DEVELOPMENT OF A GIFTS (GRAPHICS-ORIENTED INTERACTIVE
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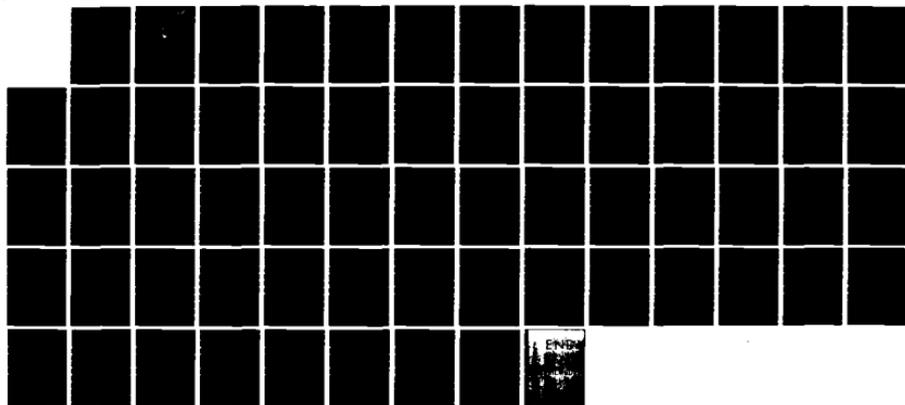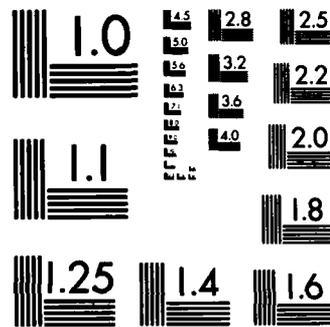
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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

DEVELOPMENT OF A GIFTS PLOTTING PACKAGE
COMPATIBLE WITH EITHER PLOT10
OR IBM/DSM GRAPHICS

by

Thomas R. Pickles

June 1983

Thesis Advisor: G. Cantin

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Development of a GIFTS Plotting Package Compatible
With either PLOT10 or IBM/DSM Graphics

by

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Submitted in partial fulfillment of the
requirements for the degrees of

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ABSTRACT

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I. INTRODUCTION

A. GENERAL DESCRIPTION OF GIFTS

The Graphics-Oriented Interactive Finite-Element Time-Sharing System (hereafter refered to as GIFTS) is a large scale interactive finite element (FEM) program with extensive pre- and post-processing capabilities as well as significant stand alone structural analysis capability. A large choice of element types is available for plate, shell, membrane, beam, and solid elements. The program is broken into modules that are loaded one at a time for various tasks such as model generation, editing, and display; load application; computation and display of results. The data is organized in many small files that remain in storage until specifically called for by one of the modules. This Unified Data Base (UDB) is structured in such a way as to easily interface with other FEM systems. The remainder of the GIFTS subroutines are contained in libraries. These library routines are called by more than one module, or are device dependent. The versions of GIFTS at NPS are divided into five or six libraries, some of which are further subdivided for ease of handling in the editors.

The need to load only one module at a time, and the modules' use of only portions of the UDB allow the GIFTS programs to be used on a variety of mini and main frame computers. Every effort is made to conform to standard FORTRAN programming standards to make the programs as portable as possible. One of the few portions that is not completely portable is the graphics portion, which must be tailored for the graphics support of the individual computer.

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The stand alone capabilities of GIFTS include model generation and editing, static analysis, substructuring and constrained substructuring (creating "super finite elements" by breaking a large problem into several small ones and superimposing the results), natural frequency and modal analysis, and transient or forced vibrational analysis. In all cases the results of stress and displacement can be tabulated and/or graphically displayed. Additionally, GIFTS provides the user with model generation capability for several higher order elements for interface with other FEM systems. Models created with any of the GIFTS elements, whether they enjoy full GIFTS support or not, can be displayed graphically. Models created with GIFTS can be two or three dimensional rods, beams, bending elements, membrane elements, solids, springs, or Lagrange elements with the ability to define axisymmetric bodies with or without axisymmetric loadings.

Graphics is a significantly important portion of the interactive finite element process. Finite element techniques are used for solving varied and complex problems that often require accurate modeling of very involved geometries. The model consists of points connected by lines, surfaces enclosed by lines, solids enclosed by surfaces, and grids subdividing the surfaces and solids. These models require large amounts of error-prone data for their description. The proper geometry, connectivity, and appropriateness of the elements and grids can be most easily checked with a concise graphical representation of the model. The user can verify the correctness of the model at a glance or easily note obvious errors for correction.

The importance of graphics in engineering applications is confirmed by the recent boom in hardware for graphics support, extensive software engineering efforts toward two and three dimensional graphic modeling systems, the influx

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of computer graphics into the industrial world, and the immense amount of publication on the subject in recent technical engineering journals.

B. HISTORICAL BACKGROUND OF GIFTS

The GIFTS program was developed and copyrighted by Dr. Hussein A. Kamel and Mr. Michael W. McCabe at the University of Arizona's Interactive Graphics Engineering Laboratory (IGEL) under contract to the Office of Naval Research and the U.S. Coast Guard. Version 5 of GIFTS became available in 1979 and has been updated almost continuously since. Dr. Kamel and the staff of the IGEL sollicit regular inputs from the extensive GIFTS users group (GUG). GIFTS version 5.07 is the most recently updated version of GIFTS available at NPS and work has commenced on version 6 at the University of Arizona.

Implementation of GIFTS on the IBM 370 at the Naval Post Graduate School was accomplished by Ron Hundley in 1982 [Ref. 1]. GIFTS was previously implemented at NPS on the PDP-11 by John Sheldon in 1980 [Ref. 2], but was not generally available to the students until the IBM version was implemented. As originally implemented on the IBM, a user had to have access to a PLOT10 compatible graphics terminal, such as the TEKTRONIX 4081, that could be linked to the IBM for graphics output. Since that time the school has installed 14 dual screen graphics stations directly to the IBM that are not plot10 compatible.

There are currently two versions of GIFTS available to users at NPS, versions 5.05 and 5.07. Although there are some internal structural differences between the versions these differences are transparent to the user. The major differences in capabilities between the versions from the standpoint of the user are the addition of double precision

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capability, full modal analysis, and earthquake simulation in the version 5.07. Due to the increased size of version 5.07 it does not fit within the virtual memory constraint of one megabyte that is imposed at NPS for individual users. The version 5.07 can still be used by accessing a special disk, as will be explained in a later chapter, but due to this limitation version 5.05 has been retained. Both versions have the same command structure and an extensive on line help facility. A user familiar with one version can use the other with no additional training or study. This is also true of the two graphics packages now available, the user working on the IBM dual screen station uses the same commands and controls as the user on a PLOT10 terminal.

The graphics package contained in GIFTS is designed to display the model at various stages of the analysis. The model can be created, displayed, edited if necessary, and redisplayed until a satisfactory model has been created. The solution of the problem proceeds with opportunities at intermediate steps to display such things as loading conditions and nodal degrees of freedom. The results can then be displayed as displacements, stresses, stress contours, residual forces, resultants, or loading histograms. These quantities are displayed superimposed directly on the model and the user can change view direction or zoom in on small portions of the model as desired. This provides an easy to understand synopsis of the numerical data that can also be obtained from GIFTS in tabulated form.

C. OBJECTIVES

The objectives of this work have been:

1. Modification of the GIFTS graphics package for operation on either the IBM/DSM dual screen stations or a PLOT10 compatible terminal.

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2. Modification of the GIFTS graphics package to allow operation with graphics screens of varying size and resolution.

3. Implementation of GIFTS version 5.07 on the IBM 370.

4. Development of a simple user friendly control scheme for choosing the desired graphics terminal type.

5. Test the various capabilities of GIFTS, including natural and forced vibrations.

II. COMPUTER GRAPHICS

A. GENERAL CONCEPTS

All computer graphics systems do several simple tasks that are necessarily similar in implementation. The tasks are not unlike those that would be done by a draftsman in making a simple view drawing of an object. The cursor on the graphics screen would correspond to the draftsman's pencil and can be positioned anywhere on the viewing area without making a mark. A draftsman could now draw a line by using a straight edge aligned between two end points, or by starting at a specified point and drawing a certain distance at a certain angle or in a certain direction. A computer graphics package can also perform these simple tasks in a similar manner. Some graphics packages contain simple shapes such as circles, triangles, rectangles, or even ellipses of varying sizes much as a draftsman would use a set of templates. There are spline or curve fitting routines in some plotting packages that would be similar to the use of a French curve. Lines or portions of lines can be "invisible" so that parts of the total picture that are not in a specified viewing area are not displayed; this is referred to as clipping. Text can be printed on the graphics screen and can be scaled and printed at any angle. Input to the graphics system can be genereated within a program, input from the computer keyboard, or obtained from some peripheral device such as a joystick, mouse, or digitizing tablet. Beyond these simple tasks the various graphics systems tend to diverge significantly in both use and complexity.

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B. PLOT10 VS IBM/DSM

The two graphics systems that are most available at NPS and are now useable by GIFTS are PLOT10 and IBM 3277 Dual Screen Management (IBM/DSM) graphics. The PLOT10 graphics terminals that are available include, but are not at NPS include, but are not limited to, TEKTRONIX 4XXX, DEC VT100/125, and some personal computers with add on graphics packages. There are several IBM dual screen graphics stations around the campus and most have an atached hard copy unit. Both systems are capable of handling the various graphics tasks that GIFTS calls on them to perform, but the software implementation is not compatible between the systems.

The PLOT10 graphics [Ref. 3] are performed by placing certain binary codes directly into the graphics buffer. This is a rather low level of programming that requires several routines for translating the binary codes and is rather difficult to program and debug. This version of the graphics package was supplied by the IGEL, and was tailored to the systems at NPS by Ron Hundley.

The IBM 3277 Graphics [Ref. 4] are performed by FORTRAN calls to IBM supplied subroutines. This is a much higher level of programming language that is considerably simpler to implement. Although the programmer and user do not have access to the graphics package subroutine codes supplied by IBM , the simplicity and variety of subroutines available makes this unnecessary.

Most of the graphics screens at NPS that are compatible with PLOT10 graphics have screen resolutions of about 800 addressable points vertically and 1023 addressable points horizontally (the different screens vary slightly). The graphics screens on the IBM dual screen stations, a TEKTRONIX 618 storage tube device, have 4096 by 4096 addres-

sable points, however, only 4096 points horizontally and 3072 points vertically can be displayed. This provides a rectangular viewing area of approximately the same proportions for both plotting systems. The resolution of the IBM dual screen graphics stations is very high and is capable of producing very smooth curves and precise lines. The resolution of the PLOT10 compatible screens is usually more than sufficient for GIFTS applications. The size of the graphics buffer is essentially a measure of the "intelligence" of the local terminal. The graphics buffer for the PLOT10 systems is 80 characters long, while the graphics buffer for the IBM/DSM graphics system is 1920 characters long. The increased size of the graphics buffer aids in speeding the processing of the graphics displays. Unfortunately the full potential of the larger buffer is not realized in the Gifts system because the graphics buffer is automatically flushed after some of the graphics operations.

C. ORGANIZATION OF GIFTS GRAPHICS

The GIFTS graphics package is contained in the libraries because it is both device dependent and accessed from several of the main modules. Originally the graphics library was library five (LIBR5), but since a different version was required for each of the graphics systems, a different name was given to each version to avoid ambiguity or confusion. The subroutine that PLOT10 uses for displaying the binary characters in the graphics buffer (PLTCHR) is not used in the IBM/DSM version.

The graphical output from GIFTS is divided into two distinct screen areas: the "main" viewing area and the "offset" viewing area. The main viewing area contains the graphical model and various labels while the offset viewing area contains other alphanumeric data pertinent to the

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model. To avoid the problem of chopping the edges when a hard copy is made the viewing areas are not quite as large as the maximum screen size. For PLOT10 the main viewing area is 750 by 750 and for the IBM/DSM the main viewing area is 3050 by 3050.

The differing screen sizes are handled through a screen scaling factor that is passed in a labeled common block. To avoid changing any of the existing common blocks a new and unique common block was created for the purpose. The scaling factor is SC$SC and is in the common block /SC$$SC/. The variable name is distinctive enough to be unique so as to avoid duplication of existing variables, and the common block label is different than the variable name as is required by some compilers. The scaling factor was used in five subroutines of the GIFTS graphics library. A list of the subroutines that were modified with the scaling factor is given in appendix A. The scaling factor was needed in only the graphics routines. This had the advantages that no changes are needed in the main modules, leaving them completely portable, and since the scaling is only done at the time of plotting, the data base is not affected.

IBM/DSM 3277 graphics contain several things that could be used to make the graphics more accurate such as routines to draw circles, boxes, second and third order curves, and automatic clipping. These were all avoided in an effort to keep the internal structure and the user commands identical for user ease. The plotting library was modified to work in precisely the same manner as the PLOT10 version by adding appropriate calls to IBM/DSM subroutines and deleting PLOT10 plotting. The subroutines that use calls to IBM/DSM graphics routines are listed in appendix A.

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III. USER CHANGES

The two versions of GIFTS reside on two separate disk spaces to avoid ambiguity. The single precision version, 5.06, is on the 3161P disk as it has been since implementation by Ron Hundley. The single/double precision version, 5.07, is on the 1119P disk. Version 5.06 can be run by linking to 3161P from the user's personal disk. Version 5.07 is considerably larger and must be used by logging on one of the public 2-megabyte disks and then linking to 1119P. Complete procedures for accessing both versions of GIFTS are contained in appendix B. Every attempt has been made to maintain all commands as they appear in the GIFTS User's Reference Manual [Ref. 5].

The first thing that must be done once the user has accessed one of the GIFTS disks is to execute the GIFTS EXEC by issuing the command GIFTS. The user will then be given the opportunity to choose between the PLOT10 and IBM/DSM graphics packages. This is an additional step that must be done once each terminal session whether or not the problem has been previously formulated. Once a problem has been run using one of the graphics systems it can then be run on the other system as long as the appropriate selection is made during the execution of the GIFTS EXEC. This is possible because all of the model data is stored in an unscaled state, and is scaled only immediately prior to display. If no plotting is going to be done the GIFTS EXEC must still be run, but it doesn't matter which system is selected. The PLOT10 selection in the GIFTS EXEC tends to execute the EXEC a few seconds faster than the IBM/DSM version, but the execution of the subsequent modules is not affected. The GIFTS operation from this point on is identical to Ron

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Hundley's IBM version as outlined in the IGEL GIFTS User Guide. Don't forget to run IBMUDB for creation of the UDB at the start of a new problem.

There are some peculiarities from the user's standpoint when using the IBM/DSM terminals. The TEKTRONIX 618 graphics screens used in the IBM dual screen graphics stations have some controls of their own. There are two knobs at the bottom center of the screen. The hard copy intensity can be adjusted for lighter or darker hard copies. The write through intensity has only one use for the GIFTS user, and that is the intensity of the graphics cursor cross hairs used in the window command. If the intensity is too high (usually above 50%) the cross hair will burn lines on the screen that can obliterate porions of the model and appear on the hard copy. After about 90 seconds the graphics screen will automatically dim to avoid permanently burning images on the graphics storage tube. Normal intensity can be restored by pushing the button labeled "VIEW". If a hard copy unit is attached to the dual screen station a thermal paper copy of exactly what appears on the graphics screen can be obtained by pressing the hard copy button on either the TEKTRONIX screen or the hard copy unit. The hard copy units must be warmed up for about 5 minutes before attempting to make a copy, and there is a second intensity knob on the hard copy unit itself.

The joystick for cursor control is on a separate box connected to the dual screen station. There are three rocker switches at the top of the joystick control box that must all be placed in the lower or "normal" position before issuing any graphics commands. The speed of the cursor movement is directly proportional to the distance off center that the joystick is pushed. The joystick returns to the neutral center position when it is released. If cursor motion continues after releasing the joystick, adjust the

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two slide switches immediately below and to the right of the joystick until cursor motion stops. When initially turned on the cursor may appear in the lower left corner and be obscured by the border around the screen. Using the joystick, move the cursor cross hairs up and to the right before adjusting the write through intensity.

The alphanumeric screen displays all of the prompts and user issued commands, but is slightly different than PLOT10 single screens and has some minor peculiarities of which the user should be aware. When the programs query the user for an input at any of the command levels the appropriate prompt will appear on the next unused line of the screen. The user response, however, will be typed on the bottom line and will move up to just below the prompt when entered. Whether or not a prompt appears a user response is expected if, and only if, the VM READ appears in the lower right corner of the screen. During program execution the ready and input inhibited prompts at the right of the screen may flash repeatedly until execution and plotting are complete.

When using the window command the cross hairs will appear but the alphanumeric prompt will remain in the lower right corner. The user must push enter before continuing. The VM READ will now appear and an alphanumeric response can be provided after positioning the cross hair. The user will now be in the same position as when the command was first issued and must follow the same steps for the second input.

Each of the GIFTS disks has an EXEC program that can be copied to the user's disk for linking to the particular version of GIFTS. Listings of those EXECs appear in Appendix B.

IV. PROGRAMMING TIPS

As new graphics terminals become available at NPS it may
be desirable to expand the choices of display screen resolu-
tion for GIFTS.   If the new display screen is controlled by
one of the two presently implemented graphics operating
systems, there are two basic changes that need to be made.
First an additional choice for screen type must be added to
the GIFTS EXEC. This is a straightforward addition that can
be done by simply mimicking the format for the present
choices. The GIFTS EXEC is shown in appendix B.   The second
change involves the screen scaling factor, SC$SC.   The
screen scaling factor is initialized in Subroutine TINITT of
LIBR5 and is always the dimension of the main viewing area
divided by 800.   With this change the library should be
compiled and a TXTLIB created with a unique name to be
called by the GIFTS EXEC.

The dimension of the main viewing area is usually deter-
mined by the vertical dimension of the graphics screen. The
main viewing area is square and if the scaling factor were
unity would be 800 by 800 addressable points.   The offset
viewing area would be 800 by 223 addressable points.   It is
recommended that a viewing area slighly smaller than the
maximum be used to provide a more aesthetic display that
will not be chopped off by a hard copy unit.

There are two text libraries (TXTLIB) compiled from the
GIFTS libraries.   One is the TXTLIB containing the appro-
priate version of the plotting library.   This TXTLIB must
have a unique name for each of the plotting systems selec-
table in the GIFTS EXEC.   The other TXTLIB contains the
remainder of the GIFTS libraries and is common to all of the
plotting systems, it is therefore named GIFTLIB TXTLIB.

If a new plotting system is to be added, careful modification of LIBR5 using the primitive commands of the new system will be necessary. Although there may be far more efficient or glamorous ways to put a graphics package together using the given graphics system to its fullest capacity, it is highly desirable to maintain the same format that exists in the most recent version of GIFTS. The size of the buffer in the graphics system should be used to its maximum extent. Placing information into the buffer is a relatively fast operation, but while the buffer is being flushed to the graphics screen the user can perform no other operations. Therefore, the number of times that the buffer must be flushed should be small. The alphanumerics that appear on the graphics screen should be scaled to approximately the same size as presently exists to accommodate the placement and clipping of the characters.

V. TESTING

A. GRAPHICS PACKAGE

The GIFTS graphics package is in itself a primitive but complete plotting system. A user familiar with the subroutines in the GIFTS plotting library can use it as a stand alone graphics package without the need to have any knowledge of the graphics system under which the computer is operating. It was in this stand alone configuration that the graphics package was first tested using some standard test routines supplied by IGEL. One of these tests involved drawing a square, slightly rotated, within a square where all lines are clipped to remain in the first square. The results with both graphics systems were satisfactory and an example of the test is shown in Appendix D.

The graphics package was then tested within GIFTS. This involved the testing of each of the available plotting commands with all combinations of GIFTS versions and plotting systems. Plotting was done at the model generation and editing phases, the load and boundary condition application phases, and the final result phase. Each of the plotting commands was tested at each phase and the graphics outputs from each system and version were compared for uniformity of display. When the graphic outputs are contained in any of the appendices the files that were used to create the model and define the load and boundary conditions, as well as a short synopsis of the running procedure is included immediately preceeding the graphics. Any comparisons with analytic or experimental results are also done preceeding the graphics in the appropriate appendix.

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B. BEAM ELEMENTS

Beam elements can be shown in cross section with a variety of library beam elements available. The model cross section gives graphic and numeric data on dimensions, areas, centers, moments of inertia, and axes orientation. During the results, phase the beam loading, shear and normal stress distributions, and shear and bending moment diagrams can be superimposed on the length or cross section of the beam element as appropriate. There are eleven beam elements available, several of which are shown in Appendix E, others of which are used in subsequent models for system tests.

C. STATICS PACKAGE

For static analysis a cantilever beam under uniform load was modeled. The beam element chosen was a GIFTS standard "I" beam, which corresponds to the AMERICAN INSTITUTE of STEEL CONSTUCTION (AISC) wide flange section (Ref. 3). The cross section dimensions chosen are those for an AISC W8X17 wide flange section. The length to height ratio was chosen as 20 so that results could be compared with those expected for a slender beam. The GIFTS and analytic results are compared in appendix F.

D. DYNAMICS PACKAGE

1. Natural Frequencies

GIFTS contains extensive dynamic analysis of structures capabilities. The free vibration, or natural frequency, analysis finds the natural frequencies of the model by a subspace iteration technique that is controlled by the user. Iterations are continued until the eigenvalues and/or natural frequencies, which are displayed at each iteration, converge to the satisfaction of the user. The

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mode shapes and stress distributions for each of the computed natural frequencies can be displayed.

Two models were developed for natural frequency analysis. A cantilever beam of solid rectangular cross section and length to height ratio of 20 was used for ease in comparison with analytic results. A model of one of the vibration laboratory apparatus at NPS was used for comparison with experimental results. The GIFTS output and comparison data for both models are shown in appendix G.

The natural frequency results agree very well with analytic and experimental results. For the first three natural frequencies of the cantilever beam the results agree to about 3%. The experimental results for the laboratory apparatus agreed to between 8% and 12% for the first three frequencies.

2. Forced Vibrations

There are two ways that the user can create a time varying load. Loads can be specified at discrete time steps in BULKLB/EDITLB, or a previously defined time varying load can be applied using WAVE. The user can compile their own time varying load in WAVE or use one of the supplied loadings. A sinusoidal load, or one of three earthquake models can be used. The three earthquake models are El Centro, Taft, and an artificially simulated quake. The model used for the earthquake loading is the model of the experimental apparatus that was used in the free vibration analysis. The graphic results from this analysis, including a histogram of the loading and the stress distribution in the cross section of a beam element, are shown in appendix H.

VI. CONCLUSIONS AND RECOMMENDATIONS

The modification of the graphics package to operate
under the IBM/DSM graphics if desired is complete and has
been tested satisfactorily. The graphics screen size is now
scaled, allowing for differing screen resolutions. Version
5.07 of GIFTS is installed on the IBM 370, has been tested
and compared to analytic, experimental, and other FEM
results. The operation of version 5.07 is deemed satisfac-
tory. The GIFTS EXEC provides an easy to use and understand
method of choosing graphic screen type without altering any
user inputs.

It is recommended that the IGEL include parameterized
screen sizes in future version of GIFTS. This is a highly
desirable feature in a rapidly expanding computer graphics
market.

For further thesis work in the areas of computer
graphics, computer aided design and manufacturing, or
related subjects the department's aquisition of the Apollo
computer work station will open many new horizons.

APPENDIX A
LIST OF MODIFIED SUBROUTINES

A. SUBROUTINES CONTAINING THE SCALING FACTOR

        CURSOR
        DRAW
        MCVE
        TEXT
        TINITT

B. SUBROUTINES USING CALLS TO IBM/DSM GRAPHICS ROUTINES

        CURSOR
        DRAW
        FLUSH
        MCVE
        TBELL
        TERASE

APPENDIX B
LINKING PROCEDURE

A. LINKING EXECS

1. EXEC for linking to version 5.05

```
&TRACE
&ERROR EXIT
CP LINK 3161P 191 195 RR PASS= GIFTS
ACCESS 195 C
&BEGTYPE 8
*****************************************************************
*NOTE!: YOU ARE NOW LINKED TO GIFTS VERSION 5.05        ***
*        CN YOUR 195 DISK, MODE C.                      ***
*****************************************************************
*  TO BEGIN A SESSION WITH GIFTS TYPE:                  ***
*               GIFTS                                   ***
*****************************************************************
&EXIT &RC
```


2. EXEC for linking to version 5.07

```
&TRACE
&ERROR EXIT
CP LINK 1119P 191 195 RR PASS= ROPW
ACCESS 195 C
&BEGTYPE 8
*****************************************************************
*NOTE!: YOU ARE NOW LINKED TO GIFTS VERSION 5.07        ***
*        CN YOUR 195 DISK, MODE C.                      ***
*****************************************************************
*  TO BEGIN A SESSION WITH GIFTS TYPE:                  ***
*               GIFTS                                   ***
*****************************************************************
&EXIT &RC
```

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B. PUBLIC 2 MEGABYTE DISK

There are two public disks with virtual memory capacity
of 2-megabytes. The disk numbers are 0090P and 0091P. The
passwords for both of the disks is DISSPLA. The user can
log on these disks as if they were disks belonging to the
individual user, but anything that is left on the disk is
liable to errasure by the next user of the disk. As a
matter of courtesy the user should delete anything that was
placed on the public disks as soon as possible so that there
is room for the other users. To use the GIFTS version 5.07
simply log on one of the 2-megabyte disks and link with the
1119P disk as shown in the above EXEC routines.

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APPENDIX C
GIFTS EXEC

```
&TRACE OFF
&ERROR EXIT
&BEGTYPE -STOPTYPE
*********************************************************************
**    GIFTS  USERS ARE  REMINDED THAT A   NULL LINE   CANNOT BE
***
**    ENTERED USING  A CR ALONE.    YOU MUST USE   AT LEAST ONE
***
**     SPACE (WITH   THE  SPACE   BAR)   FOLLOWED   BY  A  CR.
***
*********************************************************************


##################################################################
##        ENTER  THE  CODE  FOR THE  TERMINAL TYPE  BEING USED:
###
##           1     PLOT 10 COMPATIBLE (TEK4014, VT100,  ETC.)
###
##           2     IBM/DSM  TEK618  DUAL   SCREEN  STATION
###
##################################################################
-STOPTYPE
&READ ARGS
&IF &1 EC 2 &GOTO -DSM
GLOBAL TXTLIB FORTMOD2 MOD2EEH GIFTLIB PLT10LIB NONIMSL
&GOTO -LAST
-DSM
CP LINK GRAF77 191 399 RR
ACCESS 399 G
GLOBAL  TXTLIB  FORTMOD2  MOD2EEH   GIFTLIB  GRAFLIB  DSMLIB
NONIMSL
-LAST
CP TERMINAL LINESIZE 80
&EXIT &RC
```

28

APPENDIX D
STAND ALONE GRAPHICS TEST

A. DESCRIPTION OF TEST

The user specifies a box size in screen coordinates (based on an 800 by 800 main viewing area size) and the percentage rotation. A succession of boxes is drawn, one inside the other rotated by the specified percentage. Each box is clipped to the edges of the preceeding box. The test can be run repeatedly until a zero screen size is specified.
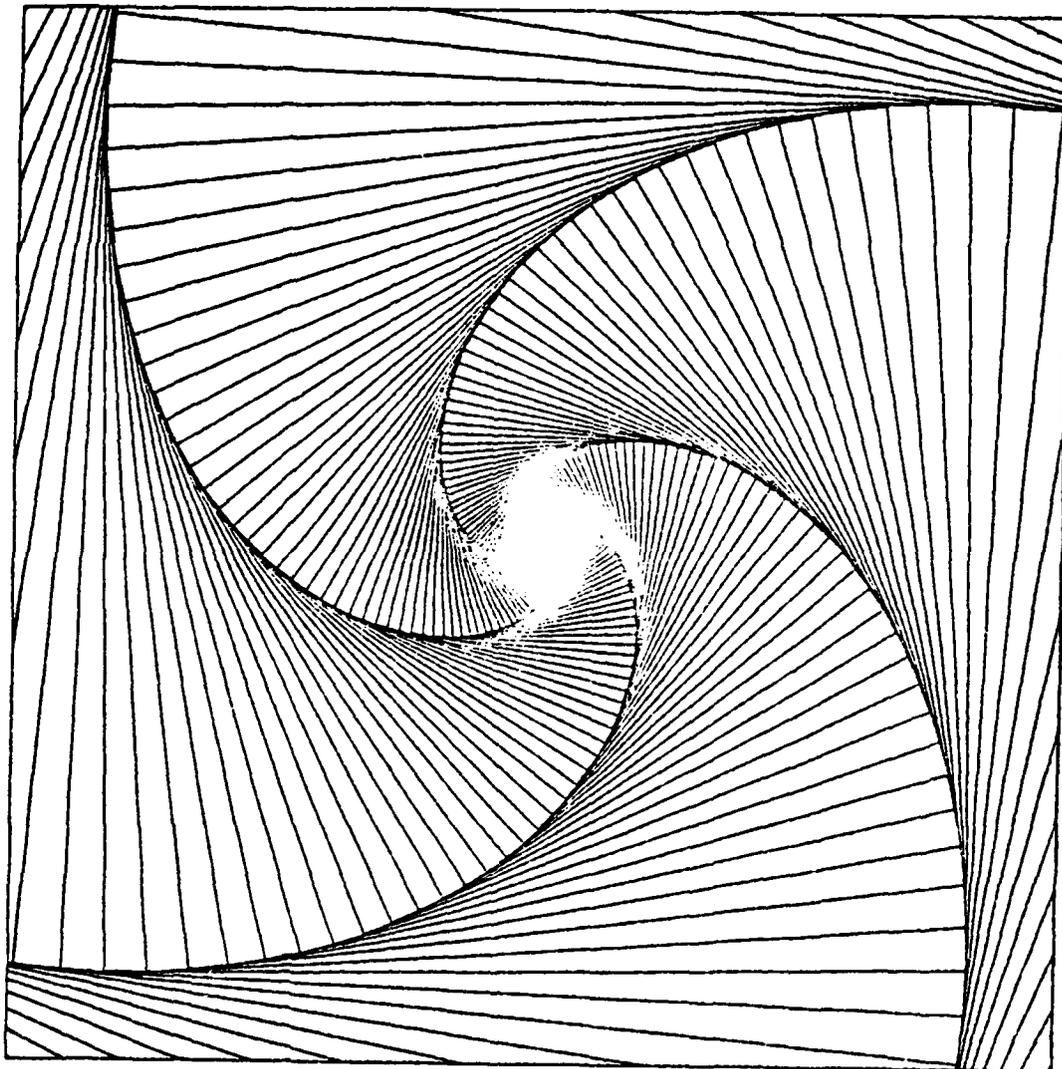
Figure D.1   Stand alone graphics test.

APPENDIX E
BEAM CROSS SECTIONS

A. DESCRIPTION OF CROSS SECTIONS

Three of the eleven beam cross sections are shown in the following figures. Included in the beam cross section output are centers of area and gravity, origin of the principal axes, cross sectional area, moments of inertia about various axes, effective shear area, and the cross section dimensions.

BEAM PROPERTIES
A = 3.560E+00
AQ= 2.000E+00
AP= 1.800E+00
IP= 1.279E+01
IQ= 4.805E+00
J = 1.055E+01
ZG= 0.0
YG= 0.0
ZO= 0.0
YO= 0.0
AL= 0.0

CROSS-SECTION
DIMENSIONS
H = 5.000E+00
B = 3.000E+00
TH = 2.000E-01
TB = 3.000E-01
ZA= 0.0
YA= 0.0

JOB: THESIS
6- 4-83
14:48:11
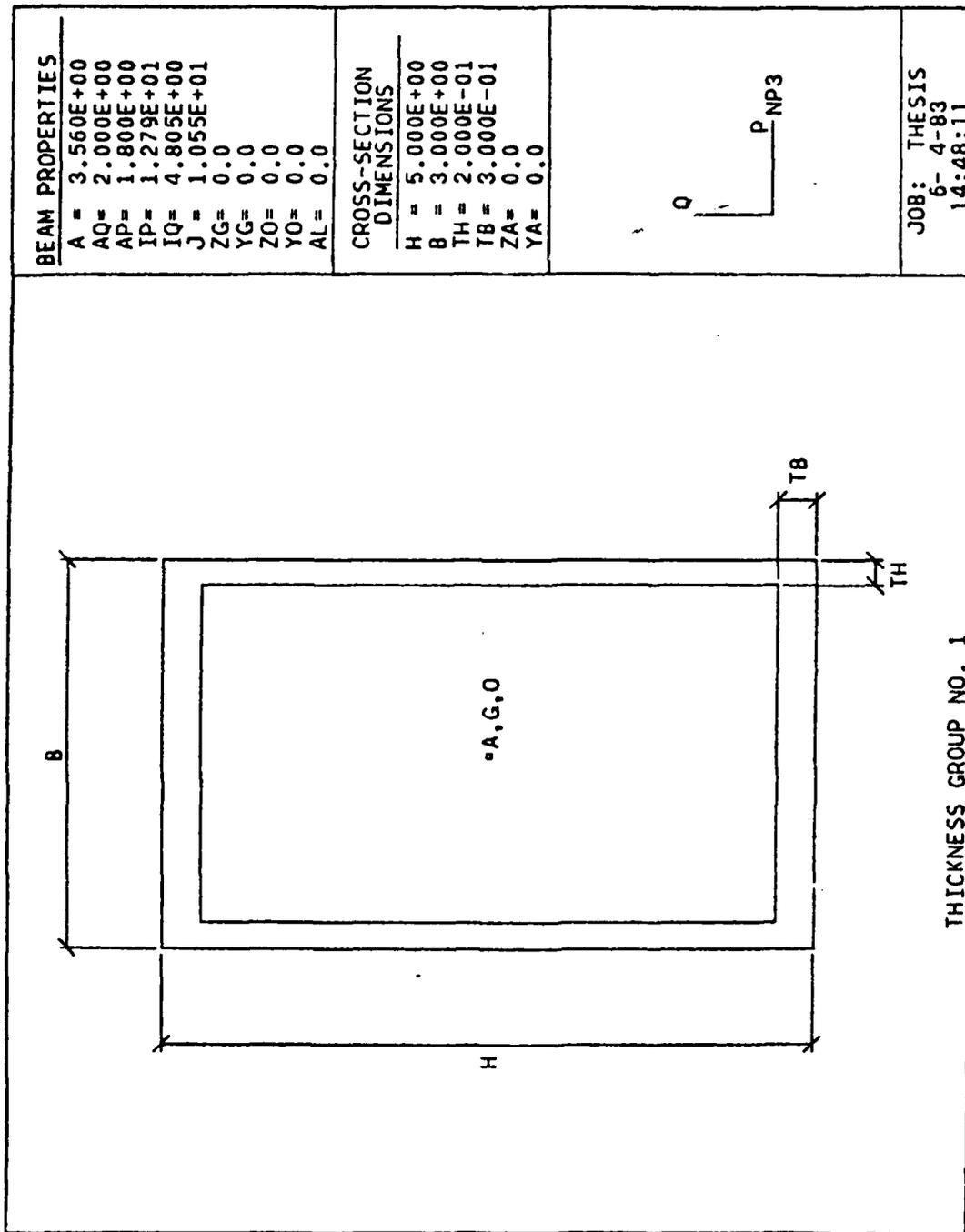
THICKNESS GROUP NO. 1

Figure E.1   Box beam.

32

The figure contains the following data tables:

BEAM PROPERTIES
```
A = 2.160E+00
AQ= 8.607E-01
AP= 1.007E+00
IP= 5.465E+00
IQ= 9.032E-01
J = 7.680E-02
ZG= 0.0
YG= 0.0
ZO= 0.0
YO= 1.156E+00
AL= 0.0
```

CROSS-SECTION DIMENSIONS
```
H = 5.000E+00
B1= 3.000E+00
TW= 2.000E-01
T1= 4.000E-01
ZA= 0.0
YA= 3.844E+00
```

Q P_{NP3}

JOB: THESIS
6- 4-83
14:49:35

THICKNESS GROUP NO. 2

Figure E.2   "T" beam.

33

Figure E.3   "Z" beam.

BEAM PROPERTIES

A = 2.140E+00
AQ= 1.006E+00
AP= 6.286E-01
IP= 1.008E+01
IQ= 5.374E-01
J = 4.853E-02
ZG= 0.0
YG= 0.0
ZO= 0.0
YO= 0.0
AL= 1.724E+01

CROSS-SECTION DIMENSIONS

H = 5.000E+00
B1= 2.000E+00
B2= 2.000E+00
TW= 2.000E-01
T1= 3.000E-01
T2= 3.000E-01
ZA= 0.0
YA= 2.500E+00

THICKNESS GROUP NO. 3

34

APPENDIX F
STATIC RESULTS

A. GIFTS RESULTS

$Ytip = -5.11$ in

B. ANALYTIC RESULTS

Tip deflection including shear deformation:

$Ytip =$ $= -5.11$ in

C. SRC FILES

```
$ SRC FILE TO CREATE STATIC TEST CASE MODEL
IBEAM/1/8,5.25/0.23,0.308/  /
MSTEEL/1/  /LETY/BEAM2/1,1/
KPOINT/1/0,0,0/2/160,0,0/3/80,0,5/  /
SLINE,10/BEAM/1,2,5/3,3/  /END
```

```
$ SRC FILE TO SPECIFY LOADING AND BOUNDARY CONDITIONS
$ FOR THE STATIC TEST CASE
SUPK,0/1/  /
LOADL,2/BEAM/-110,-110/  /END
```

D. GRAPHIC RESULTS

Figure F.1 Cantilever beam model.
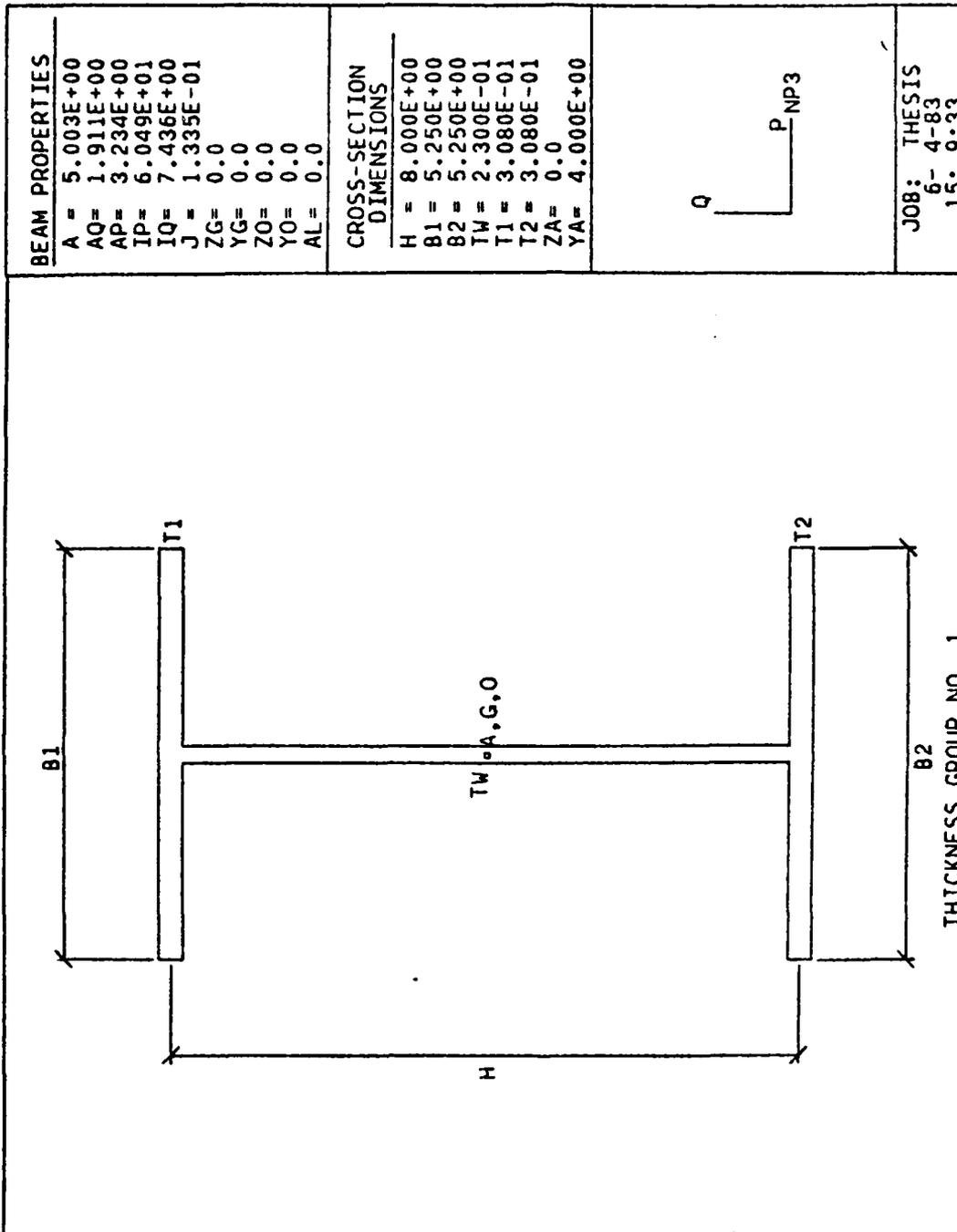
Figure F.2   Beam cross section.

LOADING CASE   1

5.000E+03

LOAD PLOT
RESULTANTS

VIEW DIR.:
0   0   100
VIEWING DIST.
1.000E+20
PLOT LIMITS
X   0.0   1.600E+02
Y   0.0   0.0
Z   0.0   5.000E+00
JOB: THESIS
6- 4-83
15: 2: 7

MODEL
1.000E+01

LOADS

Figure F.3   Beam loading.

38
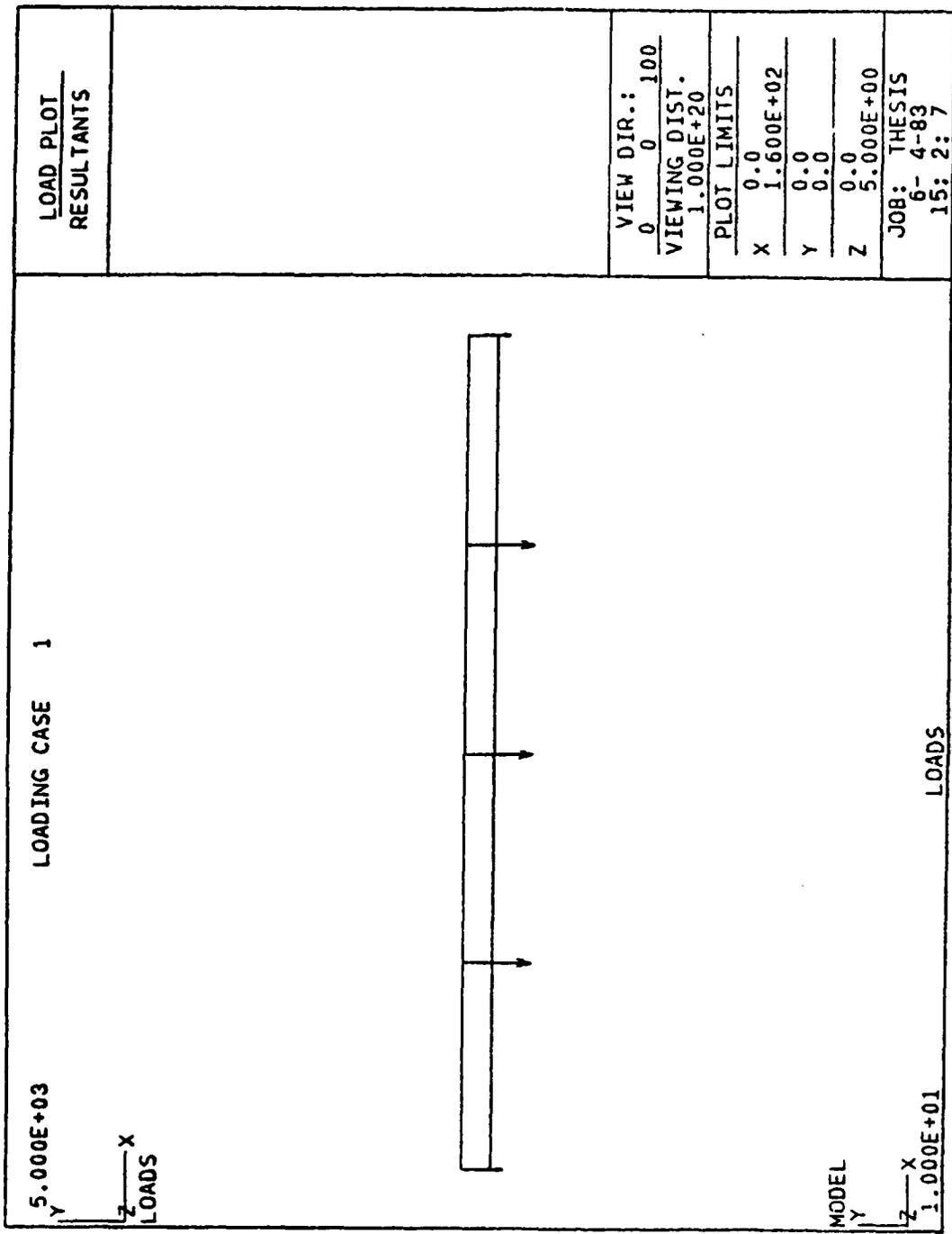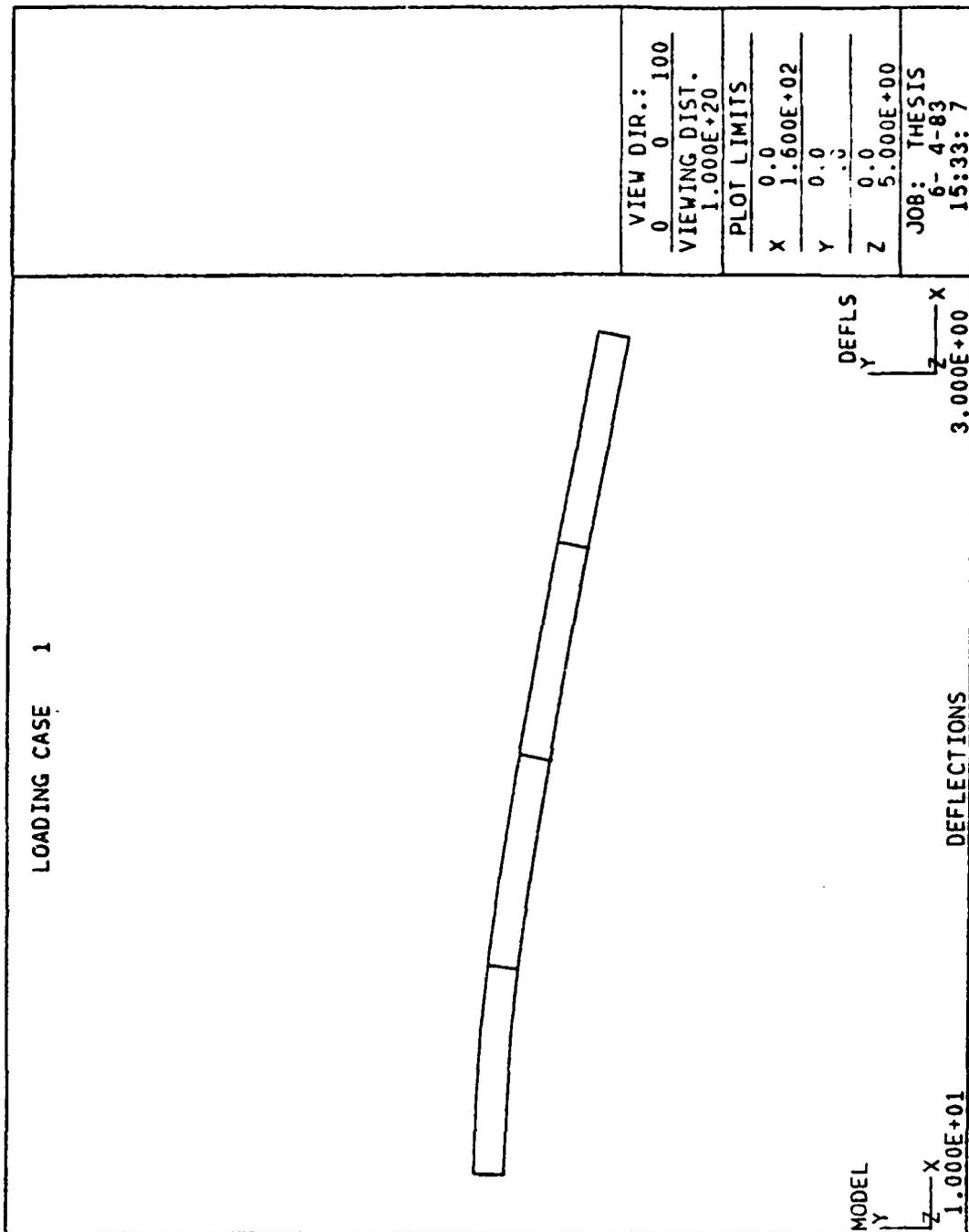
Figure F.4   Deflected beam.

39

BEAM PROPERTIES

A = 5.003E+00
AQ= 1.911E+00
AP= 3.234E+00
IP= 6.049E+01
IQ= 7.436E+00
J = 1.335E-01
ZG= 0.0
YG= 0.0
ZO= 0.0
YO= 0.0
AL= 0.0

YIELD STRESS

3.400E+04

BEAM FORCES

N = 0.0
UY= -1.100E+04
UZ= 0.0
MX= 0.0
BY= 0.0
BZ= 5.572E+05

Q ⌐ P -3

JOB: THESIS
6- 4-83
15:37:23

RESULTANT FORCES

N _____ 0.0

UY _____ -1.320E+04

UZ _____ 0.0

MX _____ 0.0

BY _____ 0.0

BZ _____ 7.919E+05

APPLIED LOADS

QX _____ 0.0

QY _____ -1.100E+02

QZ _____ 0.0

QMX _____ 0.0

ELEMENT NO.   2
LOADING CASE   1
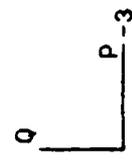
Figure F.5   Element loading.

40

BEAM PROPERTIES

A = 5.003E+00
AQ= 1.911E+00
AP= 3.234E+00
IP= 6.049E+01
IQ= 7.436E+00
J = 1.335E-01
ZG= 0.0
YG= 0.0
ZO= 0.0
YO= 0.0
AL= 0.0

YIELD STRESS
3.400E+04

BEAM FORCES

N = 0.0
UY= -1.012E+04
UZ= 0.0
MX= 0.0
BY= 0.0
BZ= 4.654E+05

Q
P -3

JOB: THESIS
6- 4-83
15:41: 6

SHEAR STRESS
MAX = 6.042E+03

18
5
-5
5
-5

NORMAL STRESS
MAX = 3.078E+04

91
91
-91
91
-91
-91

ELEMENT NO.   2
LOADING CASE   1

STRESSES LABELLED
IN PERCENT OF YIELD

5
X/L = 7.000E-01
4
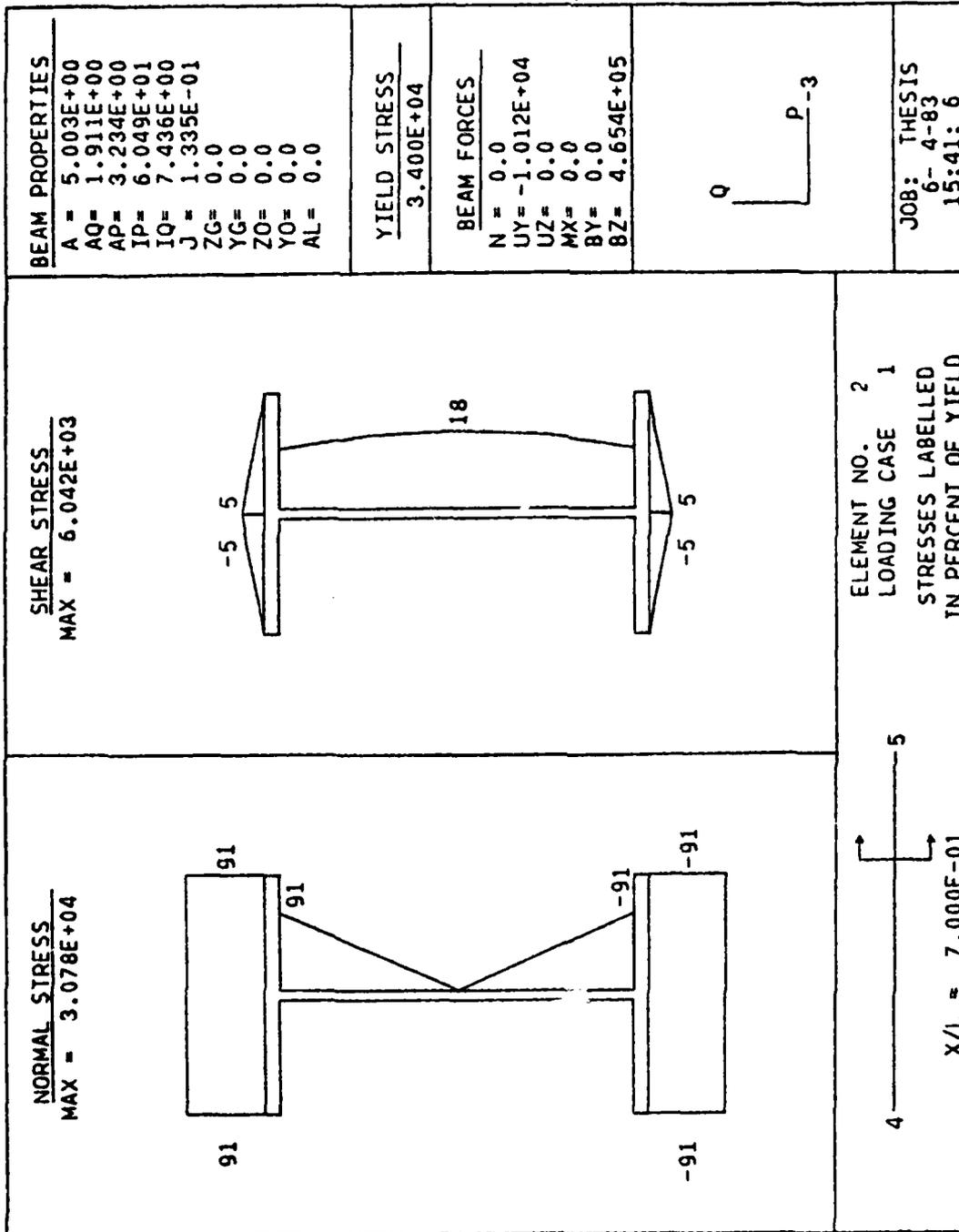
Figure F.6   Shear and normal stress distribution.

41

APPENDIX G
NATURAL FREQUENCY RESULTS

A. CANTILEVER BEAM

1. Comparison to analytic results

GIFTS Results: f1=8.14 Hz   f2=50.1 Hz   f3=138. Hz

Analytic Results: f1=8.10 Hz   f2=50.7 Hz   f3=142. Hz

2. SRC files

```
$ SRC FILE TO CREATE NATURAL FREQUENCY TEST CASE
RECTS/1/10,5/   /LETY/BEAM2/1,1/   /
SKPOINT/1,2,2/0,0,0,0/200,0,0/   /
KPOINT/3/25,0,10/   /SLINE,10/BEAM/1,2,25/3/   /END


$ SRC FILE TO SPECIFY BOUNDARY CONDITIONS
$ FOR NATURAL FREQUENCY TEST CASE
SUPK/1/   /MASS/END
```

B. SHEAR TABLE MODEL

1. Comparison to experimental results

GIFTS Results: f1=28.2 Hz   f2=29.8 Hz   f3=38.3 Hz

Analytic Results: f1=31.8 Hz   f2=31.8 Hz   f4=39.6 Hz

2. SRC files

```
$ SRC FILE TO CREATE SHEAR TABLE MODEL
ETH,1/1/2.25/   /CIRCS/2/0.5/   /
MSTEEL/1/2/   /LETY/BEAM2/2,2/   /
GETY/CB4/1,1/   /
KPOINT/1/0,0,0/2/0,15.5,0/3/0,31,0/4/12,15.5,0
/5/12,15.5,0/6/12,31,0/7/12,0,10/8/12,15.5,10
/9/12,31,10/10/0,0,10/11/0,15.5,10/12/0,31,10/   /
SLINE/L25/2,5,3/L58/5,8,3/L811/8,11,3/L211/2,11,3
/L36/3,6,3/L69/6,9,3/L912/9,12,3/L312/3,12,3/   /
SLINE,10/L12/1,2,9/4,4/L23/2,3,9/4,4/L45/4,5,9/1,1
/L56/5,6,9/1,1/L78/7,8,9/1,1/L89/8,9,9/1,1
/L1011/10,11,9/1,1/L1112/11,12,9/1,1/   /
GRID4/TABLE1/L25,L58,L811,L211/TABLE2
/L36,L69,L912,L312/   /END
```

$ BOUNDARY SPECIFICATIONS FOR SHEAR TABLE MODEL
SUPK,0/1/4/7/10/ /MASS/END

C. GRAPHICS

Figure G.1   Beam model.

Figure G.2   Beam cross section.

45
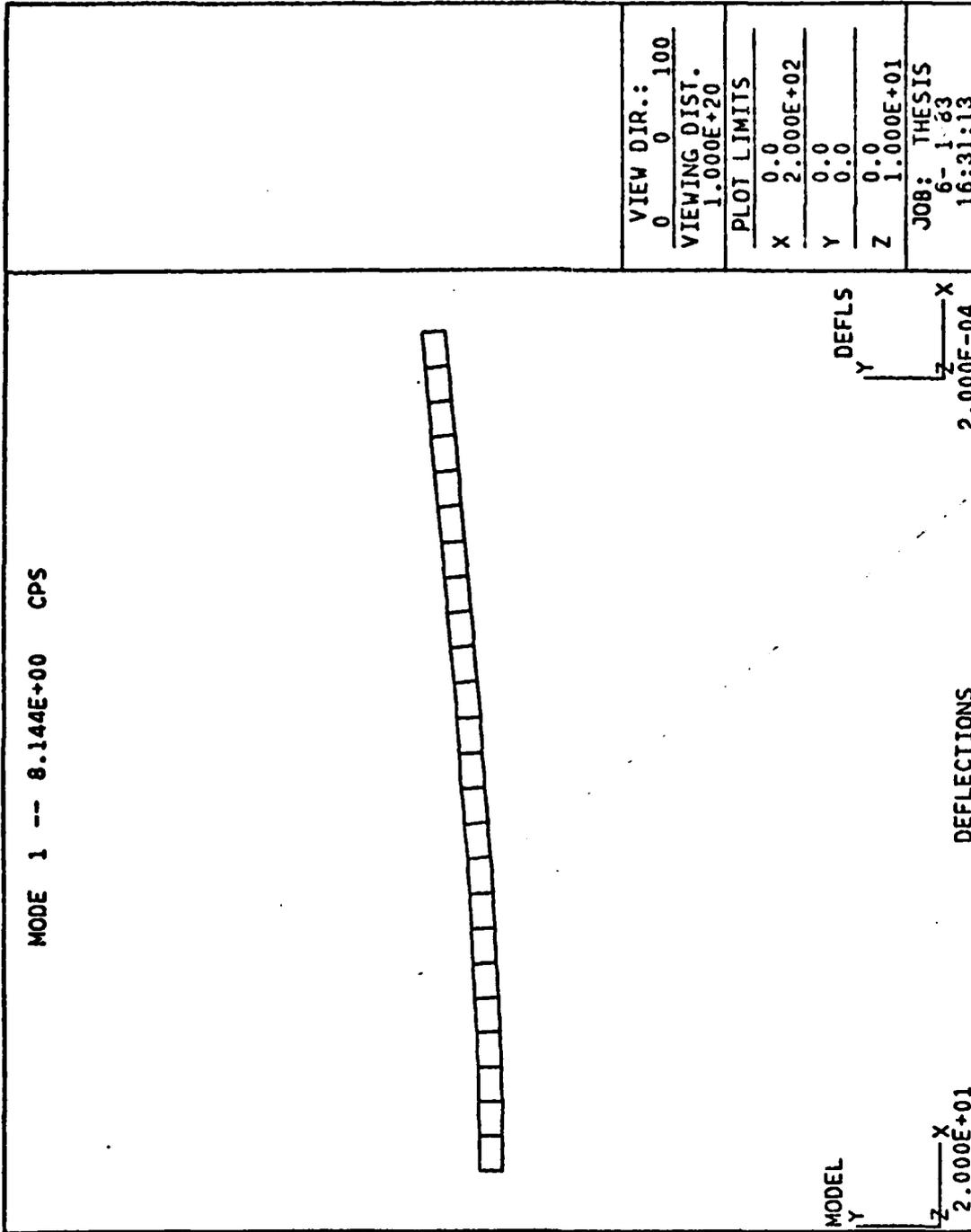
Figure G.3 Beam first mode shape.
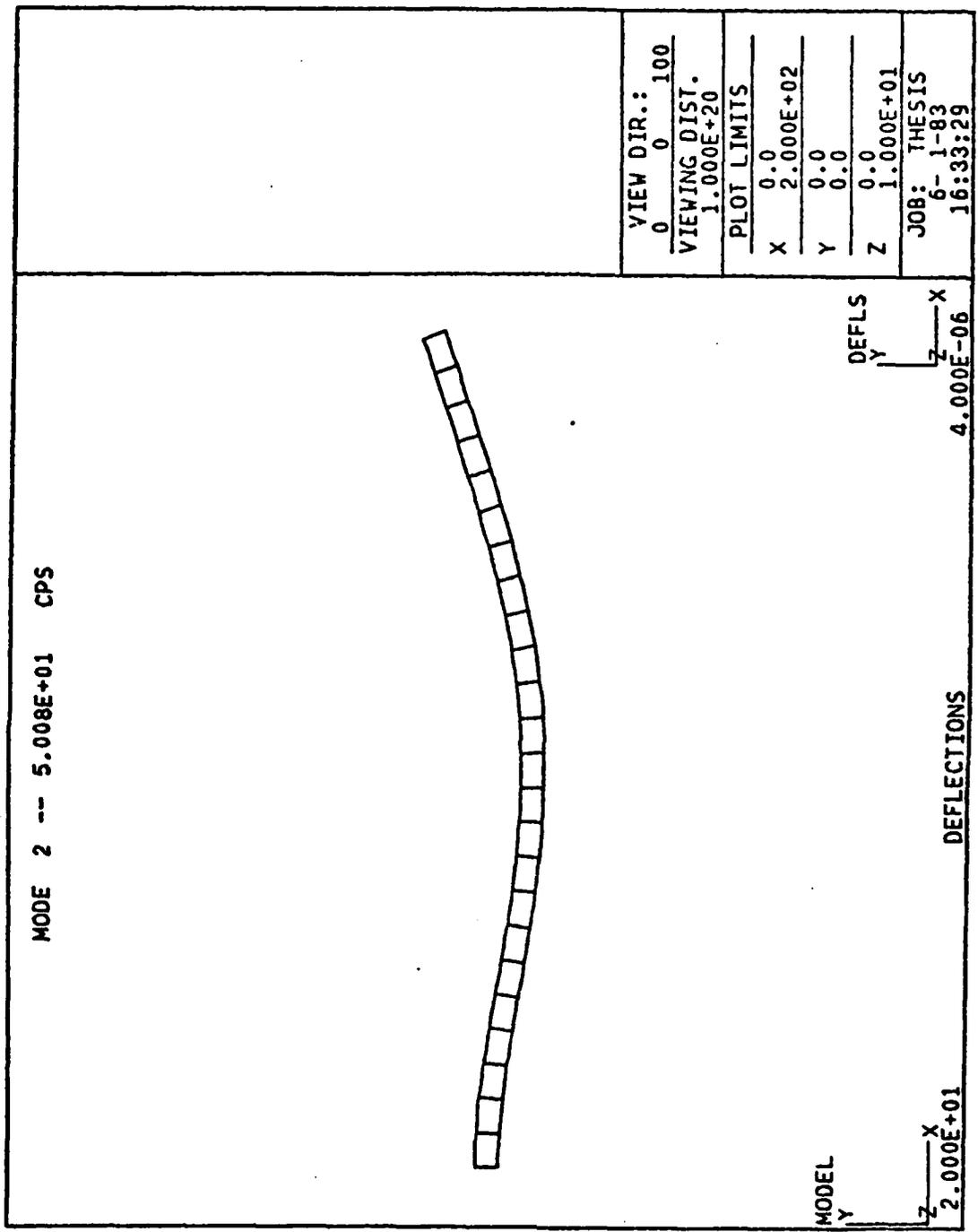
Figure G.4   Beam second mode shape.

47

MODE 3 -- 1.380E+02 CPS

VIEW DIR.:
0   0   100
VIEWING DIST.
1.000E+20

PLOT LIMITS

X	0.0	2.000E+02
Y	0.0	0.0
Z	0.0	1.000E+01

JOB: THESIS
6- 1-83
16:35:15

DEFLS

DEFLECTIONS

6.000E-07

MODEL

2.000E+01
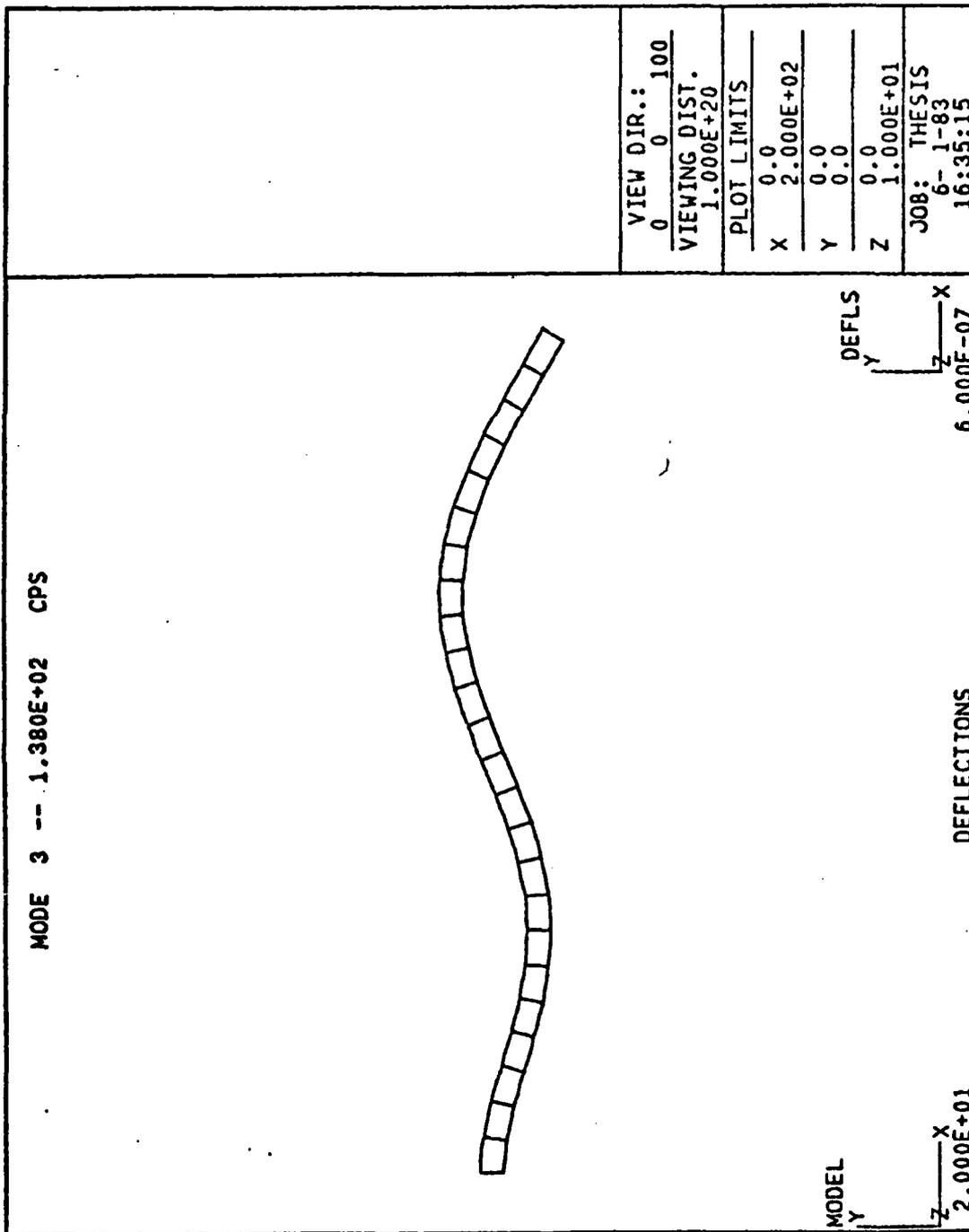
Figure G.5   Beam third mode shape.
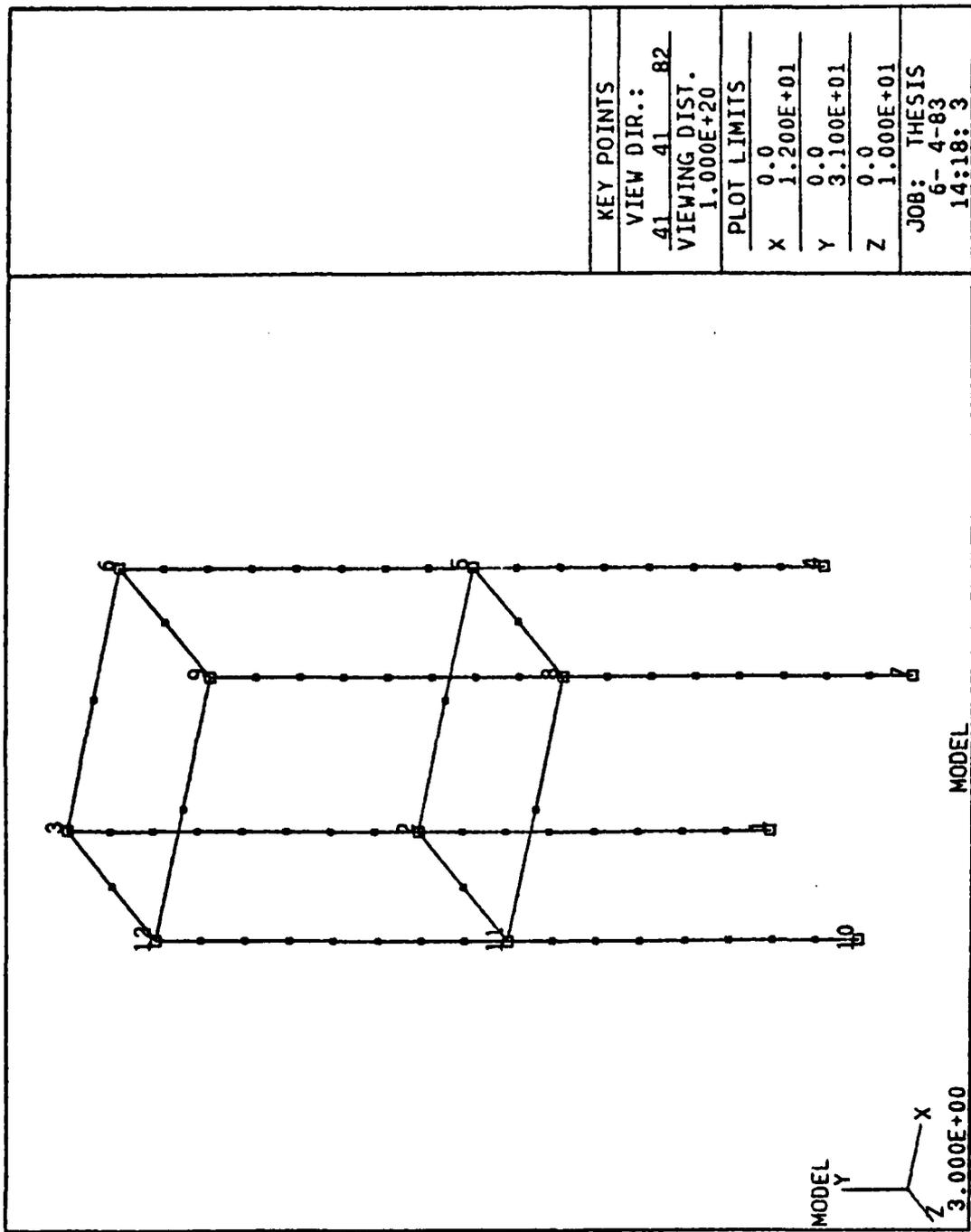
Figure G.6   Shear table model.

MODE 1 -- 2.823E+01 CPS

VIEW DIR.:
41   41   82
VIEWING DIST.
1.000E+20
PLOT LIMITS
X   0.0
     1.200E+01
Y   0.0
     3.100E+01
Z   0.0
     1.000E+01
JOB: THESIS
      6- 4-83
      14:22:12

DEFLS
Y
X
Z
3.000E-06

MODEL
Y
X
Z
3.000E+00

DEFLECTIONS
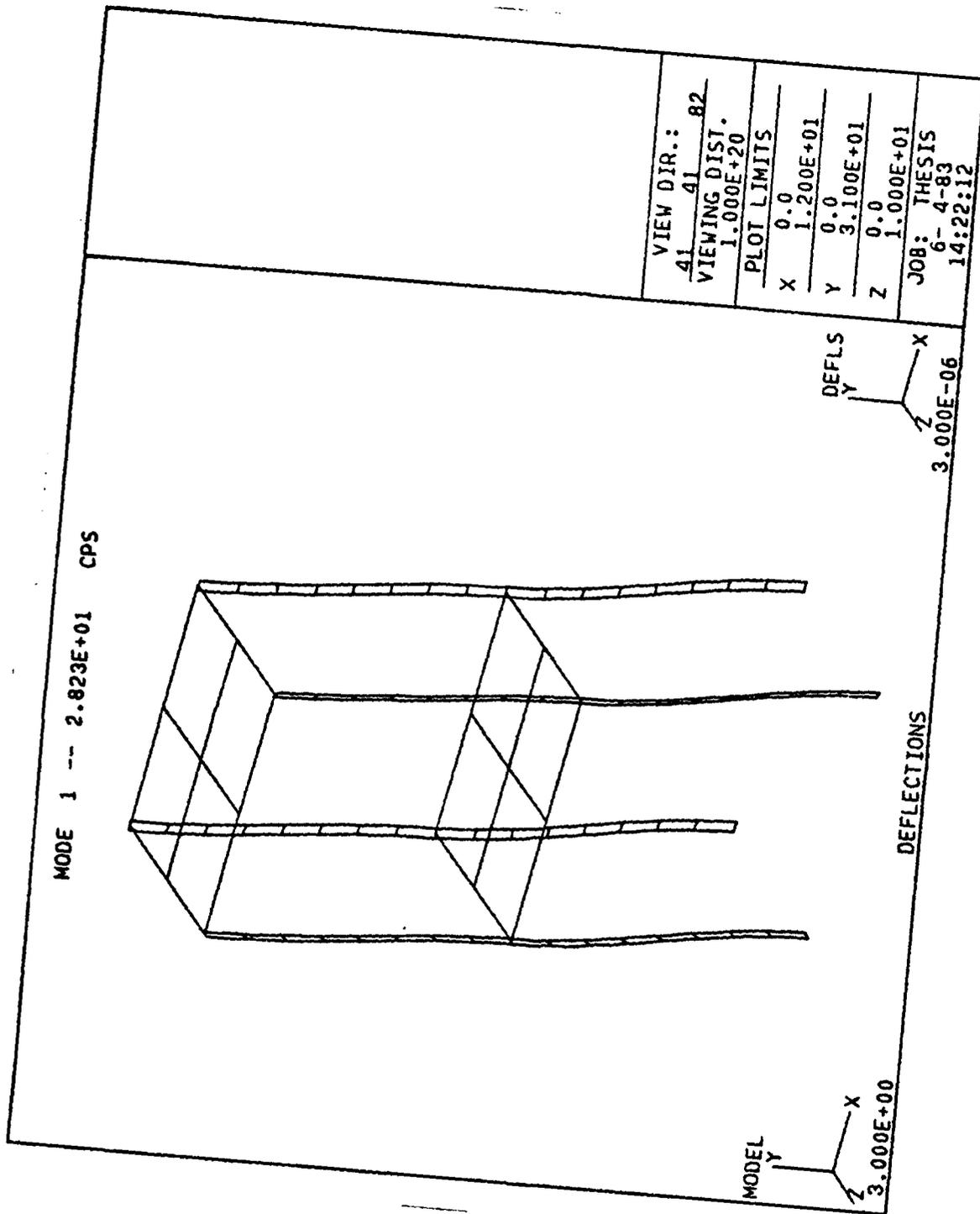
Figure G.7   First mode shape.
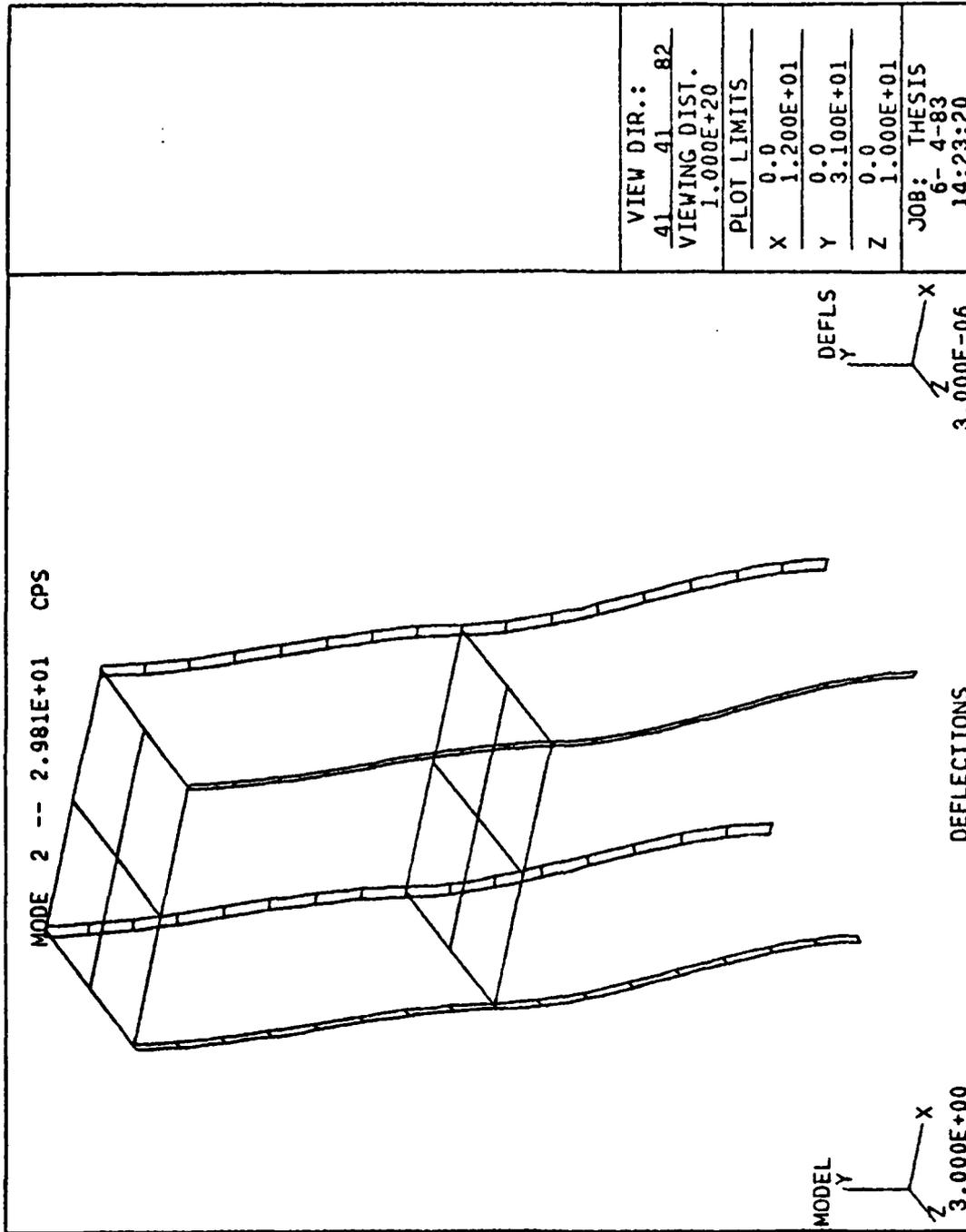
Figure G.8   Second mode shape.
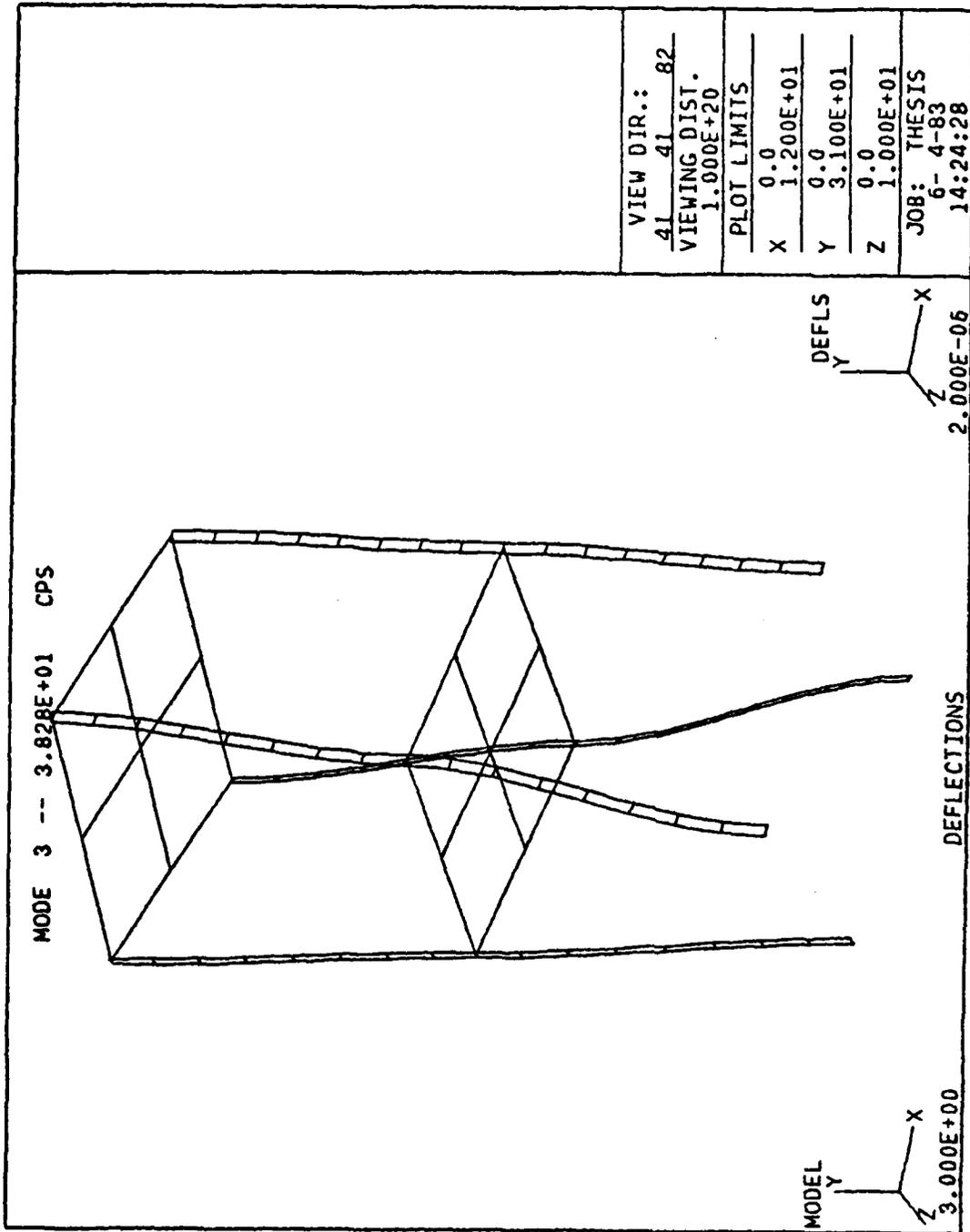
Figure G.9   Third mode shape.

APPENDIX H
EARTHQUAKE RESULTS

A. RUNNING SEQUENCE

```
BULKM, EDITM
BULKF
OPTIM
WAVE
BULKLB, EDITLB
STIFF
TRAN1
DECCM
TRAN2
DECCM
TRANS
STRESS
RESULT
```

B. SRC FILES

The SRC files for the model generation and boundary condition specification are the same as those for the shear table model used in the natural frequency test.

### C. GRAPHICS
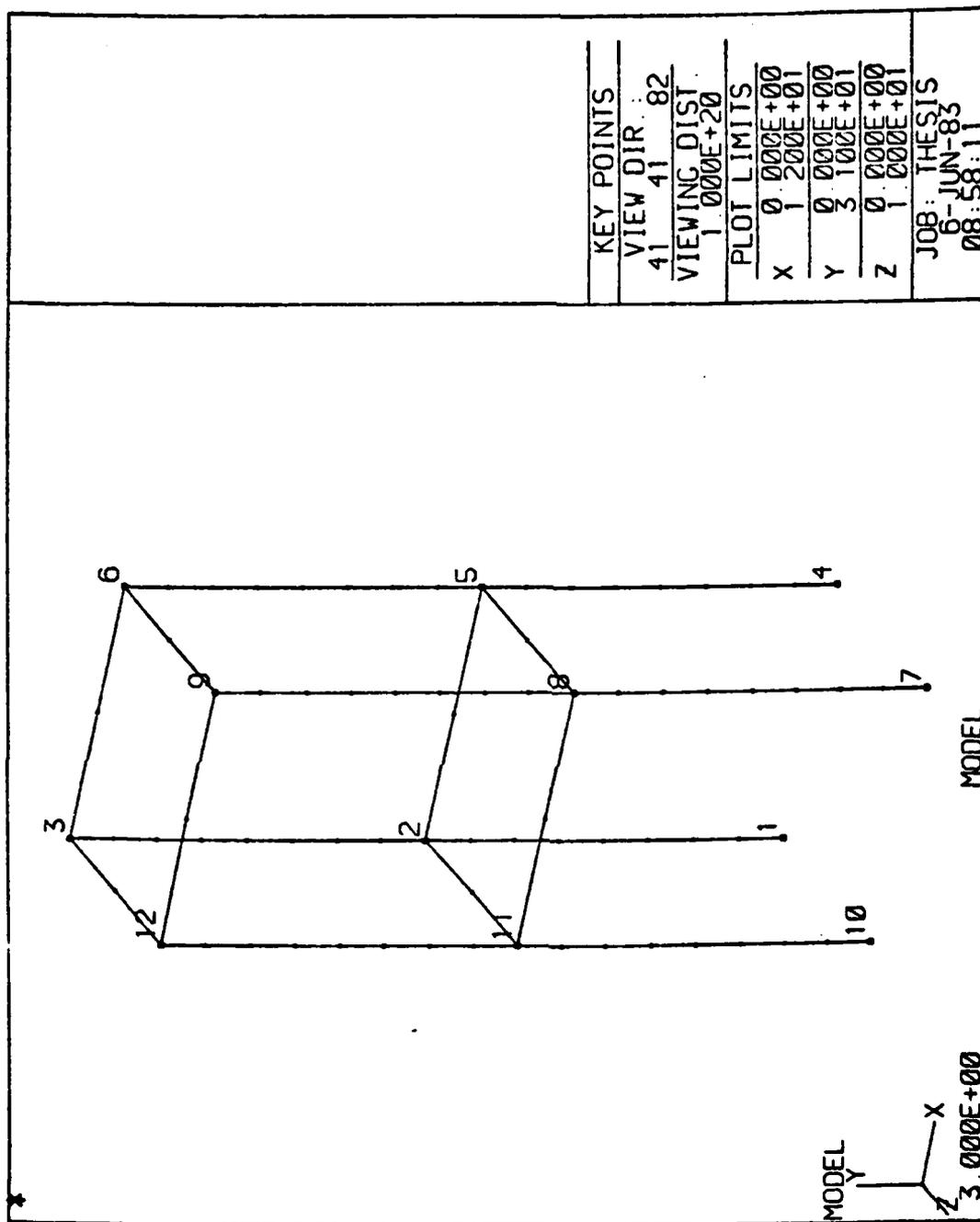
Figure B.1   Earthquake model.

54
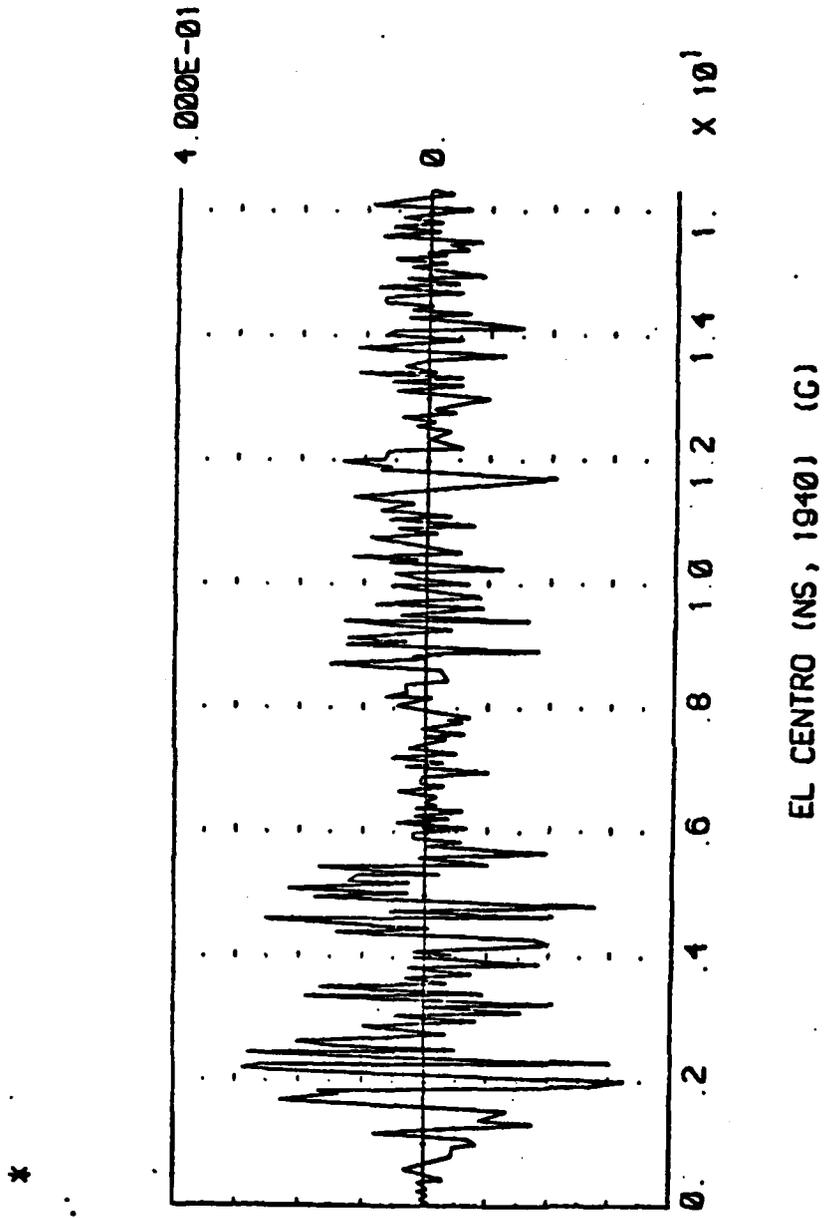
**Figure H.2   Time history of El Centro earthquake.**

55
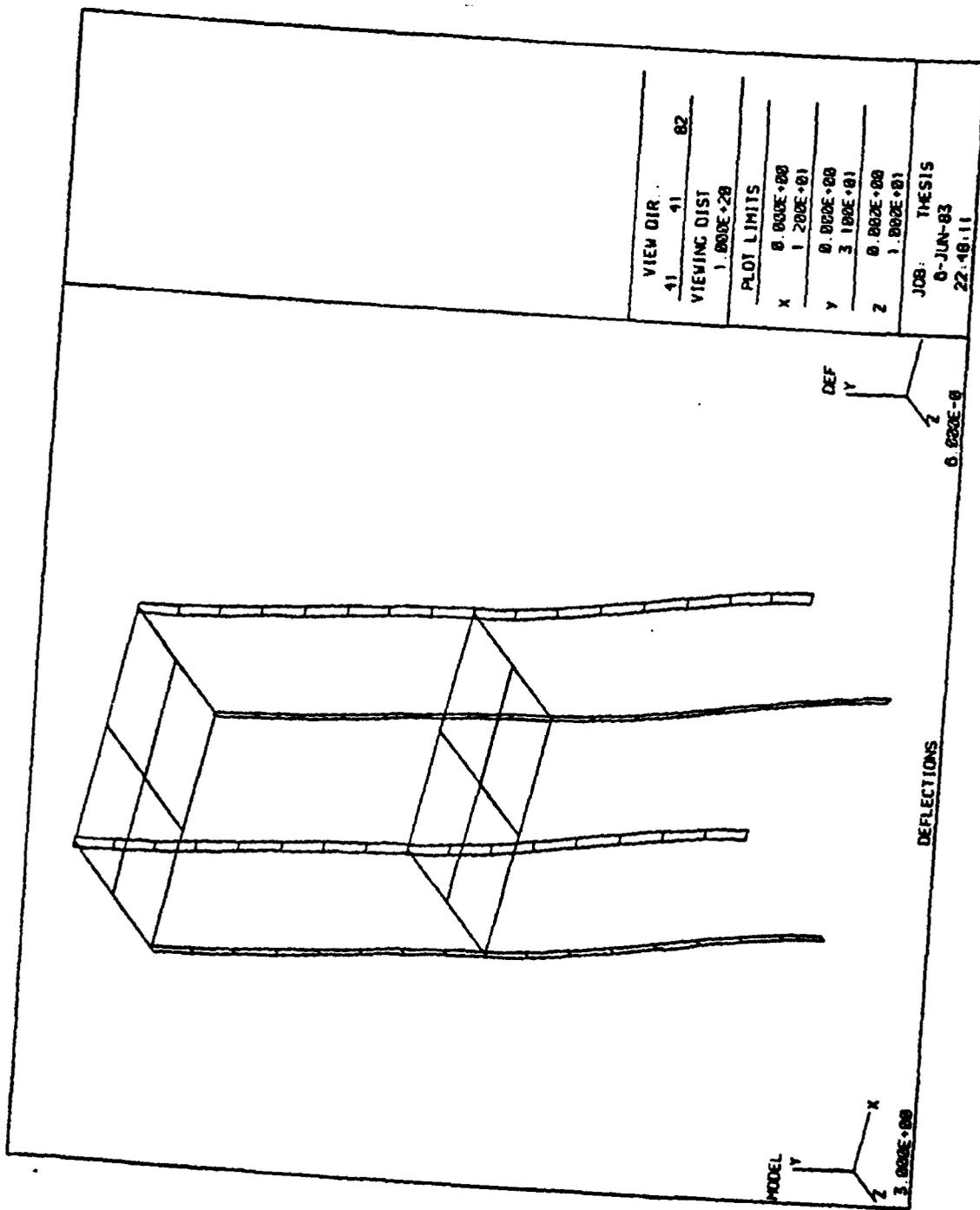
Figure H.3   Model response (Time: 0.05 sec).

56
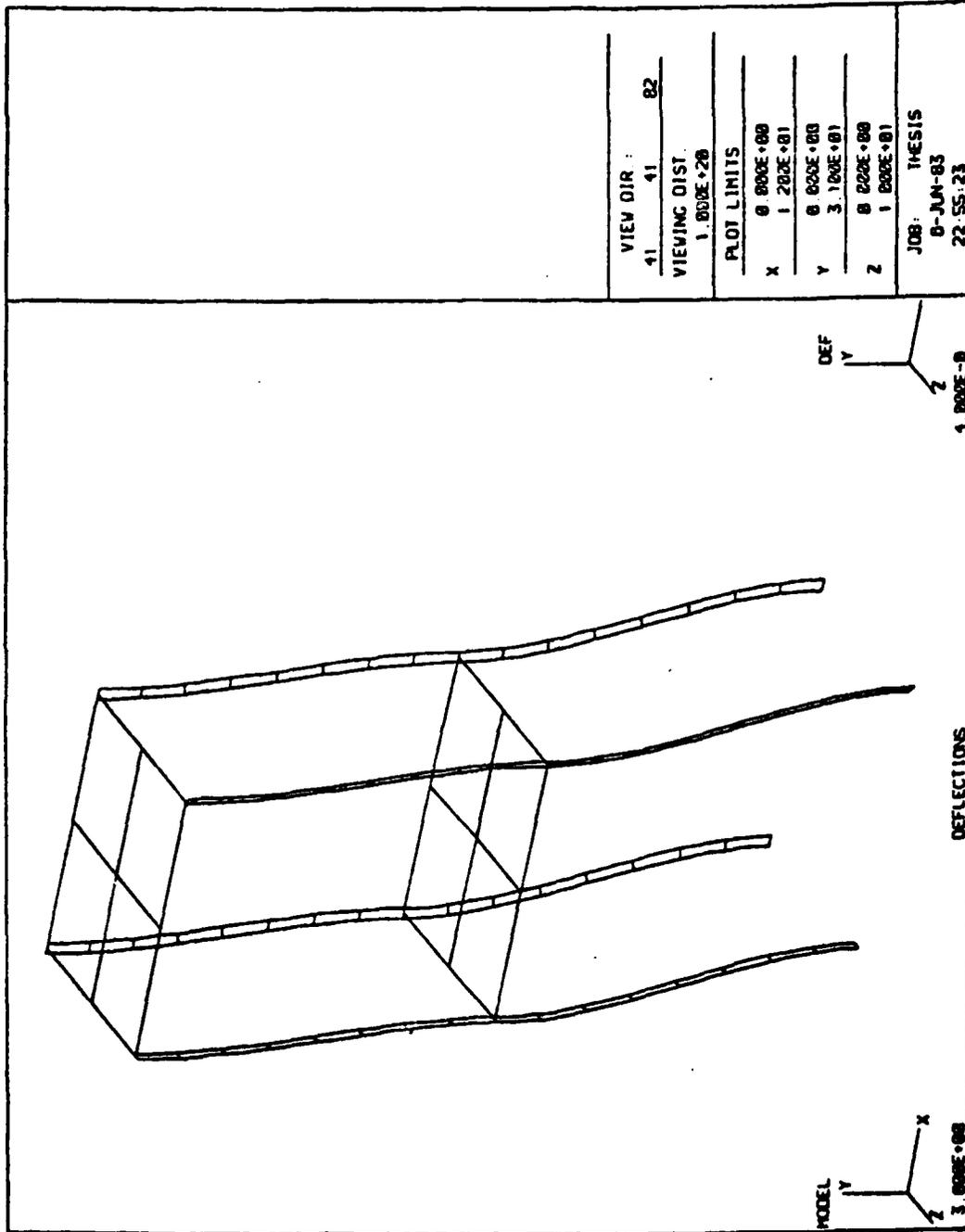
Figure H.4   Model response (Time: 4.05 sec).
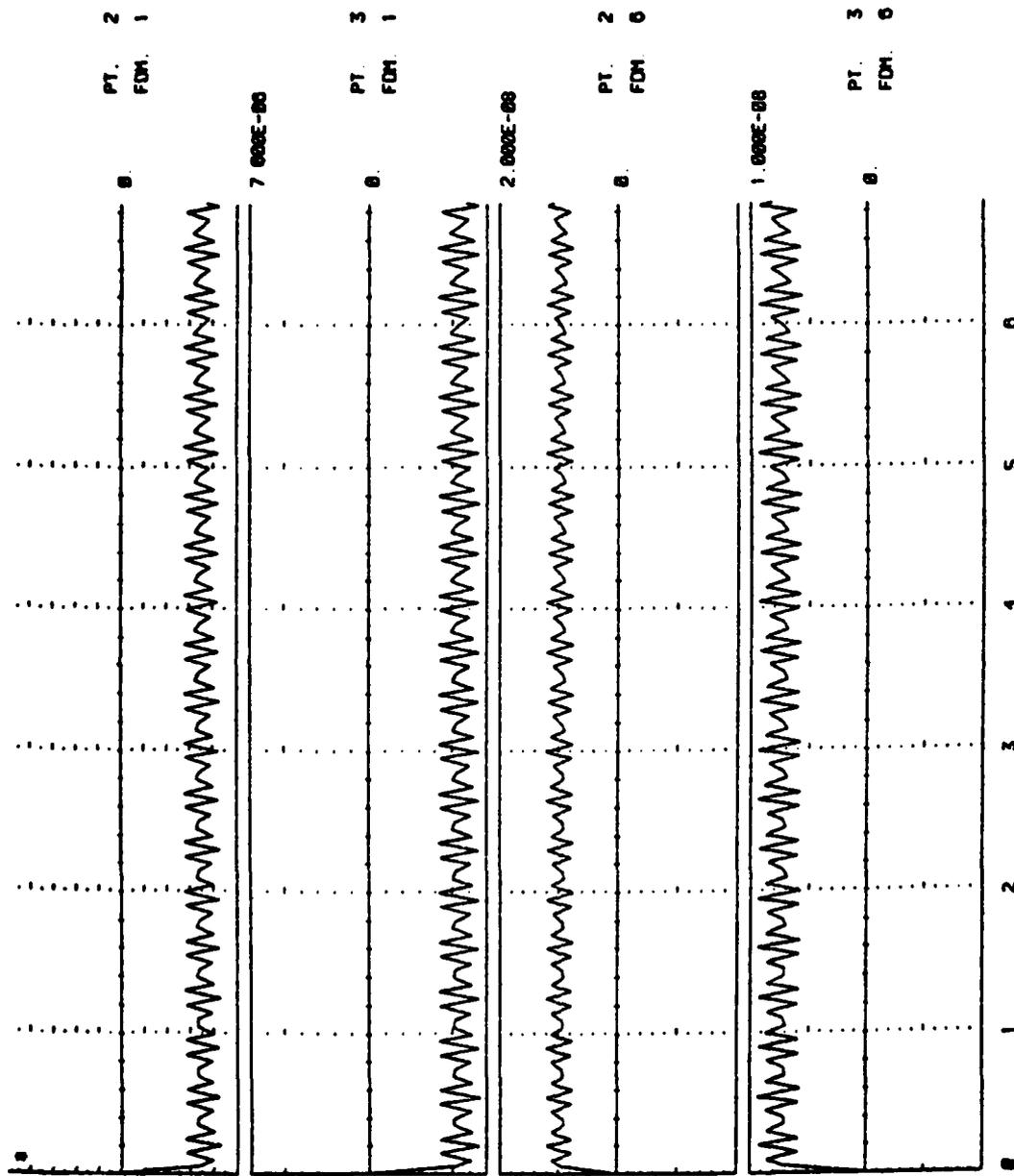
Figure H.5   Selected point/freedom time history.

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LIST OF REFERENCES

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2. Sheldon, J. T., _Implementation of the Graphics-Oriented Interactive Finite Element Time-Sharing System (GIFTS) on the PDP-11_ M.S.M.E. Thesis, Naval Postgraduate School, Monterey, California, 1980.

3. TEKTRONIX Publication 070-2241-00, _PLOT10 Terminal Control System User's Manual_ 1979.

4. International Business Machine Publication SH20-2137-0, _IBM-3277 Graphics Attachment Support Program Reference and Operations Manual_ 1979.

5. University of Arizona, _GIFTS User's Reference Manual_ 1981.

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