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16. Abstract

Computer Program B30 performs finite-element simulation of a linearly elastic continuous beam subjected to fixed and movable loads. Enhancements are made to an existing FORTRAN code using currently available hardware and software. The original code runs on a minicomputer with alphanumeric terminals, while the enhanced version runs on a microcomputer with an improved user interface that includes panel-oriented input and extensive use of graphics. Low level assembly language routine are written to provide functions for manipulating screens, and calls to a commercial software package provide functions for graphical capabilities. The existing code is integrated with the new program as subroutines, but no other modifications are made to facilitate avoidance of new error sources. Panel-oriented input eases the user's burden of creating and editing problems. Graphical representation of input data allows error-checking before execution of the code. In addition to the conventional numerical presentation, output data from analysis is also displayed graphically. A menu structure controls access to various capabilities of the software package. FORTRAN 77 is used as the primary language for new code development.

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# GRAPHICALLY-ORIENTED ANALYSIS OF CONTINUOUS BEAMS FOR P-LOADS ON MICROCOMPUTERS

by


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Research Report 1183-5F

on

**User-Oriented Analysis Packages for Bridges**
Research Study No. 2-5-88-1183

Sponsored by

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Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843-3135

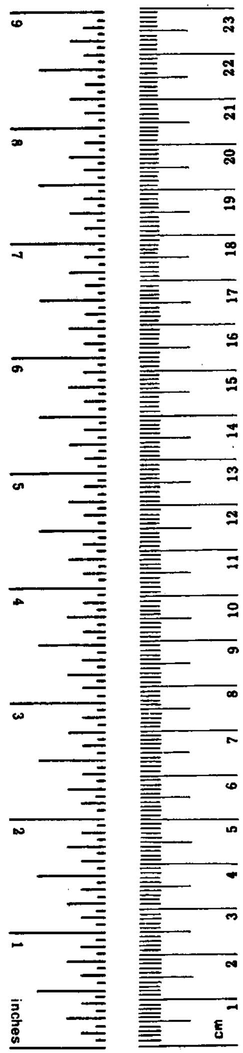
# METRIC (SI*) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | **LENGTH** | | | |
| in | inches | 2.54 | millimetres | mm |
| ft | feet | 0.3048 | metres | m |
| yd | yards | 0.914 | metres | m |
| mi | miles | 1.61 | kilometres | km |
| | **AREA** | | | |
| $in^2$ | square inches | 645.2 | millimetres squared | $mm^2$ |
| $ft^2$ | square feet | 0.0929 | metres squared | $m^2$ |
| $yd^2$ | square yards | 0.836 | metres squared | $m^2$ |
| $mi^2$ | square miles | 2.59 | kilometres squared | $km^2$ |
| ac | acres | 0.395 | hectares | ha |
| | **MASS (weight)** | | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams | Mg |
| | **VOLUME** | | | |
| fl oz | fluid ounces | 29.57 | millilitres | mL |
| gal | gallons | 3.785 | litres | L |
| $ft^3$ | cubic feet | 0.0328 | metres cubed | $m^3$ |
| $yd^3$ | cubic yards | 0.0765 | metres cubed | $m^3$ |

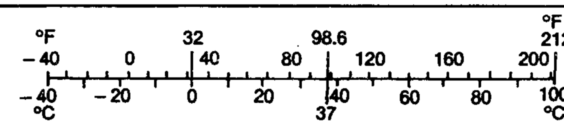
NOTE: Volumes greater than 1000 L shall be shown in $m^3$.

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | **TEMPERATURE (exact)** | | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |




## APPROXIMATE CONVERSIONS TO SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | **LENGTH** | | | |
| mm | millimetres | 0.039 | inches | in |
| m | metres | 3.28 | feet | ft |
| m | metres | 1.09 | yards | yd |
| km | kilometres | 0.621 | miles | mi |
| | **AREA** | | | |
| $mm^2$ | millimetres squared | 0.0016 | square inches | $in^2$ |
| $m^2$ | metres squared | 10.764 | square feet | $ft^2$ |
| $km^2$ | kilometres squared | 0.39 | square miles | $mi^2$ |
| ha | hectores (10 000 $m^2$) | 2.53 | acres | ac |
| | **MASS (weight)** | | | |
| g | grams | 0.0353 | ounces | oz |
| kg | kilograms | 2.205 | pounds | lb |
| Mg | megagrams (1 000 kg) | 1.103 | short tons | T |
| | **VOLUME** | | | |
| mL | millilitres | 0.034 | fluid ounces | fl oz |
| L | litres | 0.264 | gallons | gal |
| $m^3$ | metres cubed | 35.315 | cubic feet | $ft^3$ |
| $m^3$ | metres cubed | 1.308 | cubic yards | $yd^3$ |
| | **TEMPERATURE (exact)** | | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |




These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

## ABSTRACT

Computer program B30 performs finite-element simulation of a linearly elastic continuous beam subjected to fixed and movable loads. Enhancements are made to an existing FORTRAN code using currently available hardware and software. The original code runs on a minicomputer with alphanumeric terminals, while the enhanced version runs on a microcomputer with an improved user interface that includes panel-oriented input and extensive use of graphics. Low level assembly language routines are written to provide functions for manipulating screens, and calls to a commercial software package provide functions for graphical capabilities. The existing code is integrated with the new program as subroutines, but no other modifications are made to facilitate avoidance of new error sources. Panel-oriented input eases the user's burden of creating and editing problems. Graphical representation of input data allows error-checking before execution of the code. In addition to the conventional numerical presentation, output data from analysis is also displayed graphically. A menu structure controls access to various capabilities of the software package. FORTRAN 77 is used as the primary language for new code development.

## DISCLAIMER



## KEY WORDS

Computers, Continuous Beams, Elastic, Finite-element, Graphics, Linear, Microcomputers, Software

## ACKNOWLEDGMENTS

This research study was conducted under a cooperative program between the Texas Transportation Institute, the Texas State Department of Highways and Public Transportation, and the Federal Highway Administration. Mark Bloschock of the SDHPT worked closely with the researchers, and his comments and suggestions are appreciated.

## IMPLEMENTATION STATEMENT

Results of this study are available for immediate implementation by the Texas State Department of Highways and Public Transportation. Use of the improved computer code is expected to reduce analysis times for continuous beam structures, including data preparation and interpretation by engineers. Microcomputers with color monitors can be effectively used for the structural analysis rather than mainframes. A large number of similar programs that currently run on mainframes could also be enhanced in this manner. No new specifications, standards, or designs are warranted from this study. Other states may want to realize benefits from this study.

## TABLE OF CONTENTS

## LIST OF FIGURES

## I. BACKGROUND AND SIGNIFICANCE OF WORK

Since the time when many of the current bridge analysis codes in use by the Texas State Department of Highways and Public Transportation (SDHPT) were written, substantial advancements in hardware and software have been made. Both minicomputer and microcomputer equipment with large memory and graphics capabilities have been installed for use by bridge engineers. Faster compilers and graphics routines are available for software modification.

In view of these changes, the purpose of this research is to use currently available hardware and software to enhance existing analysis programs toward optimum usefulness for design engineers. As a general method of approach, languages and routines which are within the mainstream of engineering and scientific computation are employed. In light of SDHPT maintenance requests, FORTRAN 77 is used as the primary language for new code development, and it remains the mainstay of numerical calculations. Special purpose, low level routines are written in assembly language. They are isolated for facile identification should future hardware dependent changes require maintenance of these portions of the code. This report describes enhancements to an analysis code, B30, which performs a numerical simulation of a linearly elastic continuous beam subjected to fixed and movable loads.

This is the fifth in a series of reports that document enhancements to five existing analysis codes used at SDHPT. This report describes modifications to analysis code B30.

## II. INTRODUCTION

Computer program B30 numerically simulates a linearly elastic continuous beam subjected to fixed and movable loads [1]. While the original code performs its intended analytical function, it was written without programming enhancements, such as color graphics, which can simplify data input at the preprocessing stage and graphically summarize output. Engineers currently must sift through large quantities of numerical data in order to interpret results. Other than painstakingly "checking" by hand, no facile means of verifying geometry, material, and support locations is available to an analyst.

The original analysis code has been enhanced towards optimum usefulness for design engineers. Analysis portion of the code is left unmodified to avoid introduction of new error sources. Capability to directly manipulate screens has been included to provide a highly interactive system which is easy to use. Panel-oriented input provides for facile data entry. Graphical capabilities complement panel-oriented alphanumeric input by providing a quick, visual verification of data. Output from the analysis is available in either alphanumeric or graphical form. Comprehensive error trapping is also provided.

These additions to the B30 code provide the user with a program that is not only executable at the engineer's own desk (saving numerous trips to remote terminal locations), but also through panel-oriented input and graphics capabilities, allow error-checking before the analysis code is executed. Graphical output also provides rapid access to important design parameters without having to interpret large quantities of numerical data.

In what follows, salient features of the new, complete B30 code are described by means of narrative and gray-scale images of a microcomputer screen. A sample session guides the first-time user in execution of a typical problem. Finally, an installation procedure is described which transfers the program from diskette media to an executable location on a microcomputer.

## III. DESCRIPTION OF PROGRAM

The new software package for B30 utilizes a menu structure for accessing and controlling execution of the program. Various capabilities of the new, enhanced code are divided into the following six (6) modules:

1. FILE INFORMATION
2. EDIT/INPUT DATA
3. PREVIEW GRAPHICS
4. RUN ANALYSIS
5. ALPHANUMERIC RESULTS
6. GRAPHICAL RESULTS

These major subdivisions of the program are integrated together under a master menu structure which allows the user easy access to various capabilities of the program. Pertinent file information (current input file and current output file) is also displayed on the main menu (Fig. 1). The original B30 analysis code is integrated into the menu structure by means of the fourth module, RUN ANALYSIS.

These six modules and their subdivisions are described in the following sections.


**FIG. 1. Main Menu and Screen Layout**

## 1. FILE INFORMATION

In order to execute B30, an input file which describes geometry, material, loading, etc. must be prepared. The name for this file must follow naming conventions specified by the Disk Operating System (DOS). After execution, results of the analysis are placed in an output file for subsequent review, printing, or plotting.

The FILE INFORMATION module aids the user in preparation and manipulation of input and output files. Three selections are available to the user from within this module's menu (Fig. 2):

**A. Change Input File** - The user specifies which input file is to be used by entering a filename by means of the keyboard. The default filename is left blank, until the user assigns a specific filename.

**B. Change Output File** - The name of the current output file is specified by selecting this option. The default filename for this case is left blank, until the user assigns a specific filename.

**C. Quit** - Program execution can be terminated using this option. Pressing the letter "Q" from within the main menu also performs the same function.

It should be noted that all changes in file information are immediately updated on screen and internally within the code. For this reason, file information displayed on the main menu is always up-to-date.


**FIG. 2. Submenu "File Information" Module**

## 2. EDIT/INPUT DATA

This module provides for creation of new input data files and modification of existing data files. The first seven entries in this submenu allow the user to view and/or edit basic data for the problem and data for each of a maximum of six spans as described in Ref. 1 (Fig. 3). Examples of these input forms are shown in Section IV, **Sample Session.**

When any one of these seven options is selected, data for that entry is displayed. The user can easily move between fields on any screen by using the up, down, left, and right cursor keys. The current field is highlighted. If the user begins typing a new value for the current field, it is written to a buffer which is simultaneously displayed at the top left of the screen. When the user presses [Enter], the value in the buffer is written to the current field. If the user presses any of the cursor keys, the value displayed in the buffer is written to the current field and the highlight is moved from the current field to a new field, depending on which direction was previously indicated by the cursor key. If at any time while the user is typing data into the buffer, the [Esc] key is pressed, the buffer is cleared and no changes are made to data on the screen.

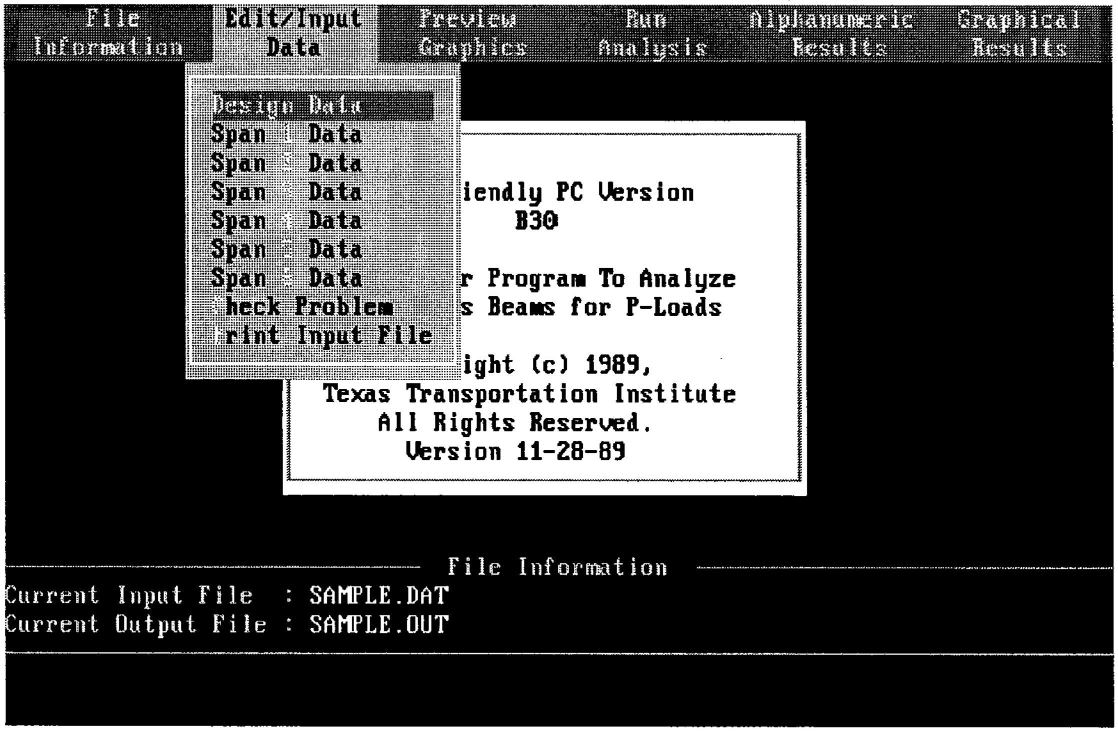



**FIG. 3. Submenu "Edit/Input Data" Module**

Another way to modify data on the screen is to press the [F2] function key. This transfers data in the current field to a buffer which is displayed at the top left of the screen where it can be edited. Once data has been transferred to the buffer, left and right cursor keys can be used to move within the buffer. The [Delete] key erases the character above the cursor, while the [Backspace] key erases the character immediately to the left of the cursor. Numbers or letters typed will be inserted at the current cursor position. As before, if the [Enter] key is pressed, data in the buffer is transferred back to the current field. If the [Esc] key is pressed, the buffer is cleared and the original data remains unchanged.

Error checking of the input file can be accomplished through the eighth option of the **Edit/Input Data** submenu, **"Check Problem."** This option checks the current input file for errors and displays messages for any errors that occur (Fig. 4). The user can then quickly change the input data as described above to correct these errors.

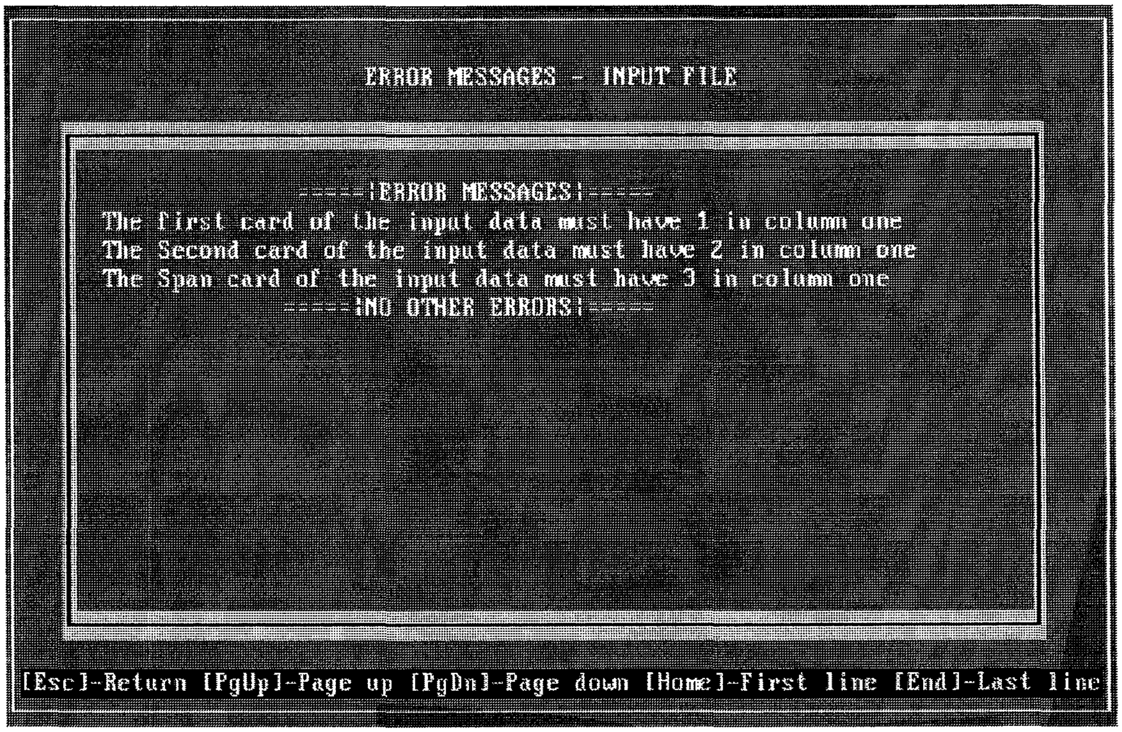



**FIG. 4. Error Messages - Input File**

The input file can be sent to a printer from within B30 by selecting the last option on this submenu, **"Print Input File."** Options LPT1, LPT2, COM1, and COM2 in the submenu (Fig. 5) refer to the communications port assigned to the printer connector from within DOS.

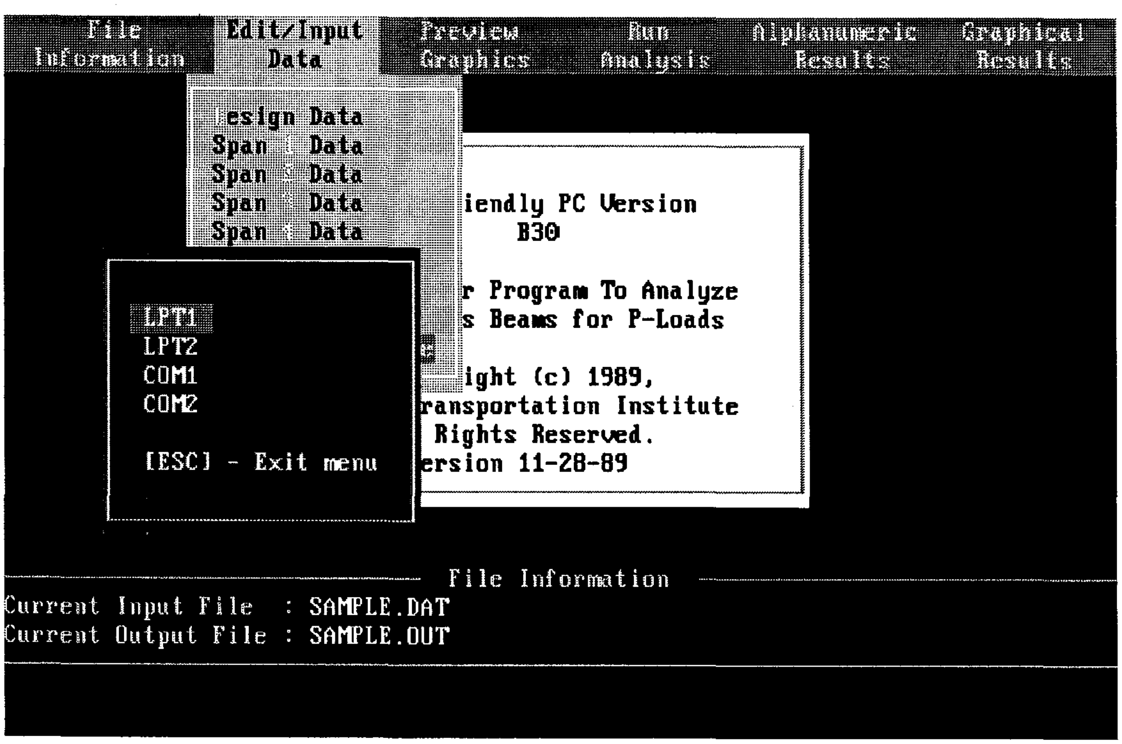



**FIG. 5. Port Selection Screen**

### 3. PREVIEW GRAPHICS

This module reads the current input file and reports important input data in graphical form. It provides the user with a quick visual check of beam support geometry so that simple errors can be detected before execution of the analysis code (Fig. 6). No logic is provided in this module to check errors for input as required by the B30 analysis code. The input file is read and the data is simply displayed (for format checks of input file refer to **"Check Input File"** option in **EDIT/INPUT DATA** module). Knife-edge support conditions are displayed along with span numbers.

More extensive graphics are available to the user after the analysis has been performed. Although some advantages accrue to graphical viewing of the input geometry before the analysis step, several factors weigh against this approach for B30. First of all, the logic flow is somewhat unusual in that B30 internally computes many geometric parameters from an abbreviated input data file rather than simply reading them. However, these dimensions are readily available from the output file. In addition, B30 execution times are very small which makes it only slightly inconvenient to view the graphics after the analysis and, if necessary, make adjustments to the input and run the analysis module again.

An example of the usage of this module is described in Section IV (**Sample Session**), under **"Preview Graphics"** and **"Graphical Results."**

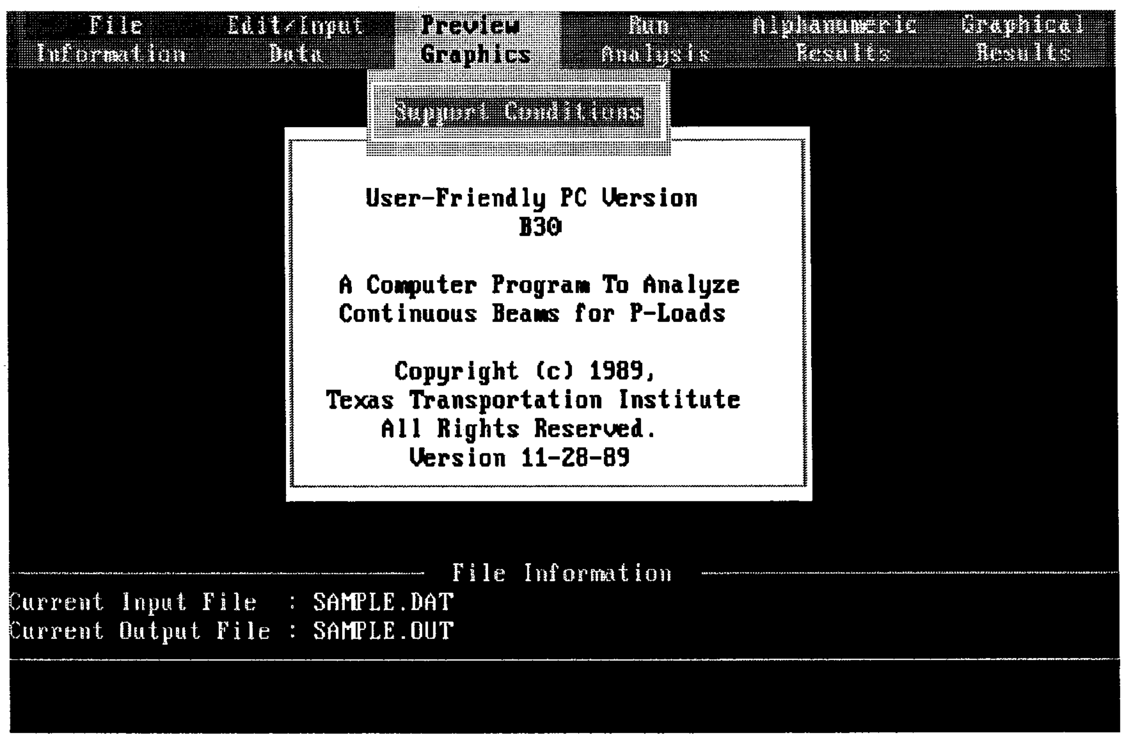



**FIG. 6. Submenu "Preview Graphics" Module**

## 4. RUN ANALYSIS

Selection of this option triggers execution of the analysis code with the specified input data file. In this implementation, the original B30 analysis code is a set of subroutines which run at the selection of this menu item. If input and output files have not been specified, they can be input at this stage.

A message is overlaid on the display screen to keep the user informed that calculation is in progress. Error messages inside the analysis code check the validity of the input and output files specified by the user. Execution time varies depending on the complexity of the problem. Typical runs such as the Sample Session analysis require only a few seconds on an IBM PS/2 Model 80 running at 16 megahertz.

## 5. ALPHANUMERIC RESULTS

This module allows the user to view alphanumeric results output by the analysis part of the code. Alphanumeric results are useful if the user needs to determine the exact value of a result at a particular point, while graphical results are more useful for visualizing overall behavior of forces or deflections over the entire length of the beam or within a given span.

Alphanumeric results of B30 are divided into a print option and seven (7) submenus (Fig. 7) whose format follows that of Ref. 1. Each result's submenu is presented in a table format on a separate screen or, in some cases, several screens. Once inside a submenu display table, the user can scroll through data using up and down arrow keys, and [Page Up] and [Page Down] keys.

The first submenu's selection gives beam section properties at 1/10th points of each span [1]. Span properties such as moment carryover factors and relative end stiffnesses for each end are reported in a screen as a consequence of selecting the second option. The third option leads to a set of individual span screens which list the summation of dead load deflections due to beam weight, concentrated P-Loads, and noncomposite uniform dead load. Total dead load moments due to weight of the girder, concentrated P-Loads, and the uniform dead load are provided in the fourth option at 1/10th points along the beam. Shears for each span due to dead loads, and sidewalk and live loads are reported by means of the fifth submenu. The sixth and seventh menus list stress ranges of top and bottom flanges for truck and lane loading, respectively. Finally, a printout of the entire alphanumeric output file can be obtained by selecting the **"Print Output File"** option in this module. Printing is set up for a 132-column printer. After printing is complete, the user has the option to either keep or delete the output file.

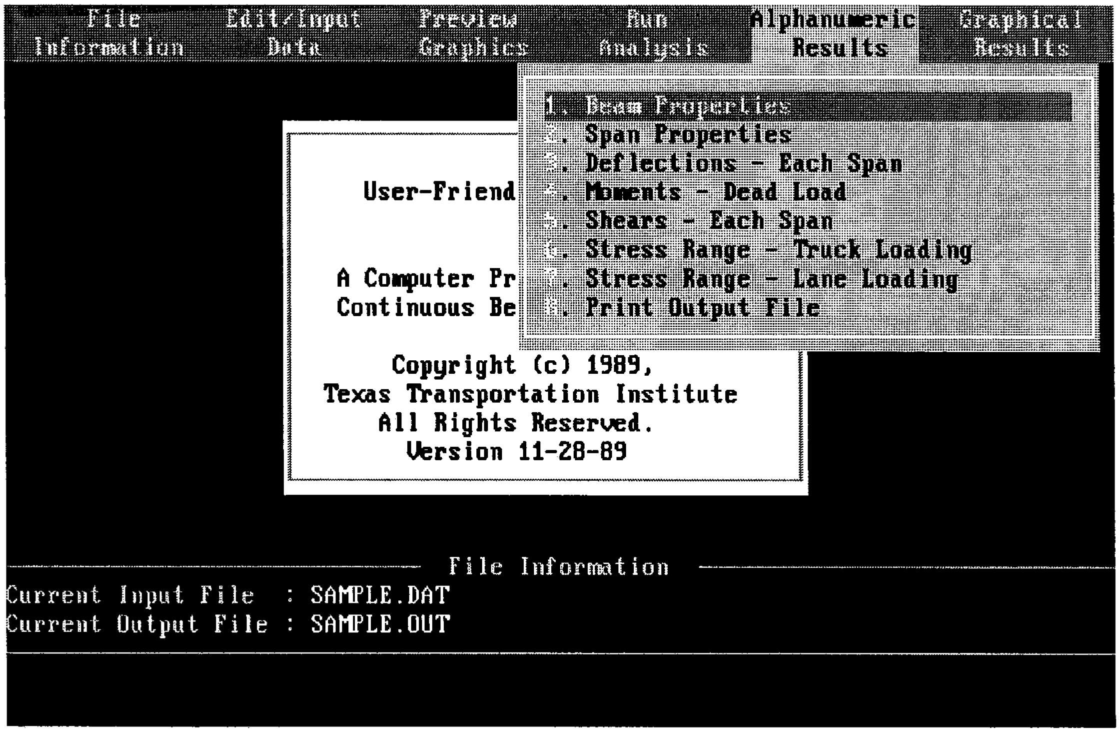



**FIG. 7. Submenu "Alphanumeric Results" Module**

## 6. GRAPHICAL RESULTS

Graphical output from results of the analysis is presented under this option. Eight submenu selections are provided: (1) a diagram of moment of inertia of the entire beam, (2) a set of diagrams showing deflection for each span of the beam, (3) a diagram of dead load moments, (4) a set of diagrams showing shear for each span of the beam, (5) stress ranges due to truck loads for the top fibers, (6) stress ranges due to truck loads for the bottom fibers, (7) stress ranges due to lane loads for the top fibers, and (8) stress ranges due to lane loads for the bottom fibers. The submenu for this module is displayed in Fig. 8. Graphs include problem number and appropriate scales. An example from many of these options is presented in the **SAMPLE SESSION** section.

Hardcopy plots for each graph can be obtained by accessing plot options through pressing the [F1] key after the graph is displayed on the screen. Three options are available for obtaining hardcopy plots (see Fig. 9):

**(1) Screen Dump** - Plots can be dumped from a screen to a printer by using this option. Printers supported are Epson, IBM, Okidata, HP LaserJet, and those fully compatible with one of the above types. Hardcopy obtained is in black and white and takes from several to many minutes to complete.

**(2) Plotter** - All plotters that support the Hewlett-Packard Graphics Language (HPGL) are supported. Various parameters displayed on the graphs are assigned default pen numbers and pen speeds (cm/sec), which may be changed if desired by means of an additional submenu (Fig. 10). Areas between curves and axes are not filled with color for hardcopy output.

**(3) Copy to File** - This option can be used to copy a graph to a file. This file can be copied to an output device at a later time to obtain the hardcopy completely independent from the enhanced B30 software package. Plotter defaults can also be changed by means of a special submenu.

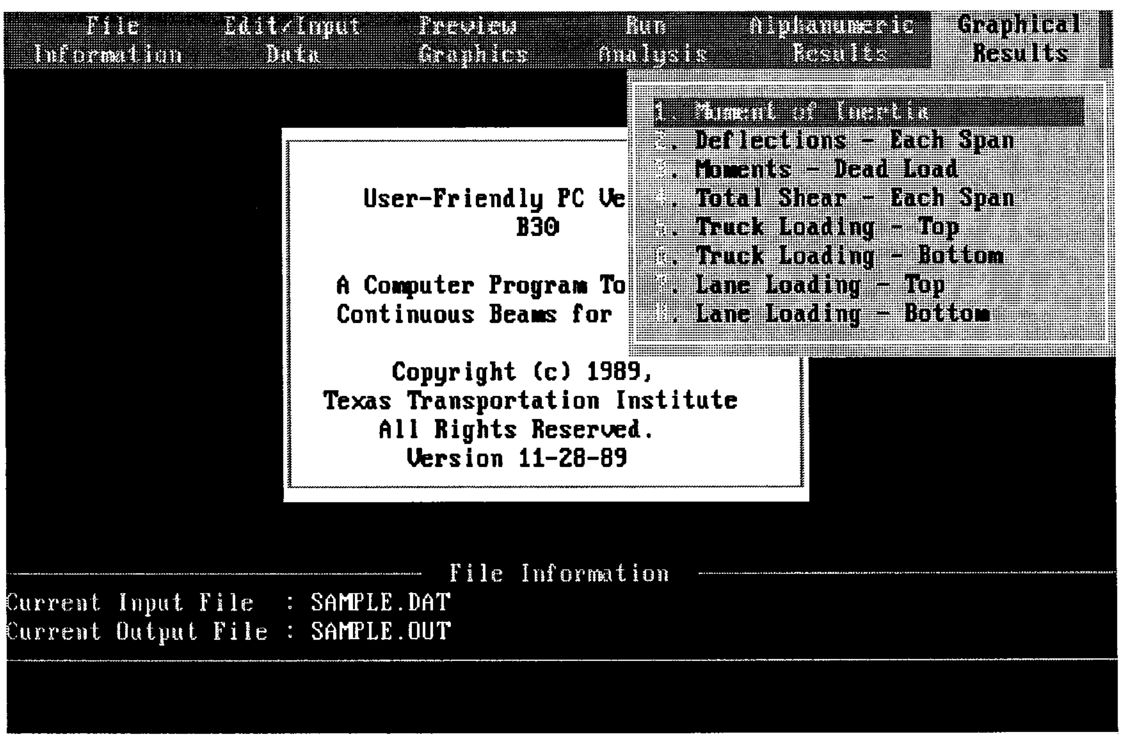



**FIG. 8. Submenu "Graphical Results" Module**

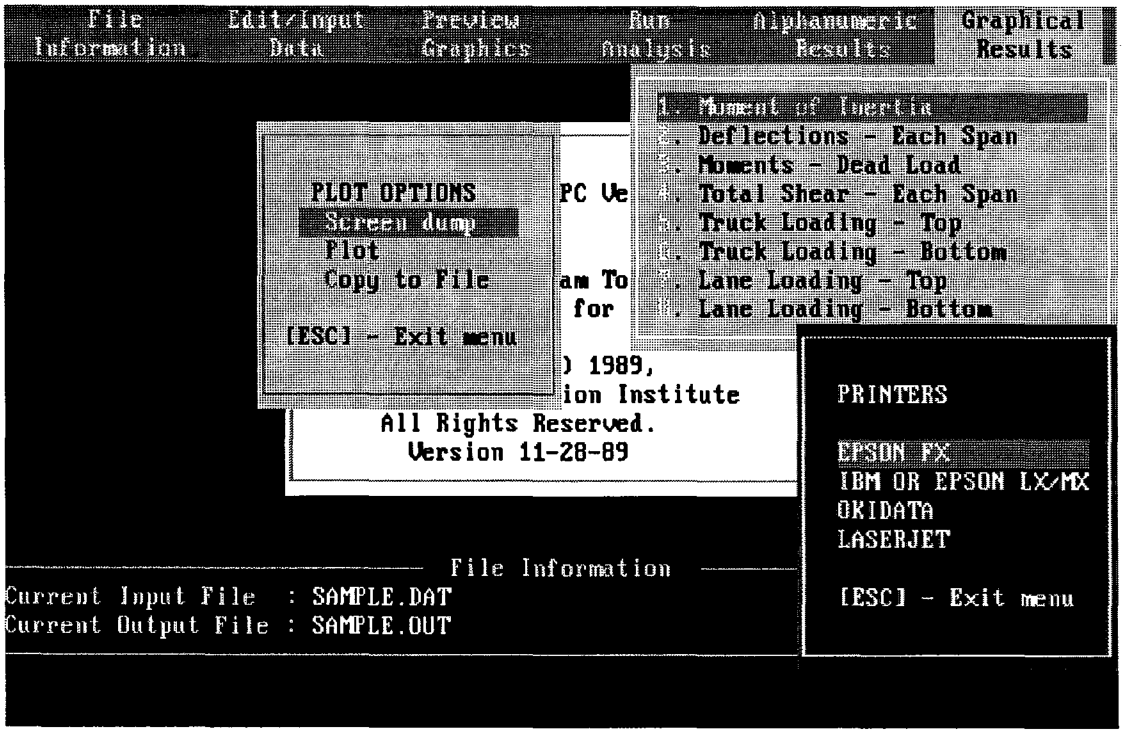



**FIG. 9. Screen Dump - Printer Selection Screen**

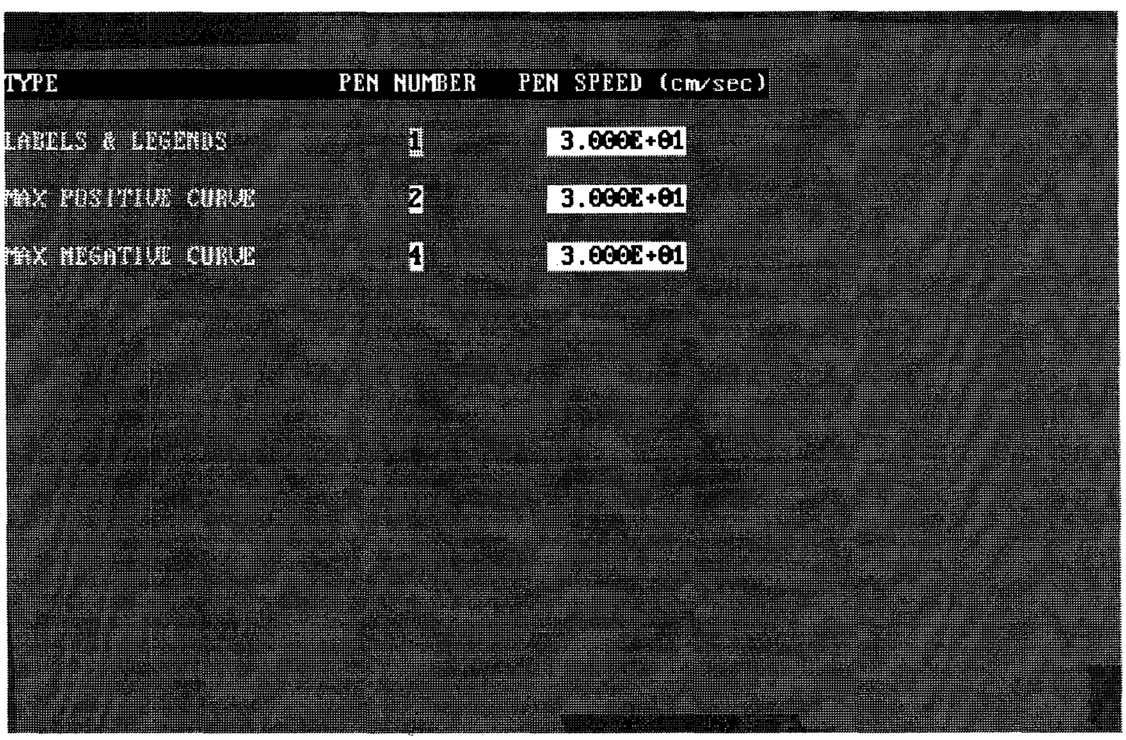



**FIG. 10. Plot Parameter Selection Screen**

## IV. SAMPLE SESSION

This sample session is a description of the steps required to create and execute a typical continuous beam problem. The run contains one problem which is described in detail below and in Ref. 1.

The 159 ft continuous beam shown in Fig. 11 is chosen to illustrate important features of the enhanced B30 program. Many but not all available options are used in creating, running, and evaluating this problem. Before explicit creation of this problem, the general scheme for using menus is described below.

### 1. MENU SCHEME

An option can be selected from the main menu by either using the direction arrow keys to highlight a desired option, or by pressing the highlighted letter of the option desired. Once the option selected is highlighted, the [Enter] key can be pressed to invoke the submenu within that option. Procedures for selecting an option from a pull-down menu are the same as for the main menu except that the [Up] and [Down] arrow keys are used to move from one option to another. Using the [Left] and [Right] arrow keys within a pull-down menu allows movement from one menu to the next. The option highlighted within this new pull-down menu is the most recently selected option. The [Esc] key can be used from within a submenu to return to the main menu.

In the description that follows, selection of an option will imply use of this scheme without specific mention.

### 2. FILE INFORMATION

Default filenames for input and output files are left as blanks. Let the new input file containing this problem be called SAMPLE.DAT and the output file SAMPLE.OUT (user should make sure these files do not exist in the current directory). To initially assign and change filenames, select **FILE INFORMATION** and invoke the **"Change Input File"** submenu within this option. Enter SAMPLE.DAT using the keyboard when the program prompts for the filename (Fig. 12). Similarly, to assign a name to the output file, select **"Change Output File"** and enter SAMPLE.OUT.

### 3. EDIT/INPUT FILE

Once the filenames and problem number have been selected, the data can be entered into the appropriate submenu forms. A novice user of B30 is referred to Ref. 1 for complete details and other options available. For this example, data is entered as shown in Figure 11:

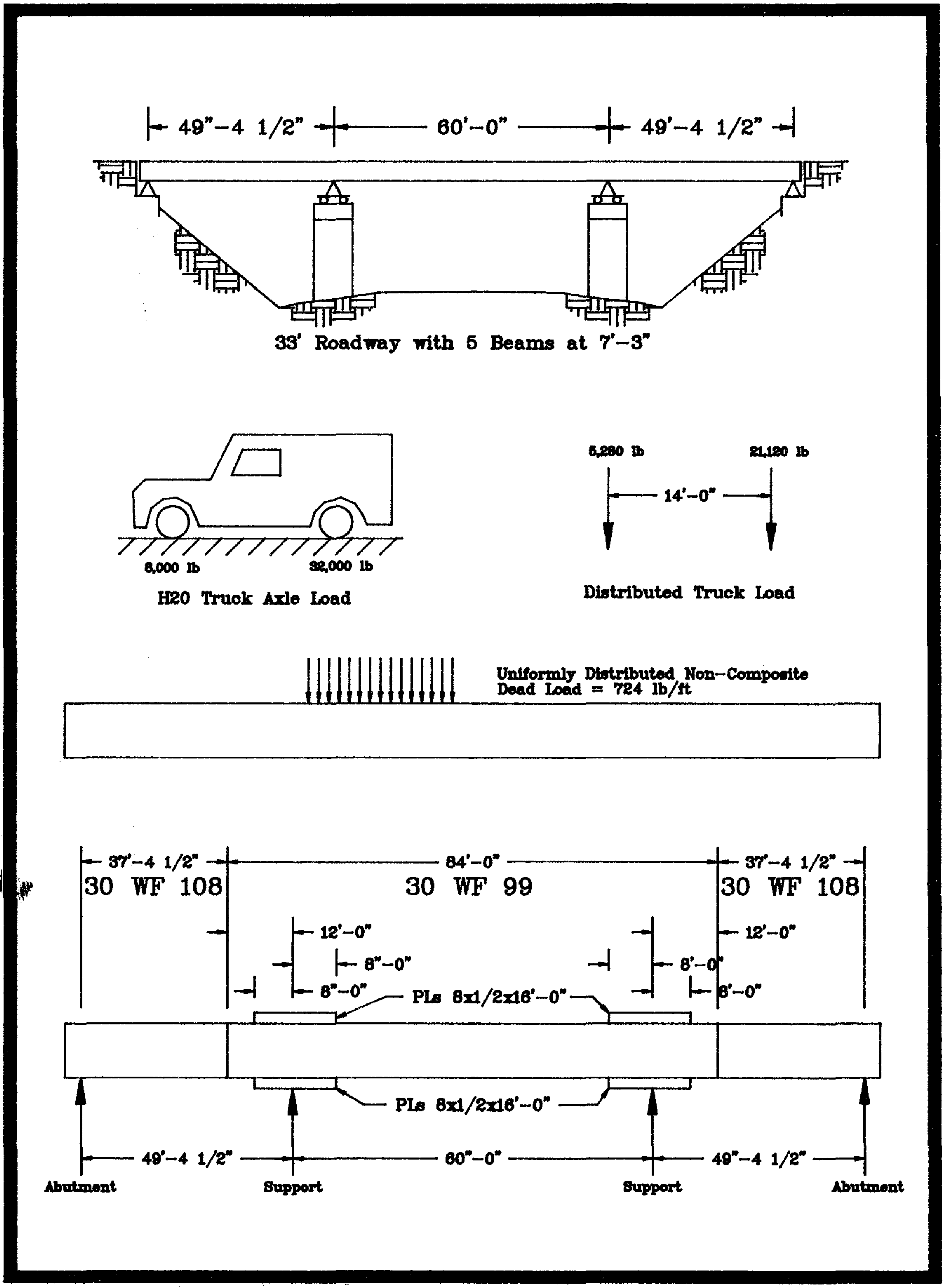



**FIG. 11. Geometry and Loading of Example Problem**

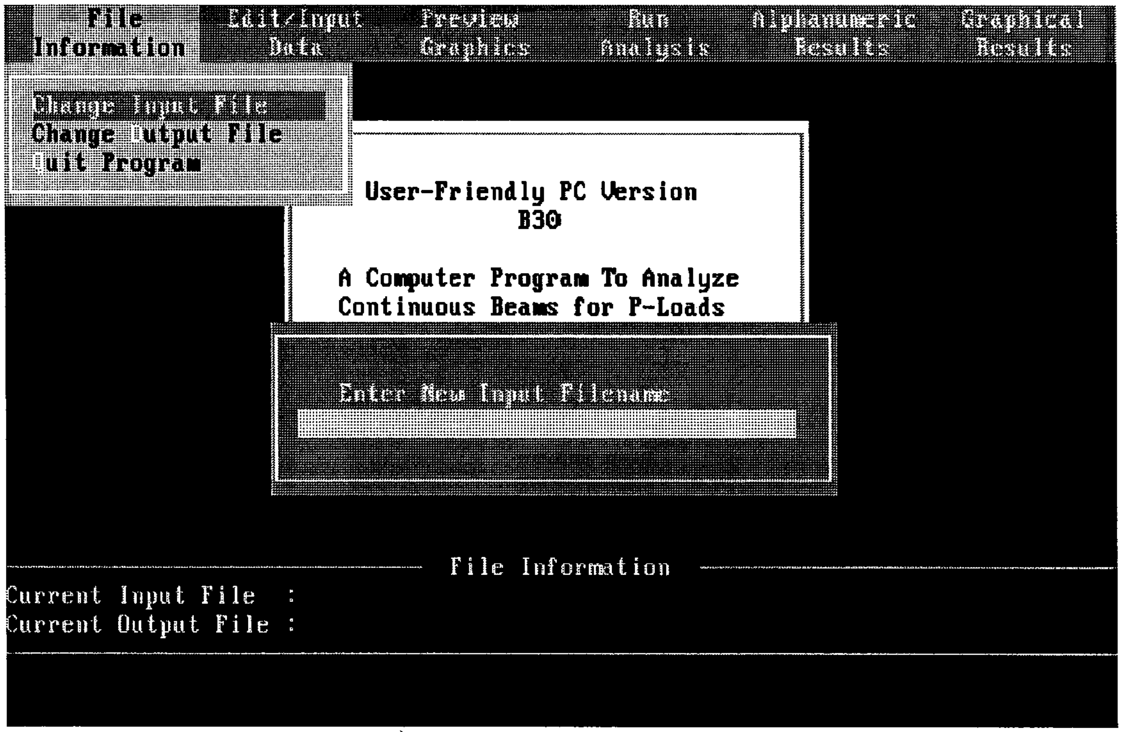



**FIG. 12. Specification of Input File**

**A. Design Data** - This submenu has two rows of data entry, an identification record, and the second record for beam constants (see Fig. 13). Enter the following data:

IDENTIFICATION

| K | Prbn | Remarks, Project Number, Date, County, Name, etc. |
|---|---|---|
| 1 | 5001 | SAMPLE.DAT 159' 3-span, 33 ft Roadway, H20 Loading |

BEAM CONSTANTS

| K | Beamidentity | M | Bmcod | Wg | E | LLm | LLv | WDLnc | WDLc | WSWK | QUC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | 3 | 1110 | 4900 | 2900 | 21120 | 21120 | 724 | | | |

The problem number, 5001, is an arbitrary constant. Note also that the plot option for a line printer, which is used in the mainframe version of B30, does not appear on the beam constants line. This option is omitted since the **Graphical Results** menus present the user with a variety of plot options. This is one of the very few changes made to the B30 source code.

**B. Span 1 Data** - A sequence of three menu screens are used to enter the following information for span 1. Reference is made to Fig. 11 and a table of standard beam properties. The first screen for span one (see Fig. 14) is filled out as follows for this problem:

```
K M SPNLTH   CROSS SECTION CODE
3 1  49375 0 1 1 0 0 1 0 0 0 0
```

The remaining two screens for span 1 are as follows (see Figs. 15 and 16):

| Card Code | Number Ranges | Range1 | Range2 | Range3 | Range4 | Range5 | Range6 | Range7 |
|---|---|---|---|---|---|---|---|---|
| 411 | 2 | 37375 | 49375 | | | | | |
| 412 | 2 | 29820 | 29640 | | | | | |
| 413 | 2 | 31770 | 29110 | | | | | |
| 414 | 2 | 4461000 | 3988600 | | | | | |
| 441 | 2 | 41375 | 49375 | | | | | |
| 442 | 2 | 000 | 4000 | | | | | |
| 443 | 2 | 000 | 500 | | | | | |
| 451 | 2 | 41375 | 49375 | | | | | |
| 452 | 2 | 000 | 4000 | | | | | |
| 453 | 2 | 000 | 500 | | | | | |

**C. Span 2 Data** - A sequence of three menu screens are used to enter the following information for span 2. Reference is made to Fig. 11 and a table of standard beam properties. The first screen for span two is filled out as follows:

```
K M SPNLTH   CROSS SECTION CODE
3 2  60000 0 1 1 0 0 0 1 0 0 0
```

The remaining two screens for span 2 are as follows:

| Card Code | Number Ranges | Range1 | Range2 | Range3 | Range4 | Range5 | Range6 | Range7 |
|---|---|---|---|---|---|---|---|---|
| 412 | 1 | 29640 | | | | | | |
| 413 | 1 | 29110 | | | | | | |
| 414 | 1 | 3988600 | | | | | | |
| 441 | 3 | 8000 | 52000 | 60000 | | | | |
| 442 | 3 | 4000 | 000 | 4000 | | | | |

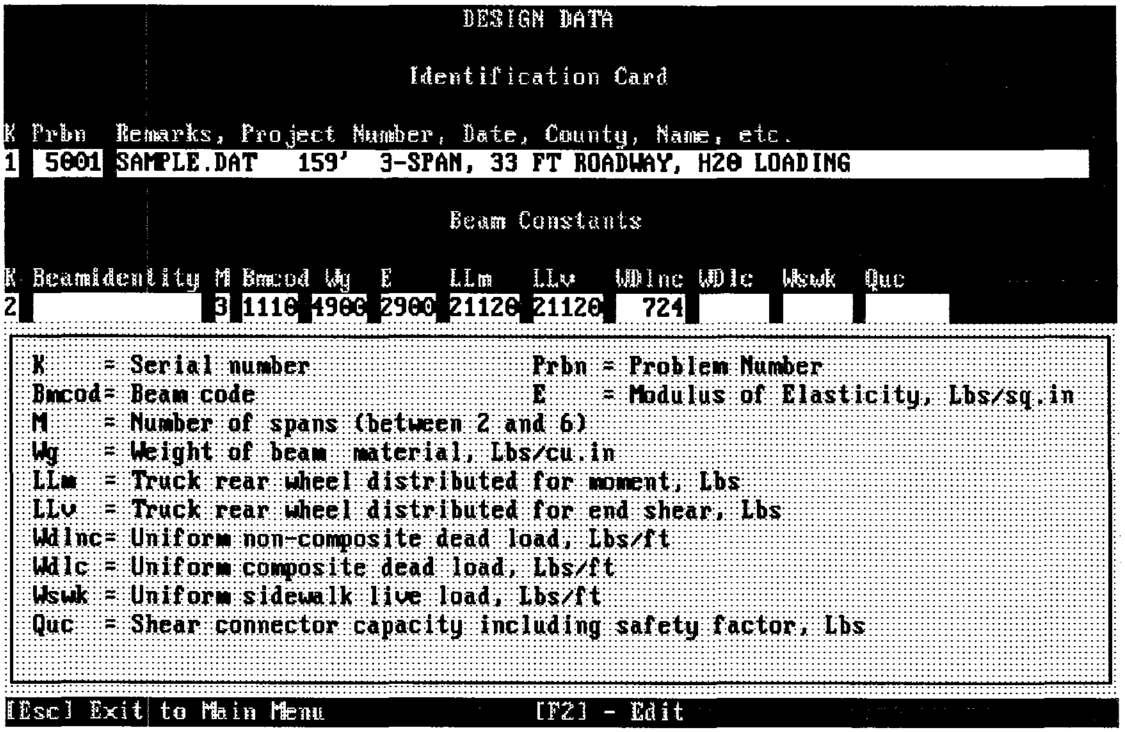



**FIG. 13. Design Data - Identification and Beam Constants**


**FIG. 14. Design Data - Span 1 Length and Code**

SPAN 1 DATA

| Card Code | Number Ranges |
|---|---|
| 411 | 2 |
| 412 | 2 |
| 413 | 2 |
| 414 | 2 |
| 441 | 2 |
| 442 | 2 |
| 443 | 2 |
| 451 | 2 |
| 452 | 2 |
| 453 | 2 |

[Esc] to continue input [F1] - Help [F2] - Edit

**FIG. 15. Design Data - Span 1 Load Code and Ranges**

SPAN 1 DATA

| Range 1 | Range 2 | Range 3 | Range 4 | Range 5 | Range 6 | Range 7 |
|---|---|---|---|---|---|---|
| 37375 | 49375 | | | | | |
| 29820 | 29640 | | | | | |
| 31770 | 29110 | | | | | |
| 4461000 | 3988600 | | | | | |
| 41375 | 49375 | | | | | |
| 000 | 4000 | | | | | |
| 000 | 500 | | | | | |
| 41375 | 49375 | | | | | |
| 000 | 4000 | | | | | |
| 000 | 500 | | | | | |

[Esc] to Exit [F1] - Help [F2] - Edit

**FIG. 16. Design Data - Span 1 Range Values**

| | | | | |
|---|---|---|---|---|
| 443 | 3 | 500 | 000 | 500 |
| 451 | 3 | 8000 | 52000 | 60000 |
| 452 | 3 | 4000 | 000 | 4000 |
| 453 | 3 | 500 | 000 | 500 |

**D. Span 3 Data** - A sequence of three menu screens is used to enter the following information for span 3. Reference is made to Fig. 11 and a table of standard beam properties. The first screen for span three is filled out as follows:

```
K M SPNLTH  CROSS SECTION CODE
3 3  49375 0 1 1 0 0 1 0 0 0 0
```

The remaining two screens for span 3 are as follows:

| Card Code | Number Ranges | Range1 | Range2 | Range3 | Range4 | Range5 | Range6 | Range7 |
|---|---|---|---|---|---|---|---|---|
| 411 | 2 | 12000 | 49375 | | | | | |
| 412 | 2 | 29640 | 29820 | | | | | |
| 413 | 2 | 29110 | 31770 | | | | | |
| 414 | 2 | 3988600 | 4461000 | | | | | |
| 441 | 2 | 8000 | 49375 | | | | | |
| 442 | 2 | 4000 | 000 | | | | | |
| 443 | 2 | 500 | 000 | | | | | |
| 451 | 2 | 8000 | 49375 | | | | | |
| 452 | 2 | 4000 | 000 | | | | | |
| 453 | 2 | 500 | 000 | | | | | |

**E. Span 4 Data** - No data is needed for this nonexistent span.

**F. Span 5 Data** - No data is needed for this nonexistent span.

**G. Span 6 Data** - No data is needed for this nonexistent span.

Explanation of card codes are available during span data entry through the [F1] function key. Pressing [F1] leads to a help screen with a detailed description of the card codes related to a specific grouping, such as "Thickness of Web" (see Fig. 17).

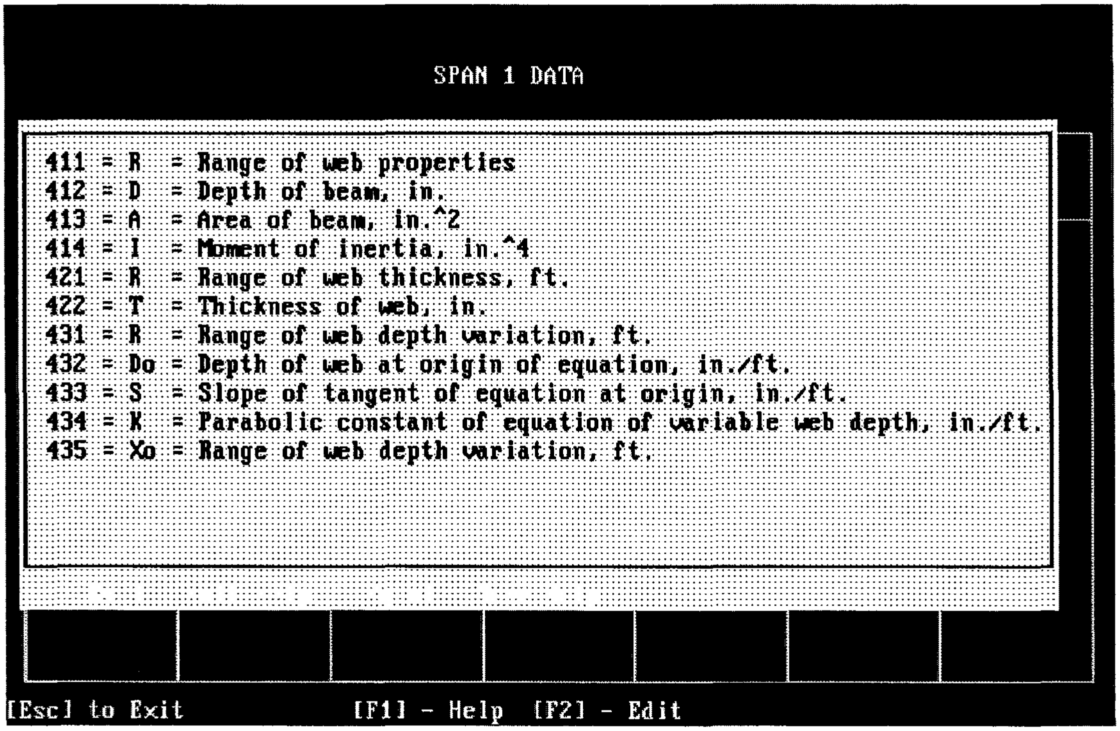



**FIG. 17. Explanation of Card Codes**

## 4. PREVIEW GRAPHICS

After the problem has been created, it can be visually checked for mistakes by accessing the **PREVIEW GRAPHICS** option. This option provides the user with a rapid check of the beam support locations before the execution process. Invoking this submenu leads to the screen display of Fig. 18. Use the [Esc] key to return to the pull-down **PREVIEW GRAPHICS** menu. Return control to the main menu of B30 by using the [Esc] key or [Left] and [Right] arrow keys from within the submenu, as described before.

## 5. RUN ANALYSIS

Select this option and execute the input file to obtain the alphanumeric output file (Fig. 19). During execution a "Calculating..." message is written to the screen for the user. Upon completion of the run, the message menu is erased. Return control to the main menu from within the **RUN ANALYSIS** submenu by using the [Esc] key or [Left] and [Right] arrow keys, as described before.

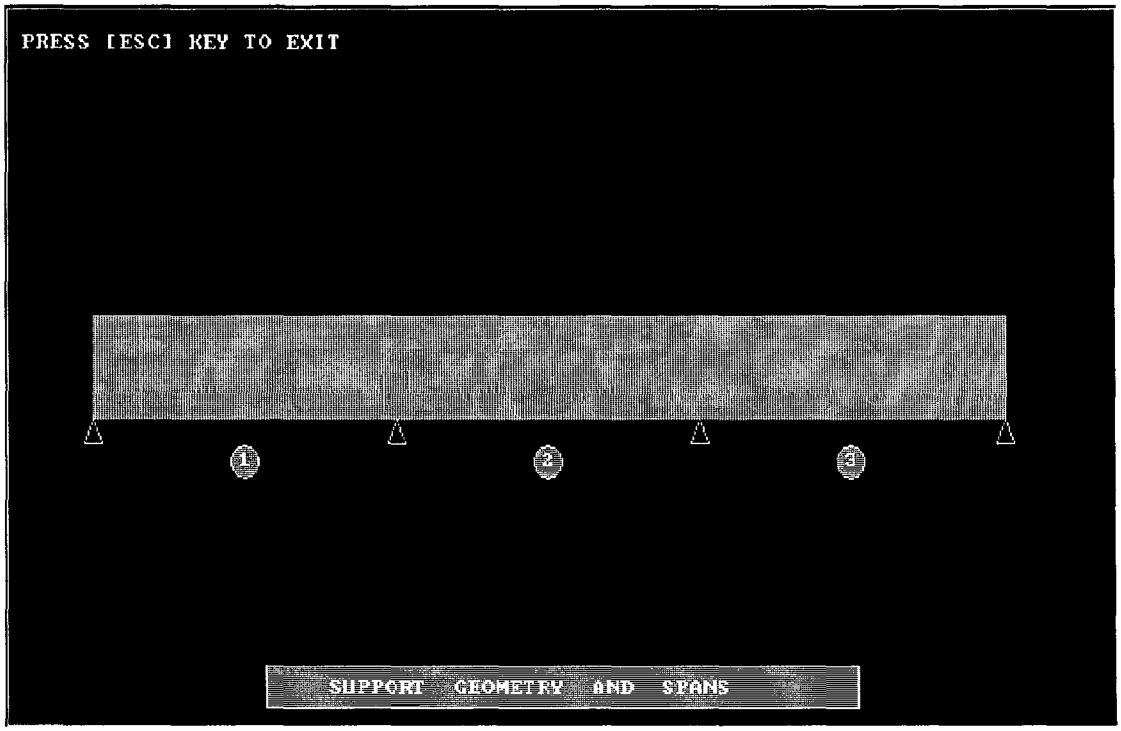



**FIG. 18. Support Geometry and Spans**

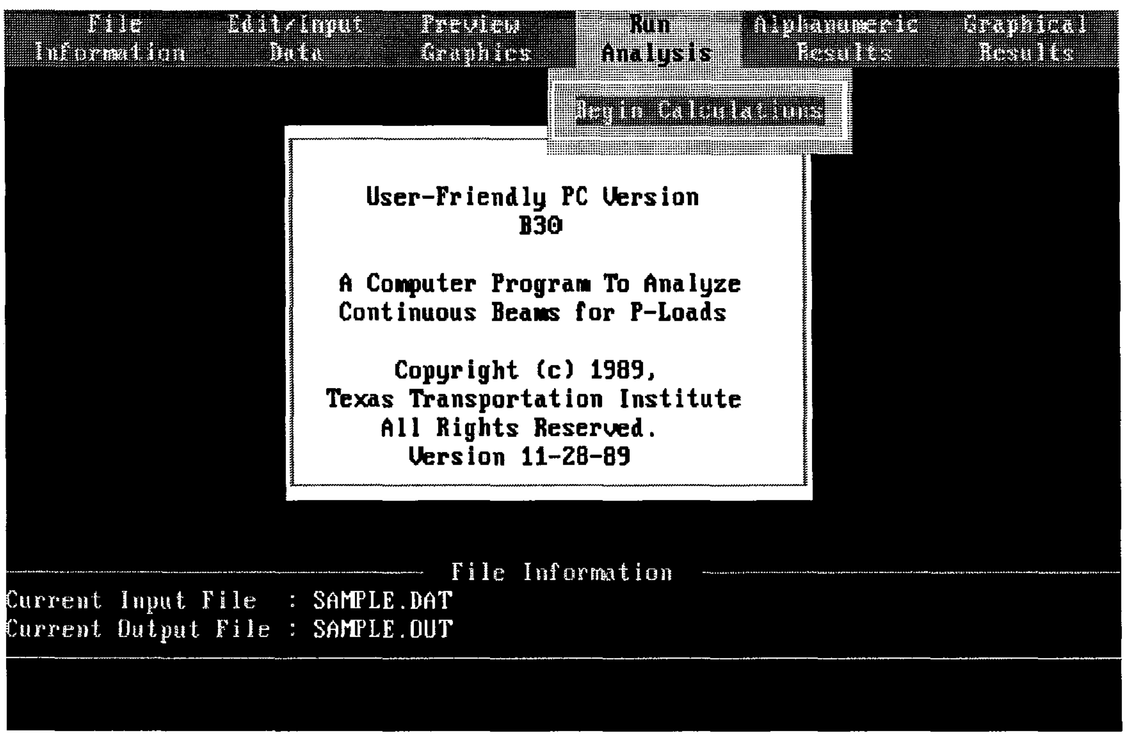



**FIG. 19. Screen Display "Run Analysis"**

## 6. ALPHANUMERIC RESULTS

This option presents the output data from analysis in numerical form. After invoking this option, select one of the following submenu options:

**A. Beam Properties (Beam Only)** - Selection of this submenu elicits display of the table shown in Fig. 20. Use the direction arrow keys to move within this table. Pressing the [Home] key positions the screen on the first line of the table, while the [End] key positions the screen on the last line. [Page Up] and [Page Down] keys can be used to move through the table one page at a time. The [Esc] key is used to return to the previous pull-down menu.

BEAM PROPERTIES, SPAN 1/10TH POINTS (BEAM ONLY)

| Span Point | Depth of Web | Moment Inertia | Neutrl Axis T | Section Moduls T | Neutrl Axis B | Section Moduls B |
|---|---|---|---|---|---|---|
| 11 | 29.82 | 4461.0 | 14.9 | 299.2 | 14.9 | 299.2 |
| 12 | 29.82 | 4461.0 | 14.9 | 299.2 | 14.9 | 299.2 |
| 13 | 29.82 | 4461.0 | 14.9 | 299.2 | 14.9 | 299.2 |
| 14 | 29.82 | 4461.0 | 14.9 | 299.2 | 14.9 | 299.2 |
| 15 | 29.82 | 4461.0 | 14.9 | 299.2 | 14.9 | 299.2 |
| 16 | 29.82 | 4461.0 | 14.9 | 299.2 | 14.9 | 299.2 |
| 17 | 29.82 | 4461.0 | 14.9 | 299.2 | 14.9 | 299.2 |
| 18 | 29.64 | 3988.6 | 14.8 | 269.1 | 14.8 | 269.1 |
| 19 | 29.64 | 5805.6 | 15.3 | 379.0 | 15.3 | 379.0 |
| 20 | 29.64 | 5805.6 | 15.3 | 379.0 | 15.3 | 379.0 |
| 21 | 29.64 | 5805.6 | 15.3 | 379.0 | 15.3 | 379.0 |
| 22 | 29.64 | 3988.6 | 14.8 | 269.1 | 14.8 | 269.1 |
| 23 | 29.64 | 3988.6 | 14.8 | 269.1 | 14.8 | 269.1 |
| 24 | 29.64 | 3988.6 | 14.8 | 269.1 | 14.8 | 269.1 |
| 25 | 29.64 | 3988.6 | 14.8 | 269.1 | 14.8 | 269.1 |

[Esc] to Exit

**FIG. 20. Beam Section Properties**

**B. Span Properties (Beam Only)** - Upon selecting this submenu's table, beam span properties are given for each span in the continuous unit (Fig. 21). A value of zero for any of the properties indicates that a value was not required in the computations. Also a concise explanation of each table heading and the units of each variable are available by pressing the [F1] key. Press [Esc] key to return to the main menu.

SPAN PROPERTIES (BEAM ONLY)

| S | DL | KL | KLM | CL | CLM | CRM | CR | KRM | KR | DR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .000 | 0.000 | 0.000 | .000 | .000 | .000 | .000 | .003 | 0.000 | .519 |
| 2 | .480 | .003 | .002 | .546 | .308 | .308 | .546 | .002 | .003 | .480 |
| 3 | .519 | 0.000 | .003 | .000 | .000 | .000 | .000 | 0.000 | 0.000 | .000 |

[Esc] to Exit [F1] for Help

**FIG. 21. Beam Span Properties**

**C. Deflections - Each Span** - A table of deflections similar to the one shown in Fig. 22 is available for each individual span. Alphanumeric results are presented at 1/10th points. The same keys are used to move within this table as previously described.

**D. Dead Load Moments** - A table as shown in Fig. 23 gives dead load moments. Alphanumeric results are available at 1/10th points of each span for the entire beam. The same keys are used to move within this table as previously described.

**E. Shears - Each Span** - These tables are similar to the one shown in Fig. 24 for Span 1. Alphanumeric results are available at 1/10th points of each span for the entire beam. The same keys are used to move within this table as previously described.

**F. Stress Range - Truck Loading** - This table is shown in Fig. 25. Alphanumeric results are available at 1/10th points of each span for the entire beam. The same keys are used to move within this table as previously described.

**G. Stress Range - Lane Loading** - This table is similar to that shown in Fig. 25. Alphanumeric results are available at 1/10th points of each span for the entire beam. The same keys are used to move within this table as previously described.

**H. Print Output File** - This option is used to obtain a printout of numerical results from analysis. After this option is selected, the program displays a menu of communication ports. Select the port to which the printer is connected to obtain a printout.

DEAD LOAD DEFLECTIONS(FEET) SPAN 1

| Span Point | Deflection |
|---|---|
| 0.05L | .01 |
| 0.10L | .011 |
| 0.15L | .016 |
| 0.20L | .020 |
| 0.25L | .023 |
| 0.30L | .026 |
| 0.35L | .028 |
| 0.40L | .028 |
| 0.45L | .028 |
| 0.50L | .027 |
| 0.55L | .025 |
| 0.60L | .023 |
| 0.65L | .020 |
| 0.70L | .016 |
| 0.75L | .012 |

[Esc] to Exit

**FIG. 22. Deflections - Span 1**

## 7. GRAPHICAL RESULTS

Invoke the submenu to begin this option. To choose the type of diagram, select the parameter whose graph is desired from the options provided. A representative set of example graphical results output screens is presented in what follows.

**A. Deflections - Each Span** - Select this option and enter "1" for Span 1 in the dialogue request menu. The graph displayed on the screen is shown in Fig. 26.

DEAD LOAD MOMENTS

| Span Point | Moment Beam Wt | Moment P-Loads | Moment Deadload | Total Moment |
|---|---|---|---|---|
| 11 | 9 | 0 | 56 | 65 |
| 12 | 14 | 0 | 95 | 109 |
| 13 | 18 | 0 | 116 | 134 |
| 14 | 18 | 0 | 119 | 137 |
| 15 | 16 | 0 | 105 | 121 |
| 16 | 12 | 0 | 73 | 85 |
| 17 | 4 | 0 | 23 | 27 |
| 18 | -5 | 0 | -44 | -49 |
| 19 | -18 | 0 | -129 | -147 |
| 20 | -33 | 0 | -232 | -265 |
| 21 | -16 | 0 | -115 | -131 |
| 22 | -4 | 0 | -23 | -27 |
| 23 | 5 | 0 | 42 | 47 |
| 24 | 10 | 0 | 81 | 91 |
| 25 | 12 | 0 | 94 | 106 |

[Esc] to Exit

**FIG. 23. Dead Load Moments**

SHEARS(KIPS) SPAN 1

| Span Point | Total DL Shear | Liveload Plus Impct | Total Shear |
|---|---|---|---|
| 11 | 11.066 | 29.210 L | 40.276 |
| 12 | 6.957 | 24.352 L | 31.309 |
| 13 | 2.849 | 19.785 L | 22.634 |
| 14 | -1.260 | 15.645 L | -17.161 |
| 15 | -5.368 | -19.825 L | -25.193 |
| 16 | -9.477 | -23.863 L | -33.339 |
| 17 | -13.585 | -27.956 L | -41.541 |
| 18 | -17.677 | -32.041 L | -49.718 |
| 19 | -21.825 | -35.905 L | -57.730 |
| 20 | -26.023 | -39.556 L | -65.579 |

[Esc] to Exit

**FIG. 24. Shears - Span 1**

TRUCK LOADING - Top and Bottom Flanges

| Span Point | Pos Moment PlusImpact | Neg Moment PlusImpact | Range | Pos Moment PlusImpact | Neg Moment PlusImpact | Range |
|---|---|---|---|---|---|---|
| 11 | 5422.0 | -748.4 | 6170.4 | -5422.0 | 748.4 | 6170.4 |
| 12 | 9210.4 | -1496.7 | 10707.1 | -9210.4 | 1496.7 | 10707.1 |
| 13 | 11446.0 | -2245.1 | 13691.1 | -11446.0 | 2245.1 | 13691.1 |
| 14 | 12251.5 | -2993.4 | 15244.9 | -12251.5 | 2993.4 | 15244.9 |
| 15 | 11952.0 | -3741.8 | 15693.8 | -11952.0 | 3741.8 | 15693.8 |
| 16 | 10835.8 | -4490.1 | 15326.0 | -10835.8 | 4490.1 | 15326.0 |
| 17 | 8695.3 | -5238.5 | 13933.8 | -8695.3 | 5238.5 | 13933.8 |
| 18 | 6437.1 | -6655.5 | 13092.6 | -6437.1 | 6655.5 | 13092.6 |
| 19 | 1923.8 | -5317.6 | 7241.3 | -1923.8 | 5317.6 | 7241.3 |
| 20 | 1526.4 | -5908.4 | 7434.8 | -1526.4 | 5908.4 | 7434.8 |
| 21 | 2123.1 | -4298.3 | 6421.4 | -2123.1 | 4298.3 | 6421.4 |
| 22 | 6967.1 | -5140.9 | 12108.0 | -6967.1 | 5140.9 | 12108.0 |
| 23 | 10146.8 | -4229.7 | 14376.5 | -10146.8 | 4229.7 | 14376.5 |
| 24 | 12130.2 | -3318.4 | 15448.6 | -12130.2 | 3318.4 | 15448.6 |
| 25 | 12688.2 | -2407.2 | 15095.4 | -12688.2 | 2407.2 | 15095.4 |

[Esc] to Exit

**FIG. 25. Stress Range - Truck Loading**

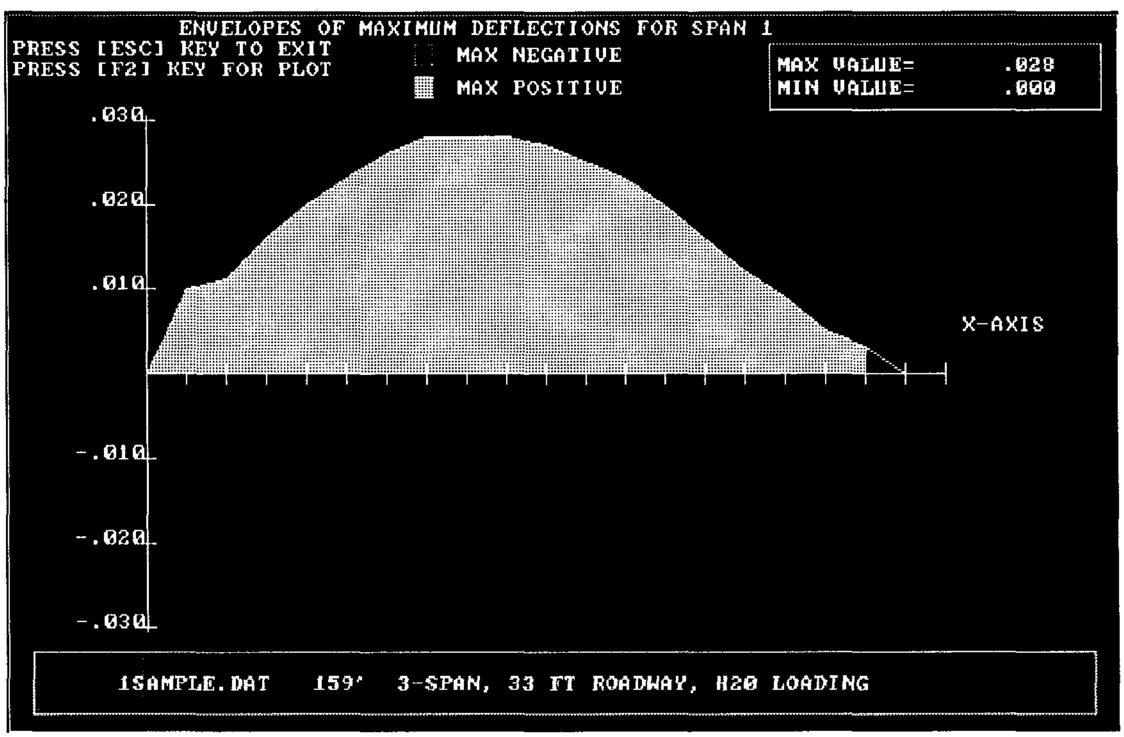



**FIG. 26. Deflections - Span 1**

**B. Dead Load Moments** - Select this option. The graph displayed on the screen is shown in Fig. 27.

**C. Total Shear - Each Span** - Select this option and enter "1" for Span 1 in the dialogue request menu. The graph displayed on the screen is shown in Fig. 28.

**D. Truck Loading - Top** - Select this option. The graph displayed on the screen is shown in Fig. 29.

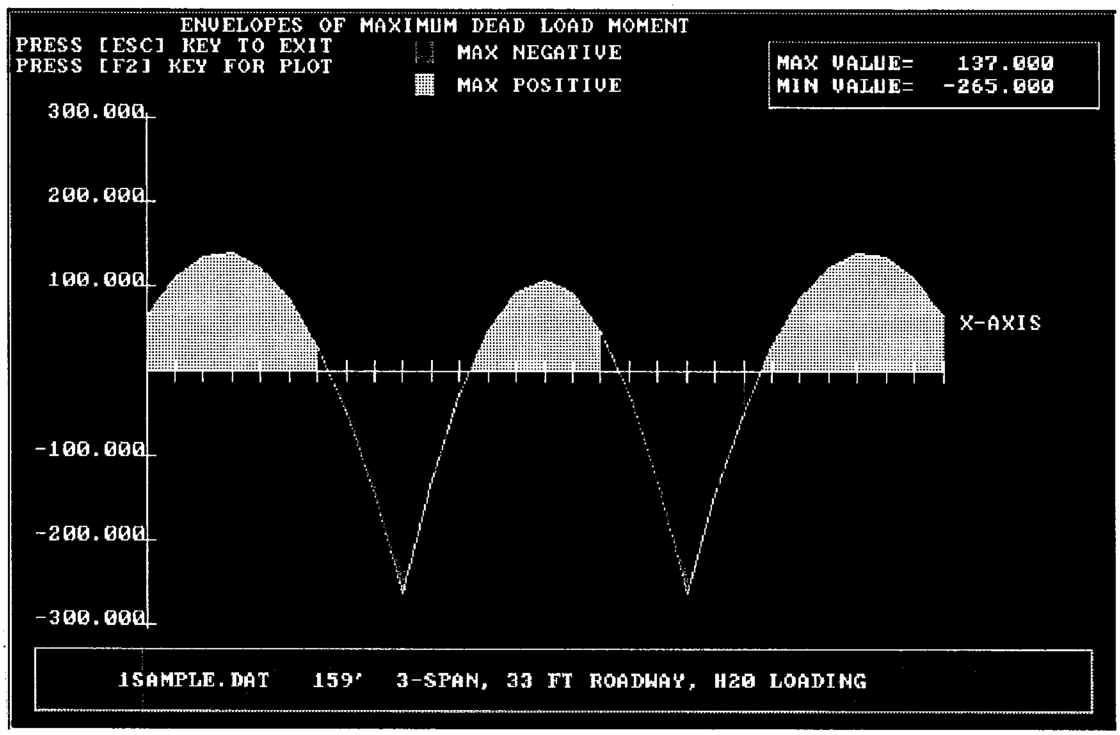



**FIG. 27. Dead Load Moments**

## 8. HARDCOPY PLOTS

Hardcopy plots can be obtained once a graph is displayed on the screen. The procedure will be outlined for the Dead Load Moments graph. The same basic procedure applies to all types of graphs.

Select this option. The graph will be displayed on the screen as before. Press [F1] key to select plotting options. The graph on the screen will be replaced by a plotting options menu. Three choices are available as to the kind of hardcopy desired. Select one of these options according to the following:

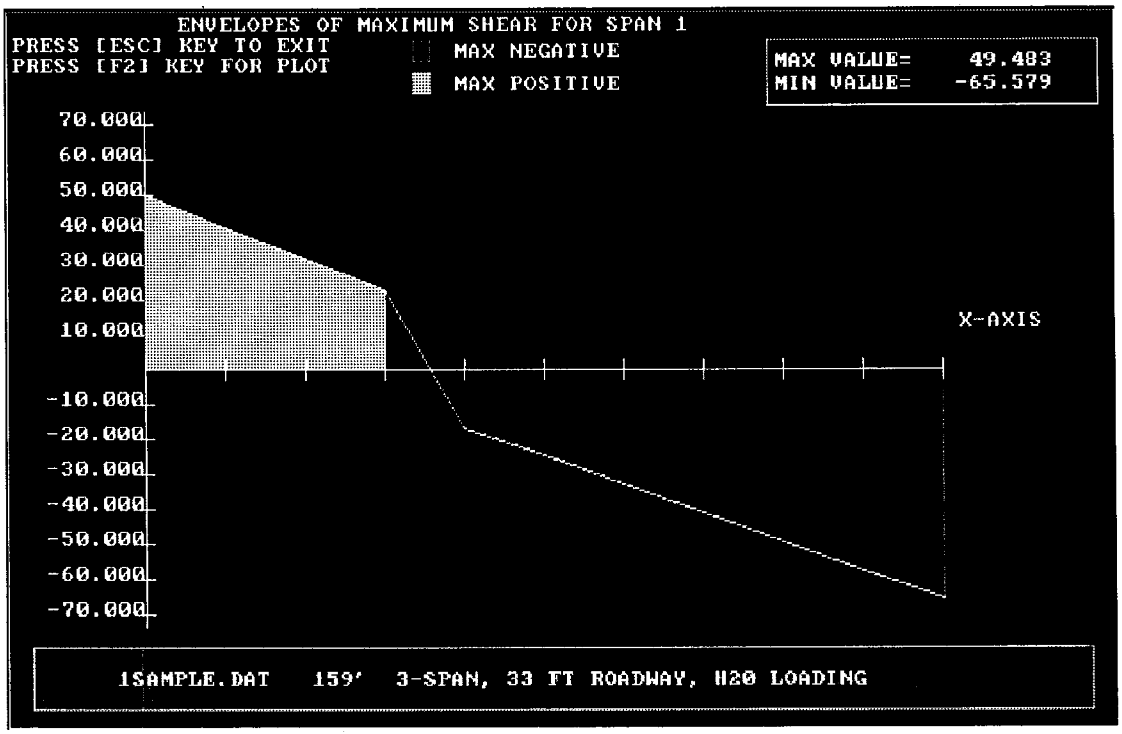



**FIG. 28. Total Shear - Span 1**

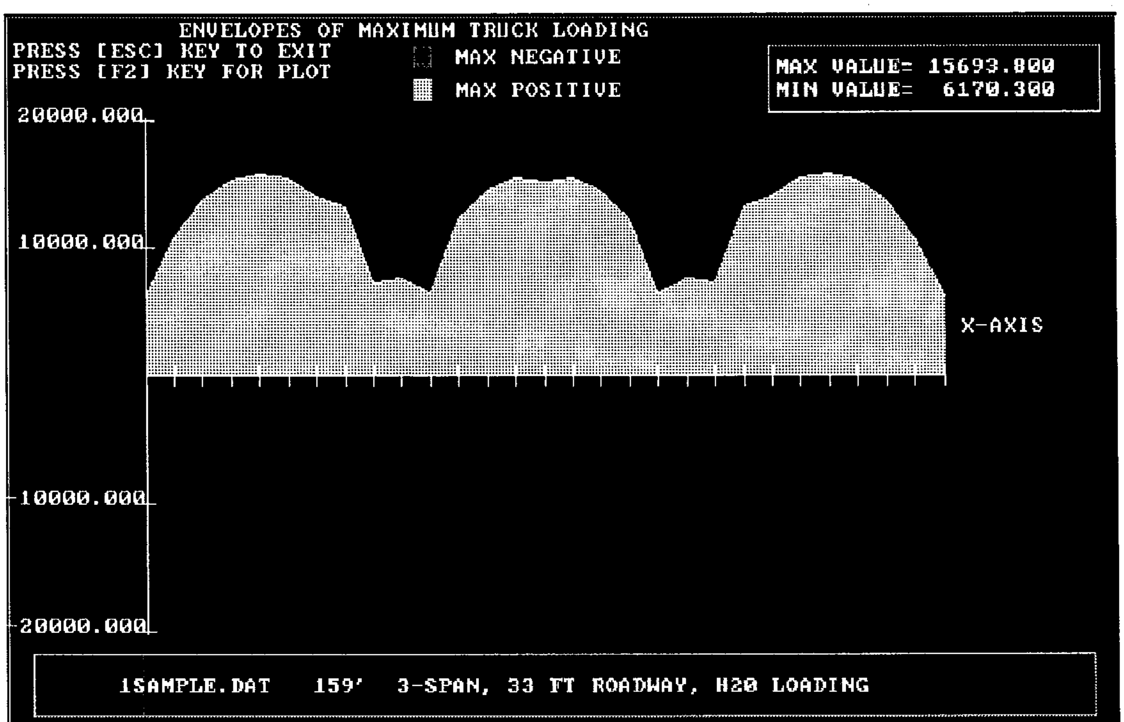



**FIG. 29. Truck Loading - Top**

**A. Screen Dump** - Once this option is selected, a second menu will appear specifying printer names supported by the software. Select the type of printer connected to the computer. The graph is displayed on the screen as it will appear on the hardcopy. Once the hardcopy has been completed, the display on the screen will return to the original colored graph.

**B. Plot** - Selection of this option leads the program to prompt the user for plot option changes. Press [Y] at this prompt to change or view the defaults. The plot options screen will be displayed at this point. Editing of the default pen numbers and speeds is performed in the same manner as in the editing of input tables (refer to **EDIT/INPUT DATA**). If there is an error in the pen number or speed selected (for example, specifying a pen number greater than 6), the program will select the most recent pen number and the default pen speed of the plotter being used. After editing or viewing this screen, press the [Esc] key. The program will prompt the user to connect the plotter to the computer. Press any key other than the [Esc] key (this key will cause a return to the original graph) to invoke the plotter. Once the hardcopy has been completed, the display on the screen will return to the original colored graph.

**C. Copy to File** - The program prompts the user for plot option changes. Edit the plot options as described before. Once the main option has been selected, the program will prompt the user for the name of a file to write the plot to. Enter the name desired (for this example, name the file "SAMPLE.DAT"). The plot will be written to this file and upon completion, the display on the screen will return to the original colored graph.

This plot file is independent from the B30 program. A hardcopy can be obtained by issuing a "copy" command at the DOS prompt. For example, if the plotter is connected to COM1 and the default drive is C, this command will take the form:

```
C:\> COPY   SAMPLE.DAT   COM1:
```

## V. WORK FILES

The program uses temporary files called work files for all manipulations. The input file specified by the user is copied to a new temporary file with the same name and a .WKF extension. This is the file used as the input file by the program. All edits are made to this .WKF file, while the original file specified by the user is left unchanged. If either the "Quit" or the "Change Input File" option is selected, the program prompts the user as to whether the work file is to be saved or not. If the user presses [Y], the program prompts for a filename under which the file is to be saved. Any valid DOS name can be used including the original filename specified. In this case, the original file is overwritten by the work file. If the user presses [N], the .WKF file is deleted without being copied to another file. The original file, however, is saved. In specifying an input file, the user should **NOT** use a .WKF extension because this file is used by the program.

Work files are invoked only if the specified input file already exists. If this is not the case, the program creates the file specified by the user. The user is not provided with the option of deleting this file, and it is saved under the specified name.

## VI. GENERAL DOCUMENTATION

### 1. HARDWARE REQUIREMENTS

Program **B30.EXE** requires certain minimum hardware in order to run:

**A. CPU** - This program will run on any IBM PC or 100% compatible.

**B. Memory** - 640K of memory must be installed on the machine. The program requires a minimum of 510 kilobytes of free memory in order to run.

**C. Graphics Card** - The program requires either an EGA card connected to an EGA monitor, or a VGA card connected to a color VGA monitor.

**D. Disk Drives** - The program can be run from a machine with only one floppy disk drive, but a hard disk is strongly recommended.

**E. Math Coprocessor** - The program requires a math coprocessor (8087, 80287, or 80387) to be installed in the machine used.

### 2. INSTALLATION AND EXECUTION PROCEDURE

Insure that the computer is equipped with the hardware required to run the program (see hardware requirements above). The program can run on a computer from a floppy disk, but it is advisable to install and execute the program from a hard drive. To install B30 on a computer with a hard drive, use the DOS COPY command to transfer the executable file from a floppy disk onto a hard drive. For example, to copy the program from a floppy disk in drive A to the root directory on hard drive C, issue the following command:

> **> COPY A:\B30.EXE C:**

To begin execution of the code, enter:

> **> B30**

## VII. REFERENCES


1. "Continuous Beam Analysis," User Manual, Texas State Department of Highways and Public Transportation, Austin, Texas, October, 1978.

2. "Microsoft FORTRAN Optimizing Compiler for the MS-DOS Operating System: User's Guide, Version 4.1," Microsoft Corporation, Redmond, WA, 1987.

3. "Microsoft FORTRAN Optimizing Compiler for the MS-DOS Operating System: Language Reference, Version 4.1," Microsoft Corporation, Redmond, WA, 1987.

4. "Microsoft Macro Assembler: Programmer's Guide, Version 5.0," Microsoft Corporation, Redmond, WA, 1987.

5. "Essential Graphics User Guide, Version 1.5," Essential Software Inc., Maplewood, NJ, 1986.