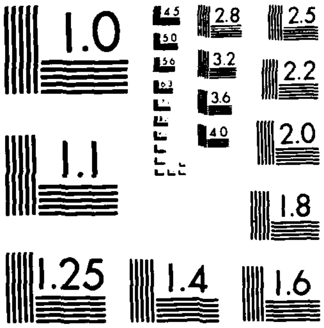
AD-A195 977 COMPUTER-AIDED STRUCTURAL ENGINEERING (CASE) PROJECT 1/1
COMPUTER PROGRAM FOR..(U) ARMY ENGINEER WATERWAYS
EXPERIMENT STATION VICKSBURG MS INFOR.. W P DAWKINS
UNCLASSIFIED APR 88 WES/IR/ITL-88-1 F/G 12/5 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

PROGRAM INFORMATION

Description of Program

CGRID, called X0068 in the Conversationally Oriented Real-Time Program-Generating System (CORPS) Library, is a computer program for the analysis of planar grid structures. The program employs conventional matrix analysis techniques based on the assumptions of linearly elastic structural response to infinitesimally small displacements. Instructions for using the program are provided in the Waterways Experiment Station (WES) Instruction Report ITL-88-1, "User's Guide: Computer Program for Analysis of Planar Grid Structures (CGRID)," dated April 1988.

Coding and Data Format

CGRID is written in FORTRAN 77 and is operational on the following systems:

a. US Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., and Division office Honeywell DPS/8.

b. District office Harris 500.

c. Cybernat Computer Service's CDC CYBER 175.

Data are input to the program from a prepared data file in free field format or from the user's terminal during execution. If data are input from a terminal, the user may enter data by following a prompting sequence. Output from the program may be directed to a file or printed at the user's terminal. If graphics are desired, the terminal must be a Tektronix 4014.

How to Use CGRID

Directions for accessing the program on each of the three systems is provided below. It is assumed that the user can sign on the appropriate system before attempting to use CGRID. In the example initiation of execution commands below, all user responses are underlined, and each should be followed by a carriage return.

Honeywell System

After the user has signed on the system, the system command FORT brings the user to the level to execute the program. Next, the user issues the run command

<u>RUN WESLIB/CORPS/X0068,R</u>

to initiate execution of the program. The program is then run as described in this user's guide. A data file is typically prepared prior to issuing the run command. An example initiation of execution is as follows:

```
HIS TIME-SHARING ON Ø3/Ø4/81 AT 13.3Ø1 CHANNEL 5647
USER ID - RØKACASECON
PASSWORD - WHERE/ARE/YØU?
*FORT
*RUN WESLIB/CORPS/XØØ68,R
```

CYBERNET System

The log-on procedure is followed by a call to the CORPS procedure file

OLD,CORPS/UN=CECELB

to access the CORPS library. The file name of the program is used in the command

BEGIN,,CORPS,XØØ68

to initiate execution of the program. An example is:

```
84/12/Ø5.  16.41.ØØ.  AC2F5DA
EASTERN CYBERNET CENTER SN9Ø4 NOS     1.4/531.669/2ØAD
FAMILY:  KOE
USER NAME:  CEROXX
PASSWORD -
XXXXXXXX
TERMINAL:  23, NAMIAF
RECOVER/CHARGE:  CHARGE,CEROEGC, CEROXX
$CHARGE
12.49.07.  WARNING (Various information messages may appear here.)

11/29 FOR IMPORTANT INFO TYPE EXPLAIN, WARNING.  (Various information messages
                                                  may appear here.)

OLD,CORPS/UN=CECELB
/BEGIN,,CORPS,XØØ68
```

Harris 500 System

The log-on procedure is followed by a call to the program executable file, with the user typing the asterisk and file description

*CORPS,XØØ68

to initiate execution of the program. An example is:

```
"ACOE-ABLESVILLE (H500 V3.1)"
ENTER SIGN-ON
1234ABC, STRUCT
**GOOD MORNING STRUCTURES, IT'S 7 DEC 84 Ø8:33:12
AED HARRIS 500 OPERATING HOURS 0700-1800 M-S
*CORPS,XØØ68
```

<u>How to Use CORPS</u>

The Corps system contains many other useful programs which may be catalogued from CORPS by use of the LIST command. The execute command for CORPS on the Honeywell system is:

```
RUN WESLIB/CORPS/CORPS,R
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

on the Cybernet system, the commands are:

```
OLD,CORPS/UN=CECELB
BEGIN,,CORPS
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

on the Harris system, the commands are:

```
*CORPS
ARE YOU USING A PRINTER TERMINAL OR CRT?
ENTER P OR C
P
CORPS SYSTEM COMMANDS:
BRIEF - LIST EXPLANATION OF A PROGRAM.
EXECUTE - RUN A CORPS PROGRAM.
LIST - LIST THE AVAILABLE CORPS PROGRAMS.
STOP - EXIT FROM CORPS SYSTEM MACRO.
HELP - HELP AND EXPLANATION OF CORPS
       SYSTEM AND THE RUNNING OF ITS MACRO.

NOTE:  COMMANDS MAY BE ABBREVIATED TO THE
       FIRST LETTER OF THE COMMAND.

ENTER COMMAND (BRIEF,EXECUTE,LIST,HELP,STOP):
LIST
```

This capability is not yet implemented on the Apollo.

ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM			PROGRAM NO.
Analysis of Planar Grid Structures (CGRID)			
PREPARING AGENCY US Army Engineer Waterways Experiment Station, Information Technology Laboratory, PO Box 631, Vicksburg, MS 39180-0631			
AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM	
		PHASE	STAGE
William P. Dawkins	July 1987	Final	OP

A. PURPOSE OF PROGRAM

This program may be used for the analysis of planar grid structures possessing no more than 100 joints and 180 members. The user can specify joint and member loads, joint displacements, spring supports, load combinations, and member end force releases.

B. PROGRAM SPECIFICATIONS

Time-sharing FORTRAN 77 Program

C. METHODS

This program uses conventional matrix analysis techniques based on the assumptions of linearly elastic structural response to infinitesimally small displacements.

D. EQUIPMENT DETAILS

This program is operational on the Honeywell DPS/8, CDC Cyber, and Harris 500 computers in time-sharing mode. Any ASCII time-sharing terminal may be used, but if graphics are desired a Tektronix 4014 terminal must be used.

E. INPUT-OUTPUT

Data may be input from a prepared data file or from the user's terminal during execution. When data are entered from the user's terminal, prompts are provided to indicate the amount and type of data to be entered. Output consists of joint displacements, reactions, and member forces which may be directed to the user's terminal or to a file. Graphical output consists of a plot of the input geometry and plots of the variation of torsion, bending moment, and shear for the structural or a particular member for any selected load case.

F. ADDITIONAL REMARKS

This program is available as part of the CORPS Library System. Documentation is available from the Engineering Computer Program Library (ECPL), US Army Engineer Waterways Experiment Station; telephone: (601) 634-2581. This program is designated X0068 in the CORPS Library.

Unclassified

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6c. ADDRESS (City, State, and ZIP Code) PO Box 631 Vicksburg, MS 39180-0631	7b. ADDRESS (City, State, and ZIP Code)
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User's Guide: Computer Program for Analysis of Planar Grid Structures (CGRID)

12. PERSONAL AUTHOR(S)

Dawkins, William P.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final report	FROM ______ TO ______	April 1988	63

16. SUPPLEMENTARY NOTATION

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17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Computer programs; Planar grid structures; Matrix analysis; Structural analysis

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The computer program CGRID, described in this user's guide, performs an analysis of planar grid structures using conventional matrix analysis techniques based on the assumptions of linearly elastic structural response to infinitesimally small displacements.

The program is limited to structures with no more than 100 joints and 180 members. All members are assumed to be prismatic possessing straight centroidal axes and composed of a linearly elastic, homogeneous material.

Output consists of joint displacements, reactions, and member forces. The output may be printed at the user's terminal or directed to a file. Graphical output of the results is also available. Keywords: Structural Engineering. (S

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DEPARTMENT OF THE ARMY, Engineering and Construction Directorate of the Headquarters, US Army Corps of Engineers Computer-Aided Structural Engineering (CASE) Project.

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PREFACE

This user's guide describes an interactive computer program, CGRID, that analyzes planar grid structures. The work in developing the program and writing the user's guide was accomplished with funds provided to the US Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., by the Engineering and Construction Directorate of the Headquarters, US Army Corps of Engineers (HQUSACE), under the Computer-Aided Structural Engineering (CASE) Project.

Specifications for the program were prepared by the members of the Building Systems Task Group of the CASE Project. Members of the task group during the development of the program were as follows (not all members served for the entire period):

Dan Reynolds, Chairman, Sacramento District
Anjana Chudgar, Louisville District
Joe Hartman, Southwestern Division
George Henson, Tulsa District
David Illias, Portland District
Sefton Lucas, Memphis District
David Raisanen, North Pacific Division
Pete Rossbach, Baltimore District
Dan Sommer, Omaha District
Chris Merrill, WES
Michael Pace, WES
Paul Senter, WES

The computer program and user's guide were written by Dr. William P. Dawkins, P.E., a professor at Oklahoma State University, Stillwater, Okla., while working under the Intergovernmental Personnel Act of 1970 at WES.

The project was under the general supervision of Mr. Paul K. Senter, Acting Assistant Chief, Information Technology Laboratory (ITL), WES, and Dr. N. Radhakrishnan, Chief, ITL, and CASE Project Manager. The HQUSACE Technical Monitor was Mr. Don Dressler and later Mr. M. K. Lee. Mr. Michael Pace, Engineering Applications Office, Information Research Division, ITL, WES, aided in the preparation of this report for publication. This report was prepared for publication by Contract Editor Phyllis Davis, Information Products Division, ITL, WES.

COL Dwayne G. Lee, CE, was the Commander and Director of WES at the time of publication. Dr. Robert W. Whalin was Technical Director.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degree (angle)	0.01745329	radians
feet	0.3048	metres
inches	2.54	centimetres
kips (force)	4.448222	kilonewtons
kips (force)-feet	1355.818	newtons-metres
pounds (force)	4.448222	newtons
pounds (force) per cubic foot	0.157087	kilonewtons per cubic metre
pounds (force) per cubic inch	0.2714	megapascals per metre
pounds (force) per foot*	14.5939	newtons per metre
pounds (force) per inch	175.1268	newtons per metre
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6.894757	kilopascals
square inches	6.4516	square centimetres

* The same conversion factor applies for pounds (force) per linear foot (PLF).

USER'S GUIDE: COMPUTER PROGRAM FOR ANALYSIS OF PLANAR GRID STRUCTURES (CGRID)

PART I: INTRODUCTION

General

1. This user's guide describes the computer program CGRID for analysis of planar grid structures. The program employs conventional matrix analysis techniques based on the assumptions of linearly elastic structural response to infinitesimally small displacements. This program only provides information regarding the response of the structure and does not perform any design functions or attempt to judge the quality of the structural performance.

Disclaimer

2. The program was developed using criteria furnished by the CASE task group on Building Systems. Furthermore, this program has been checked within reasonable limits to ensure that the results are accurate for the assumptions and limitations of the procedures employed. In all cases, it is the responsibility of the user to judge the validity of the results. The author assumes no responsibility for designs or the performance of any structure based on the results of the program.

PART II: GEOMETRY

Coordinate Systems

3. A global coordinate system is used to establish the geometry of the structure and positive directions for displacements and certain external loads on the system. A right-handed Cartesian set is used for the global coordinate system with the X-Y plane horizontal with the positive Z-axis vertically upward.

4. A right-handed Cartesian local (or member) coordinate system is used for each member in the system. The positive local X-axis extends from the "from" end of the member toward the "to" end of the member according to the member joint connectivity data provided as input to the program. The local Z-axis is parallel to the global Z-axis (positive upward), and the local Y-axis is assigned to provide the right-handed Cartesian set.

Structure

5. All joints in the structure are assumed to lie entirely in the global X-Y plane. Members connecting the joints are assumed to have straight centroidal axes lying in the global X-Y plane. Each member is assumed to be prismatic and composed of a linearly elastic, homogeneous material.

Sign Conventions of System Parameters

6. The following sign conventions are employed by the program:

   a. Joint displacements consist of rotations about the global X- and Y-axes and a translation parallel to the global Z-axis. A rotation is positive if its vector representation by the "right-hand screw rule" is in the positive global X- or Y-direction. A positive translation is upward.

   b. Joint loads consist of applied couples about the global X- or Y-axes and a translational force parallel to the global Z-axis. A joint load is positive if its vector representation is in the positive global coordinate direction.

   c. Specified joint displacements represent the effects of an external mechanism which enforces a particular value (either zero or nonzero) of one or more of the joint displacement components. A specified displacement is positive if its vector representation is in the positive global coordinate direction.

d. A joint spring support consists of an external mechanism which develops a reaction proportional to one of the three joint displacements. Three spring supports may be attached to each joint: two rotational springs resisting rotations about the global X- and Y-axes, respectively; and a translational spring resisting the global Z-displacement.

e. Members loads, either concentrated or distributed, are positive if their vector representations are in the positive local coordinate directions for that member. (Note: All Z-loads, either joint loads or member loads, are positive upward.)

f. Six end forces are associated with each member: two moments about the local X- and Y-axes and a force parallel to the local Z-direction at each end. Member end forces are positive if their vector representations are in the positive local coordinate directions.

g. Member internal forces consist of a torsion, a bending moment, and a shear force at every cross section. A positive torsion tends to rotate the end of a segment nearer the "from" end of the member in a positive sense about the local X-axis. A positive bending moment produces compression on the top (plus Z-face) of the member. A positive shear force tends to move the end of a segment nearer the "from" end of the member upward.

Joint Coordinates

7. Each joint in the structure is assigned an integer identifier (joint number) and an attendant set of global X- and Y-coordinates. Joint numbers may be generated automatically by the program for regular (essentially rectangular) systems or may be supplied explicitly by the user.

8. A rectangular (essentially) mesh must conform to the following:

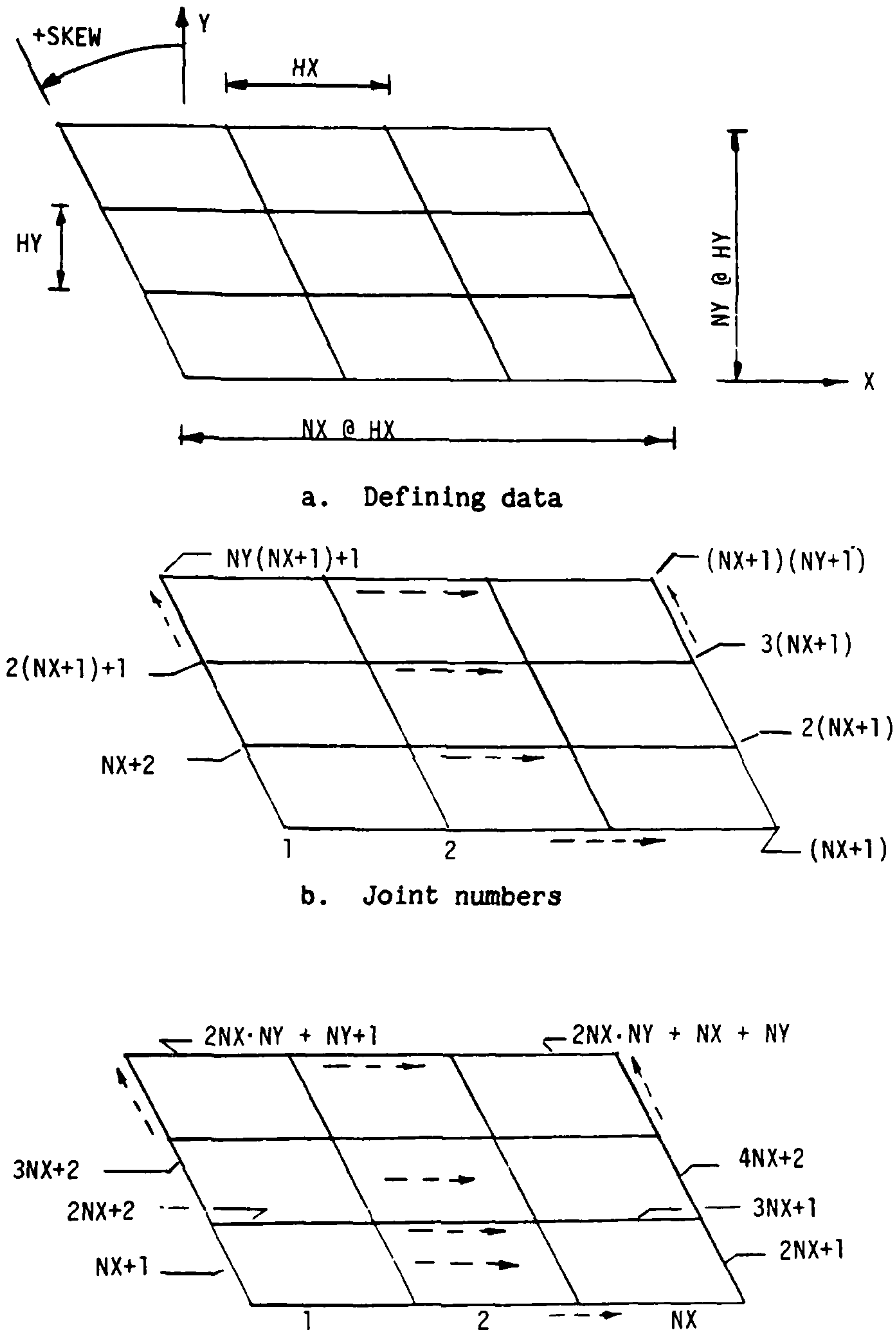
a. Two or more lines of nodes at equal spacing lie on equally spaced lines parallel to the global X-axis ("X-lines") with the same number of nodes on each "X-line."

b. Two or more lines of nodes at equal spacing lie on equally spaced lines essentially parallel to the global Y-axis ("Y-lines") with the same number of nodes on each "Y-line."

A rectangular (essentially) mesh with the joint and member numbers generated by the program is shown in Figure 1.

9. An irregular mesh must be described explicitly by the user. Joint numbers and coordinates may be specified individually for each joint. A line of joints may be generated automatically under the following conditions:

a. The joints lie at equal spacing along a straight line.



a. Defining data

b. Joint numbers

c. Member numbers

Figure 1. Automatic generation for "rectangular" mesh

b. The joint numbers increase sequentially by the same joint number increment along the line.

A line of joints which may be generated automatically is illustrated in Figure 2.

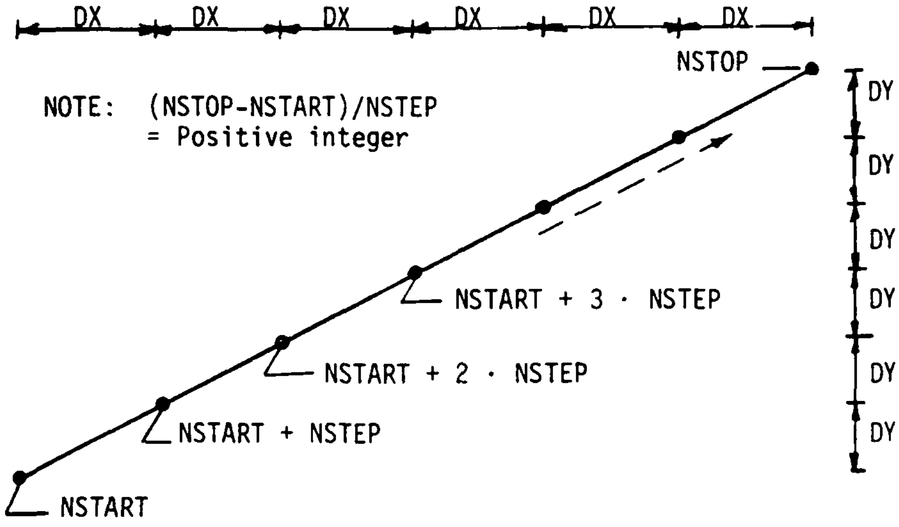


Figure 2. Generation of line of nodes

Member Connectivity

10. The connectivity of each member in the system is designated by "member m goes from joint I to joint J." The "from" joint - "to" joint dictates the positive direction of the local X-coordinate. When a rectangular mesh is automatically generated by the program, member connectivities are assigned such that the lower numbered of the two member end joints is the "from" end (i.e., the local and global X-axes have the same positive sense for all members parallel to the global X-axis; the local X-axis has a positive sense essentially in the positive global Y-direction for members essentially parallel to the global Y-axis).

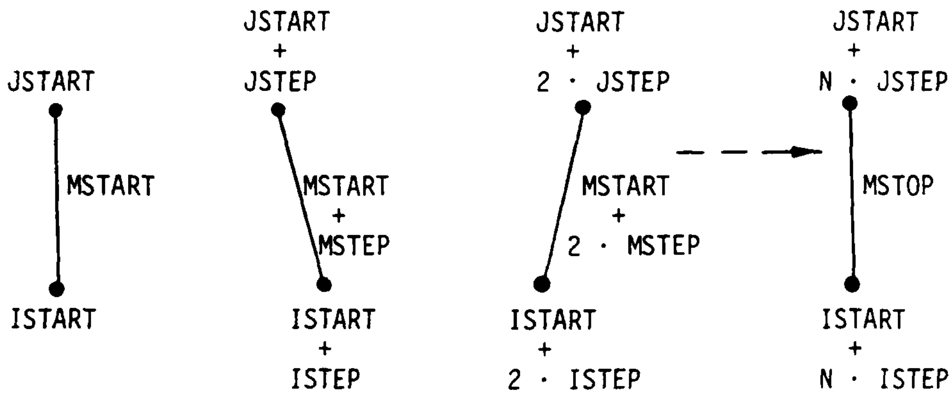
11. For irregular meshes the user may specify the connectivity explicitly for each member. However, connectivities may be automatically generated for a sequence of members under the following conditions:

a. Member numbers in the sequence increase sequentially by the same member number increment.

b. "From" joint numbers increase sequentially by the same increment.

c. "To" joint numbers increase sequentially by the same increment.

A sequence of members which may be generated automatically is shown in Figure 3.



NOTE: N = (MSTOP-MSTART)/MSTEP = Positive Integer

Figure 3. Generation of sequence of members

Effect of Member Connectivity on Solution

12. The efficiency of the solution is governed by the maximum difference between the "from" joint number and "to" joint number for all members in the structure. For the most efficient solution, this difference must be made as small as possible (e.g., in an automatically generated rectangular mesh, lines containing the fewest number of nodes should be oriented parallel to the global X-axis).

PART III: COMPUTER PROGRAM

General

13. The computer program CGRID is written in the FORTRAN 77 language for execution on computer systems employing word lengths equivalent to 15 decimal digits. Double precision computations may be required for machines with shorter word lengths.

14. The program is written for operation in a time-sharing environment. Although program prompts must be answered interactively from the user terminal, the user should take advantage of the permanent file capabilities provided for input and output of data. Because the output from the program may be extensive, it will usually be more efficient for the user to direct the output to a permanent file for retrieval on a high-speed printer after execution of the program is terminated.

Input Data

15. Input data (see Appendix A) may be supplied from a predefined data file or from the user terminal. When data are supplied during execution, prompts are provided to indicate the type and amount of data to be entered.

16. Input data are divided into the following sections:

a. Heading (required).

b. Geometry Data (required).

c. Cross-Section Data (required).

d. Material Properties (required).

e. Member End Force Releases (optional).

f. Specified Joint Displacements (optional if spring supports provided).

g. Spring Supports (optional if specified displacements provided).

h. Independent Load Case(s) (required).

i. Load Combinations (optional).

j. Termination (required).

17. During the input phase, data values are checked for completeness and consistency. If an error is detected during input from a file, the user is notified and execution of that problem is terminated. If an error is

detected during entry from the terminal, the user is offered an opportunity to reenter the data which produced the error.

Data File Creation

18. After data entry from the terminal, the user is offered the opportunity to save the existing input data in a permanent file in input file format.

Output Data

19. Output data may be directed to a permanent file, to the user terminal, or to both simultaneously. The following input data and generated data may be displayed before an attempt is made to solve for system response:

- a. Echoprint of Input Data (optional). A listing in tabular form, including headings, of all input data.
- b. Generated Joint Data (optional). A tabulation of joint numbers, joint coordinates, and joint support conditions (spring or specified displacements).
- c. Generated Member Data (optional). A tabulation of member numbers, end joint numbers, cross-section moments of inertia, shear area, elastic moduli, and member end force releases (if present).
- d. Generated Independent Load Case Data (optional). A tabulation of joint and member loads for each independent load case.

20. The following results data are available:

- a. Independent Load Case Results. The entire results for any or all independent load cases may be suppressed or may be displayed in the following subsections:
  - (1) Joint Displacements (optional). A tabulation of the three joint displacement components for each joint.
  - (2) Reactions (optional). The reaction induced at each joint subjected to either a specified displacement or a spring support.
  - (3) Member Forces (optional). A tabulation of the forces at each end of each member with a tabulation of the maximum positive and negative internal forces and their locations in each member.
- b. Load Case Combination Results. The three results subsections described above are displayed for each load combination.

c. Member Results Grouped by Members. The member forces and maxima for each load case and each load combination for each member are tabulated.

Graphics Output

21. The following graphics may be displayed during execution:

a. Input Geometry. A plot of the structure including joint numbers, member numbers, and the locations of specified displacements and spring supports.

b. Structure Results. Plots of the variation of internal torsion, bending moment, and/or shear force throughout the structure for any selected load case or combination.

c. Member Plots. A plot of the variation of torsion, bending moment, and shear throughout the member for any selected member and load case.

Program Verification

22. The results produced by the program for a variety of problems have been compared with hand computations and with results obtained using the general purpose frame analysis program GTSTRUDL.

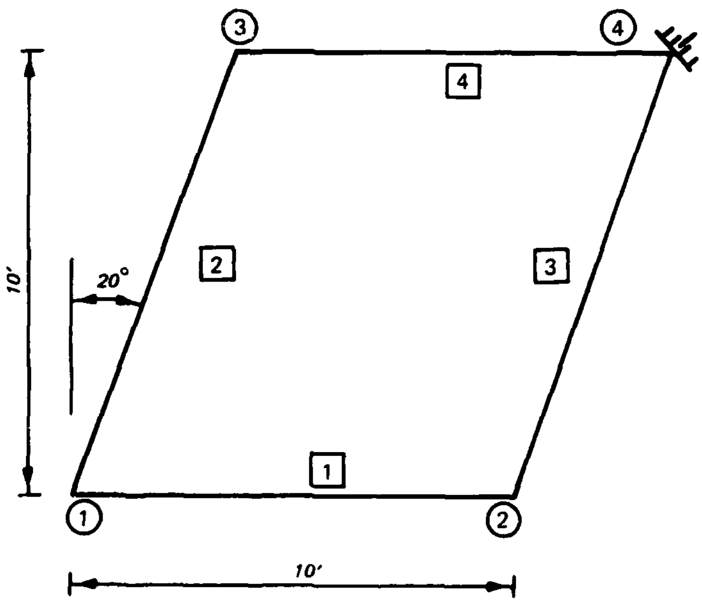
PART IV: EXAMPLE SOLUTIONS

General

23. The examples presented below are intended only to illustrate the operation of the program and are not intended to be a guide for its application.

Example 1

24. A simple skewed "rectangular" grid and attendant characte·istics are shown in Figure 4.* The structure was subjected to the three independent load cases indicated and to one combination. Data were entered from the user terminal during execution as illustrated in Figure 5. The permament input file created by CGRID is also given in Figure 5.



MATERIALS: E=30x10^6 psi, G=12x10^6 psi
SECTIONS: J=864 in.^4, I=576 in.^4, A_S=0
LOADS: DEAD LOAD - 300 lb/ft DOWN ON ALL MEMBERS
COLUMN LOADS - 5 kips DOWN AT 2.5 ft FROM JOINT 1 ON MEMBERS 1 AND 2
JOINT LOAD - 10 kips UP AT JOINT 1

Figure 4. System for Example 1

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

```
     PROGRAM CGRID - ANALYSIS OF PLANE GRID STRUCTURES
     DATE: 09/16/86                      TIME: 10:37:35

     ARE INPUT DATA TO BE READ FROM TERMINAL OR A FILE?
     ENTER 'TERMINAL' OR 'FILE'.
? T

     ENTER NUMBER OF HEADING LINES.
? 1
     ENTER  1 HEADING LINES.
? EXAMPLE 1 - FOUR MEMBER SKEWED RECTANGULAR GRID
     ARE GEOMETRY DATA TO BE GENERATED FOR A RECTANGULAR MESH
     OR PROVIDED LINE-BY-LINE?
     ENTER 'RECTANGULAR' OR 'LINE'.
? R
     ENTER LENGTH UNITS ('INCHES', 'FEET', 'CENTIMETERS', OR 'METERS').
? F
     ENTER DATA FOR RECTANGULAR MESH.
         <---X-DIRECTION--->          <-----Y-DIRECTION----->
         NO. OF      MEMBER           NO. OF       MEMBER          SKEW
         MEMBERS     LENGTH           MEMBERS   Y-PROJECTION       ANGLE
                      (FT)                          (FT)           (DEG)
? 1 10 1 10 -20
     CROSS SECTION DATA
     ENTER LENGTH UNITS ('INCHES', 'FEET', 'CENTIMETERS', OR 'METERS').
? I

     ENTER CROSS SECTION DATA  -- UNITS ARE IN.
     ENTER 'END' WHEN FINISHED WITH CROSS SECTION DATA.

     DATA TYPE               TORSION    BENDING    SHEAR
      ('PROP')               INERTIA    INERTIA     AREA
        OR        START        OR         OR         OR        STOP     MEM. NO.
      ('DIM')   MEM. NO.     WIDTH      HEIGHT     FACT.    MEM. NO.     INCR.
? P 1 864 576 0 4
? E
     MATERIAL PROPERTIES DATA
     ENTER LENGTH UNITS ('INCHES', 'FEET', 'CENTIMETERS', OR 'METERS').
? I
     ENTER FORCE UNITS ('POUNDS', 'KIPS', 'NEWTONS', OR 'KILONEWTONS'='KN').
? P

     ENTER MATERIAL PROPERTIES DATA.
     ENTER 'END' WHEN FINISHED WITH MATERIAL PROPERTIES.

           START      MODULUS OF      SHEAR        STOP        MEM. NO.
         MEM. NO.     ELASTICITY     MODULUS     MEM. NO.     INCREMENT
                      ( P/IN**2)    ( P/IN**2)
? 1 3.E7 1.2E7 4
? E

     ARE MEMBER END FORCE RELEASES TO BE ENTERED?
     ENTER 'YES' OR 'NO'.
? N
```

Figure 5. Input data for Example 1 entered from user terminal during execution (Sheet 1 of 4)

```
          ARE SPECIFIED JOINT DISPLACEMENTS TO BE ENTERED?
          ENTER 'YES' OR 'NO'.
     ? Y
          SPECIFIED JOINT DISPLACEMENTS.
          ENTER LENGTH UNITS ('INCHES', 'FEET', 'CENTIMETERS', OR 'METERS').
     ? I
          ENTER SPECIFIED JOINT DISPLACEMENTS.
          ENTER 'END' WHEN FINISHED WITH SPECIFIED DISPLACEMENTS.

          START      <---SPECIFIED DISPLACEMENT (OR 'FREE')--->      STOP    JOINT
          JT.NO.     X-ROTATION    Y-ROTATION   Z-DISPLACEMENT      JT.NO.   INCR.
                        (RAD)         (RAD)          (IN)
     ? 4 0 0 0
     ? E

          ARE SPRING SUPPORTS TO BE PROVIDED?
          ENTER 'YES' OR 'NO'.
     ? N

          INDEPENDENT LOAD CASES
          ENTER LOAD CASE NUMBER (1 TO 15).
     ? 1

          ENTER DATA FOR LOAD CASE  1
          ENTER LENGTH UNITS ('INCHES', 'FEET', 'CENTIMETERS', OR 'METERS').
     ? F
          ENTER FORCE UNITS ('POUNDS', 'KIPS', 'NEWTONS', OR 'KILONEWTONS'='KN').
     ? P
          ENTER TITLE FOR LOAD CASE  1
     ? DEAD LOAD
          ENTER JOINT LOADS FOR LOAD CASE  1
          ENTER 'END' WHEN FINISHED WITH JOINT LOADS.

          START          <-----CONCENTRATED LOAD------>      STOP      JT.NO.
          JT.NO.         X-MOM.      Y-MOM.     Z-FORCE     JT.NO.     INCR.
                         ( P-FT)     ( P-FT)     ( P)
     ? E
          MEMBER LOADS FOR LOAD CASE  1
          ENTER 'CONCENTRATED', 'UNIFORM', 'TRAPEZOIDAL', OR 'END'.
     ? U
          ENTER MEMBER UNIFORM LOADS FOR LOAD CASE  1
          ENTER 'END' WHEN FINISHED WITH MEMBER UNIFORM LOADS.

           START      <--------UNIFORM LOAD--------->      STOP        MEM.NO.
          MEM.NO.     X-TORS.       Y-MOM.     Z-FORCE    MEM.NO.      INCR.
                       ( P)          ( P)      ( P/FT)
     ? 1 0 0 -300 4
     ? E

          MEMBER LOADS FOR LOAD CASE  1
          ENTER 'CONCENTRATED', 'UNIFORM', 'TRAPEZOIDAL', OR 'END'.
     ? E
          DO YOU WANT TO ENTER ANOTHER LOAD CASE?
          ENTER 'YES' OR 'NO'.
     ? Y
```

Figure 5. (Sheet 2 of 4)

```
      ENTER LOAD CASE NUMBER (1 TO 15).
? 3
      ENTER DATA FOR LOAD CASE  3
      ENTER LENGTH UNITS ('INCHES', 'FEET', 'CENTIMETERS', OR 'METERS').
? F
      ENTER FORCE UNITS ('POUNDS', 'KIPS', 'NEWTONS', OR 'KILONEWTONS'='KN').
? KIPS
      ENTER TITLE FOR LOAD CASE  3
? COLUMN LOADS
      ENTER JOINT LOADS FOR LOAD CASE  3
      ENTER 'END' WHEN FINISHED WITH JOINT LOADS.

      START          <-----CONCENTRATED LOAD------>      STOP      JT.NO.
      JT.NO.          X-MOM.     Y-MOM.    Z-FORCE     JT.NO.      INCR.
                     (KP-FT)    (KP-FT)     (KP)
? E
      MEMBER LOADS FOR LOAD CASE  3
      ENTER 'CONCENTRATED', 'UNIFORM', 'TRAPEZOIDAL', OR 'END'.
? C

      ENTER MEMBER CONCENTRATED LOADS FOR LOAD CASE  3
      ENTER 'END' WHEN FINISHED WITH MEMBER CONCENTRATED LOADS.

      START    DIST. FROM    <------CONCENTRATED LOAD------>    STOP    MEM. NO.
     MEM.NO.   'FROM' END    X-TORS.     Y-MOM.     Z-FORCE   MEM.NO.    INCR.
                  (FT)      (KP-FT)     (KP-FT)      (KP)
? 1 2.5 0 0 -5 2
? E

      MEMBER LOADS FOR LOAD CASE  3
      ENTER 'CONCENTRATED', 'UNIFORM', 'TRAPEZOIDAL', OR 'END'.
? E
      DO YOU WANT TO ENTER ANOTHER LOAD CASE?
      ENTER 'YES' OR 'NO'.
? Y
      ENTER LOAD CASE NUMBER (1 TO 15).
? 5
      ENTER DATA FOR LOAD CASE  5
      ENTER LENGTH UNITS ('INCHES', 'FEET', 'CENTIMETERS', OR 'METERS').
? F
      ENTER FORCE UNITS ('POUNDS', 'KIPS', 'NEWTONS', OR 'KILONEWTONS'='KN').
? KIPS
      ENTER TITLE FOR LOAD CASE  5
? JOINT LOAD
      ENTER JOINT LOADS FOR LOAD CASE  5
      ENTER 'END' WHEN FINISHED WITH JOINT LOADS.

      START          <-----CONCENTRATED LOAD------>      STOP      JT.NO.
      JT.NO.          X-MOM.     Y-MOM.    Z-FORCE     JT.NO.      INCR.
                     (KP-FT)    (KP-FT)     (KP)
? 1 0 0 10
? E
```

Figure 5. (Sheet 3 of 4)

```
          MEMBER LOADS FOR LOAD CASE  5
          ENTER 'CONCENTRATED', 'UNIFORM', 'TRAPEZOIDAL'. OR 'END'.
? E

          DO YOU WANT TO ENTER ANOTHER LOAD CASE?
          ENTER 'YES' OR 'NO'.
? N

          ARE LOAD CASE COMBINATIONS TO BE PROVIDED?
          ENTER 'YES' OR 'NO'.
? Y

          ENTER LOAD CASE COMBINATIONS NUMBER (1 TO 15).
? 1
          ENTER TITLE FOR LOAD COMBINATION  1
? COMBINE THREE INDEPENDENT LOAD CASES
          LOAD COMBINATION  1
          ENTER INDEPENDENT LOAD CASE NUMBER AND SCALE FACTOR
          ONE PAIR AT A TIME.
          ENTER 'END' WHEN FINISHED WITH THIS COMBINATION.

                IND. LOAD       SCALE
                CASE NO.        FACTOR
? 1 1
? 3 1.5
? 5 2
? E

          DO YOU WANT TO ENTER ANOTHER LOAD COMBINATION?
          ENTER 'YES' OR 'NO'.
? N
          INPUT COMPLETE.
          DO YOU WANT INPUT DATA SAVED IN A FILE?
          ENTER 'YES' OR 'NO'.
? Y
          ENTER FILE NAME FOR SAVING INPUT DATA (6 CHARACTERS MAXIMUM).
? CGEX1I

********** INPUT FILE FOR EXAMPLE 1 **********


1000 'EXAMPLE 1 FOUR MEMBER SKEWED RECTANGULAR GRID
1010 RECT    1   1.000E+01   1   1.000E+01  -2.000E+01  FT
1020  CROSS SECTION   IN
1030  P     1   864.000   576.000      .000    4    1
1040  MATERIALS   IN    P
1050    1   3.000E+07   1.200E+07    4    1
1060  DISPLACEMENTS   IN
1070    4     .000E+00    .000E+00    .000E+00
1080  LOADS   1  FT    P
1090 'DEAD LOAD
1100 M U    1     .000E+00    .000E+00  -3.000E+02                 4    1
1110  LOADS   3  FT   KP
1120 'COLUMN LOADS
1130 M C    1   2.500E+00    .000E+00    .000E+00  -5.000E+00    2    1
1140  LOADS   5  FT   KP
1150 'JOINT LOAD
1160 JOINT LOAD    1    .000E+00    .000E+00   1.000E+01
1170  COMBINE   1   3   1  1.000   3  1.500   5  2.000
1180 'COMBINE THREE INDEPENDENT LOAD CASES
1190  FINISH
```

Figure 5. (Sheet 4 of 4)

25. All input data were directed to a permanent file and retrieved following termination of the run. An echoprint of the input data and a listing of the joint, member, and load case data generated from the sequences input for each section are shown in Figure 6. Each section of the input data may be entered with its own set of units. CGRID converts all input values to units of inches and pounds as indicated in the generated data.

26. A plot of the input geometry is included in Figure 6. This plot indicates the locations and identifying numbers for each joint and member in the system as well as the overall dimensions of the system. For an automatically generated "rectangular" grid, the origin of the global coordinate system is at joint 1 (Figure 6d) with the positive X-axis extending to the right. This plot also indicates the joints at which specified displacements and/or spring supports are applied to the structure. An indication of any member end force release would also appear on this plot.

27. Control of numerical results output is shown in Figure 7. Output units may be chosen as either the default units (inches and pounds) or any other desired combination of length and force units or may be assigned to specific items of output as illustrated in Figure 7. Any or all of the results for independent load cases may be omitted. Results for all load combinations are reported for the sections of output shown in Figure 7. When output of member forces grouped by member is requested, this section of output contains the results for all independent load cases and load case combinations regardless of whether or not any independent load case has been previously suppressed.

```
     DO YOU WANT OUTPUT WRITTEN TO YOUR TERMINAL, TO A FILE, OR BOTH?
     ENTER 'TERMINAL', 'FILE', OR 'BOTH'.
? F
     ENTER OUTPUT FILE NAME (6 CHARACTERS MAXIMUM).
? CGEX10
     DO YOU WANT OUTPUT DATA TO INCLUDE:
          ECHO PRINT OF INPUT DATA?
          GENERATED JOINT DATA?
          GENERATED MEMBER DATA?
          GENERATED INDEPENDENT LOAD CASE DATA?

     ENTER FOUR ANSWERS ('YES' OR 'NO').
? Y Y Y Y
     DATA GENERATION COMPLETE.
     DO YOU WANT TO PLOT INPUT GEOMETRY?
     ENTER 'YES' OR 'NO'.
? Y
     ENTER PLOT LENGTH UNITS ('IN', 'FT', 'CM', OR 'M').
? F
```

a. Selection of input and generated data to be sent to a file

Figure 6. Echoprint of input and generated data for Example 1
(Sheet 1 of 5)

PROGRAM CGRID - ANALYSIS OF PLANE GRID STRUCTURES
DATE: 09/16/86 TIME: 10:44:55

I.--HEADING
'EXAMPLE 1 FOUR MEMBER SKEWED RECTANGULAR GRID

****
* ECHOPRINT OF INPUT DATA *
****

II.--GEOMETRY
RECTANGULAR MESH

<--X-DIRECTION-->		<-------Y-DIRECTION-------->		
NO. OF MEMBERS	MEMBER LENGTH (FT)	NO. OF MEMBERS	MEMBER Y-PROJ. (FT)	SKEW ANGLE (DEG)
1	10.00	1	10.00	-20.00

III.--CROSS SECTION DATA (UNITS ARE 'IN')

DATA TYPE	START MEM.NO.	TORSION INERTIA OR WIDTH	BENDING INERTIA OR HEIGHT	SHEAR AREA OR FACT.	STOP MEM.NO.	MEM.NO INCR.
PROP	1	8.640E+02	5.760E+02	.000E+00	4	1

IV.--MATERIAL PROPERTIES

START MEM.NO.	MODULUS OF ELASTICITY (P/IN**2)	SHEAR MODULUS (P/IN**2)	STOP MEM.NO.	MEM.NO. INCR.
1	3.000E+07	1.200E+07	4	1

V.--MEMBER END FORCE RELEASES
NONE

VI.--SPECIFIED DISPLACEMENTS

START JT.NO.	<________SPECIFIED DISPLACEMENT---------> X-ROTATION (RAD)	Y-ROTATION (RAD)	Z-TRANSLATION (IN)	STOP JT.NO.	JT.NO. INCR.
4	.000E+00	000E+00	.000E+00		

VII.--SPRING SUPPORTS
NONE

VIII.--INDEPENDENT LOAD CASES

VIII.A.--LOAD CASE 1
TITLE: 'DEAD LOAD

VIII.A.1.--JOINT LOADS
NONE

VIII.A.2.--MEMBER CONCENTRATED LOADS
NONE

b. Echoprint of input data (Continued)

Figure 6. (Sheet 2 of 5)

VIII.A.3.--MEMBER UNIFORM LOADS

START MEM.NO.	X-TORSION (P)	Y-MOMENT (P)	Z-FORCE (P/FT)	STOP MEM.NO.	MEM.NO. INCR.
1	.000E+00	.000E+00	-3.000E+02	4	1

VIII.A.4.--MEMBER TRAPEZOIDAL LOADS
NONE

VIII.B.--LOAD CASE 3
TITLE: 'COLUMN LOADS

VIII.B.1.--JOINT LOADS
NONE

VIII.B.2.--MEMBER CONCENTRATED LOADS

START MEM.NO.	DIST. FROM 'FROM' END (FT)	X-TORSION (KP-FT)	Y-MOMENT (KP-FT)	Z-FORCE (KP)	STOP MEM.NO.	MEM.NO. INCR.
1	2.50	.000E+00	.000E+00	-5.000E+00	2	1

VIII.B.3.--MEMBER UNIFORM LOADS
NONE

VIII.B.4.--MEMBER TRAPEZOIDAL LOADS
NONE

VIII.C.--LOAD CASE 5
TITLE: 'JOINT LOAD

VIII.C.1.--JOINT LOADS

START JT.NO.	X-MOMENT (KP-FT)	Y-MOMENT (KP-FT)	Z-FORCE (KP)	STOP JT.NO.	JT.NO. INCR.
1	.000E+00	.000E+00	1.000E+01		

VIII.C.2.--MEMBER CONCENTRATED LOADS
NONE

VIII.C.3.--MEMBER UNIFORM LOADS
NONE

VIII.C.4.--MEMBER TRAPEZOIDAL LOADS
NONE

IX.--LOAD CASE COMBINATIONS

IX.A.--LOAD COMBINATION 1
TITLE: 'COMBINE THREE INDEPENDENT LOAD CASES

INDEP. LOAD CASE	SCALE FACTOR
1	1.000
3	1.500
5	2.000

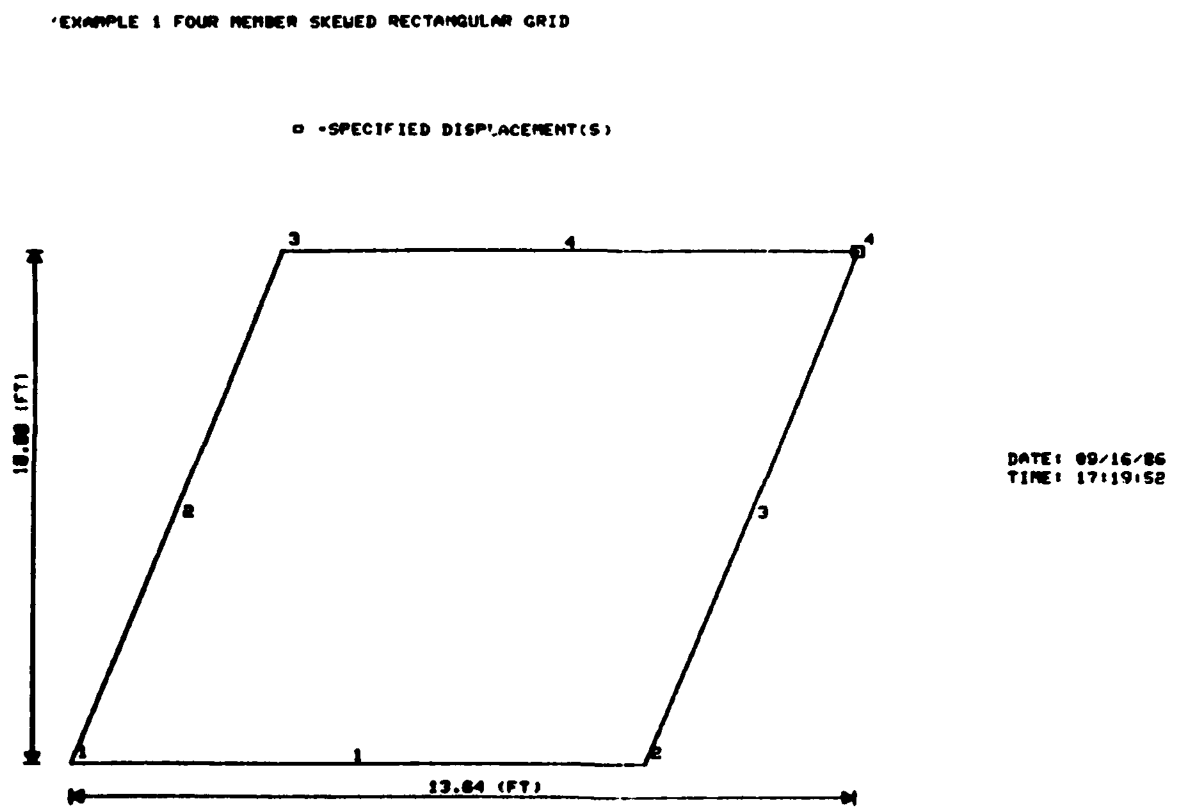
b. (Concluded)

Figure 6. (Sheet 3 of 5)

```
PROGRAM CGRID - ANALYSIS OF PLANE GRID STRUCTURES
DATE: 09/16/86                     TIME: 10:44:57
I.--HEADING
       'EXAMPLE 1 FOUR MEMBER SKEWED RECTANGULAR GRID
               ******************
               * GENERATED DATA *
               ******************
II.--JOINT DATA
                                             <----------------SUPPORTS---------------->
JT <----COORDINATES---->                     (D=SPECIFIED DISPLACEMENT (IN. OR RAD.)
NO       X          Y                        (S=SPRING STIFFNESS (IN. OR RAD., AND LBS.
       (IN)        (IN)                         X-DIRECTION    Y-DIRECTION    Z-DIRECTION
 1    .000E+00    .000E+00
 2   1.200E+02    .000E+00
 3   4.368E+01   1.200E+02
 4   1.637E+02   1.200E+02                      D=  .000E+00   D=  .000E+00   D=  .000E+0
III.--MEMBER DATA
                                     TORSION     BENDING    SHEAR   <------MODULI------>
      FROM TO    LENGTH   INERTIA     INERTIA    AREA        E           G
  MEM  JT  JT     (IN)    (IN**4)     (IN**4)   (SQIN)     (PSI)       (PSI)
    1   1   2   120.00  8.640E+02   5.760E+02     .00   3.000E+07   1.200E+07
    2   1   3   127.70  8.640E+02   5.760E+02     .00   3.000E+07   1.200E+07
    3   2   4   127.70  8.640E+02   5.760E+02     .00   3.000E+07   1.200E+07
    4   3   4   120.00  8.640E+02   5.760E+02     .00   3.000E+07   1.200E+07
IV.--INDEPENDENT LOAD CASE DATA
  IV.A.--LOAD CASE NUMBER  1
TITLE:    'DEAD LOAD
     <--------------JOINT LOADS-------------->
               NONE
    <------------------------MEMBER LOADS------------------------>
                         DIST. FROM     X-TORSION     Y-MOMENT     Z-FORCE
    MEM.     LOAD       'FROM' END      (LB-IN        (LB-IN       (LB/IN
     NO.     TYPE          (IN)         OR LBS)        OR LBS)      OR LBS)
      1      UNIF                       .000E+00      .000E+00   -2.500E+01
      2      UNIF                       .000E+00      .000E+00   -2.500E+01
      3      UNIF                       .000E+00      .000E+00   -2.500E+01
      4      UNIF                       .000E+00      .000E+00   -2.500E+01
  IV.B.--LOAD CASE NUMBER  3
TITLE:    'COLUMN LOADS
     <--------------JOINT LOADS-------------->
               NONE
    <------------------------MEMBER LOADS------------------------>
                         DIST. FROM     X-TORSION     Y-MOMENT     Z-FORCE
    MEM.     LOAD       'FROM' END      (LB-IN        (LB-IN       (LB/IN
     NO.     TYPE          (IN)         OR LBS)        OR LBS)      OR LBS)
      1      CONC          30.00        .000E+00      .000E+00   -5.000E+03
      2      CONC          30.00        .000E+00      .000E+00   -5.000E+03
  IV.C.--LOAD CASE NUMBER  5
TITLE:    'JOINT LOAD
     <--------------JOINT LOADS-------------->
     JT.         X-MOMENT     Y-MOMENT     Z-FORCE
     NO.          (LB-IN)      (LB-IN)       (LB)
      1          .000E+00     .000E+00    1.000E+04
    <------------------------MEMBER LOADS------------------------>
               NONE
```

c. Echoprint of generated data

Figure 6. (Sheet 4 of 5)



d. Plot of input geometry for Example 1

Figure 6. (Sheet 5 of 5)

```
     DO YOU WANT TO CONTINUE WITH THE SOLUTION?
     ENTER 'YES' OR 'NO'.
? Y
     SOLUTION COMPLETE.
     RESULTS ARE AVAILABLE FOR INDEPENDENT LOAD CASES:
             1   3   5


     ENTER A LIST OF INDEPENDENT LOAD CASES FOR WHICH RESULTS ARE DESIRED,
     OR 'ALL', OR 'ALL BUT' FOLLOWED BY A LIST OF LOAD CASES TO BE EXCLUDED,
     OR 'NONE'.
? N
     ENTER DESIRED OUTPUT UNITS.
          ENTER 'DEFAULT' (=INCHES AND POUNDS)
          OR LENGTH UNITS ('I', 'F', 'CM', OR 'M')
               FOLLOWED BY FORCE UNITS ('P', 'KIPS', 'N', OR 'KN')
          OR 'SELECTIVE'.
? S
     ENTER LENGTH UNITS FOR COORDINATES ('I', 'F'. 'CM' OR 'M').
? F
     ENTER LENGTH UNITS FOR DISPLACEMENTS ('I','F'.'CM', OR 'M').
? I
     ENTER FORCE UNITS ('P', 'KIPS', 'N', OR 'KN').
? KIPS
     ENTER LENGTH UNITS FOR MOMENTS ('I','F','CM' OR 'M').
? I
     DO YOU WANT OUTPUT TO INCLUDE:
          JOINT DISPLACEMENTS?
          REACTIONS?
          MEMBER FORCES GROUPED BY LOAD CASE?
          MEMBER FORCES GROUPED BY MEMBER?

     ENTER FOUR ANSWERS ('YES' OR 'NO').
? Y Y Y Y
```

a. Selection of numerical results output

Figure 7. Numerical results output for Example 1
(Sheet 1 of 4)

PROGRAM CGRID - ANALYSIS OF PLANE GRID STRUCTURES
DATE: 09/16/86 TIME: 10:56:05

HEADING:
'FXAMPLE 1 FOUR MEMBER SKEWED RECTANGULAR GRID

****
* LOAD COMBINATION 1 *
*TITLE: 'COMBINE THREE INDEPENDENT LOAD CASES *
****

<-------------------------JOINT DISPLACEMENTS------------------------->

JT. NO.	<--COORDINATES (FT)--> X	Y	X-ROTATION (RAD)	Y-ROTATION (RAD)	Z-DISP. (IN)
1	.000E+00	.000E+00	-2.238E-03	3.314E-03	3.887E-01
2	1.000E+01	.000E+00	-2.893E-04	2.144E-03	4.313E-02
3	3.640E+00	1.000E+01	-1.752E-03	9.244E-04	3.718E-02
4	1.364E+01	1.000E+01	.000E+00	.000E+00	.000E+00

<-------REACTIONS DUE TO SPECIFIED DISPLACEMENTS OR CONCENTRATED SPRINGS-----

JT. NO.	<--COORDINATES (FT)--> X	Y	X-MOMENT (KP-IN)	Y-MOMENT (KP-IN)	Z-FORCE (KP)
4	1.364E+01	1.000E+01	6.833E+01(D)	-1.068E+02(D)	7.385E+00(I

<------------------MEMBER END FORCES------------------>

MEM. NO.	JT. NO.	X-TORSION (KP-IN)	Y-MOMENT (KP-IN)	Z-FORCE (KP)
1	1	-1.684E+02	-1.184E+02	1.000E+01
	2	1.684E+02	-2.268E+02	4.987E-01
2	1	1.688E+02	-1.177E+02	9.999E+00
	3	-1.688E+02	-2.225E+02	6.938E-01
3	2	1.555E+02	2.358E+02	-4.987E-01
	4	-1.555E+02	3.175E+01	3.691E+00
4	3	-1.514E+02	2.347E+02	-6.938E-01
	4	1.514E+02	2.851E+01	3.694E+00

<------MAXIMUM MEMBER INTERNAL FORCES (UNITS ARE 'IN' AND 'KP')------>

MEM. NO.	ITEM	MAXIMUM POSITIVE	DIST. FROM 'FROM' END	MAXIMUM NEGATIVE	DIST. FROM 'FROM' END
1	X-TORSION:	.000E+00	.000E+00	-1.684E+02	1.200E+02
	Y-MOMENT :	2.318E+02	7.005E+01	-1.184E+02	.000E+00
	Z-SHEAR :	1.000E+01	.000E+00	-4.987E-01	1.200E+02
2	X-TORSION:	1.688E+02	1.277E+02	.000E+00	.000E+00
	Y-MOMENT :	2.321E+02	6.995E+01	-1.177E+02	.000E+00
	Z-SHEAR :	9.999E+00	.000E+00	-6.938E-01	1.277E+02
3	X-TORSION:	1.555E+02	1.277E+02	.000E+00	.000E+00
	Y-MOMENT :	2.358E+02	.000E+00	-3.175E+01	1.277E+02
	Z-SHEAR :	.000E+00	.000E+00	-3.691E+00	1.277E+02
4	X-TORSION:	.000E+00	.000E+00	-1.514E+02	1.200E+02
	Y-MOMENT :	2.347E+02	.000E+00	-2.851E+01	1.200E+02
	Z-SHEAR :	.000E+00	.000E+00	-3.694E+00	1.200E+02

b. Joint displacements, reactions, and member forces

Figure 7. (Sheet 2 of 4)

****
*   MEMBER END FORCES GROUPED BY MEMBER   *
****

MEM. NO.	LOAD CASE	JT. NO.	X-TORSION (KP-IN)	Y-MOMENT (KP-IN)	Z-FORCE (KP)
******* MEMBER FORCES DUE TO INDEPENDENT LOAD CASES*******					
1	1	1	2.540E+01	2.275E+01	-5.142E-02
		2	-2.540E+01	1.634E+02	3.051E+00
	3	1	1.179E+02	9.252E+01	-9.920E-02
		2	-1.179E+02	3.694E+02	5.099E+00
	5	1	-1.853E+02	-1.400E+02	5.101E+00
		2	1.853E+02	-4.721E+02	-5.101E+00
*********MEMBER FORCES DUE TO LOAD COMBINATIONS*********					
	1	1	-1.684E+02	-1.184E+02	1.000E+01
		2	1.684E+02	-2.268E+02	4.987E-01
******* MEMBER FORCES DUE TO INDEPENDENT LOAD CASES*******					
2	1	1	-3.006E+01	1.608E+01	5.142E-02
		3	3.006E+01	1.812E+02	3.141E+00
	3	1	-1.273E+02	7.912E+01	9.920E-02
		3	1.273E+02	3.967E+02	4.901E+00
	5	1	1.949E+02	-1.262E+02	4.899E+00
		3	-1.949E+02	-4.994E+02	-4.899E+00
*********MEMBER FORCES DUE TO LOAD COMBINATIONS*********					
	1	1	1.688E+02	-1.177E+02	9.999E+00
		3	-1.688E+02	-2.225E+02	6.938E-01
******* MEMBER FORCES DUE TO INDEPENDENT LOAD CASES*******					
3	1	2	-1.449E+02	-7.976E+01	-3.051E+00
		4	1.449E+02	6.733E+02	6.244E+00
	3	2	-3.068E+02	-2.371E+02	-5.099E+00
		4	3.068E+02	8.883E+02	5.099E+00
	5	2	3.803E+02	3.356E+02	5.101E+00
		4	-3.803E+02	-9.870E+02	-5.101E+00
*********MEMBER FORCES DUE TO LOAD COMBINATIONS*********					
	1	2	1.555E+02	2.358E+02	-4.987E-01
		4	-1.555E+02	3.175E+01	3.691E+00
******* MEMBER FORCES DUE TO INDEPENDENT LOAD CASES*******					
4	1	3	1.600E+02	-9.022E+01	-3.141E+00
		4	-1.600E+02	6.472E+02	6.141E+00
	3	3	3.293E+02	-2.553E+02	-4.901E+00
		4	-3.293E+02	8.434E+02	4.901E+00
	5	3	-4.026E+02	3.539E+02	4.899E+00
		4	4.026E+02	-9.418E+02	-4.899E+00
*********MEMBER FORCES DUE TO LOAD COMBINATIONS*********					
	1	3	-1.514E+02	2.347E+02	-6.938E-01
		4	1.514E+02	2.851E+01	3.694E+00

c. Member end forces grouped by member (Continued)

Figure 7. (Sheet 3 of 4)

************MAXIMUM MEMBER INTERNAL FORCES (UNITS ARE 'IN' AND 'KP')************

MEM. NO.	LOAD CASE	ITEM	MAXIMUM POSITIVE	DIST. FROM 'FROM' END	MAXIMUM NEGATIVE	DIST. FROM 'FROM' END
		******* MEMBER FORCES DUE TO INDEPENDENT LOAD CASES*******				
1	1	X-TORSION:	2.540E+01	1.200E+02	.000E+00	.000E+00
		Y-MOMENT :	2.275E+01	.000E+00	-1.634E+02	1.200E+02
		Z-SHEAR :	.000E+00	.000E+00	-3.051E+00	1.200E+02
	3	X-TORSION:	1.179E+02	1.200E+02	.000E+00	.000E+00
		Y-MOMENT :	9.252E+01	.000E+00	-3.694E+02	1.200E+02
		Z-SHEAR :	.000E+00	.000E+00	-5.099E+00	1.200E+02
	5	X-TORSION:	.000E+00	.000E+00	-1.853E+02	1.200E+02
		Y-MOMENT :	4.721E+02	1.200E+02	-1.400E+02	.000E+00
		Z-SHEAR :	5.101E+00	1.200E+02	.000E+00	.000E+00
		*********MEMBER FORCES DUE TO LOAD COMBINATIONS*********				
	1	X-TORSION:	.000E+00	.000E+00	-1.684E+02	1.200E+02
		Y-MOMENT :	2.318E+02	7.005E+01	-1.184E+02	.000E+00
		Z-SHEAR :	1.000E+01	.000E+00	-4.987E-01	1.200E+02
		******* MEMBER FORCES DUE TO INDEPENDENT LOAD CASES*******				
2	1	X-TORSION:	.000E+00	.000E+00	-3.006E+01	1.277E+02
		Y-MOMENT :	1.614E+01	2.057E+00	-1.812E+02	1.277E+02
		Z-SHEAR :	5.142E-02	.000E+00	-3.141E+00	1.277E+02
	3	X-TORSION:	.000E+00	.000E+00	-1.273E+02	1.277E+02
		Y-MOMENT :	8.209E+01	3.000E+01	-3.967E+02	1.277E+02
		Z-SHEAR :	9.920E-02	3.000E+01	-4.901E+00	1.277E+02
	5	X-TORSION:	1.949E+02	1.277E+02	.000E+00	.000E+00
		Y-MOMENT :	4.994E+02	1.277E+02	-1.262E+02	.000E+00
		Z-SHEAR :	4.899E+00	1.277E+02	.000E+00	.000E+00
		*********MEMBER FORCES DUE TO LOAD COMBINATIONS*********				
	1	X-TORSION:	1.688E+02	1.277E+02	.000E+00	.000E+00
		Y-MOMENT :	2.321E+02	6.995E+01	-1.177E+02	.000E+00
		Z-SHEAR :	9.999E+00	.000E+00	-6.938E-01	1.277E+02
		******* MEMBER FORCES DUE TO INDEPENDENT LOAD CASES*******				
3	1	X-TORSION:	.000E+00	.000E+00	-1.449E+02	1.277E+02
		Y-MOMENT :	.000E+00	.000E+00	-6.733E+02	1.277E+02
		Z-SHEAR :	.000E+00	.000E+00	-6.244E+00	1.277E+02
	3	X-TORSION:	.000E+00	.000E+00	-3.068E+02	1.277E+02
		Y-MOMENT :	.000E+00	.000E+00	-8.883E+02	1.277E+02
		Z-SHEAR :	.000E+00	.000E+00	-5.099E+00	1.277E+02
	5	X-TORSION:	3.803E+02	1.277E+02	.000E+00	.000E+00
		Y-MOMENT :	9.870E+02	1.277E+02	.000E+00	.000E+00
		Z-SHEAR :	5.101E+00	1.277E+02	.000E+00	.000E+00
		*********MEMBER FORCES DUE TO LOAD COMBINATIONS*********				
	1	X-TORSION:	1.555E+02	1.277E+02	.000E+00	.000E+00
		Y-MOMENT :	2.358E+02	.000E+00	-3.175E+01	1.277E+02
		Z-SHEAR :	.000E+00	.000E+00	-3.691E+00	1.277E+02
		******* MEMBER FORCES DUE TO INDEPENDENT LOAD CASES*******				
4	1	X-TORSION:	1.600E+02	1.200E+02	.000E+00	.000E+00
		Y-MOMENT :	.000E+00	.000E+00	-6.472E+02	1.200E+02
		Z-SHEAR :	.000E+00	.000E+00	-6.141E+00	1.200E+02
	3	X-TORSION:	3.293E+02	1.200E+02	.000E+00	.000E+00
		Y-MOMENT :	.000E+00	.000E+00	-8.434E+02	1.200E+02
		Z-SHEAR :	.000E+00	.000E+00	-4.901E+00	1.200E+02
	5	X-TORSION:	.000E+00	.000E+00	-4.026E+02	1.200E+02
		Y-MOMENT :	9.418E+02	1.200E+02	.000E+00	.000E+00
		Z-SHEAR :	4.899E+00	1.200E+02	.000E+00	-.000E+00
		*********MEMBER FORCES DUE TO LOAD COMBINATIONS*********				
	1	X-TORSION:	.000E+00	.000E+00	-1.514E+02	1.200E+02
		Y-MOMENT :	2.347E+02	.000E+00	-2.851E+01	1.200E+02
		Z-SHEAR :	.000E+00	.000E+00	-3.694E+00	1.200E+02

c. (Concluded)

Figure 7. (Sheet 4 of 4)

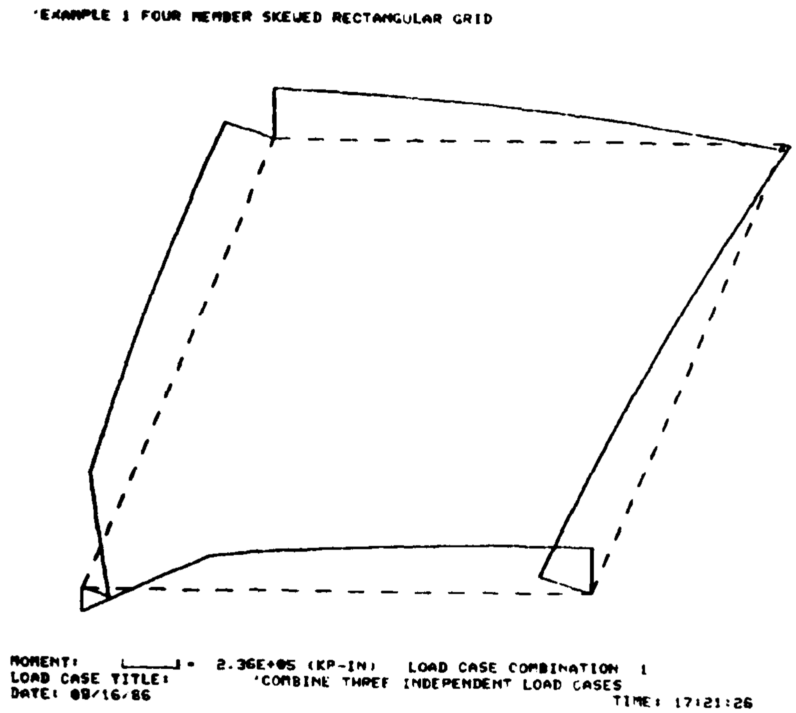
28. It should be noted that any of the internal forces (torsion, bending moment, or shear) may be constant at a maximum throughout a segment of a member. When this condition occurs, the location of the maximum effect for this member may be reported at any location within the constant region.

29. Graphic display of results, as illustrated in Figure 8, may be obtained for any or all independent load cases and load combinations. Available plots are designated as either "structure" plots or "member" plots. Structure plots shown in Figure 8 provide the variation of internal forces (torsion, bending momemt, or shear) throughout the structure.

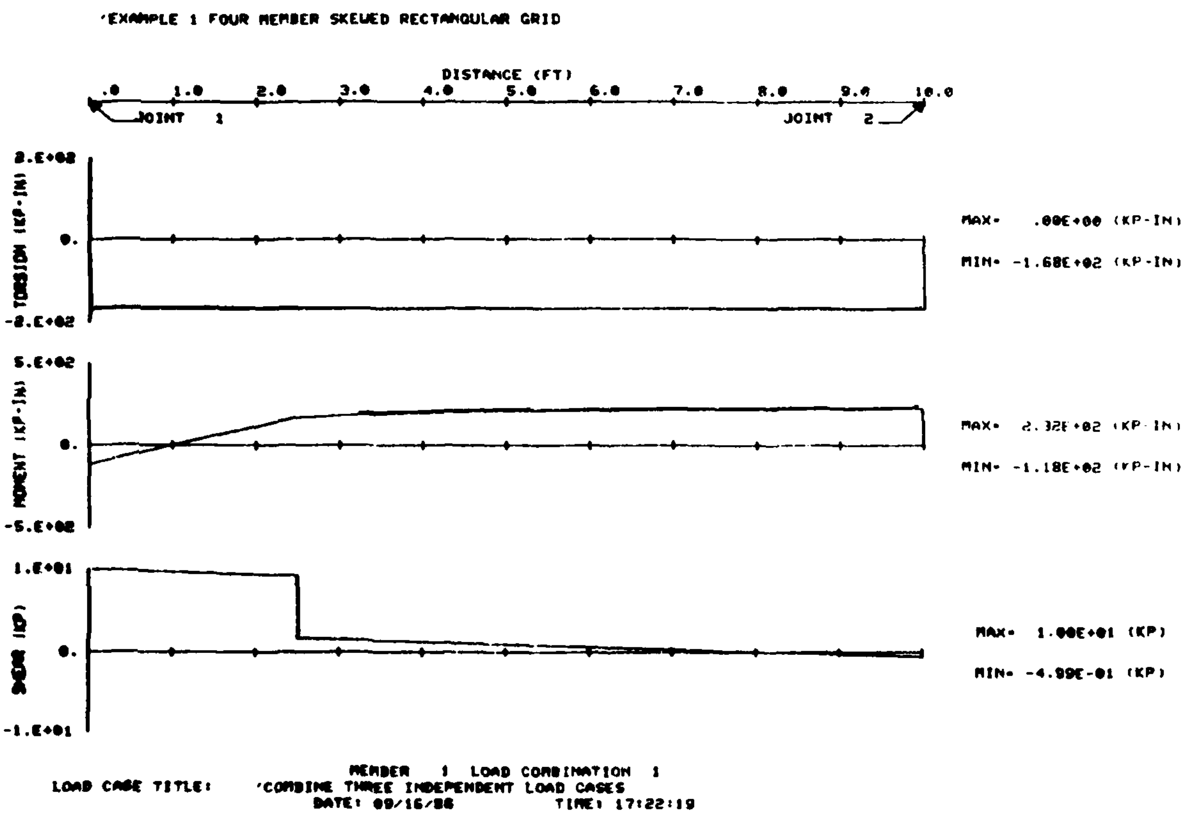
```
      OUTPUT COMPLETE.
      DO YOU WANT ADDITIONAL OUTPUT OR OUTPUT WITH DIFFERENT UNITS?
      ENTER 'YES' OR 'NO'.
 ? N
      OUTPUT SAVED IN FILE 'CGEX10'.
      DO YOU WANT TO PLOT RESULTS?
      ENTER 'YES' OR 'NO'.
 ? Y
      ENTER DESIRED PLOT UNITS.
           ENTER 'DEFAULT' (=INCHES AND POUNDS)
           OR LENGTH UNITS ('I', 'F', 'CM', OR 'M')
                FOLLOWED BY FORCE UNITS ('P', 'KIPS', 'N', OR 'KN')
           OR 'SELECTIVE'.
 ? S
      ENTER LENGTH UNITS FOR COORDINATES ('I', 'F', 'CM' OR 'M').
 ? F
      ENTER FORCE UNITS ('P', 'KIPS', 'N', OR 'KN').
 ? KIPS
      ENTER LENGTH UNITS FOR MOMENTS ('I','F','CM' OR 'M').
 ? I
      RESULTS ARE AVAILABLE FOR INDEPENDENT LOAD CASES:
          1    3    5
      ENTER DESIRED INDEPENDENT LOAD CASE. 'END', OR 'HELP'.
 ? E
      RESULTS ARE AVAILABLE FOR LOAD CASE COMBINATIONS:
          1
      ENTER DESIRED LOAD CASE COMBINATION. 'END', OR 'HELP'.
 ? 1
      ENTER TYPE OF PLOT: 'STRUCTURE' OR 'MEMBER'.
 ? S
      ENTER FORCE TO BE PLOTTED: 'TORSION', 'MOMENT', 'SHEAR', 'ALL', OR 'END'.
 ? M
      ENTER FORCE TO BE PLOTTED: 'TORSION'. 'MOMENT', 'SHEAR', 'ALL', OR 'END'.
 ? E
      RESULTS ARE AVAILABLE FOR MEMBERS 1 TO    4.
      ENTER LIST OF MEMBERS TO BE PLOTTED FOR LOAD CASE COMBINATION  1,
      'END', OR 'HELP'.
 ? 1 3
```

a. Selection of results to plot for structure and members

Figure 8. Graphic display of results for independent load cases and load combinations (Sheet 1 of 3)

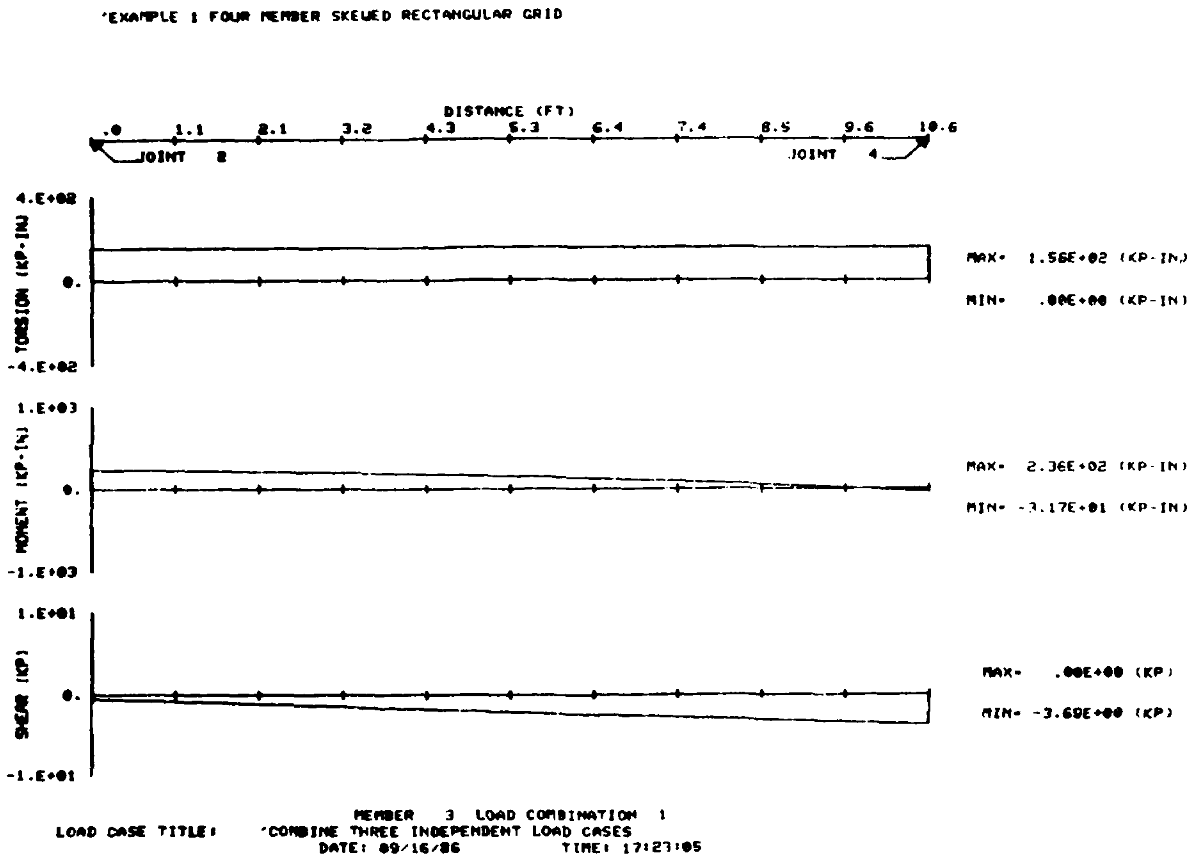


b. Moment plot of structure for load combination 1



c. Shear, moment, and torsion plots of member 1 for load combination 1

Figure 8. (Sheet 2 of 3)



d. Shear, moment, and torsion plots of member 3 for load combination 1

```
    ENTER LIST OF MEMBERS TO BE PLOTTED FOR LOAD CASE COMBINATION  1.
    'END', OR 'HELP'
? E
    ENTER DESIRED LOAD CASE COMBINATION, 'END', OR 'HELP'
? E
    DO YOU WANT TO PLOT WITH DIFFERENT UNITS?
    ENTER 'YES' OR 'NO'
? N
    DO YOU WANT TO MAKE ANOTHER RUN?
    ENTER 'YES' OR 'NO'.
    **********NORMAL TERMINATION**********
```

e. Conclusions of graphics and option to rerun

Figure 8. (Sheet 3 of 3)

In these plots positive values are plotted on the side of the member in the positive local Y-coordinate direction. Member plots provide the variations of torsion, bending moment, and shear throughout the length of each member selected. Member plot are also shown in Figure 8. Plot axes for member plots are chosen so that the individual force effects are plotted to the same scale for all load cases (independent and combinations).

30. When all desired output has been obtained, the user is offered the opportunity to rerun the program with new data or terminate execution. Any interruption of program execution prior to the "NORMAL TERMINATION" indication may result in the loss of output directed to permanent files.

Example 2

31. One half of a symmetric grid subjected to symmetric loading is shown in Figure 9. Input data were provided from the input file presented in Figure 10. An echoprint of the input data is also shown in Figure 10. Note that some joints appear in more than one line in the spring support section. Only the data for the last reference to a joint encountered in this section are used.

32. Generated data are shown in Figure 11 with a program generated plot of input geometry. The joint support data in this case consist of both spring

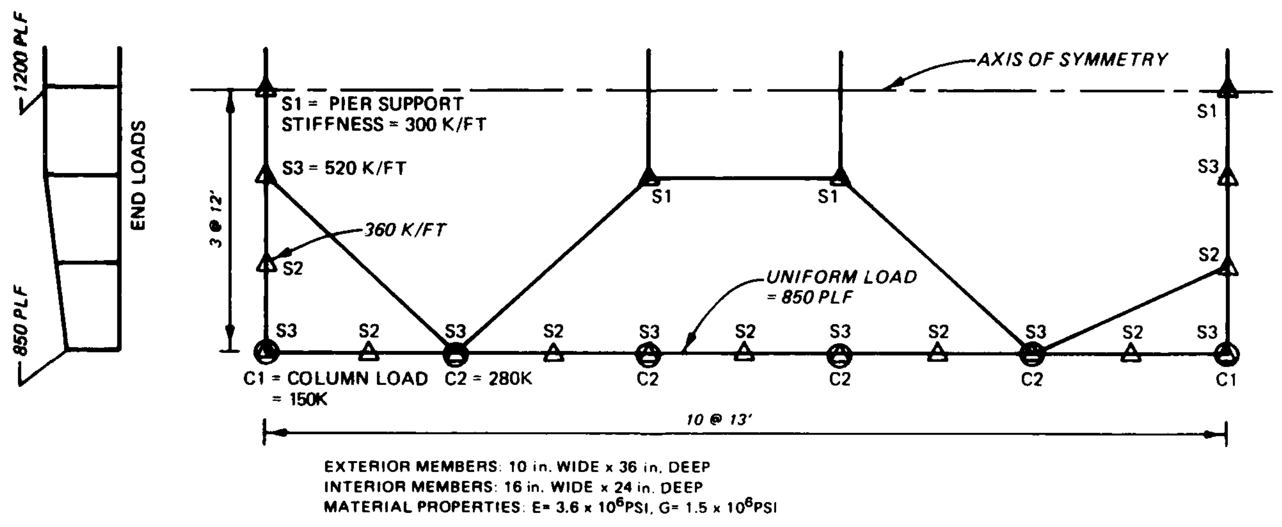


Figure 9. System for Example 2

```
1000 'EXAMPLE 2  -- SYMMETRIC GRID ON PIER SUPPORTS
1010 LINE FT
1020 JOINT COORDINATES
1030 (LEFT END)
1040 1 0 0 4 0 36
1050 (BOTTOM SIDE)
1060 5 13 0 8 52 0
1070 11 65 0 12 78 0
1080 15 91 0 17 117 0
1090 (RIGHT END)
1100 18 130 0 21 130 36
1110 (INTERIOR JOINTS)
1120 9 52 24 10 52 36
1130 13 78 24 14 78 36
1140 MEMBER CONNECTIVITY
1150 (LEFT END)
1160 1 1 2 3
1170 (BOTTOM SIDE)
1180 4 1 5 9 5 10 7
1190 5 5 6 7
1200 8 8 11 10 2 4 4
1210 11 15 16 13
1220 (RIGHT END)
1230 14 18 19 16
1240 (INTERIOR MEMBERS)
1250 17 3 6 18 1 3 3
1260 19 9 10 21 2 4 4
1270 20 9 13
1280 22 13 16 23 1 3 3
1290 CROSS SECTIONS INCHES
1300 DIMENSION 1 14 30 1 16
1310 DIMENSION 17 16 24 1 23
1320 MATERIALS I P
1330 1 3.6E6 1.5E6 23
1340 DISPLACEMENTS
1350 4 0 F F 10 6
1360 14 0 F F 21 7
1370 SPRINGS F KP
1380  2 0 0 360 20
1390  1 0 0 520 6 5
1400  8 0 0 520 16 4
1410  18 0 0 520
1420  9 0 0 300 13 4
1430  10 0 0 0 14 4
1440  4 0 0 180 21 17
1450  3 0 0 520 20 17
1460 LOADS 1 F P
1470 MEM UNIF 4 0 0 -850 13
1480 MEM TRAP 1 0 0 0 -850 12 0 0 -1025 14 13
1490 MEM TRAP 2 0 0 0 -1025 12 0 0 -1200 15 13
1500 MEM UNIF 3 0 0 -1200 16 13
1510 JOINT 6 0 0 -2.8E4
1520 JOINT 8 0 0 -2.8E4 16 4
1530 JOINT 1 0 0 -1.5E4 18 17
1540 FINISH
```

a. Input data file

Figure 10. Input data for Example 2 (Sheet 1 of 3)

PROGRAM CGRID - ANALYSIS OF PLANE GRID STRUCTURES
DATE: 09/17/86 TIME: 11:25:54

I.--HEADING
'EXAMPLE 2 -- SYMMETRIC GRID ON PIER SUPPORTS

****
* ECHOPRINT OF INPUT DATA *
****

II.--GEOMETRY
II.A.--JOINT COORDINATES

<----START----			----STOP---->			
JOINT NO.	X-COORD. (FT)	Y-COORD. (FT)	JOINT NO.	X-COORD. (FT)	Y-COORD. (FT)	JT.NO INCR
1	.000E+00	.000E+00	4	.000E+00	3.600E+01	1
5	1.300E+01	.000E+00	8	5.200E+01	.000E+00	1
11	6.500E+01	.000E+00	12	7.800E+01	.000E+00	1
15	9.100E+01	.000E+00	17	1.170E+02	.000E+00	1
18	1.300E+02	.000E+00	21	1.300E+02	3.600E+01	1
9	5.200E+01	2.400E+01	10	5.200E+01	3.600E+01	1
13	7.800E+01	2.400E+01	14	7.800E+01	3.600E+01	1

II.B.--MEMBER CONNECTIVITY

<----START		---->	STOP	<----INCREMENT IN		---->
MEMBER NO.	FROM JOINT	TO JOINT	MEMBER NO.	MEMBER NO.	FROM JOINT	TO JOINT
1	1	2	3	1	1	1
4	1	5	9	5	10	7
5	5	6	7	1	1	1
8	8	11	10	2	4	4
11	15	16	13	1	1	1
14	18	19	16	1	1	1
17	3	6	18	1	3	3
19	9	10	21	2	4	4
20	9	13				
22	13	16	23	1	3	3

III.--CROSS SECTION DATA (UNITS ARE 'IN')

DATA TYPE	START MEM.NO.	TORSION INERTIA OR WIDTH	BENDING INERTIA OR HEIGHT	SHEAR AREA OR FACT.	STOP MEM.NO.	MEM.NO. INCR.
DIM	1	1.400E+01	3.000E+01	1.000E+00	16	1
DIM	17	1.600E+01	2.400E+01	1.000E+00	23	1

IV.--MATERIAL PROPERTIES

START MEM.NO.	MODULUS OF ELASTICITY (P/IN**2)	SHEAR MODULUS (P/IN**2)	STOP MEM.NO.	MEM.NO. INCR.
1	3.600E+06	1.500E+06	23	1

V.--MEMBER END FORCE RELEASES
NONE

b. Echoprint of input data (Continued)

Figure 10. (Sheet 2 of 3)

VI.--SPECIFIED DISPLACEMENTS

START JT.NO.	<--------SPECIFIED DISPLACEMENT---------> X-ROTATION (RAD)	Y-ROTATION (RAD)	Z-TRANSLATION (IN)	STOP JT.NO.	JT.NO. INCR.
4	.000E+00	FREE	FREE	10	6
14	.000E+00	FREE	FREE	21	7

VII.--SPRING SUPPORTS

START JT.NO.	<-----CONCENTRATED SPRING STIFFNESS-----> X-ROTATION (KP-FT)	Y-ROTATION (KP-FT)	Z-TRANSLATION (KP/FT)	STOP JT.NO.	JT.NO. INCR.
2	.000E+00	.000E+00	3.600E+02	20	1
1	.000E+00	.000E+00	5.200E+02	6	5
8	.000E+00	.000E+00	5.200E+02	16	4
18	.000E+00	.000E+00	5.200E+02		
9	.000E+00	.000E+00	3.000E+02	13	4
10	.000E+00	.000E+00	.000E+00	14	4
4	.000E+00	.000E+00	1.800E+02	21	17
3	.000E+00	.000E+00	5.200E+02	20	17

VIII.--INDEPENDENT LOAD CASES

VIII.A.--LOAD CASE 1

TITLE: NONE

VIII.A.1.--JOINT LOADS

START JT.NO.	X-MOMENT (P-FT)	Y-MOMENT (P-FT)	Z-FORCE (P)	STOP JT.NO.	JT.NO. INCR.
6	.000E+00	.000E+00	-2.800E+04		
8	.000E+00	.000E+00	-2.800E+04	16	4
1	.000E+00	.000E+00	-1.500E+04	18	17

VIII.A.2.--MEMBER CONCENTRATED LOADS

NONE

VIII.A.3.--MEMBER UNIFORM LOADS

START MEM.NO.	X-TORSION (P)	Y-MOMENT (P)	Z-FORCE (P/FT)	STOP MEM.NO.	MEM.NO INCR.
4	.000E+00	.000E+00	-8.500E+02	13	1
3	.000E+00	.000E+00	-1.200E+03	16	13

VIII.A.4.--MEMBER TRAPEZOIDAL LOADS

START MEM.NO.	DIST. FROM 'FROM' END (FT)	X-TORSION (P)	Y-MOMENT (P)	Z-FORCE (P/FT)	STOP MEM.NO.	MEM.NO. INCR.
1	.00	.000E+00	.000E+00	-8.500E+02		
	12.00	.000E+00	.000E+00	-1.025E+03	14	13
2	.00	.000E+00	.000E+00	-1.025E+03		
	12.00	.000E+00	.000E+00	-1.200E+03	15	13

IX.--LOAD CASE COMBINATIONS

NONE

b. (Concluded)

Figure 10. (Sheet 3 of 3)

PROGRAM CGRID - ANALYSIS OF PLANE GRID STRUCTURES
DATE: 09/17/86 TIME: 11:25:56

I.--HEADING

'EXAMPLE 2 -- SYMMETRIC GRID ON PIER SUPPORTS

****
* GENERATED DATA *
****

II.--JOINT DATA

JT NO	<----COORDINATES----> X (IN)	Y (IN)	<----SUPPORTS----> (D=SPECIFIED DISPLACEMENT (IN. OR RAD.) (S=SPRING STIFFNESS (IN. OR RAD., AND LBS.) X-DIRECTION	Y-DIRECTION	Z-DIRECTION
1	.000E+00	.000E+00			S= 4.333E+04
2	.000E+00	1.440E+02			S= 3.000E+04
3	.000E+00	2.880E+02			S= 4.333E+04
4	.000E+00	4.320E+02	D= .000E+00		S= 1.500E+04
5	1.560E+02	.000E+00			S= 3.000E+04
6	3.120E+02	.000E+00			S= 4.333E+04
7	4.680E+02	.000E+00			S= 3.000E+04
8	6.240E+02	.000E+00			S= 4.333E+04
9	6.240E+02	2.880E+02			S= 2.500E+04
10	6.240E+02	4.320E+02	D= .000E+00		
11	7.800E+02	.000E+00			S= 3.000E+04
12	9.360E+02	.000E+00			S= 4.333E+04
13	9.360E+02	2.880E+02			S= 2.500E+04
14	9.360E+02	4.320E+02	D= .000E+00		
15	1.092E+03	.000E+00			S= 3.000E+04
16	1.248E+03	.000E+00			S= 4.333E+04
17	1.404E+03	.000E+00			S= 3.000E+04
18	1.560E+03	.000E+00			S= 4.333E+04
19	1.560E+03	1.440E+02			S= 3.000E+04
20	1.560E+03	2.880E+02			S= 4.333E+04
21	1.560E+03	4.320E+02	D= .000E+00		S= 1.500E+04

III.--MEMBER DATA

MEM	FROM JT	TO JT	LENGTH (IN)	TORSION INERTIA (IN**4)	BENDING INERTIA (IN**4)	SHEAR AREA (SQIN)	<------MODULI------> E (PSI)	G (PSI)
1	1	2	144.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
2	2	3	144.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
3	3	4	144.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
4	1	5	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
5	5	6	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
6	6	7	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
7	7	8	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
8	8	11	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
9	11	12	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
10	12	15	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
11	15	16	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
12	16	17	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
13	17	18	156.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
14	18	19	144.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
15	19	20	144.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
16	20	21	144.00	1.932E+04	3.150E+04	350.00	3.600E+06	1.500E+06
17	3	6	424.60	1.927E+04	1.843E+04	320.00	3.600E+06	1.500E+06
18	6	9	424.60	1.927E+04	1.843E+04	320.00	3.600E+06	1.500E+06
19	9	10	144.00	1.927E+04	1.843E+04	320.00	3.600E+06	1.500E+06
20	9	13	312.00	1.927E+04	1.843E+04	320.00	3.600E+06	1.500E+06
21	13	14	144.00	1.927E+04	1.843E+04	320.00	3.600E+06	1.500E+06
22	13	16	424.60	1.927E+04	1.843E+04	320.00	3.600E+06	1.500E+06
23	16	19	343.63	1.927E+04	1.843E+04	320.00	3.600E+06	1.500E+06

a. Echoprint of generated data (Continued)

Figure 11. Generated data for Example 2 plus a plot of input geometry (Continued)

IV.--INDEPENDENT LOAD CASE DATA

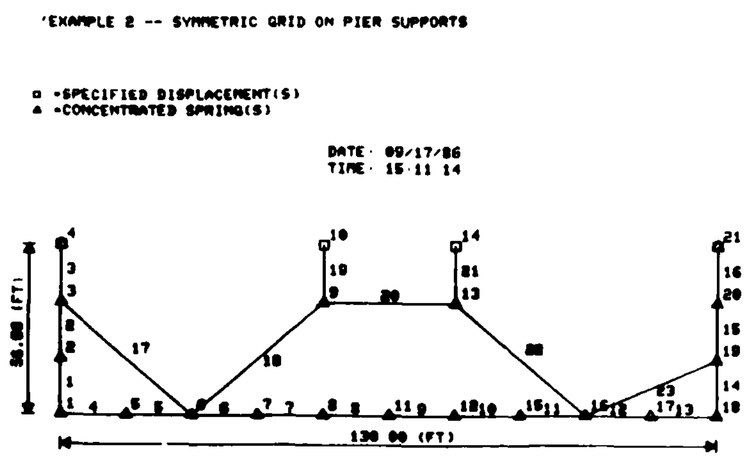
IV.A.--LOAD CASE NUMBER 1

TITLE: NONE

JT. NO.	X-MOMENT (LB-IN)	Y-MOMENT (LB-IN)	Z-FORCE (LB)
	<--------------JOINT LOADS-------------->		
1	.000E+00	.000E+00	-1.500E+04
6	.000E+00	.000E+00	-2.800E+04
8	.000E+00	.000E+00	-2.800E+04
12	.000E+00	.000E+00	-2.800E+04
16	.000E+00	.000E+00	-2.800E+04
18	.000E+00	.000E+00	-1.500E+04

MEM. NO.	LOAD TYPE	DIST. FROM 'FROM' END (IN)	X-TORSION (LB-IN OR LBS)	Y-MOMENT (LB-IN OR LBS)	Z-FORCE (LB/IN OR LBS)
		<-----------------------MEMBER LOADS----------------------->			
1	TRAP	.00	.000E+00	.000E+00	-7.083E+01
		144.00	.000E+00	.000E+00	-8.542E+01
2	TRAP	.00	.000E+00	.000E+00	-8.542E+01
		144.00	.000E+00	.000E+00	-1.000E+02
3	UNIF		.000E+00	.000E+00	-1.000E+02
4	UNIF		.000E+00	.000E+00	-7.083E+01
5	UNIF		.000E+00	.000E+00	-7.083E+01
6	UNIF		.000E+00	.000E+00	-7.083E+01
7	UNIF		.000E+00	.000E+00	-7.083E+01
8	UNIF		.000E+00	.000E+00	-7.083E+01
9	UNIF		.000E+00	.000E+00	-7.083E+01
10	UNIF		.000E+00	.000E+00	-7.083E+01
11	UNIF		.000E+00	.000E+00	-7.083E+01
12	UNIF		.000E+00	.000E+00	-7.083E+01
13	UNIF		.000E+00	.000E+00	-7.083E+01
14	TRAP	.00	.000E+00	.000E+00	-7.083E+01
		144.00	.000E+00	.000E+00	-8.542E+01
15	TRAP	.00	.000E+00	.000E+00	-8.542E+01
		144.00	.000E+00	.000E+00	-1.000E+02
16	UNIF		.000E+00	.000E+00	-1.000E+02

a. (Concluded)



b. Plot of input geometry for Example 2

Figure 11. (Concluded)

supports and specified displacements. When both a spring support and a specified displacement are both applied to the same component of joint displacement, the specified displacement overrides the spring support. Member cross section torsion and bending inertias and shear area have been calculated from section dimensions which were input.

33. Output data are given in Figure 12. Member forces grouped by member were omitted since this section would add no new information. A structure bending moment plot and typical member plots are included in Figure 12.

PROGRAM CGRID - ANALYSIS OF PLANE GRID STRUCTURES
DATE: 09/17/86 TIME: 11:27:21
HEADING:
'EXAMPLE 2 -- SYMMETRIC GRID ON PIER SUPPORTS

****
* INDEPENDENT LOAD CASE 1 *
*TITLE: NONE *
****

<-------------------------JOINT DISPLACEMENTS-------------------------->

JT. NO.	<--COORDINATES (FT)--> X	Y	X-ROTATION (RAD)	Y-ROTATION (RAD)	Z-DISP. (IN)
1	.000E+00	.000E+00	6.160E-04	4.770E-04	-5.249E-01
2	.000E+00	1.200E+01	5.397E-04	3.870E-04	-4.377E-01
3	.000E+00	2.400E+01	2.677E-04	2.971E-04	-3.775E-01
4	.000E+00	3.600E+01	.000E+00	2.971E-04	-3.626E-01
5	1.300E+01	.000E+00	1.023E-03	4.727E-04	-5.941E-01
6	2.600E+01	.000E+00	1.429E-03	7.836E-05	-6.532E-01
7	3.900E+01	.000E+00	1.455E-03	1.171E-04	-6.563E-01
8	5.200E+01	.000E+00	1.481E-03	6.672E-05	-6.853E-01
9	5.200E+01	2.400E+01	7.061E-04	-6.042E-04	-7.752E-02
10	5.200E+01	3.600E+01	.000E+00	-6.042E-04	-2.668E-02
11	6.500E+01	.000E+00	1.507E-03	3.751E-06	-6.765E-01
12	7.800E+01	.000E+00	1.533E-03	-6.033E-05	-6.864E-01
13	7.800E+01	2.400E+01	7.124E-04	5.670E-04	-7.247E-02
14	7.800E+01	3.600E+01	.000E+00	5.670E-04	-2.117E-02
15	9.100E+01	.000E+00	1.559E-03	-1.192E-04	-6.580E-01
16	1.040E+02	.000E+00	1.585E-03	-1.069E-04	-6.527E-01
17	1.170E+02	.000E+00	1.115E-03	-4.625E-04	-5.927E-01
18	1.300E+02	.000E+00	6.440E-04	-4.518E-04	-5.265E-01
19	1.300E+02	1.200E+01	5.670E-04	-3.416E-04	-4.356E-01
20	1.300E+02	2.400E+01	2.236E-04	-3.416E-04	-3.773E-01
21	1.300E+02	3.600E+01	.000E+00	-3.416E-04	-3.655E-01

<-------REACTIONS DUE TO SPECIFIED DISPLACEMENTS OR CONCENTRATED SPRINGS------

JT. NO.	<--COORDINATES (FT)--> X	Y	X-MOMENT (KP-IN)	Y-MOMENT (KP-IN)	Z-FORCE (KP)
1	.000E+00	.000E+00			2.275E+01(S
2	.000E+00	1.200E+01			1.313E+01(S
3	.000E+00	2.400E+01			1.636E+01(S
4	.000E+00	3.600E+01	-2.568E+02(D)		5.439E+00(S
5	1.300E+01	.000E+00			1.782E+01(S
6	2.600E+01	.000E+00			2.830E+01(S
7	3.900E+01	.000E+00			1.969E+01(S
8	5.200E+01	.000E+00			2.970E+01(S
9	5.200E+01	2.400E+01			1.938E+00(S
10	5.200E+01	3.600E+01	-3.254E+02(D)		
11	6.500E+01	.000E+00			2.030E+01(S
12	7.800E+01	.000E+00			2.974E+01(S
13	7.800E+01	2.400E+01			1.812E+00(S
14	7.800E+01	3.600E+01	-3.283E+02(D)		
15	9.100E+01	.000E+00			1.974E+01(S
16	1.040E+02	.000E+00			2.829E+01(S
17	1.170E+02	.000E+00			1.778E+01(S
18	1.300E+02	.000E+00			2.281E+01(S
19	1.300E+02	1.200E+01			1.307E+01(S
20	1.300E+02	2.400E+01			1.635E+01(S
21	1.300E+02	3.600E+01	-2.252E+02(D)		5.482E+00(S

a. Joint displacements, reactions, and member forces (Continued)

Figure 12. Output data for Example 2 (Sheet 1 of 6)

<-----------------MEMBER END FORCES----------------->

MEM. NO.	JT. NO.	X-TORSION (KP-IN)	Y-MOMENT (KP-IN)	Z-FORCE (KP)
1	1	1.810E+01	-7.552E+01	3.790E+00
	2	-1.810E+01	3.146E+02	7.460E+00
2	2	1.810E+01	-3.146E+02	5.669E+00
	3	-1.810E+01	4.343E+02	7.681E+00
3	3	-3.492E-12	-5.104E+02	8.961E+00
	4	3.492E-12	2.568E+02	5.439E+00
4	1	-7.552E+01	-1.810E+01	3.956E+00
	5	7.552E+01	2.629E+02	7.094E+00
5	5	-7.552E+01	-2.629E+02	1.073E+01
	6	7.552E+01	-5.489E+02	3.210E-01
6	6	-4.830E+00	1.328E+02	1.620E+00
	7	4.830E+00	4.764E+02	9.430E+00
7	7	-4.830E+00	-4.764E+02	1.026E+01
	8	4.830E+00	-2.623E+02	7.896E-01
8	8	-4.830E+00	2.623E+02	9.070E-01
	11	4.830E+00	4.581E+02	1.014E+01
9	11	-4.830E+00	-4.581E+02	1.015E+01
	12	4.830E+00	-2.639E+02	8.966E-01
10	12	-4.830E+00	2.639E+02	8.483E-01
	15	4.830E+00	4.656E+02	1.020E+01
11	15	-4.830E+00	-4.656E+02	9.538E+00
	16	4.830E+00	-1.603E+02	1.512E+00
12	16	8.741E+01	5.105E+02	4.527E-01
	17	-8.741E+01	2.807E+02	1.060E+01
13	17	8.741E+01	-2.807E+02	7.183E+00
	18	-8.741E+01	2.218E+01	3.867E+00
14	18	-2.218E+01	-8.741E+01	3.946E+00
	19	2.218E+01	3.040E+02	7.304E+00
15	19	-2.794E-12	-3.885E+02	5.916E+00
	20	2.794E-12	4.726E+02	7.434E+00
16	20	.000E+00	-4.726E+02	8.918E+00
	21	.000E+00	2.252E+02	5.482E+00
17	3	-6.818E+01	-3.830E+01	-2.811E-01
	6	6.818E+01	1.577E+02	2.811E-01
18	6	6.767E+01	4.091E+02	-1.919E+00
	9	-6.767E+01	4.056E+02	1.919E+00
19	9	.000E+00	-3.254E+02	.000E+00
	10	.000E+00	3.254E+02	.000E+00
20	9	-5.809E-01	-2.521E+02	1.942E-02
	13	5.809E-01	2.461E+02	-1.942E-02
21	13	1.397E-12	-3.283E+02	1.455E-13
	14	-1.397E-12	3.283E+02	-1.455E-13
22	13	-7.475E+01	-4.039E+02	1.831E+00
	16	7.475E+01	-3.736E+02	-1.831E+00
23	16	8.602E+01	-6.718E+01	1.510E-01
	19	-8.602E+01	1.528E+01	-1.510E-01

a. (Continued)

Figure 12. (Sheet 2 of 6)

<------MAXIMUM MEMBER INTERNAL FORCES (UNITS ARE 'IN' AND 'KP')------>

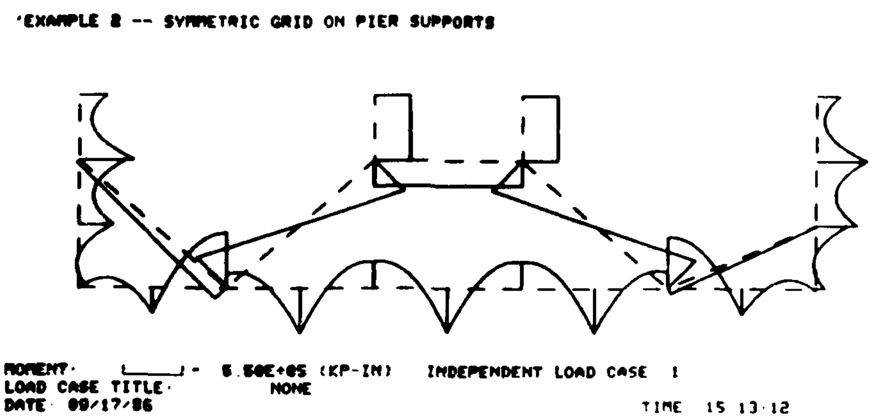
MEM. NO.	ITEM	MAXIMUM POSITIVE	DIST. FROM 'FROM' END	MAXIMUM NEGATIVE	DIST. FROM 'FROM' END
1	X-TORSION:	1.810E+01	1.440E+02	.000E+00	.000E+00
	Y-MOMENT :	2.340E+01	5.160E+01	-3.146E+02	1.440E+02
	Z-SHEAR :	3.790E+00	.000E+00	-7.460E+00	1.440E+02
2	X-TORSION:	1.810E+01	1.440E+02	.000E+00	.000E+00
	Y-MOMENT :	.000E+00	.000E+00	-4.343E+02	1.440E+02
	Z-SHEAR :	5.669E+00	.000E+00	-7.681E+00	1.440E+02
3	X-TORSION:	.000E+00	.000E+00	-3.492E-12	1.440E+02
	Y-MOMENT :	.000E+00	.000E+00	-5.104E+02	.000E+00
	Z-SHEAR :	8.961E+00	.000E+00	-5.439E+00	1.440E+02
4	X-TORSION:	.000E+00	.000E+00	-7.552E+01	1.560E+02
	Y-MOMENT :	9.234E+01	5.584E+01	-2.629E+02	1.560E+02
	Z-SHEAR :	3.956E+00	.000E+00	-7.094E+00	1.560E+02
5	X-TORSION:	.000E+00	.000E+00	-7.552E+01	1.560E+02
	Y-MOMENT :	5.496E+02	1.515E+02	-2.629E+02	.000E+00
	Z-SHEAR :	1.073E+01	.000E+00	-3.210E-01	1.560E+02
6	X-TORSION:	.000E+00	.000E+00	-4.830E+00	1.560E+02
	Y-MOMENT :	1.513E+02	2.287E+01	-4.764E+02	1.560E+02
	Z-SHEAR :	1.620E+00	.000E+00	-9.430E+00	1.560E+02
7	X-TORSION:	.000E+00	.000E+00	-4.830E+00	1.560E+02
	Y-MOMENT :	2.667E+02	1.449E+02	-4.764E+02	.000E+00
	Z-SHEAR :	1.026E+01	.000E+00	-7.896E-01	1.560E+02
8	X-TORSION:	.000E+00	.000E+00	-4.830E+00	1.560E+02
	Y-MOMENT :	2.681E+02	1.280E+01	-4.581E+02	1.560E+02
	Z-SHEAR :	9.070E-01	.000E+00	-1.014E+01	1.560E+02
9	X-TORSION:	.000E+00	.000E+00	-4.830E+00	1.560E+02
	Y-MOMENT :	2.696E+02	1.433E+02	-4.581E+02	.000E+00
	Z-SHEAR :	1.015E+01	.000E+00	-8.966E-01	1.560E+02
10	X-TORSION:	.000E+00	.000E+00	-4.830E+00	1.560E+02
	Y-MOMENT :	2.690E+02	1.198E+01	-4.656E+02	1.560E+02
	Z-SHEAR :	8.483E-01	.000E+00	-1.020E+01	1.560E+02
11	X-TORSION:	.000E+00	.000E+00	-4.830E+00	1.560E+02
	Y-MOMENT :	1.765E+02	1.346E+02	-4.656E+02	.000E+00
	Z-SHEAR :	9.538E+00	.000E+00	-1.512E+00	1.560E+02
12	X-TORSION:	8.741E+01	1.560E+02	.000E+00	.000E+00
	Y-MOMENT :	5.120E+02	6.391E+00	-2.807E+02	1.560E+02
	Z-SHEAR :	4.527E-01	.000E+00	-1.060E+01	1.560E+02
13	X-TORSION:	8.741E+01	1.560E+02	.000E+00	.000E+00
	Y-MOMENT :	8.341E+01	1.014E+02	-2.807E+02	.000E+00
	Z-SHEAR :	7.183E+00	.000E+00	-3.867E+00	1.560E+02
14	X-TORSION:	.000E+00	.000E+00	-2.218E+01	1.440E+02
	Y-MOMENT :	1.974E+01	5.365E+01	-3.040E+02	1.440E+02
	Z-SHEAR :	3.946E+00	.000E+00	-7.304E+00	1.440E+02

a. (Continued)

Figure 12. (Sheet 3 of 6)

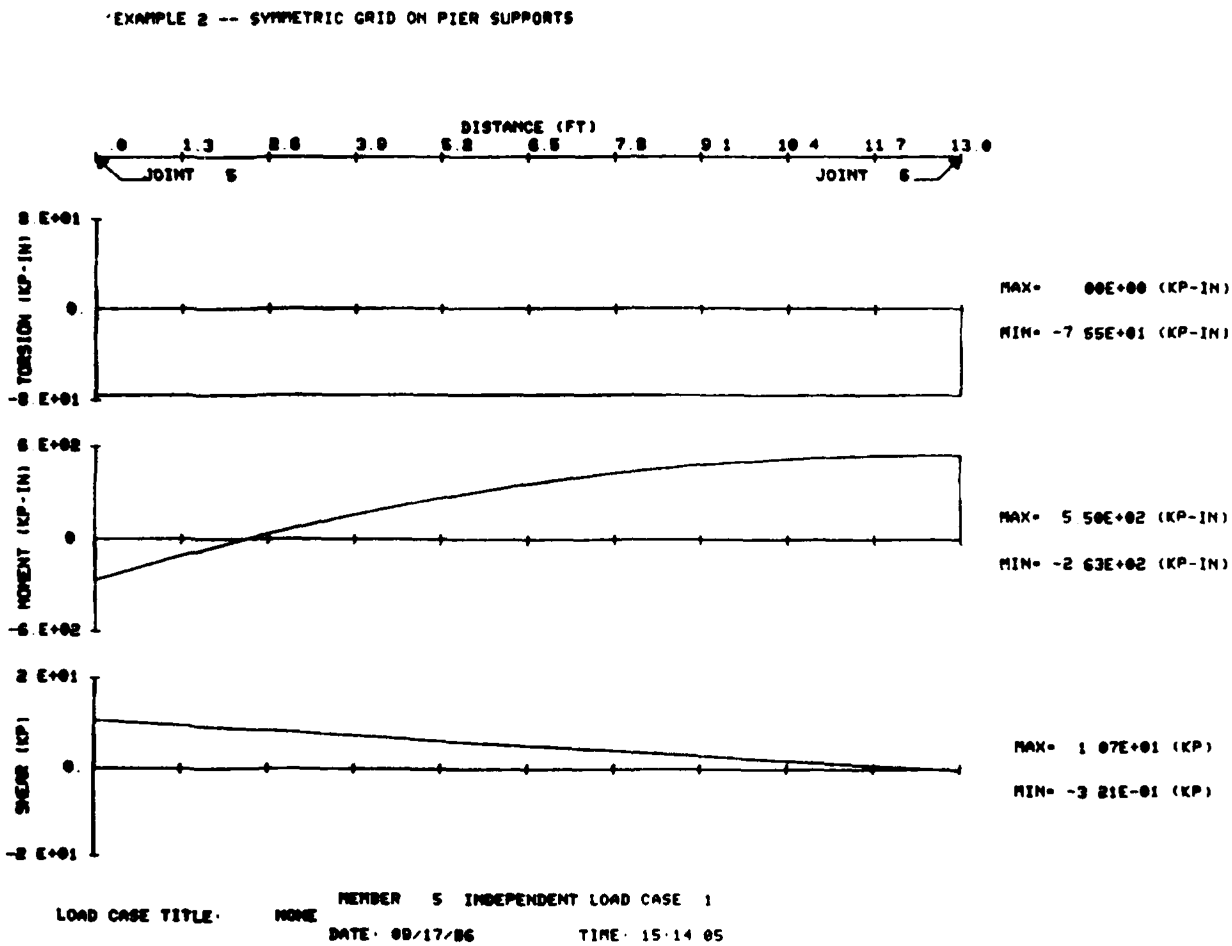
15	X-TORSION:	.000E+00	.000E+00	-2.794E-12	1.440E+02
	Y-MOMENT :	.000E+00	.000E+00	-4.726E+02	1.440E+02
	Z-SHEAR :	5.916E+00	.000E+00	-7.434E+00	1.440E+02
16	X-TORSION:	.000E+00	1.440E+02	.000E+00	1.440E+02
	Y-MOMENT :	.000E+00	.000E+00	-4.726E+02	.000E+00
	Z-SHEAR :	8.918E+00	.000E+00	-5.482E+00	1.440E+02
17	X-TORSION:	.000E+00	.000E+00	-6.818E+01	4.246E+02
	Y-MOMENT :	.000E+00	.000E+00	-1.577E+02	4.246E+02
	Z-SHEAR :	.000E+00	.000E+00	-2.811E-01	4.246E+02
18	X-TORSION:	6.767E+01	4.246E+02	.000E+00	.000E+00
	Y-MOMENT :	4.091E+02	.000E+00	-4.056E+02	4.246E+02
	Z-SHEAR :	.000E+00	.000E+00	-1.919E+00	4.246E+02
19	X-TORSION:	.000E+00	1.440E+02	.000E+00	1.440E+02
	Y-MOMENT :	.000E+00	.000E+00	-3.254E+02	1.440E+02
	Z-SHEAR :	.000E+00	1.440E+02	.000E+00	1.440E+02
20	X-TORSION:	.000E+00	.000E+00	-5.809E-01	3.120E+02
	Y-MOMENT :	.000E+00	.000E+00	-2.521E+02	.000E+00
	Z-SHEAR :	1.942E-02	3.120E+02	.000E+00	.000E+00
21	X-TORSION:	1.397E-12	1.440E+02	.000E+00	.000E+00
	Y-MOMENT :	.000E+00	.000E+00	-3.283E+02	.000E+00
	Z-SHEAR :	1.455E-13	1.440E+02	.000E+00	.000E+00
22	X-TORSION:	.000E+00	.000E+00	-7.475E+01	4.246E+02
	Y-MOMENT :	3.736E+02	4.246E+02	-4.039E+02	.000E+00
	Z-SHEAR :	1.831E+00	4.246E+02	.000E+00	.000E+00
23	X-TORSION:	8.602E+01	3.436E+02	.000E+00	.000E+00
	Y-MOMENT :	.000E+00	.000E+00	-6.718E+01	.000E+00
	Z-SHEAR :	1.510E-01	3.436E+02	.000E+00	.000E+00

a. *(Concluded)*



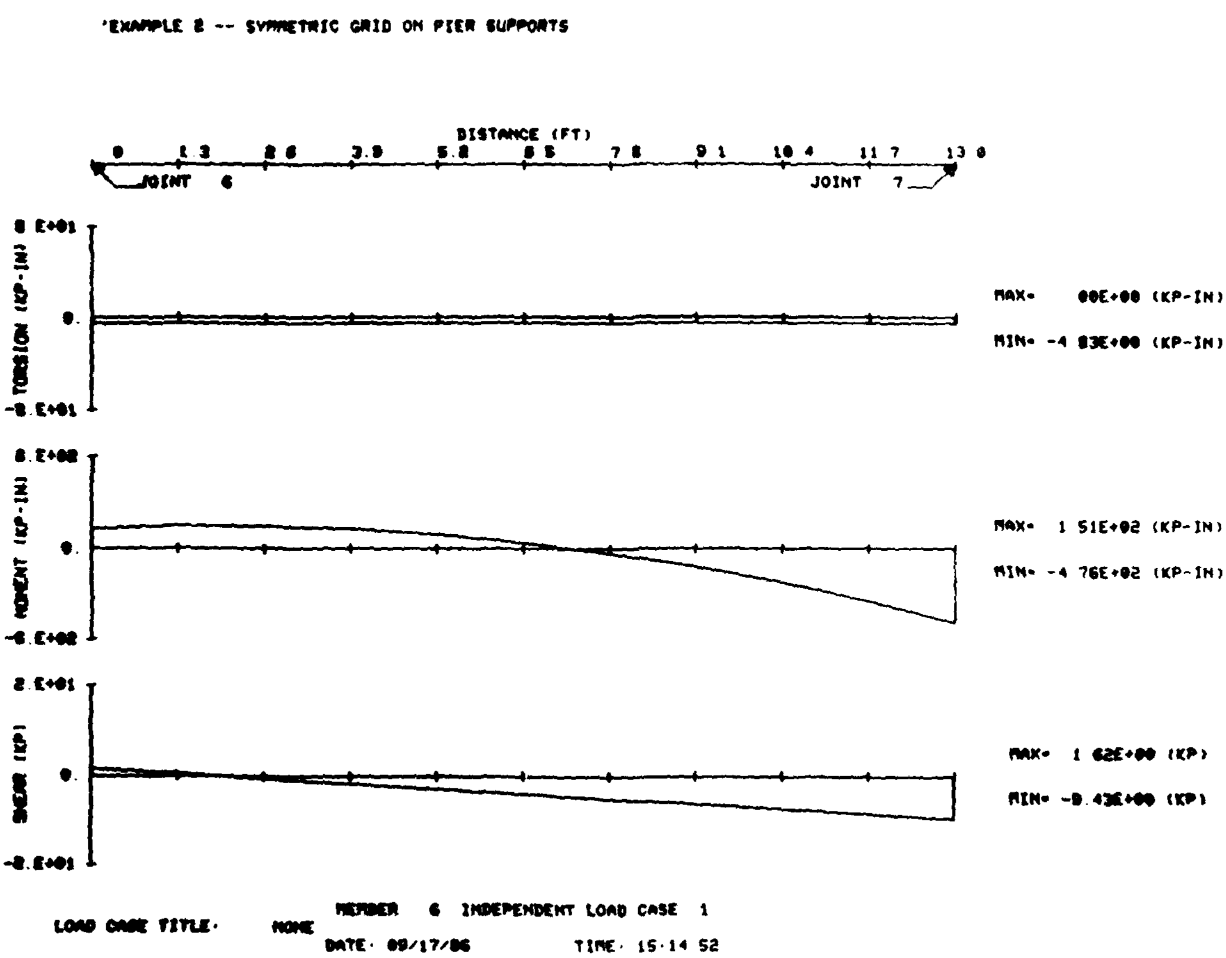
b. Moment plot of structure for independent load case 1

Figure 12. (Sheet 4 of 6)



c. Shear, moment, and torsion plot of member 5 for independent load case 1

Figure 12. (Sheet 5 of 6)



d. Shear, moment, and torsion plot of member 6 for independent load case 1

Figure 12. (Sheet 6 of 6)

APPENDIX A: GUIDE FOR DATA INPUT

Source of Input

1. Input data may be supplied from a predefined data file or from the user's terminal during execution. When data are entered during execution, prompts are provided to indicate the amount and character of data to be entered. Furthermore, when data are entered during execution, the user may direct the program to save the input data to a permanent file in input file format.

Data Format

2. All input data (whether supplied from the user terminal or from a file) are read in free-field format:

a. Data items must be separated by one or more blanks (comma separators are not permitted).

b. Integer numbers must be of form NNN.

c. Real numbers may be of form

±xxx or ±xx.xx or ±xx.xxE±ee.

d. User responses to all requests for control by the program for alphanumeric input maybe abbreviated by the first letter of the indicated word response, e.g.,

ENTER 'YES' OR 'NO' -- respond Y or N.

Sections of Input

3. Input data are divided into the following sections:

a. Heading (required).

b. Geometry (required).

c. Cross-Section Data (required).

d. Material Properties (required).

e. Member End Force Releases (optional).

f. Specified Joint Displacements (optional if spring supports provided).

g. Spring Supports (optional if specified displacements provided).

h. Independent Load Case Data (required).

i. Load Combinations (optional).

j. Termination (required).

When data are entered from the terminal, the user is prompted for each section. When data are read from a file, the order of sections shown above must be preserved.

Units

4. The program recognizes the following units (acceptable abbreviations indicated by underlined capital letters):

a. Length: Inches, Feet, Centimeters, Meters.

b. Force: Pounds, KIPS = KP, Newtons, KILonewtons = KN.

Default units are Inches and Pounds.

5. In the following paragraphs, the notation [{'units'}] indicates that any desired combination of length (first) units followed by force units are to appear as the last two data items on that line. If a data section (i.e., Geometry or Specified Displacements) requires only length units, force units may be omitted. If a section requires both length and force units, then both units must be provided. If units are omitted entirely, default is to inches and pounds.

Predefined Data File

6. In addition to the general format requirements given in paragraph 5 above, the following pertain to a predefined data file and to the input data description which follows:

a. Each line must commence with a nonzero, positive integer line number, denoted LN below.

b. A line of input may require both alphanumeric and numeric data items. Alphanumeric data items are enclosed in single quotes in the following paragraphs.

c. A line of input may require a keyword. The acceptable abbreviation for the keyword is indicated by underlined capital letters, e.g., the acceptable abbreviation for the keyword 'Load' is 'L'.

d. Lower case words in single quotes indicate a choice of keywords defined following.

e. Items designed by upper case letters and numbers without quotes indicate numeric data values. Numeric data values are either real or integer according to standard FORTRAN variable naming conventions.

f. Data items enclosed in brackets [ ] may not be required. Data items enclosed in braces { } indicate special note follows.

g. Input data are divided into the sections discussed in paragraph 3 above. Except for the heading, each section consists of a header line and one or more data lines.

h. Comment lines may be inserted in the input file by enclosing the line, following the line number, in parentheses. Comment lines are ignored, e.g.,

1234b̸ (THIS LINE IS IGNORED).

Input Guide

7. HEADING -- One (1) or more lines

a. Line Contents

LN 'heading'

b. Definition

'heading' = any alphanumeric information up to 80 characters including LN and any embedded blanks. The first nonblank character following LN must be a single quote ('). At least one heading line must be provided.

8. GEOMETRY -- One (1), or five (5) or more lines

a. Control -- one (1) line

(1) Line Contents

LN 'type' [NX HX NY HY SKEW] [{'units'}]

(2) Definitions

'type' = 'Rectangular' if node numbers, node coordinates, member numbers, and member connectivity are to be generated automatically for a parallelogram structure.

= 'Line' if node data and member connectivity are provided.

NX = number of members parallel to global X-axis.

HX = length of members parallel to global X-axis.

NY = number of members parallel (nominally) to global Y-axis.

HY = length of projection on global Y-axis of members parallel (nominally) to global Y-axis.

SKEW = angle (degrees) between global Y-axis and member axis of members parallel (nominally) to global Y-axis.

[omit NX, HX, NY, HY, SKEW] if 'type' = 'Line'

b. Joint Data Lines for type = 'Line' -- two (2) or more lines

(1) Control -- one (1) line

(a) Line Contents

LN 'Joint [coordinates]'

(b) Definition

'Joint [coordinates]' = keyword

(2) Joint Data Lines -- one (1) or more lines

(a) Line Contents

LN JSTART XSTART YSTART [JSTOP XSTOP YSTOP] [JINCR]]

(b) Definitions

JSTART = joint number at start of line of joints.

XSTART, YSTART = global X- and Y-coordinates of JSTART.

JSTOP = joint number at end of line of joints.

XSTOP, YSTOP = global X- and Y-coordinates of JSTOP.

JINCR = increment in joint number; assumed to be equal to one (1) if omitted.

(3) Discussion

(a) Joint coordinates are generated at equal intervals along a straight line between JSTART and JSTOP. The number of joints generated is given by

N = (JSTOP-JSTART)/JINCR (therefore N * JINCR must be equal to (JSTOP-JSTART))

Increments in coordinates are:

ΔX = (XSTOP-XSTART)/N
ΔY = (YSTOP-YSTART)/N

Resulting generated data are:

Joint No.	X-Coord	Y-Coord
JSTART	XSTART	YSTART
JSTART+JINCR	XSTART+ΔX	YSTART+ΔY
JSTART+2*JINCR	XSTART+2*ΔX	YSTART+2*ΔY
.	.	.
.	.	.
.	.	.
JSTOP	XSTOP	YSTOP

(b) If JSTOP, XSTOP, YSTOP, JINCR are all omitted, only one joint is generated.

(c) If any joint is referenced more than once, only the data for the last reference are used.

c. Member Connectivity Data Lines for 'type' = 'Line' -- two (2) or more lines

(1) Control -- one (1) line

(a) Line Contents

LN 'Member [connectivity]'

(b) Definition

'Member [connectivity]' = keyword

(2) Member Connectivity Data Lines -- one (1) or more lines

(a) Line Contents

LN MSTART ISTART JSTART
[MSTOP [MINCR IINCR JINCR]]

(b) Definitions

MSTART = member number at start of sequence.

ISTART = joint number at "front" end of MSTART.

JSTART = joint number at "to" end of MSTART.

MSTOP = member number at end of the sequence of members.

MINCR = increment in member number.

IINCR = increment in "from" end joint number.

JINCR = increment in "to" end joint number.

(c) Discussion

1. Member connectivity data are generated for a sequence of members from MSTART to MSTOP. MSTART, MSTOP, MINCR must conform to:

N = (MSTOP-MSTART)/MINCR;
N * MINCR = (MSTOP-MSTART)

Resulting generated data are:

Member No.	"from" joint	"to" joint
MSTART	ISTART	JSTART
MSTART+MINCR	ISTART+IINCR	JSTART+JINCR
MSTART+2*MINCR	ISTART+2*IINCR	JSTART+2*JINCR
.	.	.
.	.	.
.	.	.
MSTOP	ISTART+N*IINCR	JSTART+N*JINCR

2. If MINCR, IINCR, and JINCR are omitted, all are assumed to be equal to one (1).

3. If MSTOP, MINCR, IINCR, and JINCR are omitted, only one member is generated.

4. If any member is referenced more than once, only the data for the last reference are used.

d. Restrictions

(1) A maximum of one hundred (100) joints is permitted in the structure. The number of joints generated for a 'Rectangular' mesh is NJ = (NX+1)(NY+1), with joint numbers assigned consecutively from 1 to NJ. When joint data are provided line-by-line, it is assumed that the total number of joints in the mesh, NJ, is equal to the highest joint number encountered in all joint data lines (must be less than or equal to 100). Joint data must be provided for all joints consecutively from 1 to NJ.

(2) A maximum of one hundred eighty (180) members is permitted in the structure. The number of members generated for a rectangular mesh is NM = 2*NX*NY+NX+NY, with members numbered consecutively from 1 to NM. When member connectivity data are provided line-by-line, it is assumed that the total number of members in the structure, NM, is equal to the highest member number encountered in all member connectivity data lines (must be less than 180). Member connectivity data must be provided for all members consecutively from 1 to NM.

(3) In addition to the limits on number of joints and members stated above, the maximum difference, B, between "from" joint number and "to" joint number for all members must conform to the following limitation:

(3B+4)(3*NJ-3B/2)+3*NJ<=12000

9. MEMBER CROSS SECTIONS -- Two (2) or more lines

a. Control -- one (1) line

(1) Line Contents

LN 'Cross [section]' [{'units'}]

(2) Definition

'Cross [section]' = keyword

b. Cross-Section Data Lines

(1) Data Lines for Area Properties -- zero (0) or one (1) or more lines; entire subsection may be omitted.

(a) Line Contents

LN 'Properties' MSTART XJ YI AS [MSTOP [MINCR]]

(b) Definitions

'Properties' = keyword.

MSTART = member number at start of sequence.

XJ = torsional moment of inertia.

YI = cross-section moment of inertia for bending about member local Y-axis.

AS = cross-section shear area; if specified to be zero, shear deformations are excluded.

MSTOP = member number at end of sequence.

MINCR = increment in member number; assumed to be equal to one (1) if omitted.

(2) Data Lines for Section Dimensions -- zero (0) or one (1) or more lines; entire subsection may be omitted.

(a) Line Contents

LN 'Dimensions' MSTART B H SHRFAC
[MSTOP [MINCR]]

(b) Definitions

'Dimensions' = keyword.

MSTART = member number at start of sequence.

B = width of rectangular section.

H = height of rectangular section.

SHRFAC = indicator for shear effects; if equal to zero (0), shear deformations are excluded.

MSTOP = member number at end of sequence.

MINCR = increment in member number; assumed to be one (1) if omitted.

c. Discussion

(1) Identical section properties or dimensions are assigned to members MSTART, MSTART+MINCR, MSTART+2*MINCR, -----, MSTOP in each sequence.

(2) Every member in the structure (1 to NM) must be assigned either section properties or dimensions. Except for AS and/or SHRFAC, properties and/or dimensions must be positive and nonzero.

(3) Moments of inertia and area are obtained from section dimensions as follows:

$YI = BH^3/12$

$XJ = CHB^3$ for H>B, or

$XJ = CH^3B$ for H<B, where C is interpolated from the following table.

H/B	1	1.5	2.0	2.5	3	5	10	20
C	0.141	0.196	0.229	0.249	0.263	0.291	0.312	0.333

$AS = BH/1.2$ for SHRFAC not equal to zero

(4) If any member is referenced more than once, only the data for the last reference are used.

(5) If MSTOP and MINCR are omitted, only one member is generated.

(6) Any member greater than NM is ignored.

10. MATERIAL PROPERTIES -- Two (2) or more lines

a. Control -- one (1) line

(1) Line Contents

LN 'Materials' [{'units'}]

(2) Definition

'Materials' = keyword

b. Data Lines -- one (1) or more lines

(1) Line Contents

LN MSTART E G [MSTOP [MINCR]]

(2) Definitions

MSTART = member number at start of sequence.

E = modulus of elasticity.

G = shear modulus.

MSTOP = member number at end of sequence.

MINCR = increment in member number; assumed to be one (1) if omitted.

c. Discussion

(1) Identical material properties are assigned to members MSTART, MSTART+MINCR, MSTART+2*MINCR, MSTOP in each sequence.

(2) Every member in the structure (1 to NM) must be assigned positive, nonzero values of E and G.

(3) If any member is referenced more than once, only the data for the last reference are used.

(4) If MSTOP and MINCR are omitted, only one member is generated.

(5) Any member number greater than NM is ignored.

11. MEMBER END FORCE RELEASES -- Zero (0) or one (1) or more lines; entire section may be omitted.

a. Line Contents

LN 'Releases' MSTART {'end'} {'specs'} [MSTOP [MINCR]]

b. Definitions

'Releases' = keyword.

MSTART = member number at start of sequence.

{'end'} = 'From' if releases are imposed at "from" end of member.
= 'To' if releases are imposed at "to" end of member.

{'spec'} = any combination (1 to 3) of following keywords:

'Bending' if bending moment is zero.
'Torsion' if torsion is zero.
'Shear' if shear force is zero.

MSTOP = member number at end of sequence.

MINCR = increment in member number; assumed to be one (1) if omitted.

c. Discussion

(1) Identical member releases are assigned to MSTART, MSTART+MINCR, START+2*MINCR, -----, MSTOP in each sequence.

(2) If MSTOP and MINCR are both omitted, only one member is generated.

(3) Torsion force may not be released at both ends of a member.

(4) Shear force may not be released at both ends of a member.

(5) If any member is referenced more than once, only the data for the last reference are used.

(6) Any member number greater than NM is ignored.

12. SPECIFIED JOINT DISPLACEMENTS -- Zero (0) or two (2) or more lines; entire section may be omitted.

a. Control -- one (1) line

(1) Line Contents

LN 'Displacements' [{'units'}]

(2) Definition

'Displacements' = keyword

b. Data Lines -- one (1) or more lines

(1) Line Contents

LN JSTART {XR} {YR} {ZD} [JSTOP[JINCR]]

(2) Definitions

JSTART = joint number at start of sequence.

{XR} = specified rotation (rad.) about global X-axis.
= 'Free' if X-rotation is unrestrained.

{YR} = specified rotation (rad.) about global Y-axis.
= 'Free' if Y-rotation is unrestrained.

{ZD} = specified displacement in global Z-direction.
= 'Free' if Z-displacement is unrestrained.

JSTOP = joint number at end of sequence.

JINCR = increment in joint number; assumed to be equal to one (1) if omitted.

c. Discussion

(1) Identical joint displacements are assigned to joints JSTART, JSTART+JINCR, JSTART+2*JINCR, -----, JSTOP in each sequence.

(2) If any joint is referenced more than once, only the data for the last reference are used.

(3) Any joint number greater than NJ is ignored.

(4) Sufficient joint displacements and/or spring supports must be applied to the structure to inhibit all rigid body motions.

13. SPRING SUPPORTS -- Zero (0) or two (2) or more lines; entire section may be omitted.

a. Control -- one (1) line

(1) Line Contents

LN 'Springs' [{'units'}]

(2) Definitions

'Springs' = keyword

b. Data Lines for Concentrated Springs -- zero (0) or one (1) or more lines; entire subsection may be omitted.

(1) Line Contents

LN 'Concentrated' JSTART XCS YCS ZCS
[JSTOP [JINCR]]

(2) Definitions

'Concentrated' = keyword.

JSTART = joint number at start of sequence.

XCS = stiffness (force*length/radian) of spring resisting rotation about global X-axis.

YCS = stiffness (force*length/radian) of spring resisting rotation about global Y-axis.

ZCS = stiffness (force/length) of spring resisting translation in global Z-direction.

JSTOP = joint number at end of sequence.

JINCR = increment in joint number.

c. Discussion

(1) Identical concentrated spring supports are applied to joint JSTART, JSTART+JINCR, JSTART+2*JINCR, -----, JSTOP in each sequence.

(2) If any joint is referenced more than once, only the data for the last reference are used.

(3) Any joint number greater than NJ is ignored.

(4) Sufficient joint displacements and/or spring supports must be applied to the structure to inhibit all rigid body motions.

14. INDEPENDENT LOAD CASES -- Two (2) or more lines

a. Control -- one line

(1) Line Contents

LN 'Loads' LCN [{'units'}] ['title']

(2) Definitions

'Loads' = keyword.

LCN = load case integer identifier (1 to 15).

'title' = any alphanumeric information to identify load case; length of 'title' must be such that this line does not exceed 80 characters; the first character of 'title' must be a single quote ('). 'title' may be placed on a second line following a line number.

(3) Discussion -- load case identifiers need not be consecutive but must be in ascending order.

b. Data Lines for Joint Loads -- zero (0) or one (1) or more lines; entire subsection may be omitted.

(1) Line Contents

LN 'Joint [loads]' JSTART XM YM ZF [JSTOP [JINCR]]

(2) Definitions

'Joint [loads]' = keyword.

JSTART = joint number at start of sequence.

XM = moment about global X-axis.

YM = moment about global Y-axis.

ZF = force in global Z-direction.

JSTOP = joint number at end of sequence.

JINCR = increment in joint number; assumed to be one (1) if omitted.

(3) Discussion

(a) Identical joint loads are applied to JSTART, JSTART+JINCR, JSTART+2*JINCR, -----, JSTOP in each sequence.

(b) If any joint is referenced more than once, JOINT LOAD DATA ARE CUMULATIVE.

(c) Any joint number greater than NJ is ignored.

c. Data Lines for Concentrated Member Loads -- zero (0) or one (1) or more lines; entire subsection may be omitted.

(1) Line Contents

LN 'Member [loads]' 'Concentrated' MSTART XL XCM YCM ZCF [MSTOP [MINCR]]

(2) Definitions

'Member [loads]' = keyword.

'Concentrated' = keyword.

MSTART = member number at start of sequence.

XL = distance from "from" end of member to point of application of concentrated load.

XCM = moment about member X-axis.

YCM = moment about member Y-axis.

ZCF = force in Z-direction.

MSTOP = member number at end of sequence.

MINCR = increment in member number; assumed to be equal to one (1) if omitted.

(3) Discussion

(a) Identical concentrated loads are applied to MSTART, MSTART+MINCR, MSTART+2*MINCR, -----, MSTOP in each sequence.

(b) If any member is referenced more than once, MEMBER LOAD DATA ARE CUMULATIVE.

(c) If the distance XL exceeds the length of the member, the load is ignored.

(d) Any member number greater than NM is ignored.

d. Data Lines for Uniformly Distributed Loads -- zero (0) or one (1) or more lines; entire subsection may be omitted.

(1) Line Contents

```
LN  'Member  [loads]'  'Uniform'  MSTART
    XDM  YDM  ZDF  [MSTOP [MINCR]]
```

(2) Definitions

'Member [loads]' = keyword.

'Uniform' = keyword.

MSTART = member number at start of sequence.

XDM = uniform distributed moment about member X-axis.

YDM = uniform distributed moment about member Y-axis.

ZDF = uniform distributed force in Z-direction.

MSTOP = member number at end of sequence.

MINCR = increment in member number, assumed to be equal to one (1) if omitted.

(3) Discussion

(a) Identical uniform distributed loads over the entire length of the member are applied to MSTART, MSTART+MINCR, MSTART+2*MINCR, -----, MSTOP in each sequence.

(b) If any member is referenced more than once, MEMBER LOAD DATA ARE CUMULATIVE.

(c) Any member number greater than NM is ignored.

e. Data Lines for Trapezoidally Distributed Member Loads -- zero (0) or one (1) or more lines; entire subsection may be omitted.

(1) Line Contents

```
LN  'Member [loads]'  Trapezoidal'  MSTART
    X1  XDM1  YDM1  ZDF1  X2  XDM2  YDM2  ZDF2
   [MSTOP [MINCR]]
```

(2) Definitions

'Member [loads]' = keyword.

'Trapezoidal' = keyword.

MSTART = member number at start of sequence.

X1 = distance from "from" end of member to start of load distribution.

XDMI = distributed moment about member X-axis at start of distribution.

YDMI = distributed moment about member Y-axis at start of distribution.

ZDFI = distributed force in Z-direction at start of distribution.

X2 = distance from "from" end of member at end of distribution.

XDM2, YDM2, ZDM2 = distributed loads at end of distribution.

MSTOP = member number at end of sequence.

MINCR = increment in member number.

(3) Discussion

(a) Trapezoidally distributed loads are applied to MSTART, MSTART+MINCR, MSTART+2*MINCR, -----, MSTOP in each sequence.

(b) If any member is referenced more than once, <u>MEMBER LOAD DATA ARE CUMULATIVE</u>.

(c) If X1 exceeds the length of any member in the sequence, the load for that member is ignored.

(d) If X2 exceeds the length of any member in the sequence, the distribution is terminated at the end of the member with values of load interpolated between X1 and X2.

(e) Any member number greater than NM is ignored.

<u>f</u>. Discussion of Load Case Data

(1) Repeat the entire section for each load case.

(2) No more than fifteen (15) independent load cases are permitted.

(3) At least one (1) load case is required.

15. LOAD COMBINATIONS -- Zero (0) or one (1) or more lines; entire section may be omitted.

<u>a</u>. Line Contents

LN 'Combine' LCCN NCOM LCN(1) C(1) LCN(2) C(2) ... LCN(NCOM) C(NCOM) ['title']

<u>b</u>. Definitions

'Combine' = keyword.

LCCN = integer identifying the combination.

NCOM = number of independent load cases in this combination.

LCN(1) = integer identifier of independent load case.

C(1) = scale factor to be applied to results of LCN(1).

'title' = any alphanumeric information to identify load combinations; length of 'title' must be such that length of this line does not exceed 80 characters; the first character of 'title' must be a single quote (').

c. Discussion

(1) NCOM pairs of LCN( ) and C( ) must be provided. Data values and/or ['title'] may be placed on a second line following a line number.

(2) A maximum of fifteen (15) load combinations may be specified.

(3) No more than 15 independent load cases may be included in any one combination.

(4) Results for a load case combination are obtained by superimposing the scaled results of the independent load cases.

(5) Load combination identifiers, LCCN, need not be consecutive, but must be in ascending order.

16. TERMINATION -- One (1) line

a. Line Contents

LN 'Finish'

b. Definition

'Finish' = keyword

Abbreviated Input Guide

17. HEADING -- One (1) or more lines

LN 'heading'

[LN 'heading']

.

.

.

[LN 'heading']

18. GEOMETRY DATA -- One (1) or five (5) or more lines

a. Control -- one (1) line

```
      ( 'Rectangular' NX HX NY HY SKEW )
   LN {                                } [{'units'}]
      ( 'Line'                         )
```

b. Joint Data Lines for line-by-line mesh -- zero (0) or two (2) or more lines; omit if 'Rectangular' mesh.

(1) Control -- one (1) line

```
LN  'Joint [coordinates]'
```

(2) Data Lines -- one (1) or more lines

```
LN  JSTART  XSTART  YSTART
    [JSTOP XSTOP YSTOP [JINCR]]
```

c. Member Connectivity Data Lines for line-by-line mesh -- zero (0) or two (2) or more lines; omit if 'Rectangular' mesh.

(1) Control -- one (1) line

```
LN  'Member [connectivity]'
```

(2) Data Lines -- one (1) or more lines

```
LN  MSTART  ISTART  JSTART
    [MSTOP [MINCR IINCR JINCR]]
```

19. MEMBER CROSS SECTION DATA -- Two (2) or more lines

a. Control -- one (1) line

```
LN  'Cross [section]'  [{'units'}]
```

b. Data Lines for Area Properties -- zero (0) or one (1) or more lines.

```
LN  'Properties' MSTART XJ YI AS [MSTOP [MINCR]]
```

c. Data Lines for Section Dimensions -- zero (0) or one (1) or more lines.

```
LN  'Dimensions' MSTART B H SHRFAC [MSTOP [MINCR]]
```

20. MATERIAL PROPERTIES -- Two (2) or more lines

a. Control -- one (1) line

```
LN  'Materials'  ['units']
```

b. Data Lines -- one (1) or more lines

```
LN  MSTART  E  G  [MSTOP [MINCR]]
```

21. MEMBER END FORCE RELEASES -- Zero (0) or one (1) or more lines

```
                          ( 'From' )     ( 'Bending' )  *
LN  'Releases' MSTART     { 'To'   }     { 'Torsion' }
    [MSTOP [MINCR]]       (        )     ( 'Shear'   )
```

* any combination, 1 to 3 specifications

22. SPECIFIED JOINT DISPLACEMENTS -- Zero (0), or two (2) or more lines

a. Control -- one (1) line

```
LN 'Displacements' [{'units'}]
```

b. Data Lines -- one (1) or more lines

```
LN JSTART            { XR     }     { YR     }     { ZD     }
   [JSTOP [JINCR]]   { 'Free' }     { 'Free' }     { 'Free' }
```

23. SPRING SUPPORTS -- Zero (0) or two (2) or more lines

a. Control -- one (1) line

```
LN 'Springs' [{'units'}]
```

b. Concentrated Springs -- zero (0) or one (1) or more lines

```
LN 'Concentrated' JSTART XCS YCS ZCS [JSTOP [JINCR]]
```

24. INDEPENDENT LOAD CASES -- Two (2) or more lines

a. Control -- one (1) line

```
LN 'Loads' LCN [{'units'}] ['title']
```

b. Joint Loads -- zero (0) or one (1) or more lines

```
LN 'Joint [loads]' JSTART XM YM ZF [JSTOP [JINCR]]
```

c. Member Loads -- zero (0) or one (1) or more lines

```
      LN 'Member [loads]' {specs} [MSTOP [MINCR]]

            { 'Concentrated'  MSTART  XL    XCM   YCM   ZCF  }
{specs} =   { 'Uniform'       MSTART  XDM   YDM   ZDF        }
            { 'Trapezoidal'   MSTART  X1    XDM1  YDM1  ZDF1 }
            {                 X2      XDM2  YDM2  ZDF2       }
```

25. LOAD COMBINATIONS -- Zero (0) or one (1) or more lines

```
LN 'Combine' LCCN NCOM LCN(1) C(1) LCN(2) C(2) ...
   LCN(NCOM) C(NCOM) ['title']
```

26. TERMINATION -- One (1) line

```
LN 'Finish'
```

[illegible]

Instruction Report K-80-3 A Three-[illegible] [illegible]

Instruction Report K-80-4 A Three-[illegible] Stat[illegible]

Report 1 General Geometr[illegible]

Report [illegible] General Analys[illegible]

Report [illegible] Special Purpose [illegible]

Instruction Report K-80-6 Basic User's Guide [illegible] of Inverted T Retaining Walls [illegible]

Instruction Report K-80-[illegible] User's Reference Manual [illegible] Analysis of Inverted T Retaining [illegible]

Technical Report K-80-[illegible] Documentation of Finite Element [illegible]

Report [illegible]

Report [illegible]

Technical Report K-80-[illegible] [illegible]

Instruction Report K-[illegible] [illegible]

WATERWAYS EXPERIMENT STATION REPORTS PUBLISHED UNDER THE COMPUTER-AIDED STRUCTURAL ENGINEERING (CASE) PROJECT

(Concluded)

	Title	Date
Technical Report ITL-87-4	Finite Element Studies of a Horizontally Framed Miter Gate Report 5: Alternate Configuration Miter Gate Finite Element Studies—Additional Closed Sections Report 6: Elastic Buckling of Girders in Horizontally Framed Miter Gates Report 7: Application and Summary	Aug 1987
Instruction Report GL-87-1	User's Guide: UTEXAS2 Slope-Stability Package; Volume I, User's Manual	Aug 1987
Instruction Report ITL-87-5	Sliding Stability of Concrete Structures (CSLIDE)	Oct 1987
Instruction Report ITL-87-6	Criteria Specifications for and Validation of a Computer Program for the Design or Investigation of Horizontally Framed Miter Cates (CMITER)	Dec 1987
Technical Report ITL-87-8	Procedure for Static Analysis of Gravity Dams Using the Finite Element Method — Phase Ia	Jan 1988
Instruction Report ITL-88-1	User's Guide: Computer Program for Analysis of Planar Grid Structures (CGRID)	Apr 1988

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