$$

$$e_i = F_{i+1} - 0.25h(R_{i+1} + hP_{i+1}) \quad (4.19)$$

$$f_i = h^3Q_i - 0.5h^2(T_{i-1} - T_{i+1}) \quad (4.20)$$

In combining the finite-difference forms of Eqs 4.1 and 4.6 into Eqs 4.14 - 4.20, no assumptions were made concerning the continuity of the derivatives over the interval considered and no conventional derivatives of products were taken. Instead, each term of the equations was expressed in finite-difference form immediately upon its introduction and any subsequent combinations were made by algebraic manipulation. Thus, in effect, the above process is only a more general version of the earlier finite-element development leading to Eq 2.19. In fact, if the effects of axial tension, applied couples, and rotational and transverse springs are set to zero in Eqs 4.14 - 4.20 they reduce to Eq 2.19.

Mechanical Model

The representation in Fig 8 is an exact mechanical analog of the beam-column behavior described by Eqs. 4.14 - 4.20. The figure shows all quantities related to a typical point, Station i. The flexural stiffness F_i is represented as concentrated at the increment point in the form of a spring-restrained hinge between two rigid segments. All load and support values are ultimately felt by the beam as transverse forces applied at increment points. This is obvious for the lateral load Q_i and for the couple created by forces $T_i/2h$. It is also

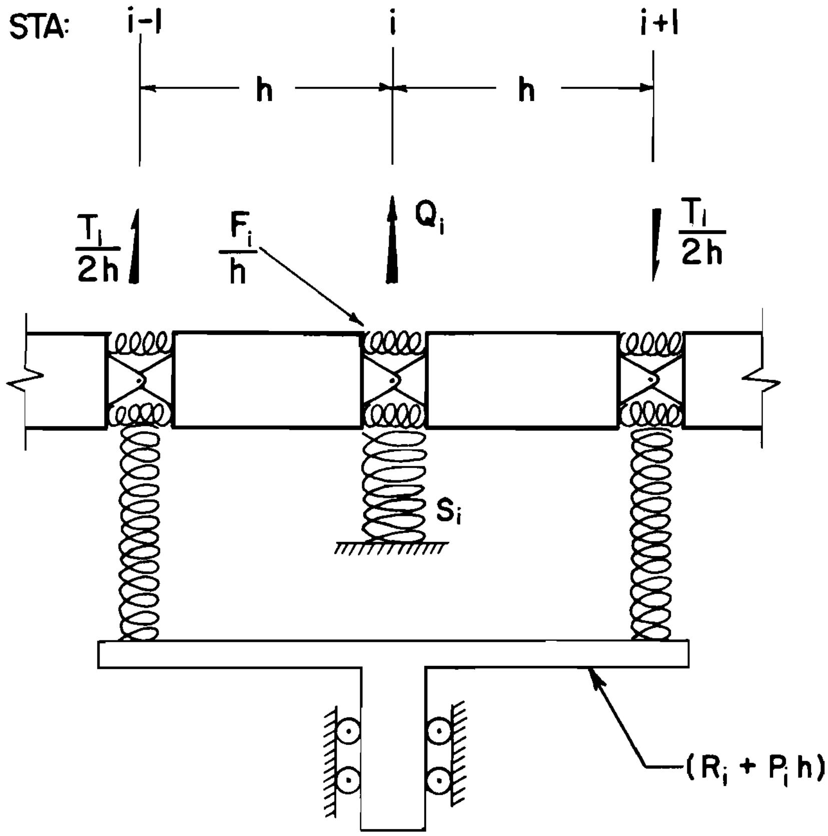


Fig 8. Mechanical model corresponding exactly to beam-column equations.

true for the reaction from the spring S_i as well as for two equal but opposite reactions from the angular restraint mechanism which acts as an exact analog for the combined effect of a rotational spring R_i and the axial tension (or compression) P_i .

Distributed and Concentrated Effects

The concentrated or lumped quantities of Eqs 4.14 - 4.20 may represent either effects acting only at the increment point or approximations of effects distributed per increment length h of the beam-column. The length over which distributed effects may be considered to extend includes a distance h/2 on each side of the increment point or station. Thus, to correctly express an effect distributed between two stations some distance apart along the beam-column, half-values of the distributed effect should be put at the end stations and full values at intermediate stations. The rule applies not only to distributed values of loads Q and springs S , but also to bending stiffness F and axial tension P . Rotational restraints R and couples T normally are needed only as concentrated effects.

Method of Solution for the General Beam-Column System

The general process is particularly convenient for machine computations since it can be summarized as a set of equations which are solved repeatedly at station after station along the beam. Figure 9 illustrates the sequence of computations and summarizes all the equations that are needed.

Figure 9a shows a finite-element model of the beam-column. Any of the input loads and restraints shown at Station i can also be placed at other stations. The flexural stiffness F must be stated at every real station.

Equations 4.14 through 4.20 are reproduced in Fig 9b, which also shows the quidiagonal stiffness matrix (a matrix with five unknown deflection coefficients) that is produced by applying the equations at every station, including one fictitious station beyond each end of the real beam-column. The corresponding load matrix is shown in Fig 9c.

The zeroes at the ends of the quidiagonal-band stiffness matrix are created automatically by the general beam-column equation, provided that no load or stiffness data exist for the fictitious extensions at the ends of the beam-column. In the computation of Continuity Coefficients in Fig 4 (by Eqs 3.3

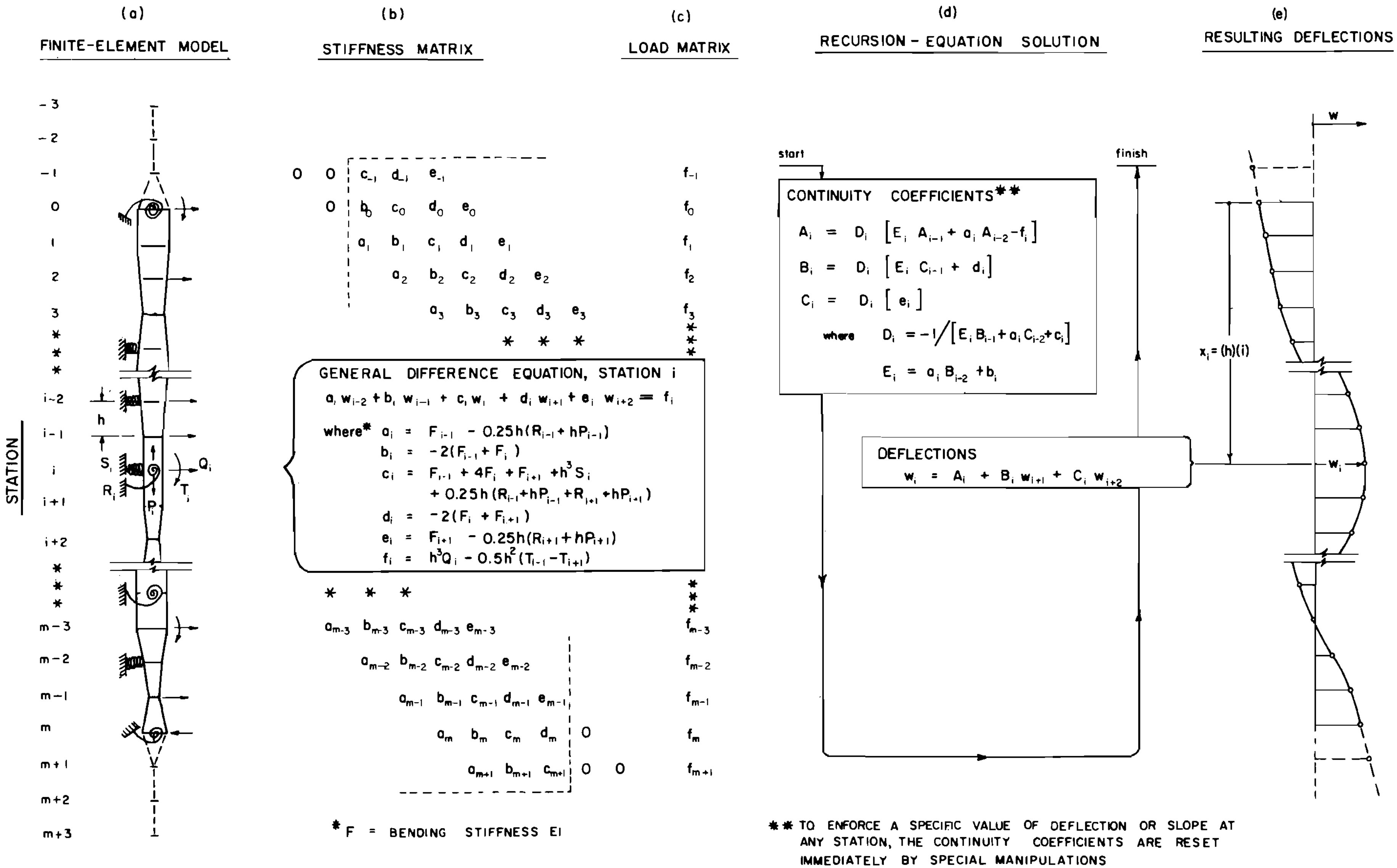


Fig 9. The system of m + 3 simultaneous equations and the method of direct, once-through solution.

through 3.7) these zero terms serve to blind the equations to any extraneous effects that might be thought of as existing further beyond the ends of the beam-column. They are the means by which the recursion process is enabled to get underway and then to get turned around at the far end so that deflections finally may be calculated.

Boundary Conditions and Specified Conditions

The conventional concept of prescribing boundary conditions only at the ends of some region under consideration is unnecessarily restrictive in relation to the present finite-element approach. While it is true that finite-difference expressions can be written to represent almost any condition at the ends, the generality of the available input data in the present method tends to supplant the need for any special equations.

Since the fictitious stations beyond each end of the model beam-column of Fig 9 have no flexural stiffness, they act as multiple hinges and thus isolate the model beam-column and the recursion equations describing its behavior from consideration of any effects beyond the ends.

Instead of using special boundary equations for end moments and shears, they can be produced simply by input data in the form of T and Q terms.

In addition to boundary equations that may be automatically created, specified values of deflection and slope may be enforced at any station on the beam-column by manipulation of the Continuity Coefficients.

Specified Deflections

Because of the interdependent nature of the Continuity Coefficient equations, any special manipulation of these coefficients must occur as they are being computed from beginning to end along the beam-column. Thus both physical continuity and that of the simultaneous equations describing beam-column behavior are preserved.

The following expression for deflection at any Station i along the beam-column has been given (as Eq 3.8):

$$w_i = A_i + B_i w_{i+1} + C_i w_{i+2} \tag{4.21}$$

If, during the computation of the Continuity Coefficients A_i, B_i, and

C_i along the beam-column, a specified deflection is desired at Station i, the computational process is interrupted as it reaches Station i, the Continuity Coefficients B_i and C_i are set equal to zero, and the Continuity Coefficient A_i is set equal to the desired deflection. The normal process is then resumed at Station i+1. The effect is that a reaction is produced on the beam of sufficient magnitude to give the required deflection at the designated station. The same effect can be approximated by introducing a very large force Q_i and a correspondingly large spring constant S_i in such a ratio that all other effects are overridden and the desired deflection is physically enforced.

Specified Slopes

The slope at any Station i along the beam-column may be written in difference form as

$$\theta_i = \frac{-w_{i-1} + w_{i+1}}{2h} \tag{4.22}$$

By immediate manipulation of the Continuity Coefficients A, B, and C at Stations i-1 and i+1, a specified slope may be produced at Station i of the beam-column. The process is developed in App 3.

In effect, loads of opposite sign but equal magnitude are produced at Stations i-1 and i+1 to tilt the beam to the desired slope at Station i.

Based on the alternate method of physically specifying a deflection with extremely large values of Q and S, it would seem feasible to use a large rotational restraint R and a large applied couple T in correct ratio to physically enforce a specified slope at a particular station. Such is not the case, however, as the use of extremely large R-values tends to cause a loss of significant digits in the matrix elimination process. (R-values within the range of reasonable physical structural characteristics have not been found to cause any difficulty.)

The form of the equations for specified slope and deflection allows values of either slope or deflection, or both, to be specified at a particular station.

Errors

The errors in numerical solutions arise because of (1) truncation and

(2) loss of significant figures in arithmetic operations.

Some degree of truncation is inherent in most finite-difference expressions of continuous functions. Such errors in the present method are suggested by the mechanical model in Fig 8. The model represents a finite, lumped-value approximation of the real beam-column. No further truncation error is introduced in the solution since the equations are an exact representation of the finite-element model. Truncation errors may be minimized by increasing the number of increments into which the member is divided, provided that loss of significant digits does not become a problem. As an example of truncation errors that may be produced, the maximum deflection of a simply supported beam with constant cross-section and a concentrated load at the center can be computed to an accuracy of 2.0 per cent with 10 increments and 0.1 per cent with 50 increments.

With the long sequences of computation that are employed, the loss of significant figures may be important. Using a CDC 1604 computer with a word length of 48 binary bits (about 11 decimal digits), no significant errors have been encountered in the variety of problems solved to date. However, difficulties have arisen in some solutions on the IBM 7094 which normally uses a 36-bit word length (about 8 decimal digits). The troubles were overcome by using the double-precision option available in FORTRAN IV.

Based on a study of computation errors, using the variable word length capability of the IBM 1620 computer, it appears that 10 to 12 decimal digits are sufficient for good results for the considerable range of engineering problems that have been studied.

It is strongly recommended that the accuracy of solution for any new ranges or types of problems be tested by simple-case comparisons between computer and exact solutions. It is also recommended that unreasonably small increment lengths be avoided.

CHAPTER 5. PROGRAM BMCOL 34

BMCOL 34 is a computer program written to solve problems involving linearly elastic beam-columns with continuous or freely discontinuous transverse and angular loads and restraints. As discussed in Chapter 4, the mathematical representation is consistent with a finite-element analog of the real beam-column. The program logic closely parallels the summary of the method given in Fig 9.

The number, 34, simply means that this is the 34th significantly distinct version in the chronological sequence of development. Different purposes are served by various programs in the series; many are inactive or superseded, and a few were not carried past an initial idea stage.

Detailed procedures for preparing input data are given at the end of this chapter. Example problems are considered in Chapter 6.

Program Operations

The general procedures followed by the program are described in the flow diagram in Fig 10. An identification card at the beginning of each problem controls the start of each solution. Unless an error stop occurs because of unacceptable data, the program will work any desired number of problems in sequence, finally stopping when a blank problem-number card is encountered.

Table 1 is comprised of a single data card that includes options to hold data from a preceding problem, a count of cards added to each table in the current problem, and an option to obtain automatically plotted curves in addition to the printed tabulations of results.

Tables 2 and 3 are either held or they are erased completely and recreated in the current problem. Table 4 provides for the input of all values of all of the stiffness and load terms considered in the general beam-column method. Several variations in input are provided by which concentrated or distributed data are read into storage. All data in Table 4 are algebraically accumulated and new values therefore may be added regardless of whether such data are held from the preceding problem. This feature has been found to be a versatile and convenient device for solving many types of analysis or design problems that involve progressive changes in loads or in structural characteristics.

Once the data are stored, the program develops the matrix coefficients and Continuity Coefficients at all stations and proceeds to solve for deflections.

Computed Results

Once the deflections w have been computed, the first and second derivatives are determined numerically to yield the slope at each station and, by application of Eq 4.2, the bending moment. The bending moment is also differentiated twice. Each line of the final tabulation gives the station and distance x along the beam-column, plus the deflection, slope, bending moment, and the results from differentiating the bending moment.

The second derivative of the bending moment, multiplied by the increment length h , is equal to the algebraic sum of all forces or reactions, from any source whatsoever, that acts on the beam-column at any one station.

Specified values of deflection or slope are introduced at any particular station after all of the regular input data have been applied in the general fourth-order beam-column equation. Reactions caused by specified conditions were not included in Eq 4.9 or Eqs 4.14 - 4.20. If such a reaction is denoted by Q_i^s and added to Eq 4.9 and all data quantities are lumped according to Eqs 4.10 - 4.13, the result can be arranged in the following form.

$$\left[h\frac{d^2M}{dx^2}\right]_i \approx Q_i^s + Q_i - \frac{1}{2h}(T_{i-1} - T_{i+1})$$

$$+ \frac{1}{4h^2}(R_{i-1} + hP_{i-1})\, w_{i-2}$$

$$- \left[S_i + \frac{1}{4h^2}(R_{i-1} + hP_{i-1} + R_{i+1} + hP_{i+1})\right] w_i$$

$$+ \frac{1}{4h^2}(R_{i+1} + hP_{i+1})\, w_{i+2} \qquad (5.1)$$

The output for Program BMCOL 34 is arranged to print at each station the composite "net reaction" as computed by Eq 5.1.

The second derivative of the bending moment has units of force per unit of

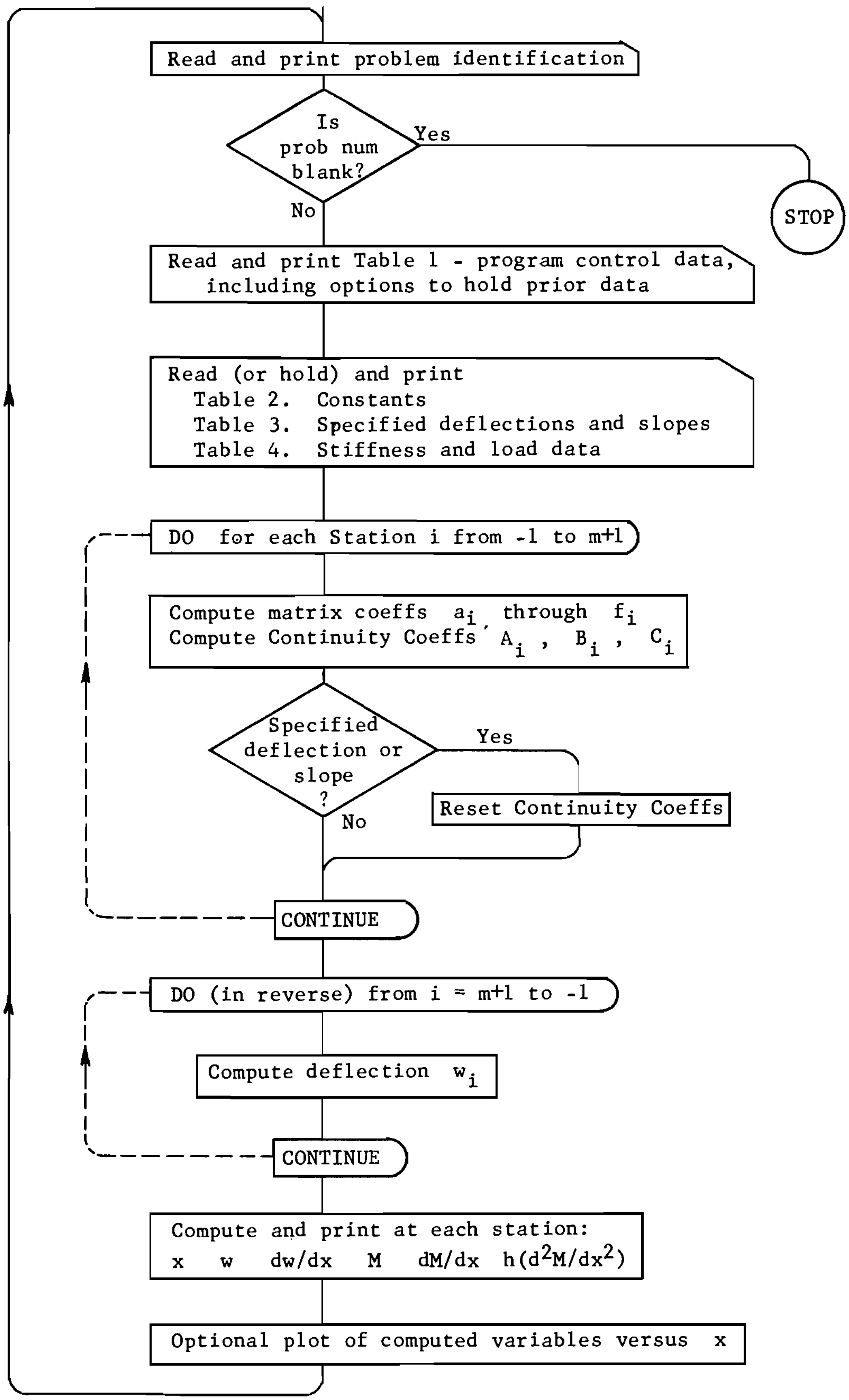


Fig 10. Summary flow diagram for the beam-column program.

length of the beam-column. Multiplication by increment length h in Eq 4.9 results in units of force per increment length. With this value and all deflections w and all input data terms known, it is possible to use Eq 5.1 to make any desired separation of reaction effects. Where there are no R, P, or T terms the process is obviously quite simple.

Any concentrated couple applied externally as a T-value or developed as the result of a specified slope or a rotational restraint R , must be sensed by the beam as two equal but opposite forces acting one increment each way from the station considered. Thus, within the zone influenced by such a pair of forces, the internal shear V changes in a manner that is different from that usually considered when structures are idealized as line members and each couple is assumed to act at a point. However, in an actual structural member an abrupt discontinuity in shear does not really occur and, depending on the increment length chosen, it is possible for the beam-column analog to provide a more satisfactory approximation of such couples.

Program BMCOL 34 is also arranged to output the first derivative of the bending moment. No attempt should be made to extract conventional values of shear V from the output listings closer than two increments from a station where a couple T is applied or where a rotational restraint R or a specified slope is placed. Also, due account should be taken of the influence of an axial load P at the station considered. The proper procedure can be deduced from Eq 4.4.

All output values are printed for each station, including one auxiliary station at each end. Each problem may be terminated with the printed tabulations, or a set of five automatically plotted curves may be obtained also.

The FORTRAN Program

A general flow diagram plus detailed diagrams for significant parts of the program will be found in App 4. A list of the notation used within the program is given in App 5 and a listing of the program itself is in App 6.

The program is written in FORTRAN-63 language for a Control Data Corporation 1604 digital computer having a 48-bit word length and operated with a FORTRAN-63 Monitor system. Compile time is about 80 seconds. Exact storage requirements are undetermined. Required machine time is variable, depending upon the problem to be run. Most problems are solved in 15 seconds or less, including input and output manipulations.

The FORTRAN coding has not been optimized from the standpoint of machine operations. Clarity of program logic and ease in understanding have been given priority in several places. It is felt, however, that a reasonable compromise has been obtained.

An attempt has been made to write the program to be reasonably compatible with the IBM 7090-7094 system. However, at least minor revision will probably be required, particularly in the input and output formats. Depending on equipment available, it may be necessary to delete the automatic plotting routines. Because the standard IBM word length is limited to 36 binary bits, the double-precision option of FORTRAN IV is recommended.

Error Messages

There are four possible error messages that may be encountered in the use of the program. The program stops when any one of these is encountered.

(1) TOO MUCH DATA FOR AVAILABLE STORAGE (occurs if number of specified conditions exceeds 20).

(2) STATIONS NOT IN ORDER (occurs if cards of specified conditions are not in order of station number or if cards of Table 4 input are not in order of station within a particular distribution sequence).

(3) NON-ZERO TABLE 4 DATA BEYOND END (prevents retaining unwanted data at first station beyond end of beam-column).

(4) UNSPECIFIED ERROR STOP -- PROGRAM TERMINATED (provides a general-purpose stop for a number of unlikely errors; check input data carefully).

Guide for Data Input

The following pages consist of a Guide for Data Input. These pages may be extracted for routine use. It should be expected that revisions of these forms and instructions may be developed in the future and may supersede the present versions.

Example problems are discussed in the next chapter. The first two cases are very simple ones that are intended to aid in learning to use the input data forms, and the other examples serve to illustrate a variety of coding situations. Input and output listings for all of the examples are given in App 7 and App 8 and should be used to check practice coding.

GUIDE FOR DATA INPUT FOR BMCOL 34

with Supplementary Notes

extract from

A FINITE-ELEMENT METHOD OF SOLUTION
FOR LINEARLY ELASTIC BEAM-COLUMNS

by

Hudson Matlock and T. Allan Haliburton

1 September 1966

BMCOL 34 GUIDE FOR DATA INPUT -- Card forms

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

Field	Columns
(card 1)	1–80
(card 2)	1–80

IDENTIFICATION OF PROBLEM (one alphanumeric card each problem)

Field	Columns
PROB	1–5
Description of problem	11–80

TABLE 1. PROGRAM CONTROL DATA (one card each problem)

Field	Column
ENTER "1" TO HOLD PRECEDING TABLE 2	15
ENTER "1" TO HOLD PRECEDING TABLE 3	20
ENTER "1" TO HOLD PRECEDING TABLE 4	25
NUM CARDS ADDED FOR TABLE 2	35
NUM CARDS ADDED FOR TABLE 3	40
NUM CARDS ADDED FOR TABLE 4	45
ENTER 1, 2, OR 3 TO PLOT	60

TABLE 2. CONSTANTS (one card, or none if Table 2 of preceding problem is held)

Field	Columns
NUM INCRS	6–10
INCR LENGTH	21–30

TABLE 3. SPECIFIED DEFLECTIONS AND SLOPES (number of cards according to Table 1; none if preceding Table 3 is held)

Field	Columns
STATION	6–10
CASE	16–20
DEFLECTION	21–30
SLOPE	31–40

CASE = 1 for deflection only, 2 for slope only, 3 for both

TABLE 4. FIXED VALUES OF STIFFNESS AND LOAD (number of cards according to Table 1). Data added to storage as lumped quantities per increment length, linearly interpolated between values input at indicated end stations, with ½ − values at each end station. Concentrated effects are established as full values at single stations by setting final station = initial station.

STA	TO STA	ENTER 1 IF CONT'D ON NEXT CARD	F FLEXURAL STIFFNESS	Q TRANSVERSE FORCE	S SPRING SUPPORT	T TRANSVERSE COUPLE	R ROTATIONAL RESTRAINT	P AXIAL TENSION OR COMPRESSION
6–10	10–15	15–20	20–30	30–40	40–50	50–60	60–70	70–80

STOP CARD (one blank card at end of run)

GENERAL PROGRAM NOTES

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

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 right-justified integers or whole decimal numbers . . . . -43

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

TABLE 1. PROGRAM-CONTROL DATA

For each of Tables 2 and 3, 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 either table is set equal to 1, the number of cards input for that table must be zero.

For Table 4, 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 plot option has four possible values. If the plot option is blank or zero, no plots are drawn. If the plot option is specified as 1, 2, or 3, then each of w , dw/dx , M , dM/dx , and $h(d^2M/dx^2)$ is plotted versus station number, with the size of the axes depending on the value of the plot option. If the plot option is 1, the plots are drawn on 1 × 5-in. axes such that the group of five plots will fit on an 8-1/2 × 11-in. page. If the plot option is 2, the plots are drawn on 2 × 10-in. axes such that the group of five plots will fit on an 11 × 17-in. page. If the plot option is 3, the plots are drawn on 1 × 15-in. axes such that the group of five plots will fit on an 11 × 17-in. page.

TABLE 2. CONSTANTS

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

The maximum number of increments into which the beam-column may be divided is 200.

The length of the beam-column may be changed and data may be held in Tables 3 and 4. The user is cautioned that when the beam is shortened, non-zero data past the end of the beam may disrupt the solution. An error message is printed out when this occurs.

TABLE 3. SPECIFIED DEFLECTIONS AND SLOPES

The maximum number of stations at which deflections and slopes may be specified is 20.

Cards must be arranged in order of station numbers.

A slope may not be specified closer than 3 increments from another specified slope.

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 4. STIFFNESS AND LOAD DATA

Typical units:

variables:	F	Q	S	T	R	P
values per station:	lb × in^2	lb	lb / in	in × lb	in × lb / radian	lb

Axial tension or compression values P must be stated at each station in the same manner as any other distributed data; there is no mechanism in the program to automatically distribute the internal effects of an externally applied axial force.

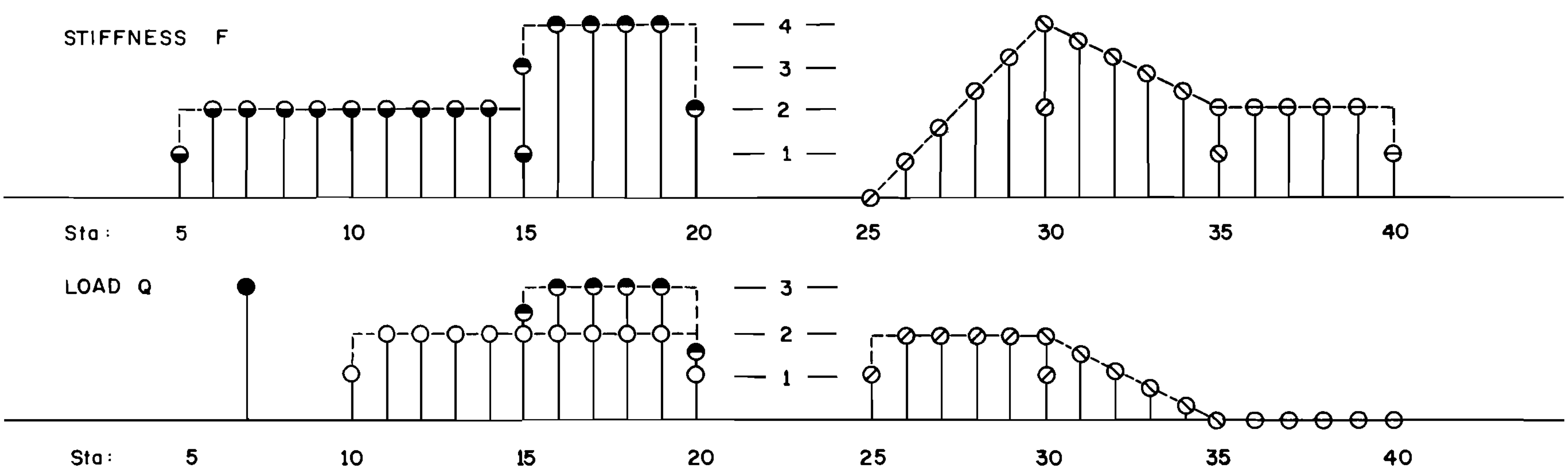
Data in this table should not be entered (nor held from the preceding problem) which would express effects at fictitious stations beyond the ends of the real beam-column.

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 4 except that within a distribution sequence the stations must be in regular order.

	FROM STA	TO STA	CONT'D TO NEXT CARD ?	F	Q	etc...
Individual – card Input						
Case a.1. Data concentrated at one sta	7	→ 7	0 = NO		3.0	
Case a.2. Data uniformly distributed	5	→ 15	0 = NO	2.0		
	15	→ 20	0 = NO	4.0	1.0	
	10	→ 20	0 = NO		2.0	
Multiple – card Sequence						
Case b. First – of – sequence	25		1 = YES	0.0	2.0	
Case c. Interior – of – sequence		→ 30	1 = YES	4.0	2.0	
		→ 35	1 = YES	2.0	0.0	
Case d. End – of – sequence		→ 40	0 = NO	2.0		

Resulting Distribution of Data



CHAPTER 6. EXAMPLE PROBLEMS

Several example problems have been selected to illustrate the beam-column method of solution and the use of Program BMCOL 34. Input data listings are given in App 7 and computer output listings are in App 8. Though the examples are hypothetical, an attempt has been made to select cases that are reasonably typical of actual highway and bridge-design problems.

Uniformly Loaded Simple Beam

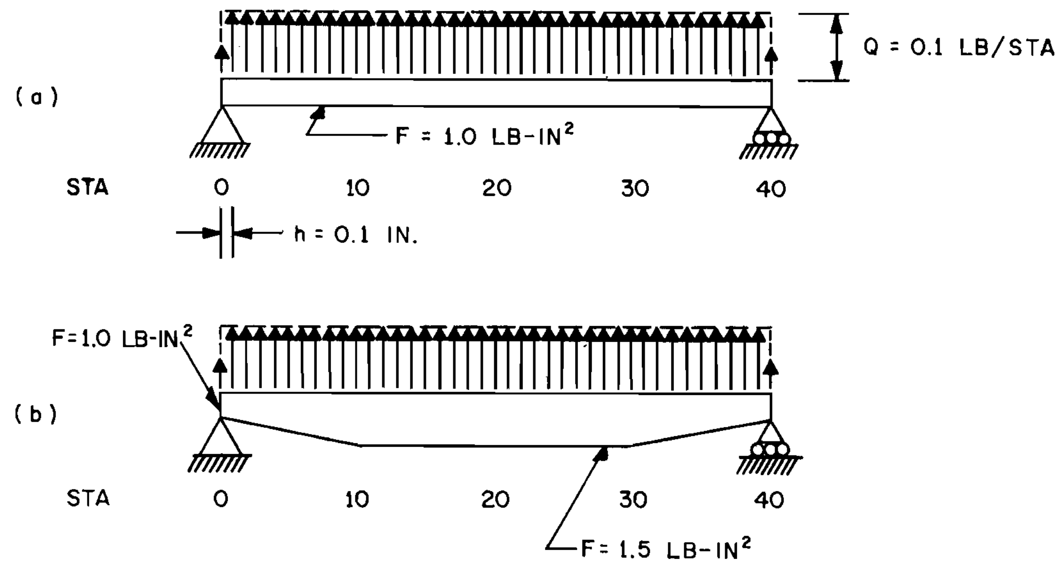
The first two examples are intended to provide the simplest possible introduction to the use of Program BMCOL 34, including the Guide for Data Input given in the preceding chapter. Example Problem 1A in Fig 11a is the same as that discussed in Chapter 3 and solved by hand in Fig 4, except that the beam now is divided into 40 increments. In Problem 1B, the flexural stiffness is varied along the length as indicated in Fig 11b.

Figure 11c shows the necessary information for these two problems as entered on a general-purpose 80-column form prior to key punching the data cards. A listing of the punched cards for these problems appears at the beginning of App 7.

Since both the load Q and the flexural stiffness F are constant for the full length of the beam in Problem 1A, they are entered together on the one card in Table 4. The only change in Problem 1B is that the flexural stiffness is increased. Therefore, options are exercised in Table 1 to hold Tables 2, 3, and 4 from Problem 1A. The increase in F is then distributed to storage at the various stations by linear interpolation according to the four-card sequence that is added to Table 4.

The output listings for these two problems are given at the beginning of App 8. Automatically plotted curves were called for in Table 1 of each problem but only those for Problem 1A are reproduced in Fig 12. The maximum deflection for Problem 1A is 3.335 in. which is only .06 percent more than the theoretically exact value of 3.333 in.

In both of these problems the results labelled dM/dx may be interpreted as the conventional beam shear since no external couples are applied nor developed by restraints. At the end stations, the value of dM/dx is one-half



(c)

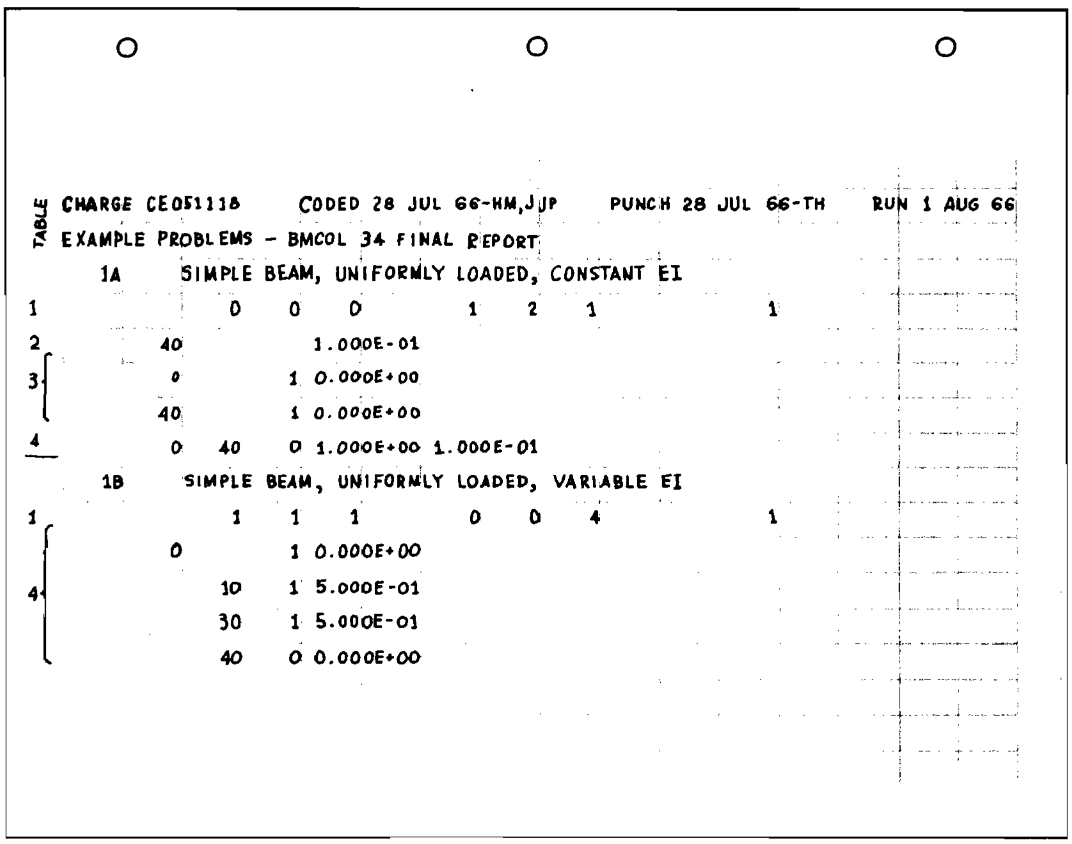


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TABLE CHARGE CE051118     CODED 28 JUL 66-HM,JJP     PUNCH 28 JUL 66-TH     RUN 1 AUG 66
      EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT
      1A      SIMPLE BEAM, UNIFORMLY LOADED, CONSTANT EI
1                 0    0    0         1    2    1              1
2          40                 1.000E-01
3           0              1  0.000E+00
           40              1  0.000E+00
4           0    40        0  1.000E+00 1.000E-01
      1B      SIMPLE BEAM, UNIFORMLY LOADED, VARIABLE EI
1                 1    1    1         0    0    4              1
            0              1  0.000E+00
4                10        1  5.000E-01
                 30        1  5.000E-01
                 40        0  0.000E+00
```

Fig 11. Example Problem 1A (40-increment beam) and Problem 1B (variable bending stiffness).

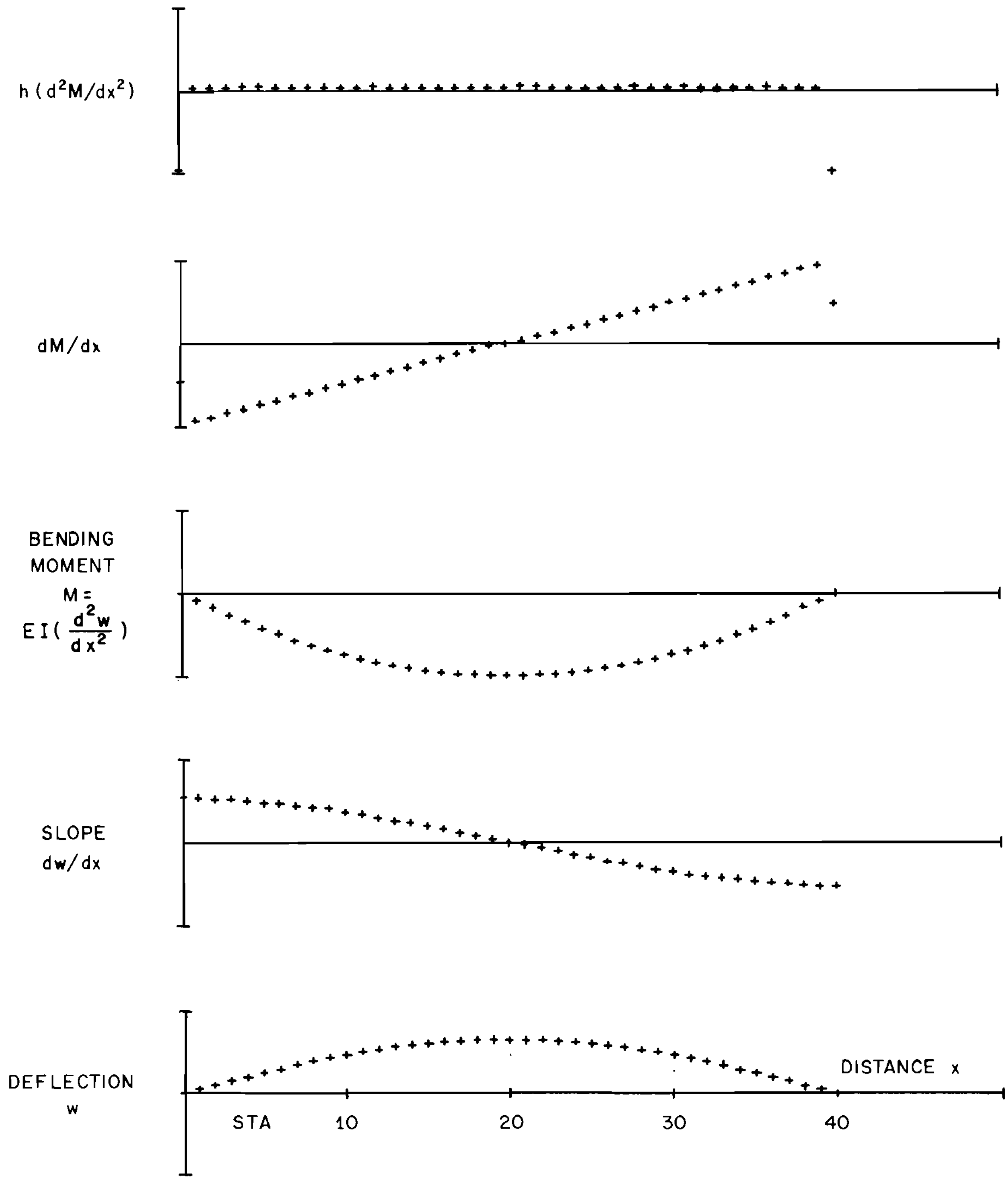

Fig 12. Automatically plotted curves from solution for Problem 1A.

the value of shear that would be expected just inside of each end support. This is a correct numerical approximation of the fact that the shear is being reduced from its full value to zero by the support reaction. Obviously, two values (zero and the full shear) cannot both appear at the end station; thus, the computed shear is zero at the station beyond the end, a half-value at the end station, and a full value at the first interior station. The tabulated results are consistent with the idea of half-values that must be entered at the ends of distributions of input data values, as discussed in Chapters 4 and 5.

As previously discussed, the net reactions are obtained by taking the numerical second derivatives of the computed bending moments (multiplied by increment length h). In the interior of each beam they are seen to agree with the input loads of +0.1 lb per station. At each end station, the value of -1.95 lb represents the algebraic sum of a half-value of load Q (+0.05 lb per station) and the support reaction of -2.00 lb. The negative sign represents a downward force or reaction.

Steel Bent Cap

Figure 13a shows a bent cap similar to some that are currently used in highway construction. The steel cap carries its own weight plus dead load and live load transferred from the roadway slab through stringers spaced at five-foot intervals. The live loading is asymmetric as might occur from some pattern of lane loadings. In accordance with current Texas Highway Department design practice, the bent cap is assumed to be simply supported; however, rotational restraints from supporting columns could have been included. Cover plates are added in the vicinity of the center support. For the beam-column solution, the bent cap was divided into 80 twelve-inch increments.

The resulting deflected shape was plotted from the listing in App 8 and is shown in Fig 13c. Figure 13d shows the computed bending moment curve for the bent cap. The maximum positive moment occurred in the more heavily loaded span and the maximum negative moment occurred at the interior support.

For problems similar to the above, the "hold-data" options in the program may be used to investigate variations of design parameters with a minimum of additional input data coding. Such parameters as the size and location of cover plates, the placement of supports, and the magnitude and location of

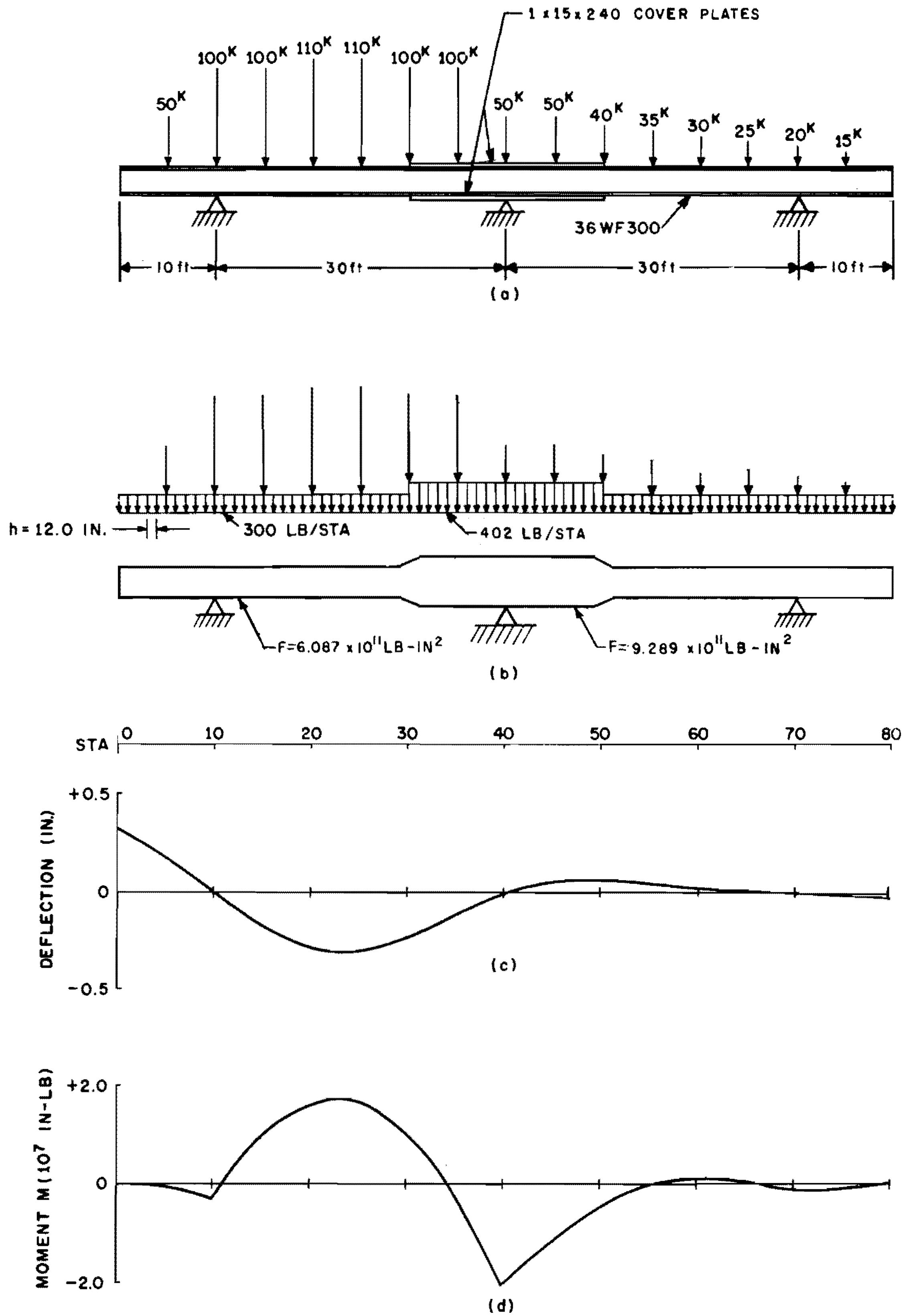

Fig 13. Example Problem 2: steel bent cap.

applied loads may be varied and their effects analyzed to determine the most efficient and economical design for the required loadings.

Multiple-Span Bridge

Figure 14a illustrates a problem taken from Ref 10 in which settlements of piers influence the bending and deflection of a bridge girder. The 10 spans are assumed to be supported near the ends by a rock foundation and in the middle by a compressible soil. In the present example, the soil behavior is represented by simple, independent, linear springs. Repeated solutions, with intermediate adjustments of the spring stiffnesses, could be applied to solve for nonlinear soil response or for the effects of the interaction of pressure bulbs on the settlements of adjacent footings.

Two hinges are shown, and haunches are used across the supports to represent cover plates on the girder. It is desired (1) to determine the effect of dead load on the settlement of supports and on the bending moments throughout the structure and (2) to observe the effects of the dead load and dead-load settlements combined with a live load whose duration is not enough to produce any significant additional settlement.

The structure, as modeled in the beam-column solution, is shown in Fig 14b. It has been divided into 100 increments, each 8 ft in length. In the middle zone, the linear spring at each column represents the soil support, and the angular restraint provided by the rigidly connected columns is indicated by a spiral spring. The flexural stiffness variations are shown; also, the two hinges are modeled by simply setting the flexural stiffness equal to zero at the proper station.

The solid curve in Fig 14c shows the deflected shape of the structure and the settlement at each central support caused by the dead load. Zero deflections were specified for the piers founded on rock. Settlements of approximately 0.5 inch occurred at each of the five central columns. The solid curve in Fig 14d shows the corresponding dead-load bending moments. The maximum negative moment occurred at the first interior support, and a moment of zero occurred at each of the two hinges.

To study the effects of a temporary live load, the five central supports were locked at the deflections previously found by the dead-load solution, and then the live load shown in Fig 14a was added to the dead-load values. The

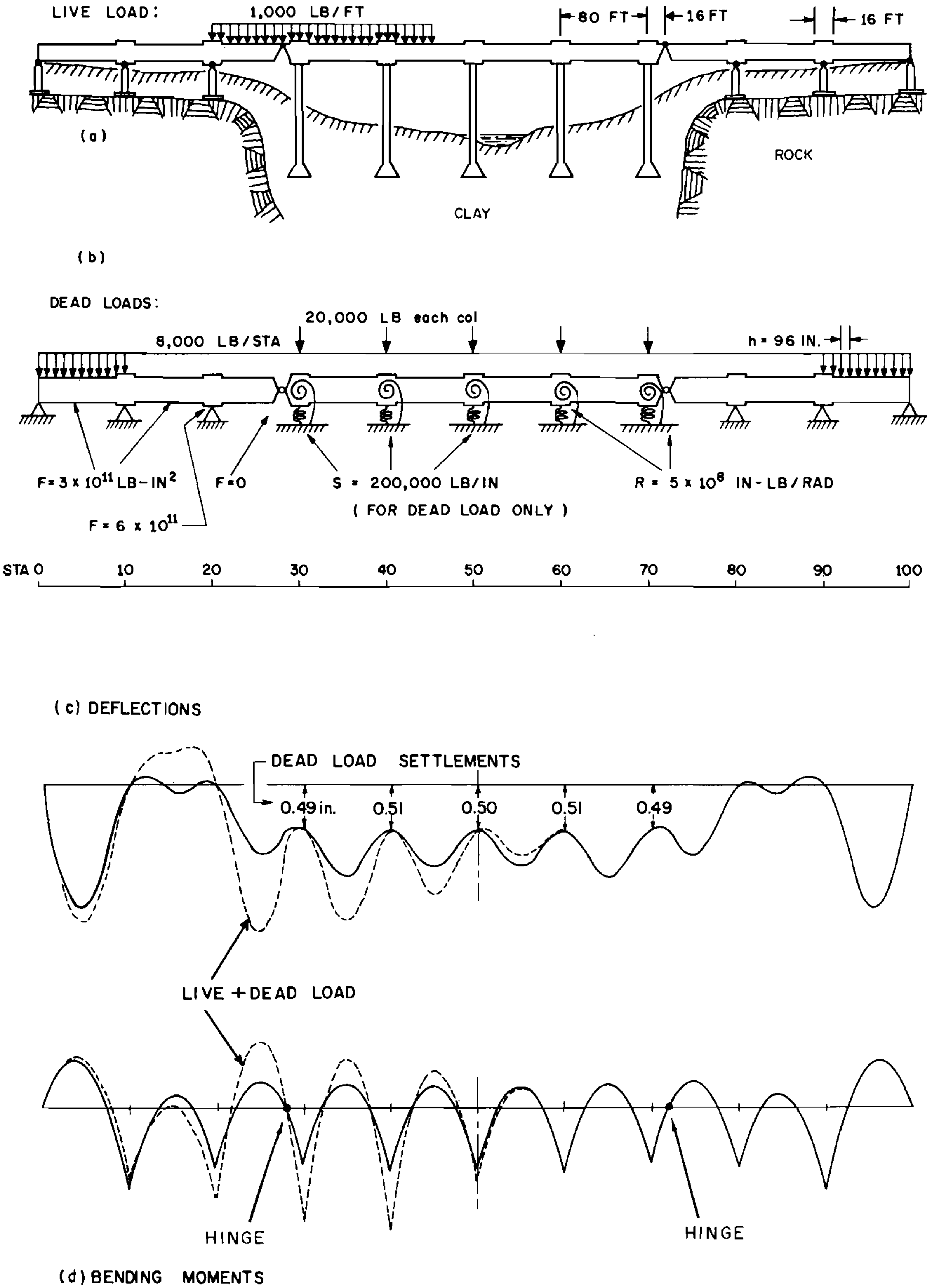

Fig 14. Example Problems 3A and 3B: solution of girder-type bridge considering both dead-load and live-load effects.

resulting deflection and bending moment curves are given as dashed lines. It would be relatively easy to move the live load and repeat the solution until the most critical position is found.

Braced Trench

Figure 15a shows a braced trench that is 120 inches wide. The trench is lined with continuous sheet piling, with wales arranged so that the soil pressure on each five-foot length of trench is transferred to timber struts located at the third points of the trench depth. The applied lateral soil pressure is assumed to be as shown in Fig 15b, and the restraint provided by the toe of the sheet piling is simulated by a series of springs whose stiffness varies in simple proportion to depth. For the beam-column solution, the sheet piling was divided into 40 twelve-inch increments.

Figure 15c shows the deflected shape resulting from the computer solution. The maximum deflection occurred in the region of the trench bottom, and the lower trench brace was also compressed significantly under a reaction of -57,160 lb. This value may be obtained either as the net reaction of -53,860 lb at Sta 20 corrected for the soil load of +3,300 lb/sta or, otherwise, as the computed deflection of 0.2141 inch multiplied by the brace stiffness of 267,000 lb/in.

The resulting bending moment diagram is shown in Fig 15d. The maximum moments occurred near the point of greatest sheet piling deflection and at the lower trench brace.

As shown in Fig 15c, a large toe deflection has occurred, as well as excessive deformation and loading of the lower trench brace. This indicates that the design assumed is unsatisfactory. In actual practice, more beam-column solutions would be made using combinations of stiffer sheet piling, greater depth of toe embedment, more braces, or different spacing of the existing braces to effect a more efficient and stable design for final use. Sets of such solutions can be made with a minimum of additional input data coding by use of the options to hold data from problem to problem.

Problems of this type with nonlinear soil pressure and restraint characteristics may also be solved in a similar manner (Refs 9 and 11).

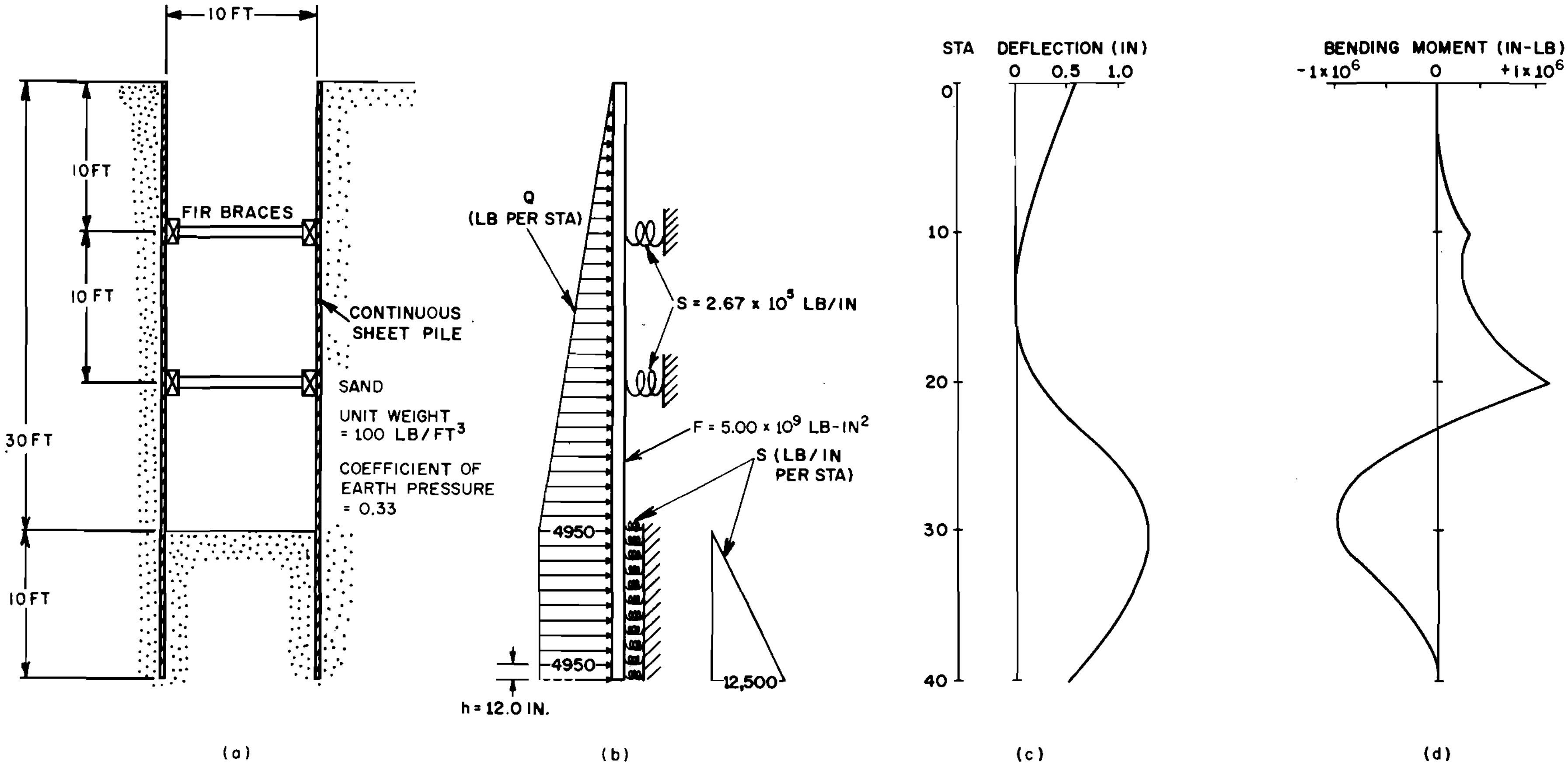

Fig 15. Example Problem 4: solution of a typical 5-foot section of braced trench.

Buckling of a Long Pile-Column

To illustrate the use of the general beam-column procedure to solve elastic buckling problems by incremental variation of axial load, the problem shown in Fig 16 has been selected. Previous methods for determining the effective length of a column partially embedded in soil have involved various methods of approximation. Because the degree of end restraint is a critical factor in determining buckling loads, such approximations may lead to considerable error.

The structure selected is shown in Fig 16a. The pile chosen is one of a group supporting a bent cap and driven to rock through a soft riverbed deposit. The beam-column model used in the solution is shown in Fig 16b. The spiral spring at the pile top represents the angular restraint provided by the bent cap. The soil characteristics are represented by the series of linear springs. Just as required by a real column, some eccentricity or applied lateral force is required to initiate the buckling process. As shown in Fig 16b, an eccentricity of one inch in axial-load application is assumed at the pile top, and a lateral current force is also applied to the pile.

Figure 16c shows a plot of maximum pile deflection (occurring at the pile top) versus applied axial load. In addition, the deflected shape and corresponding bending moments at an intermediate load are shown. When the axial load is increased progressively to values near the critical buckling load, the pile deflections increase more and more rapidly. On passing the critical buckling load, the process is mathematically discontinuous, and the sign of deflections reverses suddenly as the region of unstable equilibrium is entered. The reversal in signs of deflections can be seen by comparing the results for Problems 5J and 5K in App 8.

With this procedure, the complete column is modeled and solved at one time and no equivalent pinned-end length or point-of-fixity assumptions are necessary. Nonlinear behavior of both the soil and the pile also may be considered in the solution of such problems (Ref 12).

The method is not limited to soil-supported elements, but can be applied to a wide variety of problems of axial-load buckling.

Rigid-Frame Bent

The example in Fig 17 is included to illustrate the applicability of the BMCOL method to certain aspects of the solution of simple frames. If it can be

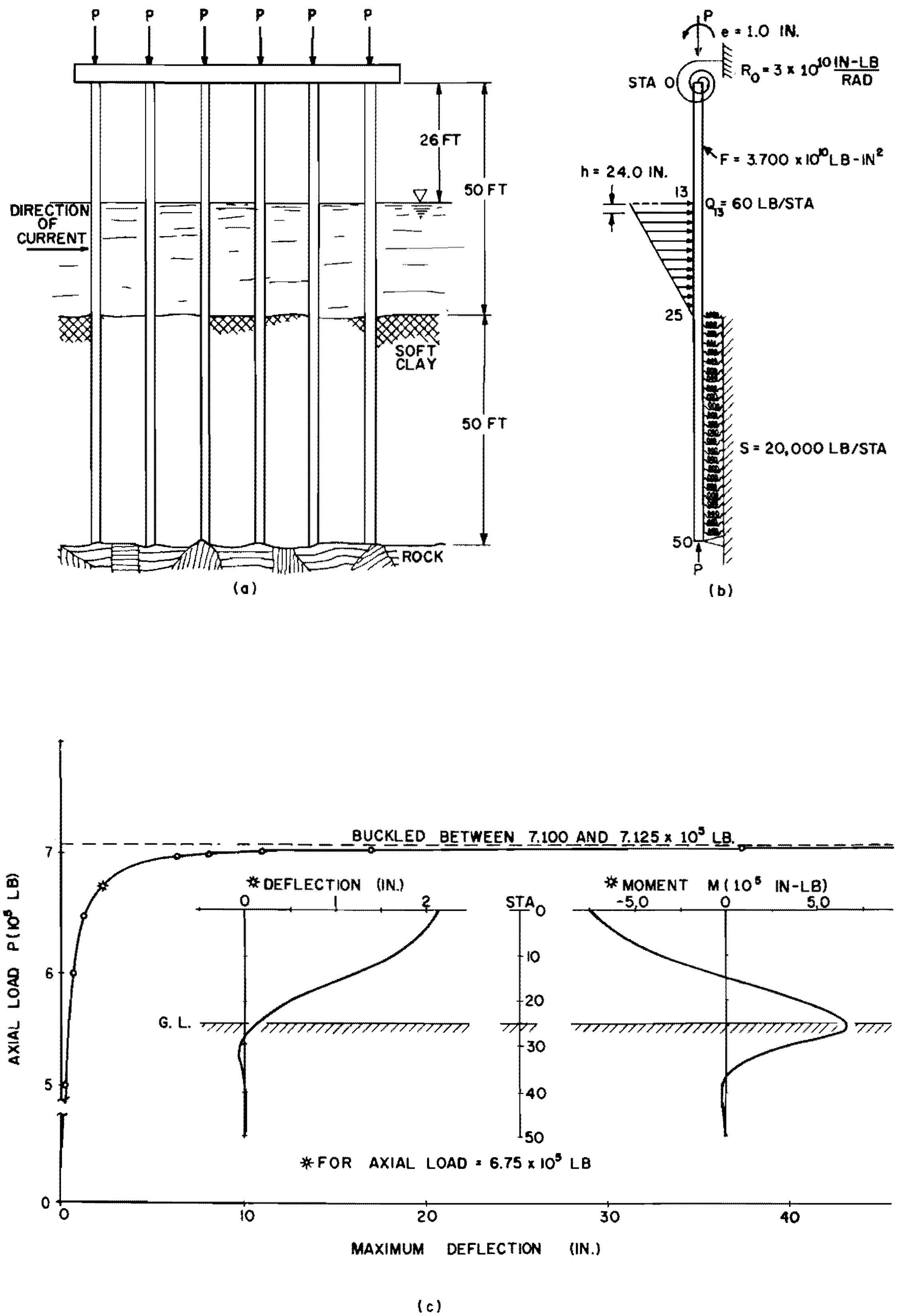

Fig 16. Example Problem 5: buckling of a long pile.

assumed that no translation (sidesway) occurs at the joints, and if the bending deflections caused by axial-load effects are negligible, the rigid-frame bent in Fig 17a can be represented for solution as the continuous member shown in Fig 17b. Axial loads could also be included, but a rigorous treatment would require repeated solution with new axial-load values being determined after each trial and applied in the next solution until satisfactory closure is established. In the current problem, as in many others, the effects of axial load on bending are very small and the conventional practice of neglecting them is entirely appropriate. (Whether or not they are included in the bending analysis, axial loads normally would still be included in computing stresses on any given section.)

The example is intended to represent a hypothetical grade-separation structure where live loads are produced by railway wheel loadings. A slice of the structure five feet thick is analyzed as the two-dimensional frame shown and is assumed to carry one set of tracks. Additional transverse loads occur from the dead weight of the structure and from the adjoining fill. The columns are assumed to be fixed against rotation at the bottom. They could just as easily have been represented as partially restrained.

The flexural stiffness variation for the tapered haunches is approximated by a series of straight-line variations, as indicated in Fig 17b.

The resulting deflections are shown in Fig 17c and the bending-moment diagram is given in Fig 17d. To determine the most critical loading condition, a series of similar solutions could be performed, with the live load shifted in position each time.

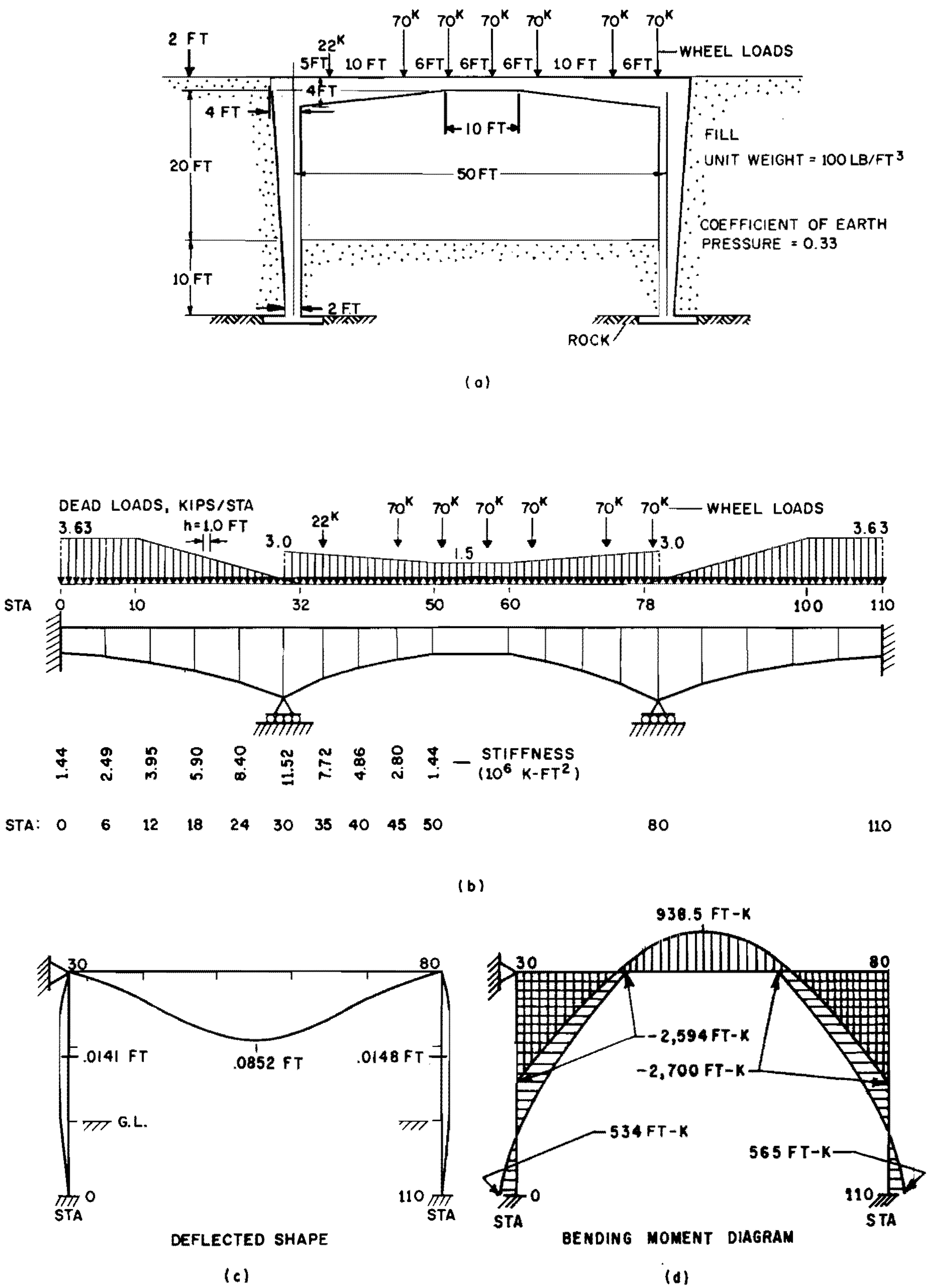

Fig 17. Example Problem 6: rigid-frame bent (with no sidesway).

CHAPTER 7. USE OF THE BMCOL METHOD

Summary

The beam-column solution which has been described provides for direct analytical simulation of a wide variety of problems in structural bending or buckling. The principal features of the approach are summarized as follows:

(1) Equations are derived in such a way that all data for beam stiffness and for loads and supports may be varied independently at each increment point along the beam-column.

(2) The expressions provide exact mathematical correspondence to a mechanical finite-element beam-column model which may be used as an aid for engineering visualization and interpretation.

(3) A direct two-pass method is used which achieves maximum computational efficiency in solution of the equations for elastic beam-columns.

Use of the method in design tends to promote the application of engineering judgment and decision while minimizing the time spent in tedious calculations. Its generality (within stated bounds) allows a reduction in the usual efforts to adapt conventional special-case solutions in mechanics to complex problems.

Once the basic data for a problem have been determined and coded, variations of individual parameters are quite simple to introduce and the effects of a wide range of variables can be evaluated with a minimum of additional effort.

Recommendations Pertaining to the Use of BMCOL 34

This report and Program BMCOL 34 are intended to provide a basic version of the general beam-column method, both for immediate application in design and to serve as a basis for future developments. Users will no doubt find it desirable to adapt the program to many specific purposes. Modifications are therefore to be expected and even encouraged, subject only to correct interpretation and application of the concepts and principles.

The basic method is relatively simple, but it is somewhat different in approach from conventional techniques. It should be thoroughly understood and careful attention should be paid to the detailed rules and instructions for coding of problems. Sign conventions for all input data quantities are particularly important.

Those who are interested in using this method to solve their own problems are urged to practice first with some of the example problems in this report. Subsequently, the user will find it possible to extend the method to many other types of problems. In any new area of application, it is important that results be compared with known correct solutions from generally similar problems.

One particularly interesting area of application appears to be where the designer wishes to vary significant parameters through reasonable ranges and thereby optimize his designs. With the convenience and economy of making multiple computer solutions, such an approach becomes feasible.

Extensions of the Basic Method

The example problems have indicated a wide range of application of the method. A number of additional uses are suggested below.

(1) Problems involving nonlinear loads and supports may be solved by the use of techniques in which the nonlinear loads and supports are represented by load-deformation curves; and multiple trial-and-adjustment solutions are made until a final, stable solution is achieved (Refs 9 and 11).

(2) The method described is being used in the development of a design-oriented computer program to analyze bent caps under complex highway loading conditions (Ref 13).

(3) The method is being successfully applied as a key technique in an alternating-direction solution of generalized grid-beam and slab systems (Ref 14).

(4) It appears to be feasible and expedient to use the present method as an element in the solution of more complex structural frames.

(5) Problems in inelastic bending may be handled by adjusting the nonlinear flexural stiffness F between trial solutions in much the same way as nonlinear loads and supports may be treated (Refs 12 and 15).

(6) The BMCOL method can be used as the key element in the solution of problems involving time-dependent response to dynamic loadings (Ref 16). Extensions to slabs and grids and pavements appear to be quite feasible.

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APPENDIX 1

CENTRAL-DIFFERENCE APPROXIMATIONS

APPENDIX 1. CENTRAL-DIFFERENCE APPROXIMATIONS

The methods of analysis in this report are based on a finite-element mechanical model that approximates real structural members. The most nearly equivalent approximations of conventional numerical analysis are the central-difference forms used to express continuous functions and their derivatives. Central-difference expressions for four orders of derivatives are of interest in beam-column problems. They are developed and illustrated below. Mathematically rigorous derivations and proofs are available in almost any standard text on numerical analysis and usually include appropriate consideration of error terms. However, for present purposes, the validity of the approximations may be accepted intuitively. For example, it is easy to see from Fig A1.1 that the slope of the curve at Station i may be closely approximated by a secant drawn through points on the curve at the two adjacent stations. It is also obvious that the errors tend to decrease as the increment length is reduced. The resulting approximation for the first derivative is

$$\left(\frac{dw}{dx}\right)_i \approx \frac{-w_{i-1} + w_{i+1}}{2h} \qquad \text{(A1.1)}$$

For higher derivatives, the process could be repeated by taking simple differences and dividing by 2h each time. However, to keep the system more compact, temporary stations j and k are considered with slopes at these points computed on the basis of half-spaces. The second derivative is then written as the difference between these slopes, divided by one increment length. The result is as follows:

$$\left(\frac{d^2w}{dx^2}\right)_i \approx \frac{-\left(\frac{dw}{dx}\right)_j + \left(\frac{dw}{dx}\right)_k}{h} = \frac{\frac{-(-w_{i-1} + w_i)}{h} + \frac{(-w_i + w_{i+1})}{h}}{h}$$

$$= (w_{i-1} - 2w_i + w_{i+1})/h^2 = 2\delta/h^2 \qquad \text{(A1.2)}$$

Proceeding in a similar way, the third derivative is approximated by

$$\left(\frac{d^3w}{dx^3}\right)_i \approx \frac{-\left(\frac{d^2w}{dx^2}\right)_{i-1} + \left(\frac{d^2w}{dx^2}\right)_{i+1}}{2h}$$

$$= \frac{-\frac{(w_{i-2} - 2w_{i-1} + \cancel{w_i})}{h^2} + \frac{(\cancel{w_i} - 2w_{i+1} + w_{i+2})}{h^2}}{2h}$$

$$= (-w_{i-2} + 2w_{i-1} - 2w_{i+1} + w_{i+2}) \Big/ 2h^3 \qquad \text{(A1.3)}$$

and the fourth derivative is

$$\left(\frac{d^4w}{dx^4}\right)_i \approx \frac{\left(\frac{d^2w}{dx^2}\right)_{i-1} - 2\left(\frac{d^2w}{dx^2}\right)_i + \left(\frac{d^2w}{dx^2}\right)_{i+1}}{h^2}$$

$$= \frac{(w_{i-2}-2w_{i-1}+w_i) - 2(w_{i-1}-2w_i+w_{i+1}) + (w_i-2w_{i+1}+w_{i+2})}{h^4}$$

$$= \frac{w_{i-2} - 4w_{i-1} + 6w_i - 4w_{i+1} + w_{i+2}}{h^4} \qquad \text{(A1.4)}$$

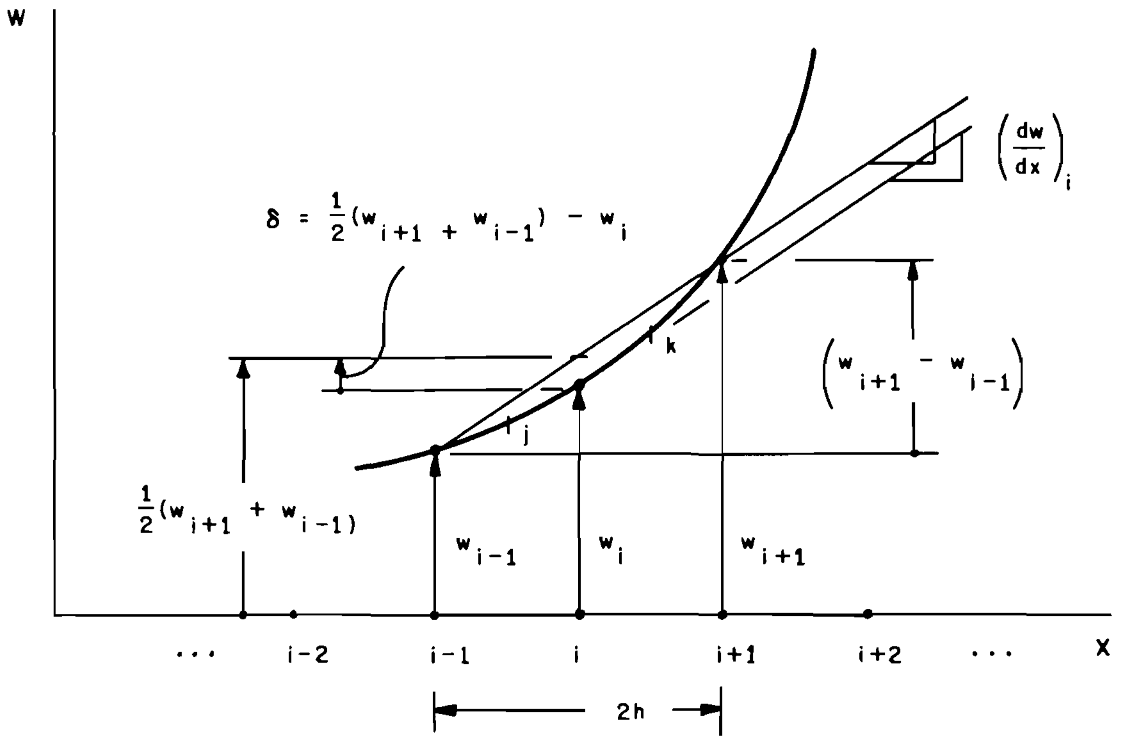


Fig A1.1. Geometric basis for central-difference approximations.

APPENDIX 2

DERIVATION FOR RECURSIVE SOLUTION OF EQUATIONS

APPENDIX 2. DERIVATION FOR RECURSIVE SOLUTION OF EQUATIONS

Any of the fourth-order difference equations for beams or beam-columns may be written in the following form:

$$a_i w_{i-2} + b_i w_{i-1} + c_i w_i + d_i w_{i+1} + e_i w_{i+2} = f_i \qquad \text{(A2.1)}$$

Definitions of the coefficients a_i through f_i will vary according to the particular beam formulation considered. The general process of simultaneous solution of a complete system of such equations will be the same in any case. The matrix formed by writing coefficients a_i through e_i at all stations has non-zero terms only along the five main diagonals, and the most efficient method of solution is therefore a direct process that amounts to simple Gaussian elimination. In a forward pass, two unknowns are eliminated from each equation, resulting in a triangularized coefficient matrix of only three diagonals. On the reverse pass, the solution is completed by back substitution.

The necessary recursion equations for the process are derived below.

Assume (temporarily) that w_{i-2} and w_{i-1} can be eliminated so that w_i can be written in terms of deflections at two stations to the right. In general

$$w_i = A_i + B_i w_{i+1} + C_i w_{i+2} \qquad \text{(A2.2)}$$

Writing equations of this form for w_{i-2} and w_{i-1},

$$w_{i-2} = A_{i-2} + B_{i-2} w_{i-1} + C_{i-2} w_i \qquad \text{(A2.3)}$$

$$w_{i-1} = A_{i-1} + B_{i-1} w_i + C_{i-1} w_{i+1} \qquad \text{(A2.4)}$$

Substituting Eqs A2.3 and A2.4 into Eq A2.1,

$$a_i\left[A_{i-2} + B_{i-2}\,(A_{i-1} + B_{i-1} w_i + C_{i-1} w_{i+1}) + C_{i-2} w_i\right]$$

$$+ b_i\,(A_{i-1} + B_{i-1} w_i + C_{i-1} w_{i+1})$$

$$+ c_i w_i + d_i w_{i+1} + e_i w_{i+2} = f_i \qquad \text{(A2.5)}$$

Multiplying and collecting terms,

$$(a_i B_{i-2} B_{i-1} + a_i C_{i-2} + b_i B_{i-1} + c_i)\, w_i$$

$$+ (a_i B_{i-2} C_{i-1} + b_i C_{i-1} + d_i)\, w_{i+1}$$

$$+ (e_i)\, w_{i+2} = f_i - (a_i A_{i-2} + a_i B_{i-2} A_{i-1} + b_i A_{i-1}) \qquad \text{(A2.6)}$$

Eq A2.6 can be rewritten in the form assumed in Eq A2.2:

$$w_i = A_i + B_i w_{i+1} + C_i w_{i+2} \qquad \text{(A2.7)}$$

where

$$A_i = D_i\,(E_i A_{i-1} + a_i A_{i-2} - f_i) \qquad \text{(A2.7a)}$$

$$B_i = D_i\,(E_i C_{i-1} + d_i) \qquad \text{(A2.7b)}$$

$$C_i = D_i\,(e_i) \qquad \text{(A2.7c)}$$

and where

$$D_i = -1/(E_i B_{i-1} + a_i C_{i-2} + c_i) \qquad \text{(A2.7d)}$$

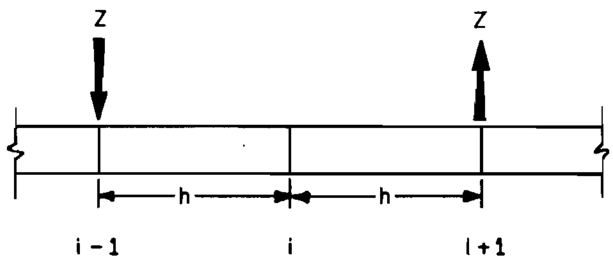
$$E_i = a_i B_{i-2} + b_i \qquad \text{(A2.7e)}$$

For beam and beam-column problems, the coefficients A_i, B_i, and C_i can be thought of as expressing the physical continuity of the system. In these coefficients all of the known input data are digested and stored. The coefficients at any one station depend not only on the load and stiffness data at that station but also on effects from all previous stations. These coefficients have therefore been termed "Continuity Coefficients."

APPENDIX 3

DERIVATIONS FOR SPECIAL EQUATIONS TO ESTABLISH A SPECIFIED SLOPE

APPENDIX 3. DERIVATIONS FOR SPECIAL EQUATIONS TO ESTABLISH A SPECIFIED SLOPE



It is desired to manipulate Continuity Coefficients A, B, and C (discussed in Chapter 3) so that a required slope θ_i will be enforced at Station i, without any net lateral force being created which would tend to cause deflection at Station i. It is therefore necessary to apply two unknown but equal and opposite forces Z at Stations i-1 and i+1. The resulting couple = 2Zh must be exactly that required to tilt the beam to the desired slope. The actual value of Z cannot possibly be known until the entire solution is completed, since it will depend on all loads and restraints that may act on the beam; fortunately, Z may be eliminated from the equations that are developed. Nevertheless, it should be clear that the required manipulations of the regular equations must be done within the regular recursion sequence so that both physical and mathematical continuity of the fabric of the process will be maintained.

The following procedure is considered in development of the necessary equations:

(1) Compute regular Continuity Coefficients A_{i-1}, B_{i-1}, C_{i-1}.

(2) Immediately revise by adding the effect of the unknown force Z to the regular recursion equation (Eq A3.2) for w_{i-1}. This equation is arranged so that the slope

$$\theta_i = (-w_{i-1} + w_{i+1}) / 2h \qquad \text{(A3.1)}$$

(3) Obtain an expression for the force Z , plus revised Continuity Coefficients A'_{i-1}, B'_{i-1}, and C'_{i-1}.

(4) Proceed with regular recursion formulas using the <u>revised</u> Continuity Coefficients from Station i-1, and compute usual coefficients at Station i and i+1.

(5) With the expression for Z previously obtained at Station i-1, add the effect of an equal but opposite force at Station i+1 and thereby revise the Continuity Coefficients to A'_{i+1}, B'_{i+1}, and C'_{i+1}.

In accordance with the procedure outlined above, the following derivation is given. In the general recursion equation for w_i ,

$$w_i = A_i + B_i w_{i+1} + C_i w_{i+2} \quad \text{(A3.2)}$$

a lateral load Q is introduced at Station i only through the load term f_i as follows:

$$A_i = D_i \, (E_i A_{i-1} + a_i A_{i-2} - f_i) \quad \text{(A3.3)}$$

where

$$f_i = h^3 Q_i \text{ , possibly plus other terms.} \quad \text{(A3.4)}$$

Thus, a load equal to -Z may be introduced at Station i-1 by combining its effect with the regular A_{i-1} .

$$w_{i-1} = \left[A_{i-1} + D_{i-1} \, (h^3 Z) \right] + B_{i-1} w_i + C_{i-1} w_{i+1} \quad \text{(A3.5)}$$

To achieve the specified slope θ_i it is required by Eq A3.1 that

$$w_{i-1} = -2h\theta_i + 0 + w_{i+1} \quad \text{(A3.6)}$$

According to the form of Eq A3.2, the finally applicable Continuity Coefficients therefore must be

$$A'_{i-1} = -2h\theta_i, \quad B'_{i-1} = 0, \quad C'_{i-1} = 1.0 \quad \text{(A3.7)}$$

To find an expression for the force Z , Eqs A3.5 and A3.6 are combined and w_{i-1} is eliminated.

$$Z = \left[-1/h^3 D_{i-1}\right] \left[+ (A_{i-1} + 2h\theta_i) + (B_{i-1})w_i + (C_{i-1} - 1)w_{i+1}\right] \tag{A3.8}$$

Considering that the load Z has already been applied at Station i-1, the coefficients at Station i are computed in the regular manner using the revised Continuity Coefficients at Station i-1 (unless the deflection at Station i is also specified, in which case the coefficients are reset to A_i = specified w, $B_i = 0$, $C_i = 0$).

Upon reaching Station i+1, the regular recursion equations are again applied to compute temporary values of Continuity Coefficients A_{i+1}, B_{i+1}, and C_{i+1}. The revised values at Station i-1 are again used.

The deflection w_i may be eliminated from Eq A3.8 by substituting Eq A3.2. Collecting terms, the expression for the force Z is

$$Z = \left[-1/h^3 D_{i-1}\right] \left[(A_{i-1} + 2h\theta_i + B_{i-1} A_i) + (B_{i-1}B_i + C_{i-1} - 1)w_{i+1} + B_{i-1}C_i w_{i+2}\right] \tag{A3.9}$$

Next, a load equal to $+Z$ is applied at Station i+1. The equation for w_{i+1} becomes

$$w_{i+1} = \left[A_{i+1} - D_{i+1}(h^3 Z)\right] + B_{i+1}w_{i+2} + C_{i+1}w_{i+3} \tag{A3.10}$$

Eliminating Z by substituting Eq A3.9 into Eq A3.10, and then rearranging,

$$\begin{aligned} w_{i+1}\left[1 - (D_{i+1}/D_{i-1})(B_{i-1}B_i + C_{i-1} - 1)\right] &= \left[A_{i+1} + (D_{i+1}/D_{i-1})(A_{i-1} + 2h\theta_i + B_{i-1} A_i)\right] \\ &+ \left[B_{i+1} + (D_{i+1}/D_{i-1}) B_{i-1}C_i\right] w_{i+2} \\ &+ \left[C_{i+1}\right] w_{i+3} \end{aligned} \tag{A3.11}$$

Eq A3.11 may be rewritten as

$$w_{i+1} = A'_{i+1} + B'_{i+1}w_{i+2} + C'_{i+1}w_{i+3} \tag{A3.12}$$

where the three coefficients are

$$A'_{i+1} = D'_{i+1} \left[A_{i+1} + (D_{i+1}/D_{i-1})(A_{i-1} + 2h\theta_i + B_{i-1}A_i) \right] \quad (A3.12a)$$

$$B'_{i+1} = D'_{i+1} \left[B_{i+1} + (D_{i+1}/D_{i-1})\, B_{i-1}C_i \right] \quad (A3.12b)$$

$$C'_{i+1} = D'_{i+1} \left[C_{i+1} \right] \quad (A3.12c)$$

and where

$$D'_{i+1} = +1/ \left[1 - (D_{i+1}/D_{i-1})(B_{i-1}B_i + C_{i-1} - 1) \right] \quad (A3.12d)$$

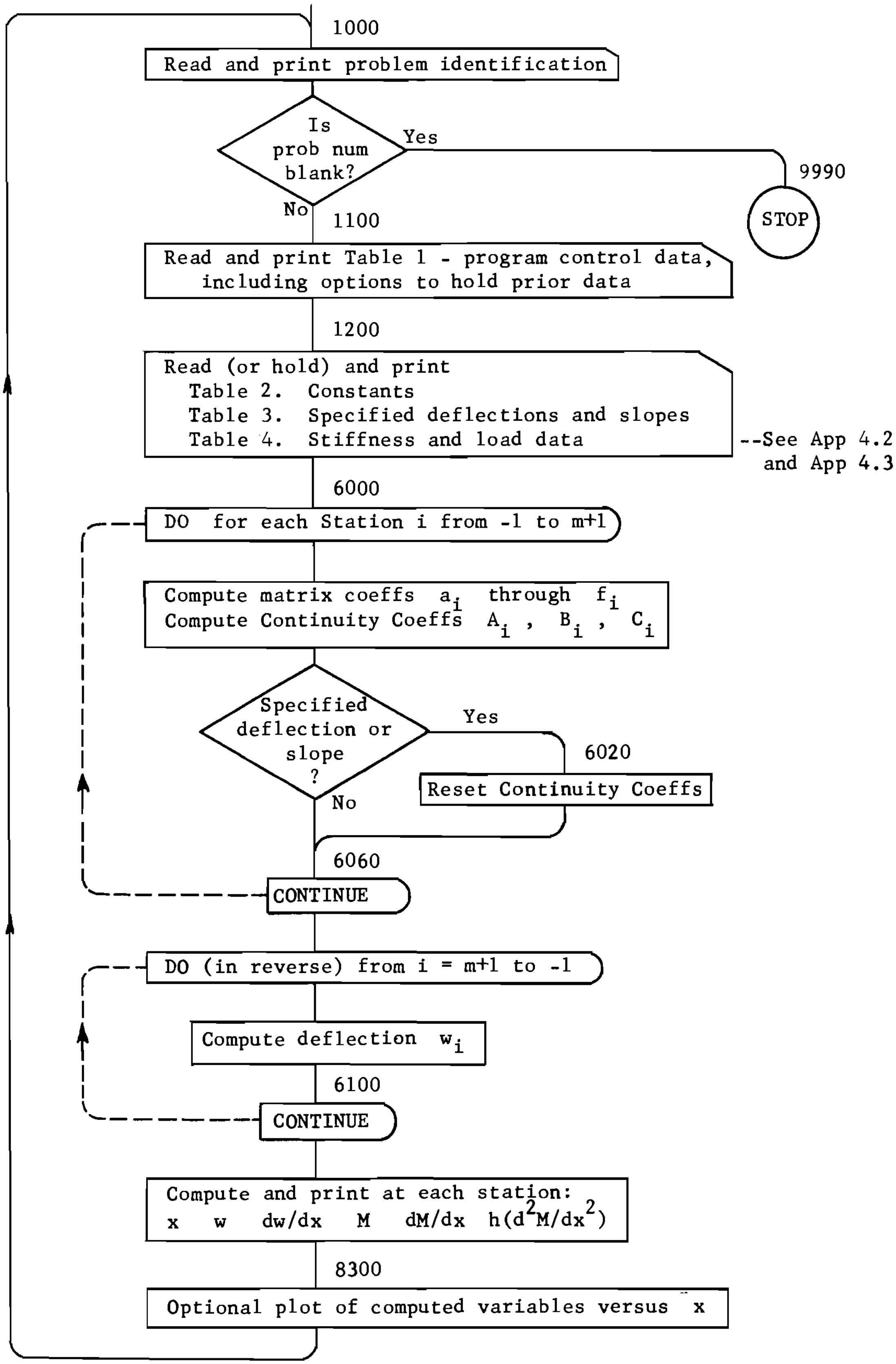
The Continuity Coefficients A_{i-1} , B_{i-1} , and C_{i-1} , and also the value D_{i-1} used in Eqs A3.12a through A3.12d, are the original non-revised values. The Continuity Coefficients A_i , B_i , and C_i used in Eqs A3.12a through A3.12d are those coefficients computed which considered the effect of the load at Station i-1.

Thus, Eqs A3.12a through A3.12d give the revised Continuity Coefficients at Station i+1 which are needed to complete the process of establishing the desired slope at Station i.

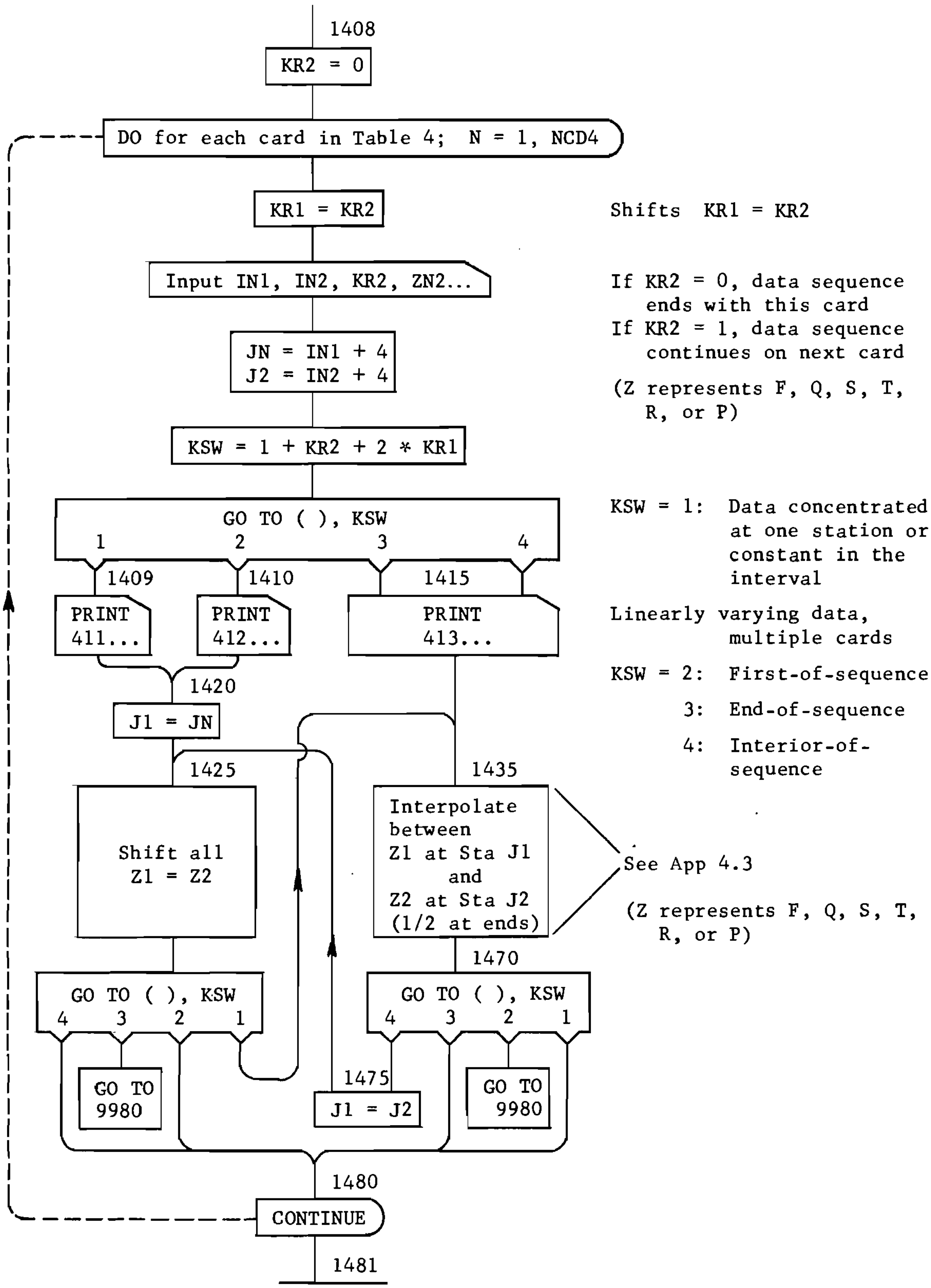
APPENDIX 4

FLOW DIAGRAMS FOR PROGRAM BMCOL 34

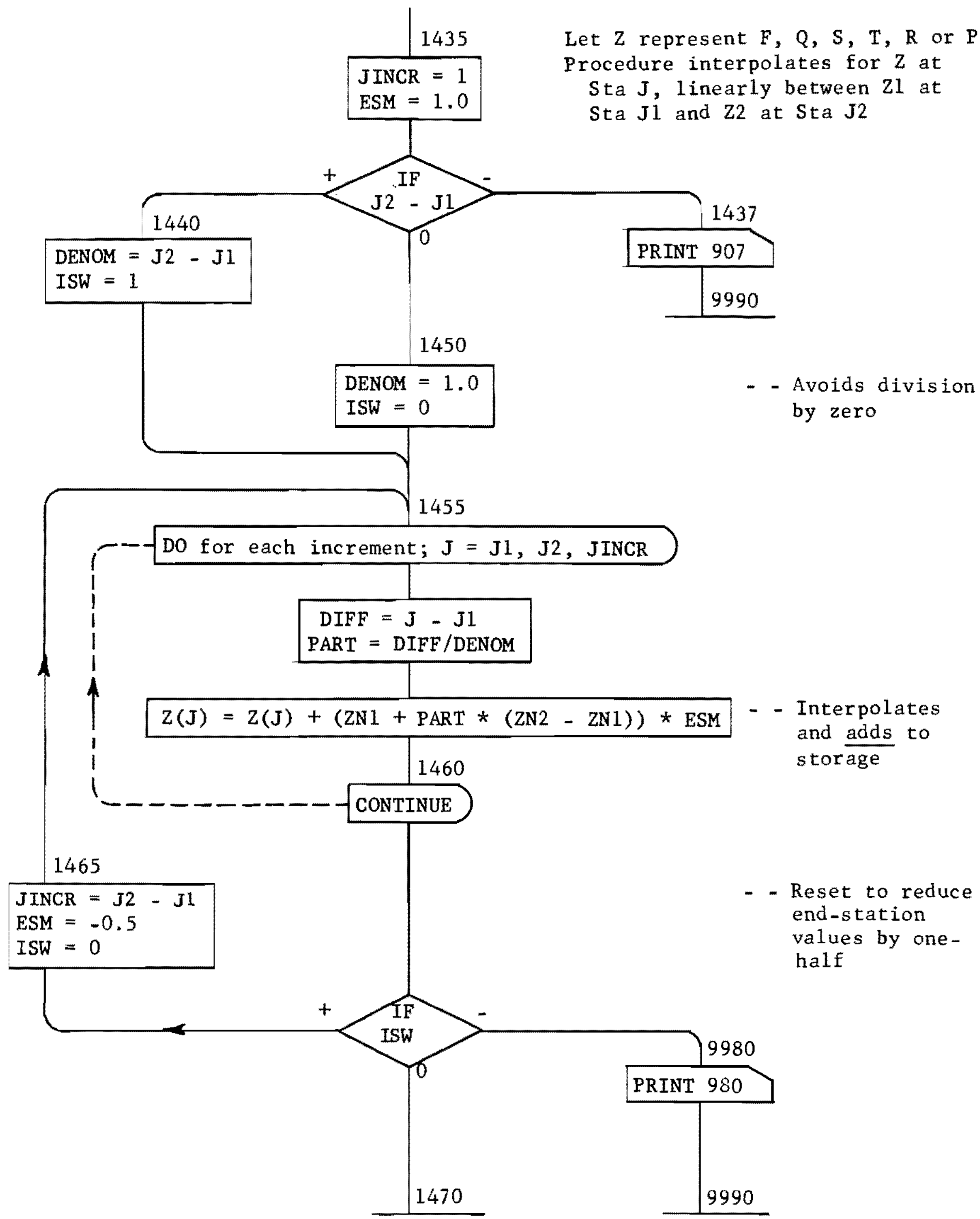
APPENDIX 4.1. SUMMARY FLOW DIAGRAM FOR THE BEAM-COLUMN PROGRAM



APPENDIX 4.2. PROCEDURE FOR TABLE 4 INPUT



APPENDIX 4.3. TABLE 4 INTERPOLATION AND DISTRIBUTION



APPENDIX 5

GLOSSARY OF NOTATION FOR BMCOL 34

```
C-----NOTATION FOR BMCOL 34                                                20NO4
C          AA                   COEFF IN STIFFNESS MATRIX                  12JE3
C          A(J), ATEMP, AREV    CONTINUITY COEFFICIENT                     12JE3
C          AN1(N), AN2(N)       IDENTIFICATION AND REMARKS(ALPHA-NUM)      01MY6
C          BB                   COEFF IN STIFFNESS MATRIX                  12JE3
C          B(J), BTEMP, BREV    CONTINUITY COEFFICIENT                     12JE3
C          BM                   BENDING MOMENT AT STA J                    23MR4
C          CC                   COEFF IN STIFFNESS MATRIX                  12JE3
C          C(J), CTEMP, CREV    CONTINUITY COEFFICIENT                     12JE3
C          D, DTEMP, DREV       MULTIPLIER IN CONTINUITY COEFF EQS         12JE3
C          DBM                  FIRST DERIV OF BENDING MOMENT, DM/DX       07JE3
C          DD                   COEFF IN STIFFNESS MATRIX                  12JE3
C          DENOM                DENOMINATOR                                07JE3
C          DIFF                 DIFFERENCE                                 12JE3
C          DW                   FIRST DERIV OF BMCOL DEFL, DW/DX           07JE3
C          DWS( )               VALUE OF SPECIFIED SLOPE DW/DX             04JE3
C          E                    TERM IN CONTINUITY COEFF EQS               12JE3
C          EE                   COEFF IN STIFFNESS MATRIX                  12JE3
C          ESM                  MULTIPLIER FOR HALF VALUES AT END STAS     07JE3
C          FF                   COEFF IN LOAD MATRIX                       12JE3
C          FN1, FN2, F(J)       FLEXURAL STIFFNESS (EI) (INPUT AND TOTAL)  12JE3
C          H                    INCREMENT LENGTH                           12JE3
C          HE2                  H SQUARED                                  12JE3
C          HE3                  H CUBED                                    12JE3
C          HT2                  H TIMES 2                                  12JE3
C          I, IN1, IN2, ISTA    EXTERNAL STA NUMBER = J - 4                10JE3
C          ISW                  ROUTING SWITCH FOR TABLE  4                27SE3
C          ITEST                PARAMETER TO STOP PROGRAM (5H      )       01MY6
C          J, JN                INTERNAL STA NUM =  I + 4                  12JE3
C          J1, J2               INITIAL AND FINAL STATIONS IN SEQUENCE     05JE3
C          JINCR                INCREMENTATION INDEX                       12JE3
C          JS                   STA OF SPECIFIED DEFLECTION OR SLOPE       05JE3
C          KASE                 CASE NUM FOR SPECIFIED CONDITIONS          07JE3
C          KEEP2 THRU KEEP4     IF = 1, KEEP PRIOR DATA, TABLES 1-4        24JL3
C          KEY(J), KEYJ         ROUTING SWITCH FOR SPECIFIED CONDITIONS    11JE3
C          KPLOT                OPTION TO PLOT,                            23JE4
C                               IF = 0  DO NOT PLOT                        23JE4
C                               IF = 1  PLOT ON 8.5 X 11 PAPER WITH        23JE4
C                                    1 INCH AND 5 INCH AXES                23JE4
C                               IF = 2  PLOT ON 11 X 17 PAPER WITH         23JE4
C                                    2 INCH AND 10 INCH AXES               23JE4
C                               IF = 3  PLOT ON 11 X 17 PAPER WITH         23JE4
C                                    1 INCH AND 15 INCH AXES               23JE4
C          KR1                  PRIOR VALUE OF KR2                         27SE3
C          KR2                  IF = 1, REFER TO NEXT CARD(MUST = 1 OR 0)  01MY6
C          KSW                  ROUTING SWITCH FOR TABLE  4                27SE3
C          KSHORT               IF = 1, PRINT ERROR MESSAGE                01MY6
C          KSTOP                ROUTING SWITCH FOR PLOT TAPE TERMINATION   23JE4
C          L                    DEFLECTION COMPUTATION INDEX               01MY6
C          M                    TOTAL NUMBER OF INCREMENTS OF BMCOL        12JE3
C          MHOLD                M FROM PREVIOUS PROBLEM                    01MY6
C          MP1, MP4 THRU MP7    M + 1, M + 4 THRU M + 7                    23MR4
C          N                    MISCELLANEOUS INDEX                        01MY6
C          NCD2 THRU NCD4       NUM CARDS IN TABLES 2 THRU 4, THIS PROB    24JL3
C          NPROB                PROBLEM NUMBER (PROG STOPS IF BLANK)       01MY6
```

```
C         NS                  INDEX NUM FOR SPECIFIED CONDITIONS         05JE3
C         PART                INTERPOLATION FRACTION                     12JE3
C         PN1, PN2, P(J)      AXIAL TENSION OR COMPRESSION(INPUT, TOTAL)12JE3
C         QN1, QN2, Q(J)      TRANSVERSE FORCE (INPUT, TOTAL )           24JL3
C         REACT               NET REACTION ON THE BMCOL AT EACH STA      07JE3
C         RN1, RN2, R(J)      ROTATIONAL RESTRAINT ( INPUT, TOTAL )      12JE3
C         SN1, SN2, S(J)      SPRING SUPPORT STIFFNESS( INPUT, TOTAL )   01MY6
C         TN1, TN2, T(J)      TRANSVERSE TORQUE ( INPUT, TOTAL )         12JE3
C         W(J)                LATERAL DEFLECTION OF BMCOL AT STA J       12JE3
C         WS(  )              SPECIFIED VALUE OF DEFL                    25JL3
C         X                   DISTANCE ALONG THE BMCOL                   30MY3
C         ZI                  DECIMAL VALUE FOR ISTA                     25JL3
C-----NOTATION FOR AUTOMATIC PLOT ROUTINE                                01JE4
C         HAXIS               OUTPUT VALUES OF HEND                      23JE4
C         HEND                VALUE ASSIGNED TO END OF HORIZONTAL-AXIS.  16AP4
C         HMAX                MAXIMUM ABSOLUTE VALUE OF HPLOT            16AP4
C         HNEG                LENGTH, IN INCHES, OF THE NEGATIVE H-AXIS.14AP4
C         HPLOT( )            NAME OF ARRAY TO BE PLOTTED ON H-AXIS      07MY4
C         HPLTTMP             TEMPORARY VALUE USED TO POSITION PEN FOR   24JL4
C                             NEXT PLOT                                  24JL4
C         HPOS                LENGTH, IN INCHES, OF THE POSITIVE H-AXIS  14AP4
C         HTCKS               INCREMENT LENGTH BETWEEN TICK MARKS ON     14AP4
C                             H-AXIS IN TERMS OF HEND                    07MY4
C         INCH                NUM OF HOR PLOT INC (.01 INCH) TO MOVE PEN06JL4
C         INCV                NUM OF VER PLOT INC (.01 INCH) TO MOVE PEN06JL4
C         KAXES               INDEX USED TO DESCRIBE MANNER IN WHICH     16AP4
C                             AXES SHOULD BE PLACED ON PAPER             14AP4
C                             IF = 0    DRAW AXES WITH H-AXIS HORIXONTAL16AP4
C                                       ON PAPER AND V-AXIS LENGTHWISE   16AP4
C                                       ON PAPER                         16AP4
C                             IF = 1    ROTATE AXES 90 DEGREES TO PLACE  14AP4
C                                       H-AXIS LENGTHWISE ON PAPER       14AP4
C         KEXP                EXPONENT OF 10 USED WHEN EXPRESSING HMAX   16AP4
C                             IN SCIENTIFIC NOTATION                     23JE4
C         KPS                 CODE FOR PLOT SYMBOL TO BE USED            07MY4
C                             1 DENOTES SMALL PLUS SIGN                  14AP4
C                             8 DENOTES NO SYMBOL TO BE PLOTTED, BUT     14AP4
C                                       PEN TO BE MOVED                  16AP4
C         MAXSTA              FIXED PT PRINT OUT VALUE OF VEND           07JL4
C         NUMPTS              NUMBER OF POINTS TO BE PLOTTED             14AP4
C         SPACE               DISTANCE, IN INCHES, FROM LEFT EDGE OF     14AP4
C                             PAPER TO END OF NEGATIVE H-AXIS            14AP4
C         VAXIS               OUTPUT VAL OF MAX DIST PLOTABLE ON V-AXIS  06JL4
C         VEND                VALUE ASSIGNED TO END OF VERTICAL-AXIS.    14AP4
C         VINCH               DISTANCE BETWEEN AXES UNDER PLOT OPTION    07JL4
C         VNEG                LENGTH, IN INCHES, OF THE NEGATIVE V-AXIS.14AP4
C         VPLOT( )            NAME OF ARRAY TO BE PLOTTED ON V-AXIS      07MY4
C         VPLTTMP             TEMPORARY VALUE USED TO POSITION PEN FOR   24JL4
C                             NEXT PLOT                                  24JL4
C         VPOS                LENGTH, IN INCHES, OF THE POSITIVE V-AXIS  14AP4
C         VTCKS               INCREMENT LENGTH BETWEEN TICK MARKS ON     14AP4
C                             V-AXIS IN TERMS OF VEND                    16AP4
C         ZTMP                TEMPORARY STORAGE LOCATION USED WHEN       14AP4
C                             DETERMINING THE MAX ABS VALUE OF HPLOT     16AP4
```

APPENDIX 6

LISTING OF PROGRAM DECK OF BMCOL 34

```
-COOP,CE051118,MATLOCK,S/2S/0/34.          BMCOL 34 DECK 2
-FTN,L,E,R,N.
      PROGRAM BMCOL 34                                                  20NO4
    1 FORMAT (    52H     PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON 20NO4
     1            28H  REVISION DATE = 01 JUL 66 )                      -------*
C-----CARDS THAT ARE EXPECTED TO BE DELETED, OR MODIFIED FOR SPACING-   07FE4*
C         CONTROL, FOR IBM 7090-94 HAVE AN ASTERISK IN COL 78           23MR4*
      DIMENSION     AN1(32), AN2(14),                                   01DE4 ID
     1              F(207), Q(207), S(207), T(207), R(207), P(207),     20NO4
     2              A(207), B(207), C(207), W(207), KEY(207),           20NO4
     3              WS(20), DWS(20), DW(207), BM(207), DBM(207),        25NO4
     4              REACT(207), ZI(207), HAXIS(5), HPLOT(207),          20NO4
     5              VPLOT(207)                                          20NO4
   10 FORMAT (     5H      , 80X, 10HI-----TRIM )                       03FE4*ID
   11 FORMAT (     5H1     , 80X, 10HI-----TRIM )                       03FE4*ID
   12 FORMAT ( 16A5 )                                                   03FE4 ID
   13 FORMAT (        5X, 16A5 )                                        03FE4*ID
   14 FORMAT ( A5, 5X, 14A5 )                                           01DE4 ID
   15 FORMAT (///10H      PROB , /5X, A5, 5X, 14A5 )                    01DE4 ID
   16 FORMAT (///17H      PROB (CONTD), /5X, A5, 5X, 14A5 )             01DE4 ID
   19 FORMAT (///48H      RETURN THIS PAGE TO TIME RECORD FILE -- HM   ) 26AG3*ID
   20 FORMAT ( 5X, 2(5X, 3I5), 10X, I5 )                                20NO4
   21 FORMAT ( 5X, I5, 10X, E10.3 )                                     26MR4
   31 FORMAT ( 2(5X, I5), 2E10.3 )                                      23MR4
   41 FORMAT ( 5X, 3I5, 6E10.3 )                                        23MR4
  100 FORMAT (///35H      TABLE 1 - PROGRAM-CONTROL DATA                24JA4*
     1    /  66X, 27H     TABLES NUMBER                                 31MR4
     2    /  67X, 30H     2    3    4                                   31MR4
     3   //       39H          PRIOR-DATA OPTIONS (1 = HOLD), 29X, 3I5, 31MR4
     4    /       38H          NUM CARDS INPUT THIS PROBLEM, 30X, 3I5,  20NO4
     5   //       37H          OPTION (IF=1, 2, 3) TO PLOT, 31X, I5 )   20NO4
  200 FORMAT (///24H      TABLE 2 - CONSTANTS / )                       23MR4*
  201 FORMAT (    28H          NUM INCREMENTS     , 50X, I5,            31MR4*
     1    /       28H          INCREMENT LENGTH   , 45X, E10.3 )        31MR4
  300 FORMAT (///47H      TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES    20JA4*
     1   //    5X, 48H    STA      CASE       DEFLECTION         SLOPE, /)03FE4
  311 FORMAT (       10X, I3, 7X, I2, 8X, E10.3, 9X, 4HNONE )           23MR4*
  312 FORMAT (       10X, I3, 7X, I2, 11X, 4HNONE, 8X, E10.3 )          23MR4*
  313 FORMAT (       10X, I3, 7X, I2, 3X, 2(5X, E10.3) )                23MR4*
  400 FORMAT (///38H      TABLE 4 - STIFFNESS AND LOAD DATA             20JA4*
     1   //       51H     FROM TO CONTD      F          Q          S    03FE4
     2            28H     T          R          P / )                   13JE3
  411 FORMAT (       5X, 2I4, I3, 1X, 6E11.3 )                          23MR4*
  412 FORMAT (       5X, I4, 4X, I3, 1X, 6E11.3 )                       23MR4*
  413 FORMAT (       9X, I4, I3, 1X, 6E11.3 )                           23MR4*
  500 FORMAT (// 22H      TABLE 5 - RESULTS )                           19MR4
  501 FORMAT ( / 48H      STA I         X            W           DW/DX  19MR4*
     1            36H      M          DM/DX        NET REACT   / )     05JE3
  511 FORMAT (       5X, I4, 2X, 6E12.3 )                               23MR4*
  600 FORMAT ( //51H      TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT 20NO4
     1            13H ENDS OF AXES                                      20NO4
     2         // 48H     STA I         X            W           DW/DX  20NO4
     3            36H     M          DM/DX        NET REACT   / )      20NO4
  903 FORMAT ( / 25H                           NONE )                   04FE4*
  904 FORMAT (// 40H      TOO MUCH DATA FOR AVAILABLE STORAGE // )      04FE4*
```

```
  905 FORMAT (   46H          USING DATA FROM THE PREVIOUS PROBLEM )    05FE4*
  906 FORMAT (   51H          USING DATA FROM THE PREVIOUS PROBLEM PLUS)06FE4*
  907 FORMAT ( //40H     ERROR STOP -- STATIONS NOT IN ORDER )          03FE4*
  908 FORMAT ( //46H     ERROR -- NON-ZERO TABLE 4 DATA BEYOND END )    06FE4*
  980 FORMAT ( / 51H     UNSPECIFIED ERROR STOP  --  PROGRAM TERMINATED)20NO4
C-----START EXECUTION OF PROGRAM - SEE GENERAL FLOW CHART                23MR4
                KSTOP = 0                                               01DE4
                ITEST = 5H                                              01DE4 ID
 1000 PRINT 10                                                          12JL3 ID
      CALL TIME                                                         23MR4*
C-----PROGRAM AND PROBLEM IDENTIFICATION                                04MY3 ID
      READ  12, ( AN1(N), N = 1, 32 )                                   01DE4 ID
 1010 READ  14,  NPROB, ( AN2(N), N = 1, 14 )                           28AG3 ID
         IF ( NPROB - ITEST )  1020, 9990, 1020                         01DE4 ID
 1020 PRINT 11                                                          26AG3 ID
      PRINT 1                                                           01DE4 ID
      PRINT 13, ( AN1(N), N = 1, 32 )                                   01DE4 ID
         CALL TIME                                                      01MY6
      PRINT 15, NPROB, ( AN2(N), N = 1, 14 )                            26AG3 ID
C-----INPUT TABLE 1                                                     10JE3
 1100 READ 20, KEEP2, KEEP3, KEEP4, NCD2, NCD3, NCD4, KPLOT             20NO4
      PRINT 100, KEEP2, KEEP3, KEEP4, NCD2, NCD3, NCD4, KPLOT           20NO4
C-----INPUT TABLE 2                                                     10JE3
 1200 PRINT 200                                                         13JE3
         IF ( KEEP2 ) 9980, 1210, 1230                                  20NO4
 1210 READ 21, M, H                                                     19MR4
      PRINT 201, M, H                                                   18JE3
         GO TO 1240                                                     03JE3
 1230 PRINT 905                                                         04JE3
C-----COMPUTE CONSTANTS AND INDEXES                                     10JE3
 1240           HT2 = H + H                                             03JE3
                HE2 = H * H                                             30MY3
                HE3 = H * HE2                                           30MY3
                MP1 = M + 1                                             25NO4
                MP4 = M + 4                                             30MY3
                MP5 = M + 5                                             30MY3
                MP6 = M + 6                                             10JE3
                MP7 = M + 7                                             30MY3
C-----INPUT TABLE 3                                                     10JE3
 1300 PRINT 300                                                         03JE3
         IF ( KEEP3 ) 9980, 1310, 1305                                  20NO4
 1305 PRINT 905                                                         03JE3
         GO TO 1399                                                     04JE3
 1310    DO 1315  J = 3, MP5                                            23MR4
                KEY(J) = 1                                              03JE3
 1315    CONTINUE                                                       03JE3
         IF ( NCD3 ) 9980, 1320, 1325                                   20NO4
 1320 PRINT 903                                                         03JE3
         GO TO 1399                                                     04JE3
 1325           IF ( NCD3 - 20 ) 1327, 1327, 1326                       05JE3
 1326 PRINT 904                                                         04JE3
         GO TO 9990                                                     01MY6
 1327           JS = 3                                                  03FE4
         DO 1350 N = 1, NCD3                                            03FE4
      READ 31, IN1, KASE, WS(N), DWS(N)                                 03FE4
```

```
      IF ( IN1 + 4 - JS ) 1328, 1328, 1329                             03FE4
 1328 PRINT 907                                                        03FE4
      GO TO 9990                                                       01MY6
 1329       JS = IN1 + 4                                               03FE4
C-----SET INDEXES FOR FUTURE CONTROL OF SPECIFIED CONDITION ROUTINES   10JE3
      GO TO ( 1330, 1335, 1340 ), KASE                                 05JE3
 1330       KEY(JS) = 2                                                05JE3
   PRINT 311, IN1, KASE, WS(N)                                         03FE4
      GO TO 1350                                                       03JE3
 1335       KEY(JS-1) = 3                                              05JE3
            KEY(JS+1) = 5                                              05JE3
   PRINT 312, IN1, KASE, DWS(N)                                        03FE4
      GO TO 1350                                                       03JE3
 1340       KEY(JS-1) = 3                                              05JE3
            KEY(JS) = 4                                                05JE3
            KEY(JS+1) = 5                                              05JE3
   PRINT 313, IN1, KASE, WS(N), DWS(N)                                 03FE4
 1350 CONTINUE                                                         03JE3
 1399 CONTINUE                                                         04JE3
C-----INPUT TABLE 4                                                     10JE3
 1400 PRINT 400                                                        04JE3
      IF(KEEP4)9980,1401,1402                                          01JL6
 1401       MHOLD1 = 1                                                 12MY6
 1402 DO 1403  J = MHOLD1 , MP7                                        01JL6
            F(J) = 0.0                                                 30MY3
            Q(J) = 0.0                                                 19MR4
            S(J) = 0.0                                                 19MR4
            T(J) = 0.0                                                 30MY3
            R(J) = 0.0                                                 30MY3
            P(J) = 0.0                                                 30MY3
 1403 CONTINUE                                                         01JL6
      IF(KEEP4)9980,1406,1405                                          01JL6
 1405 PRINT 906                                                        01JL6
 1406 IF ( NCD4 ) 9980, 1407, 1408                                     01JL6
 1407 PRINT 903                                                        01JL6
      GO TO 1481                                                       01JL6
C-----SEE FLOW CHART, TABLE SEQUENCING PROCEDURE                        23MR4
 1408       KR2 = 0                                                    01JL6
      DO 1480 N = 1, NCD4                                              04JE3
            KR1 = KR2                                                  28MY3
   READ 41, IN1, IN2, KR2, FN2, QN2, SN2, TN2, RN2, PN2                03FE4
            JN = IN1 + 4                                               28MY3
            J2 = IN2 + 4                                               28MY3
            KSW = 1 + KR2 + 2 * KR1                                    28MY3
      GO TO ( 1409, 1410, 1415, 1415 ), KSW                            01JL6
 1409 PRINT 411, IN1, IN2, KR2, FN2, QN2, SN2, TN2, RN2, PN2           01JL6
      GO TO 1420                                                       04EJ3
 1410 PRINT 412, IN1, KR2, FN2, QN2, SN2, TN2, RN2, PN2                03FE4
      GO TO 1420                                                       04JE3
 1415 PRINT 413, IN2, KR2, FN2, QN2, SN2, TN2, RN2, PN2                03FE4
      GO TO 1435                                                       04JE3
 1420       J1 = JN                                                    04JE3
 1425       FN1 = FN2                                                  04JE3
            QN1 = QN2                                                  28MY3
            SN1 = SN2                                                  28MY3
```

```
                TN1 = TN2                                                  28MY3
                RN1 = RN2                                                  28MY3
                PN1 = PN2                                                  28MY3
           GO TO ( 1435, 1480, 9980, 1480 ), KSW                           20NO4
C-----SEE FLOW CHART, TABLE4 INTERPOLATION AND DISTRIBUTION                23MR4
 1435           JINCR = 1                                                  07JE3
                ESM = 1.0                                                  07JE3
           IF ( J2 - J1 ) 1437, 1450, 1440                                 03FE4
 1437 PRINT 907                                                            03FE4
           GO TO 9990                                                      01MY6
 1440           DENOM = J2 - J1                                            07JE3
                ISW = 1                                                    07JE3
           GO TO 1455                                                      07JE3
 1450           DENOM = 1.0                                                07JE3
                ISW = 0                                                    07JE3
 1455      DO 1460  J = J1, J2, JINCR                                      04JE3
                DIFF = J - J1                                              28MY3
                PART = DIFF / DENOM                                        28MY3
                F(J) = F(J) + ( FN1 + PART * ( FN2 - FN1 ) ) * ESM         28MY3
                Q(J) = Q(J) + ( QN1 + PART * ( QN2 - QN1 ) ) * ESM         19MR4
                S(J) = S(J) + ( SN1 + PART * ( SN2 - SN1 ) ) * ESM         19MR4
                T(J) = T(J) + ( TN1 + PART * ( TN2 - TN1 ) ) * ESM         28MY3
                R(J) = R(J) + ( RN1 + PART * ( RN2 - RN1 ) ) * ESM         28MY3
                P(J) = P(J) + ( PN1 + PART * ( PN2 - PN1 ) ) * ESM         28MY3
 1460      CONTINUE                                                        04JE0
           IF ( ISW ) 9980, 1470, 1465                                     20NO4
 1465           JINCR = J2 - J1                                            07JE3
                ESM = - 0.5                                                07JE3
                ISW = 0                                                    28MY3
           GO TO 1455                                                      04JE3
 1470      GO TO ( 1480, 9980, 1480, 1475 ), KSW                           20NO4
 1475           J1 = J2                                                    04JE3
           GO TO 1425                                                      04JE3
 1480      CONTINUE                                                        04JE3
C-----TEST FOR DATA ERRONEOUSLY STORED BEYOND END STA                       23MR4
 1481      IF (F(MP5) + F(MP6)+ Q(MP5) + S(MP5) + T(MP5) + T(MP6) +        01JL6
    1        R(MP5) + R(MP6) + P(MP5) + P(MP6) ) 1485, 1499, 1485          06FE4
 1485 PRINT 908                                                            06FE4
           GO TO 9990                                                      01MY6
 1499      CONTINUE                                                        04JE3
C-----START OF BEAM-COLUMN SOLUTION                                        10JE3
 6000           NS = 1                                                     04JE3
                A(1) = 0                                                   01MY6
                A(2) = 0                                                   01MY6
                B(1) = 0                                                   01MY6
                B(2) = 0                                                   01MY6
                C(1) = 0                                                   01MY6
                C(2) = 0                                                   01MY6
           DO 6060 J = 3, MP5                                              04JE3
C-----COMPUTE MATRIX COEFFS AT EACH STA J                                  10JE3
                AA = F(J-1) - 0.25 * H * ( R(J-1) + H * P(J-1) )           03JE3
                BB = - 2.0 * ( F(J-1) + F(J) )                             28MY3
                CC = F(J-1) + 4.0 * F(J) + F(J+1) + HE3 * S(J) +           04JE3
    1                0.25 * H * ( ( R(J-1) + H * P(J-1) ) + ( R(J+1)       03JE3
    2                + H * P(J+1) ) )                                      03JE3
```

```
              DD = - 2.0 * ( F(J) + F(J+1) )                             28MY3
              EE = F(J+1) - 0.25 * H * ( R(J+1) + H * P(J+1) )           30MY3
              FF = HE3 * Q(J) - 0.5 * HE2 * ( T(J-1) - T(J+1) )          14JE3
C-----COMPUTE RECURSION OR CONTINUITY COEFFS AT EACH STA                 10JE3
              E = AA * B(J-2) + BB                                       28MY3
              DENOM = E * B(J-1) + AA * C(J-2) + CC                      28MY3
          IF ( DENOM ) 6010, 6005, 6010                                  28MY3
C-----NOTE IF DENOM IS ZERO, BEAM DOES NOT EXIST, D = 0 SETS DEFL = 0.   10JE3
 6005         D = 0.0                                                    28MY3
          GO TO 6015                                                     28MY3
 6010         D = - 1.0 / DENOM                                          28MY3
 6015         C(J) = D * EE                                              28MY3
              B(J) = D * ( E * C(J-1) + DD )                             28MY3
              A(J) = D * ( E * A(J-1) + AA * A(J-2) - FF )               28MY3
C-----CONTROL RESET ROUTINES FOR SPECIFIED CONDITIONS                    10JE3
              KEYJ = KEY(J)                                              04JE3
          GO TO ( 6060, 6020, 6030, 6020, 6050 ), KEYJ                   20JA4
C-----RESET FOR SPECIFIED DEFLECTION                                     20JA4
 6020         C(J) = 0.0                                                 05JE3
              B(J) = 0.0                                                 28MY3
              A(J) = WS(NS)                                              05JE3
          IF ( KEYJ - 3 ) 6059, 6030, 6060                               20JA4
C-----RESET FOR SPECIFIED SLOPE AT NEXT STA                              17JA4
 6030         DTEMP = D                                                  05JE3
              CTEMP = C(J)                                               28MY3
              BTEMP = B(J)                                               28MY3
              ATEMP = A(J)                                               28MY3
              C(J) = 1.0                                                 28MY3
              B(J) = 0.0                                                 28MY3
              A(J) = - HT2 * DWS(NS)                                     05JE3
          GO TO 6060                                                     04JE3
C-----RESET FOR SPECIFIED SLOPE AT PRECEDING STATION                     23MR4
 6050         DREV = 1.0 / ( 1.0 - ( BTEMP * B(J-1) + CTEMP - 1.0 ) *    05JE3
     1                 D / DTEMP )                                       04JE3
              CREV = DREV * C(J)                                         28MY3
              BREV = DREV * ( B(J) + ( BTEMP * C(J-1) ) * D / DTEMP )    28MY3
              AREV = DREV * ( A(J) + ( HT2 * DWS(NS) + ATEMP + BTEMP     05JE3
     1                 * A(J-1) ) * D / DTEMP )                          04JE3
              C(J) = CREV                                                28MY3
              B(J) = BREV                                                28MY3
              A(J) = AREV                                                28MY3
 6059         NS = NS + 1                                                20JA4
 6060     CONTINUE                                                       28MY3
C-----COMPUTE DEFLECTIONS                                                 23MR4
              W(MP5 + 1) = 0                                             01MY6
              W(MP5 + 2) = 0                                             01MY6
          DO 6100  L = 3, MP5                                            23MR4
              J = M + 8 - L                                              30MY3
              W(J) = A(J) + B(J) * W(J+1) + C(J) * W(J+2)                30MY3
 6100     CONTINUE                                                       30MY3
      PRINT 11                                                           23MR4 ID
      PRINT 1                                                            01MY6 ID
      PRINT 13, ( AN1(N), N = 1, 32 )                                    01MY6 ID
      PRINT 16, NPROB, ( AN2(N), N = 1, 14 )                             28AG3 ID
C-----COMPUTE AND PRINT RESULTS                                          10JE3
```

```
      PRINT 500                                                         23MR4
      PRINT 501                                                         23MR4
            W(2) = 2.0 * W(3) - W(4)                                    23MR4
            W(M+6) = 2.0 * W(MP5) - W(MP4)                              23MR4
         DO 8150  J = 3, MP5                                            24JL4
            DW(J) = ( -W(J-1) + W(J+1) ) / HT2                          18MR4
            BM(J) = F(J) * ( W(J-1) - 2.0 * W(J) + W(J+1) ) / HE2       18MR4
 8150    CONTINUE                                                       24JL4
            BM(2) = 0.0                                                 18MR4
            BM(M+6) = 0.0                                               18MR4
         DO 8200  J = 3, MP5                                            18MR4
            DBM(J) = ( -BM(J-1) + BM(J+1) ) / HT2                       18MR4
            REACT(J) = ( BM(J-1) -2.0 * BM(J) + BM(J+1) ) / H           18MR4
            ISTA = J - 4                                                03JE3
            ZI(J) = ISTA                                                19FE4
            X = ZI(J) * H                                               28FE4
      PRINT 511, ISTA, X, W(J), DW(J), BM(J), DBM(J), REACT(J)          20NO4
 8200    CONTINUE                                                       07JE3
C-----BEGIN AUTOMATIC PLOT ROUTINE                                       16MR4
      PRINT 600                                                         20NO4
         IF ( KPLOT )  9980, 8300, 8310                                 19JE4
 8300 PRINT 903                                                         23MR4
         GO TO 8700                                                     23MR4
C-----DETERMINE STATION NUMBER AT END OF STATION AXES                    19JE4
 8310       KSTOP = 1                                                   19JE4
         IF ( M - 200 ) 8320, 8350, 8340                                19JE4
 8320    IF ( M - 100 ) 8330, 8360, 8350                                25FE4
 8330    IF ( M - 50 ) 8370, 8370, 8360                                 25FE4
 8340       VEND = -500.0                                               01JE4
         GO TO 8400                                                     25FE4
 8350       VEND = -200.0                                               01JE4
         GO TO 8400                                                     25FE4
 8360       VEND = -100.0                                               01JE4
         GO TO 8400                                                     25FE4
 8370       VEND = -50.0                                                01JE4
C-----SET PLOT ARRAY EQUAL TO W, DW/DX, M, DM/DX, AND NET REACT           16MR4
 8400    DO 8600  N = 1, 5                                              19JE4
         GO TO ( 8410, 8420, 8430, 8440, 8450 ), N                      25FE4
 8410    DO 8415  J = 4, MP4                                            01JE4
            HPLOT(J-3) = W(J)                                           01JE4
            VPLOT(J-3) = -ZI(J)                                         01JE4
 8415    CONTINUE                                                       25FE4
            SPACE = 3.0                                                 01JE4
         GO TO 8465                                                     16MR4
 8420    DO 8425  J = 4, MP4                                            01JE4
            HPLOT(J-3) = DW(J)                                          01JE4
 8425    CONTINUE                                                       25FE4
         GO TO 8460                                                     25FE4
 8430    DO 8435  J = 4, MP4                                            01JE4
            HPLOT(J-3) = BM(J)                                          01JE4
 8435    CONTINUE                                                       25FE4
         GO TO 8460                                                     25FE4
 8440    DO 8445  J = 4, MP4                                            01JE4
            HPLOT(J-3) = DBM(J)                                         01JE4
 8445    CONTINUE                                                       25FE4
```

```
         GO TO 8460                                                     25FE4
 8450    DO 8455  J = 4, MP4                                            01JE4
              HPLOT(J-3) = REACT(J)                                     01JE4
 8455    CONTINUE                                                       25FE4
 8460         SPACE = SPACE + 1.5                                       23MR4
 8465         HMAX = 0.0                                                01JE4
C-----DETERMINE LARGEST VALUE IN NEXT ARRAY TO BE PLOTTED               16MR4
         DO 8470  J = 4, MP4                                            01JE4
              ZTMP = ABSF( HPLOT(J-3) )                                 23JE4
              HMAX = MAX1F( ZTMP, HMAX )                                01JE4
 8470    CONTINUE                                                       25FE4
C-----DETERMINE EXPONENT OF MAX VALUE OF FUNCTION AND SET H-AXIS SCALE  23JE4
              KEXP = 0                                                  01JE4
         IF ( HMAX )  9980, 8570, 8500                                  19JE4
 8500    DO 8530  L = 1, 100                                            25JE4ARB
         IF ( 1.0 - HMAX )  8505, 8570, 8510                            01JE4
 8505         HMAX = HMAX / 10.0                                        01JE4
              KEXP = KEXP + 1                                           01JE4
         GO TO 8530                                                     18MR4
 8510    IF ( 0.1 - HMAX )  8540, 8560, 8520                            01JE4
 8520         HMAX = HMAX * 10.0                                        01JE4
              KEXP = KEXP - 1                                           01JE4
 8530    CONTINUE                                                       18MR4
         GO TO 9980                                                     19JE4
 8540    IF ( 0.2 - HMAX )  8550, 8580, 8580                            01JE4
 8550    IF ( 0.5 - HMAX )  8570, 8590, 8590                            01JE4
 8560         HEND = 0.1                                                01JE4
         GO TO 8595                                                     18MR4
 8570         HEND = 1.0                                                01JE4
         GO TO 8595                                                     18MR4
 8580         HEND = 0.2                                                01JE4
         GO TO 8595                                                     18MR4
 8590         HEND = 0.5                                                01JE4
C-----SET PLOT VARIABLE VALUE AT END OF VARIABLE AXES                   01JE4
 8595         HEND = HEND * 10.0**KEXP                                  01JE4
              HAXIS(N) = HEND                                           19JE4
C-----SET REMAINING AXES AND PLOT ARGUMENTS                             23JE4
              VPOS  = 0.0                                               19JE4
              VNEG  = 5.0 * KPLOT                                       19JE4
              HTCKS = HEND                                              19JE4
              VTCKS = -VEND                                             30JE4
              NUMPTS = MP1                                              19JE4
              KPS = 1                                                   19JE4
         IF ( KPLOT - 2 )  8596, 8597, 8596                             19JE4
C-----DRAW AXES AND  PLOT FOR KPLOT = 1 AND 3                           23JE4
 8596         HPOS = 0.5                                                19JE4
              HNEG = 0.5                                                19JE4
              KAXES = 0                                                 19JE4
     CALL AXES ( HEND, HPOS, HNEG, SPACE, VEND, VPOS, VNEG, HTCKS,      19JE4
    1          VTCKS, KAXES )                                           19JE4
     CALL PLOT ( HPLOT, VPLOT, NUMPTS, KPS )                            19JE4
C-----SET PEN FOR NEXT PLOT                                             19JE4
              HPLTTMP = 0.0                                             24JL4
              VPLTTMP = VEND                                            24JL4
              NUMPTS = 1                                                19JE4
```

```
             KPS = 8                                                  19JE4
      CALL PLOT  ( HPLTTMP, VPLTTMP, NUMPTS, KPS )                    24JL4
         GO TO 8600                                                   23JE4
C-----DRAW AXES AND PLOT FOR KPLOT = 2                                23JE4
 8597        HPOS = 1.0                                               19JE4
             HNEG = 1.0                                               19JE4
             SPACE = 0.75                                             19JE4
             KAXES = 1                                                19JE4
             VINCH = 1.0                                              19JE4
      CALL AXES ( HEND, HPOS, HNEG, SPACE, VEND, VPOS, VNEG, HTCKS,   19JE4
     1           VTCKS, KAXES )                                       01JE4
      CALL PLOT ( HPLOT, VPLOT, NUMPTS, KPS )                         01JE4
C-----SET PEN FOR NEXT PLOT                                           23JE4
      CALL AXESTERM ( 1 )                                             19JE4
             INCH = 0                                                 06JL4
             INCV = ( -4.0 + VINCH ) * 100.0                          06JL4
             KPS = 8                                                  06JL4
      CALL STRPLOT ( INCH, INCV, KPS )                                06JL4
 8600    CONTINUE                                                     25FE4
C-----PRINT PLOT SCALES AND ROLL PAPER FOR NEXT PROBLEM                01JE4
             MAXSTA = -VEND                                           01JE4
             VAXIS = -VEND * H                                        19JE4
      PRINT 511, MAXSTA, VAXIS, ( HAXIS(N), N = 1, 5 )                20NO4
      CALL AXESTERM ( 1 )                                             19JE4
 8700    CONTINUE                                                     23MR4
      CALL TIME                                                       27FE4
             MHOLD1 = MP5                                             12MY6
C-----RETURN FOR NEW PROBLEM                                           16MR4
         GO TO 1010                                                   26AG3 ID
 9980 PRINT 980                                                       19JE4
 9990    CONTINUE                                                     19JE4
         IF ( KSTOP )  9995, 9995, 9992                               19JE4
 9992 CALL AXESTERM ( 0 )                                             19JE4
 9995    CONTINUE                                                     19JE4
 9999 CONTINUE                                                        04MY3 ID
      PRINT 11                                                        08MY3 ID
      PRINT 1                                                         01DE4 ID
      PRINT 13, ( AN1(N), N = 1, 32 )                                 01DE4 ID
      PRINT 19                                                        26AG3 ID
      END                                                             04MA3 ID
      END                                                             01JL6
        FINIS
-EXECUTE,,,1.
```

Add data cards here. The first card of data is the first card described in the Guide for Data Input for BMCOL 34.

When plot capabilities are not available by library tape routine, a plot subroutine must be properly added. A binary deck of subroutine PLOT 63 is to be provided with all BMCOL 34 decks.

APPENDIX 7

LISTING OF INPUT DATA FOR EXAMPLE PROBLEMS

```
CHARGE CE051118      CODED 28 JUL 66-HM,JJP    PUNCH 28 JUL 66-TH    RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT
   1A     SIMPLE BEAM, UNIFORMLY LOADED, CONSTANT EI
              0     0     0           1     2     1                 1
        40             1.000E-01
         0           1 0.000E+00
        40           1 0.000E+00
         0    40     0 1.000E+00 1.000E-01
   1B     SIMPLE BEAM, UNIFORMLY LOADED, VARIABLE EI
              1     1     1           0     0     4                 1
         0           1 0.000E+00
              10     1 5.000E-01
              30     1 5.000E-01
              40     0 0.000E+00
    2     STEEL BENT CAP
              0     0     0           1     3    17                 1
        80             1.200E+01
        10           1 0.000E+00
        40           1 0.000E+00
        70           1 0.000E+00
         0    80     0 6.087E+11-3.000E+02
        30    50     0 3.202E+11-1.020E+02
         5     5     0          -5.000E+04
        10    10     0          -1.000E+05
        15    15     0          -1.000E+05
        20    20     0          -1.100E+05
        25    25     0          -1.100E+05
        30    30     0          -1.000E+05
        35    35     0          -1.000E+05
        40    40     0          -5.000E+04
        45    45     0          -5.000E+04
        50    50     0          -4.000E+04
        55    55     0          -3.500E+04
        60    60     0          -3.000E+04
        65    65     0          -2.500E+04
        70    70     0          -2.000E+04
        75    75     0          -1.500E+04
   3A     MULTIPLE-SPAN BRIDGE - DEAD LOAD ONLY
              0     0     0           1     6    17                 1
       100             9.600E+01
         0           1 0.000E+00
        10           1 0.000E+00
        20           1 0.000E+00
        80           1 0.000E+00
        90           1 0.000E+00
       100           1 0.000E+00
         0   100     0 3.000E+11-8.000E+03
         9    11     0 3.000E+11
        19    21     0 3.000E+11
        29    31     0 3.000E+11
        39    41     0 3.000E+11
        49    51     0 3.000E+11
        59    61     0 3.000E+11
        69    71     0 3.000E+11
        79    81     0 3.000E+11
```

```
     89   91    0 3.000E+11
     28   28    0-3.000E+11
     72   72    0-3.000E+11
     30   30    0          -2.000E+04 2.000E+05           5.000E+08
     40   40    0          -2.000E+04 2.000E+05           5.000E+08
     50   50    0          -2.000E+04 2.000E+05           5.000E+08
     60   60    0          -2.000E+04 2.000E+05           5.000E+08
     70   70    0          -2.000E+04 2.000E+05           5.000E+08
3B     MULTIPLE-SPAN BRIDGE - LIVE LOAD ADDED AFTER DEAD LOAD SETTLEMENT
           0    0    0         1   11   18              1
    100           9.600E+01
      0         1 0.000E+00
     10         1 0.000E+00
     20         1 0.000E+00
     30         1-4.913E-01
     40         1-5.060E-01
     50         1-4.974E-01
     60         1-5.060E-01
     70         1-4.913E-01
     80         1 0.000E+00
     90         1 0.000E+00
    100         1 0.000E+00
      0  100    0 3.000E+11-8.000E+03
     20   45    0          -8.000E+03
      9   11    0 3.000E+11
     19   21    0 3.000E+11
     29   31    0 3.000E+11
     39   41    0 3.000E+11
     49   51    0 3.000E+11
     59   61    0 3.000E+11
     69   71    0 3.000E+11
     79   81    0 3.000E+11
     89   91    0 3.000E+11
     28   28    0-3.000E+11
     72   72    0-3.000E+11
     30   30    0          -2.000E+04 2.000E+05           5.000E+08
     40   40    0          -2.000E+04 2.000E+05           5.000E+08
     50   50    0          -2.000E+04 2.000E+05           5.000E+08
     60   60    0          -2.000E+04 2.000E+05           5.000E+08
     70   70    0          -2.000E+04 2.000E+05           5.000E+08
 4     BRACED TRENCH
           0    0    0         1    0    5              1
     40           1.200E+01
      0         1 5.000E+09 0.000E+00
          30    1 5.000E+09 4.950E+03 0.000E+00
          40    0 5.000E+09 4.950E+03 1.250E+04
     10   10    0                     2.670E+05
     20   20    0                     2.670E+05
5A     LONG-PILE BUCKLING, AXIAL COMPRESSION = 4.000E+05 LB
           0    0    0         1    1    5              1
     50           2.400E+01
     50         1 0.000E+00
      0   50    0 3.700E+10                                        -4.000E+05
     25   50    0                     2.000E+04
      0    0    0                              -4.000E+05 3.000E+10
```

```
    13          1              6.000E+01
        25      0              0.000E+00
5B      LONG-PILE BUCKLING, AXIAL COMPRESSION = 5.000E+05 LB
         1      1      1          0      0      2            1
    0   50      0                                                        -1.000E+05
    0    0      0                                  -1.000E+05
5C      LONG-PILE BUCKLING, AXIAL COMPRESSION = 6.000E+05 LB
         1      1      1          0      0      2            1
    0   50      0                                                        -1.000E+05
    0    0      0                                  -1.000E+05
5D      LONG-PILE BUCKLING, AXIAL COMPRESSION = 6.500E+05 LB
         1      1      1          0      0      2            1
    0   50      0                                                        -5.000E+04
    0    0      0                                  -5.000E+04
5E      LONG-PILE BUCKLING, AXIAL COMPRESSION = 6.750E+05 LB
         1      1      1          0      0      2            1
    0   50      0                                                        -2.500E+04
    0    0      0                                  -2.500E+04
5F      LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.000E+05 LB
         1      1      1          0      0      2            1
    0   50      0                                                        -2.500E+04
    0    0      0                                  -2.500E+04
5G      LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.0250E+05 LB
         1      1      1          0      0      2            1
    0   50      0                                                        -2.500E+03
    0    0      0                                  -2.500E+03
5H      LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.050E+05 LB
         1      1      1          0      0      2            1
        50                                                               -2.500E+03
    0    0      0                                  -2.500E+03
5I      LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.075E+05 LB
         1      1      1          0      0      2            1
    0   50      0                                                        -2.500E+03
    0    0      0                                  -2.500E+03
5J      LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.100E+05 LB
         1      1      1          0      0      2            1
    0   50      0                                                        -2.500E+03
    0    0      0                                  -2.500E+03
5K      LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.125E+05 LB
         1      1      1          0      0      2            1
    0   50      0                                                        -2.500E+03
    0    0      0                                  -2.500E+03
 6      RIGID-FRAME BENT
         0      0      0          1      4     37            1
  110             1.000E+00
    0           3 0.000E+00 0.000E+00
   30           1 0.000E+00
   80           1 0.000E+00
  110           3 0.000E+00 0.000E+00
    0           1 1.440E+06
         6      1 2.490E+06
        12      1 3.950E+06
        18      1 5.900E+06
        24      1 8.400E+06
        30      1 1.152E+07
```

	35	1	7.720E+06	
	40	1	4.860E+06	
	45	1	2.800E+06	
	50	1	1.440E+06	
	60	1	1.440E+06	
	65	1	2.800E+06	
	70	1	4.860E+06	
	75	1	7.720E+06	
	80	1	1.152E+07	
	86	1	8.400E+06	
	92	1	5.900E+06	
	98	1	3.950E+06	
	104	1	2.490E+06	
	110	0	1.440E+06	
0		1		-3.630E+00
	10	1		-3.630E+00
	32	0		0.000E+00
30		1		-3.000E+00
	50	1		-1.500E+00
	60	1		-1.500E+00
	80	0		-3.000E+00
78		1		0.000E+00
	100	1		-3.630E+00
	110	0		-3.630E+00
35	35	0		-2.200E+01
45	45	0		-7.000E+01
51	51	0		-7.000E+01
57	57	0		-7.000E+01
63	63	0		-7.000E+01
73	73	0		-7.000E+01
79	79	0		-7.000E+01

APPENDIX 8

COMPUTED RESULTS FOR EXAMPLE PROBLEMS

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCOL 34 FINAL REPORT

TIME = 0 MINUTES, 36 ANC 51/60 SECONDS (Compile time)

PROB
1A SIMPLE BEAM, UNIFORMLY LOADED, CONSTANT EI

TABLE 1 - PROGRAM-CONTROL DATA

	TABLES NUMBER 2	3	4
PRIOR-DATA OPTIONS (1 = HOLD)	0	0	0
NUM CARDS INPUT THIS PROBLEM	1	2	1
OPTION (IF=1, 2, 3) TO PLOT	1		

TABLE 2 - CONSTANTS

NUM INCREMENTS	40
INCREMENT LENGTH	1.000E-01

TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

STA	CASE	DEFLECTION	SLOPE
0	1	0	NONE
40	1	0	NONE

TABLE 4 - STIFFNESS AND LOAD DATA

FROM	TO	CONTD	F	Q	S	T	R	P
0	40	C	1.000E 00	1.000E-01	0	0	0	0

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCOL 34 FINAL REPORT

PROB (CCNTC)
1A SIMPLE BEAM, UNIFORMLY LOADED, CONSTANT EI

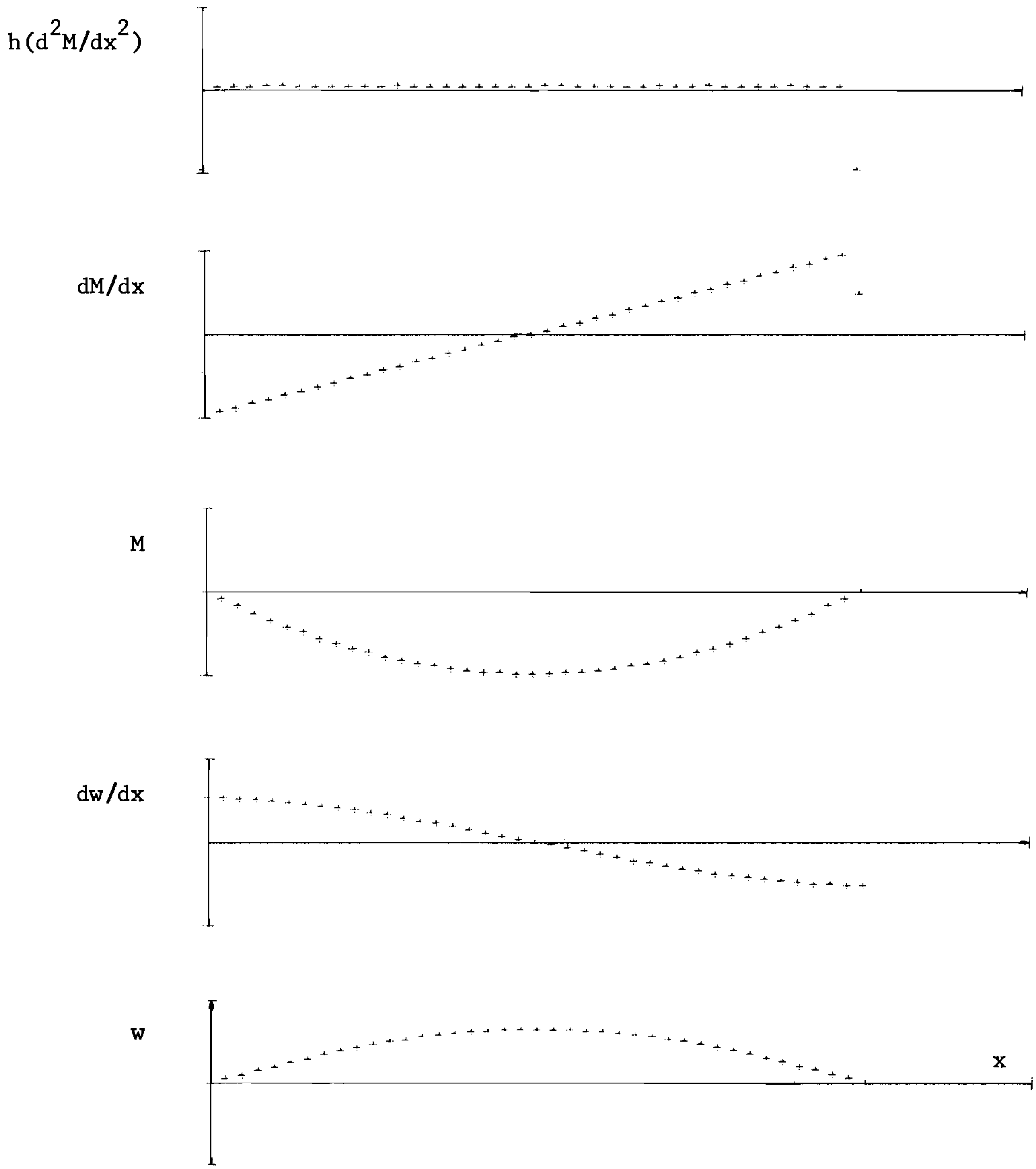
TABLE 5 - RESULTS

STA I	X	W	CW/DX	M	DM/CX	NET REACT
-1	-1.000E-01	-2.665E-01	2.665E 00	0	-1.819E-09	-3.638E-09
0	0	0	2.665E 00	-3.638E-10	-9.750E-01	-1.950E 00
1	1.000E-01	2.665E-01	2.655E 00	-1.950E-01	-1.900E 00	1.000E-01
2	2.000E-01	5.310E-01	2.626E 00	-3.800E-01	-1.800E 00	1.000E-01
3	3.000E-01	7.918E-01	2.580E 00	-5.550E-01	-1.700E 00	1.000E-01
4	4.000E-01	1.047E 00	2.516E 00	-7.200E-01	-1.600E 00	1.000E-01
5	5.000E-01	1.295E 00	2.436E 00	-8.750E-01	-1.500E 00	1.000E-01
6	6.000E-01	1.534E 00	2.341E 00	-1.020E 00	-1.400E 00	1.000E-01
7	7.000E-01	1.763E 00	2.233E 00	-1.155E 00	-1.300E 00	1.000E-01
8	8.000E-01	1.981E 00	2.111E 00	-1.280E 00	-1.200E 00	1.000E-01
9	9.000E-01	2.185E 00	1.977E 00	-1.395E 00	-1.100E 00	1.000E-01
10	1.000E 00	2.376E 00	1.832E 00	-1.500E 00	-1.000E 00	1.000E-01
11	1.100E 00	2.552E 00	1.678E 00	-1.595E 00	-9.000E-01	1.000E-01
12	1.200E 00	2.712E 00	1.514E 00	-1.680E 00	-8.000E-01	1.000E-01
13	1.300E 00	2.855E 00	1.342E 00	-1.755E 00	-7.000E-01	1.000E-01
14	1.400E 00	2.980E 00	1.163E 00	-1.820E 00	-6.000E-01	1.000E-01
15	1.500E 00	3.087E 00	9.787E-01	-1.875E 00	-5.000E-01	1.000E-01
16	1.600E 00	3.176E 00	7.890E-01	-1.920E 00	-4.000E-01	1.000E-01
17	1.700E 00	3.245E 00	5.952E-01	-1.955E 00	-3.000E-01	1.000E-01
18	1.800E 00	3.295E 00	3.985E-01	-1.980E 00	-2.000E-01	1.000E-01
19	1.900E 00	3.325E 00	1.997E-01	-1.995E 00	-1.000E-01	1.000E-01
20	2.000E 00	3.335E 00	2.270E-08	-2.000E 00	-5.239E-07	1.000E-01
21	2.100E 00	3.325E 00	-1.997E-01	-1.995E 00	1.000E-01	1.000E-01
22	2.200E 00	3.295E 00	-3.985E-01	-1.980E 00	2.000E-01	1.000E-01
23	2.300E 00	3.245E 00	-5.952E-01	-1.955E 00	3.000E-01	1.000E-01
24	2.400E 00	3.176E 00	-7.890E-01	-1.920E 00	4.000E-01	1.000E-01
25	2.500E 00	3.087E 00	-9.787E-01	-1.875E 00	5.000E-01	1.000E-01
26	2.600E 00	2.980E 00	-1.163E 00	-1.820E 00	6.000E-01	1.000E-01
27	2.700E 00	2.855E 00	-1.342E 00	-1.755E 00	7.000E-01	1.000E-01
28	2.800E 00	2.712E 00	-1.514E 00	-1.680E 00	8.000E-01	1.000E-01
29	2.900E 00	2.552E 00	-1.678E 00	-1.595E 00	9.000E-01	1.000E-01
30	3.000E 00	2.376E 00	-1.832E 00	-1.500E 00	1.000E 00	1.000E-01
31	3.100E 00	2.185E 00	-1.977E 00	-1.395E 00	1.100E 00	1.000E-01
32	3.200E 00	1.981E 00	-2.111E 00	-1.280E 00	1.200E 00	1.000E-01
33	3.300E 00	1.763E 00	-2.233E 00	-1.155E 00	1.300E 00	1.000E-01
34	3.400E 00	1.534E 00	-2.341E 00	-1.020E 00	1.400E 00	1.000E-01
35	3.500E 00	1.295E 00	-2.436E 00	-8.750E-01	1.500E 00	1.000E-01
36	3.600E 00	1.047E 00	-2.516E 00	-7.200E-01	1.600E 00	1.000E-01
37	3.700E 00	7.918E-01	-2.580E 00	-5.550E-01	1.700E 00	1.000E-01
38	3.800E 00	5.310E-01	-2.626E 00	-3.800E-01	1.800E 00	1.000E-01
39	3.900E 00	2.665E-01	-2.655E 00	-1.950E-01	1.900E 00	1.000E-01
40	4.000E 00	0	-2.665E 00	0	9.750E-01	-1.950E 00
41	4.100E 00	-2.665E-01	-2.665E 00	0	0	0

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/CX	NET REACT
50	5.000E 00	5.000E 00	5.000E 00	2.000E 00	2.00CE 00	2.000E 00

TIME = 1 MINUTES, 4 ANC 48/60 SECONDS



Prob 1A. Simple beam, uniformly loaded, constant EI.

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PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118     CODED 28 JUL 66-HM,JJP    PUNCH 28 JUL 66-TH    RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

     TIME =     1 MINUTES,  4 AND 54/60 SECONDS


PROB
   1B     SIMPLE BEAM, UNIFORMLY LOADED, VARIABLE EI


TABLE 1 - PROGRAM-CONTROL DATA
                                                                 TABLES NUMBER
                                                                  2    3    4

     PRIOR-DATA OPTIONS (1 = HOLD)                                1    1    1
     NUM CARDS INPUT THIS PROBLEM                                 0    0    4

     OPTION (IF=1, 2, 3) TO PLOT                                  1


TABLE 2 - CONSTANTS

     USING DATA FROM THE PREVIOUS PROBLEM


TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

     STA       CASE        DEFLECTION        SLOPE

     USING DATA FROM THE PREVIOUS PROBLEM


TABLE 4 - STIFFNESS AND LOAD DATA

FROM TO CONTD      F           Q           S           T           R           P

     USING DATA FROM THE PREVIOUS PROBLEM PLUS
   0      1          0           0           0           0           0           0
     10   1   5.000E-01          0           0           0           0           0
     30   1   5.000E-01          0           0           0           0           0
     40   0          0           0           0           0           0           0
```

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
18 SIMPLE BEAM, UNIFORMLY LOADED, VARIABLE EI

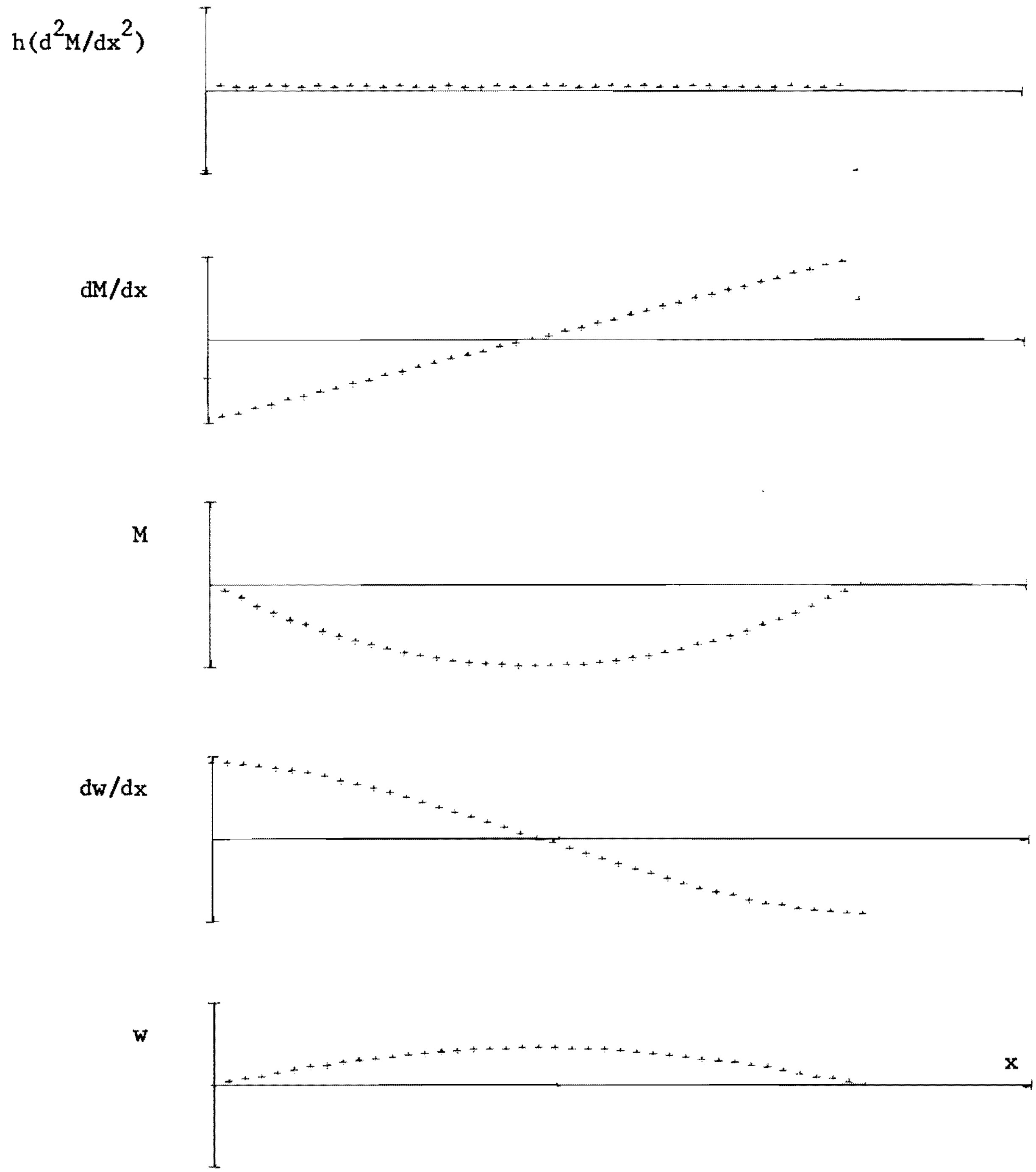
TABLE 5 - RESULTS

STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-1.000E-01	-1.855E-01	1.855E 00	0	0	0
0	0	0	1.855E 00	0	-9.750E-01	-1.950E 00
1	1.000E-01	1.855E-01	1.845E 00	-1.950E-01	-1.900E 00	1.000E-01
2	2.000E-01	3.691E-01	1.819E 00	-3.800E-01	-1.800E 00	1.000E-01
3	3.000E-01	5.492E-01	1.777E 00	-5.550E-01	-1.700E 00	1.000E-01
4	4.000E-01	7.246E-01	1.723E 00	-7.200E-01	-1.600E 00	1.000E-01
5	5.000E-01	8.939E-01	1.658E 00	-8.750E-01	-1.500E 00	1.000E-01
6	6.000E-01	1.056E 00	1.584E 00	-1.020E 00	-1.400E 00	1.000E-01
7	7.000E-01	1.211E 00	1.502E 00	-1.155E 00	-1.300E 00	1.000E-01
8	8.000E-01	1.357E 00	1.414E 00	-1.280E 00	-1.200E 00	1.000E-01
9	9.000E-01	1.493E 00	1.320E 00	-1.395E 00	-1.100E 00	1.000E-01
10	1.000E 00	1.621E 00	1.222E 00	-1.500E 00	-1.000E 00	1.000E-01
11	1.100E 00	1.738E 00	1.118E 00	-1.595E 00	-9.000E-01	1.000E-01
12	1.200E 00	1.844E 00	1.009E 00	-1.680E 00	-8.000E-01	1.000E-01
13	1.300E 00	1.940E 00	8.948E-01	-1.755E 00	-7.000E-01	1.000E-01
14	1.400E 00	2.023E 00	7.757E-01	-1.820E 00	-6.000E-01	1.000E-01
15	1.500E 00	2.095E 00	6.525E-01	-1.875E 00	-5.000E-01	1.000E-01
16	1.600E 00	2.154E 00	5.260E-01	-1.920E 00	-4.000E-01	1.000E-01
17	1.700E 00	2.200E 00	3.968E-01	-1.955E 00	-3.000E-01	1.000E-01
18	1.800E 00	2.233E 00	2.657E-01	-1.980E 00	-2.000E-01	1.000E-01
19	1.900E 00	2.253E 00	1.332E-01	-1.995E 00	-1.000E-01	1.000E-01
20	2.000E 00	2.260E 00	5.937E-08	-2.000E 00	-6.985E-07	1.000E-01
21	2.100E 00	2.253E 00	-1.332E-01	-1.995E 00	1.000E-01	1.000E-01
22	2.200E 00	2.233E 00	-2.657E-01	-1.980E 00	2.000E-01	1.000E-01
23	2.300E 00	2.200E 00	-3.968E-01	-1.955E 00	3.000E-01	1.000E-01
24	2.400E 00	2.154E 00	-5.260E-01	-1.920E 00	4.000E-01	1.000E-01
25	2.500E 00	2.095E 00	-6.525E-01	-1.875E 00	5.000E-01	1.000E-01
26	2.600E 00	2.023E 00	-7.757E-01	-1.820E 00	6.000E-01	1.000E-01
27	2.700E 00	1.940E 00	-8.948E-01	-1.755E 00	7.000E-01	1.000E-01
28	2.800E 00	1.844E 00	-1.009E 00	-1.680E 00	8.000E-01	1.000E-01
29	2.900E 00	1.738E 00	-1.118E 00	-1.595E 00	9.000E-01	1.000E-01
30	3.000E 00	1.621E 00	-1.222E 00	-1.500E 00	1.000E 00	1.000E-01
31	3.100E 00	1.493E 00	-1.320E 00	-1.395E 00	1.100E 00	1.000E-01
32	3.200E 00	1.357E 00	-1.414E 00	-1.280E 00	1.200E 00	1.000E-01
33	3.300E 00	1.211E 00	-1.502E 00	-1.155E 00	1.300E 00	1.000E-01
34	3.400E 00	1.056E 00	-1.584E 00	-1.020E 00	1.400E 00	1.000E-01
35	3.500E 00	8.939E-01	-1.658E 00	-8.750E-01	1.500E 00	1.000E-01
36	3.600E 00	7.246E-01	-1.723E 00	-7.200E-01	1.600E 00	1.000E-01
37	3.700E 00	5.492E-01	-1.777E 00	-5.550E-01	1.700E 00	1.000E-01
38	3.800E 00	3.691E-01	-1.819E 00	-3.800E-01	1.800E 00	1.000E-01
39	3.900E 00	1.855E-01	-1.845E 00	-1.950E-01	1.900E 00	1.000E-01
40	4.000E 00	0	-1.855E 00	1.819E-10	9.750E-01	-1.950E 00
41	4.100E 00	-1.855E-01	-1.855E 00	0	-9.095E-10	1.819E-09

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	5.000E 00	5.000E 00	2.000E 00	2.000E 00	2.000E 00	2.000E 00

TIME = 1 MINUTES, 17 AND 19/60 SECONDS



Prob 1B. Simple beam, uniformly loaded, variable EI.

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

TIME = 1 MINUTES, 17 AND 25/60 SECONDS

PROB
2 STEEL BENT CAP

TABLE 1 - PROGRAM-CONTROL DATA

	TABLES NUMBER 2	3	4
PRIOR-DATA OPTIONS (1 = HOLD)	0	0	0
NUM CARDS INPUT THIS PROBLEM	1	3	17
OPTION (IF=1, 2, 3) TO PLOT	1		

TABLE 2 - CONSTANTS

NUM INCREMENTS	80
INCREMENT LENGTH	1.200E 01

TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

STA	CASE	DEFLECTION	SLOPE
10	1	0	NONE
40	1	0	NONE
70	1	0	NONE

TABLE 4 - STIFFNESS AND LOAD DATA

FROM	TO	CONTD	F	Q	S	T	R	P
0	80	0	6.087E 11	-3.000E 02	0	0	0	0
30	50	0	3.202E 11	-1.020E 02	0	0	0	0
5	5	0	0	-5.000E 04	0	0	0	0
10	10	0	0	-1.000E 05	0	0	0	0
15	15	0	0	-1.000E 05	0	0	0	0
20	20	0	0	-1.100E 05	0	0	0	0
25	25	0	0	-1.100E 05	0	0	0	0
30	30	0	0	-1.000E 05	0	0	0	0
35	35	0	0	-1.000E 05	0	0	0	0
40	40	0	0	-5.000E 04	0	0	0	0
45	45	0	0	-5.000E 04	0	0	0	0
50	50	0	0	-4.000E 04	0	0	0	0
55	55	0	0	-3.500E 04	0	0	0	0
60	60	0	0	-3.000E 04	0	0	0	0

65	65	C	0	-2.500E C4	0	0	0	0
70	70	C	0	-2.000E C4	0	0	0	0
75	75	C	0	-1.500E C4	0	0	0	0

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
2 STEEL BENT CAP

TABLE 5 - RESULTS

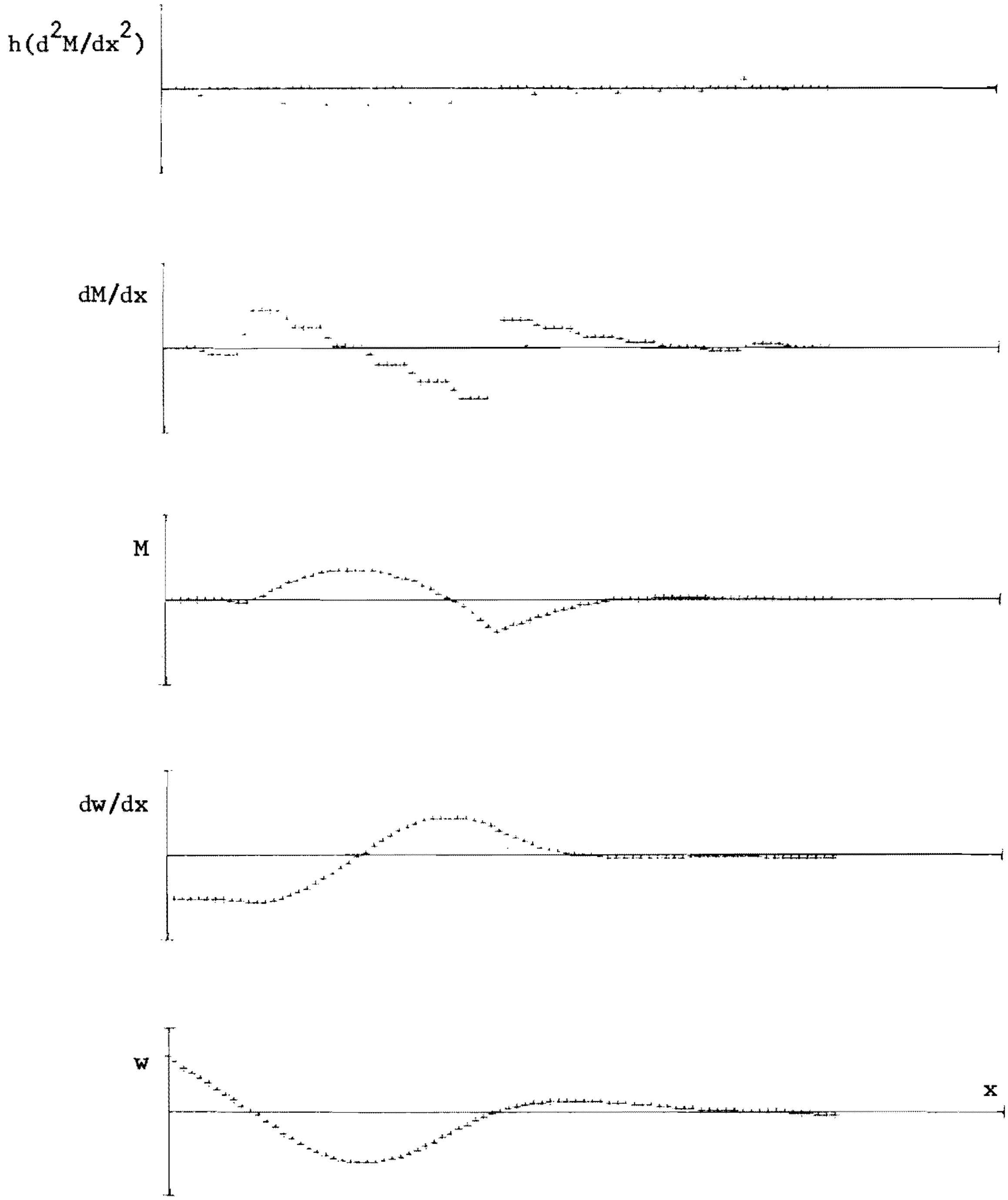
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-1.200E 01	3.617E-01	-2.716E-03	0	0	0
0	0	3.291E-01	-2.716E-03	0	-7.500E 01	-1.500E 02
1	1.200E 01	2.965E-01	-2.716E-03	-1.800E 03	-3.000E 02	-3.000E 02
2	2.400E 01	2.639E-01	-2.716E-03	-7.200E 03	-6.000E 02	-3.000E 02
3	3.600E 01	2.313E-01	-2.716E-03	-1.620E 04	-9.000E 02	-3.000E 02
4	4.800E 01	1.987E-01	-2.717E-03	-2.880E 04	-1.200E 03	-3.000E 02
5	6.000E 01	1.661E-01	-2.717E-03	-4.500E 04	-2.650E 04	-5.030E 04
6	7.200E 01	1.335E-01	-2.724E-03	-6.648E 05	-5.180E 04	-3.000E 02
7	8.400E 01	1.007E-01	-2.744E-03	-1.288E 06	-5.210E 04	-3.000E 02
8	9.600E 01	6.766E-02	-2.775E-03	-1.915E 06	-5.240E 04	-3.000E 02
9	1.080E 02	3.413E-02	-2.819E-03	-2.546E 06	-5.270E 04	-3.000E 02
10	1.200E 02	0	-2.876E-03	-3.180E 06	8.294E 04	2.716E 05
11	1.320E 02	-3.488E-02	-2.913E-03	-5.553E 05	2.186E 05	-3.000E 02
12	1.440E 02	-6.990E-02	-2.898E-03	2.066E 06	2.183E 05	-3.000E 02
13	1.560E 02	-1.044E-01	-2.831E-03	4.683E 06	2.180E 05	-3.000E 02
14	1.680E 02	-1.378E-01	-2.713E-03	7.297E 06	2.177E 05	-3.000E 02
15	1.800E 02	-1.695E-01	-2.543E-03	9.907E 06	1.674E 05	-1.003E 05
16	1.920E 02	-1.989E-01	-2.334E-03	1.131E 07	1.171E 05	-3.000E 02
17	2.040E 02	-2.256E-01	-2.097E-03	1.272E 07	1.168E 05	-3.000E 02
18	2.160E 02	-2.492E-01	-1.833E-03	1.412E 07	1.165E 05	-3.000E 02
19	2.280E 02	-2.696E-01	-1.541E-03	1.551E 07	1.162E 05	-3.000E 02
20	2.400E 02	-2.862E-01	-1.221E-03	1.690E 07	6.087E 04	-1.103E 05
21	2.520E 02	-2.989E-01	-8.873E-04	1.697E 07	5.572E 03	-3.000E 02
22	2.640E 02	-3.075E-01	-5.521E-04	1.704E 07	5.272E 03	-3.000E 02
23	2.760E 02	-3.121E-01	-2.156E-04	1.710E 07	4.972E 03	-3.000E 02
24	2.880E 02	-3.127E-01	1.221E-04	1.716E 07	4.672E 03	-3.000E 02
25	3.000E 02	-3.092E-01	4.609E-04	1.721E 07	-5.063E 04	-1.103E 05
26	3.120E 02	-3.016E-01	7.877E-04	1.594E 07	-1.059E 05	-3.000E 02
27	3.240E 02	-2.903E-01	1.089E-03	1.467E 07	-1.062E 05	-3.000E 02
28	3.360E 02	-2.755E-01	1.366E-03	1.339E 07	-1.065E 05	-3.000E 02
29	3.480E 02	-2.575E-01	1.617E-03	1.211E 07	-1.068E 05	-3.000E 02
30	3.600E 02	-2.366E-01	1.821E-03	1.083E 07	-1.572E 05	-1.004E 05
31	3.720E 02	-2.138E-01	1.960E-03	8.341E 06	-2.075E 05	-4.020E 02
32	3.840E 02	-1.896E-01	2.051E-03	5.849E 06	-2.079E 05	-4.020E 02
33	3.960E 02	-1.645E-01	2.111E-03	3.351E 06	-2.083E 05	-4.020E 02
34	4.080E 02	-1.390E-01	2.138E-03	8.487E 05	-2.087E 05	-4.020E 02
35	4.200E 02	-1.132E-01	2.133E-03	-1.659E 06	-2.591E 05	-1.004E 05
36	4.320E 02	-8.777E-02	2.087E-03	-5.371E 06	-3.095E 05	-4.020E 02
37	4.440E 02	-6.314E-02	1.994E-03	-9.088E 06	-3.099E 05	-4.020E 02
38	4.560E 02	-3.991E-02	1.853E-03	-1.281E 07	-3.103E 05	-4.020E 02
39	4.680E 02	-1.867E-02	1.663E-03	-1.654E 07	-3.107E 05	-4.020E 02
40	4.800E 02	0	1.425E-03	-2.027E 07	-7.625E 04	4.694E 05
41	4.920E 02	1.553E-02	1.176E-03	-1.837E 07	1.582E 05	-4.020E 02
42	5.040E 02	2.822E-02	9.507E-04	-1.647E 07	1.578E 05	-4.020E 02
43	5.160E 02	3.835E-02	7.502E-04	-1.458E 07	1.574E 05	-4.020E 02

44	5.280E 02	4.622E-02	5.741E-04	-1.269E 07	1.570E 05	-4.020E 02
45	5.400E 02	5.213E-02	4.223E-04	-1.081E 07	1.316E 05	-5.040E 04
46	5.520E 02	5.636E-02	2.909E-04	-9.531E 06	1.062E 05	-4.020E 02
47	5.640E 02	5.911E-02	1.760E-04	-8.259E 06	1.058E 05	-4.020E 02
48	5.760E 02	6.058E-02	7.746E-05	-6.991E 06	1.054E 05	-4.020E 02
49	5.880E 02	6.097E-02	-4.696E-06	-5.729E 06	1.050E 05	-4.020E 02
50	6.000E 02	6.047E-02	-7.659E-05	-4.471E 06	8.465E 04	-4.035E 04
51	6.120E 02	5.913E-02	-1.479E-04	-3.697E 06	6.433E 04	-3.000E 02
52	6.240E 02	5.692E-02	-2.132E-04	-2.927E 06	6.403E 04	-3.000E 02
53	6.360E 02	5.401E-02	-2.634E-04	-2.160E 06	6.373E 04	-3.000E 02
54	6.480E 02	5.060E-02	-2.984E-04	-1.397E 06	6.343E 04	-3.000E 02
55	6.600E 02	4.685E-02	-3.185E-04	-6.380E 05	4.563E 04	-3.530E 04
56	6.720E 02	4.295E-02	-3.277E-04	-3.022E 05	2.783E 04	-3.000E 02
57	6.840E 02	3.898E-02	-3.304E-04	2.989E 04	2.753E 04	-3.000E 02
58	6.960E 02	3.502E-02	-3.266E-04	3.584E 05	2.723E 04	-3.000E 02
59	7.080E 02	3.115E-02	-3.163E-04	6.834E 05	2.693E 04	-3.000E 02
60	7.200E 02	2.743E-02	-2.997E-04	1.005E 06	1.163E 04	-3.030E 04
61	7.320E 02	2.395E-02	-2.803E-04	9.624E 05	-3.672E 03	-3.000E 02
62	7.440E 02	2.070E-02	-2.618E-04	9.166E 05	-3.972E 03	-3.000E 02
63	7.560E 02	1.767E-02	-2.442E-04	8.671E 05	-4.272E 03	-3.000E 02
64	7.680E 02	1.484E-02	-2.276E-04	8.140E 05	-4.572E 03	-3.000E 02
65	7.800E 02	1.221E-02	-2.121E-04	7.573E 05	-1.737E 04	-2.530E 04
66	7.920E 02	9.750E-03	-2.008E-04	3.971E 05	-3.017E 04	-3.000E 02
67	8.040E 02	7.388E-03	-1.965E-04	3.321E 04	-3.047E 04	-3.000E 02
68	8.160E 02	5.034E-03	-1.995E-04	-3.343E 05	-3.077E 04	-3.000E 02
69	8.280E 02	2.600E-03	-2.097E-04	-7.053E 05	-3.107E 04	-3.000E 02
70	8.400E 02	0	-2.273E-04	-1.080E 06	-6.686E 03	4.907E 04
71	8.520E 02	-2.856E-03	-2.465E-04	-8.658E 05	1.770E 04	-3.000E 02
72	8.640E 02	-5.916E-03	-2.615E-04	-6.552E 05	1.740E 04	-3.000E 02
73	8.760E 02	-9.132E-03	-2.724E-04	-4.482E 05	1.710E 04	-3.000E 02
74	8.880E 02	-1.245E-02	-2.792E-04	-2.448E 05	1.680E 04	-3.000E 02
75	9.000E 02	-1.583E-02	-2.821E-04	-4.500E 04	9.000E 03	-1.530E 04
76	9.120E 02	-1.922E-02	-2.828E-04	-2.880E 04	1.200E 03	-3.000E 02
77	9.240E 02	-2.262E-02	-2.832E-04	-1.620E 04	9.000E 02	-3.000E 02
78	9.360E 02	-2.602E-02	-2.835E-04	-7.200E 03	6.000E 02	-3.000E 02
79	9.480E 02	-2.942E-02	-2.836E-04	-1.800E 03	3.000E 02	-3.000E 02
80	9.600E 02	-3.283E-02	-2.836E-04	5.767E-03	7.500E 01	-1.500E 02
81	9.720E 02	-3.623E-02	-2.836E-04	0	-2.403E-04	4.806E-04

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
100	1.200E 03	5.000E-01	5.000E-03	5.000E 07	5.000E 05	5.000E 05

TIME = 1 MINUTES, 34 AND 21/60 SECONDS



Prob 2. Steel bent cap.

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118   CODED 28 JUL 66-HM,JJP   PUNCH 28 JUL 66-TH   RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

TIME =   1 MINUTES, 34 AND 28/60 SECONDS

PROB
3A   MULTIPLE-SPAN BRIDGE - DEAD LOAD ONLY

TABLE 1 - PROGRAM-CONTROL DATA

	TABLES NUMBER 2	3	4
PRIOR-DATA OPTIONS (1 = HOLD)	0	0	0
NUM CARDS INPUT THIS PROBLEM	1	6	17
OPTION (IF=1, 2, 3) TO PLOT	1		

TABLE 2 - CONSTANTS

NUM INCREMENTS	100
INCREMENT LENGTH	9.600E 01

TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

STA	CASE	DEFLECTION	SLOPE
0	1	0	NONE
10	1	0	NONE
20	1	0	NONE
80	1	0	NONE
90	1	0	NONE
100	1	0	NONE

TABLE 4 - STIFFNESS AND LOAD DATA

FROM	TO	CONTD	F	Q	S	T	R	P
0	100	0	3.000E 11	-8.000E 03	0	0	0	0
9	11	0	3.000E 11	0	0	0	0	0
19	21	0	3.000E 11	0	0	0	0	0
29	31	0	3.000E 11	0	0	0	0	0
39	41	0	3.000E 11	0	0	0	0	0
49	51	0	3.000E 11	0	0	0	0	0
59	61	0	3.000E 11	0	0	0	0	0
69	71	0	3.000E 11	0	0	0	0	0
79	81	0	3.000E 11	0	0	0	0	0
89	91	0	3.000E 11	0	0	0	0	0
28	28	0	-3.000E 11	0	0	0	0	0

72	72	0	-3.000E 11	0	0	0	0	0
30	30	0	0	-2.000E 04	2.000E 05	0	5.000E 08	0
40	40	0	0	-2.000E 04	2.000E 05	0	5.000E 08	0
50	50	0	0	-2.000E 04	2.000E 05	0	5.000E 08	0
60	60	0	0	-2.000E 04	2.000E 05	0	5.000E 08	0
70	70	0	0	-2.000E 04	2.000E 05	0	5.000E 08	0

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
3A MULTIPLE-SPAN BRIDGE - DEAD LOAD ONLY

TABLE 5 - RESULTS

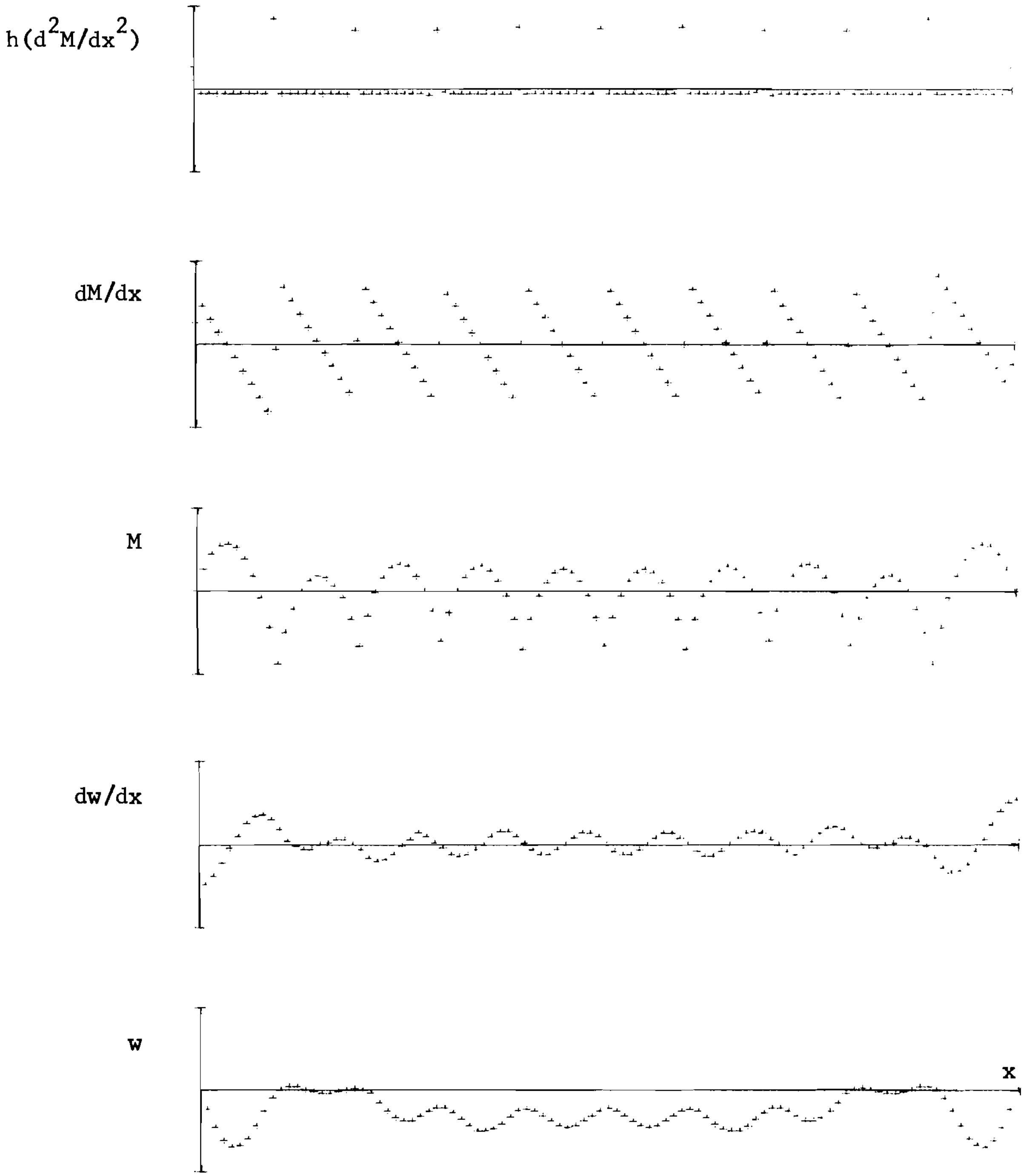
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-9.600E 01	5.262E-01	-5.481E-03	0	1.234E-06	2.467E-06
0	0	0	-5.481E-03	2.368E-04	1.336E 04	2.672E 04
1	9.600E 01	-5.262E-01	-5.071E-03	2.565E 06	2.272E 04	-8.000E 03
2	1.920E 02	-9.735E-01	-3.962E-03	4.362E 06	1.472E 04	-8.000E 03
3	2.880E 02	-1.287E 00	-2.402E-03	5.391E 06	6.717E 03	-8.000E 03
4	3.840E 02	-1.435E 00	-6.353E-04	5.651E 06	-1.283E 03	-8.000E 03
5	4.800E 02	-1.409E 00	1.092E-03	5.144E 06	-9.283E 03	-8.000E 03
6	5.760E 02	-1.225E 00	2.534E-03	3.869E 06	-1.728E 04	-8.000E 03
7	6.720E 02	-9.224E-01	3.445E-03	1.826E 06	-2.528E 04	-8.000E 03
8	7.680E 02	-5.636E-01	3.580E-03	-9.853E 05	-3.328E 04	-8.000E 03
9	8.640E 02	-2.350E-01	2.935E-03	-4.564E 06	-4.128E 04	-8.000E 03
10	9.600E 02	0	1.735E-03	-8.912E 06	-3.525E 03	8.352E 04
11	1.056E 03	9.816E-02	4.634E-04	-5.241E 06	3.423E 04	-8.000E 03
12	1.152E 03	8.898E-02	-4.698E-04	-2.339E 06	2.623E 04	-8.000E 03
13	1.248E 03	7.950E-03	-8.768E-04	-2.045E 05	1.823E 04	-8.000E 03
14	1.344E 03	-7.936E-02	-7.236E-04	1.162E 06	1.023E 04	-8.000E 03
15	1.440E 03	-1.310E-01	-2.561E-04	1.760E 06	2.233E 03	-8.000E 03
16	1.536E 03	-1.285E-01	2.800E-04	1.591E 06	-5.767E 03	-8.000E 03
17	1.632E 03	-7.722E-02	6.390E-04	6.529E 05	-1.377E 04	-8.000E 03
18	1.728E 03	-5.849E-03	5.750E-04	-1.053E 06	-2.177E 04	-8.000E 03
19	1.824E 03	3.318E-02	3.046E-05	-3.526E 06	-2.977E 04	-8.000E 03
20	1.920E 03	0	-8.871E-04	-6.768E 06	1.523E 03	7.058E 04
21	2.016E 03	-1.371E-01	-1.774E-03	-3.234E 06	3.281E 04	-8.000E 03
22	2.112E 03	-3.405E-01	-2.193E-03	-4.680E 05	2.481E 04	-8.000E 03
23	2.208E 03	-5.583E-01	-2.023E-03	1.530E 06	1.681E 04	-8.000E 03
24	2.304E 03	-7.290E-01	-1.337E-03	2.760E 06	8.812E 03	-8.000E 03
25	2.400E 03	-8.150E-01	-3.799E-04	3.222E 06	8.124E 02	-8.000E 03
26	2.496E 03	-8.019E-01	6.022E-04	2.916E 06	-7.188E 03	-8.000E 03
27	2.592E 03	-6.993E-01	1.364E-03	1.842E 06	-1.519E 04	-8.000E 03
28	2.688E 03	-5.401E-01	1.096E-03	0	-2.319E 04	-8.000E 03
29	2.784E 03	-4.890E-01	2.545E-04	-2.610E 06	-3.186E 04	-9.336E 03
30	2.880E 03	-4.913E-01	-5.132E-04	-6.116E 06	-1.397E 03	7.025E 04
31	2.976E 03	-5.875E-01	-1.309E-03	-2.878E 06	3.040E 04	-6.664E 03
32	3.072E 03	-7.427E-01	-1.661E-03	-2.797E 05	2.307E 04	-8.000E 03
33	3.168E 03	-9.065E-01	-1.458E-03	1.551E 06	1.507E 04	-8.000E 03
34	3.264E 03	-1.023E 00	-7.917E-04	2.613E 06	7.067E 03	-8.000E 03
35	3.360E 03	-1.058E 00	9.167E-05	2.908E 06	-9.328E 02	-8.000E 03
36	3.456E 03	-1.005E 00	9.463E-04	2.434E 06	-8.933E 03	-8.000E 03
37	3.552E 03	-8.768E-01	1.527E-03	1.193E 06	-1.693E 04	-8.000E 03
38	3.648E 03	-7.119E-01	1.587E-03	-8.170E 05	-2.493E 04	-8.000E 03
39	3.744E 03	-5.721E-01	1.073E-03	-3.595E 06	-3.278E 04	-7.687E 03
40	3.840E 03	-5.060E-01	1.203E-04	-7.110E 06	-2.160E 01	7.320E 04
41	3.936E 03	-5.490E-01	-8.324E-04	-3.599E 06	3.242E 04	-8.313E 03
42	4.032E 03	-6.658E-01	-1.358E-03	-8.855E 05	2.426E 04	-8.000E 03
43	4.128E 03	-8.098E-01	-1.330E-03	1.060E 06	1.626E 04	-8.000E 03

44	4.224E 03	-9.212E-01	-8.025E-04	2.237E 06	8.263E 03	-8.000E 03
45	4.320E 03	-9.638E-01	-2.120E-05	2.646E 06	2.631E 02	-8.000E 03
46	4.416E 03	-9.252E-01	7.682E-04	2.288E 06	-7.737E 03	-8.000E 03
47	4.512E 03	-8.163E-01	1.320E-03	1.161E 06	-1.574E 04	-8.000E 03
48	4.608E 03	-6.718E-01	1.388E-03	-7.339E 05	-2.374E 04	-8.000E 03
49	4.704E 03	-5.498E-01	9.085E-04	-3.397E 06	-3.174E 04	-8.000E 03
50	4.800E 03	-4.974E-01	1.971E-12	-6.827E 06	-1.494E-05	7.147E 04
51	4.896E 03	-5.498E-01	-9.085E-04	-3.397E 06	3.174E 04	-8.000E 03
52	4.992E 03	-6.718E-01	-1.388E-03	-7.339E 05	2.374E 04	-8.000E 03
53	5.088E 03	-8.163E-01	-1.320E-03	1.161E 06	1.574E 04	-8.000E 03
54	5.184E 03	-9.252E-01	-7.682E-04	2.288E 06	7.737E 03	-8.000E 03
55	5.280E 03	-9.638E-01	2.120E-05	2.646E 06	-2.631E 02	-8.000E 03
56	5.376E 03	-9.212E-01	8.025E-04	2.237E 06	-8.263E 03	-8.000E 03
57	5.472E 03	-8.098E-01	1.330E-03	1.060E 06	-1.626E 04	-8.000E 03
58	5.568E 03	-6.658E-01	1.358E-03	-8.855E 05	-2.426E 04	-8.000E 03
59	5.664E 03	-5.490E-01	8.324E-04	-3.599E 06	-3.242E 04	-8.313E 03
60	5.760E 03	-5.060E-01	-1.203E-04	-7.110E 06	2.160E 01	7.320E 04
61	5.856E 03	-5.721E-01	-1.073E-03	-3.595E 06	3.278E 04	-7.687E 03
62	5.952E 03	-7.119E-01	-1.587E-03	-8.170E 05	2.493E 04	-8.000E 03
63	6.048E 03	-8.768E-01	-1.527E-03	1.193E 06	1.693E 04	-8.000E 03
64	6.144E 03	-1.005E 00	-9.463E-04	2.434E 06	8.933E 03	-8.000E 03
65	6.240E 03	-1.058E 00	-9.167E-05	2.908E 06	9.328E 02	-8.000E 03
66	6.336E 03	-1.023E 00	7.917E-04	2.613E 06	-7.067E 03	-8.000E 03
67	6.432E 03	-9.065E-01	1.458E-03	1.551E 06	-1.507E 04	-8.000E 03
68	6.528E 03	-7.427E-01	1.661E-03	-2.797E 05	-2.307E 04	-8.000E 03
69	6.624E 03	-5.875E-01	1.309E-03	-2.878E 06	-3.040E 04	-6.664E 03
70	6.720E 03	-4.913E-01	5.132E-04	-6.116E 06	1.397E 03	7.025E 04
71	6.816E 03	-4.890E-01	-2.545E-04	-2.610E 06	3.186E 04	-9.336E 03
72	6.912E 03	-5.401E-01	-1.096E-03	0	2.319E 04	-8.000E 03
73	7.008E 03	-6.993E-01	-1.364E-03	1.842E 06	1.519E 04	-8.000E 03
74	7.104E 03	-8.019E-01	-6.022E-04	2.916E 06	7.188E 03	-8.000E 03
75	7.200E 03	-8.150E-01	3.799E-04	3.222E 06	-8.124E 02	-8.000E 03
76	7.296E 03	-7.290E-01	1.337E-03	2.760E 06	-8.812E 03	-8.000E 03
77	7.392E 03	-5.583E-01	2.023E-03	1.530E 06	-1.681E 04	-8.000E 03
78	7.488E 03	-3.405E-01	2.193E-03	-4.680E 05	-2.481E 04	-8.000E 03
79	7.584E 03	-1.371E-01	1.774E-03	-3.234E 06	-3.281E 04	-8.000E 03
80	7.680E 03	0	8.871E-04	-6.768E 06	-1.523E 03	7.058E 04
81	7.776E 03	3.318E-02	-3.046E-05	-3.526E 06	2.977E 04	-8.000E 03
82	7.872E 03	-5.849E-03	-5.750E-04	-1.053E 06	2.177E 04	-8.000E 03
83	7.968E 03	-7.722E-02	-6.390E-04	6.529E 05	1.377E 04	-8.000E 03
84	8.064E 03	-1.285E-01	-2.800E-04	1.591E 06	5.767E 03	-8.000E 03
85	8.160E 03	-1.310E-01	2.561E-04	1.760E 06	-2.233E 03	-8.000E 03
86	8.256E 03	-7.936E-02	7.236E-04	1.162E 06	-1.023E 04	-8.000E 03
87	8.352E 03	7.950E-03	8.768E-04	-2.045E 05	-1.823E 04	-8.000E 03
88	8.448E 03	8.898E-02	4.698E-04	-2.339E 06	-2.623E 04	-8.000E 03
89	8.544E 03	9.816E-02	-4.634E-04	-5.241E 06	-3.423E 04	-8.000E 03
90	8.640E 03	0	-1.735E-03	-8.912E 06	3.525E 03	8.352E 04
91	8.736E 03	-2.350E-01	-2.935E-03	-4.564E 06	4.128E 04	-8.000E 03
92	8.832E 03	-5.636E-01	-3.580E-03	-9.853E 05	3.328E 04	-8.000E 03
93	8.928E 03	-9.224E-01	-3.445E-03	1.826E 06	2.528E 04	-8.000E 03
94	9.024E 03	-1.225E 00	-2.534E-03	3.869E 06	1.728E 04	-8.000E 03
95	9.120E 03	-1.409E 00	-1.092E-03	5.144E 06	9.283E 03	-8.000E 03
96	9.216E 03	-1.435E 00	6.353E-04	5.651E 06	1.283E 03	-8.000E 03
97	9.312E 03	-1.287E 00	2.402E-03	5.391E 06	-6.717E 03	-8.000E 03
98	9.408E 03	-9.735E-01	3.962E-03	4.362E 06	-1.472E 04	-8.000E 03
99	9.504E 03	-5.262E-01	5.071E-03	2.565E 06	-2.272E 04	-8.000E 03
100	9.600E 03	0	5.481E-03	0	-1.336E 04	2.672E 04
101	9.696E 03	5.262E-01	5.481E-03	0	0	0

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
100	9.600E 03	2.000E 00	1.000E-02	1.000E 07	5.000E 04	1.000E 05

TIME = 1 MINUTES, 54 AND 17/60 SECONDS



Prob 3A. Multiple-span bridge - dead load only.

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118   CODED 28 JUL 66-HM,JJP   PUNCH 28 JUL 66-TH   RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPORT

TIME =   1 MINUTES, 54 ANC 24/60 SECONDS

PROB
3B   MULTIPLE-SPAN BRIDGE - LIVE LOAC ADDED AFTER DEAD LCAC SETTLEMENT

TABLE 1 - PRCGRAM-CCNTRCL CATA

	TABLES NUMBER 2	3	4
PRICR-CATA OPTICNS (1 = HOLC)	0	0	0
NUM CARCS INPUT THIS PROBLEM	1	11	18
CPTICN (IF=1, 2, 3) TC PLCT	1		

TABLE 2 - CCNSTANTS

NUM INCREMENTS	100
INCREMENT LENGTH	9.600E 01

TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

STA	CASE	DEFLECTICN	SLOPE
0	1	0	NONE
10	1	0	NONE
20	1	0	NCNE
30	1	-4.913E-01	NONE
40	1	-5.060E-01	NONE
50	1	-4.974E-C1	NONE
60	1	-5.060E-C1	NONE
70	1	-4.913E-C1	NCNE
80	1	0	NCNE
90	1	0	NONE
100	1	0	NCNE

TABLE 4 - STIFFNESS AND LOAD CATA

FRCM	TC	CONTC	F	Q	S	T	R	P
0	100	0	3.000E 11	-8.000E C3	0	0	0	0
20	45	0	0	-8.00CE C3	0	0	0	0
9	11	C	3.000E 11	C	0	0	0	0
19	21	C	3.000E 11	C	0	0	0	0
29	31	C	3.000E 11	C	0	0	0	0
39	41	C	3.000E 11	C	0	0	0	0

49	51	C	3.000E 11	C	0	0	0	0
59	61	C	3.000E 11	C	0	0	0	0
69	71	C	3.000E 11	C	0	0	0	0
79	81	0	3.000E 11	C	0	0	0	0
89	91	C	3.000E 11	C	0	0	0	0
28	28	C	-3.000E 11	C	0	0	0	0
72	72	C	-3.000E 11	0	0	0	0	0
30	30	C	0	-2.00CE C4	2.000E 05	0	5.0C0E 08	0
40	40	C	0	-2.00CE C4	2.00CE 05	0	5.0C0E 08	0
50	50	C	C	-2.00CE C4	2.00CE 05	0	5.0C0E 08	0
60	60	C	0	-2.00CE C4	2.00CE 05	0	5.0C0E 08	0
70	70	0	C	-2.00CE C4	2.00CE 05	0	5.0C0E 08	0

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPCRT

PROB (CCNTC)
38 MULTIPLE-SPAN BRIDGE - LIVE LOAD ADDED AFTER DEAD LCAC SETTLEMENT

TABLE 5 - RESULTS

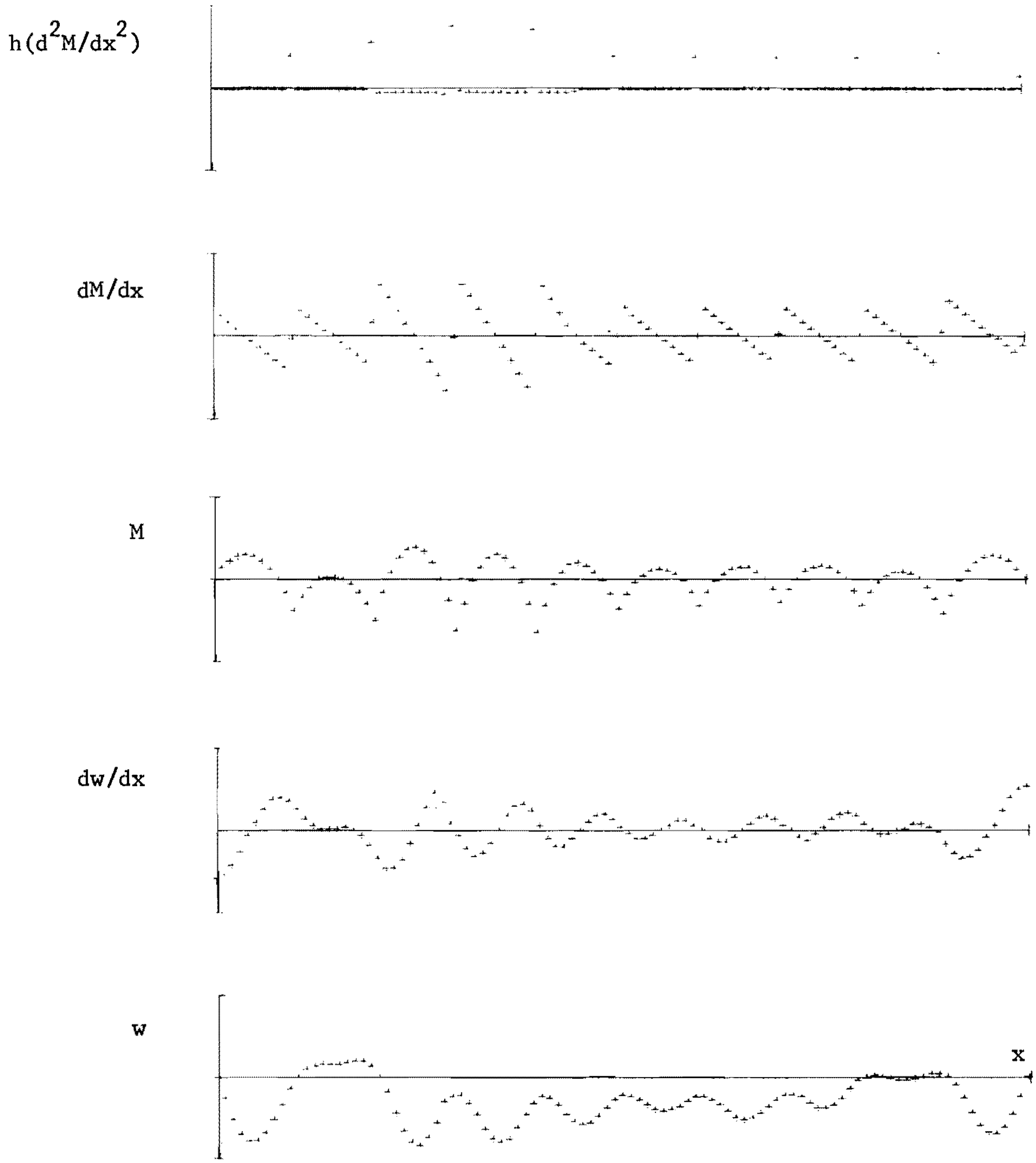
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-9.600E 01	5.747E-01	-5.986E-03	0	0	0
0	0	0	-5.986E-03	0	1.387E 04	2.773E 04
1	9.600E 01	-5.747E-01	-5.560E-03	2.662E 06	2.373E 04	-8.000E 03
2	1.920E 02	-1.068E 00	-4.405E-03	4.557E 06	1.573E 04	-8.000E 03
3	2.880E 02	-1.420E 00	-2.767E-03	5.683E 06	7.732E 03	-8.000E 03
4	3.840E 02	-1.599E 00	-8.910E-04	6.041E 06	-2.678E 02	-8.000E 03
5	4.800E 02	-1.592E 00	9.766E-04	5.631E 06	-8.268E 03	-8.000E 03
6	5.760E 02	-1.411E 00	2.590E-03	4.454E 06	-1.627E 04	-8.000E 03
7	6.720E 02	-1.094E 00	3.704E-03	2.508E 06	-2.427E 04	-8.000E 03
8	7.680E 02	-7.001E-01	4.073E-03	-2.057E 05	-3.227E 04	-8.000E 03
9	8.640E 02	-3.123E-01	3.646E-03	-3.687E 06	-4.027E 04	-8.000E 03
10	9.600E 02	0	2.618E-03	-7.937E 06	-5.331E 03	7.787E 04
11	1.056E 03	1.904E-01	1.481E-03	-4.711E 06	2.961E 04	-8.000E 03
12	1.152E 03	2.843E-01	6.176E-04	-2.253E 06	2.161E 04	-8.000E 03
13	1.248E 03	3.090E-01	1.672E-04	-5.625E 05	1.361E 04	-8.000E 03
14	1.344E 03	3.164E-01	1.347E-04	3.597E 05	5.606E 03	-8.000E 03
15	1.440E 03	3.348E-01	2.745E-04	5.139E 05	-2.394E 03	-8.000E 03
16	1.536E 03	3.691E-01	3.408E-04	-9.986E 04	-1.039E 04	-8.000E 03
17	1.632E 03	4.003E-01	8.774E-05	-1.482E 06	-1.839E 04	-8.000E 03
18	1.728E 03	3.859E-01	-7.304E-04	-3.631E 06	-2.639E 04	-8.000E 03
19	1.824E 03	2.600E-01	-2.010E-03	-6.549E 06	-3.439E 04	-8.000E 03
20	1.920E 03	0	-3.527E-03	-1.024E 07	1.547E 04	1.077E 05
21	2.016E 03	-4.172E-01	-4.728E-03	-3.580E 06	6.133E 04	-1.600E 04
22	2.112E 03	-9.078E-01	-4.863E-03	1.540E 06	4.533E 04	-1.600E 04
23	2.208E 03	-1.351E 00	-3.797E-03	5.123E 06	2.933E 04	-1.600E 04
24	2.304E 03	-1.637E 00	-1.830E-03	7.170E 06	1.333E 04	-1.600E 04
25	2.400E 03	-1.702E 00	5.459E-04	7.682E 06	-2.673E 03	-1.600E 04
26	2.496E 03	-1.532E 00	2.840E-03	6.657E 06	-1.867E 04	-1.600E 04
27	2.592E 03	-1.157E 00	4.561E-03	4.097E 06	-3.467E 04	-1.600E 04
28	2.688E 03	-6.564E-01	3.338E-03	0	-5.067E 04	-1.600E 04
29	2.784E 03	-5.162E-01	8.599E-04	-5.633E 06	-6.769E 04	-1.803E 04
30	2.880E 03	-4.913E-01	-7.806E-04	-1.300E 07	-3.517E 03	1.464E 05
31	2.976E 03	-6.661E-01	-2.493E-03	-6.308E 06	6.269E 04	-1.397E 04
32	3.072E 03	-9.700E-01	-3.320E-03	-9.602E 05	4.770E 04	-1.600E 04
33	3.168E 03	-1.303E 00	-3.017E-03	2.851E 06	3.170E 04	-1.600E 04
34	3.264E 03	-1.549E 00	-1.740E-03	5.127E 06	1.570E 04	-1.600E 04
35	3.360E 03	-1.638E 00	1.853E-05	5.867E 06	-2.951E 02	-1.600E 04
36	3.456E 03	-1.546E 00	1.768E-03	5.070E 06	-1.630E 04	-1.600E 04
37	3.552E 03	-1.298E 00	3.018E-03	2.738E 06	-3.230E 04	-1.600E 04
38	3.648E 03	-9.663E-01	3.275E-03	-1.130E 06	-4.830E 04	-1.600E 04
39	3.744E 03	-6.692E-01	2.397E-03	-6.535E 06	-6.347E 04	-1.435E 04
40	3.840E 03	-5.060E-01	6.350E-04	-1.332E 07	-6.481E 02	1.400E 05
41	3.936E 03	-5.473E-01	-1.141E-03	-6.659E 06	6.052E 04	-1.765E 04
42	4.032E 03	-7.250E-01	-2.122E-03	-1.697E 06	4.369E 04	-1.600E 04
43	4.128E 03	-9.548E-01	-2.117E-03	1.730E 06	2.769E 04	-1.600E 04

44	4.224E 03	-1.131E 00	-1.261E-03	3.620E 06	1.169E 04	-1.600E 04
45	4.320E 03	-1.197E 00	-4.580E-05	3.975E 06	-2.308E 03	-1.200E 04
46	4.416E 03	-1.140E 00	1.098E-03	3.177E 06	-1.231E 04	-8.000E 03
47	4.512E 03	-9.860E-01	1.865E-03	1.611E 06	-2.031E 04	-8.000E 03
48	4.608E 03	-7.822E-01	2.007E-03	-7.221E 05	-2.831E 04	-8.000E 03
49	4.704E 03	-6.007E-01	1.484E-03	-3.824E 06	-3.570E 04	-6.777E 03
50	4.800E 03	-4.974E-01	4.696E-04	-7.576E 06	-6.208E 02	7.693E 04
51	4.896E 03	-5.105E-01	-5.570E-04	-3.943E 06	3.323E 04	-9.223E 03
52	4.992E 03	-6.043E-01	-1.169E-03	-1.195E 06	2.462E 04	-8.000E 03
53	5.088E 03	-7.349E-01	-1.235E-03	7.843E 05	1.662E 04	-8.000E 03
54	5.184E 03	-8.414E-01	-7.898E-04	1.996E 06	8.621E 03	-8.000E 03
55	5.280E 03	-8.866E-01	-8.014E-05	2.439E 06	6.206E 02	-8.000E 03
56	5.376E 03	-8.568E-01	6.486E-04	2.115E 06	-7.379E 03	-8.000E 03
57	5.472E 03	-7.620E-01	1.151E-03	1.023E 06	-1.538E 04	-8.000E 03
58	5.568E 03	-6.359E-01	1.180E-03	-8.378E 05	-2.338E 04	-8.000E 03
59	5.664E 03	-5.354E-01	6.764E-04	-3.466E 06	-3.170E 04	-8.644E 03
60	5.760E 03	-5.060E-01	-2.473E-04	-6.924E 06	3.756E 01	7.212E 04
61	5.856E 03	-5.829E-01	-1.170E-03	-3.459E 06	3.242E 04	-7.356E 03
62	5.952E 03	-7.307E-01	-1.651E-03	-6.997E 05	2.474E 04	-8.000E 03
63	6.048E 03	-8.999E-01	-1.556E-03	1.292E 06	1.674E 04	-8.000E 03
64	6.144E 03	-1.030E 00	-9.474E-04	2.515E 06	8.743E 03	-8.000E 03
65	6.240E 03	-1.082E 00	-6.985E-05	2.970E 06	7.426E 02	-8.000E 03
66	6.336E 03	-1.043E 00	8.306E-04	2.657E 06	-7.257E 03	-8.000E 03
67	6.432E 03	-9.224E-01	1.508E-03	1.577E 06	-1.526E 04	-8.000E 03
68	6.528E 03	-7.534E-01	1.717E-03	-2.720E 05	-2.326E 04	-8.000E 03
69	6.624E 03	-5.928E-01	1.365E-03	-2.889E 06	-3.052E 04	-6.525E 03
70	6.720E 03	-4.913E-01	5.664E-04	-6.132E 06	1.446E 03	7.046E 04
71	6.816E 03	-4.840E-01	-2.026E-04	-2.611E 06	3.194E 04	-9.475E 03
72	6.912E 03	-5.302E-01	-1.078E-03	0	2.320E 04	-8.000E 03
73	7.008E 03	-6.910E-01	-1.380E-03	1.843E 06	1.520E 04	-8.000E 03
74	7.104E 03	-7.951E-01	-6.181E-04	2.918E 06	7.199E 03	-8.000E 03
75	7.200E 03	-8.097E-01	3.649E-04	3.225E 06	-8.009E 02	-8.000E 03
76	7.296E 03	-7.251E-01	1.323E-03	2.764E 06	-8.801E 03	-8.000E 03
77	7.392E 03	-5.556E-01	2.011E-03	1.536E 06	-1.680E 04	-8.000E 03
78	7.488E 03	-3.389E-01	2.183E-03	-4.613E 05	-2.480E 04	-8.000E 03
79	7.584E 03	-1.364E-01	1.765E-03	-3.226E 06	-3.280E 04	-8.000E 03
80	7.680E 03	0	8.804E-04	-6.759E 06	-1.523E 03	7.056E 04
81	7.776E 03	3.261E-02	-3.568E-05	-3.519E 06	2.976E 04	-8.000E 03
82	7.872E 03	-6.850E-03	-5.784E-04	-1.046E 06	2.176E 04	-8.000E 03
83	7.968E 03	-7.844E-02	-6.404E-04	6.584E 05	1.376E 04	-8.000E 03
84	8.064E 03	-1.298E-01	-2.799E-04	1.595E 06	5.755E 03	-8.000E 03
85	8.160E 03	-1.322E-01	2.575E-04	1.763E 06	-2.245E 03	-8.000E 03
86	8.256E 03	-8.038E-02	7.258E-04	1.164E 06	-1.024E 04	-8.000E 03
87	8.352E 03	7.181E-03	8.795E-04	-2.036E 05	-1.824E 04	-8.000E 03
88	8.448E 03	8.848E-02	4.726E-04	-2.339E 06	-2.624E 04	-8.000E 03
89	8.544E 03	9.793E-02	-4.608E-04	-5.243E 06	-3.424E 04	-8.000E 03
90	8.640E 03	0	-1.733E-03	-8.914E 06	3.520E 03	8.353E 04
91	8.736E 03	-2.348E-01	-2.933E-03	-4.567E 06	4.129E 04	-8.000E 03
92	8.832E 03	-5.632E-01	-3.579E-03	-9.873E 05	3.329E 04	-8.000E 03
93	8.928E 03	-9.219E-01	-3.445E-03	1.824E 06	2.529E 04	-8.000E 03
94	9.024E 03	-1.225E 00	-2.534E-03	3.868E 06	1.729E 04	-8.000E 03
95	9.120E 03	-1.408E 00	-1.092E-03	5.143E 06	9.286E 03	-8.000E 03
96	9.216E 03	-1.434E 00	6.346E-04	5.650E 06	1.286E 03	-8.000E 03
97	9.312E 03	-1.287E 00	2.401E-03	5.390E 06	-6.714E 03	-8.000E 03
98	9.408E 03	-9.733E-01	3.961E-03	4.361E 06	-1.471E 04	-8.000E 03
99	9.504E 03	-5.260E-01	5.069E-03	2.565E 06	-2.271E 04	-8.000E 03
100	9.600E 03	0	5.480E-03	2.368E-04	-1.336E 04	2.671E 04
101	9.696E 03	5.260E-01	5.480E-03	0	-1.234E-06	2.467E-06

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
100	9.600E 03	2.000E 00	1.000E-02	2.000E 07	1.000E 05	2.000E 05

TIME = 2 MINUTES, 14 AND 1/60 SECONDS



Prob 3B. Multiple-span bridge - live load added after dead load settlement.

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPORT

TIME = 2 MINUTES, 14 ANC 8/60 SECONDS

PROB
4 BRACED TRENCH

TABLE 1 - PROGRAM-CCNTRCL DATA

	TABLES NUMBER 2	3	4
PRICR-DATA OPTIONS (1 = HOLC)	0	0	0
NUM CARCS INPUT THIS PROBLEM	1	0	5
OPTION (IF=1, 2, 3) TC PLOT	1		

TABLE 2 - CCNSTANTS

NUM INCREMENTS	40
INCREMENT LENGTH	1.200E 01

TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

STA	CASE	DEFLECTICN	SLCPE
	NONE		

TABLE 4 - STIFFNESS AND LOAD CATA

FROM	TC	CCNTC	F	Q	S	T	R	P
0		1	5.000E 09	C	0	0	0	0
	30	1	5.000E 09	4.950E C3	0	0	0	0
	40	C	5.000E 09	4.950E C3	1.250E 04	0	0	0
10	10	C	C	C	2.670E 05	0	0	0
20	20	C	C	C	2.670E 05	0	0	0

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPORT

PROB (CCNTC)
4 BRACED TRENCH

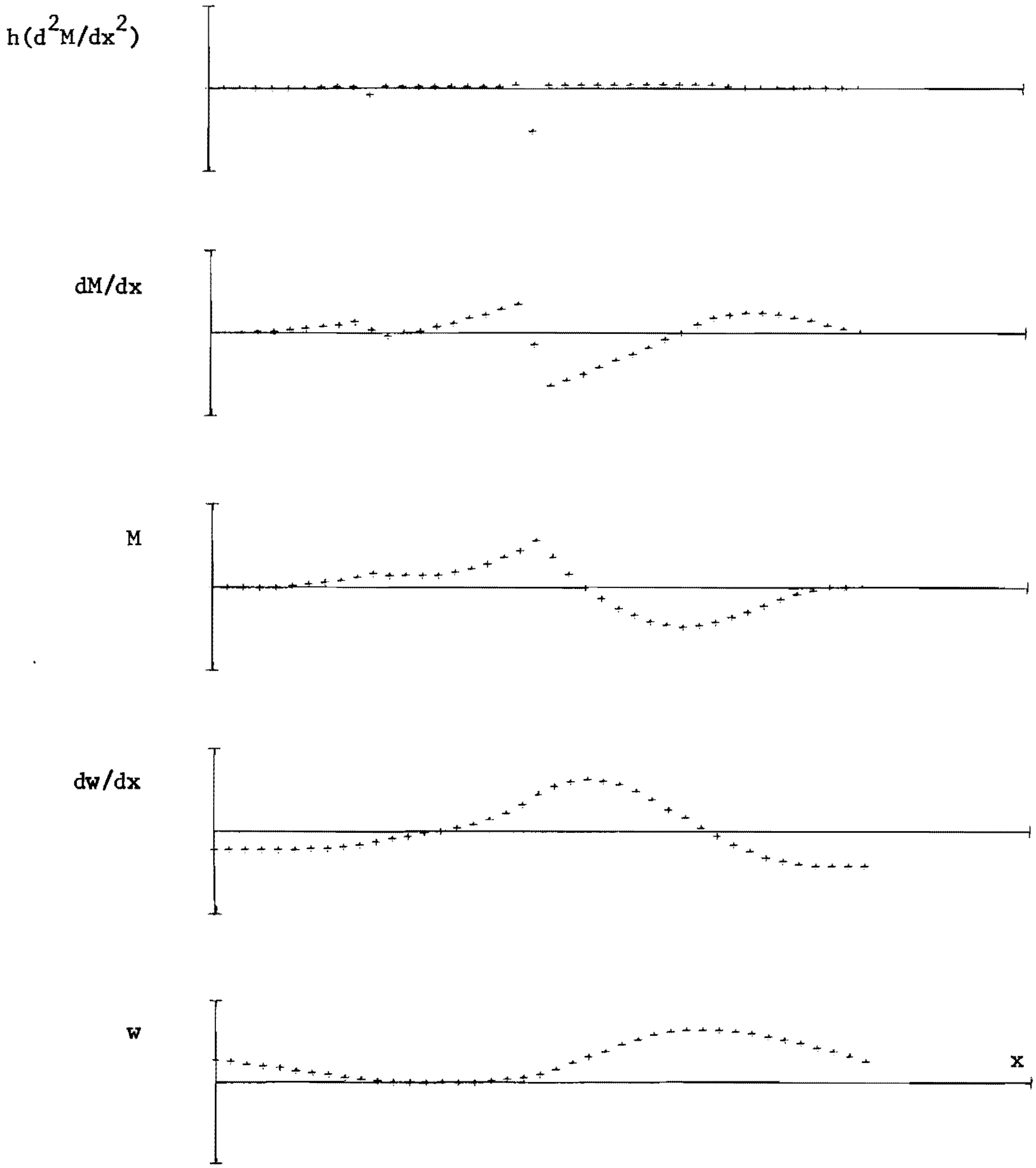
TABLE 5 - RESULTS

STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-1.200E 01	6.312E-01	-4.767E-03	0	-2.105E-05	-4.211E-05
0	0	5.740E-01	-4.767E-03	-5.053E-04	-4.211E-05	2.368E-15
1	1.200E 01	5.168E-01	-4.767E-03	-1.011E-03	8.250E 01	1.650E 02
2	2.400E 01	4.596E-01	-4.765E-03	1.980E 03	3.300E 02	3.300E 02
3	3.600E 01	4.024E-01	-4.753E-03	7.920E 03	7.425E 02	4.950E 02
4	4.800E 01	3.455E-01	-4.720E-03	1.980E 04	1.320E 03	6.600E 02
5	6.000E 01	2.892E-01	-4.648E-03	3.960E 04	2.062E 03	8.250E 02
6	7.200E 01	2.340E-01	-4.518E-03	6.930E 04	2.970E 03	9.900E 02
7	8.400E 01	1.808E-01	-4.301E-03	1.109E 05	4.042E 03	1.155E 03
8	9.600E 01	1.307E-01	-3.969E-03	1.663E 05	5.280E 03	1.320E 03
9	1.080E 02	8.551E-02	-3.484E-03	2.376E 05	6.682E 03	1.485E 03
10	1.200E 02	4.713E-02	-2.807E-03	3.267E 05	1.959E 03	-1.093E 04
11	1.320E 02	1.815E-02	-2.073E-03	2.846E 05	-2.600E 03	1.815E 03
12	1.440E 02	-2.633E-03	-1.415E-03	2.643E 05	-7.025E 02	1.980E 03
13	1.560E 02	-1.580E-02	-7.761E-04	2.678E 05	1.360E 03	2.145E 03
14	1.680E 02	-2.126E-02	-9.847E-05	2.969E 05	3.588E 03	2.310E 03
15	1.800E 02	-1.816E-02	6.825E-04	3.539E 05	5.980E 03	2.475E 03
16	1.920E 02	-4.880E-03	1.636E-03	4.405E 05	8.538E 03	2.640E 03
17	2.040E 02	2.109E-02	2.835E-03	5.588E 05	1.126E 04	2.805E 03
18	2.160E 02	6.315E-02	4.358E-03	7.107E 05	1.415E 04	2.970E 03
19	2.280E 02	1.257E-01	6.289E-03	8.983E 05	1.720E 04	3.135E 03
20	2.400E 02	2.141E-01	8.715E-03	1.124E 06	-8.163E 03	-5.386E 04
21	2.520E 02	3.348E-01	1.091E-02	7.024E 05	-3.336E 04	3.465E 03
22	2.640E 02	4.758E-01	1.214E-02	3.228E 05	-2.981E 04	3.630E 03
23	2.760E 02	6.261E-01	1.251E-02	-1.315E 04	-2.610E 04	3.795E 03
24	2.880E 02	7.760E-01	1.213E-02	-3.036E 05	-2.222E 04	3.960E 03
25	3.000E 02	9.172E-01	1.111E-02	-5.465E 05	-1.818E 04	4.125E 03
26	3.120E 02	1.043E 00	9.564E-03	-7.399E 05	-1.397E 04	4.290E 03
27	3.240E 02	1.147E 00	7.618E-03	-8.819E 05	-9.601E 03	4.455E 03
28	3.360E 02	1.225E 00	5.395E-03	-9.704E 05	-5.064E 03	4.620E 03
29	3.480E 02	1.276E 00	3.027E-03	-1.003E 06	-3.612E 02	4.785E 03
30	3.600E 02	1.298E 00	6.477E-04	-9.790E 05	4.506E 03	4.950E 03
31	3.720E 02	1.292E 00	-1.601E-03	-8.953E 05	8.649E 03	3.335E 03
32	3.840E 02	1.260E 00	-3.602E-03	-7.715E 05	1.122E 04	1.801E 03
33	3.960E 02	1.205E 00	-5.279E-03	-6.260E 05	1.233E 04	4.301E 02
34	4.080E 02	1.133E 00	-6.600E-03	-4.755E 05	1.219E 04	-7.148E 02
35	4.200E 02	1.047E 00	-7.571E-03	-3.335E 05	1.104E 04	-1.593E 03
36	4.320E 02	9.513E-01	-8.224E-03	-2.106E 05	9.147E 03	-2.184E 03
37	4.440E 02	8.495E-01	-8.613E-03	-1.139E 05	6.814E 03	-2.483E 03
38	4.560E 02	7.445E-01	-8.807E-03	-4.708E 04	4.324E 03	-2.495E 03
39	4.680E 02	6.382E-01	-8.875E-03	-1.016E 04	1.962E 03	-2.229E 03
40	4.800E 02	5.315E-01	-8.888E-03	-1.263E-04	4.235E 02	-8.470E 02
41	4.920E 02	4.249E-01	-8.888E-03	0	5.263E-06	-1.053E-05

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	6.000E 02	2.000E 00	2.000E-02	2.000E 06	5.000E 04	1.000E 05

TIME = 2 MINUTES, 26 AND 34/60 SECONDS



Prob 4. Braced trench.

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PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118     CODED 28 JUL 66-HM,JJP    PUNCH 28 JUL 66-TH    RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCOL 34 FINAL REPORT

     TIME =     2 MINUTES, 26 ANC 41/60 SECONDS


PROB
   5A     LCNG-PILE BUCKLING, AXIAL COMPRESSION = 4.000E+05 LB


TABLE 1 - PRCGRAM-CONTRCL CATA
                                                                  TABLES NUMBER
                                                                   2    3    4

     PRIOR-DATA OPTIONS (1 = HOLD)                                 0    0    0
     NUM CARCS INPUT THIS PROBLEM                                  1    1    5

     OPTION (IF=1, 2, 3) TC PLOT                                   1


TABLE 2 - CCNSTANTS

     NUM INCREMENTS                                                        50
     INCREMENT LENGTH                                               2.400E 01


TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

     STA       CASE        DEFLECTICN        SLOPE

      50         1                 0          NONE


TABLE 4 - STIFFNESS AND LOAD DATA

FROM TC CONTC     F           Q           S           T           R           P

   0  50  C   3.700E 10           0           0           0           0 -4.000E 05
  25  50  0           0           0   2.000E 04           0           0           0
   0   0  0           0           C           0 -4.000E 05   3.0C0E 10           0
  13       1          0   6.000E C1           0           0           0           0
      25  C           0           0           0           0           0           0
```

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
5A LONG-PILE BUCKLING, AXIAL COMPRESSION = 4.000E+05 LB

TABLE 5 - RESULTS

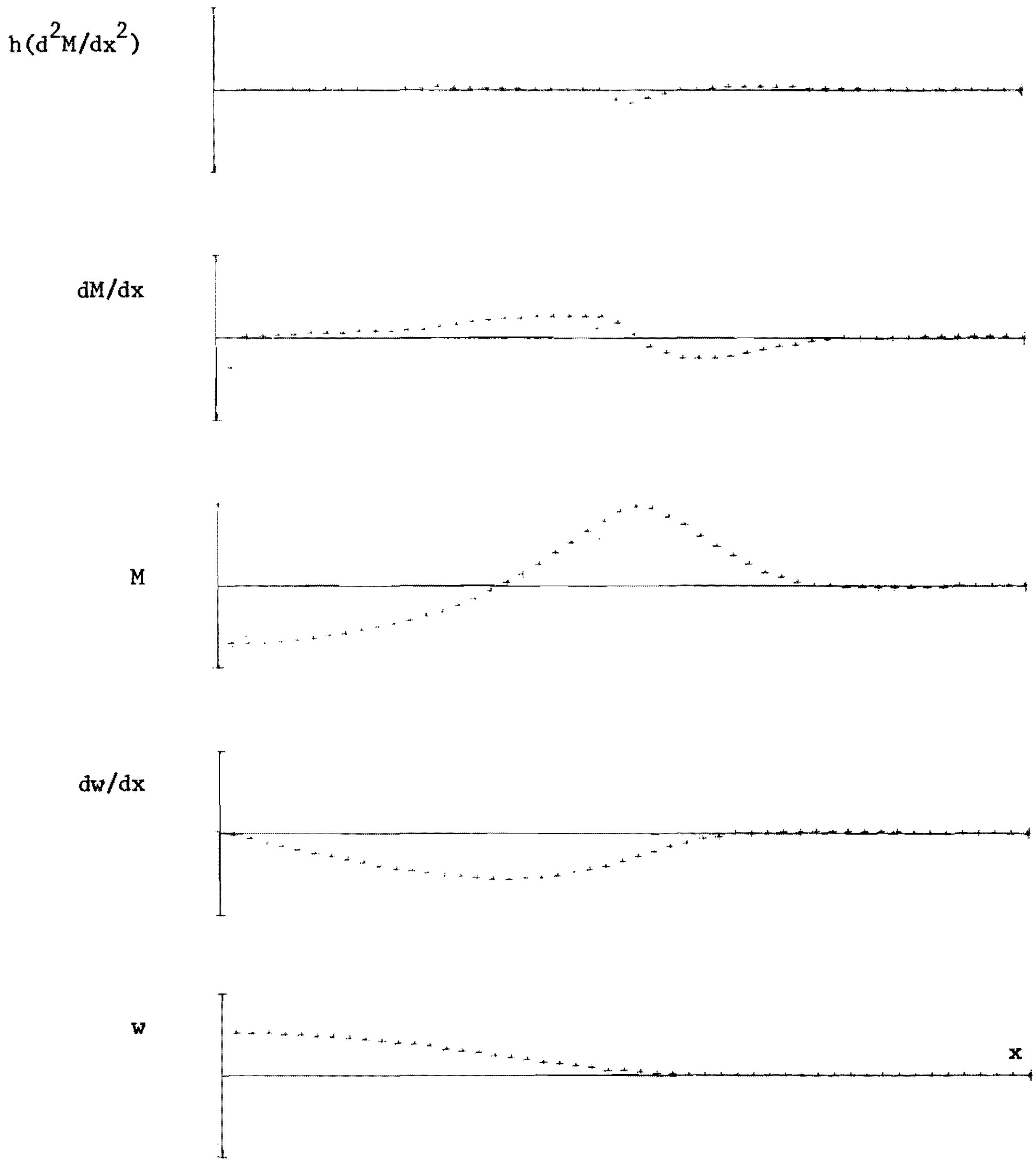
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	2.602E-01	3.459E-05	0	-7.607E 02	-1.521E 03
0	0	2.610E-01	1.090E-05	-3.651E 04	-1.518E 03	7.282E 00
1	2.400E 01	2.607E-01	-3.641E-05	-7.285E 04	-7.451E 02	1.538E 03
2	4.800E 01	2.593E-01	-8.348E-05	-7.228E 04	3.334E 01	1.872E 01
3	7.200E 01	2.567E-01	-1.300E-04	-7.125E 04	5.193E 01	1.846E 01
4	9.600E 01	2.530E-01	-1.758E-04	-6.978E 04	7.020E 01	1.808E 01
5	1.200E 02	2.483E-01	-2.204E-04	-6.788E 04	8.803E 01	1.759E 01
6	1.440E 02	2.424E-01	-2.637E-04	-6.556E 04	1.053E 02	1.698E 01
7	1.680E 02	2.356E-01	-3.053E-04	-6.283E 04	1.219E 02	1.628E 01
8	1.920E 02	2.278E-01	-3.451E-04	-5.970E 04	1.378E 02	1.547E 01
9	2.160E 02	2.190E-01	-3.827E-04	-5.621E 04	1.528E 02	1.456E 01
10	2.400E 02	2.094E-01	-4.179E-04	-5.237E 04	1.669E 02	1.357E 01
11	2.640E 02	1.990E-01	-4.505E-04	-4.820E 04	1.799E 02	1.249E 01
12	2.880E 02	1.878E-01	-4.803E-04	-4.373E 04	1.918E 02	1.133E 01
13	3.120E 02	1.759E-01	-5.071E-04	-3.899E 04	2.175E 02	4.005E 01
14	3.360E 02	1.634E-01	-5.306E-04	-3.329E 04	2.693E 02	6.354E 01
15	3.600E 02	1.504E-01	-5.498E-04	-2.607E 04	3.294E 02	5.667E 01
16	3.840E 02	1.370E-01	-5.640E-04	-1.748E 04	3.825E 02	4.946E 01
17	4.080E 02	1.234E-01	-5.721E-04	-7.706E 03	4.282E 02	4.193E 01
18	4.320E 02	1.096E-01	-5.736E-04	3.073E 03	4.662E 02	3.415E 01
19	4.560E 02	9.584E-02	-5.679E-04	1.467E 04	4.964E 02	2.615E 01
20	4.800E 02	8.233E-02	-5.544E-04	2.690E 04	5.185E 02	1.799E 01
21	5.040E 02	6.923E-02	-5.328E-04	3.956E 04	5.323E 02	9.721E 00
22	5.280E 02	5.675E-02	-5.030E-04	5.245E 04	5.379E 02	1.389E 00
23	5.520E 02	4.509E-02	-4.648E-04	6.538E 04	5.351E 02	-6.952E 00
24	5.760E 02	3.444E-02	-4.182E-04	7.813E 04	5.240E 02	-1.525E 01
25	6.000E 02	2.501E-02	-3.635E-04	9.053E 04	3.798E 02	-2.732E 02
26	6.240E 02	1.699E-02	-3.029E-04	9.636E 04	6.103E 01	-3.643E 02
27	6.480E 02	1.047E-02	-2.414E-04	9.346E 04	-2.378E 02	-2.333E 02
28	6.720E 02	5.406E-03	-1.835E-04	8.495E 04	-4.194E 02	-1.300E 02
29	6.960E 02	1.663E-03	-1.322E-04	7.333E 04	-5.105E 02	-5.221E 01
30	7.200E 02	-9.382E-04	-8.879E-05	6.045E 04	-5.351E 02	3.076E 00
31	7.440E 02	-2.599E-03	-5.373E-05	4.764E 04	-5.137E 02	3.955E 01
32	7.680E 02	-3.517E-03	-2.668E-05	3.579E 04	-4.635E 02	6.097E 01
33	7.920E 02	-3.879E-03	-6.833E-06	2.540E 04	-3.976E 02	7.088E 01
34	8.160E 02	-3.845E-03	6.821E-06	1.670E 04	-3.259E 02	7.246E 01
35	8.400E 02	-3.552E-03	1.540E-05	9.753E 03	-2.555E 02	6.840E 01
36	8.640E 02	-3.106E-03	2.001E-05	4.442E 03	-1.908E 02	6.087E 01
37	8.880E 02	-2.591E-03	2.164E-05	5.932E 02	-1.346E 02	5.159E 01
38	9.120E 02	-2.067E-03	2.118E-05	-2.018E 03	-8.789E 01	4.181E 01
39	9.360E 02	-1.575E-03	1.935E-05	-3.625E 03	-5.079E 01	3.239E 01
40	9.600E 02	-1.139E-03	1.673E-05	-4.456E 03	-2.265E 01	2.389E 01
41	9.840E 02	-7.720E-04	1.375E-05	-4.713E 03	-2.385E 00	1.664E 01
42	1.008E 03	-4.787E-04	1.074E-05	-4.570E 03	1.130E 01	1.074E 01
43	1.032E 03	-2.564E-04	7.907E-06	-4.170E 03	1.978E 01	6.201E 00

44	1.056E 03	-9.913E-05	5.380E-06	-3.621E 03	2.434E 01	2.917E 00
45	1.080E 03	1.809E-06	3.232E-06	-3.002E 03	2.617E 01	7.416E-01
46	1.104E 03	5.601E-05	1.491E-06	-2.365E 03	2.628E 01	-5.058E-01
47	1.128E 03	7.339E-05	1.598E-07	-1.740E 03	2.552E 01	-1.015E 00
48	1.152E 03	6.368E-05	-7.744E-07	-1.140E 03	2.453E 01	-9.763E-01
49	1.176E 03	3.622E-05	-1.327E-06	-5.631E 02	2.367E 01	-7.282E-01
50	1.200E 03	0	-1.512E-06	-3.628E 00	1.173E 01	-2.316E 01
51	1.224E 03	-3.634E-05	-1.514E-06	0	7.558E-02	-1.512E-01

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	5.000E-01	1.000E-03	1.000E 05	2.000E 03	2.000E 03

TIME = 2 MINUTES, 40 AND 11/60 SECONDS



Prob 5A. Long-pile buckling, axial compression = 4.000E+05 lb.

```
PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118     CODED 28 JUL 66-HM,JJP    PUNCH 28 JUL 66-TH    RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

     TIME =     2 MINUTES, 40 AND 17/60 SECONDS


PROB
   5B     LONG-PILE BUCKLING, AXIAL COMPRESSION = 5.000E+05 LB


TABLE 1 - PROGRAM-CONTROL DATA
                                                                TABLES NUMBER
                                                                 2    3    4

     PRIOR-DATA OPTIONS (1 = HOLD)                               1    1    1
     NUM CARDS INPUT THIS PROBLEM                                0    0    2

     OPTION (IF=1, 2, 3) TO PLOT                                 1


TABLE 2 - CONSTANTS

     USING DATA FROM THE PREVIOUS PROBLEM


TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

     STA        CASE         DEFLECTION        SLOPE

     USING DATA FROM THE PREVIOUS PROBLEM


TABLE 4 - STIFFNESS AND LOAD DATA

FROM TO CONTD     F          Q          S          T          R          P

     USING DATA FROM THE PREVIOUS PROBLEM PLUS
   0   50  0          0          0          0          0          0 -1.000E 05
   0    0  0          0          0          0 -1.000E 05          0          0
```

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPORT

PROB (CCNTC)
5B LCNG-PILE BUCKLING, AXIAL COMPRESSION = 5.000E+05 LB

TABLE 5 - RESULTS

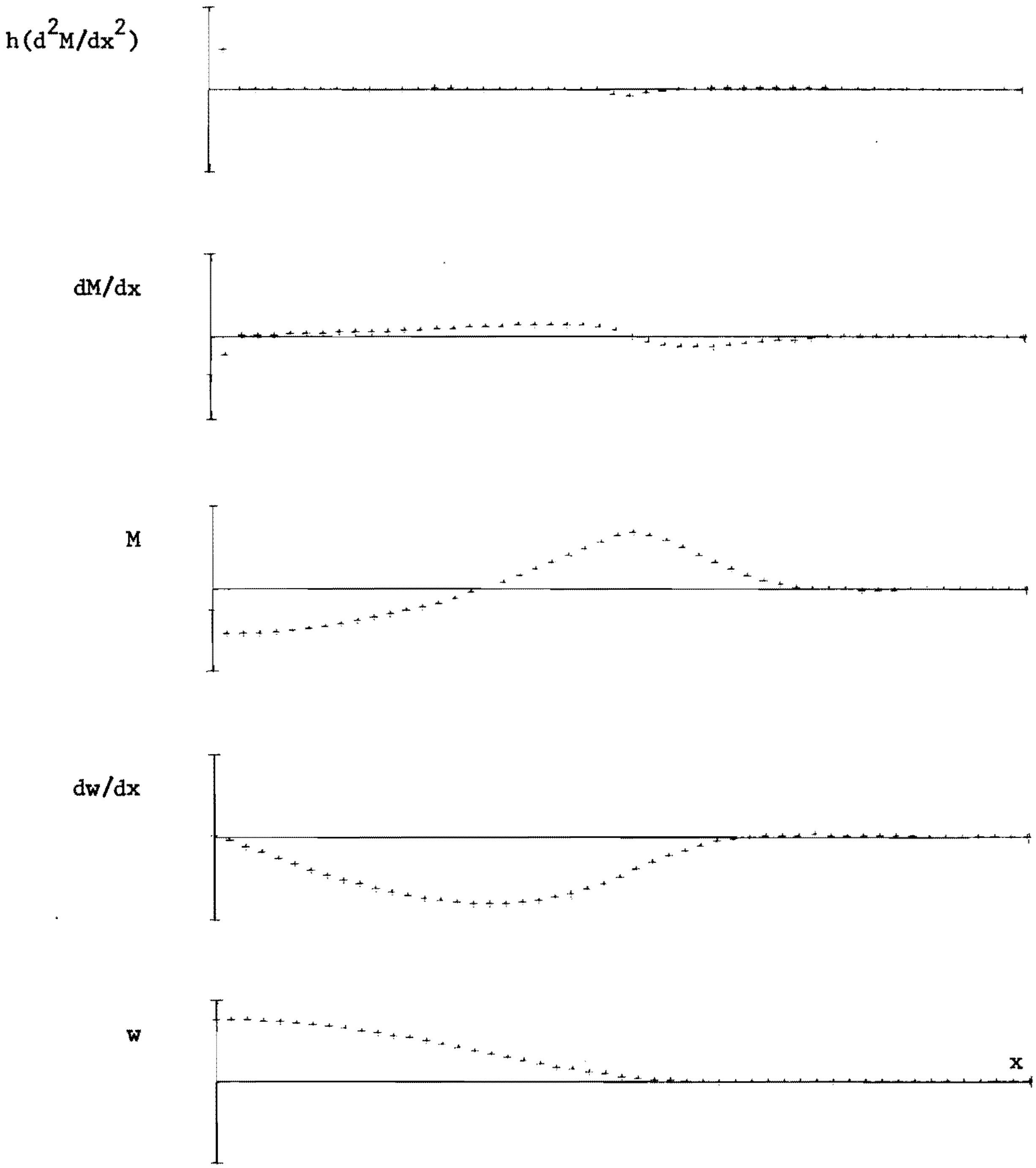
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	3.776E-01	4.988E-05	0	-1.189E 03	-2.377E 03
0	0	3.788E-01	1.287E-05	-5.706E 04	-2.370E 03	1.526E 01
1	2.400E 01	3.782E-01	-6.104E-05	-1.137E 05	-1.157E 03	2.411E 03
2	4.800E 01	3.759E-01	-1.344E-04	-1.126E 05	6.709E 01	3.644E 01
3	7.200E 01	3.718E-01	-2.068E-04	-1.105E 05	1.032E 02	3.578E 01
4	9.600E 01	3.659E-01	-2.775E-04	-1.076E 05	1.385E 02	3.484E 01
5	1.200E 02	3.584E-01	-3.461E-04	-1.039E 05	1.727E 02	3.363E 01
6	1.440E 02	3.493E-01	-4.120E-04	-9.933E 04	2.056E 02	3.215E 01
7	1.680E 02	3.387E-01	-4.748E-04	-9.401E 04	2.369E 02	3.043E 01
8	1.920E 02	3.265E-01	-5.338E-04	-8.796E 04	2.664E 02	2.847E 01
9	2.160E 02	3.130E-01	-5.886E-04	-8.122E 04	2.937E 02	2.629E 01
10	2.400E 02	2.983E-01	-6.389E-04	-7.386E 04	3.188E 02	2.391E 01
11	2.640E 02	2.824E-01	-6.843E-04	-6.592E 04	3.415E 02	2.134E 01
12	2.880E 02	2.654E-01	-7.243E-04	-5.747E 04	3.614E 02	1.860E 01
13	3.120E 02	2.476E-01	-7.587E-04	-4.857E 04	3.936E 02	4.566E 01
14	3.360E 02	2.290E-01	-7.869E-04	-3.858E 04	4.501E 02	6.738E 01
15	3.600E 02	2.098E-01	-8.082E-04	-2.697E 04	5.131E 02	5.863E 01
16	3.840E 02	1.902E-01	-8.215E-04	-1.395E 04	5.671E 02	4.943E 01
17	4.080E 02	1.704E-01	-8.259E-04	2.565E 02	6.118E 02	3.984E 01
18	4.320E 02	1.506E-01	-8.208E-04	1.542E 04	6.467E 02	2.994E 01
19	4.560E 02	1.310E-01	-8.057E-04	3.130E 04	6.715E 02	1.981E 01
20	4.800E 02	1.119E-01	-7.801E-04	4.765E 04	6.862E 02	9.527E 00
21	5.040E 02	9.355E-02	-7.438E-04	6.423E 04	6.905E 02	-8.307E-01
22	5.280E 02	7.620E-02	-6.967E-04	8.080E 04	6.845E 02	-1.118E 01
23	5.520E 02	6.011E-02	-6.391E-04	9.709E 04	6.682E 02	-2.145E 01
24	5.760E 02	4.553E-02	-5.710E-04	1.129E 05	6.417E 02	-3.155E 01
25	6.000E 02	3.270E-02	-4.929E-04	1.279E 05	4.421E 02	-3.678E 02
26	6.240E 02	2.187E-02	-4.079E-04	1.341E 05	1.823E 01	-4.799E 02
27	6.480E 02	1.312E-02	-3.226E-04	1.288E 05	-3.735E 02	-3.036E 02
28	6.720E 02	6.380E-03	-2.432E-04	1.162E 05	-6.078E 02	-1.650E 02
29	6.960E 02	1.447E-03	-1.732E-04	9.959E 04	-7.209E 02	-6.113E 01
30	7.200E 02	-1.935E-03	-1.145E-04	8.156E 04	-7.453E 02	1.222E 01
31	7.440E 02	-4.048E-03	-6.733E-05	6.382E 04	-7.091E 02	6.014E 01
32	7.680E 02	-5.167E-03	-3.122E-05	4.752E 04	-6.352E 02	8.776E 01
33	7.920E 02	-5.547E-03	-5.001E-06	3.333E 04	-5.413E 02	9.993E 01
34	8.160E 02	-5.407E-03	1.279E-05	2.154E 04	-4.409E 02	1.010E 02
35	8.400E 02	-4.932E-03	2.373E-05	1.217E 04	-3.431E 02	9.452E 01
36	8.640E 02	-4.268E-03	2.932E-05	5.067E 03	-2.541E 02	8.356E 01
37	8.880E 02	-3.525E-03	3.095E-05	-2.873E 01	-1.771E 02	7.038E 01
38	9.120E 02	-2.783E-03	2.983E-05	-3.436E 03	-1.136E 02	5.666E 01
39	9.360E 02	-2.094E-03	2.693E-05	-5.483E 03	-6.352E 01	4.356E 01
40	9.600E 02	-1.490E-03	2.305E-05	-6.484E 03	-2.582E 01	3.184E 01
41	9.840E 02	-9.870E-04	1.877E-05	-6.722E 03	1.042E 00	2.188E 01
42	1.008E 03	-5.888E-04	1.450E-05	-6.434E 03	1.890E 01	1.384E 01
43	1.032E 03	-2.908E-04	1.053E-05	-5.815E 03	2.966E 01	7.687E 00

44	1.056E 03	-8.333E-05	7.020E-06	-5.011E 03	3.515E 01	3.285E 00
45	1.080E 03	4.614E-05	4.056E-06	-4.128E 03	3.700E 01	4.151E-01
46	1.104E 03	1.114E-04	1.668E-06	-3.235E 03	3.662E 01	-1.176E 00
47	1.128E 03	1.262E-04	-1.499E-07	-2.370E 03	3.515E 01	-1.752E 00
48	1.152E 03	1.042E-04	-1.421E-06	-1.548E 03	3.349E 01	-1.578E 00
49	1.176E 03	5.802E-05	-2.170E-06	-7.629E 02	3.209E 01	-1.213E 00
50	1.200E 03	0	-2.422E-06	-7.266E 00	1.589E 01	-3.118E 01
51	1.224E 03	-5.824E-05	-2.427E-06	0	1.514E-01	-3.028E-01

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	5.000E-01	1.000E-03	2.000E 05	5.000E 03	5.000E 03

TIME = 2 MINUTES, 53 AND 36/60 SECONDS



Prob 5B. Long-pile buckling, axial compression = 5.000E+05 lb.

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

TIME = 2 MINUTES, 53 AND 43/60 SECONDS

PROB
5C LONG-PILE BUCKLING, AXIAL COMPRESSION = 6.000E+05 LB

TABLE 1 - PROGRAM-CONTROL DATA

	TABLES NUMBER 2	3	4
PRIOR-DATA OPTIONS (1 = HOLD)	1	1	1
NUM CARDS INPUT THIS PROBLEM	0	0	2
OPTION (IF=1, 2, 3) TO PLOT	1		

TABLE 2 - CONSTANTS

USING DATA FROM THE PREVIOUS PROBLEM

TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

STA CASE DEFLECTION SLOPE

USING DATA FROM THE PREVIOUS PROBLEM

TABLE 4 - STIFFNESS AND LOAD DATA

USING DATA FROM THE PREVIOUS PROBLEM PLUS

FROM	TO	CONTD	F	Q	S	T	R	P
0	50	0	0	0	0	0	0	-1.000E 05
0	0	0	0	0	0	-1.000E 05	0	0

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
5C LONG-PILE BUCKLING, AXIAL COMPRESSION = 6.000E+05 LB

TABLE 5 - RESULTS

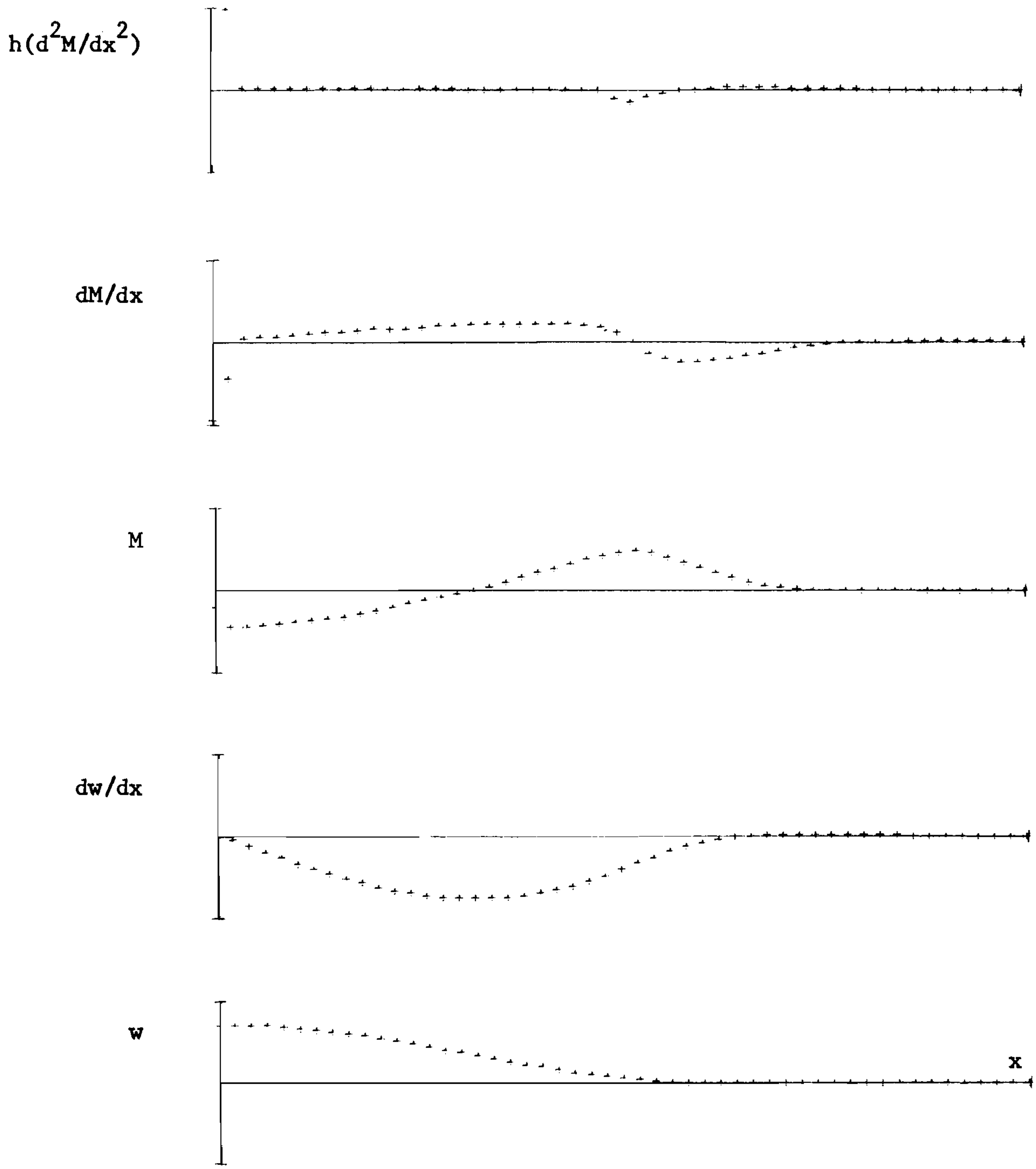
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	7.050E-01	8.686E-05	0	-2.393E 03	-4.786E 03
0	0	7.071E-01	1.234E-05	-1.149E 05	-4.766E 03	4.091E 01
1	2.400E 01	7.056E-01	-1.364E-04	-2.288E 05	-2.310E 03	4.871E 03
2	4.800E 01	7.005E-01	-2.838E-04	-2.257E 05	1.699E 02	8.765E 01
3	7.200E 01	6.919E-01	-4.285E-04	-2.206E 05	2.565E 02	8.566E 01
4	9.600E 01	6.799E-01	-5.693E-04	-2.134E 05	3.408E 02	8.287E 01
5	1.200E 02	6.646E-01	-7.048E-04	-2.043E 05	4.219E 02	7.931E 01
6	1.440E 02	6.461E-01	-8.337E-04	-1.932E 05	4.990E 02	7.501E 01
7	1.680E 02	6.246E-01	-9.548E-04	-1.803E 05	5.715E 02	7.001E 01
8	1.920E 02	6.003E-01	-1.067E-03	-1.657E 05	6.387E 02	6.435E 01
9	2.160E 02	5.734E-01	-1.169E-03	-1.496E 05	6.999E 02	5.810E 01
10	2.400E 02	5.442E-01	-1.261E-03	-1.321E 05	7.546E 02	5.131E 01
11	2.640E 02	5.129E-01	-1.340E-03	-1.134E 05	8.023E 02	4.404E 01
12	2.880E 02	4.798E-01	-1.407E-03	-9.363E 04	8.425E 02	3.636E 01
13	3.120E 02	4.453E-01	-1.462E-03	-7.298E 04	8.898E 02	5.827E 01
14	3.360E 02	4.097E-01	-1.502E-03	-5.092E 04	9.563E 02	7.464E 01
15	3.600E 02	3.732E-01	-1.527E-03	-2.707E 04	1.024E 03	6.040E 01
16	3.840E 02	3.364E-01	-1.536E-03	-1.779E 03	1.077E 03	4.559E 01
17	4.080E 02	2.995E-01	-1.529E-03	2.461E 04	1.115E 03	3.035E 01
18	4.320E 02	2.630E-01	-1.504E-03	5.173E 04	1.137E 03	1.483E 01
19	4.560E 02	2.273E-01	-1.462E-03	7.920E 04	1.144E 03	-8.235E-01
20	4.800E 02	1.928E-01	-1.401E-03	1.067E 05	1.136E 03	-1.647E 01
21	5.040E 02	1.600E-01	-1.323E-03	1.337E 05	1.111E 03	-3.197E 01
22	5.280E 02	1.293E-01	-1.228E-03	1.600E 05	1.072E 03	-4.716E 01
23	5.520E 02	1.011E-01	-1.116E-03	1.852E 05	1.017E 03	-6.192E 01
24	5.760E 02	7.572E-02	-9.885E-04	2.088E 05	9.484E 02	-7.610E 01
25	6.000E 02	5.362E-02	-8.459E-04	2.307E 05	5.981E 02	-6.245E 02
26	6.240E 02	3.511E-02	-6.941E-04	2.376E 05	-1.107E 02	-7.929E 02
27	6.480E 02	2.031E-02	-5.439E-04	2.254E 05	-7.535E 02	-4.927E 02
28	6.720E 02	9.006E-03	-4.055E-04	2.014E 05	-1.129E 03	-2.579E 02
29	6.960E 02	8.415E-04	-2.847E-04	1.712E 05	-1.299E 03	-8.326E 01
30	7.200E 02	-4.658E-03	-1.841E-04	1.390E 05	-1.321E 03	3.897E 01
31	7.440E 02	-7.993E-03	-1.040E-04	1.078E 05	-1.243E 03	1.177E 02
32	7.680E 02	-9.651E-03	-4.334E-05	7.935E 04	-1.103E 03	1.618E 02
33	7.920E 02	-1.007E-02	1.725E-07	5.480E 04	-9.327E 02	1.797E 02
34	8.160E 02	-9.643E-03	2.916E-05	3.458E 04	-7.534E 02	1.790E 02
35	8.400E 02	-8.674E-03	4.642E-05	1.864E 04	-5.810E 02	1.658E 02
36	8.640E 02	-7.415E-03	5.464E-05	6.690E 03	-4.254E 02	1.454E 02
37	8.880E 02	-6.051E-03	5.623E-05	-1.774E 03	-2.920E 02	1.214E 02
38	9.120E 02	-4.716E-03	5.328E-05	-7.324E 03	-1.828E 02	9.694E 01
39	9.360E 02	-3.494E-03	4.748E-05	-1.055E 04	-9.741E 01	7.381E 01
40	9.600E 02	-2.436E-03	4.017E-05	-1.200E 04	-3.387E 01	5.327E 01
41	9.840E 02	-1.566E-03	3.233E-05	-1.217E 04	1.075E 01	3.597E 01
42	1.008E 03	-8.844E-04	2.466E-05	-1.148E 04	3.979E 01	2.211E 01
43	1.032E 03	-3.820E-04	1.761E-05	-1.026E 04	5.664E 01	1.161E 01

44	1.C56E 03	-3.938E-05	1.143E-C5	-8.765E C3	6.454E 01	4.189E 00
45	1.C8CE 03	1.668E-04	6.267E-06	-7.166E 03	6.63CE 01	-5.460E-01
46	1.1C4E 03	2.614E-04	2.133E-06	-5.580E C3	6.457E 01	-3.050E 00
47	1.128E 03	2.692E-04	-9.952E-07	-4.067E C3	6.114E 01	-3.793E 00
48	1.152E 03	2.137E-04	-3.172E-C6	-2.645E C3	5.763E 01	-3.236E 00
49	1.176E 03	1.170E-04	-4.451E-06	-1.300E 03	5.473E 01	-2.558E 00
50	1.2C0E 03	C	-4.885E-06	-1.758E 01	2.709E 01	-5.272E 01
51	1.224E 03	-1.175E-04	-4.896E-06	0	3.663E-01	-7.327E-01

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	1.000E 00	2.000E-03	5.000E 05	5.00CE 03	5.000E 03

TIME = 3 MINUTES, 7 AND 4/60 SECONDS



Prob 5C. Long-pile buckling, axial compression = 6.000E+05 lb.

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PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118      CODED 28 JUL 66-HM,JJP    PUNCH 28 JUL 66-TH    RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCOL 34 FINAL REPORT

     TIME =     3 MINUTES,  7 ANC 10/60 SECONDS


PROB
  5D     LCNG-PILE BUCKLING, AXIAL COMPRESSION = 6.500E+05 LB


TABLE 1 - PRCGRAM-CCNTRCL CATA
                                                               TABLES NUMBER
                                                                2    3    4

     PRICR-DATA OPTIONS (1 = HOLC)                              1    1    1
     NUM CARCS INPUT THIS PROBLEM                               0    0    2

     CPTION (IF=1, 2, 3) TC PLCT                                1


TABLE 2 - CCNSTANTS

     USING CATA FROM THE PREVICUS PROBLEM


TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

     STA       CASE        DEFLECTICN         SLOPE

     USING CATA FROM THE PREVICUS PROBLEM


TABLE 4 - STIFFNESS ANC LOAD CATA

FROM TC CONTC     F          C          S          T          R          P

     USING CATA FROM THE PREVICUS PROBLEM PLUS
   0  50  C           0          0          0          0          0 -5.000E 04
   0   0  C           0          0          0 -5.000E 04          0          0
```

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118   CODED 28 JUL 66-HM,JJP   PUNCH 28 JUL 66-TH   RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
5D   LONG-PILE BUCKLING, AXIAL COMPRESSION = 6.500E+05 LB

TABLE 5 - RESULTS

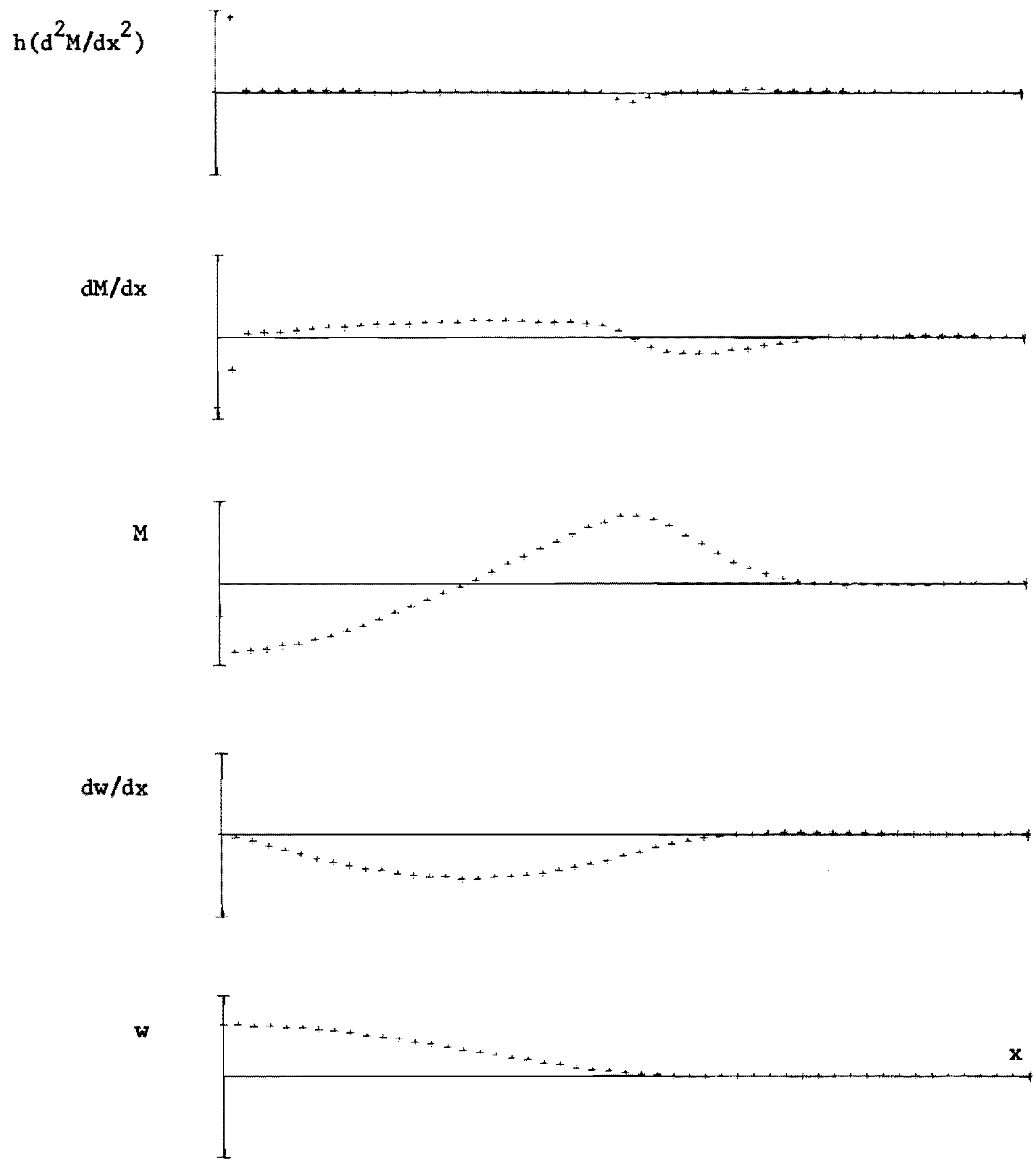
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	1.264E 00	1.463E-04	0	-4.462E 03	-8.924E 03
0	0	1.268E 00	7.391E-06	-2.142E 05	-8.880E 03	8.767E 01
1	2.400E 01	1.265E 00	-2.698E-04	-4.262E 05	-4.286E 03	9.100E 03
2	4.800E 01	1.255E 00	-5.442E-04	-4.199E 05	3.528E 02	1.766E 02
3	7.200E 01	1.239E 00	-8.131E-04	-4.093E 05	5.272E 02	1.721E 02
4	9.600E 01	1.216E 00	-1.074E-03	-3.946E 05	6.962E 02	1.659E 02
5	1.200E 02	1.187E 00	-1.324E-03	-3.759E 05	8.582E 02	1.581E 02
6	1.440E 02	1.152E 00	-1.560E-03	-3.534E 05	1.012E 03	1.486E 02
7	1.680E 02	1.112E 00	-1.781E-03	-3.273E 05	1.155E 03	1.377E 02
8	1.920E 02	1.067E 00	-1.984E-03	-2.980E 05	1.286E 03	1.253E 02
9	2.160E 02	1.017E 00	-2.167E-03	-2.656E 05	1.405E 03	1.117E 02
10	2.400E 02	9.630E-01	-2.327E-03	-2.305E 05	1.509E 03	9.695E 01
11	2.640E 02	9.053E-01	-2.465E-03	-1.931E 05	1.598E 03	8.123E 01
12	2.880E 02	8.447E-01	-2.577E-03	-1.538E 05	1.671E 03	6.469E 01
13	3.120E 02	7.816E-01	-2.664E-03	-1.129E 05	1.742E 03	7.742E 01
14	3.360E 02	7.168E-01	-2.723E-03	-7.020E 04	1.823E 03	8.438E 01
15	3.600E 02	6.509E-01	-2.754E-03	-2.543E 04	1.895E 03	6.057E 01
16	3.840E 02	5.846E-01	-2.756E-03	2.078E 04	1.944E 03	3.615E 01
17	4.080E 02	5.186E-01	-2.727E-03	6.787E 04	1.968E 03	1.136E 01
18	4.320E 02	4.537E-01	-2.668E-03	1.152E 05	1.967E 03	-1.355E 01
19	4.560E 02	3.906E-01	-2.578E-03	1.623E 05	1.941E 03	-3.832E 01
20	4.800E 02	3.300E-01	-2.457E-03	2.084E 05	1.890E 03	-6.270E 01
21	5.040E 02	2.726E-01	-2.308E-03	2.530E 05	1.815E 03	-8.645E 01
22	5.280E 02	2.192E-01	-2.130E-03	2.955E 05	1.718E 03	-1.093E 02
23	5.520E 02	1.704E-01	-1.925E-03	3.354E 05	1.597E 03	-1.311E 02
24	5.760E 02	1.268E-01	-1.696E-03	3.722E 05	1.456E 03	-1.515E 02
25	6.000E 02	8.899E-02	-1.444E-03	4.053E 05	8.513E 02	-1.058E 03
26	6.240E 02	5.749E-02	-1.178E-03	4.131E 05	-3.381E 02	-1.321E 03
27	6.480E 02	3.243E-02	-9.181E-04	3.891E 05	-1.404E 03	-8.106E 02
28	6.720E 02	1.343E-02	-6.797E-04	3.457E 05	-2.016E 03	-4.132E 02
29	6.960E 02	-1.965E-04	-4.728E-04	2.923E 05	-2.282E 03	-1.190E 02
30	7.200E 02	-9.269E-03	-3.014E-04	2.361E 05	-2.299E 03	8.559E 01
31	7.440E 02	-1.466E-02	-1.658E-04	1.820E 05	-2.148E 03	2.160E 02
32	7.680E 02	-1.723E-02	-6.362E-05	1.331E 05	-1.896E 03	2.877E 02
33	7.920E 02	-1.772E-02	9.056E-06	9.101E 04	-1.594E 03	3.152E 02
34	8.160E 02	-1.679E-02	5.691E-05	5.653E 04	-1.281E 03	3.112E 02
35	8.400E 02	-1.499E-02	8.481E-05	2.951E 04	-9.823E 02	2.866E 02
36	8.640E 02	-1.272E-02	9.742E-05	9.376E 03	-7.141E 02	2.498E 02
37	8.880E 02	-1.031E-02	9.892E-05	-4.764E 03	-4.853E 02	2.077E 02
38	9.120E 02	-7.973E-03	9.286E-05	-1.392E 04	-2.990E 02	1.649E 02
39	9.360E 02	-5.853E-03	8.215E-05	-1.912E 04	-1.542E 02	1.248E 02
40	9.600E 02	-4.030E-03	6.903E-05	-2.132E 04	-4.707E 01	8.937E 01
41	9.840E 02	-2.540E-03	5.518E-05	-2.138E 04	2.745E 01	5.965E 01
42	1.008E 03	-1.382E-03	4.176E-05	-2.000E 04	7.526E 01	3.597E 01
43	1.032E 03	-5.349E-04	2.952E-05	-1.776E 04	1.023E 02	1.814E 01

44	1.056E 03	3.520E-05	1.886E-05	-1.509E 04	1.142E 02	5.644E 00
45	1.080E 03	3.704E-04	9.984E-06	-1.228E 04	1.159E 02	-2.225E 00
46	1.104E 03	5.144E-04	2.911E-06	-9.526E 03	1.117E 02	-6.256E 00
47	1.128E 03	5.102E-04	-2.423E-06	-6.921E 03	1.049E 02	-7.267E 00
48	1.152E 03	3.981E-04	-6.124E-06	-4.490E 03	9.826E 01	-6.054E 00
49	1.176E 03	2.162E-04	-8.295E-06	-2.204E 03	9.281E 01	-4.847E 00
50	1.200E 03	0	-9.032E-06	-3.523E 01	4.593E 01	-8.892E 01
51	1.224E 03	-2.173E-04	-9.055E-06	0	7.339E-01	-1.468E 00

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	2.000E 00	5.000E-03	5.000E 05	1.000E 04	1.000E 04

TIME = 3 MINUTES, 20 AND 31/60 SECONDS



Prob 5D. Long-pile buckling, axial compression = 6.500E+05 lb.

PROGRAM BMCOL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCOL 34 FINAL REPORT

TIME = 3 MINUTES, 20 ANC 37/60 SECONDS

PROB
5E LCNG-PILE BUCKLING, AXIAL COMPRESSION = 6.750E+05 LB

TABLE 1 - PRCGRAM-CCNTRCL CATA

	TABLES NUMBER 2	3	4
PRICR-CATA OPTIONS (1 = HOLC)	1	1	1
NUM CARCS INPUT THIS PROBLEM	0	0	2
CPTICN (IF=1, 2, 3) TC PLOT	1		

TABLE 2 - CCNSTANTS

USING CATA FROM THE PREVIOUS PROBLEM

TABLE 3 - SPECIFIED DEFLECTIONS ANC SLOPES

STA CASE DEFLECTICN SLOPE

USING CATA FROM THE PREVIOUS PROBLEM

TABLE 4 - STIFFNESS AND LOAC CATA

FRCM	TC	CONTC	F	C	S	T	R	P
USING CATA FROM THE PREVIOUS PROBLEM PLUS								
0	50	C	0	C	0	0	0	-2.500E 04
0	0	C	0	C	0	-2.500E 04	0	0

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
5E LONG-PILE BUCKLING, AXIAL COMPRESSION = 6.750E+05 LB

TABLE 5 - RESULTS

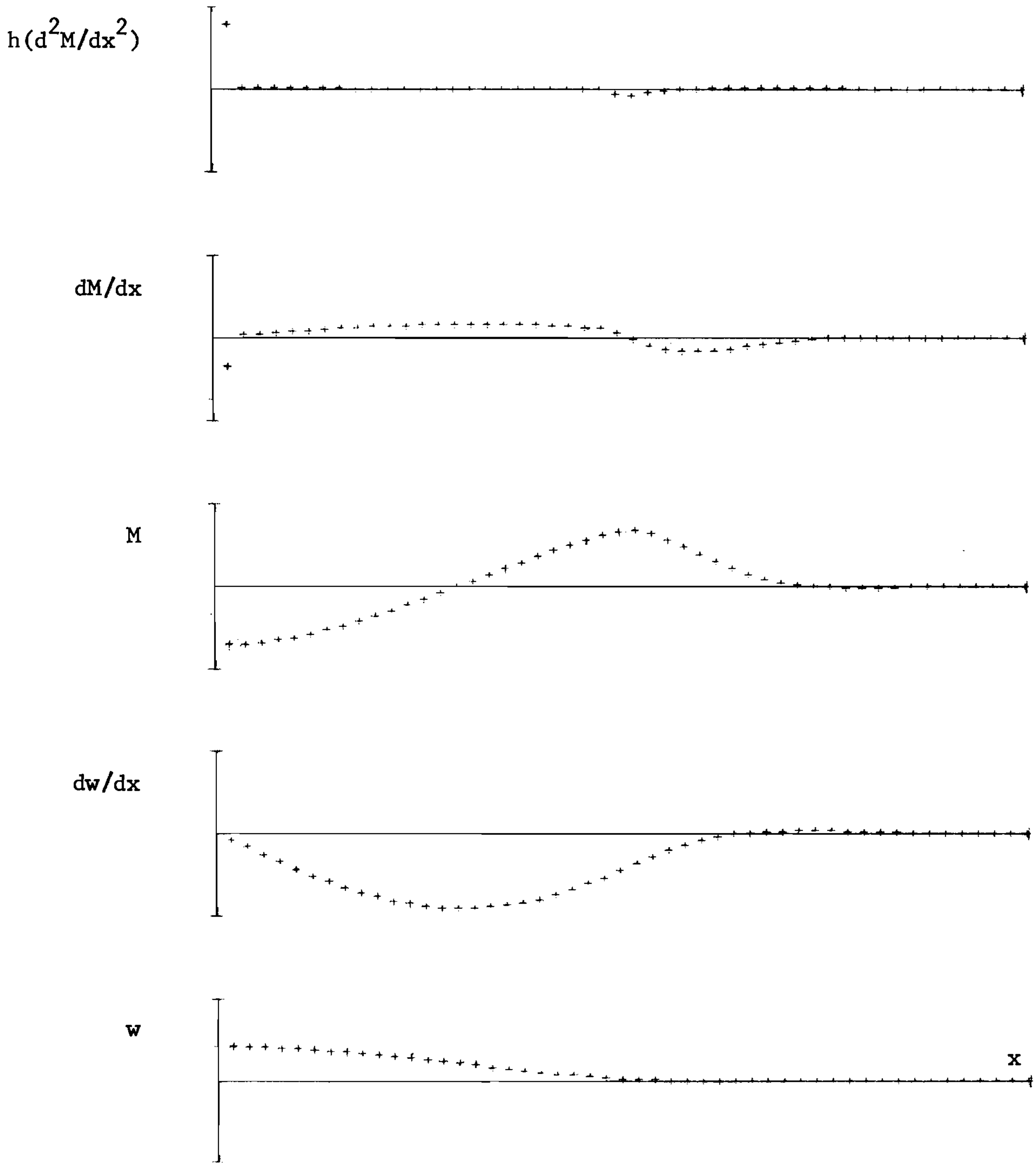
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	2.110E 00	2.346E-04	0	-7.593E 03	-1.519E 04
0	0	2.116E 00	-1.800E-06	-3.645E 05	-1.511E 04	1.598E 02
1	2.400E 01	2.110E 00	-4.734E-04	-7.251E 05	-7.275E 03	1.550E 04
2	4.800E 01	2.093E 00	-9.400E-04	-7.137E 05	6.329E 02	3.117E 02
3	7.200E 01	2.065E 00	-1.397E-03	-6.948E 05	9.404E 02	3.034E 02
4	9.600E 01	2.026E 00	-1.839E-03	-6.685E 05	1.238E 03	2.919E 02
5	1.200E 02	1.977E 00	-2.262E-03	-6.353E 05	1.523E 03	2.774E 02
6	1.440E 02	1.917E 00	-2.661E-03	-5.955E 05	1.791E 03	2.600E 02
7	1.680E 02	1.849E 00	-3.032E-03	-5.493E 05	2.041E 03	2.399E 02
8	1.920E 02	1.772E 00	-3.372E-03	-4.975E 05	2.270E 03	2.172E 02
9	2.160E 02	1.687E 00	-3.676E-03	-4.404E 05	2.475E 03	1.923E 02
10	2.400E 02	1.595E 00	-3.942E-03	-3.787E 05	2.654E 03	1.654E 02
11	2.640E 02	1.498E 00	-4.166E-03	-3.130E 05	2.805E 03	1.367E 02
12	2.880E 02	1.395E 00	-4.347E-03	-2.441E 05	2.926E 03	1.066E 02
13	3.120E 02	1.289E 00	-4.482E-03	-1.725E 05	3.032E 03	1.053E 02
14	3.360E 02	1.180E 00	-4.570E-03	-9.851E 04	3.134E 03	9.787E 01
15	3.600E 02	1.070E 00	-4.609E-03	-2.212E 04	3.212E 03	5.953E 01
16	3.840E 02	9.591E-01	-4.598E-03	5.569E 04	3.253E 03	2.056E 01
17	4.080E 02	8.492E-01	-4.536E-03	1.340E 05	3.253E 03	-1.862E 01
18	4.320E 02	7.413E-01	-4.424E-03	2.119E 05	3.215E 03	-5.761E 01
19	4.560E 02	6.368E-01	-4.262E-03	2.883E 05	3.139E 03	-9.599E 01
20	4.800E 02	5.368E-01	-4.051E-03	3.625E 05	3.024E 03	-1.334E 02
21	5.040E 02	4.424E-01	-3.793E-03	4.335E 05	2.873E 03	-1.694E 02
22	5.280E 02	3.547E-01	-3.490E-03	5.004E 05	2.686E 03	-2.036E 02
23	5.520E 02	2.748E-01	-3.145E-03	5.624E 05	2.466E 03	-2.356E 02
24	5.760E 02	2.037E-01	-2.762E-03	6.188E 05	2.216E 03	-2.652E 02
25	6.000E 02	1.423E-01	-2.344E-03	6.688E 05	1.228E 03	-1.711E 03
26	6.240E 02	9.120E-02	-1.908E-03	6.777E 05	-6.851E 02	-2.115E 03
27	6.480E 02	5.069E-02	-1.482E-03	6.359E 05	-2.387E 03	-1.289E 03
28	6.720E 02	2.008E-02	-1.093E-03	5.631E 05	-3.355E 03	-6.464E 02
29	6.960E 02	-1.766E-03	-7.562E-04	4.749E 05	-3.764E 03	-1.721E 02
30	7.200E 02	-1.622E-02	-4.781E-04	3.825E 05	-3.772E 03	1.565E 02
31	7.440E 02	-2.472E-02	-2.588E-04	2.938E 05	-3.511E 03	3.647E 02
32	7.680E 02	-2.864E-02	-9.408E-05	2.139E 05	-3.090E 03	4.778E 02
33	7.920E 02	-2.923E-02	2.250E-05	1.455E 05	-2.591E 03	5.195E 02
34	8.160E 02	-2.756E-02	9.874E-05	8.956E 04	-2.076E 03	5.106E 02
35	8.400E 02	-2.449E-02	1.427E-04	4.585E 04	-1.587E 03	4.685E 02
36	8.640E 02	-2.071E-02	1.619E-04	1.340E 04	-1.149E 03	4.073E 02
37	8.880E 02	-1.672E-02	1.632E-04	-9.284E 03	-7.763E 02	3.376E 02
38	9.120E 02	-1.288E-02	1.525E-04	-2.386E 04	-4.738E 02	2.673E 02
39	9.360E 02	-9.404E-03	1.343E-04	-3.203E 04	-2.394E 02	2.016E 02
40	9.600E 02	-6.429E-03	1.125E-04	-3.535E 04	-6.676E 01	1.437E 02
41	9.840E 02	-4.005E-03	8.958E-05	-3.523E 04	5.272E 01	9.528E 01
42	1.008E 03	-2.130E-03	6.751E-05	-3.282E 04	1.288E 02	5.681E 01
43	1.032E 03	-7.649E-04	4.744E-05	-2.905E 04	1.711E 02	2.794E 01

44	1.056E 03	1.475E-04	3.004E-05	-2.461E 04	1.890E 02	7.804E 00
45	1.080E 03	6.769E-04	1.558E-05	-1.998E 04	1.905E 02	-4.777E 00
46	1.104E 03	8.951E-04	4.081E-06	-1.546E 04	1.826E 02	-1.110E 01
47	1.128E 03	8.727E-04	-4.572E-06	-1.121E 04	1.708E 02	-1.251E 01
48	1.152E 03	6.757E-04	-1.057E-05	-7.265E 03	1.594E 02	-1.031E 01
49	1.176E 03	3.656E-04	-1.408E-05	-3.564E 03	1.501E 02	-8.300E 00
50	1.200E 03	0	-1.527E-05	-6.186E 01	7.425E 01	-1.433E 02
51	1.224E 03	-3.675E-04	-1.531E-05	0	1.289E 00	-2.577E 00

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	5.000E 00	5.000E-03	1.000E 06	2.000E 04	2.000E 04

TIME = 3 MINUTES, 33 AND 57/60 SECONDS



Prob 5E. Long-pile buckling, axial compression = 6.750E+05 lb.

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPORT

TIME = 3 MINUTES, 34 ANC 4/60 SECONDS

PROB
5F LCNG-PILE BUCKLING, AXIAL COMPRESSION = 7.C00E+05 LB

TABLE 1 - PRCGRAM-CONTRCL CATA

	TABLES NUMBER 2	3	4
PRIOR-CATA OPTICNS (1 = HOLC)	1	1	1
NUM CARCS INPUT THIS PROBLEM	0	0	2
CPTICN (IF=1, 2, 3) TC PLOT	1		

TABLE 2 - CCNSTANTS

USING CATA FROM THE PREVICUS PROBLEM

TABLE 3 - SPECIFIED DEFLECTIONS ANC SLOPES

STA CASE DEFLECTICN SLOPE

USING CATA FROM THE PREVICUS PROBLEM

TABLE 4 - STIFFNESS AND LOAD CATA

FROM	TC	CONTD	F	Q	S	T	R	P
USING CATA FROM THE PREVIOUS PROBLEM PLUS								
0	50	0	0	C	0	0	0	-2.500E 04
0	0	C	0	C	0	-2.500E 04	0	0

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPORT

PROB (CCNTC)
5F LCNG-PILE BUCKLING, AXIAL COMPRESSION = 7.000E+05 LB

TABLE 5 - RESULTS

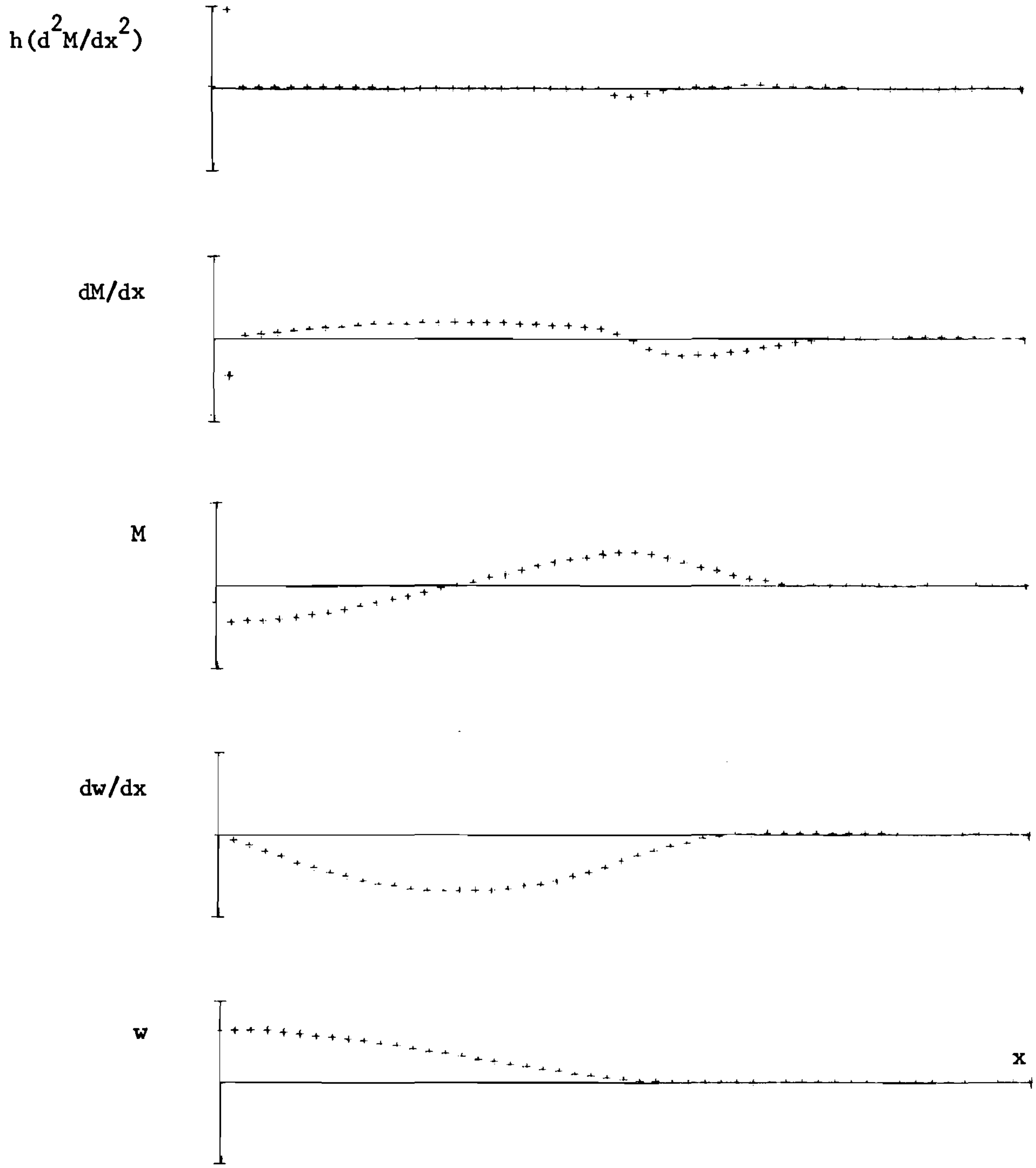
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	6.454E 00	6.852E-04	0	-2.369E 04	-4.738E 04
0	0	6.470E 00	-5.250E-05	-1.137E 06	-4.712E 04	5.333E 02
1	2.400E 01	6.451E 00	-1.524E-03	-2.262E 06	-2.264E 04	4.843E 04
2	4.800E 01	6.397E 00	-2.978E-03	-2.224E 06	2.079E 03	1.007E 03
3	7.200E 01	6.308E 00	-4.401E-03	-2.162E 06	3.072E 03	9.789E 02
4	9.600E 01	6.186E 00	-5.775E-03	-2.076E 06	4.032E 03	9.402E 02
5	1.200E 02	6.031E 00	-7.087E-03	-1.968E 06	4.947E 03	8.913E 02
6	1.440E 02	5.846E 00	-8.322E-03	-1.839E 06	5.809E 03	8.327E 02
7	1.680E 02	5.632E 00	-9.466E-03	-1.689E 06	6.608E 03	7.650E 02
8	1.920E 02	5.391E 00	-1.051E-02	-1.522E 06	7.335E 03	6.890E 02
9	2.160E 02	5.127E 00	-1.143E-02	-1.337E 06	7.983E 03	6.056E 02
10	2.400E 02	4.843E 00	-1.224E-02	-1.139E 06	8.543E 03	5.155E 02
11	2.640E 02	4.540E 00	-1.291E-02	-9.273E 05	9.011E 03	4.199E 02
12	2.880E 02	4.223E 00	-1.344E-02	-7.060E 05	9.381E 03	3.197E 02
13	3.120E 02	3.895E 00	-1.382E-02	-4.770E 05	9.663E 03	2.459E 02
14	3.360E 02	3.560E 00	-1.405E-02	-2.421E 05	9.869E 03	1.645E 02
15	3.600E 02	3.220E 00	-1.413E-02	-3.309E 03	9.977E 03	5.136E 01
16	3.840E 02	2.881E 00	-1.406E-02	2.367E 05	9.971E 03	-6.233E 01
17	4.080E 02	2.546E 00	-1.383E-02	4.753E 05	9.852E 03	-1.753E 02
18	4.320E 02	2.217E 00	-1.344E-02	7.097E 05	9.621E 03	-2.864E 02
19	4.560E 02	1.900E 00	-1.291E-02	9.371E 05	9.281E 03	-3.944E 02
20	4.800E 02	1.598E 00	-1.223E-02	1.155E 06	8.835E 03	-4.981E 02
21	5.040E 02	1.313E 00	-1.141E-02	1.361E 06	8.287E 03	-5.964E 02
22	5.280E 02	1.050E 00	-1.047E-02	1.553E 06	7.645E 03	-6.882E 02
23	5.520E 02	8.108E-01	-9.405E-03	1.728E 06	6.915E 03	-7.726E 02
24	5.760E 02	5.985E-01	-8.233E-03	1.885E 06	6.104E 03	-8.485E 02
25	6.000E 02	4.156E-01	-6.966E-03	2.021E 06	3.150E 03	-5.060E 03
26	6.240E 02	2.641E-01	-5.651E-03	2.036E 06	-2.474E 03	-6.190E 03
27	6.480E 02	1.443E-01	-4.373E-03	1.902E 06	-7.439E 03	-3.740E 03
28	6.720E 02	5.418E-02	-3.212E-03	1.679E 06	-1.023E 04	-1.841E 03
29	6.960E 02	-9.831E-03	-2.209E-03	1.411E 06	-1.137E 04	-4.430E 02
30	7.200E 02	-5.187E-02	-1.384E-03	1.133E 06	-1.133E 04	5.215E 02
31	7.440E 02	-7.627E-02	-7.354E-04	8.674E 05	-1.051E 04	1.129E 03
32	7.680E 02	-8.717E-02	-2.502E-04	6.287E 05	-9.216E 03	1.454E 03
33	7.920E 02	-8.828E-02	9.159E-05	4.250E 05	-7.705E 03	1.568E 03
34	8.160E 02	-8.278E-02	3.134E-04	2.589E 05	-6.154E 03	1.534E 03
35	8.400E 02	-7.324E-02	4.394E-04	1.296E 05	-4.686E 03	1.402E 03
36	8.640E 02	-6.168E-02	4.925E-04	3.397E 04	-3.378E 03	1.215E 03
37	8.880E 02	-4.960E-02	4.929E-04	-3.251E 04	-2.268E 03	1.004E 03
38	9.120E 02	-3.802E-02	4.581E-04	-7.490E 04	-1.370E 03	7.923E 02
39	9.360E 02	-2.761E-02	4.019E-04	-9.827E 04	-6.761E 02	5.952E 02
40	9.600E 02	-1.873E-02	3.352E-04	-1.074E 05	-1.674E 02	4.222E 02
41	9.840E 02	-1.152E-02	2.660E-04	-1.063E 05	1.827E 02	2.779E 02
42	1.008E 03	-5.965E-03	1.995E-04	-9.858E 04	4.034E 02	1.636E 02
43	1.032E 03	-1.944E-03	1.393E-04	-8.694E 04	5.243E 02	7.814E 01

44	1.056E 03	7.236E-04	8.733E-05	-7.342E 04	5.728E 02	1.881E 01
45	1.080E 03	2.248E-03	4.424E-05	-5.945E 04	5.732E 02	-1.792E 01
46	1.104E 03	2.847E-03	1.007E-05	-4.590E 04	5.462E 02	-3.600E 01
47	1.128E 03	2.732E-03	-1.559E-05	-3.323E 04	5.085E 02	-3.944E 01
48	1.152E 03	2.099E-03	-3.334E-05	-2.149E 04	4.727E 02	-3.213E 01
49	1.176E 03	1.131E-03	-4.373E-05	-1.053E 04	4.437E 02	-2.602E 01
50	1.20CE 03	C	-4.727E-05	-1.985E 02	2.195E 02	-4.224E 02
51	1.224E 03	-1.138E-03	-4.740E-05	0	4.136E 00	-8.272E 00

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	1.000E 01	2.000E-02	5.000E 06	5.000E 04	5.000E 04

TIME = 3 MINUTES, 47 AND 24/60 SECONDS



Prob 5F. Long-pile buckling, axial compression = 7.000E+05 lb.

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PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118     CODED 28 JUL 66-HM,JJP    PUNCH 28 JUL 66-TH    RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPORT

     TIME =     3 MINUTES, 47 ANC 31/60 SECONDS


PROB
   5G     LCNG-PILE BUCKLING, AXIAL COMPRESSION = 7.0250E+05 LB


TABLE 1 - PRCGRAM-CCNTRCL CATA
                                                                  TABLES NUMBER
                                                                   2    3    4

     PRICR-CATA OPTICNS (1 = HOLC)                                 1    1    1
     NUM CARDS INPUT THIS PROBLEM                                  0    0    2

     CPTICN (IF=1, 2, 3) TC PLOT                                   1


TABLE 2 - CCNSTANTS

     USING CATA FROM THE PREVIOUS PROBLEM


TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

     STA       CASE        DEFLECTICN         SLOPE

     USING CATA FROM THE PREVIOUS PROBLEM


TABLE 4 - STIFFNESS AND LOAD CATA

FRCM TC CCNTC      F           Q           S           T           R           P

     USING CATA FROM THE PREVICUS PROBLEM PLUS
   0  50  0            0           0           0           0           0 -2.500E 03
   0   0  0            0           0           0 -2.500E 03           0           0
```

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPORT

PROB (CCNTD)
5G LCNG-PILE BUCKLING, AXIAL COMPRESSION = 7.0250E+05 LB

TABLE 5 - RESULTS

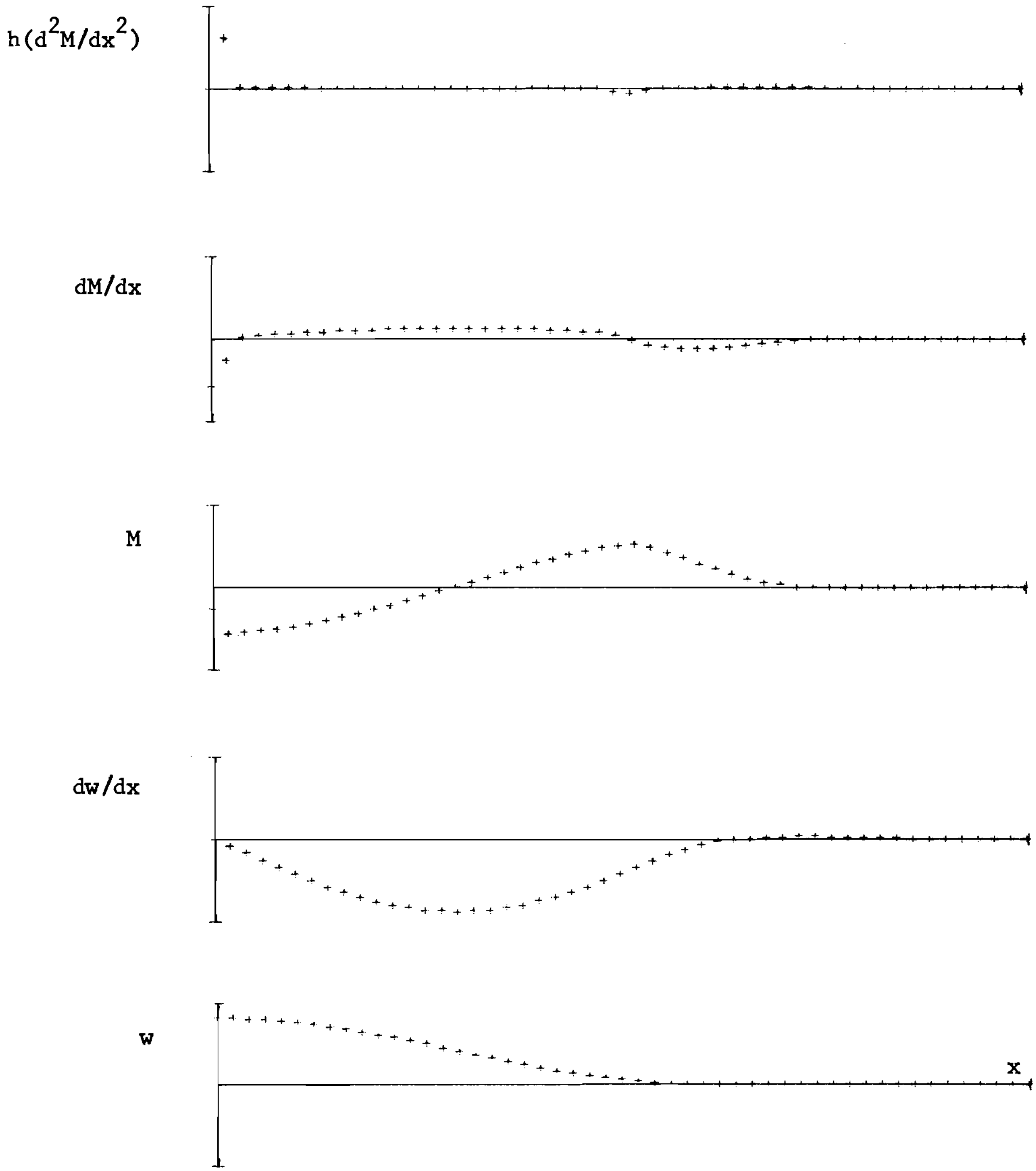
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	8.134E 00	8.592E-04	0	-2.992E 04	-5.984E 04
0	0	8.155E 00	-7.235E-05	-1.436E 06	-5.950E 04	6.780E 02
1	2.400E 01	8.131E 00	-1.930E-03	-2.856E 06	-2.858E 04	6.116E 04
2	4.800E 01	8.062E 00	-3.767E-03	-2.808E 06	2.639E 03	1.276E 03
3	7.200E 01	7.950E 00	-5.563E-03	-2.729E 06	3.897E 03	1.240E 03
4	9.600E 01	7.795E 00	-7.298E-03	-2.621E 06	5.113E 03	1.191E 03
5	1.200E 02	7.600E 00	-8.954E-03	-2.484E 06	6.273E 03	1.129E 03
6	1.440E 02	7.365E 00	-1.051E-02	-2.320E 06	7.365E 03	1.054E 03
7	1.680E 02	7.095E 00	-1.196E-02	-2.130E 06	8.376E 03	9.682E 02
8	1.920E 02	6.792E 00	-1.327E-02	-1.918E 06	9.296E 03	8.715E 02
9	2.160E 02	6.458E 00	-1.444E-02	-1.684E 06	1.011E 04	7.654E 02
10	2.400E 02	6.099E 00	-1.545E-02	-1.432E 06	1.082E 04	6.509E 02
11	2.640E 02	5.717E 00	-1.629E-02	-1.165E 06	1.141E 04	5.293E 02
12	2.880E 02	5.317E 00	-1.695E-02	-8.846E 05	1.188E 04	4.020E 02
13	3.120E 02	4.903E 00	-1.743E-02	-5.947E 05	1.223E 04	3.002E 02
14	3.360E 02	4.480E 00	-1.772E-02	-2.976E 05	1.247E 04	1.901E 02
15	3.600E 02	4.052E 00	-1.782E-02	4.095E 03	1.259E 04	4.800E 01
16	3.840E 02	3.625E 00	-1.772E-02	3.069E 05	1.257E 04	-9.459E 01
17	4.080E 02	3.202E 00	-1.742E-02	6.075E 05	1.240E 04	-2.362E 02
18	4.320E 02	2.788E 00	-1.693E-02	9.023E 05	1.210E 04	-3.751E 02
19	4.560E 02	2.389E 00	-1.625E-02	1.188E 06	1.166E 04	-5.100E 02
20	4.800E 02	2.008E 00	-1.539E-02	1.462E 06	1.108E 04	-6.394E 02
21	5.040E 02	1.650E 00	-1.436E-02	1.720E 06	1.038E 04	-7.617E 02
22	5.280E 02	1.319E 00	-1.317E-02	1.960E 06	9.562E 03	-8.758E 02
23	5.520E 02	1.018E 00	-1.183E-02	2.179E 06	8.634E 03	-9.803E 02
24	5.760E 02	7.512E-01	-1.035E-02	2.375E 06	7.607E 03	-1.074E 03
25	6.000E 02	5.213E-01	-8.754E-03	2.544E 06	3.893E 03	-6.355E 03
26	6.240E 02	3.310E-01	-7.098E-03	2.561E 06	-3.167E 03	-7.765E 03
27	6.480E 02	1.805E-01	-5.492E-03	2.392E 06	-9.394E 03	-4.688E 03
28	6.720E 02	6.737E-02	-4.031E-03	2.111E 06	-1.289E 04	-2.303E 03
29	6.960E 02	-1.295E-02	-2.771E-03	1.774E 06	-1.431E 04	-5.476E 02
30	7.200E 02	-6.566E-02	-1.735E-03	1.423E 06	-1.426E 04	6.628E 02
31	7.440E 02	-9.621E-02	-9.197E-04	1.089E 06	-1.321E 04	1.424E 03
32	7.680E 02	-1.098E-01	-3.105E-04	7.892E 05	-1.159E 04	1.832E 03
33	7.920E 02	-1.111E-01	1.183E-04	5.331E 05	-9.683E 03	1.974E 03
34	8.160E 02	-1.041E-01	3.964E-04	3.244E 05	-7.731E 03	1.929E 03
35	8.400E 02	-9.209E-02	5.542E-04	1.620E 05	-5.885E 03	1.763E 03
36	8.640E 02	-7.753E-02	6.203E-04	4.192E 04	-4.240E 03	1.527E 03
37	8.880E 02	-6.232E-02	6.204E-04	-4.150E 04	-2.845E 03	1.262E 03
38	9.120E 02	-4.775E-02	5.763E-04	-9.463E 04	-1.716E 03	9.954E 02
39	9.360E 02	-3.465E-02	5.054E-04	-1.239E 05	-8.450E 02	7.475E 02
40	9.600E 02	-2.349E-02	4.214E-04	-1.352E 05	-2.063E 02	5.299E 02
41	9.840E 02	-1.443E-02	3.342E-04	-1.338E 05	2.329E 02	3.485E 02
42	1.008E 03	-7.448E-03	2.506E-04	-1.240E 05	5.096E 02	2.049E 02
43	1.032E 03	-2.400E-03	1.749E-04	-1.093E 05	6.609E 02	9.754E 01

44	1.C56E 03	9.464E-04	1.C95E-04	-9.229E 04	7.212E 02	2.306E 01
45	1.C80E 03	2.856E-C3	5.533E-C5	-7.471E 04	7.212E 02	-2.301E 01
46	1.104E 03	3.602E-03	1.239E-05	-5.767E 04	6.86SE 02	-4.563E 01
47	1.128E 03	3.450E-03	-1.S85E-C5	-4.174E 04	6.391E 02	-4.985E 01
48	1.152E 03	2.649E-03	-4.214E-C5	-2.700E 04	5.93SE 02	-4.057E 01
49	1.176E 03	1.428E-03	-5.519E-C5	-1.323E 04	5.572E 02	-3.288E 01
50	1.2CCE 03	C	-5.964E-C5	-2.514E 02	2.75€E 02	-5.303E 02
51	1.224E 03	-1.435E-03	-5.S81E-05	0	5.237E 00	-1.047E 01

TABLE 6 -- SCALES FOR PLOT CUTPLT -- VALUES AT ENDS OF AXES

STA I	X	W	CW/DX	M	DM/CX	NET REACT
50	1.200E 03	1.000E 01	2.C00E-02	5.000E 06	1.00CE 05	1.000E 05

TIME = 4 MINUTES, 0 ANC 5C/60 SECCNDS



Prob 5G. Long-pile buckling, axial compression = 7.025E+05 lb.

PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 COCED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCOL 34 FINAL REPORT

TIME = 4 MINUTES, 0 ANC 57/60 SECONDS

PROB
5H LCNG-PILE BUCKLING, AXIAL COMPRESSION = 7.050E+05 LB

TABLE 1 - PROGRAM-CCNTRCL CATA

	TABLES NUMBER 2	3	4
PRIOR-DATA OPTIONS (1 = HOLD)	1	1	1
NUM CARCS INPUT THIS PROBLEM	0	0	2
OPTION (IF=1, 2, 3) TC PLOT	1		

TABLE 2 - CCNSTANTS

USING CATA FROM THE PREVICUS PROBLEM

TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

STA CASE DEFLECTICN SLOPE

USING CATA FROM THE PREVIOUS PROBLEM

TABLE 4 - STIFFNESS ANC LOAD CATA

USING CATA FROM THE PREVIOUS PROBLEM PLUS

FROM	TC	CONTD	F	Q	S	T	R	P
0	50	0	0	0	0	0	0	-2.500E 03
0	0	0	0	0	0	-2.500E 03	0	0

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118   CODED 28 JUL 66-HM,JJP   PUNCH 28 JUL 66-TH   RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
5H   LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.050E+05 LB

TABLE 5 - RESULTS

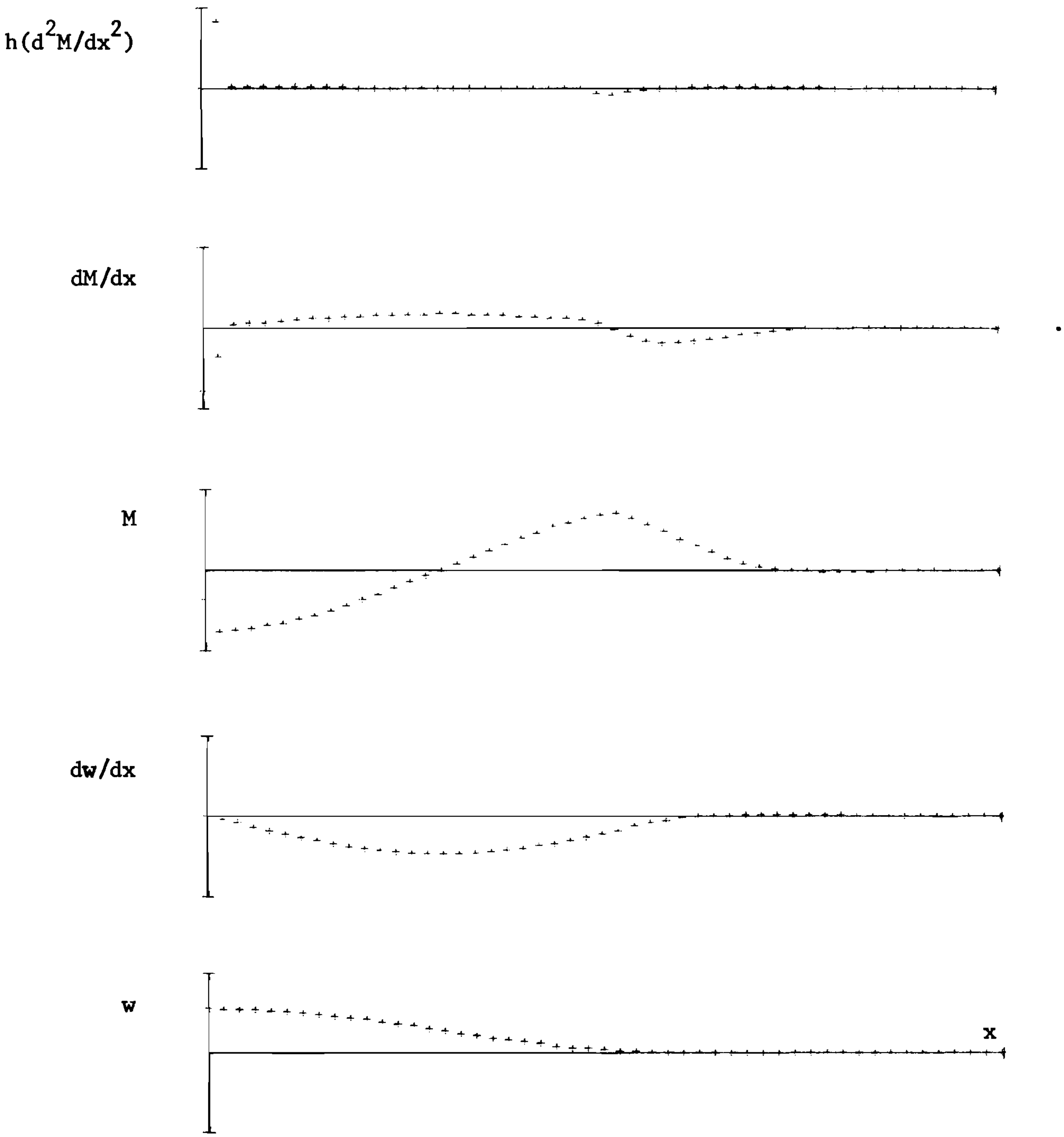
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	1.100E 01	1.156E-03	0	-4.054E 04	-8.109E 04
0	0	1.103E 01	-1.063E-04	-1.946E 06	-8.062E 04	9.249E 02
1	2.400E 01	1.100E 01	-2.624E-03	-3.870E 06	-3.872E 04	8.289E 04
2	4.800E 01	1.090E 01	-5.113E-03	-3.805E 06	3.595E 03	1.735E 03
3	7.200E 01	1.075E 01	-7.546E-03	-3.697E 06	5.305E 03	1.686E 03
4	9.600E 01	1.054E 01	-9.896E-03	-3.550E 06	6.958E 03	1.619E 03
5	1.200E 02	1.027E 01	-1.214E-02	-3.363E 06	8.534E 03	1.534E 03
6	1.440E 02	9.957E 00	-1.425E-02	-3.140E 06	1.002E 04	1.432E 03
7	1.680E 02	9.591E 00	-1.620E-02	-2.883E 06	1.139E 04	1.315E 03
8	1.920E 02	9.180E 00	-1.798E-02	-2.593E 06	1.264E 04	1.183E 03
9	2.160E 02	8.728E 00	-1.956E-02	-2.276E 06	1.375E 04	1.038E 03
10	2.400E 02	8.241E 00	-2.092E-02	-1.934E 06	1.471E 04	8.818E 02
11	2.640E 02	7.724E 00	-2.206E-02	-1.570E 06	1.551E 04	7.159E 02
12	2.880E 02	7.182E 00	-2.295E-02	-1.189E 06	1.614E 04	5.423E 02
13	3.120E 02	6.622E 00	-2.360E-02	-7.953E 05	1.660E 04	3.926E 02
14	3.360E 02	6.049E 00	-2.398E-02	-3.921E 05	1.692E 04	2.337E 02
15	3.600E 02	5.471E 00	-2.410E-02	1.676E 04	1.706E 04	4.222E 01
16	3.840E 02	4.893E 00	-2.396E-02	4.266E 05	1.700E 04	-1.497E 02
17	4.080E 02	4.321E 00	-2.355E-02	8.329E 05	1.676E 04	-3.399E 02
18	4.320E 02	3.762E 00	-2.288E-02	1.231E 06	1.632E 04	-5.265E 02
19	4.560E 02	3.223E 00	-2.196E-02	1.616E 06	1.571E 04	-7.072E 02
20	4.800E 02	2.708E 00	-2.079E-02	1.985E 06	1.491E 04	-8.803E 02
21	5.040E 02	2.225E 00	-1.939E-02	2.332E 06	1.395E 04	-1.044E 03
22	5.280E 02	1.777E 00	-1.777E-02	2.655E 06	1.283E 04	-1.196E 03
23	5.520E 02	1.372E 00	-1.596E-02	2.948E 06	1.157E 04	-1.335E 03
24	5.760E 02	1.012E 00	-1.396E-02	3.210E 06	1.017E 04	-1.459E 03
25	6.000E 02	7.015E-01	-1.180E-02	3.436E 06	5.159E 03	-8.563E 03
26	6.240E 02	4.450E-01	-9.567E-03	3.457E 06	-4.349E 03	-1.045E 04
27	6.480E 02	2.423E-01	-7.399E-03	3.228E 06	-1.273E 04	-6.305E 03
28	6.720E 02	8.986E-02	-5.429E-03	2.847E 06	-1.742E 04	-3.090E 03
29	6.960E 02	-1.827E-02	-3.730E-03	2.391E 06	-1.933E 04	-7.261E 02
30	7.200E 02	-8.918E-02	-2.332E-03	1.919E 06	-1.924E 04	9.038E 02
31	7.440E 02	-1.302E-01	-1.234E-03	1.468E 06	-1.783E 04	1.928E 03
32	7.680E 02	-1.484E-01	-4.135E-04	1.063E 06	-1.563E 04	2.476E 03
33	7.920E 02	-1.501E-01	1.639E-04	7.174E 05	-1.306E 04	2.666E 03
34	8.160E 02	-1.405E-01	5.380E-04	4.361E 05	-1.042E 04	2.604E 03
35	8.400E 02	-1.242E-01	7.499E-04	2.172E 05	-7.929E 03	2.379E 03
36	8.640E 02	-1.046E-01	8.384E-04	5.549E 04	-5.710E 03	2.060E 03
37	8.880E 02	-8.400E-02	8.379E-04	-5.682E 04	-3.829E 03	1.701E 03
38	9.120E 02	-6.433E-02	7.779E-04	-1.283E 05	-2.307E 03	1.342E 03
39	9.360E 02	-4.666E-02	6.819E-04	-1.676E 05	-1.133E 03	1.007E 03
40	9.600E 02	-3.160E-02	5.683E-04	-1.827E 05	-2.726E 02	7.136E 02
41	9.840E 02	-1.938E-02	4.505E-04	-1.807E 05	3.187E 02	4.690E 02
42	1.008E 03	-9.977E-03	3.376E-04	-1.674E 05	6.908E 02	2.753E 02
43	1.032E 03	-3.177E-03	2.355E-04	-1.475E 05	8.938E 02	1.306E 02

44	1.056E 03	1.326E-03	1.473E-04	-1.245E 05	9.743E 02	3.032E 01
45	1.080E 03	3.892E-03	7.423E-05	-1.007E 05	9.736E 02	-3.169E 01
46	1.104E 03	4.889E-03	1.634E-05	-7.775E 04	9.267E 02	-6.206E 01
47	1.128E 03	4.676E-03	-2.712E-05	-5.625E 04	8.619E 02	-6.762E 01
48	1.152E 03	3.588E-03	-5.716E-05	-3.638E 04	8.006E 02	-5.497E 01
49	1.176E 03	1.933E-03	-7.474E-05	-1.783E 04	7.508E 02	-4.457E 01
50	1.200E 03	0	-8.075E-05	-3.416E 02	3.714E 02	-7.143E 02
51	1.224E 03	-1.943E-03	-8.097E-05	0	7.116E 00	-1.423E 01

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	2.000E 01	5.000E-02	5.000E 06	1.000E 05	1.000E 05

TIME = 4 MINUTES, 14 AND 17/60 SECONDS



Prob 5H. Long-pile buckling, axial compression = 7.050E+05 lb.

```
PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118     CODED 28 JUL 66-HM,JJP    PUNCH 28 JUL 66-TH    RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

     TIME =      4 MINUTES, 14 AND 24/60 SECONDS


PROB
   5I      LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.075E+05 LB


TABLE 1 - PROGRAM-CONTROL DATA
                                                              TABLES NUMBER
                                                               2    3    4

     PRIOR-DATA OPTIONS (1 = HOLD)                             1    1    1
     NUM CARDS INPUT THIS PROBLEM                              0    0    2

     OPTION (IF=1, 2, 3) TO PLOT                               1


TABLE 2 - CONSTANTS

     USING DATA FROM THE PREVIOUS PROBLEM


TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

     STA       CASE        DEFLECTION        SLOPE

     USING DATA FROM THE PREVIOUS PROBLEM


TABLE 4 - STIFFNESS AND LOAD DATA

FROM TO CONTD      F           Q           S           T           R           P

     USING DATA FROM THE PREVIOUS PROBLEM PLUS
   0  50  0            0           0           0           0           0 -2.500E 03
   0   0  0            0           0           0 -2.500E 03            0           0
```

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
5I LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.075E+05 LB

TABLE 5 - RESULTS

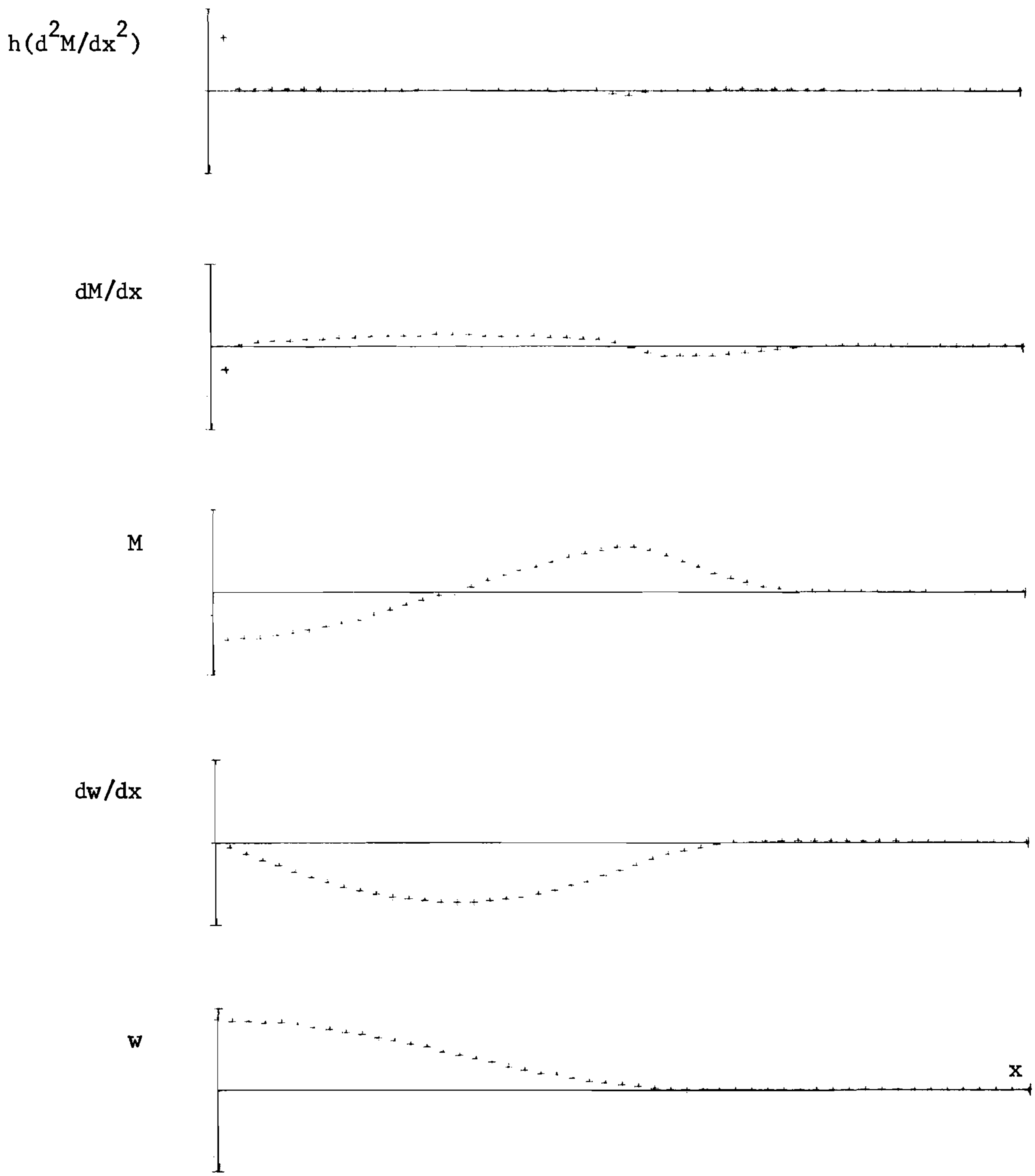
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	1.699E 01	1.776E-03	0	-6.274E 04	-1.255E 05
0	0	1.703E 01	-1.772E-04	-3.012E 06	-1.248E 05	1.441E 03
1	2.400E 01	1.698E 01	-4.073E-03	-5.988E 06	-5.990E 04	1.283E 05
2	4.800E 01	1.684E 01	-7.924E-03	-5.887E 06	5.591E 03	2.694E 03
3	7.200E 01	1.660E 01	-1.169E-02	-5.720E 06	8.247E 03	2.618E 03
4	9.600E 01	1.627E 01	-1.532E-02	-5.491E 06	1.081E 04	2.513E 03
5	1.200E 02	1.586E 01	-1.879E-02	-5.201E 06	1.326E 04	2.380E 03
6	1.440E 02	1.537E 01	-2.205E-02	-4.854E 06	1.556E 04	2.222E 03
7	1.680E 02	1.481E 01	-2.507E-02	-4.454E 06	1.769E 04	2.039E 03
8	1.920E 02	1.417E 01	-2.782E-02	-4.005E 06	1.963E 04	1.833E 03
9	2.160E 02	1.347E 01	-3.025E-02	-3.512E 06	2.135E 04	1.607E 03
10	2.400E 02	1.272E 01	-3.236E-02	-2.981E 06	2.283E 04	1.364E 03
11	2.640E 02	1.192E 01	-3.411E-02	-2.416E 06	2.407E 04	1.106E 03
12	2.880E 02	1.108E 01	-3.549E-02	-1.825E 06	2.504E 04	8.354E 02
13	3.120E 02	1.021E 01	-3.647E-02	-1.214E 06	2.575E 04	5.857E 02
14	3.360E 02	9.329E 00	-3.706E-02	-5.895E 05	2.620E 04	3.246E 02
15	3.600E 02	8.435E 00	-3.723E-02	4.326E 04	2.638E 04	3.006E 01
16	3.840E 02	7.542E 00	-3.700E-02	6.767E 05	2.626E 04	-2.648E 02
17	4.080E 02	6.659E 00	-3.636E-02	1.304E 06	2.585E 04	-5.568E 02
18	4.320E 02	5.797E 00	-3.531E-02	1.918E 06	2.515E 04	-8.427E 02
19	4.560E 02	4.964E 00	-3.388E-02	2.511E 06	2.417E 04	-1.119E 03
20	4.800E 02	4.170E 00	-3.206E-02	3.078E 06	2.292E 04	-1.384E 03
21	5.040E 02	3.425E 00	-2.989E-02	3.611E 06	2.141E 04	-1.633E 03
22	5.280E 02	2.736E 00	-2.739E-02	4.106E 06	1.966E 04	-1.864E 03
23	5.520E 02	2.110E 00	-2.458E-02	4.555E 06	1.769E 04	-2.075E 03
24	5.760E 02	1.556E 00	-2.150E-02	4.955E 06	1.552E 04	-2.263E 03
25	6.000E 02	1.078E 00	-1.817E-02	5.300E 06	7.805E 03	-1.318E 04
26	6.240E 02	6.833E-01	-1.472E-02	5.330E 06	-6.817E 03	-1.607E 04
27	6.480E 02	3.714E-01	-1.138E-02	4.973E 06	-1.969E 04	-9.683E 03
28	6.720E 02	1.369E-01	-8.349E-03	4.384E 06	-2.690E 04	-4.736E 03
29	6.960E 02	-2.939E-02	-5.733E-03	3.682E 06	-2.982E 04	-1.099E 03
30	7.200E 02	-1.383E-01	-3.581E-03	2.953E 06	-2.966E 04	1.407E 03
31	7.440E 02	-2.013E-01	-1.891E-03	2.258E 06	-2.747E 04	2.981E 03
32	7.680E 02	-2.291E-01	-6.285E-04	1.634E 06	-2.407E 04	3.821E 03
33	7.920E 02	-2.314E-01	2.592E-04	1.103E 06	-2.010E 04	4.112E 03
34	8.160E 02	-2.166E-01	8.339E-04	6.694E 05	-1.604E 04	4.015E 03
35	8.400E 02	-1.914E-01	1.159E-03	3.326E 05	-1.220E 04	3.666E 03
36	8.640E 02	-1.610E-01	1.294E-03	8.382E 04	-8.781E 03	3.173E 03
37	8.880E 02	-1.293E-01	1.292E-03	-8.884E 04	-5.884E 03	2.620E 03
38	9.120E 02	-9.898E-02	1.199E-03	-1.986E 05	-3.542E 03	2.065E 03
39	9.360E 02	-7.175E-02	1.051E-03	-2.589E 05	-1.735E 03	1.550E 03
40	9.600E 02	-4.855E-02	8.753E-04	-2.819E 05	-4.112E 02	1.097E 03
41	9.840E 02	-2.974E-02	6.935E-04	-2.786E 05	4.978E 02	7.206E 02
42	1.008E 03	-1.526E-02	5.195E-04	-2.580E 05	1.069E 03	4.225E 02
43	1.032E 03	-4.802E-03	3.621E-04	-2.273E 05	1.380E 03	1.998E 02

44	1.056E 03	2.120E-03	2.262E-04	-1.917E 05	1.503E 03	4.547E 01
45	1.080E 03	6.057E-03	1.137E-04	-1.551E 05	1.501E 03	-4.982E 01
46	1.104E 03	7.579E-03	2.460E-05	-1.197E 05	1.428E 03	-9.639E 01
47	1.128E 03	7.238E-03	-4.230E-05	-8.658E 04	1.327E 03	-1.047E 02
48	1.152E 03	5.549E-03	-8.854E-05	-5.599E 04	1.232E 03	-8.504E 01
49	1.176E 03	2.988E-03	-1.156E-04	-2.743E 04	1.155E 03	-6.900E 01
50	1.200E 03	0	-1.248E-04	-5.299E 02	5.715E 02	-1.099E 03
51	1.224E 03	-3.004E-03	-1.252E-04	0	1.104E 01	-2.208E 01

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	2.000E 01	5.000E-02	1.000E 07	2.000E 05	2.000E 05

TIME = 4 MINUTES, 27 AND 43/60 SECONDS



Prob 5I. Long-pile buckling, axial compression = 7.075E+05 lb.

```
PROGRAM BMCCL 34 - DECK 2 - MATLCCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118     CODED 28 JUL 66-HM,JJP    PUNCH 28 JUL 66-TH    RUN 1 AUG 66
EXAMPLE PRCBLEMS - BMCCL 34 FINAL REPORT

     TIME =     4 MINUTES, 27 ANC 50/60 SECONDS


PROB
   5J     LCNG-PILE BUCKLING, AXIAL COMPRESSICN = 7.100E+05 LB


TABLE 1 - PRCGRAM-CCNTRCL CATA
                                                                TABLES NUMBER
                                                                 2    3    4

     PRICR-DATA OPTIONS (1 = HOLC)                               1    1    1
     NUM CARCS INPUT THIS PROBLEM                                0    0    2

     CPTION (IF=1, 2, 3) TC PLOT                                 1


TABLE 2 - CCNSTANTS

     USING CATA FROM THE PREVICUS PROBLEM


TABLE 3 - SPECIFIED DEFLECTIONS ANC SLOPES

     STA       CASE        DEFLECTICN        SLOPE

     USING CATA FROM THE PREVICUS PROBLEM


TABLE 4 - STIFFNESS AND LOAD CATA

FRCM TC CCNTC     F            Q            S            T            R            P

     USING CATA FROM THE PREVICUS PROBLEM PLUS
  0  50  0            0            0            0            0            0 -2.500E 03
  0   0  0            0            0            0 -2.500E 03            0            0
```

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118   CODED 28 JUL 66-HM,JJP   PUNCH 28 JUL 66-TH   RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
5J   LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.100E+05 LB

TABLE 5 - RESULTS

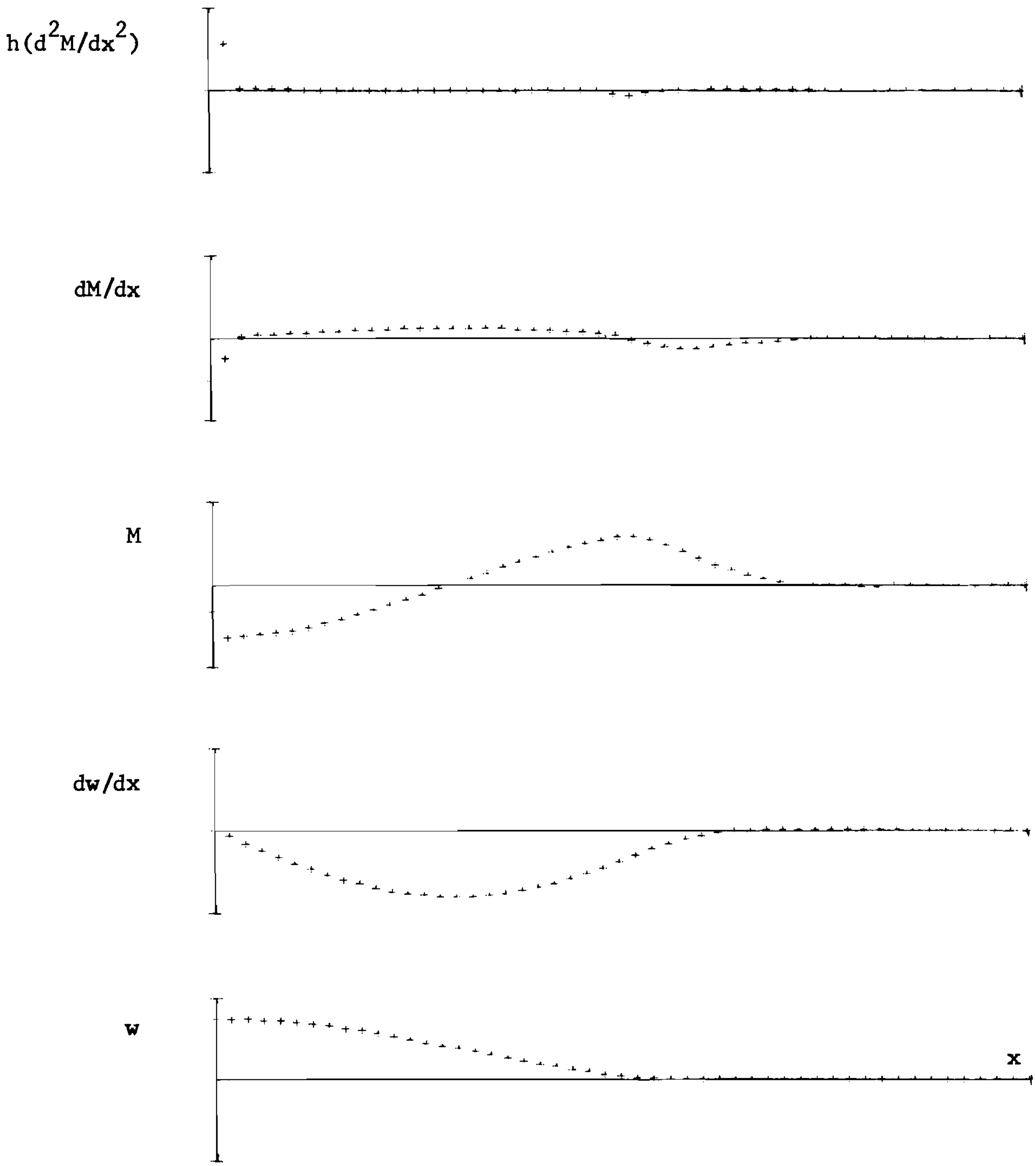
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	3.733E 01	3.882E-03	0	-1.381E 05	-2.763E 05
0	0	3.742E 01	-4.185E-04	-6.630E 06	-2.747E 05	3.193E 03
1	2.400E 01	3.731E 01	-8.995E-03	-1.318E 07	-1.318E 05	2.825E 05
2	4.800E 01	3.699E 01	-1.747E-02	-1.296E 07	1.237E 04	5.951E 03
3	7.200E 01	3.647E 01	-2.576E-02	-1.259E 07	1.824E 04	5.782E 03
4	9.600E 01	3.575E 01	-3.376E-02	-1.208E 07	2.390E 04	5.549E 03
5	1.200E 02	3.485E 01	-4.139E-02	-1.144E 07	2.931E 04	5.255E 03
6	1.440E 02	3.376E 01	-4.856E-02	-1.068E 07	3.439E 04	4.903E 03
7	1.680E 02	3.252E 01	-5.520E-02	-9.792E 06	3.909E 04	4.497E 03
8	1.920E 02	3.112E 01	-6.123E-02	-8.800E 06	4.335E 04	4.042E 03
9	2.160E 02	2.958E 01	-6.659E-02	-7.711E 06	4.715E 04	3.541E 03
10	2.400E 02	2.792E 01	-7.121E-02	-6.537E 06	5.042E 04	3.002E 03
11	2.640E 02	2.616E 01	-7.504E-02	-5.291E 06	5.313E 04	2.430E 03
12	2.880E 02	2.432E 01	-7.805E-02	-3.986E 06	5.526E 04	1.831E 03
13	3.120E 02	2.241E 01	-8.020E-02	-2.638E 06	5.680E 04	1.241E 03
14	3.360E 02	2.047E 01	-8.147E-02	-1.260E 06	5.774E 04	6.335E 02
15	3.600E 02	1.850E 01	-8.183E-02	1.334E 05	5.805E 04	-1.140E 01
16	3.840E 02	1.654E 01	-8.129E-02	1.526E 06	5.772E 04	-6.562E 02
17	4.080E 02	1.460E 01	-7.986E-02	2.904E 06	5.674E 04	-1.294E 03
18	4.320E 02	1.271E 01	-7.754E-02	4.250E 06	5.514E 04	-1.917E 03
19	4.560E 02	1.088E 01	-7.436E-02	5.550E 06	5.292E 04	-2.519E 03
20	4.800E 02	9.137E 00	-7.035E-02	6.790E 06	5.011E 04	-3.094E 03
21	5.040E 02	7.501E 00	-6.557E-02	7.956E 06	4.675E 04	-3.634E 03
22	5.280E 02	5.990E 00	-6.006E-02	9.034E 06	4.286E 04	-4.134E 03
23	5.520E 02	4.619E 00	-5.388E-02	1.001E 07	3.850E 04	-4.589E 03
24	5.760E 02	3.403E 00	-4.711E-02	1.088E 07	3.371E 04	-4.993E 03
25	6.000E 02	2.357E 00	-3.981E-02	1.163E 07	1.679E 04	-2.885E 04
26	6.240E 02	1.492E 00	-3.224E-02	1.169E 07	-1.520E 04	-3.514E 04
27	6.480E 02	8.096E-01	-2.492E-02	1.090E 07	-4.335E 04	-2.115E 04
28	6.720E 02	2.965E-01	-1.827E-02	9.607E 06	-5.909E 04	-1.033E 04
29	6.960E 02	-6.715E-02	-1.253E-02	8.065E 06	-6.543E 04	-2.365E 03
30	7.200E 02	-3.052E-01	-7.822E-03	6.466E 06	-6.506E 04	3.117E 03
31	7.440E 02	-4.426E-01	-4.122E-03	4.942E 06	-6.022E 04	6.558E 03
32	7.680E 02	-5.030E-01	-1.359E-03	3.576E 06	-5.274E 04	8.391E 03
33	7.920E 02	-5.078E-01	5.827E-04	2.411E 06	-4.404E 04	9.021E 03
34	8.160E 02	-4.751E-01	1.839E-03	1.462E 06	-3.513E 04	8.804E 03
35	8.400E 02	-4.196E-01	2.548E-03	7.246E 05	-2.671E 04	8.035E 03
36	8.640E 02	-3.528E-01	2.841E-03	1.801E 05	-1.921E 04	6.953E 03
37	8.880E 02	-2.832E-01	2.836E-03	-1.976E 05	-1.287E 04	5.739E 03
38	9.120E 02	-2.167E-01	2.630E-03	-4.375E 05	-7.735E 03	4.522E 03
39	9.360E 02	-1.570E-01	2.303E-03	-5.689E 05	-3.778E 03	3.392E 03
40	9.600E 02	-1.061E-01	1.918E-03	-6.189E 05	-8.818E 02	2.401E 03
41	9.840E 02	-6.491E-02	1.519E-03	-6.112E 05	1.106E 03	1.575E 03
42	1.008E 03	-3.321E-02	1.137E-03	-5.658E 05	2.355E 03	9.222E 02
43	1.032E 03	-1.032E-02	7.922E-04	-4.982E 05	3.033E 03	4.346E 02

44	1.056E 03	4.816E-03	4.944E-04	-4.202E 05	3.299E 03	9.691E 01
45	1.080E 03	1.341E-02	2.479E-04	-3.398E 05	3.292E 03	-1.114E 02
46	1.104E 03	1.671E-02	5.264E-05	-2.622E 05	3.130E 03	-2.130E 02
47	1.128E 03	1.594E-02	-9.387E-05	-1.896E 05	2.908E 03	-2.308E 02
48	1.152E 03	1.221E-02	-1.951E-04	-1.226E 05	2.699E 03	-1.872E 02
49	1.176E 03	6.572E-03	-2.543E-04	-6.005E 04	2.529E 03	-1.520E 02
50	1.200E 03	0	-2.746E-04	-1.170E 03	1.251E 03	-2.405E 03
51	1.224E 03	-6.608E-03	-2.753E-04	0	2.437E 01	-4.874E 01

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	5.000E 01	1.000E-01	2.000E 07	5.000E 05	5.000E 05

TIME = 4 MINUTES, 41 AND 9/60 SECONDS



Prob 5J. Long-pile buckling, axial compression = 7.100E+05 lb.

```
PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON   REVISION DATE = 01 JUL 66
CHARGE CE051118     CODED 28 JUL 66-HM,JJP    PUNCH 28 JUL 66-TH    RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

     TIME =     4 MINUTES, 41 AND 16/60 SECONDS


PROB
   5K      LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.125E+05 LB


TABLE 1 - PROGRAM-CONTROL DATA
                                                                TABLES NUMBER
                                                                 2    3    4

     PRIOR-DATA OPTIONS (1 = HOLD)                               1    1    1
     NUM CARDS INPUT THIS PROBLEM                                0    0    2

     OPTION (IF=1, 2, 3) TO PLOT                                 1


TABLE 2 - CONSTANTS

     USING DATA FROM THE PREVIOUS PROBLEM


TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

     STA       CASE        DEFLECTION        SLOPE

     USING DATA FROM THE PREVIOUS PROBLEM


TABLE 4 - STIFFNESS AND LOAD DATA

FROM TO CONTD      F           Q           S           T           R           P

     USING DATA FROM THE PREVIOUS PROBLEM PLUS
   0  50  0           0           0           0           0           0 -2.500E 03
   0   0  0           0           0           0 -2.500E 03           0           0
```

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
5K LONG-PILE BUCKLING, AXIAL COMPRESSION = 7.125E+05 LB

TABLE 5 - RESULTS

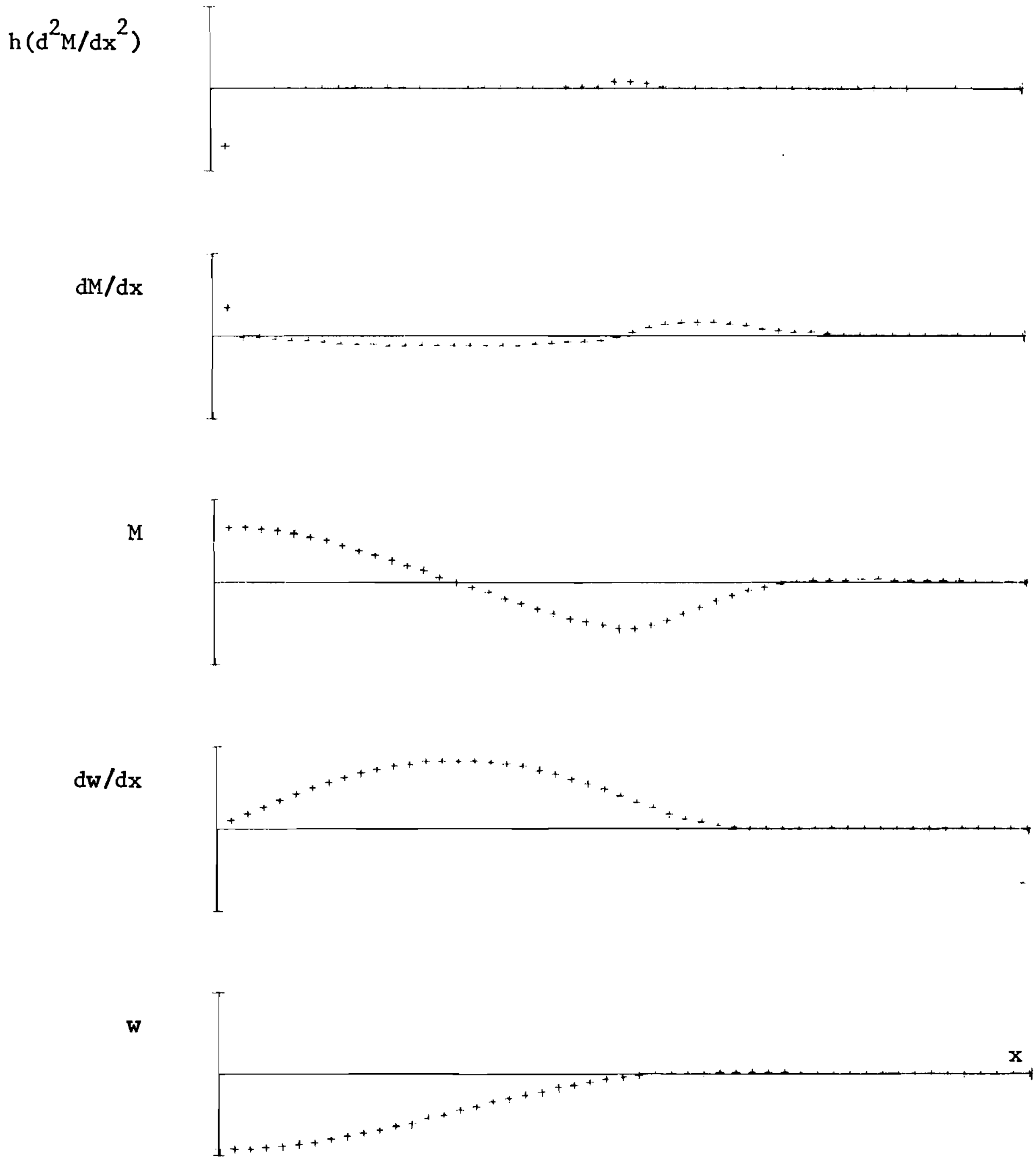
STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-2.400E 01	-1.886E 02	-1.951E-02	0	6.992E 05	1.398E 06
0	0	-1.890E 02	2.262E-03	3.356E 07	1.390E 06	-1.627E 04
1	2.400E 01	-1.884E 02	4.567E-02	6.673E 07	6.671E 05	-1.430E 06
2	4.800E 01	-1.868E 02	8.858E-02	6.558E 07	-6.294E 04	-3.023E 04
3	7.200E 01	-1.842E 02	1.305E-01	6.371E 07	-9.273E 04	-2.936E 04
4	9.600E 01	-1.806E 02	1.710E-01	6.113E 07	-1.215E 05	-2.817E 04
5	1.200E 02	-1.760E 02	2.096E-01	5.788E 07	-1.489E 05	-2.667E 04
6	1.440E 02	-1.705E 02	2.459E-01	5.398E 07	-1.747E 05	-2.488E 04
7	1.680E 02	-1.642E 02	2.794E-01	4.949E 07	-1.985E 05	-2.281E 04
8	1.920E 02	-1.571E 02	3.099E-01	4.445E 07	-2.202E 05	-2.049E 04
9	2.160E 02	-1.493E 02	3.369E-01	3.892E 07	-2.394E 05	-1.794E 04
10	2.400E 02	-1.409E 02	3.603E-01	3.296E 07	-2.560E 05	-1.519E 04
11	2.640E 02	-1.320E 02	3.796E-01	2.663E 07	-2.697E 05	-1.228E 04
12	2.880E 02	-1.227E 02	3.947E-01	2.001E 07	-2.805E 05	-9.224E 03
13	3.120E 02	-1.131E 02	4.055E-01	1.317E 07	-2.881E 05	-6.041E 03
14	3.360E 02	-1.032E 02	4.118E-01	6.186E 06	-2.925E 05	-2.796E 03
15	3.600E 02	-9.331E 01	4.135E-01	-8.681E 05	-2.937E 05	4.500E 02
16	3.840E 02	-8.339E 01	4.106E-01	-7.911E 06	-2.916E 05	3.691E 03
17	4.080E 02	-7.360E 01	4.032E-01	-1.487E 07	-2.863E 05	6.891E 03
18	4.320E 02	-6.404E 01	3.914E-01	-2.165E 07	-2.779E 05	1.001E 04
19	4.560E 02	-5.481E 01	3.752E-01	-2.820E 07	-2.663E 05	1.303E 04
20	4.800E 02	-4.602E 01	3.549E-01	-3.444E 07	-2.519E 05	1.590E 04
21	5.040E 02	-3.777E 01	3.307E-01	-4.029E 07	-2.346E 05	1.859E 04
22	5.280E 02	-3.015E 01	3.028E-01	-4.570E 07	-2.148E 05	2.108E 04
23	5.520E 02	-2.324E 01	2.716E-01	-5.060E 07	-1.926E 05	2.333E 04
24	5.760E 02	-1.712E 01	2.373E-01	-5.495E 07	-1.683E 05	2.533E 04
25	6.000E 02	-1.185E 01	2.005E-01	-5.868E 07	-8.300E 04	1.452E 05
26	6.240E 02	-7.495E 00	1.623E-01	-5.893E 07	7.793E 04	1.766E 05
27	6.480E 02	-4.058E 00	1.254E-01	-5.494E 07	2.194E 05	1.063E 05
28	6.720E 02	-1.476E 00	9.188E-02	-4.840E 07	2.984E 05	5.175E 04
29	6.960E 02	3.522E-01	6.301E-02	-4.062E 07	3.301E 05	1.169E 04
30	7.200E 02	1.548E 00	3.928E-02	-3.255E 07	3.280E 05	-1.588E 04
31	7.440E 02	2.238E 00	2.065E-02	-2.487E 07	3.035E 05	-3.316E 04
32	7.680E 02	2.540E 00	6.753E-03	-1.799E 07	2.657E 05	-4.236E 04
33	7.920E 02	2.562E 00	-3.010E-03	-1.212E 07	2.218E 05	-4.551E 04
34	8.160E 02	2.395E 00	-9.321E-03	-7.340E 06	1.768E 05	-4.439E 04
35	8.400E 02	2.114E 00	-1.288E-02	-3.628E 06	1.344E 05	-4.050E 04
36	8.640E 02	1.777E 00	-1.434E-02	-8.887E 05	9.664E 04	-3.503E 04
37	8.880E 02	1.426E 00	-1.430E-02	1.010E 06	6.467E 04	-2.890E 04
38	9.120E 02	1.090E 00	-1.326E-02	2.216E 06	3.884E 04	-2.277E 04
39	9.360E 02	7.895E-01	-1.161E-02	2.874E 06	1.892E 04	-1.707E 04
40	9.600E 02	5.333E-01	-9.662E-03	3.124E 06	4.345E 03	-1.208E 04
41	9.840E 02	3.257E-01	-7.649E-03	3.083E 06	-5.651E 03	-7.917E 03
42	1.008E 03	1.661E-01	-5.724E-03	2.852E 06	-1.192E 04	-4.628E 03
43	1.032E 03	5.096E-02	-3.984E-03	2.511E 06	-1.532E 04	-2.173E 03

44	1.056E 03	-2.513E-02	-2.484E-03	2.117E 06	-1.665E 04	-4.745E 02
45	1.080E 03	-6.826E-02	-1.242E-03	1.712E 06	-1.660E 04	5.725E 02
46	1.104E 03	-8.474E-02	-2.588E-04	1.320E 06	-1.577E 04	1.082E 03
47	1.128E 03	-8.068E-02	4.789E-04	9.545E 05	-1.465E 04	1.169E 03
48	1.152E 03	-6.176E-02	9.885E-04	6.170E 05	-1.359E 04	9.474E 02
49	1.176E 03	-3.323E-02	1.287E-03	3.022E 05	-1.273E 04	7.695E 02
50	1.200E 03	0	1.388E-03	5.936E 03	-6.296E 03	1.210E 04
51	1.224E 03	3.342E-02	1.392E-03	0	-1.237E 02	2.473E 02

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
50	1.200E 03	2.000E 02	5.000E-01	1.000E 08	2.000E 06	2.000E 06

TIME = 4 MINUTES, 54 AND 36/60 SECONDS



Prob 5K. Long-pile buckling, axial compression = 7.125E+05 lb.

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

TIME = 4 MINUTES, 54 AND 43/60 SECONDS

PROB
6 RIGID-FRAME BENT

TABLE 1 - PROGRAM-CONTROL DATA

	TABLES NUMBER 2	3	4
PRIOR-DATA OPTIONS (1 = HOLD)	0	0	0
NUM CARDS INPUT THIS PROBLEM	1	4	37
OPTION (IF=1, 2, 3) TO PLOT	1		

TABLE 2 - CONSTANTS

NUM INCREMENTS	110
INCREMENT LENGTH	1.000E 00

TABLE 3 - SPECIFIED DEFLECTIONS AND SLOPES

STA	CASE	DEFLECTION	SLOPE
0	3	0	0
30	1	0	NONE
80	1	0	NONE
110	3	0	0

TABLE 4 - STIFFNESS AND LOAD DATA

FROM	TO	CONTD	F	Q	S	T	R	P
0		1	1.440E 06	0	0	0	0	0
	6	1	2.490E 06	0	0	0	0	0
	12	1	3.950E 06	0	0	0	0	0
	18	1	5.900E 06	0	0	0	0	0
	24	1	8.400E 06	0	0	0	0	0
	30	1	1.152E 07	0	0	0	0	0
	35	1	7.720E 06	0	0	0	0	0
	40	1	4.860E 06	0	0	0	0	0
	45	1	2.800E 06	0	0	0	0	0
	50	1	1.440E 06	0	0	0	0	0
	60	1	1.440E 06	0	0	0	0	0
	65	1	2.800E 06	0	0	0	0	0
	70	1	4.860E 06	0	0	0	0	0

	75	1	7.720E 06	0	0	0	0	0
	80	1	1.152E 07	C	0	0	0	0
	86	1	8.400E 06	0	0	0	0	0
	92	1	5.900E 06	C	0	0	0	0
	98	1	3.950E C6	C	0	0	0	0
	104	1	2.490E 06	C	0	0	0	0
	110	C	1.440E 06	C	0	0	0	0
0		1	0	-3.630E C0	0	0	0	0
	10	1	0	-3.630E CC	0	0	0	0
	32	C	0	C	0	0	0	0
30		1	0	-3.000E C0	0	0	0	0
	50	1	0	-1.500E C0	0	0	0	0
	60	1	0	-1.500E C0	0	0	0	0
	80	0	0	-3.000E C0	0	0	0	0
78		1	0	0	0	0	0	0
	100	1	0	-3.630E C0	0	0	0	0
	110	0	0	-3.630E C0	0	0	0	0
35	35	0	0	-2.200E 01	0	0	0	0
45	45	0	0	-7.000E C1	0	0	0	0
51	51	C	0	-7.000E C1	0	0	0	0
57	57	C	0	-7.000E C1	0	0	0	0
63	63	0	0	-7.000E C1	0	0	0	0
73	73	C	0	-7.000E C1	0	0	0	0
79	79	C	0	-7.000E 01	0	0	0	0

PROGRAM BMCOL 34 - DECK 2 - MATLOCK-HALIBURTON REVISION DATE = 01 JUL 66
CHARGE CE051118 CODED 28 JUL 66-HM,JJP PUNCH 28 JUL 66-TH RUN 1 AUG 66
EXAMPLE PROBLEMS - BMCOL 34 FINAL REPORT

PROB (CONTD)
6 RIGID-FRAME BENT

TABLE 5 - RESULTS

STA I	X	W	DW/DX	M	DM/DX	NET REACT
-1	-1.000E 00	1.854E-04	-1.854E-04	0	1.335E 02	2.670E 02
0	0	0	0	2.670E 02	2.375E 02	-5.896E 01
1	1.000E 00	1.854E-04	3.325E-04	4.750E 02	7.272E 01	-2.706E 02
2	2.000E 00	6.649E-04	5.947E-04	4.124E 02	-6.440E 01	-3.630E 00
3	3.000E 00	1.375E-03	7.980E-04	3.462E 02	-6.803E 01	-3.630E 00
4	4.000E 00	2.261E-03	9.507E-04	2.764E 02	-7.166E 01	-3.630E 00
5	5.000E 00	3.276E-03	1.059E-03	2.029E 02	-7.529E 01	-3.630E 00
6	6.000E 00	4.379E-03	1.128E-03	1.258E 02	-7.892E 01	-3.630E 00
7	7.000E 00	5.533E-03	1.162E-03	4.506E 01	-8.255E 01	-3.630E 00
8	8.000E 00	6.703E-03	1.163E-03	-3.931E 01	-8.618E 01	-3.630E 00
9	9.000E 00	7.859E-03	1.137E-03	-1.273E 02	-8.981E 01	-3.630E 00
10	1.000E 01	8.977E-03	1.086E-03	-2.189E 02	-9.344E 01	-3.630E 00
11	1.100E 01	1.003E-02	1.012E-03	-3.142E 02	-9.699E 01	-3.465E 00
12	1.200E 01	1.100E-02	9.169E-04	-4.129E 02	-1.004E 02	-3.300E 00
13	1.300E 01	1.186E-02	8.045E-04	-5.149E 02	-1.036E 02	-3.135E 00
14	1.400E 01	1.261E-02	6.768E-04	-6.201E 02	-1.066E 02	-2.970E 00
15	1.500E 01	1.322E-02	5.355E-04	-7.282E 02	-1.095E 02	-2.805E 00
16	1.600E 01	1.368E-02	3.817E-04	-8.391E 02	-1.123E 02	-2.640E 00
17	1.700E 01	1.398E-02	2.163E-04	-9.527E 02	-1.148E 02	-2.475E 00
18	1.800E 01	1.411E-02	4.027E-05	-1.069E 03	-1.172E 02	-2.310E 00
19	1.900E 01	1.406E-02	-1.443E-04	-1.187E 03	-1.194E 02	-2.145E 00
20	2.000E 01	1.382E-02	-3.353E-04	-1.308E 03	-1.215E 02	-1.980E 00
21	2.100E 01	1.339E-02	-5.324E-04	-1.430E 03	-1.234E 02	-1.815E 00
22	2.200E 01	1.276E-02	-7.352E-04	-1.554E 03	-1.251E 02	-1.650E 00
23	2.300E 01	1.192E-02	-9.431E-04	-1.680E 03	-1.267E 02	-1.485E 00
24	2.400E 01	1.087E-02	-1.156E-03	-1.808E 03	-1.281E 02	-1.320E 00
25	2.500E 01	9.609E-03	-1.372E-03	-1.937E 03	-1.293E 02	-1.155E 00
26	2.600E 01	8.128E-03	-1.590E-03	-2.066E 03	-1.304E 02	-9.900E-01
27	2.700E 01	6.429E-03	-1.810E-03	-2.197E 03	-1.313E 02	-8.250E-01
28	2.800E 01	4.509E-03	-2.031E-03	-2.329E 03	-1.321E 02	-6.600E-01
29	2.900E 01	2.366E-03	-2.254E-03	-2.461E 03	-1.326E 02	-4.950E-01
30	3.000E 01	0	-2.479E-03	-2.594E 03	4.639E 01	3.585E 02
31	3.100E 01	-2.591E-03	-2.701E-03	-2.369E 03	2.241E 02	-3.090E 00
32	3.200E 01	-5.403E-03	-2.919E-03	-2.146E 03	2.211E 02	-2.850E 00
33	3.300E 01	-8.429E-03	-3.130E-03	-1.926E 03	2.183E 02	-2.775E 00
34	3.400E 01	-1.166E-02	-3.335E-03	-1.709E 03	2.156E 02	-2.700E 00
35	3.500E 01	-1.510E-02	-3.533E-03	-1.495E 03	2.019E 02	-2.462E 01
36	3.600E 01	-1.873E-02	-3.721E-03	-1.306E 03	1.883E 02	-2.550E 00
37	3.700E 01	-2.254E-02	-3.898E-03	-1.119E 03	1.858E 02	-2.475E 00
38	3.800E 01	-2.652E-02	-4.060E-03	-9.339E 02	1.834E 02	-2.400E 00
39	3.900E 01	-3.066E-02	-4.207E-03	-7.517E 02	1.810E 02	-2.325E 00
40	4.000E 01	-3.494E-02	-4.335E-03	-5.719E 02	1.787E 02	-2.250E 00
41	4.100E 01	-3.933E-02	-4.439E-03	-3.943E 02	1.765E 02	-2.175E 00
42	4.200E 01	-4.382E-02	-4.510E-03	-2.188E 02	1.744E 02	-2.100E 00
43	4.300E 01	-4.835E-02	-4.543E-03	-4.550E 01	1.723E 02	-2.025E 00

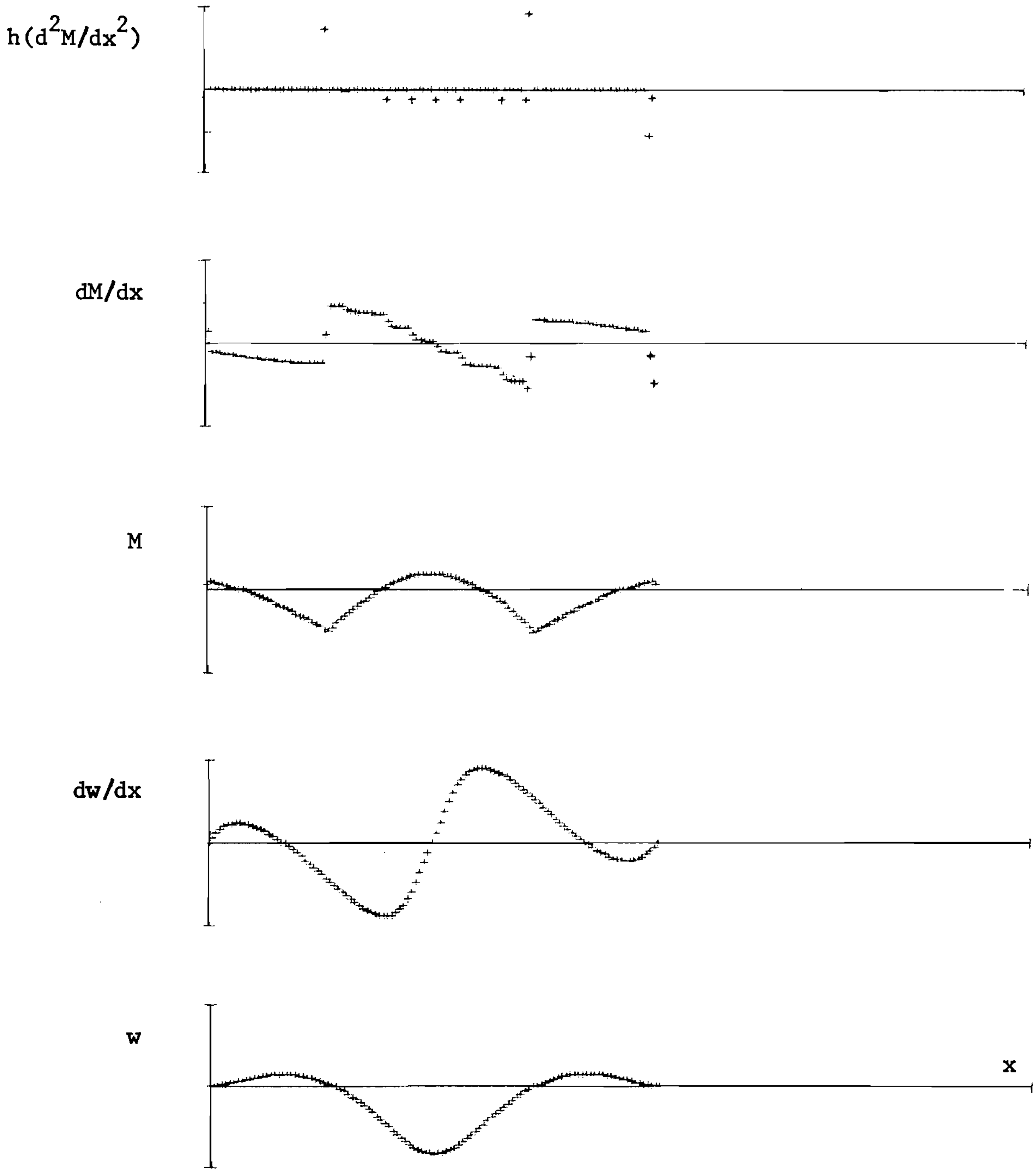
44	4.400E 01	-5.290E-02	-4.530E-03	1.258E 02	1.703E 02	-1.950E 00
45	4.500E 01	-5.741E-02	-4.458E-03	2.952E 02	1.334E 02	-7.188E 01
46	4.600E 01	-6.182E-02	-4.327E-03	3.927E 02	9.659E 01	-1.800E 00
47	4.700E 01	-6.607E-02	-4.141E-03	4.884E 02	9.483E 01	-1.725E 00
48	4.800E 01	-7.010E-02	-3.887E-03	5.823E 02	9.314E 01	-1.650E 00
49	4.900E 01	-7.384E-02	-3.543E-03	6.746E 02	9.153E 01	-1.575E 00
50	5.000E 01	-7.719E-02	-3.080E-03	7.654E 02	8.999E 01	-1.500E 00
51	5.100E 01	-8.000E-02	-2.517E-03	8.546E 02	5.349E 01	-7.150E 01
52	5.200E 01	-8.222E-02	-1.918E-03	8.723E 02	1.699E 01	-1.500E 00
53	5.300E 01	-8.384E-02	-1.306E-03	8.886E 02	1.549E 01	-1.500E 00
54	5.400E 01	-8.484E-02	-6.842E-04	9.033E 02	1.399E 01	-1.500E 00
55	5.500E 01	-8.521E-02	-5.230E-05	9.166E 02	1.249E 01	-1.500E 00
56	5.600E 01	-8.494E-02	5.883E-04	9.283E 02	1.099E 01	-1.500E 00
57	5.700E 01	-8.403E-02	1.236E-03	9.385E 02	-2.551E 01	-7.150E 01
58	5.800E 01	-8.247E-02	1.867E-03	8.773E 02	-6.201E 01	-1.500E 00
59	5.900E 01	-8.030E-02	2.454E-03	8.145E 02	-6.351E 01	-1.500E 00
60	6.000E 01	-7.756E-02	2.998E-03	7.502E 02	-6.501E 01	-1.500E 00
61	6.100E 01	-7.430E-02	3.458E-03	6.845E 02	-6.655E 01	-1.575E 00
62	6.200E 01	-7.064E-02	3.814E-03	6.171E 02	-6.816E 01	-1.650E 00
63	6.300E 01	-6.667E-02	4.091E-03	5.482E 02	-1.048E 02	-7.173E 01
64	6.400E 01	-6.246E-02	4.293E-03	4.074E 02	-1.416E 02	-1.800E 00
65	6.500E 01	-5.809E-02	4.421E-03	2.649E 02	-1.434E 02	-1.875E 00
66	6.600E 01	-5.362E-02	4.487E-03	1.205E 02	-1.454E 02	-1.950E 00
67	6.700E 01	-4.911E-02	4.502E-03	-2.579E 01	-1.473E 02	-2.025E 00
68	6.800E 01	-4.462E-02	4.477E-03	-1.742E 02	-1.494E 02	-2.100E 00
69	6.900E 01	-4.016E-02	4.419E-03	-3.246E 02	-1.515E 02	-2.175E 00
70	7.000E 01	-3.578E-02	4.333E-03	-4.773E 02	-1.538E 02	-2.250E 00
71	7.100E 01	-3.149E-02	4.226E-03	-6.321E 02	-1.560E 02	-2.325E 00
72	7.200E 01	-2.733E-02	4.102E-03	-7.894E 02	-1.584E 02	-2.400E 00
73	7.300E 01	-2.329E-02	3.964E-03	-9.490E 02	-1.958E 02	-7.248E 01
74	7.400E 01	-1.940E-02	3.809E-03	-1.181E 03	-2.334E 02	-2.550E 00
75	7.500E 01	-1.567E-02	3.635E-03	-1.416E 03	-2.359E 02	-2.625E 00
76	7.600E 01	-1.213E-02	3.446E-03	-1.653E 03	-2.386E 02	-2.700E 00
77	7.700E 01	-8.782E-03	3.246E-03	-1.893E 03	-2.413E 02	-2.775E 00
78	7.800E 01	-5.638E-03	3.037E-03	-2.136E 03	-2.442E 02	-2.850E 00
79	7.900E 01	-2.708E-03	2.819E-03	-2.381E 03	-2.821E 02	-7.309E 01
80	8.000E 01	0	2.591E-03	-2.700E 03	-9.062E 01	4.561E 02
81	8.100E 01	2.474E-03	2.358E-03	-2.562E 03	1.372E 02	-4.950E-01
82	8.200E 01	4.715E-03	2.125E-03	-2.426E 03	1.366E 02	-6.600E-01
83	8.300E 01	6.725E-03	1.895E-03	-2.289E 03	1.359E 02	-8.250E-01
84	8.400E 01	8.505E-03	1.666E-03	-2.154E 03	1.350E 02	-9.900E-01
85	8.500E 01	1.006E-02	1.439E-03	-2.019E 03	1.339E 02	-1.155E 00
86	8.600E 01	1.138E-02	1.213E-03	-1.886E 03	1.326E 02	-1.320E 00
87	8.700E 01	1.248E-02	9.909E-04	-1.754E 03	1.312E 02	-1.485E 00
88	8.800E 01	1.336E-02	7.738E-04	-1.624E 03	1.297E 02	-1.650E 00
89	8.900E 01	1.403E-02	5.620E-04	-1.495E 03	1.279E 02	-1.815E 00
90	9.000E 01	1.449E-02	3.559E-04	-1.368E 03	1.260E 02	-1.980E 00
91	9.100E 01	1.474E-02	1.560E-04	-1.243E 03	1.240E 02	-2.145E 00
92	9.200E 01	1.480E-02	-3.726E-05	-1.120E 03	1.218E 02	-2.310E 00
93	9.300E 01	1.467E-02	-2.218E-04	-9.991E 02	1.194E 02	-2.475E 00
94	9.400E 01	1.436E-02	-3.953E-04	-8.810E 02	1.168E 02	-2.640E 00
95	9.500E 01	1.388E-02	-5.569E-04	-7.655E 02	1.141E 02	-2.805E 00
96	9.600E 01	1.324E-02	-7.056E-04	-6.528E 02	1.112E 02	-2.970E 00
97	9.700E 01	1.247E-02	-8.400E-04	-5.431E 02	1.081E 02	-3.135E 00
98	9.800E 01	1.156E-02	-9.588E-04	-4.365E 02	1.049E 02	-3.300E 00
99	9.900E 01	1.055E-02	-1.059E-03	-3.332E 02	1.015E 02	-3.465E 00
100	1.000E 02	9.444E-03	-1.138E-03	-2.334E 02	9.800E 01	-3.630E 00
101	1.010E 02	8.273E-03	-1.193E-03	-1.372E 02	9.437E 01	-3.630E 00
102	1.020E 02	7.059E-03	-1.222E-03	-4.470E 01	9.074E 01	-3.630E 00
103	1.030E 02	5.830E-03	-1.221E-03	4.422E 01	8.711E 01	-3.630E 00

104	1.040E 02	4.617E-03	-1.187E-03	1.295E 02	8.348E 01	-3.630E 00
105	1.050E 02	3.456E-03	-1.115E-03	2.112E 02	7.985E 01	-3.630E 00
106	1.060E 02	2.387E-03	-1.002E-03	2.892E 02	7.622E 01	-3.630E 00
107	1.070E 02	1.452E-03	-8.419E-04	3.636E 02	7.259E 01	-3.630E 00
108	1.080E 02	7.029E-04	-6.281E-04	4.344E 02	6.896E 01	-3.630E 00
109	1.090E 02	1.962E-04	-3.515E-04	5.015E 02	-7.593E 01	-2.861E 02
110	1.100E 02	0	-1.776E-15	2.825E 02	-2.508E 02	-6.351E 01
111	1.110E 02	1.962E-04	1.962E-04	0	-1.413E 02	2.825E 02

TABLE 6 -- SCALES FOR PLOT OUTPUT -- VALUES AT ENDS OF AXES

STA I	X	W	DW/DX	M	DM/DX	NET REACT
200	2.000E 02	1.000E-01	5.000E-03	5.000E 03	5.000E 02	5.000E 02

TIME = 5 MINUTES, 15 AND 27/60 SECONDS



Prob 6. Rigid-frame bent.